THE 2025 SPRING SYMPOSIUM:

INTER+STELLAR: Harnessing the Intersection Between Stars and the Interstellar Medium

May 12 – 16, 2025

Spring Symposium Booklet

STScI

Historically, stars and the ISM in the nearby Universe have often been studied individually. However, this past decade of research has shown that the most exciting advances in each field are powered by considering both stars and the ISM together.

Gaia stellar extinction data are enabling detailed 3D maps of the ISM in the Solar neighborhood out to kiloparsec distances. The combination of high-resolution data from JWST, HST, SKA precursors, and ALMA, is unveiling how the multi-scale geometry of the ISM drives the stellar IMF, and how the energy injected from stellar populations mediates the evolution of the multi-phase ISM. Cutting-edge facilities have recently revealed young stellar objects directly orbiting Sgr A*, and unveiled the previously-inaccessible highly-attenuated stellar populations in the hearts of nearby starburst galaxies. High-resolution hydrodynamical simulations are now regularly modeling stars, gas, and dust together; whilst radiative transfer modeling is thriving thanks to exquisite observations of environments like PDRs and evolved stars. The astonishing resolution now available in the nearby Universe allows us to investigate even the smallest-scale physics of these complex processes.

The 2025 STScI Spring Symposium will focus on all the ways in which harnessing stars and the ISM together advances our understanding of both, far more than when considering them separately. We will feature work that is:

1. Focused on high resolution observations and simulations of the nearby Universe
2. Using stars and/or the ISM as a tool to better understand the other
3. Combing multi-wavelength observations from a variety of facilities
4. Modeling of stars, gas, and dust together

We find ourselves in a world where more and more astronomers harness stars and the ISM together – and where this approach is vital for answering key questions from the 2020 decadal, for which future facilities like HabWords, ELTs, and a far-infrared probe will be key. This symposium will celebrate and exploit the ever-increasing intersection of stellar and ISM astronomy, for the puzzles of today and the questions of tomorrow.

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Symposium Schedule

STScI

Monday, May 12, 2025

Time	Title	Speaker	Location
8:30am	Breakfast + Snacks **Speaker Tech Check for Session 1 in Auditorium**		Café
9:00am	Welcome from SOC & STScI Director		Auditorium
Session 1: 3D Reconstruction of Stars and the ISM, Chair: Joshua Peek			
9:20am	Variation of the dust extinction curve: a 3D perspective from Gaia	Gregory Green (I)	
9:50am	New orbital and metallicity structures in the Milky Way disk	Sihao Chang (C)	
10:10am	LightCube: A 3D Model of the Local UV Interstellar Radiation Field	Hannah Bish (C)	
10:30am	Poster Flash Talks • Xiangyu Zhang (P): *What Drives R(V) Variation in Dust Extinction Curves? A New Perspective from PAHs in 3D Dust Mapping* • Sapna Mishra (E): *The Distance to the Magellanic Stream: Constraints from Optical Absorption along Stellar Sightlines* • Nick Indriolo (E): *Mapping the Cosmic-Ray Ionization Rate in the Local ISM* • Azmain Nisak (E): *Determining the Properties of the Cold, Dense LISM Clouds that the Sun may have Recently Encountered* • Monique Aller (E): *Silicate Dust Grain Properties in the Gas-Rich Absorption Systems of Diverse Galaxies*		
10:40am	Morning Break and Poster Session **Speaker Tech Check for Session 2 in Auditorium**		Café
Session 2: 3D Reconstruction of Stars and the ISM, Chair: Joshua Peek			
11:10am	A Deep High-Angular Resolution 3D Dust Map of the Southern Galactic Plane	Catherine Zucker (C)	Auditorium
11:30am	High-Altitude Clouds in the Solar Neighborhood: Connecting 3D Dust Maps and HI Gas Kinematics	Theo O'Neill (C)	
11:50am	An Inter-Stellar Case Study of the IRAS Vela Shell with 3D Dust Mapping	Annie Gao (C)	
12:10pm	The Emerging Properties of Our Immediate Interstellar Medium and its Impact on Stars and Planets	Seth Redfield (C)	
12:30pm	Lunch **Speaker Tech Check for Session 3 in Auditorium **		Café

Session 3: 3D Reconstruction of Stars and the ISM/Unveiling the ISM through the Absorption and Scattering of Starlight, Chair: Catherine Zucker			
1:40pm	Energy Input in the Local Interstellar Medium	Bob Benjamin (I)	Auditorium
2:10pm	A Galactic Eclipse: The SMC is forming stars in two, superimposed structures	Claire Murray (C)	
2:30pm	Mapping the ISM at Parsec-Scales with Dust Extinction in Nearby Galaxies	Christina Lindberg (C)	
2:50pm	Using quasars as lighthouses for the ISM fog	Alexander Plavin (C)	
3:10pm	Poster Flash Talks • Caleb Levy (P): *Astrospheres as Sheilds: Habitability in the Interstellar Medium* • Karl Gordon (P): *Extinction Curve in the Local Group: Evidence for ISM Dust Grain Grown* • Wilma Kiviaho (E): *Untangling Interstellar Extinction of Cepheids to Refine the Extragalactic Distance Scale* • Ben Velguth (E): *Tracing turbulence with young stars* • Jeffrey Linsky (E): *Empirical measures of the inhomogeneity of the local ISM and effects on astrospheres*		
3:20pm	Afternoon Break and Poster Session **Speaker Tech Check for Session 4 in Auditorium **		Café
Session 4: Unveiling the ISM through the Absorption of Starlight, Chair: Catherine Zucker			
3:50pm	Tomographic Distance Measurements of High-Velocity Clouds with SDSS-V Milky Way Mapper	Timothy McQuaid (C)	Auditorium
4:10pm	Extended Lyman Alpha haloes as probes of ionizing radiation escape near and far	Alberto Saldana-Lopez (C)	
4:30pm	Gas, dust, and Hα/Paα decrement extinction of stellar associations in NGC 4826 with PHANGS	Qiushi Chris Tian (C)	
4:50pm	A first taste of MEAD: Measuring Extinction and Abundances of Dust	Marjorie Decleir (C)	
5:10pm Conference Reception at STScI, Café			

Tuesday, May 13, 2025

Time	Title	Speaker	Location
8:30am	Breakfast + Snacks **Speaker Tech Check for Session 5 in Auditorium **		Café
Session 5: Tracing the Dynamic ISM: Probes from Pulsars to Star Clusters, Chair: Joshua Peek			
9:00am	Linking radio dispersion measure and optical extinction using pulsars hosted in globular clusters	Cristina Pallanca (C)	Auditorium
9:20am	Propagating Star Formation in Sco-Cen: Cluster Chains as Tracers of Stellar Feedback	Sebastian Ratzenboeck (C)	
9:40am	New insights into interstellar turbulence from JWST observations of the Pleiades	Francois Boulanger (C)	
10:00am	Inter+Stellar: Revolutionizing Stellar and ISM Science with the Habitable Worlds Observatory	Janice Lee	
10:20am	Poster Flash Talks • Savannah Gramze (P): *Using JWST to Map CO Ice in a Star Forming Filament* • Guillaume Vigoureux (P): Power Spectra of the Diffuse Interstellar Emission with JWST/NIRCam • Jordan Bartlett (E): *Optical Polarization and Reddening of Dust and Magnetic Structure in 3-Dimensions Towards ζ Ophiuchi* • Yasir Abdul Qadir (E): *DH Cephei, a massive O+O binary system at the core of the young cluster NGC7380* • Robert Gutermuth (E): *Constraining the star-forming past and future of the MonR2 GMC*		
10:30am	Morning Break and Poster Session **Speaker Tech Check for Session 6 in Auditorium **		Café
Session 6: Tracing the Dynamic ISM: Probes from Pulsars to Star Clusters/ISM Beginnings from Stellar Ends, Chair: Joshua Peek			
11:00am	Simulating the Interplay of Stars and Gas: Insights into the Radcliffe Wave and Spiral Structure	Sarah Loebman (I)	Auditorium
11:30am	A JWST View of the Dynamic ISM with Thermal Echoes of Cas A	Jacob Jencson (C)	
11:50am	Expanding Horizons in Stellar Dust Formation	Melissa Shahbandeh (C)	
12:10pm	Dynamics and Dust Properties of Colliding-wind Dust Producer WR 140	Emma Lieb (C)	
12:30pm	Lunch **Speaker Tech Check for Session 7 in Auditorium **		Café

