CASCA-TO 2024 Schedule

Prepared by the SOC:
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Paul Scholz, & Josh Speagle (co-chair)

For questions, comments, or corrections, please email soc@cascato.ca.

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SIDRAT RESEARCH

Monday, 3 June

Graduate Student Workshop (8:30-17:00)

This will take place at York University.

Thanks to York University for sponsoring the Graduate Student Workshop.

Arrival and registration/coffee (9:00-9:30)

Welcome & Introductions (9:30-10:00)

- Comments from the GSC (in English and French)

How to CASCA TO & Peer Networking (10:00-11:00)

Break (11:00-11:15)

Insights beyond academia (11:15-12:15)

Preventing Burnout (12:15-12:45)

Lunch (12:45-14:00)

CASCA Board >< GSC Panel Discussion (14:00-14:45)

Break (14:45-15:00)

GSC Business Meeting & Elections (15:00-16:15)

Tuesday, 4 June

Breakfast/Coffee, Registration, & Poster Setup (8:30-9:00)

Welcome & Opening Reception (9:00-9:30)

- Comments from the CASCA Board and the LOC/SOC

J.S. Plaskett Medal Talk (9:30-10:15)

- **Invited: Antoine Bédard (University of Warwick) [postdoc]**

Coffee Break & Poster Viewing (10:15-10:45)

Parallel Session I (10:45-12:15)

Cosmology I (Dominion North)

Chair(s): Matt Johnson & Simran Nerval

- **10:45-11:15: Invited: Mustafa Amin (Rice University) [faculty/staff]**
    - **How light can dark matter particles be?**
- 11:15-11:30: Enrique Paillas (University of Waterloo) [postdoc]
    - DESI 2024: Cosmological constraints from the measurements of baryon acoustic oscillations
- 11:30-11:45: Alex Krolewski (University of Waterloo) [postdoc]
    - A new method to determine H_0 from cosmological energy-density measurements
- 11:45-12:00: Raelyn Sullivan (University of British Columbia) [grad]
    - Unravelling the Universe's Twist: Investigating Cosmic Birefringence through CMB Polarization
- 12:00-12:15: Richard Bloch (York University) [grad]
    - First constraints on the remote dipole field from kSZ tomography

Transients & Compact Objects I (Dominion South)

Chair(s): Bart Ripperda

- **10:45-11:15: Invited: Tarraneh Eftekhari (Northwestern University) [postdoc]**
    - **Uncovering the Elusive Origin of Fast Radio Bursts and Other Radio Transients**
- 11:15-11:30: Aryanna Schiebelbein-Zwack (University of Toronto) [grad]
    - Inferring Formation Parameters of Binary Black Holes with Population Studies
- 11:30-11:45: Aditya Vijaykumar (CITA) [postdoc]
    - Inferring host galaxy properties of compact binaries
- 11:45-12:00: Daryl Haggard (McGill University) [faculty/staff]
    - Multi-wavelength View of M87 during the 2018 EHT Campaign Including a Gamma-ray Flaring Episode
- 12:00-12:15: John Ruan (Bishop's University) [faculty/staff]
    - Signatures of Massive Black Hole Merger Host Galaxies from Cosmological Simulations

Star Formation & the ISM I (City Hall Room)

Chair(s): Marta Reina-Campos

- 10:45-11:00: Rachel Pillsworth (McMaster University) [grad]
    - A galaxy-scale statistical view of filaments in MHD simulations of a Milky Way galaxy
- 11:00-11:15: Terrence Tricco (Memorial University of Newfoundland) [faculty/staff]
    - The Accuracy of Dusty Turbulence Simulations
- 11:15-11:30: Nicholas Owens (McMaster University) [grad]
    - Using hyperbolic conduction to model superbubbles
- 11:30-11:45: Charmi Bhatt (Western University) [grad]
    - Rotational Contour modelling of diffuse interstellar bands
- 11:45-12:00: Ioana Zelko (CITA) [postdoc]
    - Unravelling the Radiative Properties of the Interstellar Medium: The First 3D Map of the Interstellar Dust Temperature
- 12:00-12:15: Brandon Shane (Queen's University) [grad]
    - Tracing 3D Magnetic Field Structure Using Dust Polarization and the Zeeman Effect

Break to set up lunch sessions and pick up box lunch from Dominion Foyer (12:15-12:30)

ACURA Session (12:30-14:00)

Thanks to ACURA for sponsoring lunch for this session.

- SKA (45 min)
- CASTOR (45 min)

Break to set up parallel sessions (14:00-14:15)

Parallel Session II (14:15-15:15)

Long Wavelength Astronomy (Dominion North)

Chair(s): Paul Scholz

- 14:15-14:30: Ryley Hill (University of British Columbia) [postdoc]
  - Resolving the cosmic infrared background with JWST and ALMA
- 14:30-14:45: Blake Ledger (McMaster University) [grad]
  - CN as a tool for dense gas studies in star-forming galaxies
- 14:45-15:00: Robert Main (McGill University) [postdoc]
  - The CHIME All-Sky Multiday Pulsar Stacking Survey - Overview and first results
- 15:00-15:15: Arash Mirhosseini (University of British Columbia) [grad]
  - A blind search for 21-cm absorption systems with CHIME

Milky Way & the Local Group (Dominion South)

Chair(s): Vincent Hénault-Brunet

- 14:15-14:30: Abigail Battson (Saint Mary's University) [grad]
  - High-velocity stars ejected from globular clusters: NGC 3201 candidates from Gaia DR3
- 14:30-14:45: Nathan Sandford (University of Toronto) [postdoc]
  - Chemodynamical Analyses of Ultra Faint Dwarf Galaxies: Star Formation, Galactic Outflows, and Dark Matter Profiles
- 14:45-15:00: Mairead Heiger (University of Toronto) [grad]

    - An extreme of an already extreme regime: characterization and chemistry of ultra-faint dwarf galaxy Eridanus IV
- 15:00-15:15: Gustavo Medina Toledo (University of Toronto)
    - An overview of the spectroscopic characterization and chemodynamical analysis of the RR Lyrae stars observed by the DESI survey

Astrostatistics & Astroinformatics (City Hall Room)

Chair(s): Gwen Eadie

- 14:15-14:30: Salma Salhi (iREx, Ciela, Université de Montréal, Mila) [grad]
    - Using score-based diffusion models for correlated 1/f noise reduction in JWST spectral data
- 14:30-14:45: Weixiang Yu (Bishop's University) [postdoc]
    - Scalable Gaussian Process Modeling of AGN Light Curves in LSST
- 14:45-15:00: Arefe Abghari (University of British Columbia) [grad]
    - Extracting the Hierarchical Wavelet Coefficients from Full-Sky Maps
- 15:00-15:15: Kevin McKinnon (CITA) [postdoc]
    - Precise Proper Motions of faint Milky Way halo stars with BP3M

Parallel Session III (15:20-16:20)

Harvey Richer Special Memorial Session (Dominion North)

The session is independently organized by Steffani Grondin and Gwendolyn Eadie (University of Toronto). A detailed copy of the schedule can be found here.

Chair(s): Karun Thanjavur

- 15:20-15:28: Dave Miller (University of British Columbia) [grad]
    - Developments in the white dwarf initial-final mass relation with Gaia
- 15:28-15:36: Steffani Grondin (University of Toronto) [grad]
    - A Richer Understanding of Binary Evolution: The first systematic identification of white dwarf-main sequence post-common envelope binaries in star clusters
- 15:36-15:44: Ilaria Caiazzo (Caltech/ISTA) [postdoc/faculty]
    - Janus, a new class of white dwarfs
- 15:44-15:52: Ronan Kerr (UT Austin) [grad/postdoc]
    - The SPYGLASS Program: Mapping the Dynamics and Evolution of Star Formation up to Galactic Scales

- 15:52-16:00: Jeremy Heyl (University of British Columbia) [faculty/staff]
    - Richer in Carbon: How the JAGB and JWST will measure the Universe
- 16:00-16:08: Pauline Barmby (Western University) [faculty/staff]
    - The Richer extragalactic universe
- 16:08-16:16: Dennis Crabtree (NRC Herzberg) [retired faculty/staff]
    - Harvey Richer

Next-Generation Spectroscopic Surveys Special Session (Dominion South)

The session is independently organized by Alex Krolewski and Will Percival (University of Waterloo).

- 15:20-15:35: Hanyu Zhang (University of Waterloo) [postdoc]
    - Cosmological Implications from DESI Y1 BAO and Future Forecasts
- 15:35-15:50: Andrew Sheinis (CFHT) [faculty/staff]
    - Updates to the Maunakea Spectroscopic Explorer: Thousands of Fibers, Infinite Possibilities
- 15:50-16:05: Marco Bonici (University of Waterloo) [postdoc]
    - An overview of the Euclid mission
- 16:05-16:20: Alan Nguyen (University of Waterloo) [grad]
    - The Effects of Interlopers in Next-Generation Galaxy Surveys

Education & Public Outreach (City Hall Room)

Chair(s): Michael Reid

- 15:20-15:35: Laurie Rousseau-Nepton (University of Toronto) [faculty/staff]
    - Indigenous Engagement Committee Report
- 15:35-15:50: Daniella Morrone (CASCA/Discover the Universe) [other]
    - Launch of the Westar Program
- 15:50-16:05: Alice Curtin (McGill University) [grad]
    - Building more equitable spaces in STEM through game-based learning; the case of Science in Space: How to Telescope
- 16:05-16:20: Heidi White (Université de Montréal) [faculty/staff]
    - Exoplanets in the Classroom: A Bilingual K-12 Educational Suite for Exploring Exoplanet Science

Coffee Break & Poster Viewing (16:20-16:30)

TMT Science Session (16:30-17:30)

- **Invited: Robert Kirshner (Executive Director, TMT International Observatory) [faculty/staff]**
    - **The Thirty Meter Telescope: Progress and Prospects**
- **Invited: Fengchuan Liu (Program Manager, TMT International Observatory) [faculty/staff]**
    - **Project Update and A New Paradigm in Hawaii**
- Discussion (30 min)

Public Talk (18:30-19:30)

- **Invited: Jess McIver (University of British Columbia) [faculty/staff]**
    - **Unlocking the unseen Universe with gravitational waves**

Wednesday, 5 June

Breakfast/Coffee, Registration, & Poster Viewing (8:30-9:00)

Dunlap Award Talk (9:00-9:45)

- **Invited: Roberto Abraham (University of Toronto) [faculty/staff]**

Morning Poster Session (9:45-10:30)

A full list of posters can be found at the end of the schedule.

Thank you to SKA for sponsoring this poster session.

Parallel Session IV (10:30-12:00)

Galaxies I (Dominion North)

Chair(s): Adam Muzzin

- **10:30-11:00: Invited: Jacqueline Antwi-Danso (University of Toronto) [postdoc]**
  - **Too Big to Be? Searching for the Most Massive Galaxies in the Distant Universe**
- 11:00-11:15: Hyunseop Choi (Université de Montréal) [postdoc]
  - Multi-phase AGN feedback and a bright, extended [CII] halo in a LoBAL quasar at z~6.6
- 11:15-11:30: George Wang (University of British Columbia) [grad]
  - A 100 Mpc structure traced by hyperluminous galaxies around a massive z = 2.85 protocluster
- 11:30-11:45: Nathan Steinle (University of Manitoba) [postdoc]
  - Galactic-scale magnetic fields and gravitational wave detections with LISA
- 11:45-12:00: Ralph Pudritz (McMaster University) [faculty/staff]
  - Filamentary Hierarchies and Superbubbles: Multiscale Galaxy MHD Simulations of GMC and Star Cluster Formation

Exoplanets I (Dominion South)

Chair(s): Janosz Dewberry

- **10:30-11:00: Invited: Ryan Cloutier (McMaster University) [faculty/staff]**
    - **Understanding the Origins of the Galaxy's Most Common Planets around its Most Common Stars**
- 11:00-11:15: Katie Crotts (University of Victoria) [grad]
    - Expedition Unknown: Characterizing and Modelling GPI Debris Disks in the Search for Elusive Planets
- 11:15-11:30: Christian Marois (NRC Herzberg) [faculty/staff]
    - Toward reflected light exoplanet imaging with CAL2: Project update of the NRC facility-class focal plane wavefront sensor for the Gemini Planet Imager 2 upgrade
- 11:30-11:45: Michael Radica (Université de Montréal) [grad]
    - Ultraviolet-to-Infrared Atmosphere Spectroscopy of the Ultra-Hot-Neptune LTT 9779b
- 11:45-12:00: Nicolas Cowan (McGill University) [faculty/staff]
    - Canada's Contribution to ESA's Ariel Mission

Instrumentation & Surveys I (City Hall Room)

Chair(s): Adam Hincks

- **10:30-11:00: Invited: Alan McConnachie (NRC Herzberg) [faculty/staff]**
    - **Canada and UNIONS, the definitive optical survey of the northern hemisphere for the 2020s**
- 11:00-11:15: Viraja Khatu (CFHT) [faculty/staff]
    - A Glimpse of AGN Variability Survey Planning with CASTOR
- 11:15-11:30: William Thompson (NRC Herzberg) [postdoc]
    - Deploying focal plane wavefront sensing and coherent imaging at Subaru with SPIDERS, a pathfinder 4th generation planet imager
- 11:30-11:45: Kelsey Hoffman (Bishop's University) [faculty/staff]
    - The Pandora Mission: Countdown to Launch
- 11:45-12:00: Christopher Mann (NRC Herzberg) [postdoc]
    - Coherent differential imaging on SPIDERS

Break to set up lunch sessions and pick up box lunch from Dominion Foyer (12:00-12:15)

OIR Review Committee Update (12:15-12:45)

Herzberg Astronomy and Astrophysics Research Centre Town Hall (12:45-13:45)

Break to set up parallel sessions (13:45-14:00)

Parallel Session V (14:00-15:00)

Cosmology II (Dominion North)

Chair(s): Will Percival

- 14:00-14:15: Victor Chan (Southern Methodist University) [postdoc]
    - The Small-Correlated-Against-Large-Estimator for Cosmic Microwave Background Lensing
- 14:15-14:30: Jordan Krywonos (York University & Perimeter Institute) [grad]
    - Exploring How Cross-Bin Correlations Impact Photometric Galaxy Clustering Constraints
- 14:30-14:45: Roan Haggar (University of Waterloo) [postdoc]
    - Constraining cosmological parameters with the splashback radius
- 14:45-15:00: Huanqing Chen (CITA) [postdoc]
    - Fluctuations and Evolution of the Ionizing Background and Mean Free Path during the Late Stages of Reionization

Transients & Compact Objects II (Dominion South)

Chair(s): John Ruan

- 14:00-14:15: Ariel Chitan (Western University) [grad]
    - Massive black hole triplets in the Obelisk simulation.
- 14:15-14:30: Philippe Landry (CITA) [postdoc]
    - Inference of multi-channel r-process element enrichment in the Milky Way using binary neutron star merger observations
- 14:30-15:45: Karun Thanjavur (University of Victoria) [faculty/staff]

        - SDSS J2320+0024: Supermassive binary blackholes in their final tango?!

JWST (City Hall Room)

Chair(s): Roberto Abraham

- 14:00-14:14: Breanna Crompvoets (University of Victoria) [grad]
    - Classifying YSOs in the Cosmic Cliffs JWST Data using a Probabilistic Random Forest
- 14:15-14:30: Lisa Dang (Université de Montréal) [postdoc]
    - A Hell of a Phase Curve: Mapping the Surface and Atmosphere of the Lava Planet K2-141b with JWST
- 14:30-14:45: Dori Blakely (University of Victoria) [grad]
    - The James Webb Interferometer: Joint model fitting of the protoplanets and disk around PDS 70 provides evidence for circumplanetary disk emission and additional asymmetric emission within the disk gap
- 14:45-15:00: Lucas Kuhn (University of British Columbia) [grad]
    - From Shocks to Star Formation: Ionized Gas Diagnostics with JWST MIRI in MACS1931-26

Afternoon Poster Session (15:00-16:00)

A full list of posters can be found at the end of the schedule.

Thank you to AAS publishing for sponsoring this poster session.

Equity, Diversity, & Inclusion Session (16:00-17:30)

- Ethical Gray Zone Workshop (45 min)
- Panel Discussion with the Equity & Inclusion Committee (EIC) and the Long Range Plan Community Recommendations Implementation Committee (LCRIC) (45 min)

CASCA Banquet (19:00 - 21:00)

The Banquet will take place at the Osgoode Ballroom, Sheraton Hotel, 123 Queen Street.

Thank you to the Dunlap Institute and the David A. Dunlap Department of Astronomy and Astrophysics for sponsoring the banquet.

Thursday, 6 June

Breakfast/Coffee, Registration, & Poster Viewing (8:30-9:00)

Qilak Award Talk (9:00-9:45)

- **Invited: Laurie Rousseau-Nepton (University of Toronto) [faculty/staff]**

NSERC Session (9:45-10:30)

Coffee Break & Poster Viewing (10:30-10:45)

Parallel Session VI (10:45-11:45)

Stars and Stellar Populations I (Dominion North)

Chair(s): Josh Speagle

- **10:45-11:15: Invited: Lyra Cao (Vanderbilt University) [postdoc]**
  - **Starspots and radius inflation: the evolution of stellar activity and its impact on derived stellar parameters**
- 11:15-11:30: Jay Allison (Université de Moncton) [grad]
  - Modelling Atomic Diffusion, g-mode Pulsation and Binary Interactions in HgMn Stars
- 11:30-11:45: Alison Sills (McMaster University) [faculty/staff]
  - Star Cluster Formation, Binary Stars, and Multiple Populations: Missing Links

High-Energy and Plasma Astrophysics (Dominion South)

Chair(s): Phil Landry

- **10:45-11:15: Invited: Sean Ressler (CITA) [postdoc]**
  - **Quasi-Periodicities and Jet Precession in AGN Perturbed by Black Hole Companions**
- 11:15-11:30: Margaret Ridder (University of Alberta) [grad]

    - Testing the proposed radio emission mechanisms of cataclysmic variables with QS Vir
- 11:30-11:45: Gibwa Musoke (CITA) [postdoc]
    - Forming of truncated accretion disks

Galaxies II (City Hall Room)

Chair(s): Renée Hložek

- 10:30-10:45: Allison Man (University of British Columbia) [faculty/staff]
    - Unraveling the nature of the cold interstellar medium in distant quiescent galaxies
- 10:45-11:00: Connor Stone (Université de Montréal) [postdoc]
    - Caustics: the gravitational lensing simulator of the future
- 11:00-11:15: Yunting Wang (University of British Columbia) [grad]
    - Probing the Faintest Galaxies Below the Confusion Limit
- 11:15-11:30: Solveig Thompson (University of Calgary) [grad]
    - Hide and Seek: A Census of Black Holes in Virgo Ultra-Compact Dwarf Galaxies

Break to set up lunch session and pick up box lunches from Dominion Foyer (11:45-12:00)

Very Large Optical Telescope (VLOT) Landscape Discussion (12:00-13:30)

Break to set up parallel sessions (13:30-13:45)

Parallel Session VII (13:45-14:45)

Star Formation & the ISM II (Dominion North)

Chair(s): Marta Reina-Campos

- **13:45-14:15: Invited: Kelsey Johnson (University of Virginia) [faculty/staff]**
    - **How were the most ancient objects in the universe formed?**
- 14:15-14:30: Claude Cournoyer-Cloutier (McMaster University) [grad]

    - [Massive binaries in young massive star clusters]
- 14:30-14:45: Yanlong Shi (CITA) [postdoc]
    - [Seed black hole accretion in star clusters]

Exoplanets II (Dominion South)

Chair(s): Jess Speedie

- 13:45-14:00: Jiaqing Bi (University of Toronto) [postdoc]
    - [Shoulder of Dust Rings Explained by Dust Dynamics Under Planet-Disk Interactions]
- 14:00-14:15: Charles Cadieux (Université de Montréal) [grad]
    - [Atmospheric Characterization of the Temperate Planet LHS 1140 b with JWST/NIRISS – Is LHS1140 b a Mini-Neptune or a Water-World?]
- 14:15-14:30: Alexandrine L'Heureux (Université de Montréal) [grad]
    - [TOI-2120 b: A temperate sub-Neptune transiting a M4.5 dwarf revealed by SPIRou and TESS]
- 14:30-14:45: Emily Deibert (NOIRlab/Gemini South) [postdoc]
    - [High-Resolution Spectroscopy of Ultra-Hot Jupiter Atmospheres with GHOST]

Galaxies III (City Hall Room)

Chair(s): Rahul Kannan

- 13:45-14:00: Aromal Pathayappura (Western University) [postdoc]
    - [Probing ultra-fast outflows in BAL quasars using multi-epoch spectroscopy]
- 14:00-14:15: Khadeejah Motiwala (Queen's) [grad]
    - [Are gas-rich UDGs and field dwarfs distinct?]
- 14:15-14:30: Darshak Patel (Waterloo) [grad]
    - [Early UNIONS Results: Dependence of Halo Mass on Galaxy Size at Fixed Stellar Mass, Colour, and Redshift]
- 14:30-14:45: Hamid Hassani (University of Alberta) [grad]
    - [Galactic Genesis to Twilight: Charting Stellar Evolution in Nearby Galaxies with PHANGS-JWST Mid-IR Observations]

Parallel Session VIII (14:50-15:50)

Stars and Stellar Populations II (Dominion North)

Chair(s): Alison Sills

- 14:50-15:05: Sacha Perry-Fagant (Université de Montréal) [grad]
    - Score-Based Diffusion Models for Bayesian Posterior Inference over Star Formation Histories
- 15:05-15:20: Michael Power (Memorial University of Newfoundland) [grad]
    - The Curious Case of V CVn
- 15:20-15:35: Natalia Posiłek (Université de Moncton, University of Wrocław) [grad]
    - Variability of chemically peculiar AmFm stars
- 15:35-15:50: Catherine Lovekin (Mount Allison University) [faculty/staff]
    - Asteroseismology of the eclipsing binary KIC 10727668

Instrumentation & Surveys II (Dominion South)

Chair(s): TBD

- 14:50-15:05: Nadine Manset (CFHT) [faculty/staff]
    - CFHT updates and plans for the upcoming 10 years
- 15:05-15:20: Felix Thiel (Queen's University) [grad]
    - Construction and First Ground-based Tests of the Balloon-borne VLBI EXperiment (BVEX) Telescope and Receiver
- 15:20-15:35: Mayukh Bagchi (Queen's University) [grad]
    - An RFSoC-based backend and timing reference system for balloon-borne VLBI experiments
- 15:35-15:50: Momen Diab (University of Toronto) [postdoc]
    - Astrophotonics for adaptive optics

Galaxies IV (City Hall Room)

Chair(s): Laura Parker

- 14:50-15:05: Vivian Yun Yan Tan (York University) [grad]
    - Milky Way progenitors since z=5: Resolved mass assembly and star-formation rates with JWST
- 15:05-15:20: Angelo George (Saint Mary's University) [grad]

        - From UV to Visible Light: Unveiling the Secrets of Galaxy Size Evolution in the COSMOS Field
- 15:20-15:35: Joe Bhangal (University of British Columbia) [grad]
    - Searching for Protoclusters at z ~ 2
- 15:35-15:50: D Cocroft (University of Toronto, CITA) [grad]
    - Black Holes within AGN Disks

Coffee Break & Poster Takedown (15:50-16:00)

Annual Business Meeting (16:00-17:30)

Poster awards and Closing Remarks (17:30-18:00)

Full List of Posters

The poster size for CASCA-TO posters is A1 (vertical) or 594 x 841 mm or 23.4 x 33.1 inches.

Astrostatistics & Astroinformatics

1. Ian Chow (Western University) [grad]
   - Properties of Decameter Earth Impactors
2. Jayanne English (University of Manitoba) [retired faculty/staff]
   - CosmosCanvas: Acquiring Information Through Colour Experiment
3. Nolan Koblischke (University of Toronto) [undergrad]
   - SpectraFM: Tuning into Stellar Foundation Models
4. Connor MacKeigan (University of Toronto) [undergrad]
   - Machine Learning Bayesian Mixture Density Networks for Stellar Stream Inference in the Milky Way
5. Utkarsh Mali (University of Toronto, CITA) [grad]
   - Cosmology using populations of gravitational wave sources
6. Antonio Herrera Martin (University of Toronto) [postdoc]
   - Rare events in astronomy with repeating FRBs
7. Simran Nerval (University of Toronto, Dunlap Institute) [grad]
   - Millimeter Transient Detection During Timestream Preprocessing with the Atacama Cosmology Telescope
8. Silke Rice (University of British Columbia) [grad]
   - Optimizing Lens Detection Using Ranking Algorithms and Convolutional Neural Networks
9. Dhruv Sondhi (Western University) [grad]
   - Navigating Astrophysics Literature: Harnessing AstroBERT and UAT
10. Jianing (Jenny) Su (University of Toronto [grad]
    - Improved period estimates for RR Lyrae stars using multi-tapering and the F-test
11. Phil Van-Lane (University of Toronto) [grad]
    - A probabilistic ML model for stellar age inference using gyrochronology
12. Erik Weiss (York University] [grad]
    - Quasar Spectra Informatics: Algorithms for Representation & Reconstruction

Cosmology

13. Pierre Burger (University of Waterloo) [postdoc]
    - A roadmap to cosmological parameter analysis with third-order shear statistics
14. Martine Campbell (University of Waterloo) [grad]
    - Is Lensing Low in UNIONS?
15. Nathan Carlson (CITA, University of Toronto) [grad]

- [Mocks of cosmic structure evolving from primordial non-Gaussianities with WebSky2.0]

16. Alice Chen (University of Waterloo, Perimeter Institute) [grad]
    - Predicting galaxy/halo locations from their bright neighbours
17. Kyle Finner (IPAC, Caltech) [faculty/staff]
    - Connecting Dark Matter Distributions to Merger-induced Shocks in Galaxy Clusters
18. Amber Hollinger (University of Waterloo) [postdoc]
    - Cosmological Parameters Estimated from Velocity -- Velocity Comparisons
19. James Morawetz (Waterloo Center for Astrophysics, University of Waterloo) [grad]
    - Constraining Primordial Non-Gaussianity with Density-Split Clustering
20. Charlie Mpetha (University of Waterloo) [grad]
    - Prospects for using the infall region to probe cosmology
21. Vasilii Pustovoit (CITA, University of Toronto) [grad]
    - Beyond the First Light: Novel Simulations of Pop III Stars with GIZMO
22. Rashaad Reid (University of Waterloo) [grad]
    - Constraining Cosmology with Galaxy Cluster History
23. Michael Sekatchev (University of British Columbia) [grad]
    - Axion Quark Nugget Annihilation Versus Observed Excess in Galactic Emissions
24. James Taylor (Waterloo Center for Astrophysics) [faculty/staff]
    - Cluster Formation History as a Cosmological Test
25. Harrison Winch (University of Toronto) [grad]
    - Tests of axion dark matter using galaxy UV luminosities
26. Shiming Gu (University of British Columbia) [grad]
    - Lensing Cosmology Without Small-scales

Education and Public Outreach

27. Dennis Crabtree (NRC Herzberg) [retired faculty/staff]
    - A Bibliometric Analysis of Canadian Astronomy
28. Elaina Hyde (York University, Allan I Carswell Observatory) [faculty/staff]
    - Allan I. Carswell Observatory 2024 Solar Eclipse Education and Outreach
29. Elaina Hyde (York University, Allan I Carswell Observatory) [faculty/staff]
    - Allan I. Carswell Observatory 2024 Messier Marathon with a 1m
30. Mary Beth Laychak (CFHT) [faculty/staff]
    - Cultivating Connections: CFHT’s Community Efforts
31. Nicole Mulyk (McMaster University) [grad]
    - Physics and Astronomy Undergraduate Longitudinal Survey at McMaster University
32. Janette Suherli (University of Manitoba) [grad]
    - Highlights from CASCA’s Graduate Student Committee 2023-2024

Exoplanets

33. Laurie Dauplaise (Université de Montréal) [grad]
    - A New Differential Effective Temperature tool as a Stellar Activity Indicator for the TRAPPIST-1 Planets
34. Frédéric Genest (Université de Montréal) [grad]
    - Exploration of hot Jupiter atmospheres with NIRPS
35. Erik Gillis (McMaster University) [grad]
    - Characterizing the Radius Valley around Mid-to-late M Dwarfs
36. Nicole Gromek (McMaster University) [grad]
    - Calibrating Elemental Abundances in M Dwarfs with SPIRou
37. Adam Johnson (University of Victoria) [grad]
    - A SmallSat mission study for STARLITE: Superluminous Tomographic Atmospheric Reconstruction with Laser-beacons for Imaging Terrestrial Exoplanets
38. Kim Morel (Université de Montréal) [grad]
    - Eclipse Spectroscopy of WASP-80 b with JWST/NIRISS Reveals Properties of Reflecting Aerosols
39. Joshua Parsons (York University) [grad]
    - Habitability and Observability of Earth analogs in Brown dwarf systems
40. Alexandra Rochon (McGill University) [undergrad]
    - Analysis of the Atmosphere of Hot-Jupiter KELT-20b using its full-orbit Spitzer Phase Curve
41. Jason Rowe (Bishop's University) [faculty/staff]
    - The POET Mission
42. Zoe Shu (Université de Montréal) [grad]
    - Exploring the Peculiar Western Hotspot Offset of CoRoT-2b with High-Resolution Spectroscopy
43. Bennett Skinner (McMaster University) [grad]
    - Water as a Potential Sculptor of the M Dwarf Radius Valley
44. William Thompson (NRC Herzberg) [postdoc]
    - Join modelling to discovery and characterise exoplanets: 51 Eri and Eps Eri seen with imaging, VLTI-GRAVITY, RV, and GAIA
45. Thomas Vandal (Université de Montréal, iREx) [grad]
    - From HR 8799 to Y-dwarf binaries: JWST interferometry across the stellar IMF
46. Drew Weisserman (McMaster University) [grad]
    - Obtaining Precise and Accurate Masses of Super-Earths around M Dwarfs
47. Sarah Yost (College of St. Benedict, St. John's University) [faculty/staff]
    - Comparing Exoplanet Transit Timing Methods' Predictions for Long-Period Systems

Galaxies

48. Syeda Lammim Ahad (Waterloo Centre for Astrophysics) [postdoc]
    - The measurement and interpretation of intragroup and intracluster light: combining simulations and observations
49. Ashley Bemis (Waterloo Centre for Astrophysics, University of Waterloo) [postdoc]
    - Excitation or efficiency: a multi-line analysis of dense gas tracers across the Antennae
50. Samantha Berek (University of Toronto) [grad]
    - Do zeros count? Understanding the galaxy-globular cluster connection for the smallest galaxies.
51. Rushikesh Bhutkar (University of Manitoba) [grad]
    - SMA CO (J=3-2) and dust continuum observations of a CSS radio galaxy 3C303.1 at 230 GHz and 272 GHz
52. Matias Bravo (McMaster University) [postdoc]
    - A SHARK's view of the galaxy-AGN-environment connection throughout cosmic time
53. Westley Brown (York University) [grad]
    - The Relationship Between Galaxy Structure, Stellar Mass, and Local Density at Redshift 1.6
54. Hannah Christie (Western University) [grad]
    - The Star Forming Main Sequence of Low Surface Brightness Galaxies
55. Veronika Dornan (McMaster University) [grad]
    - Determining Globular Cluster System Distributions with Voronoi Tessellations
56. Jordan Ducatel (University of Waterloo) [grad]
    - New constraints on the halo mass of ultra-diffuse galaxies with UNIONS using weak gravitational lensing
57. Lawrence Faria (Queen's University) [grad]
    - Drivers for Star Formation in Interacting Galaxies
58. Lauren Foster (McMaster University) [grad]
    - Measuring the Effect of Ram Pressure on Star Formation in Infalling Galaxies
59. Laya Ghodsi (University of British Columbia) [grad]
    - Joint ALMA+JWST analysis of the circumgalactic medium of MACS1931-26
60. Marie-Joëlle Gingras (Waterloo Centre for Astrophysics) [grad]
    - Mapping Nebular Gas Dynamics in Active Central Cluster Galaxies
61. Celine Greis (McMaster University) [grad]
    - Molecular Gas under Pressure - Molecular Gas Susceptibility to Ram Pressure Stripping in the Virgo Cluster
62. Guillaume Hewitt (University of Waterloo) [grad]

- Clues to environmental quenching mechanisms from the evolution of stellar mass functions in $0.9 < z < 1.5$ clusters

63. Patrick Horlaville (Bishop's University) [grad]
    - Searching for Dual AGNs
64. Kaitlyn Keatley (McMaster University) [grad]
    - JWST NIRCam Observations of the Globular Cluster Population in RXJ 2129.7+0005
65. Jinoo Kim (McMaster University) [grad]
    - Photometry of the Globular Cluster Populations in Abell 2744 in NIRCam LWC Bands
66. Cam Lawlor-Forsyth (University of Waterloo) [grad]
    - Signatures of quenching mechanisms in spatially-resolved star formation: predictions for Roman and CASTOR
67. Dylan Lazarus (McMaster University) [grad]
    - The Properties of Optical-UV-Selected Rejuvenating Galaxies
68. Cameron Morgan (University of Waterloo) [grad]
    - Decoding quenching in the Virgo cluster and infalling groups with spatially resolved star formation
69. Padraic Odesse (McMaster University) [grad]
    - Molecular Gas in Simulations of Nearby Spiral Galaxies
70. Megan Oxland (McMaster University) [grad]
    - Satellite quenching and morphological transformation of galaxies in groups and clusters
71. Mathieu Perron-Cormier (Queen's University) [grad]
    - Improvements to Galaxy Asymmetry in HI
72. Ian Roberts (Waterloo Centre for Astrophysics) [postdoc]
    - CLIFS: The Coma Legacy IFU Survey
73. Ghassan Sarrouh (York University) [grad]
    - High- and Low-Density Mass Functions at $z \sim 0.5$ Defy Simple Models
74. Elizaveta Sazonova (University of Waterloo) [postdoc]
    - Robust measurements of galaxy structure across surveys and cosmic time
75. Nathan Skeggs (Queen's University) [grad]
    - Asymmetry in polarized emission from nearby edge-on spiral galaxies
76. Visal Sok (York University) [grad]
    - Gas-tly origins: unraveling star-forming clumps in high-z galaxies
77. Sunna Withers (York University) [grad]
    - Medium-Band Colour Selections of High Redshift Extreme Emission Line Galaxies with JWST/NIRCam
78. Jing Yeung (McMaster University) [grad]
    - The evolution of galaxy star formation and morphology in groups and clusters with IllustrisTNG

High-Energy and Plasma Astrophysics

79. Braden Gail (University of Toronto) [grad]

- Mechanism for Sgr A* Infrared Flares

80. Brock Klippenstein (University of Manitoba) [grad]
    - On Solving the Fokker-Planck Equation with Airy Functions
81. Jonathan Zhang (University of Toronto) [grad]
    - The global plasma distribution around a magnetar

Instrumentation & Surveys

82. Daniel Devost (CFHT) [resident astronomer]
    - Decadal variations of seeing on Maunakea
83. Kyle Finner (Caltech, IPAC) [faculty/staff]
    - Detecting Microlensing Signals in the Roman Galactic Bulge Time Domain Survey
84. Braden Gail (University of Toronto) [grad]
    - Novel Method for Measuring Quantum Efficiency Using Fiber Optics
85. Aditya Khandelwal (University of Toronto) [undergrad]
    - Beyond CCDs: Characterization of sCMOS detectors for optical astronomy
86. Nadine Manset (CFHT) [director of science operations]
    - News and highlights from CFHT
87. Brenda Matthews (NRC Herzberg) [faculty/staff]
    - High stakes: The ngVLA and access to the 1.4 - 100 GHz sky at high sensitivity and resolution
88. David Bohlender (NRC Herzberg) [faculty/staff]
    - The Dominion Astrophysical Observatory Science Archive
89. Joel Roediger (Canadian Space Agency) [faculty/staff]
    - Five Years of the Guest Observer Program for the Near-Earth Object Surveillance Satellite
90. Laurie Rousseau-Nepton (University of Toronto, Dunlap Institute) [faculty/staff]
    - SIGNALS' Update
91. Bonnie Slocombe (Queen's University) [undergrad]
    - Initial Telescope Characterization for the Balloon-borne VLBI Experiment (BVEX)
92. Eric Steinbring (NRC Herzberg) [faculty/staff]
    - Canadian Gemini News
93. Robin Swanson (University of Toronto) [grad]
    - First Photon Counts at the Allan I. Carswell Observatory with a single pixel SPAD
94. Spencer Locke (University of Lethbridge) [grad]
    - Simulating Tools for Spatial-Spectral Tools for Interferometry in the Far-Infrared
95. Jade Yeung (Queen's University) [undergrad]
    - Characterising the Noise Temperature of the BVEX Radio Telescope Using a Thermally Controlled Warm Source

JWST

96. Callum Dewsnap (Western University) [grad]
    - Examining the host galaxies of active galactic nuclei in the JWST CEERS survey
97. Jean Dupuis (Canadian Space Agency) [faculty/staff]
    - Early Results and a Guide to the Canadian Space Agency Grants Program for JWST
98. Naadiyah Jagga (York University) [grad]
    - Resolved versus Unresolved Photometry: Stellar Mass Estimates of Galaxies Observed by JWST

Long Wavelength Astronomy

99. Naman Jain and Thomas Abbott (McGill University) [grads]
    - The Second CHIME/FRB Catalog
100. Osvald Klimi (McMaster University) [grad]
    - Star Formation and Gas Properties in (Ultra)-Luminous Infrared Galaxies: Insights from the ALMA Archive
101. Jennifer Laing (McMaster University) [grad]
    - Does star formation drive increased molecular gas turbulence in galaxy centres?
102. Magnus L'Argent (McGill University) [grad]
    - Confirming Pulsar Candidates from CHAMPSS using a Multiday Coherent Search
103. Jess Speedie (University of Victoria) [grad]
    - Gravitational Instability in a Planet-Forming Disk
104. Mercedes Thompson (University of British Columbia) [grad]
    - Unveiling the Universe's Symphony: Probing Gravitational Waves with Pulsar Timing Arrays
105. Alice Curtin (McGill University) [grad]
    - Constraining Fast Radio Burst-like Emission from Short Gamma-ray Bursts using CHIME/FRB

Milky Way & the Local Group

106. Andrew Li (University of Toronto) [undergrad]
    - The simultaneous globular cluster and dwarf galaxy origins of the Jhelum stellar stream
107. Tahere Parto (Memorial University of Newfoundland) [grad]
    - The star formation history and chemical enrichment of Sagittarius dwarf irregular galaxy Derived from long-period variable stars
108. Maia Wertheim (University of Toronto) [undergrad]
    - Searching for Milky Way Satellite Streams in the Distant Halo

Next-Generation Spectroscopic Surveys

109. Sofia Chiarenza (University of Waterloo) [grad]
    - Fast and accurate computation of 3x2pt statistics for weak lensing surveys
110. Tristan Fraser (University of Waterloo, Waterloo Centre for Astrophysics) [grad]
    - Cosmological constraints from voids: the power of emulating the void-galaxy cross-correlation
111. Batia Friedman-Shaw (University of Waterloo, Perimeter Institute) [grad]
    - Testing the Current Standard BAO Fitting Methodology on a Wide Range of Cosmologies
112. Peter Frinchaboy (Texas Christian University, CFHT) [faculty/staff]
    - MSE Science Case Updates for the QM Design
113. Lucas Seaton (York University) [grad]
    - Investigations into Individual Interesting Broad Absorption Line Quasars in the Sloan Digital Sky Survey's Black Hole Mapper - Reverberation Mapping
114. Marianna Veltri (York University) [undergrad]
    - A Record-Breaking Extremely High-Velocity Outflow Quasar

Star Formation & the ISM

115. Kelvin Au (University of Manitoba) [grad]
    - Investigating Extreme Scattering Events by Volumetric Ray-tracing
116. Rachel Friesen (University of Toronto) [faculty/staff]
    - The impact of protostellar feedback on dense gas in nearby star-forming regions
117. James Garland (University of Toronto) [grad]
    - Characterizing Fine Metallicity Fluctuations Across Galactic Structures with SIGNALS
118. Raina Irons (University of Toronto) [undergrad]
    - NGC 6946: HII Regions and Star Formation
119. Emma Jarvis (University of Toronto) [grad]
    - H II region candidates in M94 with SIGNALS
120. Taavishi Jindel (McMaster University) [grad]
    - The role of dynamical equilibrium pressure in elevated molecular gas ratios and star formation of cluster galaxies
121. Helen Kirk (NRC Herzberg) [faculty/staff]
    - Mass segregation in groups and clusters of star-forming dense cores
122. Sun Kwok (University of British Columbia) [faculty/staff]
    - Synthesis of Complex Organics in Planetary Nebulae
123. Christopher Matzner (University of Toronto) [faculty/staff]
    - Initial mass function in intense star cluster formation
124. Parisa Nozari (Queen's University) [grad]
    - Does OMC 2/3 have peculiar dust grains?