Session 7: ISM Beginnings from Stellar Ends, Chair: Christopher Clark			
1:40pm	JWST/MIRI view of the planetary nebula NGC 6302 UV/X-ray irradiated torus and hot bubble triggering PAH formation	Mikako Matsuura (I)	Auditorium
2:10pm	Characterizing the PAH emission in the PN NGC 7027: Spectral variations revealed by JWST	Charlotte Smith-Perez (C)	
2:30pm	Discussion Breakout Sessions	Auditorium, Café Con, Cafeteria	
3:20pm	Poster Flash Talks • Vianey Camacho (P): *Squeezing Orbits: Accretion-Induced Orbital Tightening* • Shaunak Modak (P): *Characterizing Surface Density and Potential Fluctuations of the Interstellar Medium* • Steve Goldman (E): *The impact of evolved stars on their environment, and vice versa* • Christiana Erba (E): *Analyzing Stellar and Interstellar Contributions to Polarization for Hot Stars*		
3:30pm	Afternoon Break and Poster Session **Speaker Tech Check for Session 8 in Auditorium **		Café
Session 8: ISM Beginnings from Stellar Ends, Chair: Christopher Clark			
4:00pm	JWST Observations Suggest that AGB Stars Can Undergo Significant Dust Production in the Early Universe	Martha Boyer (C)	Auditorium
4:20pm	RAENBOW: Reconstructing AGB ENvelopes by Bridging Observations across Wavelengths	Sundar Srinivasan (C)	
4:40pm	Multi-wavelength insights into the recycled material from AGB Stars	Maryam Saberi (C)	
6:35pm Baltimore Orioles Game!			

Wednesday, May 14, 2025

Time	Title	Speaker	Location
8:30am	Breakfast + Snacks **Speaker Tech Check for Session 9 in Auditorium **		Café
Session 9: Understanding Galaxy Evolution Through Chemical Enrichment, Chair: Elizabeth Tarantino			
9:00am	Modeling Cosmic Dust Evolution Atom-by-Atom in a Multiphase ISM	Clarke Esmerian (C)	Auditorium
9:20am	Disentangling galaxy and dust evolution mechanisms through chemical abundances	Stefan van der Giessen (C)	
9:40am	The origin of strong alpha-element bimodalities in FIRE simulations of Milky Way-mass galaxies	Megan Barry (C)	
10:00am	Connecting Metallicity Evolution Models to Resolved Star Formation Histories	Christopher Garling (C)	
10:20am	Poster Flash Talks • Calum Hawcroft (P): *Populations of massive stars at low metallicity* • James Garland (E): *Stirring the Pot: Spiral-Arm-Induced Star Formation and ISM Enrichment in NGC 628* • Hwihyum Kim (E): *Resolved Stellar Populations in PHANGS-HST Galaxies* • Ilyse Clark (E): *The Resolved Structure of a Low Metallicity Photodissociation Region* • Dries Van De Putter (E): *Spectral Decomposition of the Aromatic Infrared Bands in Photodissociation Regions*		
10:30am	Morning Break and Poster Session **Speaker Tech Check for Session 10 in Auditorium **		Café
Session 10: Understanding Galaxy Evolution Through Chemical Enrichment/The Impact of Stellar Feedback Across Environments, Chair: Elizabeth Tarantino			
11:00am	Local Dwarf Galaxies as Laboratories to Understand Massive Stars and the ISM in the Early Universe	Grace Telford (I)	Auditorium
11:30am	Chemical Evolution of Local Group Dwarf Irregular Galaxies with Abundances of Stars and Gas	Nao Fukagawa (C)	
11:50am	MOBStIRS: Mass-loss rates for OB Stars driving IR Bow Shocks	Matthew Povich (C)	
12:10pm	From massive O-stars to young Brown Dwarfs - the effects of feedback in the Small Magellanic Cloud	Peter Zeidler (C)	
12:30pm	Lunch **Speaker Tech Check for Session 11 in Auditorium **		Café

Session 11: The Impact of Stellar Feedback Across Environments, Chair: Thomas Megeath			
1:40pm	How stellar feedback impacts molecular gas and future star formation in galaxies	Elizabeth Watkins (I)	Auditorium
2:10pm	Where do stars explode in the interstellar medium?	Sumit Sarbadhicary (C)	
2:30pm	Discussion Breakout Sessions	Auditorium, Café Con, Cafeteria	
3:20pm	Poster Flash Talks • Tom Megeath (P): *Investigating protostellar accretion drive feedback with JWST* • Baria Khan (P): PDRs4All: *Decoding the spectral properties of PAHs and Very Small Grains in the Orion Bar* • Divakara Mayya (E): *Spatially-resolved TRGB JWST CMDs as a tool to measure fossil stellar metallicity gradients* • Leo Belloir (E): *Constraints on the efficiency of the PE heating in a molecular ridge of the metal-poor LM* • Adam Smercina (E): *A Portrait of the Triangulum: Advancing a New Frontier of Galaxy Evolution with Resolved Stars*		
3:30pm	Afternoon Break and Poster Session **Speaker Tech Check for Session 12 in Auditorium **		Café
Session 12: The Impact of Stellar Feedback Across Environments, Chair: Thomas Megeath			
4:00pm	Star-formation history of large bubbles in nearby galaxies	Avinash Chandrakumar (C)	Auditorium
4:20pm	MHMM: Molecular H2 in M83 with MIRI/MRS	Logan Jones (C)	
4:40pm	A High-Resolution study of HII Regions and Diffuse Ionized Gas in M33 with SIGNALS	Emma Jarvis (C)	
5:00pm SDAS (STScI Happy Hour), Café			

OPTIONAL EVENING EVENT: Astronomy on Tap, Doors Open at 7pm

Guilford Hall Brewery at 1611 Guilford Avenue Baltimore, MD 21202

Thursday, May 15, 2025

Time	Title	Speaker	Location
8:30am	Breakfast + Snacks **Speaker Tech Check for Session 13 in Auditorium **		Café
Session 13: The Localities of Star Formation, Chair: Yumi Choi			
9:00am	When will lunch be served?: Charting gas flows in our Galaxy's Center	Cara Battersby (I)	Auditorium
9:30am	Young Massive Star Clusters and Feedback in the Prototypical Starburst Galaxy NGC253	Rebecca Levy (C)	
9:50am	Harnessing the power of ALMA and IFUs: Joint analysis of gas and stars in nearby galaxies	Timothy Davis (C)	
10:10am	Dust as a Tracer of Gas and Stellar Feedback	Deb Pathak (C)	
10:30am	Poster Flash Talks • Brad Whitmore (P): *The Effect of Feedback on our Ability to Age-date Star Clusters in Nearby PHANGS Galaxies* • Jake Hoffman (P): *An integral partner of star formation: the dust filament network (DFN) in PHANGS-JWST galaxies* • Natascha Satter (E): *Resolving physical conditions in the Trifid Nebula with SDSS-V LVM* • Lucas Kuhn (E): *Exploring Star Formation and Multi-Phase Gas in a Brightest Cluster Galaxy with JWST, MUSE, and ALMA*		
10:40am	Morning Break and Poster Session **Speaker Tech Check for Session 14 in Auditorium **		Café
Session 14: The Localities of Star Formation/Formation, Kinematics, and Feedback of Star Clusters, Chair: Yumi Choi			
11:10am	PHANGS-JWST: Do spiral arms even matter?	Thomas Williams (C)	Auditorium
11:30am	Strong feedback from young super star clusters in nearby galaxies	Daniel Maschmann (C)	
11:50am	The Dynamics of Star Cluster Assembly	Jeremy Karam (C)	
12:10pm	The Far-infrared NASA Probe Concept Mission PRIMA	Cara Battersby	
12:30pm	Group Photo		
12:40pm	Lunch **Speaker Tech Check for Session 15 in Auditorium **		Café

Session 15: Formation, Kinematics, and Feedback of Star Clusters, Chair: Mordecai-Mark Mac Low			
1:40pm	The impact of far-ultraviolet radiation on star formation and the interstellar medium	Tim-Eric Rathjen (I)	Auditorium
2:10pm	Bridging Stars and the ISM: Insights from FIRE Simulations on Young Stellar Structures	Davoud Masoumi (C)	
2:30pm	Discussion Breakout Sessions	Auditorium, Café Con, Cafeteria	
3:20pm	Poster Flash Talks • Mordecai-Mark Mac Low (E): *Massive Star Cluster Formation and Early Evolution* • Tobin Wainer (P): *Connecting High Resolution Star Forming Simulations to Observables* • Aashish Gupta (P): *Interactions between young stars and molecular clouds* • Jimena Rodriguez (P): *The Hidden Lives of Star Clusters: Using 3.3 μm PAH emission to detected dust-embedded star clusters* • Ashley Lieber (E): *Compact Obscured Star Clusters in the Nearby Starburst Galaxy NGC 253*		
3:30pm	Afternoon Break and Poster Session **Speaker Tech Check for Session 16 in Auditorium **		Café
Session 16: Formation, Kinematics, and Feedback of Star Clusters, Chair: Mordecai-Mark Mac Low			
4:00pm	Interplay between stars, the ISM and galactic environments on resolved scales	Helena Faustino Vieira (C)	Auditorium
4:20pm	SED modeling star clusters using direct markers of gas and dust emission with the PHANGS catalog	Kiana Henny (C)	
4:40pm	Dissecting the spectral energy distributions of emerging star clusters	Alex Pedrini (C)	
6:00pm Unbanquet at R House at 301 W. 29th Street Baltimore, MD 21211			

Friday, May 16, 2025

Time	Title	Speaker	Location
8:30am	Breakfast + Snacks **Speaker Tech Check for Session 17 in Auditorium **		Café
Session 17: The Physics of Early Star Formation, Chair: Joel Green			
9:00am	Simultaneous NIR and Radio Monitoring of YSOs to Probe the Connection Between Accretion and Ejection	Arpan Ghosh (C)	Auditorium
9:20am	JWST Photometry and Spectra Reveal Dust and Ice in the Magellanic Clouds	Isha Nayak (C)	
9:40am	Physical Conditions of the Molecular Gas in the SMC's Star Forming Region NGC 346	Laura Lenkic (C)	
10:00am	Characterizing Young Stellar Objects in NGC 602 with JWST	Beena Meena (C)	
10:20am	Poster Flash Talks • Priya Hassan (E): *Star Formation in the Perseus Molecular Cloud: IC 348, NGC 1333 and Friends* • Ronan Kerr (P): *Revealing the Role of Earlier Generations in Guiding Cloud Evolution in Circinus* • Ciaran Rogers (E): *The environmental influence on star and planet formation*		
10:30am	Morning Break and Poster Session **Speaker Tech Check for Session 18 in Auditorium **		Café
Session 18: The Physics of Early Star Formation, Chair: Joel Green			
11:00am	Cluster formation in Orion and beyond the Gould Belt	Amelia Stutz (I)	Auditorium
11:30am	Multiwavelength mysteries in the most star-forming cloud in the Galactic center	Nazar Budaiev (C)	
11:50am	Detection of protostellar outflows in ALMA-IMF: top-heavy CMFs and high-mass prestellar cores	Maxime Valeille-Manet (C)	
12:10pm	Hack Day Pitches & Event Closeout		
12:30pm	Lunch		Café
Session 19			
1:40pm	Afternoon Hackday Coordinated by: Erik Tollerud & Christina Lindberg		Auditorium & Cafe
5:00pm	Hackday Celebration		Auditorium

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Symposium Abstracts

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Invited Talks

When will lunch be served?: Charting gas flows in our Galaxy's Center

Cara Battersby
University of Connecticut

The Central Molecular Zone (CMZ) is the way station at the center of our Galaxy, regulating gas flowing in from the disk, some of which is channeled toward the supermassive black hole at the center, SgrA*. Key foundational questions about the regulation and balance of these processes have been hampered by an incomplete understanding of the 3-D gas flows and structures in the CMZ. By combining data across the electromagnetic spectrum, from gas, stars, and even past flaring events of SgrA*, we present a unified method to establish the 3-D structure of the CMZ using all available constraints. We compare these data with current models, create 3-D maps of two molecular clouds, and are developing an improved global structure model informed by cutting-edge numerical simulations.

Energy Input in the Local Interstellar Medium

Robert Benjamin
University of Wisconsin – Whitewater

In order to make progress in understanding the structure and evolution of galaxies, it is important to understand the role of feedback from stars—both young and old— on the interstellar medium. The high precision measurements of stellar distances and extinctions made possible by Gaia have revolutionized our understanding of the three-dimensional structure of the local ISM, and turned the region around the Sun into a laboratory for interstellar physics, allowing for studies of the details of the injection of momentum and energy. In this talk, I will summarize three advances in this area: (1) the first 3D-maps of the distribution of ionized gas, electron temperature, and EUVE radiation field in the 1.25 kpc around the Sun (McCallum et al 2025), (2) evidence that most of the young clusters around the Sun had their origin in three star formation complexes, with a star formation beginning around 45 Myr ago and continuing to the present day (Swiggum et al 2024), and (3) "kinetic tomography" of the gas/dust in the local disk and its possible relation to the recent star formation history (Soler et al 2025). I provided updates on these three efforts, discuss how the results are related, suggest a scenario for the recent (< 60 Myr) injection of energy into the local interstellar medium, and suggest how this scenario might be tested.

Variation of the dust extinction curve: a 3D perspective from Gaia

Gregory Green
Max Planck Institute for Astronomy

Over the last decade, there have been major advances in three-dimensional mapping of the density of interstellar dust in the Milky Way using large datasets of photometric, astrometric and spectroscopic measurements of background stars. However, how the wavelength-dependence of dust extinction varies throughout the Galaxy has remained poorly understood. The dust "extinction curve" (wavelength vs. extinction) contains information about the composition and size distribution of dust grains. Low-resolution stellar spectra from Gaia have allowed us to measure the extinction curve along 130 million sightlines - orders of magnitude more than previously available. Using these measurements, we have created the first detailed three-dimensional map of extinction-curve variation throughout a large volume of the Milky Way. This qualitatively new picture of the Milky Way's dust has already yielded surprises. Much of the variation in R(V) - which describes the slope of the optical extinction curve - appears to be due to growth of polycyclic aromatic hydrocarbons in the intermediate-density interstellar medium (ISM). We find that star-forming regions in the Milky Way and Large Magellanic Cloud appear to have flatter extinction curves. We also find that a single parameter, R(V), is insufficient to describe all of the variation in the optical extinction curve, and detect a new broad extinction feature of unknown chemical origin at 850 nm. Connecting the detailed three-dimensional variation of the extinction curve with observable properties of the ISM (e.g., CO, HI and the UV radiation field) will be a powerful tool for studying the physical processes that drive dust evolution. With JWST yielding observations of dust in high-redshift galaxies, a better understanding of these processes, anchored in the Local Group, is highly timely.

Simulating the Interplay of Stars and Gas: Insights into the Radcliffe Wave and Spiral Structure

Sarah Loebman
University of California- Merced

Understanding the large-scale structure of the Milky Way requires connecting the evolution of gas and stars over time. Using high-resolution, cosmological zoom-in simulations of Milky Way-like galaxies from the FIRE-2 Latte suite, I explore how interactions between the interstellar medium (ISM) and star formation shape galactic structure. I will discuss the formation and evolution of sinusoidal gas structures akin to the recently discovered Radcliffe Wave, showing that these features naturally emerge in simulated galaxies as gas from multiple spiral arms merges over ∼100 Myr timescales. However, these waves are ultimately short-lived in our simulations, as supernova feedback drives turbulence that disrupts the coherent structure of the gas. Additionally, I will compare the morphology and longevity of spiral structure as traced by stars versus gas, highlighting key differences in how each component responds to galactic dynamics. Finally, I will touch on the early evolution of star clusters and their connection to the lifetimes of the giant molecular clouds that birth them. By leveraging simulations that model the co-evolution of gas, stars, and stellar feedback at parsec scales, this work provides a theoretical framework for interpreting cutting-edge observations of the Milky Way's ISM and young stellar populations.

JWST/MIRI view of the planetary nebula NGC 6302 UV/X-ray irradiated torus and hot bubble triggering PAH formation

Mikako Matsuura
Cardiff University

Some planetary nebulae (PNe) exhibit mixed oxygen and carbon chemistry, containing both silicate and polycyclic aromatic hydrocarbon (PAHs) dust. Among Galactic PNe, NGC 6302 is one of them, with bipolar morphology, fast outflows, and a very hot central star (~220,000 K).

A mosaic map (18.5'' x15.5'') was obtained over the core of NGC 6302 using the JWST/MIRI and medium resolution spectrometer (MRS). The spectrum reveals nearly 200 atomic and molecular lines with ionization potentials from 0 to 187 eV, and broad features from crystalline and amorphous silicates and PAHs.