125. Ayush Pandhi (University of Toronto) [grad]
    - Understanding the role of magnetic fields in the early stages of star formation
126. Hector Robinson (McMaster University) [grad]
    - Magnetized Galaxies – Star Formation, Disk Stability, and Spiral Arms.
127. Sarah Sadavoy (Queen's University) [faculty/staff]
    - Weighing the Protostars in VLA 1623
128. Ashley Stock (University of Toronto) [grad]
    - Pulsar Scintillation in the Local Bubble
129. Joseph Tang (CITA, University of Toronto Mississauga) [undergrad]
    - Confirmation of the 3D Dust Temperature Map's Correlation with 3D Stellar Radiation Fields
130. Shamus Tobin (Queen's University) [grad]
    - Dense Annular Rings found in Two Class 0/I Protostellar Disks
131. Doğa Tolgay (CITA, University of Toronto) [grad]
    - Making of Mock Maps for the Line Intensity Mapping Experiments
132. Shivan Khullar (University of Toronto) [grad]
    - Playing with FIRE: A Galactic Feedback Halting Experiment Challenges Star Formation Theories
133. Tai Withers (Queen's University) [grad]
    - Same Data, New Insights: Virial Analysis of Ammonia-Identified Clumps in Giant Molecular Clouds

Stars & Stellar Populations

134. Shannon Bowes (Mount Allison University) [undergrad]
    - Physical Constraints on Eclipsing Binary System lambda Scorpii
135. Jamie Griffiths (Western University) [grad]
    - Unraveling the Mystery of Pleione's Tearing Disk
136. Jeremy Karam (McMaster University) [grad]
    - Dynamics of Star Cluster Formation: Mergers in Gas Rich Environments
137. Viktor Khalack (Université de Moncton) [faculty/staff]
    - Spectropolarimetric study of roAp stars with rotational modulation
138. Samantha Lambier (Western University) [grad]
    - Rotation Periods of Candidate Single Ultracool Dwarfs in TESS
139. Lorne Nelson (Bishop's University) [faculty/staff]
    - Dynamic Time Warping in Population Synthesis
140. Rina Rast (Western University) [grad]
    - Disk evolution in highly eccentric Be binary systems
141. Anusha Ravikumar (Western University) [grad]
    - Exploring Heating Mechanisms in Classical Ae Star Disks: A Modeling Approach
142. Marharyta Sliusarenko (Université de Moncton) [grad]
    - Research of magnetic field in three delta Scuti stars using the LSD method

143. Kanah Smith (Institute of Science and Technology Austria) [grad]
   - Unveiling Stellar Nature Through Oscillation Pattern Recognition
144. Mark Suffak (Western University) [grad]
   - Observables of a Disk-Tearing Model and a Comparison to the Be Star Pleione (28 Tau)
145. Tashveena Surdha (Memorial University of Newfoundland) [grad]
   - Evolutionary track modelling of Classical Cepheid stars using MESA
146. Annika Vetter (Western University) [grad]
   - Investigating the Limits of the Thin Disc Approximation in Be Star Models
147. Raven Westlake (McMaster University) [grad]
   - Constraining M Dwarf Wind Rates Using White Dwarf Companions
148. Dakota Wolfe (Western University) [undergrad]
   - Evaluating the Performance of TESS-Localize on Sparse Stellar Fields: Towards Reliable Crowded Star Analysis

Transients & Compact Objects

149. Toni Cordeiro de Almeida (Western University) [grad]
   - The Colibri Telescope Array: a Dedicated TNO Occultation Facility
150. Mohammed Chamma (McMaster University) [postdoc]
   - Towards high precision spectro-temporal analyses of Fast Radio Bursts
151. Mark Dodici (University of Toronto, CITA) [grad]
   - Formation of compact object binaries under dynamical friction
152. Hannah Dykaar (University of Toronto) [grad]
   - An Untargeted Search for Radio-Emitting Tidal Disruption Events
153. Bahman Karimi (Canada Cambridge Academy) [science teacher/author]
   - Accessing Intermediate-Mass Black Holes in Globular Clusters of NGC 1399
154. Adrien Hélias (Western University) [grad]
   - GLEANing the Fields: The Search for IMBHs in Gaia’s Variable AGN Catalog
155. Nicole Mulyk (McMaster University) [grad]
   - Using Machine Learning and the Dragonfly Telephoto Array to Identify Historic Supernova Light Echoes
156. Dang Pham (University of Toronto) [grad]
   - Polluting White Dwarfs with Oort Cloud Comets
157. Shafayat Shawqi (University of Alberta) [grad]
   - Dark Matter Admixed Neutron Stars
158. Wesley Fraser (NRC Herzberg) [faculty/staff]
   - The Distant TNOs measured by The Classical and Large-a Solar System

Abstracts

Invited Speakers

Mustafa Amin

Title: How light can dark matter particles be?

Abstract: I will argue that if dark matter is produced via processes with finite correlation length in the early universe, then there is a lower bound on the mass of dark matter particles (m > 10^(-19) eV). For such dark matter, there is both (i) a free streaming suppression and (ii) white-noise enhancement in the dark matter density power spectrum. The absence of these in the existing observational data (for example, Ly-a) provides a bound on the mass. This relatively model independent bound will improve rapidly as observations probe dark matter at even smaller length scales. Moreover, the bound can also be made stronger by many orders of magnitude if additional model-dependent assumptions are included.

Jacqueline Antwi-Danso

Title: Too Big to Be?: Searching for the Most Massive Galaxies in the Distant Universe

Abstract: One of the unsolved problems in extragalactic astronomy is understanding the physics of how galaxies grow their stellar mass over cosmic time. Large-scale hydrodynamical simulations have been largely successful in matching the basic properties and number densities of galaxies at z < 2.5 (covering the past 11 Gyr). This has given us confidence in our understanding of the physics that regulates star formation and quenching over most of cosmic history. However, at earlier cosmic times, simulations underestimate the number densities of massive galaxies by a shocking 1-2 orders of magnitude. While this issue has largely been overlooked for the past decade, recent JWST discoveries of massive galaxies observed at even earlier times than we thought possible have brought this tension with theory back to the limelight. In this talk, I will give an overview of the systematics contributing to this discrepancy between theory and observations, as well as our best attempts at addressing it using (1) medium-band galaxy surveys; (2) novel color-color selection methods; and (3) physically motivated star-formation histories. I will also discuss my upcoming JWST Cycle 2 program and a few others geared at obtaining precise

redshifts, stellar masses, and chemical abundances of massive quiescent galaxies at z > 3.

Lyra Cao

Title: Starspots and radius inflation: the evolution of stellar activity and its impact on derived stellar parameters

Abstracts: Starspots and magnetic fields routinely blanket the surfaces of cool stars, leading to apparent discrepancies between precision observations of active stars and their model-derived radii, masses, and ages. Magnetic stellar evolution models suggest that the inhibition of convection due to flux-blocking starspot complexes or strong surface magnetic fields produce parameters which appear more consistent with observations. However, a sparsity of interpretable activity proxies prevents consistent tests of radius inflation scenarios in pre-main sequence stars. Recently, we developed a technique to recover spectroscopic starspot filling fractions from high-resolution infrared spectra in APOGEE using a two-temperature fitting model. We extend this technique to a sample of young stars to compare parameter estimates from spotted stellar evolution models to those derived from our spectral energy distribution fits. In this talk, we investigate the dependence of stellar magnetism and radius inflation on age, rotation, and mass. We test the accuracy of current magnetic and non-magnetic models of pre-main sequence stars. Finally, we discuss the importance of accounting for magnetic activity from both an observational and theoretical perspective.

Ryan Cloutier

Title: Understanding the Origins of the Galaxy's Most Common Planets around its Most Common Stars

Abstract: Super-Earths and sub-Neptunes represent the most common outcome of the planet formation process in our galaxy. The majority of these planets are found orbiting M dwarf stars, which are themselves the most common outcome of the galaxy's star formation process. Many open questions remain regarding the origin of the distinction between the terrestrial super-Earths and the larger, volatile-rich sub-Neptunes. Are these planet populations formed in-situ, or does atmospheric escape play an important role in explaining their differences? Are sub-Neptunes H/He-enveloped terrestials, or are they water worlds akin to many of the moons orbiting the gas giants in our solar system? How diverse are the interior structures of super-Earths relative to the refractory abundances in their host stars? And ultimately, how do the answers to these questions vary between M dwarf planetary systems compared to those around Sun-like stars? I will provide an overview of recent

advancements in this field and highlight the ongoing efforts of the Cloutier exoplanet research group at McMaster University in tackling these unresolved questions.

Tarraneh Eftekhari

Title: Uncovering the Elusive Origin of Fast Radio Bursts and other Radio Transients

Abstract: The last decade of investigations into the extragalactic radio sky has led to a paradigm shift, with all-together new and uncharacterized populations of radio transients emerging for the first time. Upgrades in multiple fast radio burst (FRB) experiments have led to the first samples of precisely localized events, enabling host galaxy associations and detailed observations of the immediate environments surrounding FRBs. Such observations play a key role in elucidating the stellar populations that give rise to FRB progenitors. In this talk, I will review our current knowledge of FRB progenitors based on the properties of a small, but growing sample of host galaxies, and I will outline major follow-up efforts to build the first statistically meaningful sample of FRB hosts. The localizations of two repeating FRBs to dwarf galaxies and their coincidence with persistent radio sources -- coupled with detections of long-lived radio transients in dwarf galaxies -- further implicate an entirely new population of radio sources on the sky. I will discuss our large-scale effort to uncover this unique population for the first time. Finally, I will discuss prospects for opening a new window into the transient sky at millimeter wavelengths.

Kelsey Johnson

Title: How were the most ancient objects in the universe formed?

Abstract: Ancient remnants from the early universe surround our galaxy, which you may know as globular clusters. Although now on their old age, understanding how these clusters were formed has the potential to provide insight into the physical conditions that prevailed during an epoch that cannot be directly observed. We now know that globular clusters can form during extreme episodes of star formation in the relatively nearby universe, but the actual physical conditions that give rise to globular clusters have vexed both observers and theorists for decades. With the new capabilities of JWST along with ALMA we are uncovering new clues about the environments in which these extreme clusters form. This talk will give an overview of progress that has been made in understanding globular clusters, and highlight the importance of using chemistry to understand physical conditions in space.

Alan McConnachie

Title: Canada and UNIONS, the definitive optical survey of the northern hemisphere for the 2020s

Abstract: The Ultra-violet Near Infrared Optical Northern Survey (UNIONS) is a multi-telescope, multi-band (ugriz), wide field survey of approximately 5000 square degrees of the northern extragalactic sky involving 240 astronomers in the Canadian, French, Hawaiian and Japanese communities. It is broadly equivalent in depth to Year 1 of the Rubin Observatory's Legacy Survey of Space and Time. UNIONS has so far formed the basis for more than 30 peer reviewed publications, 27 graduate theses, and provided a training ground for more than 60 early career researchers. It is also the essential ground-based component for the core science of the EURO1B ESA Euclid space telescope, now undertaking its much anticipated survey. Here, I describe how Canadian astronomers including students at all levels, can become part of UNIONS and use it for their science. I highlight some of our latest scientific results that demonstrate the breadth of science being addressed, including the discovery of the smallest satellite of the Milky Way, shining with a luminosity equivalent to only 16 suns. For near field cosmology, UNIONS data in combination with Euclid promises to open a treasure trove of new discoveries that together can help us answer the question of just how small can galaxies be?

Sean Ressler

Title: Quasi-Periodicities and Jet Precession in AGN Perturbed by Black Hole Companions

Abstract: Detecting and interpreting electromagnetic counterparts to binary black hole mergers will require a detailed understanding of the complex plasma dynamics governing the surrounding accretion flow, particularly for binaries including at least one supermassive black hole. Quasi-periodicities observed in active galactic nuclei (AGN) may already provide a clue as to how a secondary black hole in such a system may appear observationally. In this talk I will present an exciting and computationally efficient new way to simulate binary black hole accretion in gravitational wave-emitting systems relevant for LISA and pulsar timing arrays. Specifically, I will summarize the results of simulating a smaller mass companion black hole colliding with an established AGN accretion disk. We find that quasi-periodicities appear in both the unbound outflow rate (which could correspond to small "flares" in the light curve) and in the precession of the primary black hole disk/jet caused by spin-orbit coupling. Our results are relevant for the prospect of confirming the existence of secondary black holes in AGN systems and

for studying systems like OJ 287 where there is already a strong case for a secondary companion.

Jess McIver

Title: Unlocking the unseen Universe with gravitational waves

Abstract: Gravitational waves, tiny ripples in the fabric of spacetime, allow us to sense systems we can't usually see with telescopes, including distant black hole collisions and the interior of nearby exploding stars. These waves pass through the Earth day or night, through heavy cloud cover, and across billions of light years of galaxies and dust, allowing us to make measurements anytime our detectors are operational. In this talk, we'll explore where gravitational waves come from, how we can measure them, and what they can teach us about the Universe that we can't learn with light alone.

Contributed Talks and Posters

Astrostatistics and Astroinformatics

Extracting the Hierarchical Wavelet Coefficients from Full-Sky Maps

Arefe Abghari (UBC)

Astrostatistics and Astroinformatics - Talk

Extracting Gaussian information from data is well understood, but characterizing non-Gaussianity is challenging. We describe an approach called the ``hierarchical wavelet coefficients" (HWC) method, also known as the ``scattering transform", for analysing full-sky maps and extracting non-Gaussianity information. We introduce a spherical version of the Morlet wavelet and an algorithm using the healpy package to perform the wavelet convolutions. This method is applied to the Sunyaev-Zeldovich and Galactic dust maps constructed from the Planck satellite data to characterize their non-Gaussian features. We propose that in future this method can be used as a test of component-separation methods and robustness of simulations, as well as potentially for cosmological parameter estimation. It can also be used for generating simulated fields with the same statistical features as the real data.

Precise Proper Motions of faint Milky Way halo stars with BP3M

Kevin McKinnon (Canadian Institute for Theoretical Astrophysics)

Astrostatistics and Astroinformatics - Talk

Thanks to Gaia, we now have access to high quality positions, parallaxes, and proper motions (PM) for more than one billion stars. However, for studies of kinematic substructure in the distant Milky Way (MW) halo, Gaia's PM uncertainties become prohibitively large at faint magnitudes, and PMs are unavailable for most of the faintest Gaia sources (G > 21 mag). To address these challenges, we present the BP3M (Bayesian Positions, Parallaxes, and Proper Motions) pipeline, which provides improved astrometry for cross-matched sources between Hubble Space Telescope images and Gaia data. This tool uses Gaia-measured positions, parallaxes, and proper motions (PMs) as priors to predict the locations of sources in HST images, thereby putting the HST images onto a global reference frame without the use of background galaxies or QSOs. For nearby dwarf spheroidal galaxies, we find that BP3M PMs are a median of ~10 times more precise than Gaia DR3 alone for 20.5 < G < 21 mag targets. In this Talk, I will present results analyzing the sparse field of COSMOS (median of 9 Gaia sources per HST image) as a testbed for BP3M in the faint MW halo. Because the statistics that underpin the BP3M pipeline provide a general framework for combining images and data from different epochs and telescopes, this technique has important implications for the legacy of archival data as well as future missions.

Using score-based diffusion models for correlated 1/f noise reduction in JWST spectral data

Salma Salhi (iREx (Trottier Institute for Research on Exoplanets), Ciela (Montreal Institute for Astrophysics and Machine Learning), Université de Montréal Department of Physics, Mila (Quebec AI Institute))

Astrostatistics and Astroinformatics - Talk

Transit spectroscopy is very sensitive to various sources of noise, and this is especially true when using the Single Object Slitless Spectroscopy (SOSS) mode on the NIRISS instrument aboard the JWST. Current methods to deal with 1/f (correlated) noise leave residuals that are almost double that of the expected readout noise. Deep learning models could be a way to mitigate this problem, as they have already been shown to be very efficient at a wide variety of tasks in astrophysical data reduction, including denoising. We construct a score-based generative diffusion model to learn the structure of the noise in dark SOSS images, including bad pixels, hot pixels, cosmic rays, and 1/f noise to create a model. We will then use this noise model as the data likelihood to analyze mock trace observations in a Bayesian framework, allowing us to produce Posterior samples of the pixel values of the underlying trace. We aim to apply this method to time series spectroscopic observations, which will allow for a more accurate retrieval of the underlying trace parameters, potentially reducing our error to the photon noise limit. This has the potential to substantially improve our signal-to-noise by up to a factor of two for some spectral regions and thus enable higher precision transit spectroscopy.

Scalable Gaussian Process Modeling of AGN Light Curves in LSST

Weixiang Yu (Bishop's University)

Astrostatistics and Astroinformatics - Talk

The Vera C. Rubin Observatory Legacy Survey of Space and Time (LSST) will see its first light in less than a year. Hundreds of millions of accreting massive black holes in active galactic nuclei (AGNs) will be monitored by LSST for a period of ten years. Scalable modeling of AGN light curves is essential to AGN classification, AGN accretion flow characterization, and estimation of AGN fundamental properties (e.g., L/LEdd). We present recent progress in enhancing the scalability and flexibility of AGN light curve modeling through advancements in Gaussian process regression techniques. This effort is part of the Canadian in-kind contribution to the LSST project.

Properties of Decameter Earth Impactors

Ian Chow (University of Western Ontario)

Astrostatistics and Astroinformatics - Poster

Over the past 30 years, approximately one dozen impactors of decameter (10-meter) size have been observed as fireballs in Earth's atmosphere. These objects can have equivalent energies of up to hundreds of kilotons of TNT, posing a hazard if they impact populated areas. Moreover, some telescopic estimates of the near-Earth object population predict the impact rate of such objects to be of order 20-30 years, compared to fireball data which show recurrence intervals closer to ~2-3 years. The cause of this discrepancy remains unclear. We attempt a comprehensive study of Earth impactors in this size regime using data collected by US Government (USG)

sensors. While USG sensors provide the most complete data for many events, the sensor network is a military system; as such, the data for many impacts were classified and detailed light curve data only released in 2022. Using the newly available USG sensor data, we present the first population-level study characterizing the physical and dynamical properties of these decameter Earth impactors.

We use USG sensor data of the light curve and entry geometry for each decameter impact event to apply an ablation model for each object. Physical characteristics of the object, such as density and material strength, are then computed from the model. When available, infrasound observations allow us to compute an independent energy estimate for an impactor, which can in turn be used to validate our light-curve derived ablation model. We also define uncertainty estimates in the USG-determined orbits for these impact events, using a calibrated set of fireballs observed both from the ground and by USG sensors. With these uncertainties, we use the orbital distribution of the observed near-Earth decameter population in conjunction with the near-Earth object delivery model of Granvik et al (2018) from the main belt and Jupiter-family comets to determine the original escape regions for these impactors. These dynamical data are correlated with physical properties based on entry model inversion to estimate source origins and properties. We also perform backward N-body integration on each object and a set of clones to quantify the uncertainty of its pre-impact orbit history, evolution, and ultimately its source region.

CosmosCanvas: Acquiring Information Through Colour Experiment

Jayanne English (University of Manitoba)

Astrostatistics and Astroinformatics - Poster

Colour schemes that exploit the characteristics of visual perception can facilitate the analysis of data for discovery science and clarify figures used to communicate results in professional disseminations. We introduce examples of perceptually-based colour mappings that allow the user to chose and demarcate thresholds. We accomplish this in our CosmosCanvas project (https://ascl.net/2401.005) by adjoining different colour schemes at specified pivot points in the data. To date we have produced these “divergent” mappings for spectral index, velocity field, and uncertainty data. Our Python 3 tutorials at https://github.com/mlarichardson/CosmosCanvas demonstrate how these can be customised. This Poster also demonstrates how our approach improves upon the divergent schemes available via Matlab and Tableau.

Rare events in astronomy with repeating FRBs

Antonio Herrera Martin (University of Toronto)

Astrostatistics and Astroinformatics - Poster

Astronomy is a data-rich scientific discipline with multiple opportunities for collaboration with statisticians. Our research focuses on data for fast radio bursts (FRBs), which are radio signals produced by unknown phenomena outside our galaxy. It was initially assumed they were caused by a process that would destroy the source of the signal, causing them not to repeat.
However, it was found that some of the signals do indeed repeat without exhibiting a specific period. Furthermore, the data is heavily imbalanced, with the number of repeating FRBs being 10% of the one-off FRBs. In this Talk, I will discuss how to treat this imbalance for classification by considering the case of rare events as well as the impact of the possibility of a fraction of one-offs being less active repeating capable sources. The project is the result of a collaboration between astronomers and statisticians, developed within the Canadian Hydrogen Intensity Mapping Experiment (CHIME) as part of a CANSSI Collaborative Research Team Grant.

SpectraFM: Tuning into Stellar Foundation Models

Nolan Koblischke (University of Toronto)

Astrostatistics and Astroinformatics - Poster

Neural networks are increasingly crucial for predicting stellar properties in large spectroscopic surveys but struggle when applied to scenarios outside their training distribution, such as with new instruments or wavelength ranges. To address this, we developed SpectraFM, a 'Foundation Model' based on a Transformer neural network, a machine learning technique that can transfer knowledge from data-rich tasks to new data-scarce situations through pre-training. Our model is pre-trained on half the wavelength range of the APOGEE spectroscopic survey with ~100,000 stars to predict elemental abundances (Fe, Mg, O) and stellar properties. We then fine-tune the model using only 100 stars to predict abundances that were not in pre-training (Si, Ti, Ni), surpassing the performance of a traditional neural network with the same data and size. Additionally, we fine-tune the model to predict [Fe/H] from a wavelength range unseen during pre-training with only 100 stars, demonstrating it capability to generalize its knowledge to any wavelength range. We train the model to be uniquely flexible, so it has the ability to predict any output from any combination of inputs, therefore it can be a powerful tool for stellar astrophysics research. We plan to further train our model on a wider range of surveys, wavelengths, and stellar properties, and to include simulated spectra. This will improve its generalization capabilities and performance in situations with new instruments and small amounts of data.

Machine Learning Bayesian Mixture Density Networks for Stellar Stream Inference in the Milky Way

Connor MacKeigan (University of Toronto)

Astrostatistics and Astroinformatics - Poster

This study leverages Bayesian Mixture Density Networks (BMDNs), integrated within neural network frame-works, to intricately model the parameter spaces of complex stellar streams, such as the ATLAS/Aliqa-Uma (AAU) stream in the Milky Way, which has interesting morphological features such as its distinctive “kink”. By employing a comprehensive dataset from the Southern Stellar Stream Spectroscopic Survey (S5), the BMDNs adeptly infer posterior probability distributions, crucial for discerning stream membership amidst the AAU stream’s morphological discontinuities and density variations. The inclusion of astrometric and metallicity data enhances the model’s ability to differentiate between stream members and background stars, underlining the continuous nature of such stellar formations despite photometric uncertainties. This approach not only sheds light on the Milky Way’s evolutionary dynamics and the distribution of dark matter in its outer halos but also sets a precedent for probabilistic modeling in capturing the nuanced characteristics of stellar streams, paving the way for future enhancements in handling complex astronomical datasets.

Cosmology using populations of gravitational wave sources

Utkarsh Mali (University of Toronto, CITA)

Astrostatistics and Astroinformatics - Poster

Which subpopulation of gravitational wave (GW) sources best constrains cosmology? Cosmological parameters, such as the Hubble constant, have been a focused area of study for the astrophysics community. We aim to estimate the expansion rate using the spectral sirens method. This involves using features in the population of gravitational wave sources. By studying these features in the join distribution of observed masses and luminosity distances evolution with redshift, we are able to extract cosmological parameters. Using hierarchical Bayesian inference we simultaneously fit for the population distribution of compact objects and cosmology, finding agreement with previous results. We then study the effects of model parameters on the inference. Our study will provide insight into the impact of different astrophysical formation channels on the expansion rate.

Millimeter Transient Detection During Timestream Preprocessing with the Atacama Cosmology Telescope

Simran Nerval (University of Toronto and The Dunlap Institute for Astronomy & Astrophysics)

Astrostatistics and Astroinformatics - Poster

I will present a new machine learning classification algorithm for classifying signal bursts with short time cadence (so-called 'glitches') in microwave data. This algorithm, specifically designed for the Atacama Cosmology Telescope (ACT), helps detect and classify astrophysical transients in CMB time streams that are 'cut' from typical analyses due to an interesting signal potential being present. The ACT data 'cuts' code used for the most recent data processing pipeline does not have a way to differentiate among signal spikes due to, e.g., electronic glitches and those due to astrophysical point sources such as transients. This lack of differentiation can lead to the removal of point sources that could be of interest, such as distant galaxies and transients that are not present in the catalogue of sources used by the cuts code. Our improved algorithm is able to differentiate between spikes due to instrumental noise, cosmic rays, and astrophysical sources within the raw time streams. Our algorithm also fits the amplitudes of the detected sources, which can then be used to obtain information on short term time-variability in order to better classify the types of transients being observed. This work will be incorporated into the transient finding and alert system of the upcoming Simons Observatory.

Optimizing Lens Detection Using Ranking Algorithms and Convolutional Neural Networks

Silke Rice (University of British Columbia)

Astrostatistics and Astroinformatics - Poster

Strongly lensed systems provide a vast range of cosmological applications, such as the determination of cosmological parameters and the study of galaxy mass profiles and halo substructure. However, because these systems are very rare, many of these

studies are limited by a small sample size. Recent advancements have seen convolutional neural networks (CNNs) emerge as dependable tools for identifying lensed systems. Yet, despite their utility, these algorithms still suffer from high false positive rates and lengthy runtimes. To address these challenges, we propose a new pipeline where ranking algorithms are used for the identification of strong lenses. While ranking algorithms have found success in diverse classification tasks such as spam email detection and biostatistics, they are less commonly applied in image classification due to the complexity of image features. In our approach, convolutional layers are employed to reduce the dimensionality of galaxy features, followed by classification using a ranking algorithm. The first results on this pipeline seem promising, with a more reliable performance and a significant reduction in the runtime.

Navigating Astrophysics Literature: Harnessing AstroBERT and UAT

Dhruv Sondhi (University of Western Ontario)

Astrostatistics and Astroinformatics - Poster

The advent of LLMs or large language models such as ChatGPT has propelled us towards using these tools for understanding and summarising research papers. There are state-of-the-art models such as AstroBERT, a large language model for astrophysics that is built and trained by NASA/ADS, that are used in the astronomy domain to automatically identify astrophysical entities of interest and to classify research papers in different subdomains of astrophysics. Furthermore, there are tools like the Universal Astronomy Thesaurus or UAT which is an open, interoperable and community-supported thesaurus which unifies the existing divergent and isolated Astronomy and Astrophysics thesauri into a single high-quality, open thesaurus formalising astronomical concepts and their inter-relationships.
We are integrating this high-quality information from the UAT into the dataset that would be used to train AstroBERT. This helps us create a rich collection of documents that contains a single “root” word as well as other “synonyms” of this word, allowing the model to learn these different embeddings and provide more confident predictions. Our expectations involve improving the AstroBERT model's current performance by modifying the dataset to include duplicated sentences which contain these “root” words. We also aim to keep the original sentences to further improve the confidence in the prediction of the correct type of astrophysical entity. This in turn will allow us to have a better model that can eventually be used to classify research papers in different subdomains of astrophysics.

Improved period estimates for RR Lyrae stars using multi-tapering and the F-test

Jianing (Jenny) Su (University of Toronto)

Astrostatistics and Astroinformatics - Poster

RR Lyrae stars are important distance indicators due to their period-luminosity relation. In astronomy, the Lomb-Scargle Periodogram is often used to obtain the initial estimate of periods of variable star pulsations. Then, further methods are used to refine the periods. In this Talk, I will discuss new and more efficient ways to acquire accurate pulsation frequencies for RR Lyraes. I will first introduce the use of multi-tapering and the F variance ratio test to estimate the periods of a sample of 44 RR Lyraes from TESS. I will then demonstrate that overall, the F variance ratio test outperforms the Lomb-Scargle Periodogram in both accuracy and computational efficiency. Finally, I will show our preliminary estimate of the period-luminosity relation using our results from these 44 RR Lyraes.

A probabilistic ML model for stellar age inference using gyrochronology

Phil Van-Lane (University of Toronto)

Astrostatistics and Astroinformatics - Poster

Gyrochronology uses a star's rotation period and location on the main sequence (MS) to predict stellar age. It is particularly useful for low mass main sequence stars, the regime in which other stellar dating methods (e.g. isochrone fitting) tend to struggle. Gyrochronology has gained popularity in recent years due to the increasing availability of photometric data, but analytical models have struggled to coherently summarize the uncertainty and intrinsic variance in the photometric time series data. Thus, we have developed a generalized machine learning-based Bayesian inference framework that captures the uncertainty and variance through a probabilistic solution. Our framework implements a normalizing flow --- a neural network-based model that optimizes the transformation of parameter distributions --- to predict rotation period distributions for stars based on their age and colour. We have successfully trained and tested the model on data from eight open clusters with promising results, indicating that a data-driven approach to gyrochronology could improve upon existing models. We have now expanded and standardized our data sample to 30 open clusters. In this Talk, we will present: (i) the results of cluster age recovery testing using this new model, and (ii) the results of applying this model to fields stars.

Quasar Spectra Informatics: Algorithms for Representation & Reconstruction

Erik Weiss (York University)

Astrostatistics and Astroinformatics - Poster

With an ever-expanding pool of astronomical data, astronomy is increasingly becoming a data-driven science. At the same time, the rapid development of data science techniques gives rise to a vast number of novel ways in which we can represent, explore, analyze and interpret this data. This Poster highlights preliminary investigations of two dimensionality reduction algorithms, heteroscedastic non-negative factorization (HNF) and InfoVAE, which we use to represent and reconstruct quasar spectra. HNF is a matrix factorization algorithm in which a matrix of N vectors (in our case, spectra) is decomposed as a product of an amplitude matrix and a matrix of K < N component vectors, the latter of which can be analyzed for meaningfulness and outliers (or used to reconstruct other vectors of a similar nature). The algorithm is remarkable for its simplicity, linearity and ease of implementation, while also being robust to varying errors and missing data. InfoVAE is a type of variational autoencoder (VAE), a neural network which compresses N-dimensional data vectors into K-dimensional (K < N) sets of latent distributions, with the final latent space representation of each N-dimensional data vector being a K-dimensional vector of values drawn from the data vector's corresponding latent distributions. InfoVAE has previously been shown to be capable of meaningful unsupervised separation of object classes and outliers in the latent space; as such, InfoVAE represents a novel and potentially viable method for finding quasar (or other) spectra with interesting or abnormal features.

Cosmology

First constraints on the remote dipole field from kSZ tomography

Richard Bloch (York University)

Cosmology - Talk

The kinetic Sunyaev Zel’dovich (kSZ) effect is a blackbody cosmic microwave background (CMB) temperature anisotropy induced by Thomson scattering off free electrons in bulk motion with respect to the CMB rest frame. The statistically anisotropic cross-correlation between the CMB and galaxy surveys encodes the radial bulk velocity (more generally, the remote dipole field), which can be efficiently extracted using a quadratic estimator - the technique of kSZ tomography. We have

developed a quadratic estimator for the remote dipole field and implemented it on data from the Planck satellite and the unWISE galaxy redshift catalog. With this data combination we forecast a $\sim 1-\sigma$ detection within ΛCDM. Using reconstructions based on individual CMB temperature maps, we characterize the impact of foregrounds, concluding that they can be effectively mitigated by masking and removing the estimator monopole. We demonstrate that reconstructions based on component separated CMB maps have no detectable biases from foreground or systematics at the level of the expected statistical error. We use these reconstructions to constrain the multiplicative optical depth bias to $b < 1.1$ at 68% confidence. Our fiducial signal model with $b = 1$ is consistent with this measurement. Our results support an optimistic future for kSZ tomography with near-term datasets.

The Small-Correlated-Against-Large-Estimator for Cosmic Microwave Background Lensing

Victor Chan (Southern Methodist University)

Cosmology - Talk

The upcoming generation of cosmic microwave background experiments offers an exciting opportunity to study models of exotic dark matter and their clustering behaviors through studies of gravitational lensing at unprecedented high resolution (<~ arcmin). I will present the development and application of a novel estimator for quantifying the statistics of the cosmic background lensing field, and show that it can outperform traditional techniques when applied to future data. The Small Correlated Against Large Estimator for cosmic microwave background lensing recovers simulated lensing statistics to high accuracy and precision. I will briefly motivate and present the development of a neural network emulator for the analytical SCALE expected observables, and I show through an application of our methodology in cosmological parameter estimation that it provides critical gravitational lensing information that will enable a detection of the minimum neutrino mass. SCALE also has tremendous potential to provide constraints for more exotic models of large-scale structure formation.

Fluctuations and Evolution of the Ionizing Background and Mean Free Path during the Late Stages of Reionization

Huanqing Chen (Canadian Institute for Theoretical Astrophysics)

Cosmology - Talk

Measurements of the ionizing background and the mean free path (MFP) at the end of reionization offer valuable insights into the first generation of sources that ionized the universe. With increasing observational data from this epoch, a better theoretical understanding is imperative to interpret the data accurately.
The CROC simulations are uniquely poised to interpret observational data, with both high spatial resolution to resolve galaxy formation and fully-coupled radiative transfer to authentically simulate the reionization of the intergalactic medium (IGM). We analyze two CROC boxes with distinct reionization histories to gain insights into the uniformity of the ionizing background and MFP of photons. We find that in the late reionization box, where the volume-weighted neutral fraction x_HI drops to 0.5 at z=7.4 and below 0.001 at z=6.4, the ionizing background still displays significant fluctuations (~40%) at z=5. These fluctuations are closely related to the non-uniform distribution of ionizing sources and Lyman Limit Systems (LLSs). Additionally, we investigate the mean free path (MFP) and observe differences across different environments. Notably, the MFP around very massive halos (>1e12 Msun) is significantly smaller than in average regions of the universe, attributed to the abundance of LLSs.
Observations measure the mean free path (MFP) using quasar spectra, where the ionization of Lyman Limit Systems (LLSs) around quasar hosts must be considered. For consistent comparison to observations, we create thousands of mock quasar spectra by post-processing the sightlines centered on massive halos, and assess the accuracy of the observational procedure outlined in Becker+21. Our analysis quantifies the bias in the inferred MFP, highlighting important implications for interpreting observational data and understanding the end stage of reionization.

Constraining cosmological parameters with the splashback radius

Roan Haggar (University of Waterloo)

Cosmology - Talk

Galaxy clusters strongly impact the properties of galaxies within them, but the properties of clusters themselves are also dependent on the Universe as a whole. In particular, the splashback radius of galaxy clusters, which represents a naturally occurring divide between the bound material in a cluster and the infalling material in its outskirts, is a consequence of the growth history of clusters. This in turn depends on cosmological parameters, such as sigma-8 and the matter density parameter.

In this work, we investigate this connection between the splashback radius and cosmology, using cosmological simulations. We show that the average position of the splashback radius is dependent on the cosmological parameters used in a simulation. The splashback radius of a cluster is a measurable, observable quantity, and so this work demonstrates a new method to observationally constrain cosmological parameters and study the growth of structure in our Universe.

Upcoming wide surveys such as Euclid and LSST will provide next-generation weak-lensing data and galaxy number counts, enabling tighter constraints than ever before on the splashback radius. Our study will complement data from these upcoming surveys, using observable quantities to provide new insights into the properties of our Universe.

A new method to determine H_0 from cosmological energy-density measurements

Alex Krolewski (University of Waterloo)

Cosmology - Talk

We introduce a new method for measuring the Hubble parameter from low-redshift large-scale observations that is independent of the comoving sound horizon. The method uses the baryon-to-photon ratio determined by the primordial deuterium abundance, together with Big Bang Nucleosynthesis (BBN) calculations and the present-day CMB temperature to determine the physical baryon density \Omega_b h^2. The baryon fraction \Omega_b/\Omega_m is measured using the relative amplitude of the baryonic signature in galaxy clustering, scaling the physical baryon density to the physical matter density. The physical density \Omega_mh^2 is then compared with the geometrical density \Omega_m from Alcock-Paczynski measurements from Baryon Acoustic Oscillations (BAO) and voids, to give H_0. This measurement is currently consistent with both the distance-ladder and CMB H_0 determinations, but near-future large-scale structure surveys such as the full DESI and Euclid surveys will obtain 3--4x tighter constraints, allowing us to differentiate the local and cosmological values for H0. On current data, including type Ia supernovae, uncalibrated BAO, and the baryon amplitude from BOSS, we measure H_0 = 67.1^{+6.3}_{-5.3} km s^{-1} Mpc^{-1}. We find similar results when varying analysis choices, such as measuring the baryon signature from the reconstructed correlation function, or excluding supernovae or voids.

Exploring How Cross-Bin Correlations Impact Photometric Galaxy Clustering Constraints

Jordan Krywonos (York University and Perimeter Institute)

Cosmology - Talk

As the precision of current and near-term photometric galaxy surveys increases, it is of growing importance to improve modeling pipelines so we can obtain the most accurate constraints on the large-scale distribution of matter. Since photometric surveys do not measure redshifts precisely, they instead group galaxies into redshift bins to then study angular correlations between the binned galaxy samples. Currently, the Dark Energy Survey (DES) galaxy clustering analysis only accounts for auto-correlations of redshift bins because cross-correlations did not significantly improve cosmological constraints and are more sensitive to the photometric redshift uncertainties. However, there are additional effects which are now relevant for current survey precision, namely redshift space distortions (RSD) and magnification, which may enhance the constraining power of cross-correlations. RSD refers to how the peculiar velocity of galaxies (eg. galaxies moving into an overdensity) Doppler shifts the observed redshift, as opposed to what we would observe from Hubble expansion alone. Magnification accounts for how weak gravitational lensing causes variations in the limiting magnitude of a survey and thus affects the observed clustering. If incorporated into the analysis, these effects compose a large fraction of the cross-bin signal and can provide extra structure growth information. A concern, though, is redshift systematics since cross-correlations depend on the overlap between the tails of the redshift bin distributions, whose shape is uncertain. Therefore, we weigh the potential benefits and risks from including cross-bin correlations, along with RSD and magnification, for the DES and the upcoming Rubin Observatory Legacy Survey of Space and Time (LSST) survey.

DESI 2024: Cosmological constraints from the measurements of baryon acoustic oscillations

Enrique Paillas (University of Waterloo)

Cosmology - Talk

The Dark Energy Spectroscopic Instrument (DESI) is conducting a five-year program to measure the effect of dark energy on the expansion of the Universe and the growth of structure within it. It is the first of the new generation of so-called stage IV cosmological surveys, and will obtain optical spectra for tens of millions of galaxies and quasars. I will present the first cosmological results from the measurement of baryon acoustic oscillations (BAO) in galaxy, quasar and Lyman-alpha forest tracers from DESI, to be released in the DESI Data Release 1. DESI BAO provide robust measurements of the transverse comoving distance and Hubble expansion rate relative to the sound horizon, in seven redshift bins from over 6 million extragalactic objects in the redshift range $0.1 < z < 4.2$. In combination with CMB and Type Ia supernovae data, DESI provides clues on the dynamics of dark energy and the mass of neutrinos. This first set of cosmological results demonstrates the enormous power of the DESI instrument and survey, shedding light on current cosmological tensions and the standard model.

Unraveling the Universe's Twist: Investigating Cosmic Birefringence through CMB Polarization

Raelyn Sullivan (University of British Columbia)

Cosmology - Talk

It's truly astonishing that we can account for almost all observations of the cosmic microwave background (CMB), as well as a substantial portion of cosmology and the vast scales of the Universe, using just six parameters. Yet, intriguing questions remain unanswered. For example, what is the nature of dark matter, the invisible mass that dominates galaxies and clusters? Then there's the nature of dark energy, responsible for the current accelerated expansion of the Universe. Additionally, there are lingering uncertainties regarding inflation in the Universe's infancy. To address these questions, efforts are underway to conduct precise observations of CMB polarization. This endeavour aims to push the boundaries of our understanding by detecting B modes, polarization divergence-less modes that serve as evidence of early universe inflation. However, precise measurements of polarization may also shed light on the enigmatic nature of dark matter and dark energy. Of particular interest is a phenomenon called cosmic birefringence, whereby the plane of polarization of photons rotates as they propagate through space. This effect, potentially caused by interactions between photons and exotic dark matter or dark energy, introduces a parity violation and correlates B modes with curl-free E modes. While there appears to be a detection of this phenomenon at the 3sigma level, further investigation is needed to better understand potential systematic errors originating from foreground contamination. Before drawing any cosmological conclusions from these correlations, it's crucial to refine our understanding of foreground systematics. In this work, I introduce a map-space technique to measure cosmic birefringence, enabling a detailed analysis of its spatial variation. Applying this method to the Planck Public Release 4 data, I uncover evidence suggesting that foregrounds may significantly contaminate previously published results.

A roadmap to cosmological parameter analysis with third-order shear statistics

Pierre Burger (University of Waterloo)

Cosmology - Poster

In this joint team effort, we aim to make third-order shear statistics a valuable extension to the standard second-order shear statistics. Our work builds on a series of studies describing the roadmap to third-order shear statistics. In previous papers of this series, we validate the analytical modelling based on BiHaloFit (Takahashi et al. 2020), the conversion from three-point correlation functions to aperture mass statistics (Heydenreich et al. 2023), the analytical expression for the covariance matrix (Linke et al. 2023), we present here a fast computation method of the aperture mass statistics by measuring the shear 3PCF (Porth et al. 2024, hereafter P24) and finalise with a cosmological analysis (Burger et al. 2024, hereafter B24).

In P24, we propose an efficient procedure for measuring the third-order shear correlation functions that extend the multipole method introduced by Slepian et al. (2015). Our estimator provides a ~100-fold speedup for stage-III surveys compared to state-of-the-art tree-based estimators. We measure the tomographic third-order aperture-mass in the KiDS-1000 data and construct a numerical covariance matrix from mock catalogs built from the Takahashi et al. (2017) simulation suite.

In B24, we derived and tested a combined model of second-order shear and third-order aperture mass statistics in a tomographic setup. We validated our pipeline with N-body mock simulations of the KiDS-1000 data release. Lastly, we performed the first KiDS-1000 cosmological analysis using a combined analysis of second- and third-order shear statistics, where we constrained m= 0.248-0.055+0.062 and S8=σm/0.3=0.722±0.022. Compared to the second-order statistic, the geometric average on the errors of m and S8 of the combined statistics decreases by a factor of 2.2.

Is Lensing Low in UNIONS?

Martine Campbell (University of Waterloo)

Cosmology - Poster

An issue plaguing modern cosmological studies is the discrepancy between the clustering and (weak) lensing of galaxies, known as the “lensing is low” problem. Specifically, this problem arises when the lensing signal of massive galaxies is inferred by models trained to match their clustering. The result is an overprediction of the lensing signal by roughly 30% and, by consequence, a seemingly low observed lensing signal (hence, lensing is low). The galaxy-halo connection models used in such studies, as the name suggests, relate galaxies to their parent dark matter halos. So, resolving the tension between clustering and lensing can provide key insights into how galaxies populate dark matter halos, as well as other information like the effects of baryonification. In this study, we determine the lensing signal of CMASS galaxies using UNIONS sources and BOSS lenses. UNIONS is ideal for this study as it provides high-quality imaging data and covers thousands of square degrees in the northern hemisphere. Since UNIONS has an exceptionally large survey area, two-point correlation functions can be computed at unprecedented scales. Furthermore, UNIONS’ survey footprint overlaps significantly with BOSS. We also predict the lensing signal using Halo Occupation Distribution (HOD) models, which base galaxy population on a halo’s mass. Ultimately, the predicted and observed lensing signals will be scrutinized, and we will attempt to constrain the factors responsible for the lensing is low problem.

Mocks of cosmic structure evolving from primordial non-Gaussianities with WebSky2.0

Nathan Carlson (CITA/University of Toronto)

Cosmology - Poster

New, high-resolution mock sky maps are needed to test our theories of cosmology against the wealth of upcoming cosmological surveys. We use the Peak Patch simulations to accurately and efficiently make dark matter halo catalogues, to which WebSky applies response functions to observables, producing fully correlated mock maps. A prior release, WebSky1.0, of a suite of standard model ΛCDM mocks with primordial Gaussian initial conditions (ICs) has been highly used for cosmic microwave background (CMB) research. In addition to dominant Gaussian ICs, we have added subdominant primordial spatially-intermittent non-Gaussian (PING) ICs, uncorrelated with the dominant Gaussian. PINGs can form in multi-field inflation if instabilities occur in the direction transverse to the inflaton flow. To test for such a subdominant component in future data, such as for the Simons Observatory (SO) and CMB Stage 4, a full probability density function of the mock maps is needed.

Here, we introduce WebSky2.0, which adds non-Gaussian ICs including PINGs and improves the resolution of Sunyaev-Zel'dovich (SZ), cosmic infrared background (CIB), weak gravitational lensing and other CMB and large-scale structure (LSS) signals. We highlight the application of mocks to explore the effect of PINGs on early structure formation. The responses to first-generation star formation (probed by JWST) are shown with simulations of high-z mini-halo distribution tails, and to epoch-of-reionization (EoR) line intensity mapping (expected to be observed with CCAT) are shown with EoR CII line mocks.

Predicting galaxy/halo locations from their bright neighbours

Alice Chen (University of Waterloo/Perimeter Institute)

Cosmology - Poster

Many astronomical objects in our universe are too faint to be directly detectable, even by the most advanced telescopes. An obvious example of this is dark matter, but can also include low luminosity dwarf galaxies, rogue planets, white dwarfs, neutron stars, and black holes. While their faintness make these objects difficult to observe, their locations are highly important when studying astrophysical phenomena - one recent and well publicized case is the localization of dark sirens (binary compact objects that merge and emit gravitational waves without an EM counterpart), which can be used to measure the Hubble constant. As a result, here, we use a machine learning algorithm known as symbolic regression to model the probability of finding a dark object as a function of its separation distances to its closest two bright (directly observable) neighbours, and the distances of the bright objects between each other. The objects we use in our analysis are galaxies and halos from the Illustris(-TNG) simulations. We find that symbolic regression can be used to find a probability density function to predict object positions. This could potentially open the avenue for finding dark objects based on bright observables, constraining their positions and making them easier to locate.

Connecting Dark Matter Distributions to Merger-induced Shocks in Galaxy Clusters

Kyle Finner (Caltech/IPAC)

Cosmology - Poster

As the most energetic events in the universe since the Big Bang, collisions of galaxy clusters are important laboratories for understanding high-energy astrophysics and the formation and growth of the large-scale structure. Radio relics, synchrotron from charged particles accelerated in merger-induced shocks, are an indication of a recent collision. I will present a weak-lensing analysis of thirty merging clusters that exhibit radio relics. I will discuss the mass distributions of the most intriguing clusters and the merger scenarios that are devised from a vast multiwavelength dataset. I will then present a statistical analysis of the mass estimates for the population of merging clusters and provide insight into fitting the mass of unrelaxed systems.

Cosmological Parameters Estimated from Velocity -- Velocity Comparisons

Amber Hollinger (University of Waterloo)

Cosmology - Poster

A promising method for measuring the cosmological parameter combination $f\sigma_8$ is to compare observed peculiar velocities with those predicted from a galaxy density field using linear perturbation theory, known as velocity-velocity comparisons. Previous work has tested the accuracy of this method with N-body simulations, but generally on idealised mock galaxy surveys. However, systematic biases may arise solely due to survey selection effects. We explore the impact of these various effects individually and collectively, to quantify the accuracy and precision of this method using the semi-analytic models from numerical simulations. We generate mock catalogues that mimic the 2M++ density field and find the reconstruction and analysis methods to calibrate recent peculiar velocity samples, yielding a linear $f\sigma_8 = 0.362 \pm 0.023$. Using these results we investigate the impact reconstructing cosmological redshifts, using peculiar velocities, has on measurements of the Hubble constant. Recent measurements of H_0 using type Ia supernovae explicitly correct for their estimated peculiar velocities using the 2M++ reconstruction of the local density field. The amount of uncertainty that is generated due to this reconstruction has thus far been unquantified. To rectify this we use our mock Universe realisations of 2M++ catalogues and peculiar velocities, to quantify this component of the error budget.

Constraining Primordial Non-Gaussianity with Density-Split Clustering

James Morawetz (Waterloo Centre for Astrophysics, University of Waterloo)

Cosmology - Poster

Cosmic Inflation is now a widely accepted solution to the so-called 'flatness' and 'horizon' problems presented by the standard Lambda Cold Dark Matter (LCDM) model. While many models of inflation predict nearly Gaussian initial conditions, some models also predict detectable levels of primordial non-Gaussianity (PNG). Obtaining tight constraints on the existence of PNG, or lack thereof, is a key step in discriminating between different models for inflation. Measurements from the cosmic microwave background (CMB) currently provide the tightest constraints, but large-scale structure (LSS) measurements are expected to overtake the CMB with next generation surveys like DESI and Euclid. Given that non-linear structure growth inherently leads to a non-Gaussian density distribution in the late time universe, it is difficult to detect PNG in the absence of clear observational signatures. We seek a clustering method that is capable of capturing higher-order information on non-linear scales, and exploiting cosmic variance cancellation for tracers with different biases. Among such novel techniques is Density-Split Clustering (DSC) which measures galaxy clustering as a function of local density environment. Using the Fisher information formalism applied to the Quijote simulations, we demonstrate that DSC can provide several factors of improvement in constraining power over standard two-point statistics for PNG and the LCDM parameters. We also discuss the possible sources behind this additional information, and its ramifications for future galaxy surveys. In doing so, we also introduce a Fourier space analysis for the first time in order to compare constraining power and the required computational resources with previous DSC analyses performed in configuration space.

Prospects for using the infall region to probe cosmology

Charlie Mpetha (University of Waterloo)

Cosmology - Poster

Galaxy cluster abundance studies have become a tried and tested method to probe the matter content of the Universe. The number of clusters is extremely sensitive to the “clumpiness” of matter $\sigma 8$ and the amount of matter Ωm. Knowing these two numbers to high precision allows us to better constrain or rule out dark matter candidates. Future telescopes such as eROSITA and Euclid promise vastly increased sensitivity, and so such cluster abundance studies will be a valuable tool for understanding dark matter. However, there is a strong degeneracy between $\sigma 8$ and Ωm, limiting the precision to which we can determine these two parameters from cluster abundance studies alone. A method of breaking this degeneracy using only cluster properties would be very valuable. This project aims to use the infall region, where the gravitational field of the cluster is pulling in surrounding material, to break the degeneracy in cluster counts. I will discuss how we employ large cosmological simulations to assess how correlated the infall region is with the cluster age and the degree to which this property of clusters can be measured by future surveys using weak lensing. Finally, I will present how sensitive this method is to cosmological parameters and demonstrate how it can be used to gain valuable information on the nature of dark matter.

Beyond the First Light: Novel Simulations of Pop III Stars with GIZMO

Vasilii Pustovoit (CITA/UofT)

Cosmology - Poster

Recent observations with JWST have successfully identified galaxies at high redshifts ($ z \gtrsim 13$), yet the Initial Mass Function (IMF) of the Universe's first stars, known as Population III (Pop III) stars, remains poorly constrained. Addressing this gap, our work employs a novel numerical strategy utilizing the Meshless Finite Mass (MFM) method within the GIZMO simulation framework to study Pop III star formation with an unprecedented level of detail. This method surpasses previous methods used in such studies by offering improved accuracy in modeling accretion disks and high-density regions, crucial for understanding the early universe's star formation processes.

Incorporating the STARFORGE module enables a prediction of the IMF, a critical advancement for studying Pop III stars. Furthermore, the implementation of particle splitting and zoom-in techniques facilitates the resolution of individual stars from initial conditions (ICs) derived from the Cosmic Microwave Background (CMB) on megaparsec scales.

The goal of our initial efforts is to improve our understanding of the physics of high-redshift star formation, revealing new insights into the formation mechanisms and structural properties of Pop III stars.

Constraining Cosmology with Galaxy Cluster History

Rashaad Reid (University of Waterloo)

Cosmology - Poster

Constraints on the cosmological parameters $\sigma 8$ and Ωm derived from galaxy cluster abundance and other low-redshift tests are in tension with those derived from observations of the cosmic microwave background. Our ability to investigate this tension is limited by the degeneracy between the parameters when inferred from cluster abundance. Information about cluster age or formation history can break this degeneracy, allowing a better understanding of the σ8 and Ωm tension. We use the IllustrisTNG suite of simulations to explore structural probes of the dynamical state of clusters and their efficacy as proxies for the mass accretion history and formation time. In particular, we find that large centre-of-mass offsets in a cluster consistently identify disturbed systems that have undergone recent major mergers. This and other relationships between growth history and structural properties observable through x-ray emission, weak lensing, or intra-cluster light may greatly improve the constraining power of cluster samples in forthcoming surveys such as Euclid.

Axion Quark Nugget Annihilation Versus Observed Excess in Galactic Emissions

Michael Sekatchev (University of British Columbia)

Cosmology - Poster

Telescope observations of background radiation in the Milky Way point to an anomalous excess in ultraviolet, radio, and x-ray signals. The unconventional Axion Quark Nugget (AQN) dark matter model may provide an interpretation for this as-yet-unexplained excess. The model proposes that dark matter is dominated by macroscopic composite objects of nuclear density, in the form of matter and antimatter nuggets. Baryonic matter from ionized gas in the Warm Hot Intergallactic Medium (WHIM) surrounding the Milky Way may collide with antimatter AQNs and annihilate, resulting in an emission of a broad spectrum of electromagnetic radiation similar in form to Bremsstrahlung. The resulting spectrum was estimated to match the excesses in radio, UV, and x-ray signals in the galaxy. The aim of this project is to compare the AQN annihilation radio emissions with the observed radio haze from WMAP. This is done by computing the signal from AQN annihilations within a cosmological hydrodynamic simulation of a Milky Way-like galaxy, and using a Markov chain Monte Carlo method to produce constraints on the AQN mass range and the dark matter density distribution. Understanding the source(s) of this excess radiation in our galaxy may bring us a step closer to revealing the nature of dark matter.

Cluster Formation History as a Cosmological Test

James Taylor (Waterloo Centre for Astrophysics)

Cosmology - Poster

Current low-redshift tests of structure formation, such as weak gravitational lensing and galaxy cluster abundance, disagree with high-redshift constraints from the Cosmic Microwave Background, the so-called "S8 tension". Unfortunately, low-redshift tests are also degenerate in the Omega_m-sigma_8 plane. We note that the cluster growth rate has a different, almost orthogonal variation in this plane, allowing significant improvement on existing low-redshift constraints. The relative growth rate can be estimated from a variety of structural features, both in the core of the cluster and at larger radii. We report initial results from these tests in the UNIONS survey, and forecasts for the cluster sample expected in the Euclid Wide survey.

Tests of axion dark matter using galaxy UV luminosities

Harrison Winch (University of Toronto)

Cosmology - Poster

Axion-like particles (ALPs) are a well-motivated dark matter (DM) candidate that solve some of the problems in the clustering of large scale structure in cosmology. In this poster, I will present novel cosmological constraints on ALP DM using the galaxy UV luminosity function (UVLF), which probes a range of small scales and high redshifts that are entirely unexplored by past tests of ALP DM. We performed the first Bayesian analysis of ALP DM using UVLF measurements from the Hubble space telescope, combined with Planck measurements of the CMB. This joint analysis excludes $m_{ax} < 10^{-21.6}$ eV axions as 100% of the DM, as well as constraining the axion fraction with $-26 < \log(m_{ax}) < -23$ to be below 22%, after marginalising over all cosmological parameters and astrophysical uncertainties. Our results not only constrain a novel region of axion parameter space, but also cover a previously unexplored redshift range and have different systematics to other tests of ALP DM, providing a powerful consistency check of low-z astrophysical probes.

Lensing Cosmology without Small-scales

Shiming Gu (University of British Columbia)

Cosmology - Poster

Weak lensing by large-scale structures is a powerful tool in cosmology. However, it is well known that the cosmological interpretation of conventional statistical estimators (e.g., correlation function, moments) is sensitive to non-lensing effects, such as baryonic physics, intrinsic alignment, and other non-linear effects. The Bernardeau-Nishimichi-Taruya (BNT) Transformation was proposed as a way to mitigate these effects in an optimized and model-independent manner. In this poster, we demonstrate how the BNT transform can be used to construct a linear combination of conventional estimators such that the contribution from small-scale physics (k>0.1-0.3 h/Mpc) is strongly suppressed without a significant loss of precision for the cosmological analysis. We present a forecast of cosmological constraints for Euclid using BNT-transformed cosmic shear estimators. We show that, even with the k>0.1h/Mpc scales removed, one can still achieve competitive cosmological constraints, where conventional statistical estimators, with equivalent scale cuts, do poorly.

Education and Public Outreach

Launch of the Westar Program

Daniella Morrone (Westar Coordinator & Discover the Universe)

Education and Public Outreach - Talk

In this presentation, we will update the Canadian community about the recent launch of the Westar Program, formerly known as the CASCA-Westar Lectureship. This new program aims to establish reciprocal and long-term relationships between astronomers and under-served Canadian communities through meetings, visits, workshops, and activities, and to enable the mutual sharing of astronomy knowledge. For more information about the Westar Program, and to see the Call for Astronomers form, please visit our website: https://casca.ca/?page_id=7598

The CASCA Westar Subcommittee:
Terry Bridges (Chair), Frédérique Baron, Rob Cockcroft, Daniella Morrone (Westar Coordinator), and Christa Van Laerhoven

Building more equitable spaces in STEM through game-based learning; the case of Science in Space: How to Telescope

Alice Curtin (McGill University)

Education and Public Outreach - Talk

Science in Space: How to Telescope is an informal science learning program in which girls and gender non-conforming kids of ages 10-12 learn about astronomy by building their own telescopes in Minecraft. Founded in 2022 by the Trottier Space Institute, McGill Physics, and Dell Technologies/Girls Who Game, Science in Space is designed to foster a sense of belonging and community, thus increasing student engagement and confidence in STEM and ultimately reducing attrition from later STEM studies. The program is inquiry-based and student driven; students ultimately decide which astronomical phenomena they'd like to study and design a telescope to do so. Facilitators and mentors deliver the basics of astronomy through game-based activities, providing the foundation students need to design and build their telescope. Science in Space has successfully run eight times in the Montreal area over the course of the last two years. In this Talk, we will first describe the program and the values underpinning it. We will then discuss how we gather and incorporate student and mentor feedback in an iterative process, and how this feedback has been applied to improve the program. Finally, we will discuss what we've learned and the impact that it has had on both the students and mentors, along with our future hopes for this program.

Indigenous Engagement Committee Report

Laurie Rousseau-Nepton (University of Toronto, Dunlap Insitute)

Education and Public Outreach - Talk

During this presentation, we will introduce the Indigenous Engagement Committee members, our mission and plan of action. We will also show the first result of a survey on indigenous engagement sent recently to the members.

Exoplanets in the Classroom: A Bilingual K-12 Educational Suite for Exploring Exoplanet Science

Heidi White (Université de Montréal)

Education and Public Outreach - Talk

"Exoplanets in the Classroom" is an educational initiative developed by the Université de Montréal's Trottier Institute for Research on Exoplanets (iREx) in collaboration with partners such as Discover the Universe. Targeting Canadian K-12 classrooms, the program introduces students to the exciting field of exoplanet science. Available in both English and French, it offers a range of resources designed to engage students in hands-on activities, connect them with local researchers, and foster STEM curiosity and critical thinking. The program takes an interdisciplinary approach, incorporating concepts from physics, biology, language arts, and mathematics to provide a comprehensive understanding of (exo)planetary systems and their potential for life. "Exoplanets in the Classroom" classroom modules allow students to actively participate in the learning process through multimedia resources, online software, and engaging activities. Tailored for different age groups, the program has been developed and reviewed by Québec school teachers to align with curriculum standards and offer enriching content beyond traditional textbooks. In addition to educational resources, the program provides support for teachers, including detailed lesson plans, slide decks, worksheets, and supplementary materials. Recognizing Canada's bilingual identity, the initiative aims to provide equitable access to STEM education in both English and French. By addressing disparities in access to STEM resources between the two languages, the program promotes inclusivity and linguistic diversity in education, enriching Canada's educational landscape and providing equal opportunities for astronomy learning to all students. In this Talk, I will provide an overview of the “Exoplanets in the Classroom” educational suite, describe the development process, and reflect on our experiences in creating bilingual educational materials. I will also describe our extensive teacher feedback process, sharing the valuable insights and perspectives provided by hundreds of K-12 teachers. I will also outline our future plans for expanding the program. Finally, I will discuss various models aimed at facilitating its widespread implementation in K-12 schools across Canada. Attendees of this presentation at CASCA will gain insights into effectively leveraging this unique suite of resources for their own outreach initiatives and educational programs.

A Bibliometric Analysis of Canadian Astronomy

Dennis Crabtree (NRC-HAA)

Education and Public Outreach - Poster

The productivity and impact of Canadian astronomy will be investigated using bibliometrics. Included will be a comparison of Canadian astronomy to other leading countries in astronomy. Also, Canadian publications using data from astronomical observatories will be examined.

Allan I. Carswell Observatory 2024 Solar Eclipse Education and Outreach

Elaina Hyde (York University/ Allan I Carswell Observatory)

Education and Public Outreach - Poster

The outreach during large astronomical events is key to both education and involvement. During the 2024 solar eclipse event the Allan I Carswell Observatory led a multi-event campaign leading up to the April 8 solar eclipse in Ontario. The Allan I Carswell Observatory is located on campus at York University in Toronto. With our portable telescopes and educational materials we were able to bring outreach and educational programming for this event on-location, online, and on the York Campus itself. This Poster will outline the outreach methods, eclipse materials, and observation techniques used during this successful eclipse season. We will also show potential improvements for future large events.

Allan I. Carswell Observatory 2024 Messier Marathon with a 1m

Elaina Hyde (York University/ Allan I Carswell Observatory)

Education and Public Outreach - Poster

The Allan I Carswell Observatory is a state-of-the-art facility at York University. With our new robotic capacity and our 1m telescope we run research, outreach and education programming. This project has encapsulated all three of our main modes of operation. During March 2024 our observatory members ran a Messier Marathon, observing and reducing 41 Messier objects with the 1m telescope. Training on observation and data reduction was completed in an interactive mode with all listed authors participating in the project. This Poster will illustrate the observing techniques, data reduction, and of course lessons learned from the project.

Cultivating Connections: CFHT’s Community Efforts

Mary Beth Laychak (Canada-France-Hawai'i Telescope)

Education and Public Outreach - Poster

CFHT’s education and community engagement efforts continue to evolve in Hawai’i and across its funding partners. The crux of these efforts lies in building and sustaining relationships with schools and community partners. The pandemic and evolving situation in Hawai’i surrounding Maunakea have opened new and exciting doors. This Talk will summarize CFHT’s engagement efforts with the local community, including the Maunakea Stewardship and Oversight Authority. It will also touch on efforts in our partner countries.

Physics and Astronomy Undergraduate Longitudinal Survey at McMaster University

Nicole Mulyk (McMaster University)

Education and Public Outreach - Poster

We have developed a longitudinal survey which aims to examine students' attitudes toward their programs and courses in the Department of Physics and Astronomy at McMaster University. We are building on previous survey projects which looked at students’ motivations when selecting their programs and the variations between different introductory physics cohorts. The long-term goal of this project is to evaluate the effectiveness of undergraduate physics programs. The results of the survey will be shared with the department and considered when making program changes. We intend for students’ experiences and perceptions to be a factor in curriculum improvement. This survey will be conducted yearly at the end of the winter term, with the first round of surveys in March - April 2024, and will be distributed to all students enrolled in an undergraduate physics program. As we aim to access the entire physics student experience, the survey is divided into five sections: Student History, Current Coursework, Student Wellbeing, Plans After Graduation, and Demographic Questions.

The development of our survey involved contributions from department representatives and undergraduate students. We met with department representatives in the early stages of the survey construction to determine what kinds of information are important to program development. After completing the initial draft of the survey, we met with focus groups to get student feedback on the survey. These focus groups included ~15 undergraduate physics students ranging from first-year to 5+ year students. The overall response from the undergraduate students was that they are very motivated to have their opinions incorporated into department decision-making. We wanted to ensure that the survey included information relevant to the department while also giving the students an opportunity to express their feedback.

This work was funded by the MacPherson Institute Student Partners Program.

Highlights from CASCA’s Graduate Student Committee 2023-2024

Janette Suherli (University of Manitoba)

Education and Public Outreach - Poster

The Canadian Astronomical Society’s Graduate Student Committee (CASCA GSC) represents and advocates for approximately 480 astronomy graduate students across Canada. We are an active committee of dedicated astronomy graduate students with representations at 16 universities across Canada. In the 2023-2024 academic year, alongside continuing efforts such as GradHighlights and the annual Graduate Student Workshop, the GSC relaunched the Canadian Telescope/Theoretical Seminars (CaTS) series, revamped our social media, and distributed a follow-up survey to our 2023 Sustainability and CASCA AGMs Survey. This Poster highlights our diverse activities throughout the year and presents the 2024 Survey results.

Exoplanets

Shoulder of Dust Rings Explained by Dust Dynamics Under Planet-Disk Interactions

Jiaqing Bi (University of Toronto)

Exoplanets - Talk

Recent analyses of mm-wavelength protoplanetary disk observations have revealed several emission excesses on the previously identified dust rings, referred to as the shoulders. The prevalence of the shoulders suggests that they trace a common but unclear mechanism. In this work, we combine 3D, multifluid hydrodynamic simulations with radiative transfer calculations to provide explanations for the formation of the shoulders. We find that the ring-shoulder pairs can result from the 3D planet-disk interactions with massive, gap-opening planets. Possible mechanisms are the dust filtration effect by the outward gas flow at the outer gap edge, the warmed-up dust due to the puff-up, and the merger of puff-ups at both gap edges due to insufficient resolutions. Our work bridges the correlation between the ongoing planet-disk interactions and the existence of an inner dust shoulder in the PDS 70 disk. It also provides insights into the formation of outer shoulders in other disks and highlights the role of 3D effects in planet-disk interaction studies.

Atmospheric Characterization of the Temperate Planet LHS 1140 b with JWST/NIRISS – Is LHS1140 b a Mini-Neptune or a Water-World?

Charles Cadieux (Université de Montréal)

Exoplanets - Talk

LHS 1140 b is the second closest transiting exoplanets with a temperate equilibrium temperature potentially indicative of habitable surface conditions. A recent study (Cadieux et al. 2024) revealed that this planet is less massive and larger than previous estimates strongly suggestive of a significant volatile-rich envelope. More specifically, internal structure modelling informed by stellar abundances of refractory elements (Fe, Si and Mg) supports two new exciting possibilities for its nature: LHS 1140 b is either a mini-Neptune with a small (0.1%) H/He mass envelope or a water world with 10–20% of its bulk mass made of water. Global Climatic Modelling suggests liquid condition at the sub-stellar point whose extent depends on CO2 concentration. Discriminating the mini-Neptune and water-world scenarios requires atmospheric characterization with JWST through transmission spectroscopy over the widest possible wavelength range to assess the potential issue of stellar contamination shown to be a serious challenge for active M dwarfs like Trappist-1. I will present the results of a reconnaissance transmission spectroscopy program of LHS 1140 b with JWST/NIRISS SOSS, two visits with a simultaneous wavelength coverage from 0.6 to 2.8 microns. I will then discuss the implications of these results for future in-depth atmospheric characterization of this keystone planet.

Canada's Contribution to ESA's Ariel Mission

Nicolas Cowan (McGill University)

Exoplanets - Talk

In 2023 the Canadian Space Agency announced it was joining the European Space Agency's Ariel mission. Ariel is a 1m space telescope offering simultaneous optical–infrared spectroscopy. The $1B mission is scheduled to launch in 2029 to complete a survey of ~1000 exoplanetary atmospheres. In exchange for providing mission-critical hardware, Canadians can join the Ariel Consortium. I will a) provide an overview of Ariel's survey of exoplanet atmospheres, b) describe how current Canadian scientists are contributing to Ariel's design of experiment, and c) explain how YOU can join the consortium to participate in the planning and analysis of these data.

Expedition Unknown: Characterizing and Modelling GPI Debris Disks in the Search for Elusive Planets

Katie Crotts (University of Victoria)

Exoplanets - Talk

Debris disks, dusty disks found around main sequence stars, are often observed to harbour a variety of structures and asymmetries associated with being actively perturbed. A likely source of such perturbations are interactions with planets, however, there are very few cases where both the planet and disk are directly imaged, allowing the planet to be directly connected to the disk's morphology (e.g. beta Pic). Given that the spatially resolved debris disks are Kuiper belt analogues, far from their host star, debris disks may be probes for a population of wide-orbit, low mass (<~1 Mjup) planets that are outside what is detectable with most exoplanet detection methods. For my PhD thesis, I attempt to better understand the variety of debris disk morphologies observed, and how they might be connected to unseen planets. First, I conducted a uniform, empirical analysis on a large sample of 22 debris disks imaged in polarized light with the Gemini Planet Imager. Through this analysis, I characterized the morphologies of each disk, focusing on any asymmetries present that may suggest planet-disk interactions. Second, I take a closer look at one of the most asymmetric disks from our sample, HD 111520, which show several features associated with perturbation from a planet, including a warp and fork-like structure. Simulating the disk morphology with the N-body simulation code, REBOUND, I show how a wide-orbit, Jupiter mass planet is capable of reproducing the majority of the disk structures. This work demonstrates how debris disk morphologies can be used to constrain the masses and orbits of currently undetected planets, and can be used to determine candidates for planet searches with direct imaging using current/future high-contrast instruments such as JWST/NIRCam and GPI 2.0.

High-Resolution Spectroscopy of Ultra-Hot Jupiter Atmospheres with GHOST

Emily Deibert (NOIRLab/Gemini South)

Exoplanets - Talk

With high equilibrium temperatures and tidally locked orbits, ultra-hot Jupiters are unique laboratories within with to probe atmospheric physics and chemistry at the extreme. Recent high-resolution optical observations of ultra-hot Jupiters have

revealed more than a dozen atomic and molecular species in their atmospheres, shedding light on the distinct chemical regimes that can exist on the planets' day- and nightside hemispheres.
Here we present the first transmission and emission spectroscopy of two ultra-hot Jupiter atmospheres obtained with the new Gemini High-resolution Optical SpecTrograph (GHOST) at the Gemini South Observatory in Chile. Due to its high spectral resolution (>75,000) and broad optical wavelength coverage (~300-1000 nm), GHOST is ideally suited to detecting the atomic and molecular species present in ultra-hot Jupiter atmospheres. We discuss our detection of iron emission and a thermal inversion in the dayside atmosphere of the ultra-hot Jupiter WASP-189b, as well as our simultaneous detections of multiple atomic species in the transmission spectrum of another ultra-hot Jupiter. We will also discuss our ongoing comparative survey of ultra-hot Jupiter atmospheres with GHOST, and highlight how these detections inform our broader understanding of hot exoplanet atmospheres.

TOI-2120 b: A temperate sub-Neptune transiting a M4.5 dwarf revealed by SPIRou and TESS

Alexandrine L'Heureux (Université de Montréal)

Exoplanets - Talk

To understand planetary formation, it is essential to explain the separation of close-in exoplanets into two distinct populations: super-Earths and sub-Neptunes. In particular, the formation pathways of sub-Neptunes remain puzzling due to degeneracies in their possible compositions and interior structures from only their bulk densities. Understanding their true nature requires atmospheric characterization through transmission spectroscopy. To do so, we must find favorable candidates such as temperate sub-Neptunes (T_{eq} < 400 K), which are relatively unaffected by high-altitude aerosols.

We report the discovery TOI-2120 b, a temperate sub-Neptune orbiting a nearby M dwarf. With the TESS satellite and the SPIRou spectropolarimeter we constrain the radius and the mass to > 5σ. This places TOI-2120 b among the few well-characterized temperate exoplanets, and as the most favorable candidate for transmission spectroscopy with JWST.

Toward reflected light exoplanet imaging with CAL2: Project update of the NRC facility-class focal plane wavefront sensor for the Gemini Planet Imager 2 upgrade

Christian Marois (National Research Council of Canada)

Exoplanets - Talk

High-contrast imaging instruments are limited by speckles having a broad range of life time, from fast KHz residuals from the atmosphere residuals (after AO), to slowly (minutes to hours) changing non-common path aberrations. This noise is usually attenuated by clever observing strategies or powerful post-processing techniques, but these can be limited by wavefront evolutions with time and/or wavelength. We will present the CAL2 self-coherent camera project, a collaboration of international partners led by the National Research Council of Canada, that consists of upgrading the Gemini Planet Imager instrument calibration unit "CAL" with a next generation fast-speed and low-noise SAPHIRA-based facility-class near-infrared focal plane wavefront sensor. CAL2 is a common path interferometer based on the FAST SCC concept where the central point spread function core light is reflected off-axis by the coronagraphic focal plane mask, and into a Lyot stop small aperture (the reference beam). The two beams interfere to produce bright fringes on residual star light in the final science focal plane, allowing for fast 100Hz focal plane corrections on bright stars. The CAL2's main technical goal is to improve by up to 1-2 orders of magnitude the instrument integral field spectrograph contrast very close to the GPI focal plane mask, opening up a new regime of direct exoplanet imaging of Jupiter-mass exoplanets down to 5-10AU orbiting nearby young mass stars. We will discuss CAL2 expected performances, its final mechanical/optical designs, its focal plane masks, and its different possible approaches to control quasi-static speckles. The CAL2 final design review is expected to be completed Spring 2024, and it will then undergo several months of rigorous testing Summer/Fall 2024, before being deployed at Gemini North observatory in 2025.

Ultraviolet-to-Infrared Atmosphere Spectroscopy of the Ultra-Hot-Neptune LTT 9779b

Michael Radica (Université de Montréal)

Exoplanets - Talk

Ultra-hot-Jupiters, with dayside temperatures in excess of ~2000K, present some of the most extreme planetary environments known. Their atmospheres typically feature prominent stratospheres, where temperature temporarily increases with altitude, as well as low albedos. It is unclear, though, to what extent these trends continue to ultra-hot planets of lower mass. Moreover, attempts to extend these trends to lower-mass planets are confounded by the scarcity of ultra-hot-Neptunes; a feature of the exoplanet population called the hot-Neptune desert. Neptune-mass planets orbiting very close (period < 3d) to their host stars are predicted to simply not have sufficient gravity to retain their atmospheres against the intense stellar radiation, and thus they completely evaporate on very short timescales. LTT 9779 b is the only known ultra-hot-Neptune. With a mass of 1.7 times that of Neptune and an orbital period of 0.79d, it resides directly in the middle of the hot-Neptune desert. Moreover, previous studies have indicated that LTT 9779 b has an atmosphere with an extremely high albedo, and no stratosphere — in stark contrast to the population of ultra-hot-Jupiters. This Talk will present ultraviolet-to-infrared atmosphere observations of this unique world, combining spectra from JWST NIRISS/SOSS and HST/UVIS with archival observations from Spitzer/IRAC. We find evidence for an atmosphere extremely enriched in metals, and with clouds composed of highly-reflective silicate particles — providing a natural explanation for the planet's high albedo. Moreover, we explore the extent to which these high-albedo clouds, which are not observed on other ultra-hot planets, can aid LTT 9779 b in the retention of its atmosphere, and suppress the emergence of a stratosphere. This work takes important steps to understanding how LTT 9779 b became the only planet to survive in the hot-Neptune desert and reconciling it with the wider population of ultra-hot-Jupiters.

A New Differential Effective Temperature tool as a Stellar Activity Indicator for the TRAPPIST-1 Planets

Laurie Dauplaise (Université de Montréal)

Exoplanets - Poster

Understanding stellar activity is vital for accurately studying and characterizing exoplanets. Stellar dark spots and faculae vary temporally and spatially, presenting challenges as they mimic planetary signals in transmission spectroscopic observations, leading to potentially misleading constraints for planetary atmospheric compositions. While methods like joint retrievals of planetary and stellar activity parameters have been employed, they often rely on theoretical stellar models which may lack accuracy, especially for M dwarfs, which are typically active and rich in complex molecular features. Our objective is to address this challenge by developing a data-driven activity indicator capable of disentangling stellar activity from planetary signals. We present our work on analyzing data from the TRAPPIST-1 system obtained by the NIRPS spectrograph (Near-Infrared Planet Searcher located in La Silla, Chile) to better characterize the results of a novel stellar activity indicator called the differential effective temperature (DET), inspired by the Line-by-line technique of Artigau et al. (2022). The DET achieved by the line-by-line technique is of sub-kelvin precision, enabling the study of minute temperature variations due to stellar activity during planetary transit events within the TRAPPIST-1 system. We observe a significantly higher dispersion in the DET during transit events compared to out-of-transit, which is most likely attributable to stellar activity, such as unocculted spots/faculae and/or flares. The DET tool is a new powerful stellar activity indicator to enhance the reliability of exoplanet characterization by providing data-driven information on stellar activity.

Exploration of hot Jupiter atmospheres with NIRPS

Frédéric Genest (Université de Montréal)

Exoplanets - Poster

Transit spectroscopy is one of the most widely used methods to characterize exoplanet atmospheres. At high spectral resolution, in the near infrared, we can detect individual molecules such as water and recover information about the dynamics of the upper atmosphere (winds, jets, etc.). I analyze transit observations of multiple hot Jupiters taken with the new near infrared spectrograph NIRPS, using the cross correlation method and an atmospheric retrieval framework. I report tentative detections of water in the transits of WASP-127 b, WASP-107 b, and WASP-80 b.

Characterizing the Radius Valley around Mid-to-late M Dwarfs

Erik Gillis (McMaster University)

Exoplanets - Poster

The occurrence rate of planets around Sun-like stars and early M dwarfs forms a bimodal distribution in planet radius known as the Radius Valley which features a dearth of planets between 1.6 and 1.9 Earth radii separating rocky Super-Earths from larger sub-Neptunes. Around Sun-like stars, the dominant physical mechanism that shapes the Radius Valley appears to be a form of thermally-driven atmospheric escape; however, surveys of early M dwarfs provide tentative evidence that the

Radius Valley around M dwarfs may instead originate from a distinct channel of terrestrial planet formation. As of yet, transiting exoplanet survey missions have been largely insensitive to planets around mid-to-late M dwarfs. This presents a major gap in our understanding of the existence of the Radius Valley and the mechanisms which may shape it around these low-mass stars. Fortunately, NASA's Transiting Exoplanet Survey Satellite (TESS) has opened a window into the exoplanet population around mid-to-late M dwarfs. I am leading a systematic search for small transiting planets around more than 10,000 mid-to-late M dwarfs observed by TESS to characterize the Radius Valley and determine the dominant driver of planet formation around these low-mass stars. I will present my custom pipeline to process TESS light curves and to detect and vet signals from transiting planets, as well as the preliminary results of my transit survey around the lowest mass stars. With a false positive rate below 5%, this pipeline is sensitive to 90% of TESS Targets of Interest and 100% of confirmed planets around our sample of stars.

Calibrating Elemental Abundances in M Dwarfs with SPIRou

Nicole Gromek (McMaster University)

Exoplanets - Poster

Measuring accurate stellar abundances of planet forming elements is critical to our understanding of exoplanet compositions and their formation processes. While these values can be reliably derived from optical spectra for FGK-type stars, the recovery of accurate abundances for M dwarfs is complicated due to persistent discrepancies between models and observed spectra, such as blended absorption features and broad molecular bands that hide the continuum. These lingering uncertainties in M dwarf chemical compositions inhibit our ability to accurately model the interiors and atmospheres of exoplanets around M dwarfs. To address this issue, we have built a custom framework to extract elemental abundances from the spectra of cool stars via the spectral synthesis method. We use VALD line lists, MARCS stellar atmosphere models, and the radiative transfer code SPECTRUM to generate forward models of synthetic spectrum across a grid of abundances, followed by a chi-squared minimization. By applying this process to spectra from 24 FGK-M wide binary systems, this work will be used as the basis for the generalized empirical calibration of M dwarf abundances measured with the SPIRou spectropolarimeter. SPIRou, with its high spectral resolution and broad near-IR wavelength (R~75,000, YJHK bands), is the ideal facility to help mitigate the difficulties present in observing M dwarfs. By combining the capabilities of SPIRou with our framework, we are well equipped to ensure the accuracy of derived elemental abundances in M dwarfs. Our results will ultimately be applied to planet-hosting M dwarfs in order to place strong constraints on the planets' refractory and volatile abundances, both of which are important diagnostics of planetary formation histories and interior compositions.

A SmallSat mission study for STARLITE: Superluminous Tomographic Atmospheric Reconstruction with Laser-beacons for Imaging Terrestrial Exoplanets

Adam Johnson (University of Victoria)

Exoplanets - Poster

In the search for life in our galaxy, and for understanding the origins of our solar system, the direct imaging and characterization of earth-like exoplanets is key. In a step towards achieving these goals, the STARLITE mission (Superluminous Tomographic Atmospheric Reconstruction with Laser-beacons for Imaging Terrestrial Exoplanets) uses five CubeSats in a highly elliptical orbit as artificial guide stars to enable tomographic reconstruction of the atmosphere for extreme multi-conjugate adaptive optics (MCAO). Through the use of current and next-generation extremely-large ground-based telescopes, the STARLITE constellation at its ~350,000km apogee will provide -3 magnitude artificial guide stars from a 10cm launching telescope in a sub-arcminute field of view for up to an hour. Careful selection and design of the ~760nm on-board laser will allow O2 detection and characterization of exoplanet atmospheres. At a size of 12U, each satellite weighs only 32kg and utilizes mostly commercially available off-the-shelf parts to keep costs per satellite around $2M. In this paper we will present the satellite mission concept and early 3D system design for the STARLITE constellation.