The spatial distribution reveals stratification at the nebula's center. Highly ionized lines such as [MgVII] are confined to a relatively compact volume, while tracers of low-ionization regions show extended distributions, including filamentary arcs that appear to define boundaries of lower-density zones, or bubbles. In the bubble, H+ and H_2 emission are co-spatial, whereas PAH emission appears slightly farther out, suggesting an ionization structure distinctly different from typical photodissociation regions like the Orion Nebula. This may mark the first identification of a PAH formation site in a PN.
A dusty, warped torus surrounding the core is composed mainly of large (micron size) silicate grains with crystalline components.

The core of this PN appears to be shaped not by a steady, continuous outflow but by a series of dynamic, impulsive bubble ejections with local conditions conducive to PAH formation. The long-lived torus contains a substantial mass of material and supports equilibrium chemistry through a slow dust-formation process.

The impact of far-ultraviolet radiation on star formation and the interstellar medium

Tim-Eric Rathjen
University of Cologne

How does far-ultraviolet (FUV) radiation from young star clusters influence the structure and evolution of the interstellar medium (ISM)? We investigate this question using state-of-the-art magnetohydrodynamic simulations within the SILCC Project framework, incorporating self-consistent radiative transfer of both ionising and non-ionising radiation. This approach moves beyond conventional models based on static interstellar radiation fields. Although local FUV intensities can exceed 10^4 times the solar neighbourhood value, we find that FUV radiation exerts a surprisingly modest influence on star formation rates. Instead, it plays a crucial role in shaping the multiphase ISM by fostering the development of a cold, diffuse gas component with a distinct molecular signature, occupying 5–10 per cent of the volume. This previously underexplored phase emerges alongside elevated cold neutral medium filling factors and enhanced thermal phase separation. Our results highlight the importance of FUV radiation in regulating ISM structure and molecular gas formation, posing a challenge to existing models of stellar feedback.

Cluster formation in Orion and beyond the Gould Belt

Amelia Stutz
Universidad de Concepción

Protoclusters are gas dominated systems that represent the birth sites of most stars. I will discuss protocluster evolution, from Orion to typical systems in the Milky Way disk probed by the ALMA-IMF large program. The Integral Shaped Filament (ISF) is home to the nearest significant protocluster, the Orion Nebula Cluster (M42). By comparing 3 constituents of Orion A (gas, protostars, and pre-main-sequence stars), both morphologically and kinematically, we show that the protostars are kinematically cold compared to the disk stars, and all young stars are bound to the massive ISF. The gas reservoir in the ISF exhibits kinematic undulations that cry out for an explanation; these show evidence of setting the structure of the M42 young star cluster via tidal effects. The ISF is the 3rd in a series of star bursts that are progressively moving south, with separations of ~ 2 Myr in time and 3 pc in space. This, combined with the filament's observed undulations (spatial and velocity), suggests that repeated propagation of waves thru the filament is progressively digesting the gas that formerly connected Orion A and B into stars in approximately discrete episodes. In more distant protoclusters like those observed by ALMA-IMF, where we lack the enormous density of observations available in Orion, we capture the dense gas kinematics and morphology at the onset of cluster formation with ALMA, showing short gas depletion times requiring furter mass feeding to maintain cluster formation over their ~ expected lifetimes. JWST observations are critical to pinpoint the young star populations as star clusters emerge from the gas.

Local Dwarf Galaxies as Laboratories to Understand Massive Stars and the ISM in the Early Universe

Grace Telford
Princeton University

Feedback from low-metallicity massive stars regulates the evolution of both dwarf and high-redshift galaxies. To understand those processes requires robust models of the metal-poor ISM in which stars form and of massive stars' winds and ionizing spectra. Yet, these models remain entirely theoretical and uncertain due to a lack of observational constraints in the extremely low-metallicity regime. In this talk, I will present a suite of JWST, HST, and Keck observations of the nearby 3% Solar metallicity galaxy Leo P. First, I will describe novel constraints on the wind properties and ionizing spectrum of the galaxy's only O-type star from modeling HST/COS and Keck/KCWI spectroscopy. This star is part of the Treasury of Extremely Metal-Poor O Stars (TEMPOS), a Large Treasury HST program that will extend this initial analysis to a much larger sample at ~5-10% Solar metallicity. I will then present new JWST/MIRI-MRS observations of Leo P, which enabled the first detection of cold molecular hydrogen at such low metallicity via rotationally excited emission from the photodissociation region illuminated by the O star. Our detailed understanding of that star's UV radiation from the HST data constrains the temperature and mass of the detected molecular hydrogen, providing a benchmark for models of the ISM at the very low metallicities typical at high redshift. Leo P showcases the potential of the metal-poor dwarf galaxies in our backyard to inform models of early galaxies.

How stellar feedback impacts molecular gas and future star formation in galaxies

Elizabeth Watkins
University of Manchester

Understanding how molecular clouds form stars and the role stellar feedback has is a key problem in astronomy. These processes drive the chemical and physical evolution of galaxies and power the large-scale processes needed to maintain the interstellar medium (ISM). However, the large timescales over which stars form limits investigations. Therefore, I will present my most recent work illustrating ways to chart the interaction between molecular gas and feedback over time by using multiwavelength datasets across a range of spatial scales (0.1–100pc). In the first half of my talk, I will focus on how feedback features carve out cavities (i.e., bubbles) within the ISM. More specifically, how I used state-of-the-art JWST, ALMA and HST observations of nearby galaxies – and more recently, galactic scale zoom-in simulations – to reveal the history, and evolution of a large sample of bubbles, their local gas conditions and the impact they have on star formation. The second half of my talk will instead focus on how Herschel and Spitzer observations can be used to statistically trace the evolution of over 10,000 molecular clouds within the Milky Way. With access to the time domain, I show clouds continuously gain mass while star formation is ongoing and it is their growth rate that dictates how pre-SN feedback disrupts star formation. With metrics such as the star formation efficiency per free-fall time relying on static cloud masses, these results have far reaching implications.

Contributed Talks

The origin of strong alpha-element bimodalities in FIRE simulations of Milky Way-mass galaxies

Megan Barry
University of California – Davis

Rutgers University/Flatiron InstituteOne of the characteristic features of the Milky Way is the bimodal distribution of stellar abundances of the alpha-process elements (O, Ca, Mg, ...) at fixed [Fe/H].Using Mg as a characteristic alpha element, we examine patterns in stellar [Mg/Fe] versus [Fe/H] in the FIRE-2 simulations of Milky Way-mass galaxies. We find that 4 out of 16 galaxies are similar to the MW in their strongly bimodal distribution of stellar element abundances at z=0. In these galaxies, the element abundance transitions from high- to low-alpha begin anywhere from 5.5 Gyr to 6.5 Gyr ago, and occur over timescales ranging from 0.3 Gyr to 1.2 Gyr. In all four cases, the reduction in [Mg/Fe] follows a drop in star formation rate, causing an increase in the rate of white dwarf supernovae relative to the core-collapse supernovae, thereby causing ISM enrichment rates of Mg and Fe to diverge. We also find that in all 4 galaxies, gas accretion at this time dilutes the elemental abundances in the ISM such that Mg/Fe decreases at relatively fixed Fe/H, both galaxy-wide and in bins of stellar radial distance at formation. For two of these galaxies, the alpha transition is associated with a major merger coalescence, while the other two are associated with long-term interactions with surviving satellites. Similar to the Milky Way, the high- and low-alpha populations in each galaxy correspond spatially to thick and thin disks.

LightCube: A 3D Model of the Local UV Interstellar Radiation Field

Hannah Bish
Space Telescope Science Institute

Traditionally, studies of the Milky Way and ISM have assumed a constant value for the interstellar radiation field (ISRF) in the nearby Galaxy. This is often the most reasonable assumption given the limited information we have. In reality, the ISRF varies depending on proximity to stars, dust extinction, and other factors, and these variations can greatly influence the properties of diffuse matter. Thanks to recent progress in the quality of local dust maps and distances to UV-bright stars, we are now able to calculate a detailed representation of the UV radiation background within 1.25 kpc of the Sun - a data set we call LightCube. We present this data set, discuss our initial findings, and touch on potential uses of LightCube by the community.