Eclipse Spectroscopy of WASP-80 b with JWST/NIRISS Reveals Properties of Reflecting Aerosols

Kim Morel (Université de Montréal)

Exoplanets - Poster

Observation of exoplanet secondary eclipses in the near-infrared domain allows for the detection of both thermal emission and reflected light, which in turn provides great insights about the presence of aerosols and their properties as well as the thermal structure of the atmosphere. Here we present an eclipse spectrum of WASP-80 b obtained with JWST NIRISS/SOSS, spanning 0.69 to 2.83 μm. WASP-80 b

is an 825 K, warm gas giant orbiting a bright late-K dwarf star for which the presence of clouds has been inferred from previous transmission spectra measurements. We detect the eclipse with good significance across our whole wavelength range, notably below 1.1 um where no previous measurements were available. Our eclipse spectrum points toward a high albedo from reflective aerosols, in agreement with previous results, although we report eclipse depths that are significantly higher than previous studies with HST WFC3 and JWST NIRCam in each wavelength range overlapping that of SOSS. By comparing our results to different cloud and haze models, we will discuss the implications of our new spectrum for the aerosols properties and thermal structure of this planet's atmosphere.

Habitability and Observability of Earth analogs in Brown dwarf systems

Joshua Parsons (York University)

Exoplanets - Poster

High mass star systems are inhospitable to life for a variety of reasons; including their short lifetimes. 6 of the greater than 130 stellar and sub-stellar objects discovered within 20ly of Earth are more massive than the Sun. The locality of low mass stars is one of the primary reasons the search for habitable worlds has been directed towards red dwarf stars, which are plentiful in our neighbourhood, have long main sequence lifetimes to allow for the development of life, and are ideal for quality transit observations of exoplanets in the habitable-zone with our current technical capabilities. Recent observations have raised questions about terrestrial atmosphere retention in the habitable zone as a result of increased flare activity observed in red dwarf systems. This research explores the lower mass sub-stellar regime beyond late type M-dwarfs where flaring is less prevalent. 1-D climate and photo-chemical profiles are explored alongside transit and emission spectra of Earth analog exoplanets around brown dwarfs to gauge the habitability and observability of such systems.

Analysis of the Atmosphere of Hot-Jupiter KELT-20b using its full-orbit Spitzer Phase Curve

Alexandra Rochon (Department of Physics, McGill University)

Exoplanets - Poster

We analyze phase observations of the ultra-hot Jupiter KELT-20b obtained by the Spitzer Space Telescope, to study the thermal emissions and constrain the atmospheric dynamics of the exoplanet. Hot Jupiters are a prime target for infrared

phase curve observations, which measure the planet's brightness as a function of orbital phase. These phase curves are used to study atmospheric dynamics and heat transport in the atmosphere. Exoplanets like hot Jupiters that orbit close to their host star are often tidally locked, resulting in a permanent dayside receiving constant flux and a cold, dark nightside that receives no flux. We simultaneously fit the variation caused by the telescope's intrapixel effect and the planet's varying infrared emission to isolate the planetary signal. We use the planet's phase curve to determine the temperature of the dayside (during secondary eclipse) and the nightside of the planet (during primary transit), allowing us to constrain the advection of heat from the nightside to the dayside. We then compare the resulting light curve to an energy balance model to constrain the albedo, the wind speed and the atmospheric depth. Hot Jupiters are great observation targets to perfect our tools and understanding of exoplanet atmospheres. We review our findings and discuss how the James Webb Space Telescope can further the characterization of Hot Jupiters to understand their radiative and dynamical properties.

The POET Mission

Jason Rowe (Bishop's University)

Exoplanets - Poster

POET is a proposed Canadian Microsatellite mission designed to characterize and discover transiting exoplanets. A 20-cm all-reflective telescope will feed a trio of detectors to obtain simultaneous, high duty-cycle, photometry in the u (300-400 nm), Visible Near-Infrared (VNIR) (400-900 nm) and Short Wave Infrared (SWIR (900-1700 nm) bands to make precision measurements of exoplanet transits for atmospheric characterization and to detect transiting Earth-sized planets. POET was selected as a high priority for a Microsatellite mission by the Canadian community as part of the CASCA Long Range Plan 2020. Advancement of the payload concept and technology development for the optical telescope assembly (OTA) are currently being carried out through the Space Technology Development Program of the Canadian Space Agency. POET is a collaboration between Bishop's University, Western University, ABB and SFL-UTIAS.

Exploring the Peculiar Western Hotspot Offset of CoRoT-2b with High-Resolution Spectroscopy

Zoe Shu (Université de Montréal)

Exoplanets - Poster

Hot Jupiters are gas giant planets residing on extremely small orbits expected to have their rotation tidally locked due to strong interaction with their parent star. With exceedingly high amounts of irradiation blasting their atmospheres, these planets offer an unprecedented opportunity to study the extreme climate of some of the most exotic known planetary systems. Recent observations of the hot Jupiter CoRoT-2b have revealed a puzzling westward hotspot offset in its atmosphere that could be explained by multiple scenarios such as a non-synchronous rotation, magnetic effects or inhomogeneous clouds. To investigate the nature of this offset, we harness the power of ground-based high-resolution spectroscopy to detect the planet's doppler-shifted emission as it orbits around its host star. We acquired time-series observations of the CoRoT-2 system with the Immersion GRating INfrared Spectrometer (IGRINS) installed on the Gemini South telescope in Chile and adapted the open-source STARSHIPS pipeline, initially developed analyse and interpret CFHT/Spirou data, to IGRINS observations. In this Talk, I will present the first detection of H2O and CO in the atmosphere of CoRoT-2b in infrared high-resolution spectroscopy and constraints on their abundances. These observations highlight both the power of high-resolution spectroscopy in untangling atmospheric dynamics of exoplanets and the potential of next-generation ground-based telescopes.

Water as a Potential Sculptor of the M Dwarf Radius Valley

Bennett Skinner (McMaster University)

Exoplanets - Poster

A key insight into the planet formation process is provided by the existence of the radius valley, a dearth of planets at 1.7-1.8 Earth radii between smaller super-Earths and larger sub-Neptunes. Super-Earths are believed to have terrestrial compositions dominated by silicates and iron, but the degeneracy between composition and bulk density makes it difficult to disentangle whether the sub-Neptune population is composed of planets with significant water fractions or significant H/He fractions. Around FGK stars, the radius valley shifts to larger planet radii at higher instellation, suggesting that the valley is carved by atmospheric escape of a H/He envelope. However, this pattern may not be replicated around M dwarfs, indicating that the process forming the valley around M dwarfs may be distinct from FGK stars.

We test whether a bimodal distribution in water mass fractions can explain the emergence of the M dwarf radius valley. We have built a planetary internal structure model that includes updated equations of state for H/He, silicates, iron, and most importantly water. This will allow a precise theoretical characterization of mass-radius relations for water-rich planets for comparison to the observed planet population. We also discuss plans to incorporate this model into planet population synthesis models, which currently show a significant number of sub-Neptune mass planets migrate close to the host star from beyond the ice line and have ice fractions near 50%.

Join modelling to discovery and characterise exoplanets: 51 Eri and Eps Eri seen with imaging, VLTI-GRAVITY, RV, and GAIA

William Thompson (National Research Council)

Exoplanets - Poster

The latest exoplanet surveys carried out via direct imaging, precision radial velocity, and space-based astrometry are all converging in sensitivity. We can now routinely detect planets and substellar companions using all three kinds of data. Previous approaches to analysing these data have used separate tools, developed by each sub-community, with no easy way to directly combine data. Instead, I will show the importance of joint modelling and present new results on a few well-known exoplanetary systems, including 51 Eri b and Eps Eri b (JWST imaging coming in cycle 3), where direct imaging, radial velocity, GAIA-Hipparcos astrometric acceleration, and VLTI-GRAVITY interferometry data can be jointly modelled to give new insights into their orbits and dynamical masses. I will then discuss how we can use these techniques to guide surveys, improve scheduling, and increase yields of new exoplanets.

From HR 8799 to Y-dwarf binaries: JWST interferometry across the stellar IMF

Thomas Vandal (Université de Montréal / Institut de recherche sur les exoplanètes)

Exoplanets - Poster

High-contrast imaging is crucial for studying giant exoplanets, enabling astrometric follow-ups, luminosity measurements, and atmospheric characterization. However, imaging has so far been limited to planets more massive than Jupiter at large separations (3 AU and above). The James Webb Space Telescope (JWST) marks the beginning of a new era for direct imaging, opening the parameter space to Saturn-mass planets, but coronagraphs on board JWST are restricted to separations above 400 mas. To overcome this, the Aperture Masking Interferometry (AMI) mode of the Near Infrared Imager and Slitless Spectrograph (NIRISS) transforms JWST into an interferometer. This is ideal to search for Jupiter-mass planets as close as 100 mas from a bright star. We present the first results from a NIRISS AMI program probing the inner regions around HR 8799 and HD 95086. The structure of these two emblematic systems hints at the presence of close-in planets that have so far eluded direct confirmation. Our AMI observations mark a step further towards a complete view of these systems, which is crucial to derive mass estimates from dynamical simulations and to enable follow-up observations, both of which are required to calibrate planet formation models. For fainter hosts, clear-pupil imaging can attain similar performance to AMI thanks to Kernel Phase Imaging (KPI), a generalization of interferometric techniques to regular images. KPI, combined with the exquisite stability of JWST at 4.8 um, presents a unique opportunity to search for planetary-mass companions around the faintest and coolest brown dwarfs, with spectral type Y. We conducted a survey of 20 Y dwarfs with JWST's Near Infrared Camera (NIRCam) to probe mass ratios down to 0.1 and separations as low as 0.5 AU. This program recently unveiled the first Y+Y binary, WISE-0336, whose two components, separated by 1 AU, could both have planetary masses, depending on their age. We present a first complete analysis of this survey, including an in-depth companion search. These new constraints on Y dwarf multiplicity provide a unique insight on planet formation, extending previous studies around M dwarfs and brown dwarfs to the lowest substellar primaries. Altogether, our AMI and KPI programs outline how JWST interferometry's high-contrast capabilities at short separations can extend our knowledge of planet formation across the entire stellar initial mass function.

Obtaining Precise and Accurate Masses of Super-Earths around M Dwarfs

Drew Weisserman (McMaster University)

Exoplanets - Poster

The radius distribution of small exoplanets is split by the "radius valley", a dearth of planets between 1.6-2 Earth radii that separates rocky super-Earths from larger sub-Neptunes. For planets around FGK stars, this is commonly understood to be a consequence of an atmospheric escape process, but growing empirical evidence suggests that this may not hold true for M dwarf systems. To further our understanding of planets around the M dwarf radius valley, both precise and accurate masses of the planets in this regime are required. We measure the accuracy of reported masses of 27 planets around the M dwarf radius valley using radial velocity measurements from the existing literature. We fit the masses of these planets using a homogeneous framework that accounts for stellar variability and perform injection-recovery tests to infer the accuracy of our retrieved planet masses. Additionally, we are conducting detailed follow-up observations to refine the masses of select super-Earths to place strong constraints on their core mass fractions and to assess how the planetary compositions relate to their host stars. This data is being obtained for the M dwarfs GJ 1132 and GJ 1252 from an intensive radial velocity monitoring campaign with the newly commissioned NIRPS spectrograph. This data will deliver incredibly precise planet masses, improving upon the 20% precision typical of these detections to a precision of 10%. We conclude with a discussion of our derivations of precise core mass fractions, providing much-needed insight into the processes that formed them.

Comparing Exoplanet Transit Timing Methods' Predictions for Long-Period Systems

Sarah Yost (College of St Benedict / St John's University)

Exoplanets - Poster

With the potential for our college's observatory to contribute to exoplanet transit monitoring efforts (Exoplanet Watch), we examine the results of transit time prediction simulations in order to eventually put our results in context. We compare the timing outputs of TTVFast with various n-body simulation codes (e.g. Mikkola, Hermite) implemented in the AMUSE community code framework. Preliminary checks on an example case with long ~year orbits show some discrepancies in timing and variation trend of ~several minutes even in first few transits. TTVFast was extensively tested and validated at periods up to ~60 days, but now there are a handful of known systems with transit timing variations caused by planets with periods >200 days. Out of interest for how the results of available simulation tools may be interpreted as investigations go to longer periods, we study TTVFast and n-body results in systems based upon known cases such as TOI-199 and Kepler-419.

Galaxies

Searching for Protoclusters at z ~ 2

Joe Bhangal (University of British Columbia)

Galaxies - Talk

Cosmological simulations predict that the galaxy populations in protoclusters, may contribute considerably to the total stellar mass growth in the early universe.

However, contrary to the census achieved for galaxy clusters at redshifts $0 < z < 2$, the environmental impact on galaxy evolution is poorly understood beyond the Cosmic Noon ($z > 2$). To investigate, how the environment affects galaxy evolution, it is thus critical to identify large samples of protocluster candidates and characterize their physical properties. I have identified protocluster candidates in two $z \sim 2$ dusty star-forming galaxy (DSFG) fields: SDP.17b and HeLMS-55. Using Ks-band imaging of these fields, combined with ancillary optical/NIR observations, protocluster candidates have been identified via photometric redshift estimates. Overdensities have been identified using a statistical analysis of the surface density of photometric sources. Around 350 protocluster candidates have been identified in each field. We observe a peak overdensity value of $\delta \sim 2.6$ for SDP.17b's field and $\delta \sim 1.8$ for the HELMS-55 field. These results further support the theory that DSFGs may be strongly associated with overdense galaxy environments at $2 < z < 6$. Multi-object spectroscopy follow-up on these fields has been proposed to verify protocluster members and characterize the SFRs of member galaxies. Determining the SFR in two possible protoclusters could help determine whether galaxies evolving in dense environments have boosted or suppressed SFR compared to field galaxies.

Multi-phase AGN feedback and a bright, extended [CII] halo in a LoBAL quasar at z~6.6

Hyunseop Choi (University of Montreal)

Galaxies - Talk

Although the mass growth of supermassive black holes during the Epoch of Reionisation is expected to shape the concurrent growth of their host galaxies, observational evidence of feedback at $z > 6$ is still sparse. We performed the first multi-scale and multi-phase characterization of black-hole driven outflows in the $z \sim 6.6$ quasar J0923+0402 and assessed how these winds impact the cold gas reservoir. We employed the SimBAL spectral synthesis to fit broad absorption line (BAL) features and found a powerful ionized outflow on < 210 pc scale, with a kinetic power $\sim 2 - 100\%$ of the quasar luminosity. ALMA observations revealed high-velocity [CII] emission, likely associated with a cold neutral outflow at ~ 0.5–2 kpc scale in the host-galaxy, and a bright extended [CII] halo with a size of ~ 15 kpc. For the first time at such an early epoch, we accurately constrained the outflow energetics in both the ionized and the atomic neutral gas phases. We found such energetics to be consistent with expectations for an efficient feedback mechanism, and both ejective and preventative feedback modes are likely at play. The scales and energetics of the ionized and atomic outflows suggest that they might be associated with different quasar accretion episodes. The results of this work indicate that strong black hole feedback is occurring in quasars at $z > 6$ and is likely responsible for shaping the properties of the cold gas reservoir up to circum-galactic scales. Finally, we present our approved JWST GO3 program that will provide us with the critical information to complete the picture of the multi-scale and multi-phase characterization of AGN feedback in the early Universe.

Black Holes w/in AGN Disks

D Cocroft (University of Toronto / CITA / AMNH TIDY)

Galaxies - Talk

It has been suggested that mergers of black hole binaries within active galactic nuclei (AGN) accretion disks may be a significant contributor to the observed LIGO merger rate (Stone2017). With nuclear star cluster (NSC) stellar capture by AGN disks and the formation of massive stars in the gravitationally unstable outer regions of the disks, as has been suggested to be the case in the parsec scale disk of young stars in our own galaxy, the potential for an evolving black hole presence in AGN disks is not so far fetched. The goal of this research is to investigate the nature of black hole dynamics within AGN accretion disks via 3D global simulations using the GIZMO code. Here we present our preliminary findings on the presence of black holes, ranging from 50 solar masses to 1.2x10^4 solar masses using the canonical thin disk model. We have run simulations disks containing a single embedded object, as well as simulations of 1:1 mass ratio retrograde & prograde black hole binaries embedded within the disks. In these simple, strictly gravitational and isothermal disks, higher masses lead to partial gap openings, and we expect similar outcomes with high mass binaries. From this research, we expect to gain a better understanding of how the presence of compact objects within AGN disks affect disk structure and evolution, as well as contribute to our understanding of black hole distributions in the Universe.

From UV to Visible Light: Unveiling the Secrets of Galaxy Size Evolution in the COSMOS Field

Angelo George (Saint Mary's University)

Galaxies - Talk

Galaxy scaling relations and their observed evolution are the key tests for models of galaxy assembly. The size-stellar mass scaling relation can be traced out to a wide range of redshifts. We investigate the evolution of this scaling relation since z~1 using 22,000 massive star-forming and quiescent galaxies from the ultra-deep CFHT and Subaru imaging (George et al. 2024, MNRAS, 528, 4797). We analyze this evolution for the first time in two rest-frame wavelengths: 3000 Å (sensitive to young stars) and 5000 Å (old stars). The study reveals an inside-out growth scenario, with both star-forming and quiescent galaxies exhibiting greater extension in UV than in visible light. We observe a deceleration in the size growth rate of star-forming galaxies, driven by the emergence and growth of their bulges. While recently quenched galaxies contribute to the average size of the quiescent galaxy population across all mass bins, the dominant drivers of quiescent galaxy size growth rate are processes affecting individual galaxies, including minor mergers and accretion. I will also show preliminary results on the impact of the environment on the size-mass relation, utilizing an unprecedentedly large sample of 250,000 galaxies and 250 clusters from the entire 18.6 sq. deg of the CFHT CLAUDS + Subaru HSC imaging survey.

Galactic Genesis to Twilight: Charting Stellar Evolution in Nearby Galaxies with PHANGS-JWST Mid-IR Observations

Hamid Hassani (University of Alberta)

Galaxies - Talk

TBD

Unraveling the nature of the cold interstellar medium in distant quiescent galaxies

Allison Man (UBC)

Galaxies - Talk

Most ALMA observations of distant galaxies target actively star-forming galaxies. Little is known about the cold interstellar medium (ISM) of quiescent galaxies, the quenched descendants of star-forming galaxies. Characterizing the ISM evolution as star formation quenches will provide clues to its physical mechanism. For example, did star formation deplete the cold gas reservoir? To what extent are galaxy mergers and AGN feedback relevant in quenching?

I will present new results from a multi-wavelength survey of 14 spectroscopically-confirmed massive, quiescent galaxies at z~2 with HST and/or

JWST imaging. ALMA observations provide CO, [CI] and dust continuum constraints on their cold ISM properties. Our deep observations reveal non-detections in most cases, suggesting efficient ISM depletion as galaxies quench. However, in several cases we identify spatially offset and extended dust continuum emission, hinting at the role of galaxy interaction and mergers in quenching massive galaxies. I will discuss the implications of our results on how distant massive galaxies quench their star formation, and how their ISM content varies during this process.

Are gas-rich UDGs and field dwarfs distinct?

Khadeejah Motiwala (Queen's University)

Galaxies - Talk

The formation mechanisms of gas-rich Ultra-Diffuse Galaxies (UDGs) in low-density environments are not yet understood. For instance, some UDGs may be “failed” L* galaxies, while others appear to be the spatially extended tail of the low surface-brightness dwarf galaxy population. To constrain competing models, we explore the differences between UDG and dwarf galaxy populations using an extensive HI follow-up survey of optically-selected UDG candidates from the Systematically Measuring Ultra-Diffuse Galaxies (SMUDGes) catalogue. For each detection, the HI line provides distance (and therefore size) information that allows us to classify each SMUDGes candidate as either an actual UDG or a foreground dwarf. We also compare the SMUDGes observations with two state-of-the-art cosmological simulations: Numerical Investigation of a Hundred Astrophysical Objects (NIHAO), which forms UDGs through bursts of star formation at early times, and ROMULUS, which forms UDGs using major mergers at high redshift. Although formation scenarios for UDGs with these simulations are remarkably different, the present-day, global properties of the simulated galaxies are consistent with our observed sample. Furthermore, in both simulations and observations, we find that our UDG and dwarf samples follow similar scaling relations such as gas richness vs. optical size. Taken together, our results suggest that optically-selected, HI-rich field UDGs and dwarfs are not distinct galaxy populations in the present day Universe, either observationally or in simulations.

Early UNIONS Results: Dependence of Halo Mass on Galaxy Size at Fixed Stellar Mass, Colour, and Redshift

Darshak Patel (University of Waterloo)

Galaxies - Talk

It is often assumed that there is a tight correlation between the stellar mass and the dark-matter-dominated halo mass of galaxies. There is , however, significant scatter in this relation, which implies that galaxy formation physics is not completely understood. We investigate the dependence of halo mass on galaxy size at fixed stellar mass, redshift and colour using weak gravitational lensing. The analysis done in our work, compared to those done previously, utilizes the much larger surveys: the DESI Legacy Survey for the foreground lens galaxies and the Ultraviolet Near Infrared Optical Northern Survey (UNIONS) for the background "source" galaxies. Using galaxy-galaxy lensing measurements to obtain excess surface mass density profiles, we find significant evidence of a dependence of halo mass on galaxy size, at fixed stellar mass, redshift, and colour. We will present these findings and discuss galaxy formation models that can explain them.

Probing ultra-fast outflows in BAL quasars using multi-epoch spectroscopy

Aromal Pathayappura (Western University)

Galaxies - Talk

We present the results of a South African Large Telescope (SALT) observation campaign aimed at monitoring the time variability of C IV broad absorption lines (BAL) in a sample of 64 quasars showing ultra-fast outflows (UFO) with v(outflow,max) > 15000 km/s in their spectra. We also created a control sample of non-BAL quasars from SDSS DR12, matched in redshift and luminosity, which show similar quasar and photometric properties but differ in the distribution of blueshift of C IV broad emission line, where UFOs show more blueshift than non-BALs. We find that the strength of variability increases with time, and for each source, SALT observations enable us to look at the variability at different time scales in detail (from as short as < 0.5 years to longer time scales of > 7.5 years). We also show that the fraction of highly variable BALs increases with time, and their BAL strengthening time scale is found to be considerably shorter than the weakening time scales. We found no correlation between BAL variability and quasar properties such as black-hole mass, Eddington ratio, but found a moderate correlation with bolometric luminosity for time scales < 2 yr. Our analysis shows that both the low equivalent width and high-velocity nature of BALs are equally important for excess BAL variability. We also constrain the ionization parameter of the outflow using detailed photo-ionization modelling of two well-monitored sources and demonstrate the possible discrepancies between simple accretion disk-wind models and observations. Finally, using photometric light curves, we conclude that the continuum flux variations may be responsible for the observed BAL variability in most of the sources where the BAL equivalent width decreases as the continuum flux increases.

Filamentary Hierarchies and Superbubbles: Multiscale Galaxy MHD Simulations of GMC and star cluster formation.

Ralph Pudritz (McMaster University)

Galaxies - Talk

The remarkable JWST observations of spiral galaxies such as NGC 628 reveal hierarchical networks of filamentary gas structures over many decades of physical scale. Of equal importance are the thousands of bubble and superbubbles created in the galactic disk by concentrated supernova explosions from massive young star clusters extending up to thousands of parsecs (kpc) scales. I will present our own novel galactic multi-scale, zoom-in simulations using the RAMSES code, that allow us to track the formation of structure from galactic to sub pc scales in a magnetized, Milky Way - like galaxy undergoing supernova driven feedback processes. Our simulations produce massive, kpc long filaments of atomic and molecular gas and dust at the largest scale in a hierarchy that extends down to star forming, giant molecular clouds (100pc) within them, star clusters within the filamentary GMCs (several pc), and down to 0.3 pc scales. Our results suggest that gravitational instabilities in filaments that accrete enough gas to surpass their local critical line mass drive fragmentation and structure formation; from GMCs to stars.

Galactic-scale magnetic fields and gravitational wave detections with LISA

Nathan Steinle (University of Manitoba)

Galaxies - Talk

Electromagnetic observations have revealed large-scale, but relatively weak (i.e., ~ 10^-5 Gauss), magnetic fields in many galaxies. These fields can have complicated geometries and exhibit peculiar behavior such as radially dependent reversals of the field direction. Meanwhile, the nascent field of gravitational-wave astronomy offers a new probe into uncertain astrophysical systems. The future space-based detector LISA will be sensitive to the mergers of massive (i.e., M ~> 10^6 Msol) black-hole binaries and is highly anticipated to provide constraints on the uncertain formation and evolution of these black holes and their galactic host environments. In this work, we connect spiral galaxy magnetic fields with LISA gravitational-wave observables. We assume that a binary black hole exists in the core of a circumbinary accretion disk whose magnetic field is computed with a mean-field dynamo model, and we assume the black holes later merge to compute the LISA response to gravitational-wave signal. This allows us to correlate the magnetic field properties of the progenitor binary system with gravitational-wave measurement uncertainties. Additionally, we explore how the EM signatures of the magnetic field, i.e., faraday rotation and polarization, relate to the later GW signal, motivating future multi-messenger studies with improved astrophysical modelling.

Caustics: the gravitational lensing simulator of the future

Connor Stone (Université de Montréal)

Galaxies - Talk

We present Caustics, a tool to accelerate the analysis of gravitational lensing systems for the next generation of astronomical data. Caustics will enable precision measurements of dark matter properties, the expansion rate of the Universe, the first stars, and more. In this Talk I will discuss the benefits and challenges of how we used PyTorch (a differentiable and GPU accelerated scientific python package) to allow for fast development without sacrificing numerical performance. I will demonstrate some of the powerful capabilities that come with a differentiable lensing model, such as Bayesian Hamiltonian Monte-Carlo sampling, exact caustic extraction, and integration with machine learning models. Using tutorials freely available on our website, I will demonstrate how any user can quickly become an expert in gravitational lensing by graduating through our three user interfaces. A configuration file interface allows fast startup without much lensing knowledge, an object oriented interface allows for flexibility to model arbitrarily detailed lensing systems, and a functional interface allows for fine control and developing beyond our initial vision of caustics.

Milky Way progenitors since z=5: Resolved mass assembly and star-formation rates with JWST

Vivian Yun Yan Tan (York University)

Galaxies - Talk

In the JWST era, we have an unprecedented richness of data available to probe the intricacies of galaxy evolution up to the first Gyr of the universe's history. With this depth, not only can we trace the mass assembly of the most massive galaxies, but even the assembly history of Milky Way sized galaxies in the local universe. At low redshifts, Milky Way Analogues (MWAs) assemble stellar mass at steady rates at all radii, showing no preference for bulge or disk growth. However, as redshift increases, galaxy morphologies get clumpier, and star-formation occurs in concentrated starbursts nestled within the clumps, as opposed to the more uniform picture at lower z. Using JWST photometric data from the CANUCS fields, we search for progenitors of MWAs up to z=5 via abundance matching. To get an accurate picture of how stars are forming, we create resolved stellar mass and star-formation rate (SFR) maps of MWA progenitors via resolved SED-fitting with Dense Basis. We measure not only how stellar mass and SFR evolve at all radii within these galaxies, but also how the morphologies of stellar mass and SFR evolves with redshift. We find evidence of inside-out growth from $2.5 < z < 5$ in the stellar mass profile. As redshift decreases, star-formation moves to larger radii, occurring more frequently in star-forming clumps. Merger fractions increase with redshift, reaching 20% at z~4.5, but with a jump in merger fraction from 7% at z~2 to 13% at z~1.5. This jump, along with bulge growth in the stellar mass profiles but without a similar jump in SFR, points to merger-driven quenching for MWAs at later epochs.

Hide and Seek: A Census of Black Holes in Virgo Ultra-Compact Dwarf Galaxies

Solveig Thompson (University of Calgary)

Galaxies - Talk

Ultra-compact dwarf galaxies (UCDs) bridge the gap between globular clusters and dwarf galaxies, often appearing as the most massive star clusters within a galaxy. However, their origins are in fact more complex. Most UCDs have a dynamical mass-to-light ratio that is higher than can be explained through stellar population models, suggesting they are more than just massive star clusters. Previous detections of central supermassive black holes in some of the most massive UCDs indicate that some of these objects were once larger nucleated dwarf galaxies that had their diffuse stellar envelopes tidally stripped away in a galaxy cluster environment. Due to various technological and observational constraints, only a handful of the biggest and the brightest UCDs have been searched for central black holes. To truly understand the evolutionary pathways compact stellar systems undergo in galaxy clusters, smaller and dimmer UCDs must be probed for central black holes. The presence, or lack thereof, of a central black hole will indicate the origins of those systems. In this Talk, I will discuss my current efforts using the James Webb Space Telescope (JWST) to catalogue their presence in UCDs. I will present early results for six UCDs observed by JWST in Cycle 1, including stellar kinematic maps that provide preliminary evidence for at least some to be harbouring central supermassive black holes. The occupation fraction of massive black holes in UCDs will provide important insights on the overall origins of UCDs, as well as the evolutionary pathways of dwarf galaxies.

A 100 Mpc structure traced by hyperluminous galaxies around a massive z = 2.85 protocluster

George Wang (UBC)

Galaxies - Talk

Massive galaxy clusters containing stars formed at even earlier epochs were found as early as 3 billion years after the Big Bang. The high-redshift progenitors of these galaxy clusters, protoclusters, are identified within cosmological simulations as the highest dark matter overdensities. While their observational signatures are less well-defined than the hot ICM of virialized clusters, protoclusters contain extremely massive galaxies that can be observed as luminous starbursts. A highly significant galaxy overdensity traced by LAEs in the HS1549+19 field projects to a filamentary structure in the early Universe at a redshift of $z = 2.85$ (when the Universe was 2.3 Gyr old), mapping out a protocluster in formation. Here, we found that the vast majority of the brightest SMGs in the HS1549 field, lying within the 50 Mpc by 30 Mpc region of highest LAE overdensity, demarcate a 4100 cubic Mpc "pancake"-shaped structure. These SMGs can be interpreted as massive elliptical galaxies growing rapidly at large cluster-centric distances before collapsing into a virialized structure. HS1549 is a unique protocluster with many hyper-luminous infrared galaxies (HyLIRGs) building one of the most massive structures in the present-day Universe.

Probing the Faintest Galaxies Below the Confusion Limit

Yunting Wang (University of British Columbia)

Galaxies - Talk

The far-infrared to submillimetre sky is composed of emission from dust-enshrouded star-forming galaxies. The number counts of these galaxies imposes critical constraints on models of galaxy evolution in cosmological simulations. To obtain the strongest constraints possible, the faintest galaxies below the confusion flux limit can be statistically leveraged using the "probability of deflection" (or P(D)) method. However, the large-scale clustering of galaxies complicates the analysis, and has been shown to impact the results of galaxy number counts near the confusion limit. Here I outline a method to measure and correct for galaxy clustering, simultaneous with a P(D) analysis, which provides unbiased estimates of the distribution of the faintest galaxies below the confusion limit. I illustrate this with data from Herschel-SPIRE in the GOODS-N field. In principle, this method could be applied to any other observations where galaxies are mostly unresolved and where the beam and noise are well characterized, such as with SCUBA-2, CCAT and other upcoming submillimetre facilities.

The measurement and interpretation of intragroup and intracluster light: combining simulations and observations

Syeda Lammim Ahad (Waterloo Centre for Astrophysics)

Galaxies - Poster

The diffuse light in groups and clusters, also known as the intragroup/intracluster light (IGL/ICL) is an excellent probe to understand the growth of the brightest cluster galaxies (BCG) and their host systems. Studying the IGL is particularly interesting for the complementary halo mass range that groups cover between galaxy-mass haloes and massive clusters. However, this potential has not been fully exploited so far due to a number of challenges. One major challenge is the unambiguous detection of the group center of potential based on photometry. Another is the physical interpretation of the stacked ICL profile due to any possible dependency of the ICL distribution on the host systems. We explore these challenges using mock observations of 511 galaxy groups and clusters from the Hydrangea cosmological hydrodynamic simulation suite. I will present our findings from this work. From the observational side, the primary challenge is the low surface brightness of such diffuse light, which can be achieved by stacking data for large ensembles of systems. I will also present how we used our predictions from the simulation-based work to analyze the ICL from deep r-band imaging data of ~1000 GAMA groups from the KiloDegree Survey (KiDS). This work shows a consistent comparison of IGL and ICL over a large halo mass range (from 10^12.5 - 10^14.5 M_sun) from both simulations and observations, therefore indicating the expected performance of statistical analysis of diffuse light in large samples of groups and clusters from next-generation observational programs like Euclid and LSST.

Excitation or efficiency: a multi-line analysis of dense gas tracers across the Antennae

Ashley Bemis (Waterloo Centre for Astrophysics, University of Waterloo)

Galaxies - Poster

As extreme systems, galaxy mergers are important testbeds for constraining star formation models and the baryon cycle. The Antennae, the nearest gas-rich major merger, is of particular importance as it is well studied with interesting variations in the star formation efficiency of dense gas (SFEdense) at sub-kpc scales. LHCN/LCO appears to be enhanced in the nuclei relative to the overlap, indicating a higher dense gas fraction (fdense), while multiple SFR indicators are suppressed relative to LHCN in the nuclei indicating a lower SFEdense. Additionally, LHCN is enhanced relative to LHCO+ in NGC 4038, but not elsewhere in the Antennae. This indicates that the conversion of molecular line luminosities to dense gas masses may be different than typically assumed. We present the first multi-J radiative transfer modeling of dense gas tracers at sub-kpc scales across the Antennae to constrain the physical conditions of the gas exciting HCN and HCO+ using data from ALMA and the SMA. This includes the J=1-0, 3-2, and 4-3 lines of HCN and HCO+ in NGC4038 and SGMCs in the overlap region. We combine this with data of the CN and HNC J=1-0 transitions to explore potential chemical variations in dense gas tracers at these scales. Finally, these results are compared against the predictions of turbulent star formation models to assess if we are observing true variations in SFEdense and fdense, or if the emissivity of HCN is enhanced in the nuclei due to physical conditions of the gas.

Do zeros count? Understanding the galaxy — globular cluster connection for the smallest galaxies.

Samantha Berek (University of Toronto)

Galaxies - Poster

A remarkably tight scaling relation exists between galaxy masses and the number or combined mass of their globular cluster (GC) populations over many dex, alluding to a fundamental connection between the formation and evolution of galaxies and that of their most massive star clusters. This relation is least constrained for dwarf galaxies, and many of the lowest-mass galaxies lack GCs altogether. It is not well understood whether this is due to a fundamental difference in the formation and evolution of low-mass galaxies, or if they are simply the natural low-mass end of the normal scaling relation, too small to form very massive star clusters. In this Talk, I will investigate this open question through the use of hurdle and zero-inflated count models to describe the GC populations of low-mass galaxies. Using these models, I find that there is significant intrinsic scatter, beyond just measurement uncertainties, present in galaxy-GC scaling relations, and that GC populations of nearby dwarf galaxies follow a more complex negative binomial distribution rather than a simple Poisson distribution. Using Bayesian predictive model comparison techniques, I also show for the first time that no additional model parameters are necessary to describe the population of low-mass galaxies that lack GCs. Taken together, these results suggest that a single formation and evolutionary process acts over all galaxy masses and that there does not appear to be anything unique about the lack of GCs in many low-mass galaxies. These results provide important constraints for simulations of GC formation and evolution in low-mass galaxies and inform conclusions from the preliminary higher redshift GC data from telescopes like JWST, helping guide us toward a better understanding of GC formation and evolution across cosmic time.

SMA CO (J=3-2) and dust continuum observations of a CSS radio galaxy 3C303.1 at 230 GHz and 272 GHz

Rushikesh Bhutkar (University of Manitoba)

Galaxies - Poster

We observed the spectral emission line J=3→2 transition of carbon monoxide (^{12}CO) towards a compact-steep spectrum (CSS) radio galaxy, 3C303.1, using the Submillimeter-Array (SMA) at 345 GHz (redshifted to 272.2 GHz). CSS sources typically have total projected linear sizes between 1 kpc and 20 kpc, suggesting they are small, young objects advancing through the dense environments of their host galaxies as they journey towards evolving into larger radio galaxies and quasars. This early evolutionary phase likely represents a critical stage where the evolution of the radio galaxy has a maximum impact on the host galaxy as they interact vigorously with the ISM by driving shocks and multi-phase outflows. CO is among the most abundant elements in cold molecular gas, making it an excellent tracer of the raw material for star formation. Additionally, we have dust continuum SMA observations at both 230 and 272 GHz, and the data is currently being reduced. The CO observations will be used to place upper limits on the total molecular gas mass. Furthermore, the dust continuum observations, combined with other measurements of the infrared (IR) spectral energy distribution (SED), will allow us to measure the IR luminosity and dust mass. This will enable an independent estimate of the molecular gas mass.

While warm gas is relatively easy to study, cooler gas often dominates the mass and kinetic power in outflowing gas. SMA CO (J=3-2) observations are essential for detecting this cooler component and estimating the total kinetic power in the outflowing gas. We will then determine the efficiency factor relating radio-jet power to outflow kinetic power, which is a critical input for scaling active galactic nuclei (AGN) feedback models. These measurements are crucial for modeling radio jet-gas interactions in 3C303.1. Our results will provide valuable insights into how radio sources interact with cold gas in galaxies, leading to a more accurate and nuanced revised paradigm of AGN feedback.

A SHARK's view of the galaxy-AGN-environment connection throughout cosmic time

Matias Bravo (McMaster University)

Galaxies - Poster

Both environment and AGN play important roles in shaping the evolution of galaxies, though the relative importance of these mechanisms remains an area of active research. The combination of large surveys from upcoming observational facilities, both space-based (e.g., Athena, CASTOR, Roman) and ground-based (e.g., 4MOST, PFS, Rubin), promises to greatly expand the current range of redshifts, environments, and AGN/galaxy properties. These surveys will enable a deeper understanding of the galaxy-AGN-environment interplay. Theoretical predictions for the evolution of the galaxy-AGN-environment scaling relations will allow us to maximise the return from these surveys best. In this Talk, I will present the predictions for the evolution of these scaling relations from cosmic dawn to z=0 using the recently released v2.0 of the SHARK semi-analytic model. I will compare these predictions against current observations, where we find overall good agreement across a range of stellar masses and lookback times, including recent results from JWST that suggest that black holes at cosmic dawn/noon are overly massive relative to local scaling relations. I will conclude with what we expect the upcoming large surveys to unveil, with a particular focus on the impact of environment on galaxy-AGN scaling relations.

The Relationship Between Galaxy Structure, Stellar Mass, and Local Density at Redshift 1.6

Westley Brown (York University)

Galaxies - Poster

The relationship between galaxy morphology and environment has been well-studied in the local universe and at low redshift, showing that galaxies in dense clusters tend to be elliptical and bulge-like while galaxies in low-density fields tend to be spiral and disk-like. However, this relationship is less understood at higher redshifts, and the few studies at high-z rely on samples with incomplete redshift measurements and poorly-constrained stellar masses. We explore the relationship between galaxy structure, stellar mass, and local density at z~1.6, the tail end of cosmic noon, with a sample of 3 SpARCS clusters and 2 fields from 3D-HST/COSMOS. We use Sérsic profiles to quantify galaxy structure in F160W, while extensive photometry and spectroscopic data provide us with strong estimates of both stellar mass and redshift. We present our results as one of the first studies to explore the relationship between structure and local density at this epoch, as well as one of the few studies to directly calculate the density of field galaxies. We show how the median Sérsic index of galaxies increases with local density regardless of global environment, suggesting a unified structure-density relation across both clusters and fields. We also present findings showing a significant difference in the relationship between galaxy structure and stellar mass between cluster and field environments. Our results show that not only is the morphology-density relation is already in-place at z~1.6, but that it may be driven by mass-dependent environmental processes such as overconsumption or pre-processing.

The Star Forming Main Sequence of Low Surface Brightness Galaxies

Hannah Christie (University of Western Ontario)

Galaxies - Poster

The tight relationship between the stellar mass of a galaxy and the star formation rate, otherwise known as the star forming main sequence, has been proven to be a pivotal component in understanding galaxy evolution. Deviation from the main sequence is used as a key classifier for the star formation phase of a galaxy, which provides insight into the processes controlling the evolution of such systems. Low surface brightness galaxies (LSBs) are one of these groups that are proposed to deviate from the general galaxy population. These low luminosity systems are estimated to make up between 30-60 percent of the Local Volume by mass, yet there is much to be discovered about their formation and evolution process. By cross matching identified LSBs from catalogues with the GALEX-SDSS-WISE Legacy Catalog (GSWLC), we investigate the relationship between stellar mass and star formation rate in the low surface brightness regime. We compare our results with the star forming main sequence for the almost 700 000 galaxies in the GSWLC. We find that our sample of regular LSBs follows a similar trend to the blue, star-forming galaxies of the GSWLC. The dwarf and giant LSBs, however, are found to deviate from the larger populations and fall below the larger trend. We will explore potential explanations for these interesting results.

Determining Globular Cluster System Distributions with Voronoi Tessellations

Veronika Dornan (McMaster University)

Galaxies - Poster

Determining radial distributions of a variety of systems in astronomy is a common problem. Massive galaxies can host tens of thousands of globular clusters (GCs) and determining their radial density distribution can be difficult at times. Previous methods of determining GC distributions divided a galaxy into many spatial bins and plotted density as a function of radius. This method can fall short for galaxies with GC systems with asymmetrical distributions, those within clustered environments surrounded by other GC systems, or for galaxies with extremely massive and extended GC systems. Instead, this Talk details a new method of determining GC system radial density profiles (or density profiles for many other systems) which utilizes Voronoi tessellations. These tessellations allow for bins to be created independent of the spatial geometry for groups as small as 1 object (though we have adopted 5 objects per group), providing far more information about a system's GC distribution. We find that this new method provides more accurate fits to the underlying radial density distribution of a system, and returns more accurate estimates of the system's total population. In this Talk, we will also provide results from this method being applied to a sample of 27 extremely massive galaxies, and discuss how this method can be used to accurately determine the GC system distribution for a massive galaxy simultaneously with the distribution for its satellite.

New constraints on the halo mass of ultra-diffuse galaxies with UNIONS using weak gravitational lensing

Jordan Ducatel (University of Waterloo)

Galaxies - Poster

While a lot of progress has been made in detecting and measuring various properties of
Ultra - Diffuse Galaxies (UDGs) over the last decade, the dark matter halo mass of these extremely faint and large objects remains a mystery. A better constraint on the

total halo mass of UDGs would allow to disentangle between the wide variety of proposed formation mechanisms. We detect a sample of 675 UDGs in the ongoing Ultraviolet Near Infrared Optical Northern Sky Survey (UNIONS) using the Canada-France Imaging Survey (CFIS) r-band imaging, limiting our search to within clusters up to redshift $z \leq 0.1$. From weak gravitational lensing measurement around our UDG sample, we found an excess surface density consistent with zero (no detection) and a 2σ upper limit on the average halo mass of $\log(m200/M_\odot) \leq 11.9$. By combining our measurement with that of C. Sifon et al. (2018), the only other weak gravitational lensing measurement of UDGs, we are able to constrain the halo mass further with a 2σ upper limit of $\log(m200/M_\odot) \leq 11.6$. Our result shows that, on average, UDGs do not live in massive dark matter halos which further constrains their formation mechanism models.

Drivers for Star Formation in Interacting Galaxies

Lawrence Faria (Queen's University)

Galaxies - Poster

Mergers and interactions play pivotal roles in the evolutionary trajectory of galaxies, significantly influencing various dynamical and baryonic properties throughout their histories. Understanding the impact of these major and minor interactions on galaxy evolution is crucial for constraining galaxy formation and evolution processes. Observational studies have shown that interacting galaxies exhibit elevated star formation rates compared to their more isolated counterparts. Idealised high-resolution merger simulations indicate that this enhancement may result from a combination of enhanced fuelling or enhanced efficiency of star formation. In this Talk, I will explore how cosmological hydrodynamical simulations provide a unique opportunity for us to study these processes as a function of time within a cosmological context.

Using reconstructed orbits of galaxy pairs in the IllustrisTNG simulation, we assemble a dataset of distinct pericentric encounters over which we track changes in galaxy properties relative to the pericentre. We find that star formation rates, gas fraction, and star formation efficiency are significantly centrally enhanced approximately 0.1 Gyrs after a pericentric encounter. We identify the enhanced star formation efficiency of hydrogen gas as the primary driver for the increased star formation following a pericentric encounter. This investigation helps to better link observational pair studies of interacting galaxies with the findings of high-resolution merger simulations.

Measuring the Effect of Ram Pressure on Star Formation in Infalling Galaxies

Lauren Foster (McMaster University)

Galaxies - Poster

Galaxies living in dense group and cluster environments experience a number of physical mechanisms that drive their evolution. In particular, galaxies infalling into groups and clusters can experience ram pressure stripping, an environmental quenching mechanism that removes gas from galaxies. In extreme cases, stripping can lead to jellyfish galaxies with extended gas tails. Several studies have suggested that ram pressure can compress the gas on a galaxy's leading edge, leading to a brief period of enhanced star formation. We quantify the strength of this enhancement in a large statistical sample of infalling group and cluster galaxies using CFIS u-band imaging as a star formation tracer. We use a number of metrics to compare the leading and trailing sides for each of the galaxies in our sample. We then compare these results to environmental properties of the galaxy, such as their time since infall and halo mass, to constrain the environmental dependence of ram pressure as a star formation enhancer. We find that any statistical star formation enhancement is small for infalling galaxies, suggesting that this effect is either uncommon or short-lived.

Joint ALMA+JWST analysis of the circumgalactic medium of MACS1931-26

Laya Ghodsi (The University of British Columbia)

Galaxies - Poster

The evolution of galaxies is affected by the diffuse gas around them known as the circumgalactic medium (CGM) through gas inflows and outflows. In this work, we report an investigation of the CGM and interstellar medium (ISM) of the brightest central galaxy (BCG) of a galaxy cluster, MACS1931-26 at z~0.35 with one of the largest known H2 reservoirs, elevated star formation, and strong radio AGN. We have detected cold H2 towards MACS1931-26 using the [CI](2-1), CO(1-0) and CO(7-6) lines with the APEX 12-m and NRO 45-m telescopes. We complement these observations with archival ALMA CO data and model the gas and dust physical properties using a modified large velocity gradient (LVG) model. Our study shows that the gas in the BCG is highly excited, comparable to the local ULIRGs. However, the CGM gas is less excited, colder, less dense, and less virialized. The H2 mass of the whole system derived using [CI](2-1) is larger than H2 mass derived using CO(1-0), showing that a part of the gas in this system is CO-poor. Our recent observations of this object using JWST reveal warm H2 concomitant with the cold H2 detected by ALMA. A joint analysis of the cold and warm H2 with these two data sets would reveal any potential gas flow from the CGM to the BCG of this system which might fuel the enhanced star formation of this galaxy and correlate with the strong radio AGN in this system.

Mapping Nebular Gas Dynamics in Active Central Cluster Galaxies

Marie-Joëlle Gingras (Waterloo Centre for Astrophysics)

Galaxies - Poster

The use of high resolution Integral Field Unit (IFU) data to map the fluxes and velocities of both emission lines and stellar absorption lines allows for a detailed tracing of gas cooling in galaxy centres. Using Keck IFU observations, we study the morphology and kinematics of nebular gas using [OII]3726,9 emission. This extends up to tens of kiloparsecs in the central cluster galaxies of Abell 1835, PKS 0745-191, Abell 262, and RXJ0820.9+0752.

Our findings highlight the complex gas dynamics which can be induced by radio-mechanical feedback. The nebular gas in RXJ0820.9+0752 is offset with respect to the galaxy both spatially and in redshift by 10-20 kpc and ~150 km/s. In Abell 262, gas lies in a high angular momentum kpc-scale disk. In PKS 0745-191 and Abell 1835, nebular gas is churned to higher velocity dispersions by the buoyantly rising bubbles and jets. Churning gas flows, likely outflows behind the rising radio bubbles, are likely driven by buoyancy and ram pressure due to the galaxies' motion with respect to the gas. The churned gas is also surrounded by larger scale, lower velocity dispersion nebular emission. These motions will affect thermally unstable cooling, the dispersal of jet energy, and the angular momentum of gas accreting onto the galaxy and its nuclear black hole.

Molecular Gas under Pressure - Molecular Gas Susceptibility to Ram Pressure Stripping in the Virgo Cluster

Celine Greis (McMaster University)

Galaxies - Poster

Ram pressure stripping (RPS) is a key driver of galaxy evolution especially in dense cosmic environments (such as galaxy clusters). While it is well-established that RPS has a substantial impact on the atomic gas reservoir in galaxies, its effect on the cold molecular gas component, the direct fuel of star formation, is still not fully understood. High-resolution ALMA CO 2-1 data collected by the PHANGS and VERTICO surveys provides new opportunities to examine molecular gas RPS in the Virgo Cluster. Leveraging these datasets, we model the detailed effect of RPS in 36 Virgo galaxies by calculating the ratio of ram pressure to the galaxy gravitational restoring pressure. Our analysis shows that molecular gas located towards the galaxy outskirts and between spiral arms is more susceptible to RPS. A quarter of our galaxy sample has a substantial fraction of molecular gas susceptible to RPS, especially towards to outer disk where the susceptible fraction reaches 80%. We also find higher fraction of RPS susceptible molecular gas in galaxies exhibiting clear atomic gas tails, suggesting that RPS impacts multiple gas phases at once. Finally, among galaxies with different (projected) locations and velocities in the Virgo Cluster, we find that those undergoing the first pericenter passage are typically the ones affected the most by molecular gas RPS.

Clues to environmental quenching mechanisms from the evolution of stellar mass functions in 0.9 < z < 1.5 clusters

Guillaume Hewitt (University of Waterloo)

Galaxies - Poster

Modelling the evolution of galaxy stellar mass functions in high-density galaxy clusters can allow us to determine the importance of the underlying mechanisms that drive environmental quenching. Using a sample of 17 high-density clusters from the GOGREEN and GCLASS surveys (0.86 < z < 1.46), we measure the stellar mass function as a function of cluster-centric radius, redshift, and velocity dispersion, for both the star-forming and quiescent populations. The model is formulated in a Bayesian manner, allowing for fitting on the entire un-binned dataset and the uncertainties of the evolution parameters. We find the quenched fraction increases modestly with redshift over this range, and that this is driven in part by an increasingly steep low-mass slope to the quiescent stellar mass function. On the other hand, the quenched fraction decreases strongly with cluster-centric radius, though the shape of the quiescent galaxy stellar mass function is independent of radius. This lends further support to the emerging interpretation that there are two modes creating the overall quenched population in dense environments. Galaxies in cluster cores were quenched early, through accelerated mechanisms that are otherwise similar to what quenches isolated, massive galaxies. More recent additions to the cluster, found primarily at larger radii, have suffered late-time quenching that results in a change in the stellar mass function shape.

Searching for Dual AGNs

Patrick Horlaville (Bishop's University)

Galaxies - Poster

Merging galaxies hosting supermassive black holes (SMBHs) are expected to form a merged galaxy within which lies an unbound supermassive black hole pair known as a dual AGN (active galactic nucleus). Dual AGNs are thought to be the precursors to gravitationally bound SMBHs, known as supermassive black hole binaries (SMBHBs), which are themselves thought to be the precursors to SMBH mergers. However, very few dual AGNs have been found to date, limiting our understanding of this chain of events. For my Master's project, I am using novel insights drawn from cosmological simulations to search for dual AGNs using archival galaxy surveys (such as ATLAS3D or MASSIVE). These new theoretical results suggest that the morphology and stellar kinematic parameters of a galaxy can be used to determine its likelihood to host a SMBH merger. By using the reported morphological and kinematic parameters of these surveys' galaxies, I compute the probability that each of them harbours a SMBH merger. My project aims to come up with a list of candidate galaxies most likely to host dual AGNs and to follow them up in infrared and/or X-ray to verify their presence. I will present my current progress on this task, and notably how I use the surface brightness profile of galaxies to select, among the galaxies most likely to host a SMBH merger, those that are most likely to host a dual AGN.

JWST NIRCam Observations of the Globular Cluster Population in RXJ 2129.7+0005

Kaitlyn Keatley (McMaster University)

Galaxies - Poster

In the local universe, the colour and metallicity distributions of globular clusters have been intensively studied. With the James Webb Space Telescope (JWST), we are able to expand these observations to a much greater redshift and further investigate the nature of these ancient systems. Globular clusters can also be used to probe the dark matter halo of massive galaxy clusters. Globular clusters trace the gravitational field, which is dominated by dark matter. This research focuses on the galaxy cluster RXJ

2129.7+0005 at redshift 0.234, corresponding to a lookback time of 2.90 billion years. Utilizing images in three bands from the short wavelength channel of NIRCam (F115W, F150W, and F200W), I have conducted photometry using daophot within the Image Reduction and Analysis Facility (IRAF) software. In this Talk, I will present colour-magnitude diagrams of the globular cluster population in RXJ 2129.7+0005, and completeness curves of our sample. Additionally, I will present the spatial distribution of globular clusters, and compare to the lensing map of the gravitational potential within the cluster.

Photometry of the Globular Cluster Populations in Abell 2744 in NIRCam LWC Bands

Jinoo Kim (McMaster University)

Galaxies - Poster

The UNCOVER project, leveraging JWST's deep imaging capabilities, examines the globular cluster (GC) populations in the Abell 2744 galaxy cluster, advancing the foundational research by Harris & Reina-Campos. This follow-up study presents photometry for several thousand GCs in the previously unanalyzed NIRCam LWC bands (F277W, F356W, and F444W), adding to the previous data in the SWC filters. By implementing multiband photometry to generate Spectral Energy Distributions (SEDs) and applying model spectra, this research aims to extract the ages and metallicities of GCs, facilitating a detailed comparison with their Local Universe analogs. This work will allow a new look into the physical state of the GCs at a time of 3.5 Gyr in the past.

Signatures of quenching mechanisms in spatially-resolved star formation: predictions for Roman and CASTOR

Cam Lawlor-Forsyth (University of Waterloo)

Galaxies - Poster

Upcoming missions like Roman and CASTOR will provide an unprecedented opportunity to map the star formation distributions on spatially-resolved scales for tens of millions of galaxies out to z=2. This will allow transformational studies of how quenching depends on redshift and environment. To prepare for these datasets, we have created mock photometric observations based on the high resolution TNG50 simulation. By considering the simulated galaxies, we find that we can distinguish different quenching mechanisms based on metrics which describe the star formation distribution (e.g., the size of the star forming disk relative to the stellar mass): outside-in, inside-out, and uniform fading. We find that quenching mechanism correlates with environment, where the outside-in quenched galaxies reside mostly in dense cluster environments, and higher mass cluster galaxies are more likely to be pre-processed or experience a significant delay before the onset of quenching, compared to their lower mass counterparts. Inside-out quenched galaxies are found most often in the field, with a majority remaining as the most massive object within their dark matter halo. With our mock photometry, we demonstrate that CASTOR and Roman will have the precision to distinguish different quenching mechanisms using the metrics we have derived. While awaiting CASTOR and Roman data, we will apply our technique to existing HST/JWST data, such as the Hubble Frontier Fields.

The Properties of Optical-UV-Selected Rejuvenating Galaxies

Dylan Lazarus (McMaster University)

Galaxies - Poster

Galaxies are typically bimodal in their star formation rates, either actively forming stars or in a quenched state. However, small populations of galaxies exist in a transitional stage, either actively quenching—halting star formation—or rejuvenating—resuming star formation after a period of quiescence. Rejuvenating galaxies are significantly more rare and less well-studied than quenching galaxies but offer valuable insights into galaxy evolution processes. We identify rejuvenating and quenching galaxies with a combination of H-alpha and dust-corrected UV measurements. UV and H-alpha emission trace star formation on roughly 100- and 10-million-year timescales, respectively; as a result, we identify galaxies undergoing rejuvenation as UV-faint and H-alpha-bright, and quenching galaxies as UV-bright and H-alpha-faint. We explore the properties of rejuvenating and quenching galaxies, including concentration and asymmetry, gas content, and close pairs, and measure their environmental dependence. Our preliminary findings suggest that galaxy rejuvenation preferentially occurs in high-density environments.

Decoding quenching in the Virgo cluster and infalling groups with spatially resolved star formation

Cameron Morgan (University of Waterloo)

Galaxies - Poster

The Virgo cluster presents a unique opportunity to disentangle the roles of environmental quenching mechanisms such as ram-pressure stripping and starvation given its proximity and ongoing formation. By combining spatially resolved Hα and optical imaging from the Virgo Environmental Survey Tracing Ionised Gas Emission (VESTIGE) and the Next Generation Virgo Survey (NGVS) with deconvolved UV imaging from the GALEX Ultraviolet Virgo Cluster Survey (GUViCS), we are able to study the morphology of star forming regions in galaxies across the entire Virgo cluster region in unprecedented detail. Our results show how a combination of non-parametric morphology indicators with physically motivated techniques for measuring disk sizes and burstiness in star forming regions helps to observationally constrain ram-pressure stripping and starvation. Using toy models of these quenching mechanisms to reproduce observed trends, we find that a 'delay-then-rapid' or 'slow-then-rapid' quenching model best explains the evolutionary sequence of galaxies in the main Virgo cluster, where starvation is important early on and ram-pressure stripping 'finishes the job.' In addition, we find that pre-processing in smaller group structure prior to infall is a vitally important aspect that must be included to understand quenching in clusters. By comprehensively decoding the evolutionary sequences of galaxies in dense environments in the local universe, we are providing key insights for studies of galaxy evolution at high redshift with upcoming instruments such as the Roman space telescope and CASTOR.

Molecular Gas in Simulations of Nearby Spiral Galaxies

Padraic Odesse (McMaster University)

Galaxies - Poster

Current galaxy simulations are now capable of resolving gas densities high enough to access the molecular phase of the interstellar medium. These improvements demand a proper model for molecular hydrogen in order to investigate the physics that occur within the molecular gas of galaxies. The fraction of molecular gas that forms in a galaxy is strongly dependent on that gas' exposure to far-ultraviolet radiation. Recent improvements to radiative transfer methods have enabled simulations to efficiently compute the radiation field produced by stars within a galaxy, which provides the necessary far-ultraviolet radiation to regulate the formation of molecular gas within galaxies. With this in mind, we have developed a self-consistent chemical network to model the formation and destruction of molecular hydrogen and related primordial gas species (H, He, and their ions), which is designed to couple to a realistic ultraviolet radiation field provided by our radiative transfer model. This combined model for molecular hydrogen and radiation in a

galaxy enables simulations to produce observable quantities that can be used to evaluate the quality of our simulated galaxies. We evaluate the extent to which using this new chemical network improves the ability of our simulations to produce realistic galaxies by comparing the surface density profiles of atomic and molecular gas in nearby spiral galaxies against the profiles produced in galaxy simulation analogues.

Satellite quenching and morphological transformation of galaxies in groups and clusters

Megan Oxland (McMaster University)

Galaxies - Poster

Understanding the timescales associated with star formation quenching and morphological transformation provides key insights into the mechanisms driving galaxy evolution in dense environments. It is well known that satellite galaxies experience both a decrease in their star formation rate and a morphological transformation from disk to bulge-dominated as they fall into clusters. However, there is currently no clear consensus as to the physical mechanisms driving these changes, or the timescales associated with such processes. For a large sample of galaxies in the Sloan Digital Sky Survey we estimate time since infall using galaxy position in projected phase space. We then explore how galaxy specific star formation rate and morphology, parametrized by the bulge-to-total light ratio, change over time. After controlling for stellar mass, we find clear trends of increasing quenched and elliptical fractions as functions of infall time for galaxies falling into both groups and clusters. We find evidence that star formation quenching occurs faster than morphological transformation in both environments. We also make similar measurements for galaxies using the semi-analytical model SHARK. Preliminary results suggest the quenching prescription in SHARK is too aggressive and is not able to reproduce all the environmental trends we find observationally.

Improvements to Galaxy Asymmetry in HI

Mathieu Perron-Cormier (Queen's University)

Galaxies - Poster

Upcoming radio surveys are expected to image large numbers of galaxies in HI. Analysis of these datasets will depend on easily computable measures such as

asymmetry to characterize ensembles of data and identify objects of interest. The new 3D squared difference asymmetry combines spectral and spatial features into a single measure and features a robust background correction down to low signal to noise levels. We perform measurements on WALLABY-like mock observations made from the SIMBA simulation and discuss avenues by which future galaxy asymmetry comparisons between simulations and observations could be improved.

CLIFS: The Coma Legacy IFU Survey

Ian Roberts (Waterloo Centre for Astrophysics)

Galaxies - Poster

I will introduce and present early results from, CLIFS: The Coma IFU Legacy Survey, a new unbiased optical IFU survey of the nearby Coma Cluster. CLIFS is primarily made up of new observations from the recently commissioned Large IFU mode on the WEAVE spectrograph, and is supplemented by existing IFU data from the MaNGA survey, in order to map spatially-resolved optical spectroscopy across all star-forming and green-valley galaxies in Coma (with stellar masses above 10^10 Msun). Combined with molecular gas measurements from IRAM and the ALMA-ACA, CLIFS will provide the best-ever constraints on the physical drivers of star formation quenching in the nearest massive galaxy cluster. In this Talk I will present data products and early scientific results from CLIFS, with a particular focus on the impact of ram-pressure stripping on satellite galaxies in Coma. I will finish by forecasting future plans to push the stellar-mass limit of CLIFS down to the dwarf galaxy regime around 10^9 Msun.

High- and Low-Density Mass Functions at z~0.5 Defy Simple Models

Ghassan Sarrouh (York University)

Galaxies - Poster

Using ultra-deep Hubble Frontier Field imaging in the prime and parallel fields, we have measured the stellar mass function (SMF) of star-forming and quiescent galaxies in both low and ultra-high density environments down to a depth of 10^8 solar masses at z~0.5. These are the deepest SMFs yet measured at intermediate redshift.

The SMFs reveal two surprising results. Firstly, the low-mass slope of the quiescent

mass function is steeper for field galaxies than cluster galaxies. Taken at face value, this suggests that low-mass quiescent galaxies are formed more easily in lower-density environments, which defies expectations of galaxy evolution models that project simple empirical relations observed in the local universe to higher redshifts, such as Peng+2010.
Secondly, we find that the overall mass function is different in cluster and field environments, with clusters appearing to have an additional population of massive galaxies not found in the field. Similarly, this observation is not predicted by simple empirical quenching models.

Our results can be explained by invoking: 1) a mass-dependent environmental quenching mechanism; or 2) a non-universal halo mass function. However, both of these requirements violate key assumptions made in empirical quenching models, and assuming either scenario will likely have further consequences for predictions from those models.

Robust measuremenets of galaxy structure across surveys and cosmic time

Elizaveta Sazonova (University of Waterloo)

Galaxies - Poster

As galaxies evolve throughout the cosmic time, both their star formation properties and their structure change. Today, galaxies show a bimodality where star-forming galaxies are primarily disks, while quiescent galaxies have a strong spheroidal component. However, what physical processes give rise to this bimodality, or when in the Universe it is established and how is still unclear. To understand the relationship between the evolution of galaxy star formation and structure, it is crucial to study both as a function of time.

Traditionally, galaxy structure is quantified numerically using a set of parameters: Sersic index, CAS, Gini/M20, and more. In theory, we can trace the evolution of these parameters in different galaxy populations throughout cosmic time. However, comparison of galaxy structure is challenging as the effective resolution and depth change across different surveys, wavelengths, and cosmic epochs. We present a detailed analysis of the common measures of galaxy structure, and their behavior to changes in the image resolution and depth. We show that many parameters exhibit strong dependence on both these properties, and care must be taken when comparing results between different surveys or redshifts. We develop a new, physically-motivated approach to measuring asymmetry and shape asymmetry of galaxies, which are robust to noise down to SNR per pixel of 1, and provide consistent asymmetry measurements between SDSS and HST-like observations. With this new set of metrics that are robust to changes in noise and/or resolution, it will be possible to measure galaxy structure at different epochs – and robustly trace the structural evolution of galaxies through cosmic time.

Asymmetry in polarized emission from nearby edge on spiral galaxies

Nathan Skeggs (Queen's University)

Galaxies - Poster

Spiral galaxies are host to large scale magnetic fields, a method of studying the properties of these magnetic fields is by measuring the polarization of synchrotron radiation. The CHANG-ES study observed the radio emission of 35 nearby edge on spiral galaxies using the VLA. In that study, an asymmetry in C band polarization was noticed across the disk and halo, with 13 of the 18 galaxies having the strongest polarization intensity on the advancing side. This was a newly discovered phenomenon which had not been observed before the CHANG-ES survey. A previous model suggests that this asymmetry stems from trailing spiral arms, whose receding side polarized emission is obscured by Faraday depolarization. However, this does not account for the asymmetry present in the halo. It also assumes that the majority of the observed galaxies have a trailing arm geometry, which is not the case. This work aims to expand on the study of this asymmetry, using C and L band observations in the B, C, and D array of all 35 galaxies observed by the CHANG-ES study. The first goal is to quantify to what extent the asymmetry exists across waveband and spatial scales. The methods we will use involve determining some measure of asymmetry in each individual observation. As well as, stacking the observed polarization for each band and array, to develop a view of how the asymmetry behaves in different observations. This expanded study of the asymmetry will hopefully help us come to better understanding of polarization of radio emission in edge on spiral galaxies.

Gas-tly origins: unraveling star-forming clumps in high-z galaxies

Visal Sok (York University)

Galaxies - Poster

Understanding the physical processes of star formation within galaxies remains a crucial pursuit in extragalactic astronomy. Distant galaxies often include kiloparsec-scale, star-forming clumps, which are believed to play a significant role in the mass assembly of galaxies. However, the origin of clumps remain poorly understood. In this Talk, we introduce a novel method for studying distant clumpy galaxies, that utilizes finite-resolution deconvolution on ground-based imaging of the COSMOS field. Leveraging the extensive photometric imaging and sky coverage of the field, our deconvolution approach enables us to study the clumpiness of 20,000 galaxies at $0.5<z<2$. Additionally, near-infrared spectroscopy is used to obtain metallicity measurements from the [NII]/H-alpha line ratio for a sample of both clumpy and non-clumpy galaxies at $z\sim0.8$, carefully selected from the deconvolved data. Interestingly, we find lower metallicity in clumpy galaxies compared to non-clumpy ones. Lower metallicity is not expected if clumps form from the gas disk, suggesting that clump formation may be due to the accretion of pristine gas from cosmological gas streams.

Medium-Band Colour Selections of High Redshift Extreme Emission Line Galaxies with JWST/NIRCam

Sunna Withers (York University)

Galaxies - Poster

Extreme Emission Line Galaxies (EELGs) are characterised by powerful UV-optical emission lines driven by elevated levels of star formation. It is currently presumed that strongly star forming galaxies, such as EELGs, are the main drivers of Hydrogen reionization at $5.5 < z < 15$, thus studying EELGs can provide valuable insights on this process. The medium-band filters aboard JWST/NIRCam are ideally suited to find and characterise EELGs at a wide range of redshifts. We present a sample of EELGs at $1.7 <= z <= 6.7$ using extensive NIRCam medium-band imaging provided by the CAnadian NIRISS Unbiased Cluster Survey (CANUCS). Our sample is selected using medium-band colour cuts that target galaxies with extreme [OIII] + H beta and H alpha emission, having rest-frame equivalent widths of EW(H alpha) $>$ 500A, and EW([OIII] + H beta) $>$ 1000A. Additionally, we use NIRSpec spectroscopy of 15 of the EELGs in our sample to confirm the redshifts and EWs measured from the medium-bands. Overall, we highlight the significant advantages of using the medium-bands to study EELGs at a wide range of redshifts. Finally, we present early results from JWST in Technicolour, which provides additional NIRCam medium-band imaging in three CANUCS fields allowing us to extend our analysis out to $z \sim 9$.

The evolution of galaxy star formation and morphology in groups and clusters with IllustrisTNG

Jing Yeung (McMaster University)

Galaxies - Poster

It has long been observed that galaxies in clusters and groups have lower star formation rates, and a higher fraction of elliptical galaxies compared to isolated-galaxies, highlighting the significant role of environment in driving galaxy evolution. Studies of local galaxies have shown that the fractions of bulge-dominated and quenched galaxies increase with time since infall into groups or clusters, with evidence suggesting that quenching may precede changes in morphology. However, the predominant mechanisms that drive these transformations in dense environments remain unclear. We use the state-of-the-art hydrodynamic simulation IllustrisTNG to study infalling galaxies and investigate transformation mechanisms. Unlike observations that are limited by projection and offer only a single snapshot of time, we can access the entire infall trajectories with simulated galaxies. We find that galaxies in TNG follow the observed trend of increasing quenched fraction with infall time. We do not find a strong trend in morphology with infall time, with results depending somewhat on whether a photometric or kinematic morphology estimator is used. By bridging simulations and observations, we hope to enhance our understanding of the physical mechanisms shaping galaxies in dense environments.

High-Energy and Plasma Astrophysics

Forming of truncated accretion disks

Gibwa Musoke (Canadian Institute for Theoretical Astrophysics, University of Toronto)

High-Energy and Plasma Astrophysics - Talk

Black hole X-ray binaries and Active Galactic Nuclei transition through a series of accretion states in a well-defined order. During a state transition, the accretion flow changes from a hot geometrically thick accretion flow, emitting a power-law–like hard spectrum to a geometrically thin, cool accretion flow, producing black-body–like soft spectrum. The hard intermediate accretion state present in the midst of a state transition is thought to be associated with the presence of both a hot geometrically thick component, termed the corona, and a cool, geometrically thin component of the accretion flow. The details concerning the geometry of the disk in the hard intermediate state are not agreed upon and numerous models have been proposed: In the “truncated disk” model, the accretion flow is geometrically thick and hot close to the black hole, while the outer regions of the flow are geometrically thin and cool. There are many open questions concerning the nature of truncated accretion disks: Which mechanisms generate the truncated disk structure? What sets the radius at which the disk truncates? How is the corona formed and what is its geometry? In this work we present the first high-resolution 3D General Relativistic Magneto-Hydrodynamic (GRMHD) simulation and radiative GRMHD simulation modelling the self-consistent formation of a truncated accretion disk around a black hole.

Testing the proposed radio emission mechanisms of cataclysmic variables with QS Vir

Margaret Ridder (University of Alberta)

High-Energy and Plasma Astrophysics - Talk

QS Vir is a pre-cataclysmic variable, in which the donor is just filling its Roche lobe. Previous observations by the VLA Sky Survey (VLASS) revealed it is a bright, variable radio source ~1 mJy from 2 - 4 GHz. Differentiating between possible radio emission mechanisms requires knowledge of the polarization that cannot be extracted from the VLASS. We obtained 3 VLA observations over 2 months of QS Vir, covering 2 - 12 GHz, with full Stokes polarization. They reveal a circular polarization fraction up to 34% (2 - 4 GHz) and a possible 1 GHz-wide emission feature near 6 GHz, which suggest an origin of electron-cyclotron maser emission, a coherent plasma process seen in planetary magnetospheres and in the atmospheres of ultracool dwarf stars. However, the magnitude and sign of the polarization changes between epochs and frequency bands, which we do not understand. This Talk will outline our results and place them in the broader context of radio-emitting cataclysmic variables.

Mechanism for Sgr A* Infrared Flares

Braden Gail (University of Toronto)

High-Energy and Plasma Astrophysics - Poster

Recent GRAVITY observations of Sagitarius A* (Sgr A*) have detected multiple bright patches with flux approaching that of the nearby star S2 in the Near-Infrared (NIR). These NIR flares were seen orbiting Sgr A* and were interpreted as having super-Keplerian speeds, lasting for approximately an hour (GRAVITY Collaboration et al. 2018). The clockwise motion traced out a nearly perfect circular orbit, with a radius of 6-10 r_g, and a size of the emitting region of order r_g, where the gravitational radius is defined as: $r_g := GM/c^2$. A possible explanation for these flaring events is through the production of flux tubes (bundles of magnetic field lines) that could carry hot, NIR emitting electrons around the accretion disk. This project aims to answer a few questions related to this mechanism, including whether or not these flux tubes can reproduce the motion seen observationally by GRAVITY, and whether or not the electrons will stay in the flux tube during an orbit. This project uses a global general relativistic magneto-hydrodynamic simulation of accretion onto a black hole using the Black Hole Accretion Code (BHAC) (Porth et al. (2017), Olivares et al. (2019), Ripperda et al. (2019)), including the evolution of test electrons to trace their trajectories while they emit photons (Bacchini et al. (2020)).

On Solving the Fokker-Planck Equation with Airy Functions

Brock Klippenstein (University of Manitoba)

High-Energy and Plasma Astrophysics - Poster

When energetic particles such as cosmic rays travel through space, they encounter turbulent magnetic fields. This in turn makes predicting the motion of these particles analytically unattainable. Therefore, we turn to the next best quantity which is the probability of finding one of these particles at a given time, position and velocity. This function can be obtained from solving the so-called Fokker-Planck partial differential equation. The Fokker-Planck equation has never exactly been solved, and thus here we analytically solve a simplified version of the one dimensional equation by using Airy functions. Moreover, we show that certain expected values such as position of this simplified equation are very similar to the expected value of the more accurate equation, with the main difference being that we derive an analytical form for the simplified expected value.

The global plasma distribution around a magnetar

Jonathan Zhang (University of Toronto)

High-Energy and Plasma Astrophysics - Poster

Accurately modelling the plasma distribution around a magnetar is necessary for calculating the various emission processes that can occur in the magnetosphere. We model the generation of pair plasma in the presence of a dipole magnetic field. The

ultra-strong field enhances photon to pair plasma annihilation, and additionally allows for a single photon pair plasma creation channel. The trajectory of photons from a localized photon emission structure is used to define a global photon distribution, which then determines the pair creation rate. Confinement along a magnetic flux bundle allows us to balance the creation rate against annihilation and loss through the surface, which sets the equilibrium plasma density along a bundle. We present the equilibrium plasma densities for a variety of emission structures with luminosity 10^{35-36} erg/s, and find that the plasma density can exceed the critical density for currents generated by twists in the magnetic field.

Instrumentation and Surveys

An RFSoC-Based Backend and Timing Reference System for Balloon-Borne VLBI Experiments

Mayukh Bagchi (Queen's University)

Instrumentation and Surveys - Talk

Very Long Baseline Interferometry (VLBI) combines radio telescopes across vast distances to image astrophysical objects with exceptional angular resolution. Traditionally VLBI telescopes rely on hydrogen masers to synchronize their observations and track any drifts in phase stability. The emergence of Radio Frequency System-on-Chip (RFSoC) FPGAs has revolutionized digital backends by offering unparalleled power efficiency, cost-effectiveness, and flexibility. At the same time, near-space industry's advancements have made highly stable, compact Oven-Controlled Crystal Oscillators (OCXOs) increasingly viable as timing sources for Low Earth Orbit (LEO) satellites. Our project, the Balloon-borne VLBI Experiment (BVEX), explores the feasibility of utilizing balloon-borne telescopes as VLBI stations to enhance the sensitivity and UV coverage for future Event Horizon Telescope (EHT) and Global Millimeter VLBI Array (GMVA) campaigns. Slated for launch in Timmins, Ontario in the summer of 2025, BVEX operates at the K-band (21-23 GHz) frequency. It features a single-sideband heterodyne detector with an RFSoC 4x2 FPGA backend and a RAKON OCXO as its primary timing source. In this Talk, I will present our FPGA designs using the CASPER (Collaboration for Astronomy Signal Processing and Electronics Research) toolflow for implementing a high-resolution spectrometer and

a high-speed 100 GbE data offloading system, as well as our plans for timestamping and monitoring phase drifts of our OCXOs to VLBI standards.

Astrophotonics for adaptive optics

Momen Diab (Dunlap Institute for Astronomy and Astrophysics, University of Toronto)

Instrumentation and Surveys - Talk

Integrated photonic devices offer solutions to the growing complexity challenges faced by conventional astronomical instrumentation, especially for the upcoming extremely large telescopes (ELTs) and dense optical arrays. Photonic spectrographs, integrated beam combiners, aperiodic Bragg grating filters, and other innovations have been developed to address the shortcomings of their bulk optics counterparts. I this Talk, I will introduce the concept of astrophotonics with focus on the state-of-the-art of integrated instruments proposed to replace classical adaptive optics components. I will end by presenting novel concepts for a photonic wavefront sensor and a photonic wavefront corrector.

The Pandora Mission: Countdown to Launch

Kelsey Hoffman (Bishop's University)

Instrumentation and Surveys - Talk

The NASA Pioneer's Pandora Mission is a low-cost space telescope designed to measure the composition of distant transiting planets. The Pandora payload has the unique capability of measuring precision photometry simultaneously with near-infrared spectroscopy that will enable scientists to disentangle stellar activity from the subtle signature of a planetary atmosphere. The broad-wavelength coverage will provide constraints on the spot and faculae covering fractions of low-mass exoplanet host stars and the impact of these active regions on exoplanetary transmission spectra. Pandora will subsequently identify exoplanets with hydrogen- or water-dominated atmospheres, and robustly determine which planets are covered by clouds and hazes. Pandora observations will also contribute to the study of transit timing variations, phase curve photometry. With a launch expected in 2025, the Pandora mission represents a new class of low-cost space mission that will achieve out-of-this-world science. [Canada's participation in Pandora is support by the CSA ROSS program]

A Glimpse of AGN Variability Survey Planning with CASTOR

Viraja Khatu (Canada-France-Hawaii Telescope)

Instrumentation and Surveys - Talk

In the hearts of massive galaxies, supermassive black holes accrete through a disk of ionized gas, releasing tremendous energy as active galactic nuclei (AGN). AGN emit over a broad range of wavelengths, but their power distribution peaks in the ultraviolet (UV). In AGN, UV emission emerges from the regions close to the central black hole which allows us to look directly at the ionizing continuum in these objects. In addition, AGN are more variable and vary on several timescales in UV. With the Hubble Space Telescope nearing the end of its lifetime, the astrophysical community is in need of a UV telescope. The Cosmological Advanced Survey Telescope for Optical and ultraviolet Research (CASTOR) fills this gap. CASTOR is a UV space mission proposed to the Canadian Space Agency that will conduct wide-field photometric and spectroscopic surveys in three bands from 1500 – 5500 Angstrom. One of the key science goals of CASTOR is to understand how supermassive black holes grow over cosmic time – a long-standing question in AGN science. We propose to address this question through an AGN time domain legacy survey that would probe the inner regions of AGN and obtain their black hole masses over a wide range of cosmic times. To maximize science returns from the survey, we are designing a survey simulation pipeline that optimizes survey observables and suggests the best observing strategy for achieving a given science goal. I will demonstrate how the survey simulation pipeline can be applied to plan AGN variability surveys with CASTOR and what CASTOR can do for AGN science.

Coherent Differential Imaging on SPIDERS

Christopher Mann (NRC-HAA)

Instrumentation and Surveys - Talk

The Subaru Pathfinder Instrument for Detecting Exoplanets and Retrieving Spectra (SPIDERS) is an exploratory instrumentation project to develop advanced techniques in high-contrast imaging and direct detection and characterization of exoplanets. After using a live-correction self-coherent camera (SCC) to remove residual atmospheric speckles and greatly improve image contrast, SPIDERS then engages in a coherent differential imaging (CDI) procedure to suppress speckle noise even further. Here we describe the challenges encountered in optimizing the CDI pipeline

and our progress in overcoming them, from pixel-level artifact correction to reference beam reconstruction.

CFHT updates and plans for the upcoming 10 years

Nadine Manset (Canada-France-Hawaii Telescope Corporation)

Instrumentation and Surveys - Talk

As CFHT approaches the end of the current Maunakea lease, we plan to spend the remainder of this decade working in close consultation with the newly formed Maunakea Stewardship and Oversight Authority (MKSOA), our Hawaiʻi community, and our astronomy community to build a collaborative future that we hope results in the continuation and upgrade of CFHT on Maunakea past 2033. CFHT created a streamlined instrumental and operational plan for the next 10 years. This plan includes implementing VISION, a co-mount of ESPaDOnS and SPIRou, decommissioning WIRCam and SITELLE at the end of 2026, increasing the fraction of time allocated to Large Programs, and creating a path for MSE. Updates will be presented regarding Maunakea, the 10-year plan, and a possible CFHTLS-like Scientific Survey starting in 2028.

Construction and First Ground-based Tests of the Balloon-borne VLBI EXperiment (BVEX) Telescope and Receiver

Felix Thiel (Queen's University)

Instrumentation and Surveys - Talk

Very Long Baseline Interferometry is a technique commonly used in radio astronomy to make extremely high-resolution images of radio galaxies, as well as their jets and central black holes. Like standard single-dish radio observations these measurements are bounded by the diffraction limit given by the ratio of observation wavelength to the longest baseline. The resolution of ground-based VLBI observations are limited both by the size of the Earth and molecular atmospheric absorption which limits observations at high-frequencies. As a first step to address the high-frequency limit on VLBI observations the Balloon-borne VLBI EXperiment (BVEX) will launch from Timmins, Ontario in August 2025 and will operate above more than 99% of the Earth's atmosphere. This experiment consists of a K-band (22 GHz) balloon-borne radio telescope and will serve as a proof of concept that VLBI is possible between a balloon-borne telescope and a larger ground-based radio telescope. In this Talk I will be giving an overview of the radio telescope and receiver for this experiment including its construction from commercial off-the-shelf components as well as preliminary results from outdoor and in-lab tests, such as noise measurements and beam characterization. I will wrap up the Talk by Talking about near-future prospects for high frequency mm-VLBI observations that will have the potential to improve both the sensitivity and uv-coverage of existing VLBI networks such as the Global Millimetre VLBI Array (GMVA) and the Event Horizon Telescope (EHT).

Deploying focal plane wavefront sensing and coherent imaging at Subaru with SPIDERS, a pathfinder 4th generation planet imager

William Thompson (NRC Herzberg Astronomy and Astrophysics)

Instrumentation and Surveys - Talk

The Subaru Pathfinder Instrument for Detecting Exoplanets and Recovering Spectra (SPIDERS) has been built from the ground-up to demonstrate the fast-atmospheric self-coherent camera (SCC) technique on-sky for the first time. This technique uses a common-path interferometer to measure and suppress speckles in real-time to build a dark hole, and to enable coherent differential imaging (CDI) post-processing. These promise more than a hundred times improvement in sensitivity when imaging young giant planets and debris disks around bright stars. In addition, SPIDERS includes a high resolution imaging Fourier transform spectrograph, a first for an AO-corrected instrument, enabling simultaneous spectral and coherent differential imaging. I will present SPIDERS, its laboratory performance on post-AO residuals, and an update on SPIDERS’ commissioning at Subaru.