New insights into interstellar turbulence from JWST observations of the Pleiades

Francois Boulanger
LPENS

NIRCam observations of PAH and H2 emission in the Pleiades nebula near Merope open up new avenues for exploration of interstellar turbulence. Merope's radiation highlights the structure of the cold interstellar medium within a few parsecs, at a 25 au (0.1 mpc) resolution. The data capture the scales at which molecular hydrogen dynamically decouples from PAHs and magnetic fields. The PAH emission shows a striated pattern consistent with observations of dust-scattered starlight, while the H2 emission reveals an unexpected filamentary structure that does not follow this pattern. A straightforward interpretation suggests that H2 traces the gas density structure along a dissociation front shaped by the star motion relative to the ISM. However, the anisotropy and power spectrum of the PAH emission are indicative of magnetically-dominated subsonic MHD turbulence, where density fluctuations are weak and dynamically insignificant. Reconciling these contrasting perspectives suggests a missing physical process, perhaps involving ambipolar diffusion or magnetic reconnection. We will present this interpretive framework and discuss its implications for interstellar turbulence.

JWST Observations Suggest that AGB Stars Can Undergo Significant Dust Production in the Early Univer

Martha Boyer
Space Telescope Science Institute

Asymptotic Giant Branch (AGB) stars are a significant source of dust in nearby galaxies, but it is unclear if metal-poor AGB stars can produce dust quickly enough to contribute dust in high redshift galaxies. We present JWST imaging and spectroscopy of the AGB population in Sextans A, an extremely metal-poor nearby dwarf galaxy that has an AGB population with a metallicity ranging from 1-3% solar. Despite the low metallicity, the mid-IR spectra confirm that carbon stars (<4 Msun) form large amounts of SiC and amorphous carbon dust. Moreover, the most massive oxygen-rich AGB star in our sample (4-8 Msun) also shows a strong infrared excess, despite a lack of silicate features in the spectrum. We explore several possibilities to explain this featureless dust excess, and conclude that metallic iron dust is a likely candidate. Stars this massive enter the dust producing phase just 30-50 Myr after forming, early enough to contribute to the dust reservoirs in high redshift galaxies. If confirmed, this finding suggests that metal-poor AGB stars can form large amounts of dust at early times, which would have strong implications for dust evolution models in high redshift galaxies.

Multiwavelength mysteries in the most star-forming cloud in the Galactic center

Nazar Budaiev
University of Florida

The high-density, turbulent, and overall extreme environment of the Central Molecular Zone (CMZ) provides a unique laboratory for studying disk-scale star formation under conditions similar to those at cosmic noon. Despite the importance of the region – ranging from the formation history of stars like our Sun to informing our understanding of other galaxies, many key properties of the CMZ, such as the relatively low star formation rate, remain unexplained.

The CMZ forms ~10% of all stars in the Galaxy, half of which are born in a single cloud: Sagittarius B2. We present a multi-wavelength overview of Sgr B2, the most massive molecular cloud in the CMZ. Combining observations from ALMA, VLA, and JWST, we construct a holistic picture of both star formation and the surrounding ISM. We find a large-scale asymmetry in star formation across the cloud, with a sharp edge facing the epicenter of its orbit around the Galactic center. This asymmetry highlights that, even in high-pressure environments, feedback has escape valves. We investigate material inflow and outflow from the center of the proto-super star cluster. We examine different stages of star formation and how their interactions within the cloud – from the collapsing dust cores observed with ALMA, to highly pressurized HII regions detected by VLA, to accreting stars revealed with JWST.

Star-formation history of large bubbles in nearby galaxies

Avinash Chandrakumar
Instituto Nacional de Astrofisica, Optica y Electronica

JWST MIRI filter images of nearby star-forming galaxies have transformed our understanding of the interstellar medium (ISM). Contrary to the traditional view of the ISM as mostly static gas with isolated molecular clouds and HII regions, MIRI images reveal a dynamic ISM dominated by bubbles between HII regions. These bubbles, formed by stellar feedback processes like stellar winds and supernovae, inject energy and momentum into the ISM, possibly through multiple generations of star formation. Leveraging the JWST-FEAST data, we systematically search for remnant clusters within the MIRI bubbles in nearby face-on disk galaxies. The high spatial resolution of JWST NIRCAM images allows us to analyze the remnant stellar populations using color-magnitude diagrams of the resolved stars. In a prior study, Mayya et. al., (2023) characterized the stellar populations in one of the largest bubbles in the spiral galaxy NGC 628 (M74), dubbed the "phantom void" by Barnes et. al. (2023). This work presents our findings on the stellar populations responsible for bubble formation in all major bubbles observed in the M51, M74, and M83.

New orbital and metallicity structures in the Milky Way disk

Sihao Cheng
Institute For Advanced Study

Stars can serve as a unique tool to understand the ISM because of their rich interactions. New stars form from the ISM, which has been influenced by older stars through their gravity and metal pollution. This feedback loop may leave their imprint on the stellar distribution itself. Using Gaia DR3 data, we provide for the first time a full mapping of stellar orbits and metallicity in the Milky Way disk without projection that blurs the map and corrected for selection bias. With this clear and flat view of the phase space, we discover very sharp structures including a metallicity cliff with guiding center radius at 6.5 kpc ([M/H] dropping by 0.2 within 100 pc) and a pair of over--under-density stripes around 7.5 kpc. Both features involves a range of stellar age and are likely related to dynamical resonances of the bar or spiral arms. Our findings reveal the important role played by resonance in shaping both stars and the ISM, and motivate searches for similar structures in other disk galaxies.

Gas, dust, and Hα/Paα decrement extinction of stellar associations in NGC 4826 with PHANGS

Qiushi Chris Tian
Johns Hopkins University

Age-reddening degeneracy hinders the precise age and mass determination of stellar populations in nearby galaxies. In the Physics at High Angular Resolution in Nearby Galaxies (PHANGS) surveys, stellar associations trace loosely bound young stars in recent star formation sites. Leveraging the synergy between HST and JWST, we present dust extinction estimations of stellar associations in NGC 4826 (M 64) using the H? to Paschen-? decrement. We investigate the H? and Pa? morphology and its potential impact on the accuracy of the dust extinction estimation. We further correlate the H II emission to the dust emission from polycyclic aromatic hydrocarbons (PAH) as revealed by JWST. Through these means, our study refines measured properties of stellar associations, connects stars to the interstellar medium, and reveals their mutual influence on each other.

PAH Marks the Spot: Digging for Buried Star Clusters in Nearby Galaxies

Daniel Dale
University of Wyoming

Identifying and characterizing embedded star formation is a key goal for the Physics at High Angular Resolution in Nearby GalaxieS (PHANGS) project. Using JWST and HST imaging we have identified hundreds of deeply embedded stellar clusters in a sample of 11 nearby star-forming galaxies using both a Zooniverse-based by-eye approach as well as machine learning. The main criterion defining `embedded' in this study is visible in JWST near-infrared imaging and invisible in HST UV/optical imaging. I will present several facets of this study: the similarities and differences between the samples generated via the by-eye and machine learning approaches; how the machine learning identifications depend on the convolutional neural networks employed; the distributions of the cluster profiles, ages, masses, and extinctions and how they compare to those of samples of exposed stellar clusters; and the spatial correlations between embedded clusters and the molecular gas as observed by ALMA.

Harnessing the power of ALMA and IFUs: Joint analysis of gas and stars in nearby galaxies

Timothy Davis
Cardiff University

In this talk I will focus on how joint modelling of the gas and stars in nearby galaxies can be used to constrain the fundamental physics underpinning galaxy formation. Firstly, as part of the GECKOS program that combines MUSE and ALMA observations of edge-on spiral galaxies, I will show that the molecular ISM provides an excellent way to identify and trace bars. This especially true in edge on galaxies where they can be otherwise difficult to identify. I will show how the gas can constrain key parameters such as the bar PA and length, which when combined with the stellar kinematics sheds light on the redistribution of material and the kinematic origin of galaxy bulges. Secondly I will show that combining the kinematics of the gas with the stellar population information derived from the IFU allows one to probe the radial variation of the IMF in massive galaxies. Finally I will look forward to KILOGAS, an upcoming large ALMA program mapping the molecular material in nearly 500 galaxies with MaNGA or SAMI IFU data, which will allow the application of these joint modelling approaches across the galaxy population.

A first taste of MEAD: Measuring Extinction and Abundances of Dust

Marjorie Decleir
European Space Agency (ESA) at STScI

Interstellar dust strongly influences star formation and galaxy evolution at all cosmic times. In addition, dust absorbs and scatters a large fraction of the star light, effectively hiding entire stellar populations in galaxies. Understanding the properties of the dust grains is thus crucial to derive precise knowledge of dust-obscured stellar populations, as well as to constrain the initial conditions for star formation.

We gain insight into the properties of the interstellar dust by studying its extinction effect on the star light, using the stars as our light bulbs; extinction features in multi-wavelength spectra reveal the composition of the dust grains. In addition, measurements of the abundances of the elements that make up the dust grains enable us to quantitatively determine the chemical composition of the grains. With the MEAD (Measuring Extinction and Abundances of Dust) project we are combining these two methods to constrain the dust properties in our Galaxy. We obtained ultraviolet spectra with the Hubble Space Telescope to measure dust abundances in a sample of Milky Way sightlines that span a range of environments. Furthermore, we obtained infrared spectra for the same sightlines with the James Webb Space Telescope to study the dust extinction features.

In this talk, I will give you a first taste of MEAD, and walk you through our initial, recently published, exciting results, which show intriguing correlations between dust extinction and abundances. I will also highlight the carbonaceous and silicate extinction features that we detect, and what we can learn from those. Finally, I will demonstrate how the synergy between multi-wavelength data from the HST and JWST, as well as other telescopes is advancing our understanding of interstellar dust properties and how they vary in our Galaxy.

Modeling Cosmic Dust Evolution Atom-by-Atom in a Multiphase ISM

Clarke Esmerian
Chalmers University of Technology

Interstellar dust is a fundamentally important component of the cosmic galaxy population - both because of its impact on observable quantities and its dynamic influence on the ISM. However, many basic questions about its origin, evolution, and properties remain unanswered, in large part because of the complexities of dust physics. Our group is addressing these questions by conducting a large program of molecular dynamics simulations of individual dust grains in which every atom is accounted for. This has enabled, for the first time, estimation of some grain physical processes rates (i.e. accretion, coagulation, shattering) from first principles. I will overview these results and discuss their implications for dust evolution in the interstellar medium. I will also present high-resolution simulations of kpc-scale ISM patches which include a novel model for the evolution of cosmic dust grains in a multiphase medium that incorporates the results of these molecular dynamics calculations. These ISM simulations provide predictions for the dust chemical composition and size distribution - and thereby dust optical properties - with unprecedented physical fidelity. I will present tests of these predictions by direct comparison to the wealth of relevant observational data, highlighting both successes and challenges that indicate areas for future work.

Interplay between stars, the ISM and galactic environments on resolved scales

Helena Faustino Vieira
Stockholm University

The question of whether star formation is solely dependent on the local conditions of the interstellar medium (ISM), or if it is also directly affected by the large-scale dynamics within galaxies, is a matter of long-standing debate. To understand this problem, we must both probe the small physical scales associated with star-forming clouds, as well as the wider galactic context which might affect said clouds.

I will present my work on the resolved properties of the ISM, where we exploit the high-resolution data from HST in nearby spiral galaxies to its full potential. Our optical dust extinction technique allows us to image and study the ISM of nearby galaxies at cloud-scales over several kiloparsecs. For our sample of spirals, we find clear changes in ISM properties depending on galactic environments and dynamics, with galactic centers showing higher surface densities than the discs, whereas arm/inter-arm differences are more subtle.

The next step is to understand the interplay between stellar feedback and natal clouds. The advent of JWST has allowed us to unveil the still embedded young star clusters (eYSCs) at unprecedented detail. I will showcase our pilot NIRSpec/MOS study of a representative sample of eYSCs in NGC628, which allow us to not only characterize eYSCs, but also their surrounding ISM. Spectroscopy covering 1-5micron gives us a direct imprint of the mechanisms at work during the cluster emergence phase, probing both the ionizing conditions and extinction (through H and He recombination lines), and photo-dissociation region properties. Additionally, observed spatial variations of PAH 3.3micron emission (with distance to eYSCs) can tell us about the evolution of dust properties as clusters emerge.

Chemical Evolution of Local Group Dwarf Irregular Galaxies with Abundances of Stars and Gas

Nao Fukagawa
National Astronomical Observatory of Japan (NAOJ)

The chemical abundance of stars and gas provides insights into the astrophysical source of chemical enrichment and physical processes relevant to galaxy evolution, including star formation and gas flows. The proximity to Local Group dwarf irregular galaxies (dIrrs) allows us to measure the chemical abundance of individual stars and interstellar gas. Also, the star formation history, the stellar metallicity distribution, and the gas content can be derived for each dIrr. These observed quantities of stars and gas bring an understanding on the chemical evolution of individual dIrrs.

Using numerical models, we attempt to investigate the contribution of astrophysical sources (massive stars of different initial rotational velocities, AGB stars, type-Ia supernovae, and r-process candidates) to the chemical evolution of individual Local Group dIrrs. In the model, the occurrence rate of the astrophysical sources is estimated from the star formation history. The rates of gas accretion and outflow are roughly determined by the stellar metallicity distribution, the gas-phase oxygen abundance of star-forming regions, and the gas fraction. We discuss relevant physical processes, astrophysical sources of chemical enrichment, and observational information to explore the chemical evolution of dwarf galaxies.

An Inter-Stellar Case Study of the IRAS Vela Shell with 3D Dust Mapping

Annie Gao
The Johns Hopkins University

The IRAS Vela shell (IVS) is an interstellar cavity located around 400 pc from the Sun. It marks the inner periphery of the Gum Nebula, a region where multiple phases of the interstellar medium coexist, constituting an ideal laboratory for understanding the interplay between star formation and stellar feedback. While the IVS has been known for decades, its origin has remained an open question due to the limitations of 2D projected observations. Our work leverages a recent 3D dust extinction map (Edenhofer et al. 2024) to constrain the 3D spatial geometry of the IVS alongside its mass and momentum. Its physical properties, combined with its dynamical expansion, sheds new light on the stellar feedback mechanisms required to shape this structure. Our analysis suggests that roughly 1-2 supernovae are needed to form the IVS. We further characterize the possible stellar progenitor of the potential supernova explosion by tracing back the motion of nearby OB associations, runaway stars, and neutron stars. We find a group of young massive clusters in the region that have produced multiple supernovae and are likely responsible for the shell's expansion. Our work provides one of the most detailed case studies of a superbubble to date, and offers an ideal framework for understanding the interaction between stars and the interstellar medium in the local Milky Way.

Connecting Metallicity Evolution Models to Resolved Star Formation Histories

Christopher Garling
The University of Virginia

Measurements of the star formation histories (SFHs) of galaxies enable comparisons to theoretical models of galaxy formation and evolution. While there are several methods that can measure galactic SFHs, the measurements with the greatest precision and time resolution are made by modelling resolved photometry of stellar populations obtained from space-based observatories (e.g., HST/ACS and JWST/NIRCam). A primary systematic in these measurements is the galactic chemical evolution of the observed population -- put simply, both the star formation rate and the metallicity of the star-forming ISM must be constrained as a function of time. The chemical evolution is typically modelled through an age-metallicity relation; i.e., `Z(t)`. However, these relations are difficult to compare between galaxies and to theory because they have no direct relation to the underlying star formation activity which is enriching the ISM in the first place. We develop a class of chemical evolution models integrated with a resolved SFH fitting code in which the metallicity of the star-forming ISM evolves along with the galactic stellar mass; i.e., we model `SFR(t)` and `Z(Mstar(t))` simultaneously. By explicitly connecting the chemical evolution to the SFH, such mass-metallicity relation (MZR) models can be easily compared between different galaxies and to theoretical predictions. As the processes mediating galactic chemical enrichment (particularly stellar feedback) remain significant sources of theoretical uncertainty, observational probes of the relation between star formation activity and chemical enrichment are critical for improving theoretical models. In this talk, I will present results applying this method to several dwarf galaxies in the Local Group and discuss the hypothesis that there is a universal MZR for the star-forming ISM of dwarf galaxies at low redshift. I will additionally compare the MZRs inferred from the observations to MZR measurements of analogous samples drawn from the IllustrisTNG simulations, the GALACTICUS semi-analytic model, and other theoretical works.