Decadal variations of seeing on Maunakea

Daniel Devost (Canada-France-Hawaii Telescope)

Instrumentation and Surveys - Poster

I will present an analysis of seeing, temparature and humidity measurements done with the MaunaKea Atmospheric Monitor (MKAM) located at the summit of MaunaKea. MKAM hosts a MASS-DIMM that was provided to the Maunakea Observatories by TMT after they completed their site studies. The instrument has been functional since 2009, taking several measurements of seeing every night it was in operation.

I will present the trends seen when looking at all seeing, temperature and humidity values. In addition, particular attention will be given to the trends shown by a "good seeing" sub-sample, limiting the sample to values that are considered acceptable when evaluating image quality of an astronomical observation. I will also report on seasonal trends to see how these correlate with the El Niño Southern Oscillation.

Technical Abstract

The analysis will show the trends of all the variables that are measured by a MASS-DIMM. Data is sampled every minute and millions of points are available for analysis. The weather data (temperature, humidity, wind speed and direction) is taken from sensors located on the MKAM tower itself.

The MKAM data is also complemented with data from the Climate Prediction Center on the El Niño Southern Oscillation (ENSO) to see how it impacts weather at the summit of Maunakea.

The Dominion Astrophysical Observatory Science Archive

David Bohlender (NRC Herzberg)

Instrumentation and Surveys - Poster

Digital spectra, images, and other data acquired with the DAO 1.2-m and DAO 1.8-m telescopes have been stored off-line at the DAO since 1986. Over the last several years we have gradually been adding these data to the CADC’s DAO collection in order to make it available via their Advanced Search web interface. Since newly acquired data are archived within minutes of acquisition this means that when this project is completed, hopefully by the end of 2025, 40 years of DAO data will be on-line. This paper describes the effort and challenges faced to ensure that all of the DAO data are safely stored and readily available for archival research.

Detecting Microlensing Signals in the Roman Galactic Bulge Time Domain Survey

Kyle Finner (Caltech/IPAC)

Instrumentation and Surveys - Poster

The Roman Space Telescope is set to launch in late 2026. Three core community surveys have been chosen to take up a significant fraction of the first years of operation of the observatory. The Roman Galactic Bulge Time Domain Survey (GBTDS) will provide high-cadence imaging of approximately 2 square degrees near the galactic bulge. The survey will produce a tremendous data set for exoplanet detection. At IPAC, we are developing pipelines to deliver microlensing detections to the community. I will give an overview of the Roman surveys and provide details on the GBTDS. IPAC's role in developing the microlensing pipeline and the value of the data products that will be created will be discussed.

Novel Method for Measuring Quantum Efficiency Using Fiber Optics

Braden Gail (University of Toronto)

Instrumentation and Surveys - Poster

Quantum efficiency is the percentage of incident light on a photodetector that is recorded as electrons. In this Poster I will present a novel method for determining this quantity for CMOS sensors using fiber optics. The required components include a light source, monochromator, fiber optics, fiber splitter, and a calibrated photodiode. Instructions for the construction of both photon transfer and quantum efficiency curves are given using the Sony IMX487 sensor as an example. This project is the preliminary work for characterizing infrared detectors which must be cryogenically cooled. This method is advantageous in these situations as the fibers offer an alternative to feeding light through a cryostat window.

Beyond CCDs: Characterization of sCMOS detectors for optical astronomy

Aditya Khandelwal (University of Toronto)

Instrumentation and Surveys - Poster

Modern scientific complementary metal-oxide semiconductor (sCMOS) detectors provide a competitive alternative to charge-coupled devices (CCDs). They boast comparable performances with faster frame rates, lower read noise, higher dynamic range and have lower production costs such that industry favours sCMOS production. We characterized several commercially available sCMOS detectors to gauge the state of this technology for use in optical astronomy. This included large-pixel detectors (e.g. Teledyne Prime 95B, Andor Sona-11) comparable to traditional CCDs, along with one quantitative sCMOS detector, the Hamamatsu

Orca-Quest C15550-20UP, which has photon-resolving capability. We found low levels of dark current, read noise, faulty pixels, and fixed pattern noise, as well as >98% linearity across all detectors. The Quest, in particular, had a dark current of 0.008 +/- 0.034 e-/s/px (-20C) and a read noise of 0.37 +/- 0.10 e- (in standard scan). We also tested this detector on-sky to evaluate its photometric accuracy. Our tests demonstrated that sCMOS detectors perform superior to CCDs in optical imaging and provide more readily available alternatives for upcoming optical instruments.

Simulation Tools for Spatial-Spectral Interferometry in the Far-Infrared

Spencer Locke (University of Lethbridge)

Instrumentation and Surveys - Poster

Observations in the Far-Infrared (far-IR) provide access to critical diagnostic spectral lines for many important atoms and simple molecules for astronomical targets ranging from galactic star and planet forming regions, to extra-galactic targets, to the cosmic background itself. Distant galaxies and protoplanetary disks typically appear in the sky at sub-arcsecond scales, which rendered them unresolvable with the successful 3.5-m Herschel Space Observatory (2009-2013), the largest Far-IR telescope flown to date. A space-based interferometer observatory with baselines of at least tens of meters in length is required for far-IR astronomical observations with sub-arcsecond angular resolution and high spectral resolution. In recent years this concept has been explored in a variety of formats including structurally connected interferometers, tethered interferometers, and formation flying interferometer instruments.

News and highlights from CFHT

Nadine Manset (Canada-France-Hawaii Telescope Corporation)

Instrumentation and Surveys - Poster

We present recent and current CFHT activities, including a new Hawaiian name for the VISION instrument, new narrow-band filters for SITELLE, and results of the User Community Survey from the fall of 2023.

High stakes: The ngVLA and access to the 1.4 - 100 GHz sky at high sensitivity and resolution

Brenda Matthews (NRC Herzberg)

Instrumentation and Surveys - Poster

The next generation Very Large Array (ngVLA) was one of the two ground-based radio facilities prioritized by the Astro2020 decadal survey. LRP2020 also prioritized ngVLA among the four recommended large facilities for ground-based astronomy in the next decade. Now that Canada has joined SKA-1 as a partner, it is worthwhile to articulate why "another radio facility" like ngVLA is worthy of Canadian participation in the era of Canadian access to SKA-1 and ALMA. I will highlight the unique scientific power of this amazing facility, which is planned to have baselines spanning the continental US, and also highlight the complementary nature of these three interferometric telescopes. In particular, I will explain the depreciation timescale of the VLA and why the loss of high resolution access to this frequency range will be the reality in the absence of the ngVLA. Finally, I will give a brief update about the project and its progress in winding its way through various design reviews and funding requests. Given NRAO's historically Open Skies policy, it is important to understand how Canada's engagement with ngVLA as a partner will be advantageous for our community now and in the long term.

Five Years of the Guest Observer Program for the Near-Earth Object Surveillance Satellite

Joel Roediger (Canadian Space Agency)

Instrumentation and Surveys - Poster

We present an update on the Guest Observer (GO) program and operations for the Near-Earth Object Surveillance Satellite (NEOSSat). For nearly five years, CSA has been offering observing time on NEOSSat to Canadian astronomers through a competitive call for proposals and the GO program is now in its seventh cycle, which will run until the end of October 2024. The response from the community to the GO program has been robust so far, with most proposals harnessing NEOSSat’s unique capabilities for the study of transiting exoplanets (sometimes involving repeated visits) or monitoring of asteroids and comets at low solar angles. Additionally, many targets of opportunity, such as short-notice Earth-passing asteroids and comets, have been successfully observed throughout all cycles. Some notable achievements so far include observations of TOI-2010 b, one of the longest-period exoplanets found by the TESS mission, and the impact of NASA’s Double Asteroid Redirection Test

(DART) mission into the asteroid Didymos. Since its beginning, all the data obtained through the GO program is made accessible through CSA's open data portal and the Canadian Astronomy Data Centre (CADC). Given these successes, CSA intends to continue issuing AOs for this program while NEOSSat operates smoothly.

SIGNALS' Update

Laurie Rousseau-Nepton (University of Toronto and the Dunlap Institute)

Instrumentation and Surveys - Poster

SIGNALS, the Star-formation, Ionized Gas, and Nebular Abundances Legacy Survey, is a large program at the Canada-France-Hawaii Telescope. Between 2018 and 2022 and with 63 nights of telescope time in hands, our collaboration observed a large fraction of the local extragalactic HII regions (D < 10 Mpc))using SITELLE , an Imaging Fourier Transform Spectrograph (IFTS). With a mean spatial resolution of 15 pc, spectral information over the strong emission lines in the visible (i.e. [OII]3727, Hbeta4861, [OIII]4959,5007, [NII]6548,6583, Halpha6563, HeI6678, [SII]6716,6731), and a spectral resolution of 5000 (on Halpha), SIGNALS is unique and complementary to other surveys that are aiming at studying star formation (e.g. PHANGS, CHAOS, CALIFA, etc). In order to build a sample of more than 50,000 HII regions located in different galactic environments, SIGNALS covered about 31 galaxies actively forming stars. Along with ancestry data in the IR and UV, our collaboration aims at studying resolved star-formation activity, understanding the impact of the local environment on the star-formation process, and providing the science community with a unique dataset along with new tools to study star formation. In this Poster, I will review our latest updates and show some of the most resent results.

Initial Telescope Characterization for the Balloon-borne VLBI Experiment (BVEX)

Bonnie Slocombe (Queen's University)

Instrumentation and Surveys - Poster

The Balloon-borne VLBI Experiment (BVEX) is designed to demonstrate Very Long Baseline Interferometry (VLBI) between a balloon-borne telescope and a ground-based telescope. BVEX will launch from Timmins, Ontario in the Summer of 2025 as part of the Canadian Space Agency's (CSA) STRATOS program. The BVEX telescope is comprised of a 91cm diameter Cassegrain dish and a 22GHz heterodyne receiver, built from commercial off-the-shelf components. This Poster will provide an overview of the initial characterization of the BVEX telescope, including the gain of receiver components and first light observations using the Sun. Another quantity of interest is the power pattern of the telescope which can be used to characterize the beam size and sidelobes. We will discuss the design of a helical antenna that generates a 22GHz signal and initial measurements using this radio-frequency source to map the far-field beam of the BVEX radio dish.

Canadian Gemini News

Eric Steinbring (NRC/HAA)

Instrumentation and Surveys - Poster

We provide updates on Gemini operations over the last year, and show some statistics from Canadian use of the telescopes in recent semesters. Check out future plans, upcoming instruments and ongoing upgrades. The CASCA 2024 schedule has opportunities to meet with Gemini experts to learn about what's new and answer all your questions about Phase I and Phase II, or on getting help with your data reductions.

First Photon Counts at the Allan I. Carswell Observatory with a single pixel SPAD

Robin Swanson (University of Toronto)

Instrumentation and Surveys - Poster

Recently, single photon avalanche diode (SPAD) sensors have attracted a large amount of interest in the imaging community due to their extreme sensitivity, time resolution, and lack of read noise. In the realm of astronomical instrumentation, they have been used to varying degrees of success to image variable stars and other transient phenomena. Wavefront and tomographic instruments based on SPAD sensors are also under development for future use. However, hardware limitations in the current generation of devices, such as low quantum efficiency and spatial resolution, have led to limited success in these applications. To compensate for these deficiencies and better leverage their strengths, we propose measuring variable objects with photon arrival times instead of integrating the incoming flux as a classical sensor would. By recording the time of arrival for every photon, we can use frequency analysis techniques to recover periodic signals even in the presence of large amounts of noise and background signals.To validate this approach we have installed a single photon SPAD instrument at the Allan I. Carswell Observatory 1m telescope located at York University. Here we present the optical design, algorithmic formulation and intuition, as well as preliminary on-sky results.

Characterising the Noise Temperature of the BVEX Radio Telescope Using a Thermally Controlled Warm Source

Jade Yeung (Queen's University)

Instrumentation and Surveys - Poster

The BVEX telescope is a balloon-borne radio telescope that is designed to demonstrate very long baseline interferometry between a balloon telescope and a ground-based telescope. This Poster describes the construction and testing of a controllable warm thermal source in order to characterise the system noise temperature of the telescope. This source uses 18 2Ω resistors to evenly heat an aluminium plate. A voltage controller uses feedback from temperature sensors to turn off power to the resistors after the target temperature is exceeded. Eccosorb HR microwave absorber foam is used to approximate blackbody radiation at microwave frequencies. By calculating the ratio of the power of the source measured by the telescope at these two different temperatures, we can calculate the system noise temperature. The power from the source was measured with the radio telescope at a hot temperature of 40℃ and a cold temperature of 30℃. Our initial tests show that the noise temperature of the receiver is consistent with the predicted 400K from our telescope design.

JWST

The James Webb Interferometer: Joint model fitting of the protoplanets and disk around PDS 70 provides evidence for circumplanetary disk emission and additional asymmetric emission within the disk gap

Dori Blakely (University of Victoria)

JWST - Talk

TBD

Classifying YSOs in the Cosmic Cliffs JWST Data using a Probabilistic Random Forest

Breanna Crompvoets (University of Victoria)

JWST - Talk

Among the first observations released to the public from the James Webb Space Telescope (JWST) was a section of the star-forming region NGC 3324 known colloquially as the “Cosmic Cliffs.” We build a photometric catalog of the region and test the ability of using the Probabilistic Random Forest machine learning method to identify its Young Stellar Objects (YSOs). These classifications are verified with several different metrics, including recall and precision. Using the obtained probabilities of objects being YSOs, we employ a Monte Carlo approach to determine the surface density of cYSOs in the Cosmic Cliffs, which we find to be largely coincident with column densities derived from Herschel data, up to a column density of 1.37 × 10^22 cm^-2. The newly determined number and spatial distribution of YSOs in the Cosmic Cliffs demonstrate that JWST is far more capable of detecting YSOs in dusty regions than Spitzer. Comparisons of the observed colours and brightness of faint cYSOs with those of pre-main-sequence models suggest JWST has detected a significant population of sub-stellar YSOs in the Cosmic Cliffs. The size of this population further suggests previous estimates of star formation efficiencies in molecular clouds have been systematically low.

A Hell of a Phase Curve: Mapping the Surface and Atmosphere of the Lava Planet K2-141b with JWST

Lisa Dang (Université de Montréal)

JWST - Talk

Here we present our on-going work to expand upon the foundations of far-IR spatial/spectral interferometry towards an end-to-end simulation software suite. This software suite includes multiple interferometer point design concepts and observing modes and is presented as an open-source and publicly available tool, allowing users to customize and explore the potential of a space-based far-IR interferometer. The software tools presented in this work allow the astronomical community further exploration of the unique capabilities of such instrumentation through provision of a framework with which to study double Fourier interferometry in the far-IR.

From Shocks to Star Formation: Ionized Gas Diagnostics with JWST MIRI in MACS1931-26

Lucas Kuhn (The University of British Columbia)

JWST - Talk

TBD

Examining the host galaxies of active galactic nuclei in the JWST CEERS survey

Callum Dewsnap (Western University)

JWST - Poster

TBD

Early Results and a Guide to the Canadian Space Agency grants program for JWST

Jean Dupuis (Canadian Space Agency)

JWST - Poster

TBD

Resolved versus Unresolved Photometry: Stellar Mass Estimates of Galaxies observed by JWST

Naadiyah Jagga (York University)

JWST - Poster

TBD

Long Wavelength Astronomy

Resolving the cosmic infrared background with JWST and ALMA

Ryley Hill (University of British Columbia)

Long Wavelength Astronomy - Talk

I will Talk about combining archival ALMA data targeting the Hubble Ultra Deep Field to produce the deepest currently attainable 1-mm map of this key region. 45 galaxies are detected, 39 of which have JWST counterparts from the JADES survey. A stacking analysis on the positions of about 2000 ALMA-undetected JWST galaxies yields a surprising amount of additional information - I will Talk about the fraction of the cosmic infrared background resolved by JWST and ALMA, and argue that essentially all of the galaxies that contribute to the cosmic infrared background have now been accounted for.

CN as a tool for dense gas studies in star-forming galaxies

Blake Ledger (McMaster University)

Long Wavelength Astronomy - Talk

I will present recent work focusing on the cyanide radical, CN, as an added tool to study dense gas and star formation in nearby star-forming galaxies and U/LIRGs. We have used archival ALMA data to show that the CN (1-0)/CO (1-0) intensity ratio varies between and within individual galaxies on 0.1 – 1 kiloparsec scales. CN/CO tends to be higher in the more extreme ULIRGs compared to LIRGs and normal star-forming galaxies, higher in galaxy centres compared to their disks, and correlates with global infrared and hard X-ray luminosities. The correlations become stronger when considering the location of peak hard X-ray or peak gas surface density. Additionally, we have measured a nearly constant CN/HCN line intensity ratio using the CN (1-0) and HCN (1-0) lines, with no correlation with molecular gas surface density and only a weak correlation with star formation rate surface density and star formation efficiency. Our results imply that CN, like HCN, can be used as a tracer of dense gas mass and dense gas fraction in nearby galaxies.

The CHIME All-Sky Multiday Pulsar Stacking Survey - Overview and first results

Robert Main (McGill)

Long Wavelength Astronomy - Talk

Pulsar surveys have been an astronomical treasure-trove in recent decades, with >3000 pulsars discovered to date which have been used to test General Relativity, map the 3D distribution of galactic electrons, constrain the neutron star equation of state, and recently discover evidence of the ~nanohertz gravitational wave background. Most surveys are conducted in radio, and either tile the sky once, or focus on regions or targets where pulsars are a priori believed to inhabit.

In this Talk, I will present the progress and early results of CHAMPSS - the CHIME All-Sky Multiday Pulsar Stacking Search (formerly named the CHIME Slow Pulsar Search). As the name suggests, we will search the northern sky for pulsars daily, enabling the survey to discover intermittent sources which could be missed in previous single-pointing surveys, and probe much deeper along many under-searched sightlines by stacking months of data.

The large data rate and unique design of our survey presents technical and logistical challenges, and I will describe our strategies to overcome these. As a demonstration and proof-of-concept, I will show the first new discoveries from our commissioning survey, which is running in real-time on a small fraction of the sky. Finally, I will describe the plans to fully scale-up the project by the end of 2024, with several planned upgrades to be installed at the CHIME site.

A blind search for 21-cm absorption systems with CHIME

Arash Mirhosseini (University of British Columbia)

Long Wavelength Astronomy - Talk

We are conducting the first wide-area blind radio survey of 21-cm absorption systems in the redshift range of $0.78<z<2.5$ using CHIME. These 21-cm absorption systems are cold and dense gas clouds containing large amounts of neutral hydrogen along the line of sight to background quasars. Studying them will provide insights into the kinematics of the hydrogen gas clouds, star formation rates and evolution of the cold gas as a function of redshift. Moreover, the results of this project can be used in the long term for direct detection of cosmic acceleration with a decade of observations.

CHIME is a drift scan radio telescope, located at the Dominian Radio Astrophysical Observatory (DRAO) near Penticton in British Columbia, Canada. It scans the entire northern sky visible from DRAO every day across frequency range of 400 to 800 MHz. It is originally designed to map the expansion history of the universe by tracking the evolution of the baryon acoustic oscillation scale with redshift. The CHIME High Frequency Resolution (HFR) system is a new sub-system of CHIME designed for the detection of these narrowband 21-cm absorption systems. In this Talk, I will present the project's initial findings, including the detection of three previously known absorbers and our strategy and prospects for a blind search for new systems.

The Second CHIME/FRB Catalog

Naman Jain and Thomas Abbott (McGill University)

Long Wavelength Astronomy - Poster

Fast Radio Bursts (FRBs) are micro to millisecond duration radio pulses primarily originating from cosmological distances. There are many unanswered questions surrounding FRBs, such as what their progenitor is, whether they all repeat, or whether they come from different populations. The Canadian Hydrogen Intensity Mapping Experiment/Fast Radio Bursts (CHIME/FRB) is a unique experiment in its capabilities to detect FRBs owing to its large instantaneous field of view, 400MHz frequency range, and daily scanning of the full Northern sky. In June of 2021, CHIME/FRB released its first FRB catalog consisting of 536 events including 18 repeating sources. This sample revolutionized the FRB field by increasing the number of known FRB sources by an order of magnitude. For the first time, relatively large-scale population studies of FRBs with a consistent selection function was possible. In this Talk, we present the plans for the second CHIME/FRB Catalog which includes ~4000 events detected between July 2018 and September 2023. We present properties of the FRBs in the second Catalog, preliminary population statistics, repeater fraction, spatial distribution, and more. We conclude by discussing future plans of the CHIME/FRB Collaboration and exciting prospects in the field of FRBs.

Star Formation and Gas Properties in (Ultra)-Luminous Infrared Galaxies: Insights from the ALMA Archive

Osvald Klimi (McMaster)

Long Wavelength Astronomy - Poster

We examine the star formation rate (SFR) and gas properties for a sample of 16 (Ultra)-Luminous Infrared Galaxies (U/LIRGs) using resolved 500 pc resolution data acquired from the ALMA archive. We estimate star formation rate surface densities through 110GHz radio continuum and dense and bulk gas from CN(1-0) and CO(1-0), respectively. We focus on the power law relationships found between the SFR and the gas properties: the Kennicutt-Schmidt relation between SFR and bulk gas, and a similar relationship between SFR and dense gas. Moreover, we analyze the star formation efficiency (SFE) of the total and dense gas as a function of the dense gas fraction. We compare our results to previously published work on normal spiral galaxies to assess the role of extreme environments on the relation between gas and star formation.

Confirming Pulsar Candidates from CHAMPSS using a Multiday Coherent Search

Magnus L'Argent (McGill University)

Long Wavelength Astronomy - Poster

The Canadian Hydrogen Intensity Mapping Experiment (CHIME) is a drift scan radio telescope that offers a unique opportunity to make daily observations of the entire northern sky. The CHIME All-Sky Multiday Pulsar Stack Search (CHAMPSS) utilizes this daily cadence to search for periodic signals in the CHIME Fast Radio Burst datastream. The periodic pulsar signals appear as sharp peaks in power spectra created from a fast fourier transform of the dedispersed datastream. The power spectra from the same pointing are then summed each day to create an ongoing, multi-day stack that gives sensitivity to faint, persistent sources.

Phase coherent searches offer higher sensitivity compared to phase incoherent searches like power spectra stacking. However, it is too computationally costly to blindly search the datastream and pulsars will not align in phase over multiple days due to spindown, so the power spectra stack search provides an initial period estimate to search around. Promising candidates found in the stack are confirmed by folding the time-dependent data on their initial period estimate. Strong pulsars will appear in a single day fold. Weaker pulsars will only appear after aligning the pulsed signal in phase over multiple observations. In this Talk, I will give an overview of the CHAMPSS candidate confirmation process I have developed. I will describe how observations from multiple days are aligned in phase to create an initial timing solution and how aliased signals are removed.

In the first commissioning survey, covering 4% of the CHIME sky in over 2 months, three new pulsars have been discovered and confirmed using this phase coherent process. We also re-detect several pulsars discovered through single pulses at CHIME as well as sources in the FAST Galactic Plane Pulsar Survey (GPPS).

Does star formation drive increased molecular gas turbulence in galaxy centres?

Jennifer Laing (McMaster University)

Long Wavelength Astronomy - Poster

Galactic bars play an important role in the dynamical evolution of their host galaxy, but their own evolution and impact on the local gas reservoir and star formation rate are still open questions. Recent work by the Physics at High Angular resolution in Nearby GalaxieS (PHANGS) collaboration found higher molecular gas surface densities and velocity dispersions in barred galaxies compared to unbarred galaxies. The observed increase in line width may be due to turbulence caused by streaming motions along the bar, which is expected to cause a build up of gas and star formation in the central region. In this work, I explore bar turbulence in molecular gas using published high resolution (~100 pc) measurements of CO(2-1) from the PHANGS-ALMA survey. I compare the molecular gas surface density, velocity dispersion, and star formation rate, in the centres of barred and unbarred galaxies. All three quantities are found to be enhanced in barred galaxy centres.

Gravitational Instability in a Planet-Forming Disk

Jess Speedie (University of Victoria)

Long Wavelength Astronomy - Poster

Although gravitational instability has been long-considered as a promising pathway to planet formation, observational identification of gravitational instability is still very limited. In this Talk, I present a clear and convincing case of gravitational instability in the planet-forming disk around AB Aur, a nearby Class II YSO. High quality ALMA observations of CO isotopologue emission reveal global spiral arms in the gas density and kinematics at scales of 100-1000 au. The data show detailed agreement with numerical and analytical models. In particular, we detect the telltale kinematic signature of self-gravitating spiral arms —the "GI wiggle"— in 13CO and C18O simultaneously. Through quantitative comparisons to models, we are able to constrain the AB Aur disk mass. With multiple protoplanet candidates identified amongst the spiral arms in previous observations, the AB Aur system represents a direct observational connection between gravitational instability and planet formation.

Unveiling the Universe's Symphony: Probing Gravitational Waves with Pulsar Timing Arrays

Mercedes Thompson (UBC)

Long Wavelength Astronomy - Poster

The 2015 detection of gravitational waves (GWs) unveiled a new spectrum to probe the universe. Pulsar timing arrays (PTAs) such as NANOGrav (the North American Nanohertz Observatory for Gravitational Waves) have found evidence for a new window into the GW spectrum. The stochastic gravitational wave background corresponds to GWs on nanoHertz or lightyear scales. This background is a pervasive hum produced by the collective motion of the Universe's most massive objects. Binary supermassive black holes (SMBHs) are likely a significant source of this hum. NANOGrav has built a galaxy-sized GW detector exploiting the incredibly regular radio emission from millisecond pulsars (MSPs). By following 67 MSPs over 15 years NANOGrav has evidence of the subtle contraction and expansion of these MSPs' signal arrival times as GWs pass through our galaxy. To further bolster this evidence the Pulsar instrument on the CHIME telescope (the Canadian Hydrogen Intensity Mapping Experiment) is now being used as part of the NANOGrav collaboration. Incorporation of CHIME timing data will improve timing solutions, potentially by up to 50% for some pulsars. Key to this improvement is the daily observing cadence available with CHIME, and the potential for accurate modeling and subtraction of the systematic effects imposed on the pulsar signals by their passage through the ionized plasma known as the interstellar medium. I will describe progress in combining CHIME/Pulsar and earlier NANOGrav data, focusing on modelling the dispersive and scattering effects in the CHIME data.

Constraining Fast Radio Burst-like Emission from Short Gamma-ray Bursts using CHIME/FRB

Alice Curtin (McGill University)

Long Wavelength Astronomy - Poster

Fast radio bursts (FRBs) are extremely energetic, ~millisecond duration bursts of radio emission originating primarily from extragalactic distances. While over 750

FRBs have been published, their progenitors still remain largely unknown. One possible avenue for determining the origins of FRBs is to search for accompanying high-energy emission, as only certain models predict these high-energy counterparts. In this talk, I will first give an overview of various theoretical predictions for gamma-ray burst (GRB) counterparts to FRBs. I will then describe our work using the Canadian Hydrogen Intensity Mapping Experiment (CHIME) Fast Radio Burst (FRB) Project to perform the most expansive search yet for coincident FRBs and GRBs. I will also present our algorithm for constraining near-simultaneous FRB-like emission from GRBs and show our results for 33 short GRBs. Finally, I will compare our radio constraints with those of other astrophysical objects and different theoretical models.

Milky Way and the Local Group

High-velocity stars ejected from globular clusters: NGC 3201 candidates from Gaia DR3

Abigail Battson (Saint Mary's University)

Milky Way and the Local Group - Talk

The dense environment in the cores of globular clusters enables three-body interactions involving a binary system and a single star to occur frequently, which can eject high-velocity stars from the cluster. The velocities of these stars reflect the masses involved in the interactions which accelerated them, making them promising tracers of stellar remnants in globular clusters, particularly the black hole population. We use Gaia Data Release 3 data to locate high-velocity stars in the regions around a large number of Milky Way globular clusters. For most of these clusters, many of these high-velocity candidates are expected to be contaminant stars. But in some clusters like NGC 3201, we detect a significant excess (dozens of high-velocity stars) compared to what is expected from the contaminant population alone. We compare our results with Monte Carlo models of NGC 3201 to demonstrate how populations of high-velocity stars can be leveraged to probe the binary and stellar remnant content in the cores of globular clusters.

An overview of the spectroscopic characterization and chemodynamical analysis of the RR Lyrae stars observed by the DESI survey

Gustavo Medina Toledo (University of Toronto)

Milky Way and the Local Group - Talk

In the Lambda CDM framework, the extended halo of the Milky Way and the kinematics of halo stars retain key information to place our Galaxy in a broad cosmological context and to understand the dynamical processes that govern galaxy and stellar evolution. RR Lyrae stars are among the most used outer halo tracers, as they are intrinsically bright distance indicators ubiquitous in the halo. Therefore, studying the physics of their stellar pulsations and their chemodynamics of halo with large spectroscopic surveys is crucial to reconstruct their evolution, the accretion history of our Galaxy and its mass distribution. For this contribution, we employ the rich dataset provided by the Dark Energy Spectroscopic Instrument (DESI) survey to build a catalog of ~6,000 RR Lyrae stars with homogeneously-derived spectroscopic properties (radial velocities and atmospheric parameters). We use the reported properties not only to investigate the physics of their pulsation (stellar physics), but also to study the formation and general properties of the Milky Way (Galaxy evolution). We present several applications of the DESI RR Lyrae catalog, such as studying the metallicity dependence of their pulsational properties (periods and amplitudes) and their connection with known Milky Way satellites and streams. Additionally, we follow a hierarchical Bayesian approach based on the phase-space distribution function of distant tracers to infer the Milky Way total mass and its cumulative mass profile within 250 kpc. We report the details of our analysis and address useful approaches to overcome the difficulties of studying stellar pulsators in large sky spectroscopic surveys (e.g., the correction for the pulsating component of RR Lyrae stars' spectroscopic properties from single-epoch observations). Lastly, we compare the properties of our catalog with existing spectroscopic catalogs and discuss the cosmological implications of our results. We will highlight the tantalizing potential of DESI and its complementarity with other large spectroscopic and photometric surveys, all of which will allow us to shed new lights on key aspects of stellar astrophysics and the formation and evolution of our Galaxy.

Chemodynamical Analyses of Ultra Faint Dwarf Galaxies: Star Formation, Galactic Outflows, and Dark Matter Profiles

Nathan Sandford (University of Toronto)

Milky Way and the Local Group - Talk

Ultra-faint dwarfs (UFDs) are the oldest, lowest mass, and most metal-poor galaxies in the Local Group, and their stellar populations encode a wide range of astrophysical insight on everything from the composition of dark matter to the physics of star formation, stellar evolution, and chemical enrichment in the early universe. While the intrinsic faintness of UFDs has historically precluded detailed study of their stellar populations, recent large observational investments, including wide-field stellar spectroscopic campaigns conducted by the Southern Stellar Stream Spectroscopic Survey (S5) and deep HST narrowband Ca H&K imaging have amassed ever-growing datasets of stellar chemistry and kinematics—enabling new statistical investigations of UFD formation and evolution. Here, I present results from chemodynamical analyses of these recent observations in two of the Milky Way's brightest UFDs, Eridanus II and Boötes I. Specifically, I demonstrate how a one-zone chemical evolution model can constrain key aspects of low-mass galaxy evolution from the UFD stellar metallicity distribution functions, including short, early, and inefficient star formation, and large galactic outflows. Using stellar kinematics measured out to large galactic radii, I also provide new constraints on the dark matter mass profile of Boötes I, its cuspiness, and the existence of multiple kinematic stellar populations. I conclude by discussing the prospects of future UFD chemodynamic studies as powerful new observing facilities, including JWST and 30-m class telescopes, allow us to characterize the stellar populations of fainter and more distant galaxies.

An extreme of an already extreme regime: characterization and chemistry of ultra-faint dwarf galaxy Eridanus IV

Mairead Heiger (University of Toronto, Department of Astronomy & Astrophysics)

Milky Way and the Local Group - Talk

Ultra-faint dwarf galaxies (UFDs) lie at an extreme of galaxy formation and evolution: they are the least massive, oldest, most chemically primitive, and most dark-matter dominated galaxies known. Eridanus IV (Eri IV) is a recently characterized UFD with the lowest known mean metallicity ($\langle[Fe/H]\rangle \sim -2.85$) and evidence of an atypical chemical enrichment history. Eri IV also has an unusually high J-factor, suggesting it is a good target for indirect dark matter detection. In this presentation, I will situate Eri IV in the current census of dwarf satellites and discuss the implications that its low metallicity has for the galaxy mass-metallicity relationship and the apparent plateau at the lowest masses. I will also introduce possible chemical enrichment scenarios and present the first chemical abundance analysis of Eri IV using high-resolution spectroscopic data from Magellan/MIKE of an extremely metal-poor member star.

The simultaneous globular cluster and dwarf galaxy origins of the Jhelum stellar stream

Andrew Li (University of Toronto)

Milky Way and the Local Group - Poster

The characterization of stellar streams reveals key information about the formation of the Milky Way and the nature of dark matter. Jhelum is one such stellar stream, that is unique in that multiple distinct components have been detected, generating much discussion about the possible origins of this stream. We report a comprehensive characterization and member list of the Jhelum stream using new line-of-sight velocity and metallicity measurements from the Southern Stellar Stream Spectroscopic Survey (S5) and proper motions from Gaia DR3. Using Gaussian mixture modeling, we identify stream members based on their radial velocities, metallicities, and proper motions. We also create an updated member list with hundreds more stars than previous literature, and report the radial velocity and proper motions along each section of the stream. We confirm the presence of two kinematically distinct components in Jhelum, and find the two-stream component model is preferred to alternative models, such as a traditional one-component model or a newly reported three-component model. Additionally, our findings for velocity and metallicity dispersions are consistent with a globular cluster progenitor for one stream component and a dwarf galaxy progenitor for the other. This suggests that a dwarf galaxy with a globular cluster companion began their infall into the Milky Way and were tidally stripped together. Additionally, preliminary results reveal that another stellar stream, Indus, might also share this unique structure. We discuss further implications of these findings that reveal a new formation mechanism that provides insight into the Milky Way's history

The star formation history and chemical enrichment of Sagittarius dwarf irregular galaxy Derived from long-period variable stars

Tahere Parto (Memorial University of Newfoundland)

Milky Way and the Local Group - Poster

We present a study of constructing the star formation history of Sagittarius dwarf irregular galaxy (SagDIG) employing the PARSEC−COLIBRI stellar evolutionary model and the mass-luminosity relation of long-period variable stars (LPVs). These stars are at the final stage of evolution, and their period-luminosity relation is a reliable distance estimator. To identify the LPVs in SagDIG, we performed multi-epoch observations using the 2.5 m Isaac Newton Telescope at La Palma. We detected 27 LPV candidates within two half-light radii of SagDIG, ten of them were in common with previous studies. By adopting the metallicity Z = 0.0002 for older populations and Z = 0.0004 for younger ages, we estimated that the star formation rate changes from 0.0005 ± 0.0002 M⊙ yr−1 kpc−2 (13 Gyr ago) to 0.0021 ± 0.0010 M⊙ yr−1 kpc−2 (0.06 Gyr ago). Moreover, by combining our time-averaged photometry and other available catalogs, such as Spitzer Space Telescope mid-Infrared photometry, we modeled the spectral energy distribution of our LPV candidates, estimated their mass-loss rate, and investigated its correlation with luminosity, amplitude, color, and optical depth. We also determined a distance modulus of μ = 25.27 ± 0.05 mag, using the tip of the red giant branch.

Searching for Milky Way Satellite Streams in the Distant Halo

Maia Wertheim (University of Toronto)

Milky Way and the Local Group - Poster

Stellar streams, formed from the tidal disruption of dwarf galaxies or star clusters, offer valuable insights into the formation and evolution of galaxies. These streams act as tracers, revealing the underlying gravitational potential and dark matter distribution of galactic systems. This research aims to locate new stellar streams in the Milky Way halo. Applying the matched filter technique to data from the Dark Energy Camera Legacy Survey (DECaLS) DR10 and the Halo Outskirts With Variable Stars (HOWVAST) survey, we create stellar density maps across a range of distance moduli. We report the identification of several potential stream candidates and recover many known streams from literature. We will present the results of this process, including the method, potential stream candidates found, and their comparison with known streams. Analysis of stream candidates will include investigations into their possible progenitors and members. By analyzing the stars stripped from these clusters we can begin to discover their past interactions, mass loss processes, and the influence of external gravitational forces. With approximately 100 known stellar streams and ongoing discoveries being made, our understanding of galactic processes continues to increase with each new find. Our results open the door to extending the use of this algorithm to other large scale surveys to discover new streams, including the newest data release of the DECam Local Volume Exploration (DELVE) survey, and the upcoming data from the Large Synoptic Survey Telescope (LSST).

Next-Generation Spectroscopic Surveys

An overview of the Euclid mission

Marco Bonici (Waterloo Centre for Astrophysics)

Next-Generation Spectroscopic Surveys - Talk

The Euclid satellite, after its successful launch in July 2023, has currently starting its observative campaign, which led to analyze our universe combining spectroscopic and photometric probes. It is a Stage IV galaxy survey and will measure spectroscopic redshift of tens of millions of galaxies and the shapes of billions of galaxies. I will give an overview of the different kind of measurements the satellite will provide, along with the analysis and modelling challenges we face in order to analyze the forthcoming data, finally showing some forecasts that show how well it is going to measure cosmological parameters.

The Effects of Interlopers in Next Generation Galaxy Surveys

Alan Nguyen (University of Waterloo)

Next-Generation Spectroscopic Surveys - Talk

In the near future, the Nancy Grace Roman Space Telescope and Euclid will begin to provide astronomers with a huge wealth of new data. While these catalogues will offer unprecedented statistical power for measurements like Baryon Acoustic Oscillations (BAO), their use of grism spectroscopy can introduce sources of systematic error. In particular, galaxy samples resulting from single line redshift measurements can have relatively high fractions of interlopers due to emission line confusion. As interlopers with a small displacement between true and false redshift have the strongest effect on the measured clustering, the fraction of such interlopers and their clustering must be well known to accurately model the BAO signal. I will first introduce a new method to self-calibrate these quantities by shifting the contaminated sample towards or away from the observer along the line of sight by the interloper offset, then measuring the cross-correlations between these shifted samples. The contributions from different components of the correlation function are shifted in scale in this cross-correlation compared to the auto-correlation of the contaminated sample, enabling the decomposition and extraction of the contaminating component terms. I will also introduce a novel statistical technique called the Leave One Out-Probability Integral Transform (LOO-PIT) to provide a clear diagnostic for model validation in cosmology. This technique is sensitive to small biases in cosmological parameters due to the fitting model, and thus provides a complementary and resource-light check to any model fit.

Updates to the Maunakea Spectroscopic Explorer: Thousands of Fibers, Infinite Possibilities

Andrew Sheinis (CFHT)

Next-Generation Spectroscopic Surveys - Talk

MSE is a massively multiplexed spectroscopic survey facility that we anticipate replacing the Canada-France-Hawaii-Telescope in the 2030s. If built as planned, it will be the first major astronomical facility to reuse an existing site. MSE is slated to occupy the CFHT site on Maunakea, utilizing the same building footprint and approximate dome size. This 11-m plus telescope, with its 1.5-2.0 square degree field-of-view, will observe over 18,000 astronomical targets in every pointing from 360 nm through H-band at low/moderate resolution (R=3,000/7,000) and high (R=30,000+). A fiber positioner will allow the system to position individual fibers in parallel to enable simultaneous full-field coverage for both resolution modes. MSE will unveil the composition and dynamics of the faint Universe and impact nearly every field of astrophysics across all spatial scales, from individual stars to the largest scale structures in the Universe, including (i) the ultimate Gaia follow-up facility for understanding the chemistry and dynamics of the distant Milky Way, including the outer disk and faint stellar halo at high spectral resolution (ii) galaxy formation and evolution at cosmic noon, (iii) derivation of the mass of the neutrino and insights into inflationary physics through a cosmological redshift survey that probes a large volume of the Universe with a high galaxy density. The instrument suite, dedicated to large-scale surveys, will enable MSE to collect massive data: equivalent to a full SDSS Legacy Survey every several weeks. We present an update on the major systems development for MSE and the ongoing process of evaluating improvements to the baseline telescope design.

Cosmological Implications from DESI Y1 BAO and Future Forecasts

Hanyu Zhang (University of Waterloo)

Next-Generation Spectroscopic Surveys- Talk

We present cosmological results from the measurement of baryon acoustic oscillations (BAO) in galaxy, quasar and Lyman-α forest tracers from the first year of observations from the Dark Energy Spectroscopic Instrument (DESI), to be released in the DESI Data Release 1

Fast and accurate computation of 3x2pt statistics for weak lensing surveys

Sofia Chiarenza (University of Waterloo)

Next-Generation Spectroscopic Surveys - Poster

The accurate computation of 3x2pt statistics plays a crucial role in understanding the large-scale structures in the universe using cosmological surveys. While the Limber approximation has traditionally provided a simple and efficient method for this computation, its limitations become apparent in the context of recent and future surveys, demanding more precise and efficient techniques. In this work, we propose a novel, computationally fast, approach to compute 3x2pt statistics without relying on the Limber approximation, ensuring both efficiency and precision.