Simultaneous NIR and Radio Monitoring of YSOs to Probe the Connection Between Accretion and Ejection

Arpan Ghosh
Instituto de Radioastronomia y Astrofisica (IRyA)

Accretion and Outflows/Ejections are fundamental processes in star formation. The relationship between them is symbiotic in nature. The matter accreting from the disk onto the protostar has to lose angular momentum, which provides the energy for the jets and outflows. The centrimetric radio flux from Class I and II young stellar objects mostly originates from collimated winds or jets, which get ionized due to their interaction with the ambient medium. Radio data then permits to estimate the mass-loss rate from this emission, but it does not provide information on accretion variations. Therefore, to test the connection between accretion and ejection, a coordinated radio and near-infrared (NIR) survey of young stellar objects (YSOs) is required. In this regard, we started in 2012 a radio monitoring program of nearby star formation regions using the VLA, complemented with various infrared data. In this contribution, we will present the results of coordinated, quasi-simultaneous observations taken with KMOS-VLT and part of the VLA program in the Corona Australis region. The NIR data permits the estimation of accretion rates via the Brackett Gamma line, which are then compared to the mass-loss rates derived from VLA continuum data. We find interesting correlations between these tracers for YSOs that are not too evolved. We discuss on the possible interpretations of these trends.

Disentangling galaxy and dust evolution mechanisms through chemical abundances

Stefan Giessen
Ghent University

It remains an unanswered question what dictates the amount of dust in the interstellar medium. Asymptotic giant branch stars and supernovae are the stellar sources both in terms of production through dredge up or supernova explosions, but they also destroy dust during the star-formation and with supernova shockwaves. This lead to theories of efficient metal accretion in the interstellar medium onto dust grains. This implies that amount of dust in a galaxy is directly linked to the star formation history and how much material can interact with it.We can potentially disentangle the evolution effects by adding information on the chemical abundances of several elements. Oxygen primarily forms in high-mass stars, whereas nitrogen can form in low and intermediate-mass stars. Oxygen is also commonly suggested to accrete more efficiently onto dust grains. The goal of the talk is to combine our knowledge of metal and dust production to answer what drives the dust content in galaxies. The talk wil showcase spatially resolved maps of the stellar mass, gas mass, and dust mass surface density for local spiral galaxies NGC628 (M74), NGC5457 (M101), NGC598 (M33), and NGC300 to motivate the use of chemical and dust evolution models for disentangling the different evolution mechanisms within these galaxies by explaining the oxygen abundance and the nitrogen-to-oxygen abundance ratio explains the differences in the dust-to-stellar mass ratio and the dust-to-metal ratio.

SED modeling star clusters using direct markers of gas and dust emission with the PHANGS catalog

Kiana Henny
University of Wyoming

The large number of star clusters in nearby galaxies permits us to statistically test the predictions of stellar, dust, and gas models. Using HST broadband plus Hα imaging combined with JWST near-infrared imaging, we use a total of 10 filters spanning near-ultraviolet through near-infrared wavelengths to model key physical parameters, including age, mass and reddening, of star clusters in 16 nearby spiral galaxies from the Physics at High Angular resolution in Nearby GalaxieS (PHANGS) sample, focusing on their ages, masses and reddenings. We find that HST/Hα and JWST/NIRCam 2--3.6~μm photometry significantly improves our ability to disentangle the age-reddening degeneracy between young, gas- and dust-rich clusters and intermediate age, dustless clusters, and also reveals accepted stellar population models do not align well with a statistically large sample of single stellar populations at young ages.

A High-Resolution study of HII Regions and Diffuse Ionized Gas in M33 with SIGNALS

Emma Jarvis
University of Toronto

The large number of star clusters in nearby galaxies permits us to statistically test the predictions of stellar, dust, and gas models. Using HST broadband plus Hα imaging combined with JWST near-infrared imaging, we use a total of 10 filters spanning near-ultraviolet through near-infrared wavelengths to model key physical parameters, including age, mass and reddening, of star clusters in 16 nearby spiral galaxies from the Physics at High Angular resolution in Nearby GalaxieS (PHANGS) sample, focusing on their ages, masses and reddenings. We find that HST/Hα and JWST/NIRCam 2--3.6~μm photometry significantly improves our ability to disentangle the age-reddening degeneracy between young, gas- and dust-rich clusters and intermediate age, dustless clusters, and also reveals accepted stellar population models do not align well with a statistically large sample of single stellar populations at young ages.

A JWST View of the Dynamic ISM with Thermal Echoes of Cas A

Jacob Jencson
Caltech/IPAC

The complex environment of interstellar gas and dust around the young supernova remnant Cassiopeia A hosts a spectacular system of thermal infrared echoes powered by the burst of radiation from the historical explosion. Building on nearly two decades of observations by Spitzer and NEOWISE, JWST now offers the ability to see these echoes in unprecedented detail. We present results of a new imaging (NIRCam; 0.9-4.5 micron) and spectroscopic (MIRI/MRS; 5-24 micron) observing campaign (JWST-GO 5451) that, with angular resolution of ~400 AU, provides a path-breaking view of the 3D structure of the typical Galactic cold neutral medium. In particular, we compare the observed morphologies to modern high-resolution simulations of magnetized, multi-phase turbulence. The ongoing spectrophotometric time-series reveals the compositions and physical conditions of the echoing clouds, constrains our picture of Cas A's massive progenitor through the luminosity, hardness and duration of the incident shock-breakout radiation, and will provide a real-time view of the dynamic effects of this radiation field on the dust and molecular content of the interstellar medium.

MHMM: Molecular H2 in M83 with MIRI/MRS

Logan Jones
Space Telescope Science Institute

A complete understanding of stellar feedback in galaxies requires an accurate characterization of recent generations of stars (traced by ionized gas or stellar populations) and of the molecular gas in star-forming regions. High-sensitivity mid-IR IFU spectroscopy on JWST enables us to study both the ionized and molecular gas simultaneously, revealing the interplay between massive stars and different ISM phases at resolutions of ~a few pc even in external galaxies. We present a pixel-level MIRI/MRS view of the physical conditions of warm molecular gas (H2) in the core of the nearby spiral galaxy M83, covering its central ~200 x 200 pc at scales as small as 3 pc. We find spatial distributions of warm H2 mass and excitation that vary with proximity to areas with high star-formation rate, high concentrations of UV-bright star clusters, and/or regions of outflowing ionized gas as traced by [NeII] and [NeIII]. Our analyses, when put in the context of multi-wavelength datasets available for M83's center, also support the presence of a stellar age gradient in the star-forming ringlet. Finally, we also note the presence of two unusual point sources in our MRS data cubes - one detected only in the H2 S(1) line, which we propose is a forming or embedded star cluster, and one which shows significant emission in [NeVI]. We discuss arguments on whether the latter source, which is coincident with an outflow of ionized gas, is likely powered by shocks or a previously undetected low-luminosity AGN. All of these findings together illustrate the power of MRS to uncover critical (and sometimes unexpected) aspects of the multi-phase ISM of nearby starbursts.

The Dynamics of Star Cluster Assembly

Jeremy Karam
McMaster University

The formation of star clusters takes place embedded inside giant clouds of molecular gas (GMCs) where mergers of smaller sub-clusters into larger clusters is expected. The embedded nature of this process makes observing star cluster assembly inside a GMC challenging. Similarly, computational constraints makes resolving individual stars in a cluster alongside the surrounding gas medium challenging if the initial GMC is very massive and expected to form a massive star cluster. We perform zoom-in simulations of sub-cluster mergers inside a massive gas-rich GMC to model the evolution of individual stars and the gas environment simultaneously during the build up of a massive star cluster. We analyze the dynamics of clusters as they undergo mergers with other clusters. We show that the surrounding gas environment is extremely important in promoting sub-cluster mergers, and in producing dynamical signatures that we see in Gaia observations of gas-free star clusters (i.e. asymmetric expansion, and rotation). We perform simulations with and without star formation and stellar feedback and find that star formation increases the magnitude of the detected asymmetric expansion and rotation. As well, we study the kinematics of the cluster after it removes its background gas and determine that the cluster's embedded phase evolution plays a key role in its long term evolution.

Physical Conditions of the Molecular Gas in the SMC‚Äôs Star Forming Region NGC 346

Laura Lenkic
California Institute of Technology

The brightest star forming region in the Small Magellanic Cloud (SMC), NGC 346, is host to roughly 100 young stellar object (YSO) candidates, thousands of pre-main sequence stars, and more than 30 OB stars which are major sources of ionization and feedback in this region. Using ~0.5 pc scale ALMA observations of 12CO(1-0), 12CO(2-1), and 13CO(2-1), we characterize the properties of molecular gas clumps we identify in NGC 346 using the astrodendro package and investigate the impact of the presence of YSOs. We derive the sizes, linewidths, and molecular gas masses from 12CO(1-0) and a CO-to-H2 conversion factor and 13CO(2-1) assuming local thermal equilibrium. This allows us to derive the size-linewidth relation and to investigate the boundedness of the molecular gas structures for each CO line. James Webb Space Telescope observations of NGC 346 provide a detailed accounting of the young stellar populations present in the region. We investigate the correlation between molecular gas clump properties and the presence of YSOs to understand where stars form and what impacts the star formation process has on the environment.