Our method addresses the challenge of dealing with a 3D integral with Bessel functions by employing a combination of techniques, effectively handling the oscillatory nature of the Bessel functions.

An important aspect of our approach is its compatibility with automatic differentiation techniques, facilitating likelihood exploration and maximization even in high-dimensional parameter space. This feature enhances the usability of our method in cosmological parameter estimation tasks.

Overall, our proposed method offers a promising solution for accurately computing 3x2pt statistics in upcoming cosmological surveys, addressing the shortcomings of the Limber approximation and providing a valuable tool for extracting information from large-scale structure. In particular, the tool provided will be of critical importance for the Euclid survey, enabling the core scientific analyses to be performed using modern statistical inference techniques.

Cosmological constraints from voids: the power of emulating the void-galaxy cross-correlation

Tristan Fraser (University of Waterloo Centre for Astrophysics)

Next-Generation Spectroscopic Surveys - Poster

We present a new simulation-based model of galaxy clustering around cosmic voids, which is able to accurately predict the void-galaxy cross-correlation function. This emulator, which is based on a neural-network trained on the AbacusSummit suite of cosmological simulations coupled with the halo occupation distribution (HOD) model, is able to robustly predict redshift-space distortions and Alcock-Paczynski effects around cosmic voids, recovering unbiased cosmological constraints. We apply our pipeline to the BOSS CMASS galaxy catalog, obtaining competitive constraints on the LCDM cosmological parameters. We find consistency with previous results from voids analyses performed with template-based methods, using our more robust and accurate approach. We explore extensions to the base LCDM model where we allow a constant dark energy equation of state parameter to vary freely. We outline how this methodology can be applied to the ongoing DESI survey.

Testing the Current Standard BAO Fitting Methodology on a Wide Range of Cosmologies

Batia Friedman-Shaw (University of Waterloo, Perimeter Institute)

Next-Generation Spectroscopic Surveys - Poster

Cosmology is currently burdened by the H0 tension, which has revealed a need for improvement in the accuracy of measurements of cosmic expansion. The most useful standard ruler used to measure H0 is Baryon Acoustic Oscillations (BAO) which project the sound horizon at recombination into the pattern of galaxies observed in large surveys. By calibrating the sound horizon within a LCDM or other model, we can measure H0 with BAO. The method needs to be tested, as it involves data compression and a number of approximations. Previous work doing this testing (e.g. Carter et al 2019) is now out of date as the field has advanced in the last 5 years in a number of ways. There has been an increase in the amount of observational data available via next-generation galaxy surveys like DESI and Euclid, new galaxy simulations (AbacusSummit) are now available that contain mock catalogs for nearly 100 different cosmologies, and further improvements to the BAO fitting methodology within the BAO analysis pipeline have been developed. In light of these changes, we present work testing the upgraded BAO analysis pipeline as a robustness check on its accuracy.

MSE Science Case Updates for the QM Design

Peter Frinchaboy (TCU/CFHT)

Next-Generation Spectroscopic Surveys - Poster

The updated telescope design significantly enhances the science possible with the Maunakea Spectroscopic Explorer (MSE), a massively multiplexed spectroscopic survey facility that will replace the Canada-France-Hawaii-Telescope in the coming decade plus. We will be updating the science case to take advantage of the improved fiber density and thereby survey speed is possible by using a new quad mirror (QM) 12-meter telescope design with a 1.5 square degree field-of-view and able to observe simultaneously 18,000 - 20,000 targets. By utilizing MSE's both low/moderate resolution (360 nm through H-band at R=3,000/7,000) and high resolution (360-1000nm at R=30,000), new discoveries will be possible in nearly every field of astrophysics across all spatial scales, from individual stars to the largest scale structures in the Universe, including (i) the ultimate Gaia follow-up facility for understanding the chemistry and dynamics of the Milky Way and Local Group at high spectral resolution, (ii) galaxy formation and evolution at cosmic noon, (iii) derivation of the mass of the neutrino and insights into inflationary physics through a cosmological redshift survey that probes a large volume of the Universe with a high galaxy density. The instrument suite, dedicated to large scale surveys, will enable MSE to collect a massive amount of data: equivalent to a full SDSS Legacy Survey every several weeks.

Investigations into Individual Interesting Broad Absorption Line Quasars in the Sloan Digital Sky Survey's Black Hole Mapper - Reverberation Mapping

Lucas Seaton (York University)

Next-Generation Spectroscopic Surveys - Poster

My research aims to produce a well-defined time-domain Broad Absorption Line (BAL) quasar (QSO) catalogue for the Sloan Digital Sky Survey - Reverberation Mapping (SDSS-RM) and the Black Hole Mapper - Reverberation Mapping (BHM-RM) datasets, including appearing and disappearing troughs, and more rigorously model the constraints variability places on the outflow's distance and density values when rapid variability is seen. I plan to present preliminary results on two individual interesting BALQSOs, RM284 and RM520, which have had rudimentary velocity and redshift estimates of their outflows conducted.

Weighted averages of the multi-epoch spectra are used to create various composites and a reddened power law model is used to fit the continua of each quasar to remove extinction in the quasar host galaxy, so that identification of the transitional features across multiple epochs can be more readily assessed. Relatively Line Free regions in the spectra that are absent of any transitional features are used to estimate the continuum level for the fit. RM284, a quasar at z~2.341 that is

no longer being monitored by the Sloan collaboration, had an outflow that disappeared in June 2020. The outflow was travelling at ~(34000-56000) km/s and consisted of C IV, Si IV, and possibly Al III.
Due to the large velocity of the outflow its Si IV component is obscured by Ly α emission and its Al III components are buried in the Ly α forest. RM520, a quasar at z~3.294 that is still being monitored by the Sloan collaboration, has an outflow that emerged in June 2015. The outflow is travelling at ~(20000-32000) km/s and consists of C IV, Si IV, P V, NV, and O VI. The presence of low-abundance absorption lines like P V in outflows imply that the more common absorption lines, such as C IV and Si IV, must be highly saturated. Furthermore, the P V presence requires that the outflow has large column densities and large ionization parameters.

A Record-Breaking Extremely High-Velocity Outflow Quasar

Marianna Veltri (York University)

Next-Generation Spectroscopic Surveys - Poster

We report broad, intrinsic C IV and Si IV absorption at outflow velocities approaching 90,000 km/s in a weak-lined, radio-quiet SDSS quasar (J2318).
This intrinsic C IV absorption outflow velocity sets a new record for outflows first identified at UV wavelengths, surpassing the previous record of approximately 60,000 km/s. Furthermore, this is the highest Si IV absorption outflow velocity ever seen, and the presence of Si IV implies a high column density and thus a powerful outflow. The C IV absorption was present but weaker 795 rest-frame days earlier in an SDSS spectrum from 2015, but was not recognized until the second SDSS spectrum was obtained in 2023. Due to the uncertain redshift from the weak, broad UV lines, we obtained Gemini DDT GNIRS spectroscopy and secured a redshift of z = 2.6775 from the strong, broad H-alpha line. We present measurements of the absorption trough equivalent widths, velocity widths, and maximum depths in both spectra and compare to measurements of those quantities in other broad absorption line and extremely high-velocity outflow quasars.

Star Formation and the ISM

Rotational Contour modelling of diffuse interstellar bands

Charmi Bhatt (University of Western Ontario)

Star Formation and the ISM - Talk

The diffuse interstellar bands (DIBs) are a set of about 600 absorption features that are seen ubiquitously from the near-UV to the near-IR. They are thought to be caused by interstellar molecules, most likely large carbonaceous species. Although some of the DIBs were discovered more than a hundred years ago, the precise carrier species remain unidentified, except for C60+, which has been shown to be responsible for 2 strong and 3 weak DIBs in the near-IR. Some DIBs show double and triple sub-peaks which resemble unresolved rotational contours of large molecules. Their profiles also show clear variations along lines of sight probing different physical conditions. Analyses of such profiles can constrain the sizes and geometries of the DIB carriers and the physical conditions of the interstellar environments in which they reside. We present the results of such an analysis with a focus on the well-known DIB at 6614 Å that shows a clear triple peak substructure and variations along different lines of sight. We performed rotational contour modelling for the first time with a focus on reproducing the profile variations. We determined that the substructures in λ6614 DIB can be reproduced if the carrier is a disk-like molecule containing ~54 C atoms. The key new finding of our work is that variations in the profile cannot be attributed solely to changes in temperature across different lines of sight, but contain a significant contribution from variations in the line width, corresponding to velocity dispersions ranging from 2.7 to 4.1 km/s. The derived line width for λ6614 shows a good correlation with the linewidth of CH+ which suggests that the λ6614 DIB carrier resides near the HI to H2 transition.

Using hyperbolic conduction to model superbubbles

Nicholas Owens (McMaster University)

Star Formation and the ISM - Talk

Superbubbles are vast bubbles of hot gas driven by clustered supernova. They readily break free from galactic disks and power galactic winds. They regulate not just star formation, but the baryon content of galaxies by entraining disk gas into the circum-galactic medium. This behaviour relies on high bubble temperatures which are controlled by Spitzer thermal conduction. Hyperbolic thermal conduction is a more physical replacement for traditional, parabolic, conduction equations where heat is only allowed to propagate at the speed of the carrying particles, electrons. It is also computationally cheaper, without expensive short timesteps. We present the first implementation of hyperbolic conduction in smoothed particle hydrodynamics (Gasoline parallel code). We demonstrate that we recover parabolic conduction in the limit of moderate conductivity. We show qualitatively new behaviour for high conductivity. Superbubbles self-regulate to intermediate temperatures and conductivities. Our simulations produce bubbles that are qualitatively similar to those produced with parabolic conduction but at lower computational expense.

A galaxy-scale statistical view of filaments in MHD simulations of a Milky Way galaxy

Rachel Pillsworth (McMaster University)

Star Formation and the ISM - Talk

Results from JWST and the PHANGS surveys represent major breakthroughs in the field of star formation as they showcase the many complex structures that exist ubiquitously on spatial scales from the kpc galactic disk down to the 0.1 pc scale protostellar clumps. A hierarchy of filaments and superbubbles dominate the structure of spiral galaxies like our Milky Way. These filaments form from supersonic turbulence when shock waves collide and form overdensities. Above a critical mass per unit length, filaments are capable of fragmenting into a filamentary sub-structure. In Zhao et al. 2024, we developed high-resolution galactic multiscale MHD simulations in RAMSES which clearly show the formation of filamentary hierarchies ranging from GMC to cluster formation scales. As a next step to that project, we characterize the physical properties of the filamentary structures across the Milky Way disk. I will show our analysis of the effects of galactic environment on lengths, masses, and line masses of filaments by characterizing the systematic properties of filaments throughout the disk. I will also discuss the effects of magnetic fields and gas flows on the growth and stability of these filaments. Finally, I will show a zoomed-in look at two areas of the galactic disk, presenting analysis of the 100-pc cluster-forming filaments. With this, I will discuss the connection we find between galactic environment and star-cluster formation.

Tracing 3D Magnetic Field Structure Using Dust Polarization and the Zeeman Effect

Brandon Shane (Queens University)

Star Formation and the ISM - Talk

Understanding magnetic field strengths and morphology within molecular clouds is crucial for unraveling the intricacies of star formation dynamics and galactic evolution. Yet, the three-dimensional mapping of these fields remains a daunting

task due to the limitations of observational techniques. While dust polarization and the Zeeman effect offer insights into different aspects of the magnetic field, reconciling their measurements has been a challenge. Leveraging 3D numerical simulations conducted with the AREPO code, we explore the interrelation of different measurable under different conditions. By comparing synthetic dust polarization observations giving the plane of sky B-field orientation and Zeeman measurements giving measurements of the average LOS field strength
, we discern the inclination angle and strength of the magnetic field in regions where both Zeeman and dust polarization data are available. Notably, we find that under certain conditions, such as sub-Alfvénic clouds, dust polarization can accurately determine the inclination angle, while a comparison between polarization and Zeeman observations can be used to estimate the magnetic field strength. We find that insights gained from analyzing polarization angle dispersion and Alfvén Mach Number provide valuable clues about magnetic field strength and orientation, paving the way for qualitative measurements of magnetic field properties in star-forming regions.

Seed black hole accretion in star clusters

Yanlong Shi (Canadian Institute for Theoretical Astrophysics)

Star Formation and the ISM - Talk

Formation of black hole (BH) seeds and the subseqent accretion towards intermediate-mass and supermassive BHs are still open questions. Here we present some recent progress on the topic specified in sub-kpc to parsec scale star-forming environments, which is based on a suite of simulations of star formation/feedback and BH accretion/feedback in giant molecular clouds. We quantify the environment for possible super-Eddington accretion, and study the self-regulation of the BH mass growth by its feedback (radiation, jets/winds, cosmic rays). Moreover, we show that in dense star clusters, interactions between stars and BH seeds can boost BH accretion through the hirerarchical assembly of the clusters.

The Accuracy of Dusty Turbulence Simulations

Terrence Tricco (Memorial University of Newfoundland)

Star Formation and the ISM - Talk

Dust extinction maps correlate with observations of CO in star-forming molecular clouds. This implies that dust traces the bulk gas, making it an important ingredient for understanding the structure of molecular clouds. Dust observations permit inference of the total gas mass through the dust-to-gas ratio, canonically taken to be 1:100. Numerical simulations of dust in turbulent environments provide evidence of dust-gas decoupling, that is, local variations in the dust-to-gas ratio. This has implications on cloud mass estimates. However, there are contrasting numerical results on the degree of decoupling and for which grain sizes. This tension seems related to the choice of numerical method used to model the dust. In this work, we simulate dusty, driven turbulence using the Phantom smoothed particle hydrodynamics (SPH) code. We conduct one set of simulations where gas and dust are their own individual species of particles, and another where particles represent a mixture of dust and gas. The first method works well for large dust grains, and the second for small dust grains. We target 3, 10 and 20 micron dust grain sizes as a middle ground on accuracy between the two dust methods (Stokes number ~ 1). We find that both methods qualitatively agree on the dust density and local dust-to-gas ratio distributions (dust-gas coupling). However, increases in the dust-to-gas ratio can be exaggerated when dust and gas are modeled separately. When modeled as a combined fluid, reductions in the dust-to-gas ratio can be under-estimated.

Unraveling the Radiative Properties of the Interstellar Medium: The First 3D Map of the Interstellar Dust Temperature

Ioana Zelko (CITA-University of Toronto)

Star Formation and the ISM - Talk

Recent years have brought rapid progress in mapping dust density in 3D, but attempts to derive its temperature and other optical properties have been few. Here, we present the first comprehensive large-scale, three-dimensional map of dust temperature in the Milky Way. We show that this methodology has enough precision to discern temperature differences with 3σ significance along the line of sight. Star formation regions are clearly observable in the map. I will show how this technique and the resulting 3D dust temperature map open up new areas of research into models of galactic magnetic field in 3D, polarization maps, cosmological foreground analysis, cosmic ray propagation for dark matter searches, correlations with star forming regions and other data catalogs.

Massive binaries in young massive star clusters

Claude Cournoyer-Cloutier (McMaster University)

Star Formation and the ISM - Talk

Most massive stars are born in young massive clusters (YMCs), which assemble hierarchically within giant molecular clouds (GMCs). This picture is made yet more complex by the fact that almost all massive stars are born in binaries. Understanding how their orbits evolve while the cluster is still actively forming stars is crucial to our understanding of YMC formation in the local universe and of globular cluster formation at high redshift. Mass transfer in close massive binaries releases large quantities of enriched material (with the correct signature to explain multiple stellar populations) into the surrounding cluster. Dynamically, few-body interactions can also eject massive stars from the central regions of their natal cluster, changing the location in which they release enriched material. Those effects, however, depend strongly on the distribution of orbital separations for massive binaries. As massive stars are both rare and short-lived, observations are not sufficient to understand how a population of massive binaries evolves throughout massive cluster formation. In this Talk, I will present new simulations of cluster formation with magneto-hydrodynamics, stellar dynamics, star formation, and stellar feedback. I will discuss how hierarchical YMC formation changes an initial population of binaries, how the presence of massive binaries changes the feedback in YMCs, and how the impact of those processes depends strongly on GMC properties.

Investigating Extreme Scattering Events by Volumetric Ray-tracing

Kelvin Au (University of Manitoba)

Star Formation and the ISM - Poster

Extreme scattering events (ESEs) are observed as significant (>50%) drops in radio flux density occurring over prolonged (weeks to months) periods in some light curves from pulsars and quasars. Theory suggests ESEs are caused by tiny-scale ionized structures (TSIS) on AU-size scales acting as divergent plasma lenses, which are predicted to be highly over-pressured relative to the surrounding interstellar medium (ISM). This is problematic because it suggests TSIS have short lifetimes and can potentially inject large amounts of energy into the ISM depending on the volume filling factor. Thus, studying ESEs and the TSIS that are theorized to cause them sheds insight into the small-scale structure of the ISM. We utilize a numerical approach by creating three-dimensional plasma lenses, solving the eikonal equation to ray-trace through them, and constructing light curves with ESEs. We test the validity of this method by comparing to known analytical solutions – a point mass gravitational lens and a point diverging lens. We show examples of plasma lenses with a spherically Gaussian-distributed electron density, as well a filamentary model inspired by Grafton et al (2023) with ESE-like light curves produced by the former. This method allows us to explore plasma lenses with sheet-like geometries, and volumetric turbulence, which is currently in progress.

The impact of protostellar feedback on dense gas in nearby star-forming regions

Rachel Friesen (University of Toronto)

Star Formation and the ISM - Poster

Star formation across all mass scales drives feedback, from protostellar outflows and jets through to ionizing radiation, stellar winds, and ultimately supernovae in the case of high mass stars. Accurate prescriptions for feedback effects are critical to modelling star formation rates over time. Here, we analyze the impact of protostellar feedback from nearby star-forming regions on the surrounding dense gas, across a range of mass scales and star formation rates. In high resolution observations towards the Serpens South protocluster, we find that gas temperatures and non-thermal linewidths both increase towards the centre of the young stellar cluster. The non-thermal velocity dispersion and the gas temperature are strongly correlated, and we argue that the observed increases are primarily a result of mechanical heating and interaction between the protocluster-driven outflows and the dense gas. As a result, cores near the protocluster are more likely to be super-virial, and must accrete more mass to become gravitationally unstable. Feedback from low-mass stars will thus shift future star formation in the cluster to higher masses by a factor ~2. More broadly, we present similar correlations in the star-forming clouds mapped by the Green Bank Ammonia Survey, providing some of the first large-scale observational analysis of the effects of feedback in primarily low-mass star-forming regions on the next generation of stars.

Characterizing Fine Metallicity Fluctuations Across Galactic Structures with SIGNALS

James Garland (David A. Dunlap Department of Astronomy and Astrophysics, University of Toronto)

Star Formation and the ISM - Poster

Galactic disks have been known for some time to exhibit negative radial abundance gradients, in line with an "inside-out" model of galaxy growth. However, dynamical processes, especially those associated with nonaxisymmetric features such as bars and spiral arms, can lead to varied mixing of metal-rich gas throughout the disk. Indeed, subtle azimuthal variations in metallicity on the order of 0.01-0.1 dex can reveal the intricate flow of enriched gas through galaxies. To observe such fine chemical fluctuations, we turn to the Star formation, Ionized Gas, and Nebular Abundances Legacy Survey (SIGNALS), a program that imaged over 50,000 H II regions in 31 nearby galaxies on spatial scales down to ~1 pc and spectral resolutions of R ≈ 5000. We examine the 4,285 emission-line regions recorded in the face-on grand design spiral galaxy NGC 628. Using Bayesian inference, we simultaneously fit each region's emission-line fluxes to large grids of photoionization models, yielding well-constrained chemical abundances. These grids, provided by the Mexican Million Models database (3MdB), reflect an expansive parameter space of physical conditions. To obtain a robust quantification of galactic structure, we use novel machine learning models trained on morphologically classified galaxy images to construct a weighted map that smoothly delineates arm and inter-arm regions. Together, these precise abundances and morphological classifications form a powerful probe of subtle chemical fluctuations associated with galactic structures. We highlight the azimuthal trends measured in NGC 628, compare approaches to quantifying local variations, and frame our results in the context of gas enrichment and mixing models.

NGC 6946: HII Regions and Star Formation

Raina Irons (University of Toronto)

Star Formation and the ISM - Poster

We study NGC 6946, a face-on spiral galaxy located at a distance of 5.5 Mpc using the neutral atomic Hydrogen (HI) and ionized atomic Hydrogen (HII) content, two key components in the Interstellar Medium (ISM). Our project focuses on characterizing the star forming rate and the star formation efficiency in the HII regions of NGC 6946 using various emission lines. We present these results as functions of the galactocentric radius of NGC 6946 and discuss the implications of their trends. In addition we investigate two different methods to estimate the metallicity content of the HII regions using the [OIII]λ 5007 and [NII]λ 6583 emission lines and another relation using the [NII]λ 6583 and Hα lines. Using the two methods we confirm their consistency and present their trends as a function of the galactocentric radius. This project uses data from the SITELLE instrument at the Canada-France-Hawaii Telescope, which covers Hα and Hβ emission, along with ancillary data of HI and CO emission.

H II region candidates in M94 with SIGNALS

Emma Jarvis (University of Toronto, Department of Astronomy & Astrophysics)

Star Formation and the ISM - Poster

The study of ionized gas regions provides important information on star formation mechanisms, stellar feedback and, more globally, galaxy evolution. By studying large ensembles of these regions we can learn about the role of the local environment on the star formation process. We present observations of M94 from The Star formation, Ionized Gas, and Nebular Abundances Legacy Survey (SIGNALS); the largest and most detailed spectroscopic study of star-forming region properties in different galactic environments. We use data cubes from the imaging Fourier transform spectrometer SITELLE which has a high spatial resolution (0.8") and large field of view (11'x11'). With these data cubes, we perform corrections to the observed data by subtracting the stellar population contribution and the sky contribution before extracting the corrected fluxes of observed emission lines (including Hα, Hβ, O[III] and N[II]). We then use a technique adapted to imaging spectroscopy to identify and extract parameters from H II region candidates found in M94. This enables the extraction of the position, velocity, luminosity, size, dust extinction, and the emission-line fluxes and line ratios for individual spaxels as well as the integrated spectrum for each region. All of these parameters are compiled in a new HII region catalog ideal to study variations in the HII region characteristics over their environment.

The role of dynamical equilibrium pressure in elevated molecular gas ratios and star formation of cluster galaxies

Taavishi Jindel (McMaster University)

Star Formation and the ISM - Poster

The environment of a galaxy influences its gas and star formation properties via evolutionary mechanisms, such as ram pressure stripping and tidal stripping. In particular, the molecular to atomic gas ratio and dynamical equilibrium pressure are key parameters for understanding star formation in galaxies. I use 1.2kpc data for galaxies in the Virgo Cluster from the VERTICO survey and for field galaxies from the HERACLES survey to study the spatially resolved relationship between molecular gas ratios and star formation properties (eg. star formation rate, molecular gas depletion time) in galaxies as a function of dynamical equilibrium pressure. I find that cluster galaxies have higher molecular gas ratios at a given dynamical equilibrium pressure than field galaxies. Within both samples there is strong galaxy to galaxy variation in the relationship driven by the gas content of the galaxy. To gain a better understanding of the roles that cluster pressure and ram pressure stripping play in the elevated molecuar gas ratios of cluster galaxies, I explore how the HI-deficiency, cluster pressure, and the extent of ram pressure stripping the galaxies experience impact the relationship.

Mass segregation in groups and clusters of star-forming dense cores

Helen Kirk (HAA-NRC)

Star Formation and the ISM - Poster

Most stars form in clusters and groups, yet many of the processes and conditions associated with star formation beyond the idealized isolated formation model are not well understood. Here, we focus on one component of star formation within a group or cluster, namely the initial spatial distribution of stellar masses. The presence of primordial mass segregation within young stellar clusters has been debated for many years, as numerous observational challenges make it difficult to distinguish primordial mass segregation from rapid early dynamical mass segregation. The JCMT Gould Belt Survey, which mapped the full population of dense star-forming cores within nearby (<500 parsec) molecular clouds visible in the northern hemisphere, offers a novel avenue to address this question. Many of the observational challenges in studying mass segregation in young stellar systems are diminished or removed entirely by studying instead dense cores in the midst of forming stars. Our results, validated by using several independent mass segregation measures, suggest that mass segregation exists along a continuum in these young star-forming systems. More vigourously star-forming environments, like Orion, show strong signs of mass segregation, while more quiescent environments, such as Taurus, do not. Models of star and cluster formation therefore need to account for this varied behaviour in dense core populations.

Synthesis of Complex Organics in Planetary Nebulae

Sun Kwok (University of British Columbia)

Star Formation and the ISM - Poster

Complex organics are observed to be synthesized in the planetary nebulae stage of stellar evolution. These organics are ejected into the interstellar medium and may have enriched the primordial solar system, leading to the reservoir of complex organics in comets, asteroids, and interplanetary dust particles. The infrared signatures of such mixed aromatic/aliphatic organic nanoparticles (MAONs) are discussed through computational models and vibrational analysis of complex organics. An evolutionary scenario of synthesis pathway from simple molecules to complex organics is presented.

Initial mass function in intense star cluster formation

Christopher Matzner (University of Toronto)

Star Formation and the ISM - Poster

I examine how the stellar mass function arises during the formation of a massive globular cluster. Dust reprocessing of starlight ties stellar mass scales to fundamental constants, while radiation pressure is the primary feedback. Mass function slopes reflect both turbulence and fragmentation effects. A key question is the initial abundance of very massive stars whose winds might enrich the star forming environment for future generations.

Does OMC 2/3 have peculiar dust grains?

Parisa Nozari (Queen's university)

Star Formation and the ISM - Poster

Previous research on the OMC 2/3 star-forming filament in the Orion Molecular Cloud has produced conflicting values for the dust opacity index, beta, on core scales. Typical values of beta on core scales are ~ 1.7, whereas from single-dish data, OMC 2/3 has beta values consistent with expectations when measured with wavelength < 2 mm but has a flatter index of beta <1 when measured with 3 mm data. The cause of this discrepancy is unknown. We investigate the value of beta in six protostellar cores in OMC 2/3 using NOEMA from 2.9 to 3.6 mm and ALMA-ACA in Bands 4 and 5 from

(1.6 to 2.1mm). We confirm a flattened dust opacity index of beta <1 at ~ 3 mm. The ALMA data however show that some cores have flattened slopes in the 2 mm range whereas other ones show steeper slopes consistent with expectations for cores in the same wavelength range. These results indicate different explanations for the flattened slopes. For some sources, we attribute the flattened slopes due to a bias in the flux coming from the embedded protostellar disk, however this explanation cannot describe all the sources in the sample. The remaining sources may have this enhanced long wavelength flux due to dust grain growth on core scales or unusual properties in the dust grains themselves. Both cases have profound implications for our understanding of dust grain evolution and for how we derive masses from thermal dust emission. We discuss these implications and propose why such elevated emission may be detected on core scales in Orion.

Understanding the role of magnetic fields in the early stages of star formation

Ayush Pandhi (University of Toronto)

Star Formation and the ISM - Poster

Magnetic fields are often oriented perpendicular to filamentary structure within molecular clouds (MCs), suggesting that they assist in regulating gas flows towards high-density MC regions. The overdensities in these filaments (“dense cores”) are progenitors of future stellar systems. Analysis connecting dense core observations with polarimetry are sparse and there is no consensus on what role magnetic fields play in this early stage of star formation. In this work, we cross-match 399 dense cores identified in the Green Bank Ammonia survey (providing velocity distributions) with continuum observations using Herschel and the James Clerk Maxwell Telescope (providing core morphology, size, and mass) and with Planck dust polarization at 353 GHz (providing plane-of-sky magnetic field orientation). We produce the largest catalog of dense cores with angular momentum information to date and compare their core orientation and rotation axes with the ambient magnetic field. We find no global preference for alignment/anti-alignment, suggesting that magnetic fields do not play a dominant role in the evolution of most dense cores. Yet, we see preferred anti-alignment between core orientation and magnetic fields specifically for protostellar cores, which is in agreement with simulations of core-contraction in magnetically-regulated environments or cases where cores grow via anisotropic accretion.

Magnetized Galaxies – Star Formation, Disk Stability, and Spiral Arms.

Hector Robinson (McMaster University)

Star Formation and the ISM - Poster

Magnetic fields are present in all scales of astrophysics and can have important implications to galaxy evolution and star formation. Previous work has investigated the evolution of magnetic fields in galactic environments, but by using magnetohydrodynamic (MHD) simulations we instead investigate how magnetic fields affect the evolution of their host galaxy. To that end we conduct MHD simulations of isolated disk galaxies with the AMR code Ramses. We initialize the galaxies with a variety of magnetic field strengths and configurations, and include other physics such as stellar feedback, star formation, gas cooling, and turbulence. We then isolate the effects of magnetic fields on the distributions of gas, spiral structures, and shaping of the interstellar medium. We find that magnetized galaxy disks have less star formation than if they were purely hydrodynamic, due to an enhanced stability against collapse and reduced amount of cold gas. We also demonstrate how the expansion of supernova bubbles is significantly limited by the inclusion of magnetic fields. Lastly, we show that galaxies with stronger spiral arms result in higher overall field strengths, demonstrating that dynamo amplification is closely tied to a galaxies spiral features. Magnetic fields contribute to the regulation of star formation in the galaxies with minimal free parameters, helping to add to the predictive power of galaxy simulations. We discuss the overall implications of using MHD in galaxy simulations.

Weighing the Protostars in VLA 1623

Sarah Sadavoy (Queen's University)

Star Formation and the ISM - Poster

VLA 1623 is a very young, nearby protostellar system consistent of four sources in the first few hundred kyr of formation. We present ALMA Band 7 molecular line observations in C17O (3-2) of these young objects. The observations capture the circumbinary disk around VLA 1623A and the outflow cavity walls of the collimated outflow. We further detect red-shifted and blue-shifted velocity gradients in the circumstellar disks around VLA 1623B and VLA 1623W that are consistent with Keplerian rotation. We use the radiative transfer modeling code, pdspy, and simple flared disk models to measure stellar masses of 0.41 Msun, 1.9 Msun, and 0.64 Msun for the VLA 1623A binary, VLA 1623B, and VLA 1623W, respectively. These results represent the strongest constraints on stellar mass for both VLA 1623B and VLA

1623W, and the first measurement of mass for all stellar components using the same tracer and methodology. We use these masses to discuss the relationship between the young stellar objects (YSOs) in the VLA 1623 system. We find that VLA 1623W is unlikely an ejected YSO, as have been previously proposed. While we cannot rule out that VLA 1623W is a unrelated YSO, we propose that it is a true companion star to the VLA 1623A/B system and that the these stars formed in situ through turbulent fragmentation and have had only some dynamical interactions since their inception.

Pulsar Scintillation in the Local Bubble

Ashley Stock (University of Toronto)

Star Formation and the ISM - Poster

Small structures in the interstellar medium cause the intensity of compact radio sources to vary on timescales of minutes -- a phenomena called scintillation. Measurement of scintillation give us information about the geometry and electron density gradients of the interstellar medium structures but cannot tell us about the physical gas properties such as temperature or ionization fraction. However, with significant recent improvements in 3D dust mapping enabled by GAIA it has become much easier to connect features in the interstellar medium with their distance. I will discuss comparisons between nearby scintillation structures and 3D dust maps, focusing especially on connections with the Local Bubble.

Confirmation of the 3D Dust Temperature Map's Correlation with 3D Stellar Radiation Fields

Joseph Tang (CITA / UTM)

Star Formation and the ISM - Poster

The 3D dust temperature map is a defining leap toward understanding the complexity of interstellar dust. It was created by modelling a modified black body with Planck emission data while making no assumptions about the radiative power obtained by neighbouring stars which is the leading theory for where interstellar dust obtains its energy. In this Talk, I will elucidate how we calculated the correlation coefficient between interstellar radiation fields and the temperature of the dust in 3D. This was done by first creating the first-ever 3D interstellar radiation field and then comparing the stellar radiation on the dust with its temperature. Through this, it was shown that interstellar dust is heated, and strongly correlated with surrounding stellar radiation. This validation of the 3D dust temperature map allows for the creation of 3D magnetic field morphology, discovery of new star formation regions, disentangling cosmological foregrounds, probing dust optical properties and deriving new theories for star formation processes. To further expand our understanding of interstellar dust, future projects could explore the radiative transfer of the interstellar radiation field through the dust, and include additional catalogues with hot OBA stars as they dominate the interstellar radiation field. Additionally, higher resolution dust temperature maps that are in the works could help to constrain this correlation.

Dense Annular Rings found in Two Class 0/I Protostellar Disks

Shamus Tobin (Queen's University)

Star Formation and the ISM - Poster

We select two protostellar disks that are less than 500,000 years old, Oph IRS 63 and GSS 30 IRS 3, which have evidence of annular rings. For each disk, we use multi-wavelength, between 870 and 2000 microns, observations from ALMA to constrain disk models with and without rings using radiative transfer code, pdspy. We find that the models containing rings produce superior fits to both disks and that the location of the rings match previous studies. Additionally, we find that each ring is approximately 60% denser than its underlying disk, which could make these rings more likely locations for future pebble accretion, resulting in the formation of planetesimals and eventually planets.

Making of Mock Maps for the Line Intensity Mapping Experiments

Doğa Tolgay (1. Canadian Institute for Theoretical Astrophysics 2. University of Toronto)

Star Formation and the ISM - Poster

Line Intensity Mapping (LIM) experiments are innovative techniques for studying structures at high redshift. They allow us to uncover previously inaccessible astrophysical data by making 3D tomographic maps with 2D spatial line intensity fluctuations. As efforts like COMAP progress in detecting carbon monoxide (CO) and other spectral lines, generating precise mock maps becomes crucial for data analysis, prediction of future observations, and development of new statistical methods for LIM analysis. These mock maps are generated by interpolating line luminosities across the specified dark matter halo distribution, using response functions that are defined by the relationship between the line luminosities and both observable and derived properties of simulated galaxies.

In my presentation, I will detail the statistical connections between line luminosities and galaxy observables using high-resolution hydrodynamical FIRE (Feedback In Realistic Environment) galaxy simulations, focusing on CO(1-0), Lyα, and Hα lines. I will discuss the role of ongoing and future LIM experiments in exploring distant galaxies and elaborate on how FIRE simulations, post-processed by radiative transfer codes SKIRT and CLOUDY, help define essential response functions for creating mock maps.

Playing with FIRE: A Galactic Feedback Halting Experiment Challenges Star Formation Theories

Shivan Khullar (University of Toronto)

Star Formation and the ISM - Poster

Stellar feedback influences the star formation rate (SFR) and the interstellar medium of galaxies in ways that are difficult to quantify numerically, because feedback is an essential ingredient of realistic simulations. To overcome this, we conduct a feedback-halting experiment starting with a Milky Way-mass galaxy in the FIRE-2 simulation framework. Terminating feedback, and comparing to a simulation in which feedback is maintained, we monitor how the runs diverge. We show that without feedback, interstellar turbulent velocities decay and that stellar feedback is the dominant contributor to the turbulent energy budget in the inner galaxy (within ~ 10kpc). There is a marked increase of dense material, while the SFR increases by over an order of magnitude. Importantly, this SFR boost is a factor of ~15-20 larger than is accounted for by the increased free fall rate caused by higher densities. This implies that the star formation efficiency per free-fall time is very sensitive to the presence of stellar feedback. We identify GMCs using density and virial parameter thresholds, tracking clouds as the galaxy evolves. Halting feedback stimulates rapid changes, including a proliferation of new bound clouds, a decrease of turbulent support in loosely-bound clouds, an overall increase in cloud densities, and a surge of internal star formation. We also show that turbulence regulated theories of star formation under predict the surge in SFR. Thus galactic star formation is essentially feedback-regulated on scales that include GMCs, and that stellar feedback affects GMCs in multiple ways.

Same Data, New Insights: Virial Analysis of Ammonia-Identified Clumps in Giant Molecular Clouds

Tai Withers (Queen's University)

Star Formation and the ISM - Poster

The KEYSTONE (KFPA Examinations of Young STellar Object Natal Environments) Survey observed ammonia gas toward 11 high-mass star-forming regions at distances of 0.7-2.7 kpc. Previous analysis of these data (Keown+, 2019) utilized a single line-of-sight velocity component in fitting the ammonia gas. Here we present results of a multiple-component fit to the same clouds over the NH3 (1,1) inversion transition. We find that at least two components justifiably improve the fit in an average of 20% of fitted pixels, with ~4% necessitating a third component. From this multi-component fitting, we produce a catalogue of dense cores and their associated virial parameters. We examine the dynamical state of these cores, to study the effect of external pressure on boundedness, how well these high-mass star-forming cores are contained under self-gravity. We highlight connections between the properties of these compact sources and those of the broader clouds. This work emphasizes the importance of applying detailed and adaptive models to the complex data generated by observations of highly active regions.

Stars and Stellar Populations

Modeling Atomic Diffusion, g-mode Pulsation and Binary Interactions in HgMn Stars

Jay Allison (Université de Moncton)

Stars and Stellar Populations - Talk

A detailed simulation of g-mode pulsations in mercury-manganese (HgMn) stars has been carried out employing MESA and GYRE codes. Comprehensive analysis of the available TESS data has recently shown that several HgMn stars (members of binaries) clearly display g-mode pulsations, most probably generated by the tidal forces in binary systems (Kochukhov et al. 2021). Recent upgrades to MESA stellar evolution code have enabled modelling of atomic diffusion and radiative acceleration of individual chemical elements within stars at different stages of their evolution. We have applied these new developments to simulate interiors of HgMn stars starting with solar abundances and obtained an enhanced abundance of mercury and a depletion of helium close to the stellar surface. Based on these models, the asteroseismology code GYRE provides pulsation frequencies similar to those observed in the HgMn members of binary systems. The obtained results suggest that vertical abundance stratification caused by atomic diffusion influences propagation of gravitational waves close to the stellar surface and must be considered during the asteroseismology analysis.

Asteroseismology of the eclipsing binary KIC 10727668

Catherine Lovekin (Mount Allison University)

Stars and Stellar Populations - Talk

The eclipsing binary system KIC 10727668 was previously studied (Odesse & Lovekin, 2021) and found to consist of a delta Scuti pulsator and a white dwarf companion. In this work, we present analysis of three quarters of Kepler data, including updated binary fitting and preliminary asteroseismic analysis of the delta Scuti component.

Variability of chemically peculiar AmFm stars

Natalia Posiłek (Université de Moncton, University of Wrocław)

Stars and Stellar Populations - Talk

The metallic-line (AmFm) stars, classified as chemically peculiar (CP) A and early F stars, exhibit unique spectral characteristics with weak Ca II K and Sc lines alongside the strong Fe-group features compared to their H-line spectral type. AmFm stars, though located in the classical instability zone, have traditionally been believed to be incapable of pulsations caused by the gravitational settling of helium in the He II partial ionization zone. This mechanism drives delta Scuti pulsations. However, recent studies have unveiled pulsations in many AmFm stars (Smalley et al., 2017), challenging current insights in stellar seismology. The mechanisms behind these pulsations remain unclear, suggesting turbulent pressure as a possible pulsation source (Antoci et al., 2014), potential misclassification as CP stars, or a different chemical peculiarity of studied targets. By conducting a detailed analysis of high-resolution and high signal-to-noise spectra from SALT (HRS) and CFHT (ESPaDOnS) alongside an analysis of TESS photometric data, we studied the problem of pulsations in AmFm stars. This analysis is necessary to better understand their nature, as well as the origin of their chemical peculiarity and stellar pulsations. We carried out spectral classification of approximately 400 targets previously classified as metallic stars, revealing that only about half of them exhibit features typical of Am stars. Furthermore, we have obtained atmospheric parameters and chemical abundances for a few slowly rotating stars and will present the preliminary results of our spectroscopic analysis combined with pulsation information for these targets.

Score-Based Diffusion Models for Bayesian Posterior Inference over Star Formation Histories

Sacha Perry-Fagant (University of Montreal)

Stars and Stellar Populations - Talk

Star formation histories (SFHs) are a key component for understanding galactic evolution. As SFHs themselves are unobservable, information about a galaxy's SFH must be inferred from the galaxy's spectrum, often in the form of binned photometric data. However, the SFHs are poorly constrained by this data, and recovering them is an ill-posed inverse problem. For this reason, SFHs are often modeled using simple parametric models. To generate more realistic SFHs, we train a score-based diffusion model to act as a prior over the SFHs. Diffusion models employ an annealed sampling technique that has proven to be useful for Bayesian Posterior inference. The model is trained on SFHs and metallicity histories from numerical simulations since the ground truth values are available. Posterior sampling then consists of simulating a galaxy's composite stellar population (CSP) from the sampled SFH and metallicity history, and extracting the observable bands to

compare to the input data. Ultimately, once sufficiently trained and validated on simulations, the model will be used to draw samples of SFHs and metallicity histories using data from real galaxies. We need not rely on ad hoc priors in the form of regularization since our prior knowledge is encoded explicitly in our diffusion model.

The Curious Case of V CVn

Michael Power (Memorial University of Newfoundland)

Stars and Stellar Populations - Talk

V Canum Venaticorum (V CVn) is a semi-regular variable star with bizarre behaviour in its polarization measurements. It is well known for its variable linear polarization, which has a roughly inverse relationship with its light curve, and associated polarization position angle (PA), which has remained roughly constant for decades. Furthermore, a recently discovered lead/lag time between the brightness minimum and polarization maximum (and the same for the brightness maximum and polarization minimum) has added another layer of complication to this strange star. The cause of this star's curious behaviour has been a topic of much debate. However, one of the prevailing theories is that a variable, pulsation-driven dusty wind combined with the star's high velocity sets up hydrodynamic interactions between the circumstellar medium and a bow shock, producing the observed strange behaviours. With hydrodynamical simulations using Zeus3D, we show that a pulsation-driven stellar wind with the parameters of V CVn produces a roughly inverse relationship between the brightness and polarization and a relatively constant PA, giving computational legitimacy to this theory.

Star Cluster Formation, Binary Stars, and Multiple Populations: Missing Links

Alison Sills (McMaster University)

Stars and Stellar Populations - Talk

Stars are primarily formed in clustered environments in giant molecular clouds. Stars are also primarily found in binary or higher order multiple systems. This hierarchy of binaries inside clusters, particularly at early times, means that binary systems interact with other stars from the first moments of their life. Both the binaries and the cluster will be changed as a result of these encounters. Taking the effects of stellar dynamics and binary interactions into account is an important component to furthering our understanding of the formation & evolution of the stellar content of clusters. I will discuss results from simulations of star cluster formation and binary evolution, and will touch on the implications for cluster formation and the multiple populations problem in globular clusters.

Physical Constraints on Eclipsing Binary System lambda Scorpii

Shannon Bowes (Mount Allison University)

Stars and Stellar Populations - Poster

How big are stellar cores? Stars more massive than the Sun are crucial sites for the production of heavy elements in the universe. Convective overshoot influences how large the helium core is at the end of the main sequence, but this overshoot is often loosely constrained. Uncertainties in the extent of stellar convective cores lead to large uncertainties in the end state of stellar evolution; this has implications for supernova rates and the prevalence of white dwarfs, neutron stars, and black holes. We attempt to address this problem on a small scale by providing tighter constraints on convective overshoot and other physical parameters for an eclipsing binary system, lambda Scorpii. We report results and methodology of performing asteroseismic and binary analyses in tandem, with the use of observational data from TESS and a combination of stellar modelling codes such as MESA, GYRE, and PHOEBE.

Unraveling the Mystery of Pleione's Tearing Disk

Jamie Griffiths (University of Western Ontario)

Stars and Stellar Populations - Poster

B-emission (Be) stars, which are characterized by rapid rotation and emission lines in the Balmer series, exhibit significant emission components in their spectra due to circumstellar envelopes of ionized gas. These envelopes are colloquially known as ‘decretion disks’ due to the radial outflow of material. This study focuses on modeling the Be star, Pleione (28 Tau), and its associated decretion disk. Observations spanning decades including polarization, Hα line strength and shape, and V-band magnitude reveal that Pleione has likely undergone a tearing of its disk, forming inner and outer portions that can have different inclination angles with respect to the observer. Using the 3-dimensional Monte Carlo radiative transfer code HDUST, we produce synthetic spectra during disk tearing while varying the tearing radius, inclination of the inner and outer portions,

and the disk density. We compare these spectra to the trends observed for Pleione, specifically the sharp drops in the Hα equivalent width and V-band magnitude, along with the concurrent increase in polarization. This analysis provides the first comparison between the observations of Pleione and a disk tearing model consistent with Pleione's known parameters. The insights gained from this comparison will be invaluable in future investigations of Pleione, and the evolution of other Be stars and their disks.

Dynamics of Star Cluster Formation: Mergers in Gas Rich Environments

Jeremy Karam (McMaster University)

Stars and Stellar Populations - Poster

The evolution of star clusters embedded inside their host giant molecular clouds (GMCs) is a process which involves the merging of smaller sub-clusters with one another in the gas rich environment of the GMC. This process is difficult to observe due to the extinction present around deeply embedded sources. While simulations do provide insight, they come with their own limitations as well. When studying the formation of massive clusters in very massive GMCs (1 - 10 million solar masses), simulators are unable to model the individual sub-clusters along with the large amounts of GMC gas. Instead, they use point particles to model the clusters. These carry with them parameters that describe the cluster they represent (i.e. its mass, position, and velocity). As such, the effects of mergers on the stars and gas that make up the clusters involved are not well understood. We take a previous GMC simulation and zoom into it allowing us to model the clusters as collections of stars and gas. We simulate mergers of these clusters in the GMC environment and compare the dynamics of the merged clusters to observations of older star clusters. We find that mergers imprint dynamical signatures on the resultant cluster including rotation, and anisotropic expansion. As well, we find that background gas can significantly enhance the assembly of star clusters through sub-cluster mergers.

Spectropolarimetric study of roAp stars with rotational modulation

Viktor Khalack (Université de Moncton)

Stars and Stellar Populations - Poster

An extensive spectropolarimetric observation of known and recently discovered roAp stars has been carried out with the spectropolarimeter ESPaDOnS at the Canada-France-Hawaii Telescope (CFHT) following the comprehensive study of roAp type pulsations using the TESS data (Holdsworth et al. 2023). For several selected targets with rotational modulation, the high-resolution (R=65000) and high signal to noise (SNR>500) Stokes I & V spectra have been acquired for different rotational phases. Use of the Least Square Deconvolution (LSD) method has resulted in detection of a significant mean longitudinal magnetic field Bz that varies with the period of stellar rotation derived from the TESS photometry. New Bz measurement are consistent with the published data on magnetic field but have much smaller error-bars. Detected variability of phased (with the rotational period) line profiles that belong to the ions of Rare Earth Elements (REE) clearly shows their horizontal abundance stratification. The derived new Bz measurements will serve to reconstruct the magnetic field configuration and to study the origin of magnetic field on cold chemically peculiar stars.

Rotation Periods of Candidate Single Ultracool Dwarfs in TESS

Samantha Lambier (Western University)

Stars and Stellar Populations - Poster

Recent studies suggest that the angular momentum evolution of ultracool dwarfs differs from the well-known spin-down evolution of hotter stars. Characterizing the distribution rotation periods of ultracool dwarfs in the solar neighbourhood can help elucidate this evolutionary pathway just above, at, and below the hydrogen burning limit. Here, we present the results of our study focusing on determining rotation periods for our initial catalogue ~ 400 candidate single ultracool dwarfs. We conducted our analysis in uncrowded TESS fields, utilizing SPOC PDCSAP data. To achieve this, we employed Lomb-Scargle Periodograms to provide a first estimate of the period, then refined them with a Gaussian Process approach. We further confirm that the periodicity observed is not due to contamination using TESS-Localize. In our comparison with rotation periods reported in the literature, we found consistent results, while also uncovering new periods ranging from 2 hours to 2.5 days. Future research aims to address ultracool dwarfs in TESS crowded fields, with the end goal of a complete analysis of ultracool dwarf rotations within the TESS flux limits.

Dynamic Time Warping in Population Synthesis

Lorne Nelson (Bishop's University)

Stars and Stellar Populations - Poster

Binary Population Synthesis (BPS) is the conventional tool used for studying the evolution of interacting binaries with the objective of better quantifying the underlying physical mechanisms such as common envelope evolution, non-conservative mass transfer, magnetic stellar winds, consequential angular momentum loss, and natal kicks. BPS requires that very large numbers of evolutionary tracks be calculated. Unless highly simplified algorithms are implemented, most BPS computations lack sufficiently high resolution due to the computational expense. This problem can be mitigated by accurately interpolating relatively sparse grids of evolutionary models. We have developed a new method of interpolation between evolutionary tracks that incorporates Dynamic Time Warping (DTW). This DTW algorithm aligns and stretches two time series curves according to their shape, facilitating an interpolation method based on the curvature of evolutionary tracks. The method replicates the physical phenomena of the pre-computed tracks with greater fidelity. We apply this class of AI methods to the evolution of Cataclysmic Variables and show how it leads to improved estimations of the minimum period, the limits of the period gap, among other phenomena.

Disk evolution in highly eccentric Be binary systems

Rina Rast (Western University)

Stars and Stellar Populations - Poster

Be stars are high-mass, rapidly rotating stars of spectral class B characterized by gaseous circumstellar decretion disks. We examine the behaviour of the disks surrounding Be stars in binary systems with highly eccentric orbits. We compare the effects of the companion star on the disk in a short-period Be/X-ray binary (BeXRB) where the secondary is a neutron star (A0538-66, e = 0.72) to a long-period system (δ Scorpii, e = 0.94), where the secondary is a high-mass, non-degenerate star. We use the non-local thermodynamic equilibrium (NLTE) Monte Carlo radiative transfer code HDUST to predict observables such as Hα lines, and a 3-dimensional smoothed particle hydrodynamics (SPH) code to model the density structure of the disk. For the BeXRB, we assume a primary stellar mass of 9 $M_{\odot}$ and secondary mass of 1.44 $M_{\odot}$, along with an orbital period of 16.64 days. We vary the inclination of the disk relative to the equatorial plane and test the accretion rates of particles onto the neutron star, as well as the strength and duration of perturbations in the circumstellar disk. For δ Scorpii, we assume a primary mass of 15.3 $M_{\odot}$, a secondary mass of 9.11 $M_{\odot}$, and an orbital period of 3951 days. We find that tidal interactions between the secondary and the disk in δ Scorpii are too brief to cause spiral density enhancements in the Hα emitting region, while the disk in the BeXRB shows significant disruptions at periastron. We also compare the shape and intensity of predicted and observed Hα profiles for each system, to create model-supported interpretations of these observations.

Exploring Heating Mechanisms in Classical Ae Star Disks: A Modeling Approach

Anusha Ravikumar (University of Western Ontario)

Stars and Stellar Populations - Poster

The Classical Ae (CAe) stars represent intermediate-mass main-sequence stars that can be considered as the cooler extension of the classical Be stars. Analogous to their Be counterparts, CAe stars showcase prominent emission lines in their spectra, notably in Hα (6562.8 Å), indicating the presence of circumstellar material. In comparison to the Be stars, CAe stars have received relatively less attention, primarily because their weaker emission makes them harder to detect and study and their variability may occur at a slower pace. In this work, we investigate whether the heating mechanism observed in classical Be star disks can elucidate the emission patterns observed in classical Ae stars. We focus on computing the temperature structure of gaseous circumstellar disks surrounding A-type stars. Our methodology incorporates radiative heating from the central star and viscous shear heating in the disk. We then utilize the temperature and density profiles of the disks to compute Hα profiles for the combined star+disk systems, which are subsequently compared with observational data. Our key findings reveal that significant amounts of shear heating become prominent around spectral type A2 and later, thereby preventing the occurrence of very low disk temperatures predicted by purely radiatively heated disks. Moreover, we observe a notable increase in the role of shear heating with the presence of Hα emission for spectral types later than A4. We highlight that endeavors to identify very late-type Ae stars could furnish valuable constraints on the disk α-viscosity parameter. Our findings hold significant implications for advancing the understanding of Ae star disks, as they contribute to developing a more comprehensive model for these systems and provide valuable inputs to refine existing theoretical frameworks. Through the integration of modeling techniques and spectroscopic analyses, our study sheds light on the behavior of emission-line stars within relatively cooler circumstellar environments for the first time.

Research of magnetic field in three delta Scuti stars using the LSD method

Marharyta Sliusarenko (Physics, Université de Moncton)

Stars and Stellar Populations - Poster

Pulsation variability of two δ Scuti stars HD159541 and HD192640 has been meticulously studied using photometric data provided by TESS during the cycles 2 and 4 of its operation. Employing the Period04 software, we derived frequencies of significant signals (SNR>4), corresponding amplitudes and phases, and their error-bars. Application of a histogram and of a 2D autocorrelation function to the derived frequencies allowed us to obtain consistent values of large frequency separation which agree well with the results reported by Hasanzadeh et al. (2021) for these two targets. High-resolution Stokes I&V spectra of HD159541, HD192640, and of known magnetic δ Scuti variable HD41641 have been obtained with ESPaDOnS with the aim to search for magnetic field signatures. Their analysis employing the LSD approach resulted in detection of a substantial mean longitudinal magnetic field (Bz=140+_12G) only in HD41641, while neither HD159541 nor HD192640 harbors a magnetic field larger then 15G. Considering the absence of magnetic field in the two studied δ Scuti stars we conclude that the significant pulsations observed in HD 192640 at ν>70 c/d are most probably the combination of p-modes present at lower frequencies (10 c/d < ν < 40 c/d).

Unveiling Stellar Nature Through Oscillation Pattern Recognition

Kanah Smith (Institute of Science and Technology Austria (ISTA))

Stars and Stellar Populations - Poster

Solar-like stars oscillate as a result of sound and gravity waves that propagate through the sphere; the waves allow us to then probe the stellar interior for information on its physical properties. These stars will evolve off the main sequence to the red giant branch (RBG) and subsequently either to the red clump or secondary red clump stages depending on their mass. Asteroseismology allows us to disentangle these evolutionary stages, as red giant star populations (on the Hertzsprung-Russell diagram) tend to overlap between these regions.
With the large amount of data currently available for asteroseismic analysis, in addition to the impending influx from the European Space Agency's PLATO mission, it is necessary for the community to develop automatic methods to process this data for asteroseismic studies, as well as to benefit the more broad astrophysical community. In undertaking this project, I employ a machine learning-based method to automate the disentanglement of stellar evolutionary stages. Doing so by using asteroseismology to extract information from the photometric data of Kepler red giant stars. As this seismic information results from stellar oscillations, and these oscillations are characteristic of stellar evolution, using this data to create échelle diagrams allowed me to sort the stars according to their evolutionary stages. Using échelle diagrams, which are created through the manipulation of stellar power

spectra densities, I work to explore the diversity of solar-like oscillation patterns of red giants observed by Kepler. With this method, I perform the automatic classification of ~ 6000 (6381 as of April 2024) Kepler red giant stars based on their oscillation patterns.

Observables of a Disk-Tearing Model and a Comparison to the Be Star Pleione (28 Tau)

Mark Suffak (Western University)

Stars and Stellar Populations - Poster

Classical Be stars are rapidly rotating B type stars that are surrounded by a gaseous circumstellar decretion disk. Like many massive stars, Be stars are frequently found in binary systems, with a wide array of orbital configurations. With 3-dimensional (3D) smoothed particle hydrodynamics (SPH) simulations, we have shown that the disk can undergo phenomena of disk-tearing or Kozai-Lidov (KL) oscillations if the binary companion's orbit is misaligned to the plane of the disk. Here, we use the 3D Monte Carlo radiative transfer code HDUST to produce synthetic spectra of a disk that is tearing, and a disk undergoing KL oscillations. Through investigating the change in the Halpha line, V-band magnitude, and V-band polarization, we find that the trends over a disk-tearing episode match those seen in the Be star Pleione (28 Tau), which has been previously suggested to have a two-disk configuration. We also show that when the disk is torn, both the inner and outer disk pieces contribute to different parts of the H-alpha emission line, and that the outer disk has a detectable contribution to the polarization position angle. Overall, our results demonstrate how phenomena from a misaligned binary companion can cause variations in observables across the whole disk, and that these phenomena need to be considered when analyzing the time evolution of Be star spectra.

Evolutionary track modelling of Classical Cepheid stars using MESA

Tashveena Surdha (Memorial University of Newfoundland)

Stars and Stellar Populations - Poster

Through the observations of distant galaxies, it has been discovered that the Universe is expanding. The expansion rate of the Universe is still a topic of debate due to the various measurement discrepancy of the Hubble parameter. The Hubble parameter can be determined through the use of standard candles, such as supernovae or variable stars whose absolute luminosities, hence distance from us, are known. For this study, the standard candle used is the Classical Cepheid (CC) stars whose Period-Luminosity (P-L) relation relates to the Hubble parameter. To construct better P-L relation of these stars, it is important to understand how they work and to improve their models. To do so, theoretical developments and computational modelling using MESA (Modules for Experiments in Stellar Astrophysics) are done, by varying parameters according to recent literature.

Investigating the Limits of the Thin Disc Approximation in Be Star Models

Annika Vetter (Western University)

Stars and Stellar Populations - Poster

B-emission (Be) stars are hot, massive, rapidly-rotating stars which have or have had Balmer emission lines. They are known for their decretion discs, which are composed of outflowing ionized gas and contribute significantly to the stars spectral signature. When modelling Be star discs, it is common to use a series of analytical equations which assume hydrostatic equilibrium in z direction, perpendicular to the equatorial plane. A thin disc ($z<<r$) approximation is often used to simplify the solution. When these equations are solved without invoking the thin disc approximation, they represent a “thick disc” system. While some discs have been observationally confirmed to be geometrically thin, the thin disc approximation has not been thoroughly investigated. A comparison between thick and thin disc approximations will provide important insight into the structure of discs surrounding massive stars, and notably how this affects the observables of the system. In this work, we provide a detailed analysis of the limitations of this approximation. To do this, we first calculate theoretical scale heights for thin and thick discs. Then, using the three-dimensional Monte Carlo radiative transfer code HDUST, we predict observables such as the Hα line, photometry, and the polarization for both. These comparisons between the thin and thick disc models improve our understanding of the limitations of the thin disc approximation, and aid in future modelling efforts of Be star discs.

Constraining M Dwarf Wind Rates Using White Dwarf Companions

Raven Westlake (McMaster University)

Stars and Stellar Populations - Poster

M dwarf stars are known to have stellar winds that likely impact the habitability of their planets. Stellar winds are composed of high energy particles that cannot be directly observed with telescopes, so indirect methods must be used to place observational constrains on M dwarf wind rates. Close binary pairs containing a white dwarf and an M dwarf companion can be used to infer M dwarf wind rates via metal pollution in the white dwarf's atmosphere. Due to the high surface gravities of white dwarfs, metal lines are not long-lived in their atmospheres unless material is being continuously accreted, such as from the stellar wind of its M dwarf companion. I will present a selection of white dwarf – M dwarf binaries which are suitable for measuring the stellar wind rate and for which spectra are available through the Sloan Digital Sky Survey. For these targets, I will measure the equivalent widths of metal lines in the white dwarf atmospheres and calculate the metal abundances. When combined with known system parameters such as the binary's orbit and models of metal mixing and diffusion, I will determine the M dwarf wind rates. With this sample, we hope to establish the distribution of M dwarf wind rates to assess the impact that stellar winds have on atmospheric escape, atmospheric chemistry, and planet habitability.

Evaluating the Performance of TESS-Localize on Sparse Stellar Fields: Towards Reliable Crowded Star Analysis

Dakota Wolfe (University of Western Ontario)

Stars and Stellar Populations - Poster

This study rigorously investigates the effectiveness of TESS-Localize, a recently developed tool designed for the identification and analysis of periodic signals from ultra-cool dwarf (UCD) stars, specifically within both non-crowded and crowded stellar environments. The tool was investigated using its open source python package developed by Higgins and Bell 2023. Utilizing data from the Transiting Exoplanet Survey Satellite (TESS), the study is predicated on a foundational analysis aimed at understanding the tool's precision and reliability in sparse fields, a crucial step before its application to more complex, crowded regions. The research meticulously tested 138 UCD targets, of which the results of 106 were analyzed, employing a comprehensive methodology that included detailed signal analysis, algorithmic evaluation, and statistical testing. This process was aimed to assess TESS-Localize's accuracy in source localization and its efficiency in periodic signal verification under conditions deemed to be less challenging yet essential for benchmarking purposes. Key findings from this analysis indicated that TESS-Localize successfully confirmed periodic signals for 30 of the UCD targets, marking a confirmation rate of approximately 28%. This outcome not only demonstrates the tool’s potential in enhancing the detection and analysis of stellar phenomena but also illuminates its current limitations within even non-crowded fields. Importantly, the study identified that a considerable number of targets resulted in unconfirmed periodic signals or were categorized as ambiguous (18% likely 54% questionable), raising critical questions about the underlying factors affecting the tool's performance. Further in-depth analysis revealed several challenges, including algorithmic limitations, data quality issues, and the need for improved signal processing techniques. Moreover, the research critically examines the broader implications of these findings for future astronomical research, particularly highlighting the importance of rigorous tool validation in non-crowded fields as a prerequisite for tackling the complexities of crowded stellar environments. This work not only contributes significantly to our understanding of TESS-Localize's current capabilities but also sets a strategic path forward for its development, aiming to unlock new potentials in the search for exoplanets and the study of stellar dynamics.

Transients and Compact Objects

Massive black hole triplets in the Obelisk simulation.

Ariel Chitan (Western University)

Transients and Compact Objects - Talk

We analysed mergers of massive black holes (MBHs) from Obelisk, a cosmological radiative hydrodynamical simulation of a protocluster of galaxies (Trebitsch et al., 2021). From this dataset, we constructed merger trees and found potential hierarchical MBH triplets. A grid of initial conditions for N-body simulations of MBH triplets was then formed. In total, 48,000 MBH triplets were simulated in vacuum using ARC code (Mikkola & Tanikawa, 2013). In these simulations we defined the lifetime of a MBH triplet as ending in either of two ways: 1. a merger of two of the MBHS or 2. an escape from the center of mass of the system of one of the MBHs. We found that in 30% of cases simulations ended via merger while in 70% of cases, simulations ended via escape. In ~99% of the simulations ending in escape, this runaway MBH is able to escape the host galaxy entirely. This has implications for the Obelisk simulation as black holes that may have been counted as merging due to spatial resolution limits might have actually resulted in runaway MBHs. In the astrophysical realm, this may correspond to MBHs that have been found offset from the centers of their galaxies.

Multi-wavelength View of M87 during the 2018 EHT Campaign Including a Gamma-ray Flaring Episode

Daryl Haggard (McGill University)

Transients and Compact Objects - Talk

In 2017, the first image of the black-hole shadow in the center of the M87 galaxy was captured by the Event Horizon Telescope (EHT). In parallel an extensive multi-wavelength (MWL) observational campaign with ground- and space-based facilities from radio all the way up to the TeV energy range was organized. M87 was found to be in a historically low state. With the second epoch of EHT observations in 2018, a similar extensive MWL campaign has been performed. Fortuitously, during our accompanying MWL campaign, the source underwent a very high energy gamma-ray flare episode, the first in over a decade, providing crucial information for investigating the origin of the gamma-ray emission in M87 radio galaxy. In this Talk I will present the results of the 2018 EHT-MWL campaign, as well as a comparison with the 2017 campaign and historical results.

Inference of multi-channel r-process element enrichment in the Milky Way using binary neutron star merger observations

Philippe Landry (CITA)

Transients and Compact Objects - Talk

Can binary neutron star (BNS) mergers account for all the r-process element enrichment in the Milky Way's history? While a BNS population model informed by multimessenger neutron star observations predicts a merger rate and per-event yield consistent with geophysical and astrophysical abundance constraints, we show using a one-zone Galactic chemical evolution model that the BNSs have to merge shortly after the formation of their progenitors to explain the r-process enrichment of stars in the Galaxy. Such short delay times are in tension with those predicted by standard BNS formation models and those inferred from samples of short gamma-ray bursts (sGRBs). However, we find that a two-channel enrichment scenario, where the second channel follows the star formation history, can account for both Galactic stellar and sGRB observations. Our results suggest that 45-90% of the r-process abundance in the Milky Way today was produced by a star-formation-tracking channel, rather than BNS mergers with significant delay times.

Signatures of Massive Black Hole Merger Host Galaxies from Cosmological Simulations

John Ruan (Bishop's University)

Transients and Compact Objects - Talk

Lower-frequency gravitational wave experiments such as the Laser Interferometer Space Antenna and pulsar timing arrays are expected to detect individual massive black hole (MBH) binaries and mergers. However, secure methods of identifying the exact host galaxy of each MBH merger amongst the large number of galaxies in the gravitational wave localization region are currently lacking. We investigate the distinct morphological and stellar kinematic signatures of MBH merger host galaxies, using the Romulus25 cosmological simulation. We produce mock telescope images and IFU spectral datacubes of 201 simulated galaxies in Romulus25 hosting recent MBH mergers, through stellar population synthesis and dust radiative transfer. Based on comparisons to mass- and redshift-matched control samples, we show that galaxies hosting MBH binaries and mergers have (1) more prominent classical bulges, (2) slower rotation, and (3) stronger kinematic misalignments. These morphological and kinematic properties can thus aid in identifying the host galaxies of future MBH binaries and mergers detected in gravitational waves.

Inferring Formation Parameters of Binary Black Holes with Population Studies

Aryanna Schiebelbein-Zwack (University of Toronto)

Transients and Compact Objects - Talk

It is still unknown how the binary black holes (BBHs) observed by LIGO-Virgo-KAGRA form. The connections to their stellar progenitors are uncertain but can be characterized by the fraction of all stellar mass that ends up in BBHs that merge and the delay in time between star formation and BBH merger. To constrain the possible formation mechanisms, we develop a model for the BBH merger rate starting from the cosmic star formation history and then accounting for metallicity dependences and the distribution of delay times. Using the Third Gravitational-Wave Transient

Catalog (GWTC-3) we find that stars which eventually partake in a BBH merger preferentially form in low-metallicity environments. The data also prefer short time delays, indicating BHs that merge tend to do so not long after their progenitor stars formed. Our model allows us to extrapolate the mass density in BBHs out to high redshifts, beyond the LVK detection horizon. We find that today there may be more mass in merging BBHs than in living massive stars. We also find that the mass densities in supermassive BHs were comparable to that of stellar-mass BBHs ~ 12.5 Gyr ago. These extrapolated conclusions will be directly tested by next-generation gravitational wave detectors which will extend our detector horizons to the high redshift universe.

SDSS J2320+0024: Supermassive binary blackholes in their final tango?!

Karun Thanjavur (UVic)

Transients and Compact Objects - Talk

Dramatic time evolution in the observed Mg II emission line profile of SDSS J2320+0024 strongly supports our model of the system being a supermassive binary black hole (SMBBH) pair with {\it milliparsec} separation - one of the smallest separations in reported literature! In the era of multi-messenger astronomy, the observed properties of this compact SMBBH, would provide strong constraints to theoretical models of black hole mass growth by mergers and consequent low frequency gravitational wave production. This candidate was discovered during a systematic search for long period variables using Lomb-Scargle periodogram analysis of optical light curves of >1 million sources in the SDSS Stripe 82 region with multi band photometry. Our initial estimated period, P = 278 days, was further reaffirmed by including public PanStarrs and ZTF light curves, thus stretching the baseline to nearly 20 years. SDSS spectroscopic classification of SDSS J2320+0024 (SDSS r = 21.3mag) is a QSO, with a broad Mg II emission line at 570nm seen in the low resolution SDSS spectrum, which corresponds to a redshift of 1.05. With follow-up Gemini GMOS and Magellan LDSS-3 medium resolution (R~3000) spectroscopy, we resolved the double-peaked structure and have observed time evolution of the Mg II line profile over two epochs separated by a month. Our model of the evolution of this complex Mg II line profile indicates a SMBBH of total mass, M = 10^8.3 solar mass, a mass ratio of ~0.1, and separation of 0.0025pc, all these to be refined with further follow-up spectroscopy. My presentation summarizes the story we have unravelled so far of this evolving tango, and upcoming steps to confirm and fully characterize this SMBBH system.

Inferring host galaxy properties of compact binaries

Aditya Vijaykumar (Canadian Institute for Theoretical Astrophysics)

Transients and Compact Objects - Talk

Although the LIGO-Virgo-KAGRA (LVK) network of gravitational wave (GW) detectors has reported the detection of ~90 binary black hole (BBH) signals, none of them have been confidently associated with a host galaxy. This is not surprising, since GW detectors have poor pointing accuracy. However, thinking about the detected BBHs as a population instead of individual events has allowed measurements of the merger rate of binaries as a function of redshift. We show that that the measured redshift evolution of the merger rate from the latest catalog of BBHs can constrain the parameter space of their host galaxies. This results directly from the observation that galaxies with different physical properties have different evolutions for their number density. We find that we can place upper limits on the fraction of mergers coming from a stellar mass weighted sample of galaxies, and infer properties of the population of host galaxies at redshift $z < 1$. Our results can be used to design optimal electromagnetic follow-up strategies for BBHs, and also to aid the measurement of cosmological parameters using the statistical dark siren method.

Towards high precision spectro-temporal analyses of Fast Radio Bursts

Mohammed Chamma (McMaster University)

Transients and Compact Objects - Poster

Fast Radio Bursts (FRBs), especially those from repeating sources, exhibit a rich and diverse variety of morphologies. In particular, the dynamic spectrum of an FRB can show frequency drifting behaviour, burst blending, microshot forests, varying burst-to-burst Dispersion Measures (DMs), and so on. These morphologies likely contain important physical information about the FRB source, as evidenced by the discovery of the inverse relationship between sub-burst slope (i.e. intra-burst drift) and burst duration that suggests a dynamical model for the FRB source. The recent discovery of ultra-FRBs, FRBs that are just a few microseconds long, from well-observed repeaters challenges the existing methodologies for performing spectro-temporal measurements. This is especially true with regards to the sub-burst slope, which suffers from a forbidding precision loss as the burst duration decreases. We present here a simplified technique that involves the tagging of per-channel arrival times of an FRB to perform sub-burst slope, duration, and bandwidth measurements. This technique naturally increases precision by several orders of magnitude allowing it to be easily applied to ultra-FRBs as well as longer duration

FRBs, while also being easier to apply to low SNR bursts. In addition, it provides flexibility for bursts that may exhibit more complicated drifting behaviours, and naturally allows for power-law drifting models (for example) to be applied instead of typical linear models. While scattering and dispersion remain important and often dominating sources of uncertainty in measurements, this technique provides an adaptable and firm foundation for obtaining spectro-temporal properties from all kinds of FRB morphologies. We will present here measurements using this technique of about 400 bursts from the repeating sources FRB 20121102A, FRB 20220912A and FRB 20200120E, all of which exhibit microsecond long FRBs. In addition to retrieving the sub-burst slope relationship with duration, we explore other correlations between burst properties and additional questions.

Accessing Intermediate-Mass Black Holes in Globular Clusters of NGC 1399

Bahman Karimi (Canada Cambridge Academy)

Transients and Compact Objects - Poster

Intermediate Mass Black Holes (IMBHs) with the mass range of 100-100000 Msun are the missing link between stellar mass black holes and supermassive black holes. Discovering IMBHs in present-day globular clusters (GCs) would confirm the existence of black-hole seeds for growing supermassive black holes in the initial cosmos. In this study, we want to figure out the possibility of detecting IMBHs in globular star clusters of NGC 1399 with SKA observations. For this purpose, we collected X-ray luminosities of low mass X-ray binaries (LMXBs) in NGC 1399's GCs to estimate IMBH masses using the Bondi model and the fundamental plane formula that demonstrates the relationship between the black hole mass and radio plus X-ray luminosities. Preliminary results from our study show that the Bondi model predicts a minimum detectable IMBH mass of 5.84e5 Msun in GCs of NGC 1399. Meanwhile, the Fundamental Plane Formula predicts minimum detectable IMBH masses in the range of 2.41e3 - 4.9e3 Msun. Therefore, the results of this work show that the Bondi model and fundamental plane formula predict that IMBHs in GCs of NGC 1399 are detectable.

The Colibri Telescope Array: a Dedicated TNO Occultation Facility

Toni Cordeiro de Almeida (University of Western Ontario)

Transients and Compact Objects - Poster

The Colibri Telescope Array is operated by Western University and is located at Elginfield Observatory near Lucan, Ontario. Colibri comprises three identical 50 cm telescopes each equipped with a 1.48-degree Kepler SCMOS Camera operating at 40 Hz. The primary goal of Colibri is the detection of kilometre-sized trans-Neptunian Objects (TNOs) using the method of Serendipitous Stellar Occultations (SSO), in order to determine their population and size distribution. Such small TNOs are too faint to detect in direct imaging even with the James Webb Space Telescope. The SSO method offers an alternative approach to this science at very low cost. We describe the instrumentation and current status of the project, and solicit interest from the Canadian astronomy community for joint projects in areas of ancillary science.

Formation of compact object binaries under dynamical friction

Mark Dodici (University of Toronto/CITA)

Transients and Compact Objects - Poster

Gas dynamical friction can dissipate orbital energy during interactions between two objects in a disk, leading to capture into a binary. This process, occurring in accretion disks around supermassive black holes that contain compact objects, could contribute to or even dominate the rate of mergers observed by LIGO. We significantly expand on previous studies of this binary formation process using a scale-free approach based on Hill's problem. We also consider stellar dynamical friction from a surrounding star cluster as a supplement to gas friction. We simulate ~10^8 interactions between bodies on neighboring orbits using a simple model for dynamical friction, yielding the estimated binary formation rate as a function of (a) friction strength and (b) the mutual eccentricity and inclination of the bodies' initial orbits. Notably, we find that the local binary formation rate is a linear function of the strength of the friction, so long as the friction is weak. Our formation rates for interactions between bodies on eccentric and inclined initial orbits are the first in the literature. Due to the dimensionless nature of our model problem, our findings are generalizable to binary formation over a wide range of disk conditions (across a range of contexts for which Hill's problem is an appropriate framework).

An Untargeted Search for Radio-Emitting Tidal Disruption Events

Hannah Dykaar (University of Toronto)

Transients and Compact Objects - Poster

A Tidal Disruption Event (TDE) occurs when a star gets close enough to a supermassive black hole, such that the tidal forces are able to rip the star apart, causing a multiwavelength transient flare. These events illuminate the complex environments of galactic centers in what may otherwise be quiescent galaxies. TDEs are typically discovered at shorter wavelengths (optical, X-ray) but with systematic time-domain radio surveys becoming available, we now have an unprecedented opportunity to discover TDEs in the radio regime. A population of radio-discovered TDEs provides distinct insights including an independent constraint on their volumetric rate. We have identified a population of twelve radio-bright TDE candidates identified with the the recently completed Variables and Slow Transients (VAST) Pilot Survey, a time domain radio survey from the Australian Square Kilometre Array Pathfinder. I will present how we discovered this population, its implications for the radio emission of TDEs, and prospects for discovering these sources in future surveys.

GLEANing the Fields: The Search for IMBHs in Gaia's Variable AGN Catalog

Adrien Hélias (Western University)

Transients and Compact Objects - Poster

The ongoing search for intermediate-mass black holes (IMBHs) is driven by the desire to better understand how the seeds of supermassive black holes were formed in the early universe, and how they evolved. However, it remains difficult to identify large amounts of IMBHs, as they are much less luminous than their supermassive colleagues and can easily be blended in their host galaxy signal. Optical variability studies on the other hand have shown promising results for IMBH detection. GLEAN, the variability-selected AGN catalog of Gaia, contains individual light curves and parameters for more than 872 000 objects, with more than 16 800 labeled as galaxy candidates. We use a damped random walk stochastic model to fit all the GLEAN light curves, to quantify their variability by extracting a delay timescale from them. Secondly, we characterize the black hole virial masses of the most variable GLEAN galaxy candidates with optical spectroscopy using the broad Hα line. We use optical spectra from the Sloan Digital Sky Survey and we perform a Gaussian decomposition around the Hα emission line. We observe no correlation between the delay timescale and the black hole mass, nor with the fractional variability from GLEAN. This leads us to think that neither the timescale nor the fractional variability parameters can be used as a proxy for the black hole mass.

Using Machine Learning and the Dragonfly Telephoto Array to Identify Historic Supernova Light Echoes

Nicole Mulyk (McMaster University)

Transients and Compact Objects - Poster

We have improved the supernova light echo machine-learning Python package ALED (Automated Light Echo Detection), created by Bhullar et al. 2021, by adding false positive masks as an additional input and expanding the selection of false positives to include a variety of commonly misidentified objects, such as diffraction artifacts from bright stars. Supernova light echoes occur when light from a supernova scatters off interstellar dust. The scattered light takes a longer path and reaches the observer after the direct light - sometimes centuries later. Therefore, light echoes are a useful tool for studying historic supernovae. ALED utilizes capsule networks and routing path visualization to identify and locate light echoes in difference images. Additionally, we have developed a method for manufacturing light echo training sets, which has previously not been applied to light echoes, by extracting light echoes from Canada-France-Hawaii Telescope difference images and overlaying them on Dragonfly Telephoto Array (DTA) difference images. The DTA is a promising tool for light echo detection because of its ability to observe ultra-low surface brightness structures. We hope that with the DTA's advanced ability to detect faint and extended objects and ALED's capacity to efficiently and accurately identify light echoes, we will be able to detect light echoes around the Crab supernova.

Polluting White Dwarfs with Oort Cloud Comets

Dang Pham (University of Toronto)

Transients and Compact Objects - Poster

Observations point to white dwarfs (WDs) accreting metals at a relatively constant rate over 8 Gyrs. Exo-Oort clouds around WDs have been proposed as potential reservoirs of materials, with galactic tide as a mechanism to deliver distant comets to the WD’s Roche limit. In this work, we characterise the dynamics of comets around a WD with a companion having semi-major axes on the orders of 10 - 100 AU. We develop simulation techniques capable of integrating a large number (10^8) of objects over a 1 Gyr timescale. Our simulations include galactic tide and are capable of resolving close-interactions with a massive companion. Through simulations, we study the accretion rate of exo-Oort cloud comets into a WD’s Roche limit. We also characterise the dynamics of precession and scattering induced on a comet by a massive companion. We find that (i) WD pollution by an exo-Oort cloud can be sustained over a Gyr timescale, (ii) an exo-Oort cloud with structure like our own Solar System's is capable of delivering materials into an isolated WD with pollution rate ~ 10^8 g /s, (iii) adding a planetary-mass companion reduces the pollution rate to ~ 10^7 g /s, and (iv) if the companion is stellar-mass, with $Mp \gtrsim 0.1\ M\odot$, the pollution rate reduces to ~ 3 × 10^5 g /s due to a combination of precession induced on a comet by the companion, a strong scattering barrier, and low-likelihood of direct collisions of comets with the companion.

Dark matter Admixed Neutron Stars

Shafayat Shawqi (University of Alberta)

Transients and Compact Objects - Poster

The high densities of neutron stars (NSs) could provide astrophysical locations for dark matter (DM) to accumulate. Depending on the DM model, these DM admixed NSs (DANSs) could have significantly different properties than pure baryonic NSs, accessible to probing through X-ray observations of rotationally powered pulsars. We adopt the two-fluid formalism in general relativity to numerically simulate stable configurations of DANSs, assuming a fermionic equation of state (EOS) for the DM with repulsive self-interaction. Distribution of DM in the DANS as a halo affects the path of X-rays emitted from hot spots on the visible baryonic surface $\left(R_{B} \right)$ causing notable changes in the pulse-profile observed by telescopes such as NICER, compared to pure baryonic NSs. In this work, we explore how various DM models affect the DM mass distribution within and outside R_{B}, leading to different types of dark halos. We quantify the deviation in observed X-ray flux from stars with each of these types of halos, and propose methods on how to interpret mass-radius measurements of NSs inferred from gravitational self-lensing if these dark halos exist.

The Distant TNOs measured by The Classical and Large-a Solar System

Wesley Fraser (Herzberg Astronomy and Astrophysics)

Transients and Compact Objects - Poster

Here we present results of CLASSY: the Classical and Large-A Solar SYstem survey. This 2-year Large Program on the Canada-France-Hawaii Telescope is allotted 75 nights from 2022B through 2024A inclusive, with extension into 25B to accommodate time loss due to equipment failure. Using shift'n'stack techniques, CLASSY is surveying 6 independent pointings (12.2 square degrees total) of the cold classical belt's forced midplane, achieving depths of r~26.8 in search of Kuiper Belt Objects and extreme trans-Neptunian objects (eTNOs). Field opposition locations are chosen to be spaced as evenly as possible and span a two month window (AS: Aug-Sept, ON, JF, MA, MJ, JA). By design each field is visited in 5 visits across the first year (discovery), and are tracked to a second opposition one year later for some fields, and 2 years later for others (tracking). All discovery fields have been acquired, with one field having received the full 2-year complement. This presentation will focus on the second of CLASSY's primary goals: to test cosmogonic models of orbital emplacement and measure the mass of the distant population, particularly at large semimajor axes (a>100AU). To facilitate this science goal, CLASSY is the first survey designed explicitly to avoid longitudinal discovery biases that may be present in the known eTNOs sample. At time of writing, two of the six fields have undergone preliminary search efforts linking all of the discovery year observations of each field. Amongst the more than 200 new TNOs discovered, only a handful of objects have semi-major axis measurements consistent with being eTNOs. Though with only 2-month arcs the semi-major axes are insufficiently precise for proper classification, and none have distances larger than d~55 au. We will discuss implications for the purported distant population, and discuss implications for the alignment of eTNOs.