Young Massive Star Clusters and Feedback in the Prototypical Starburst Galaxy NGC253

Rebecca Levy
Space Telescope Science Institute

The cycle of star formation governs the evolution of galaxies. In some local galaxies, the star formation rate in their centers are much higher than other normally star-forming galaxies and may be more similar to galaxies at earlier cosmic times. I present observational results from the prototypical nearby starburst galaxy NGC253. First, I will discuss how gas flows to the center of NGC253 along its bar to fuel the extreme burst of star formation. Using very high spatial resolution data from ALMA tracing emission from dust and dense molecular gas, we find that the massive, compact, very young “super” star clusters (SSCs) found in the center of NGC253 are arranged in a ring. Moreover, we find that the SSCs and dense molecular gas are found at the innermost orbit predicted by the barred potential of this galaxy, as expected. Next, I will discuss the detection of massive quasi-spherical outflows of molecular gas detected from three of the SSCs in NGC253. These outflows carry a substantial fraction of the gas mass away from the clusters and into the ISM and may stop these clusters from growing even larger. The precise physical mechanism powering these outflows is uncertain, but winds from massive stars and dust-reprocessed radiation pressure are the best candidates - different from lower mass, less extreme star clusters. Recently, we have also detected outflows of ionized material from the SSCs using new MIRI MRS observations.

Dynamics and Dust Properties of Colliding-wind Dust Producer WR 140

Emma Lieb
University of Denver

Carbon-rich Wolf–Rayet (WR) binaries are a prominent source of carbonaceous dust that contribute to the ISM of galaxies. In the "textbook" episodic dust-producing WR binary, WR140, dust forms in the colliding winds of the two stars and expands outwards, forming the dramatic shell structures we see with JWST. In this talk, I will discuss our analysis of two sets of JWST/MIRI imaging observations of WR140 taken 14 months apart to confirm the kinematics and morphology of the dusty shells. After careful PSF subtraction and image alignment, we measure the outward expansion velocity of the 16 detected dust shells to be 2714 km/s, almost 1% the speed of light. Our observations show that these dusty shells are astrophysical (i.e., not associated with any PSF artifact) and that their substructure is caused by instabilities in the wind collision region between the stars. The shells also appear to propagate without significant deceleration into the ISM, suggesting that WR140 and other carbon-rich WR binaries are important contributors of carbonaceous material to the Galactic dust budget. Our ongoing research using these JWST images aims to address how the properties of this WR-formed dust might evolve as it expands out into the local ISM.

Mapping the ISM at Parsec-Scales with Dust Extinction in Nearby Galaxies

Christina Lindberg
Johns Hopkins University

Dust extinction is a valuable tool for tracing the multi-phase distribution and content of the ISM. In nearby galaxies like the SMC and LMC, we leverage multi-band photometry of resolved stellar populations to measure the amount of extinction along the line of sight. With extinction measurements towards half a million stars across the Magellanic Cloud from the Scylla survey, we developed a new method to construct high-resolution extinction maps, independent from other dust mapping techniques. These maps provide an unprecedented parsec-scale view of the multi-phase structure of the ISM, giving us new opportunities to study how stars form and interact with the ISM.

Strong feedback from young super star clusters in nearby galaxies

Daniel Maschmann
Space Telescope Science Institute

The recently published PHANGS-HST catalogs of 100,000 star clusters and compact associations provide a unique laboratory to study the baryonic cycle of star formation and allowing us to put our current understanding of star cluster formation and evolution to a test. In order to better understand the evolutionary path of the most massive young star cluster we used new JWST NIRCAM+MIRI imaging to study the interplay with their local ISM. We selected 11 very peculiar star clusters that show a distinct 10 micron emission feature, indicating the presence of hot massive stars that have recently ejected their envelopes. This type of star cluster is very rare and are all without exception amongst the most massive young star clusters (<5 Myr and >10^5 M_sun) in the parent sample. They have mostly freed themself from the natal dust cloud and show strong outflow components in the ionized gas estimated from MUSE spectra. They are all situated in dense star-forming rings in the center of galaxies, at the end of large galactic bars or in the densest parts of grand-design spiral arms. These objects are of particular interest as we suspect the hot stars to be responsible for large parts of dust that gets re-injected into the ISM, driving the metallic enrichment. We will present a complete study of these objects with high resolution observations from the optical to mid IR with additional MUSE spectra.

Bridging Stars and the ISM: Insights from FIRE Simulations on Young Stellar Structures

Davoud Masoumi
University of California – Merced

The interplay between young stars and the interstellar medium (ISM) is central to unraveling the physics of star formation and feedback. Using high-resolution, zoom-in cosmological simulations from the Latte suite of FIRE simulations, we investigate the properties and evolution of young massive stellar groups (both bound and unbound) within a Milky Way-like disk at redshift zero. These simulations, spanning 110 Myr, resolve spatial (~1 pc), mass (7100 M⨀), and temporal (~1 Myr) scales, allowing for a direct comparison with observations from Gaia, HST, and SDSS. Applying a Friends-of-Friends algorithm, we identify stellar groups with ages ≲3 Myr and masses ≳10^4.5 M⨀, revealing a striking agreement with observed cluster properties, including the mass function slope, median size, velocity dispersion, and metallicity spread.
Our results underscore the crucial role of ISM conditions in shaping stellar structures. Notably, when magnetic fields are included in the simulations, star formation rates increase significantly, yet the formation rate of massive stellar groups exhibits only a modest rise. This paradox highlights the role of turbulence induced by magnetic fields, which enhances global star formation but disrupts large-scale gravitational collapse, limiting the formation of dense clusters. This study emphasizes the necessity of modeling stars and the ISM together, as their coupled dynamics govern the emergence and evolution of young stellar populations. By leveraging simulations that integrate gas physics, stellar feedback, and magnetized turbulence, we bridge theoretical models with multi-wavelength observations. This work demonstrates that a holistic approach—one that treats stars and the ISM as an interconnected system—is essential for advancing our understanding of galactic evolution and for interpreting future high-resolution observations from JWST, ELTs, and next-generation surveys.

Tomographic Distance Measurements of High-Velocity Clouds with SDSS-V Milky Way Mapper

Timothy McQuaid
New Mexico State University

The Smith Cloud, a prominent high-velocity cloud (HVC), exemplifies the role of cold gas accretion from the circumgalactic medium (CGM) in sustaining star formation in galaxies. Accurate HVC distances are crucial for estimating their mass and accretion rates, which are vital for understanding their influence on Milky Way evolution. The only direct method to measure these distances involves detecting absorption lines (e.g., Na I and Ca II) in the spectra of stars with known distances at the velocity of the HVC. However, this approach typically requires time-intensive surveys that can only obtain a limited number of stars covering a HVC with sufficient spectral resolution. For example, the Smith Cloud's currently accepted distance of 12 kpc is highly uncertain, relying on a single detection of Ca II absorption. We leverage the extensive optical spectra from the Sloan Digital Sky Survey V (SDSS-V) Milky Way Mapper, which has obtained spectra for over two million stars across the sky and several thousand covering the Smith Cloud, alongside precise distance measurements from Gaia. By fitting stellar models to these spectra, we isolate the residual Na I and Ca II absorption associated with the interstellar medium and HVCs, as well as measure stellar extinction. This approach enables a tomographic analysis to accurately map the distances to HVCs such as the Smith Cloud. Our analysis reveals the onset of both Ca II absorption and reddening at 5 kpc towards the Smith Cloud, indicating a significantly revised, closer distance estimate.

Characterizing Young Stellar Objects in NGC 602 with JWST

Beena Meena
Space Telescope Science Institute

The discovery and classification of embedded, low-mass young stellar objects (YSOs) have traditionally been limited to nearby Milky Way regions, such as the Orion Nebula. With JWST's high resolution and sensitivity in NIRCam and MIRI, we investigate the properties of embedded YSOs and pre-main sequence (PMS) stars down to ~1 Solar mass in NGC 602, a young, metal-poor cluster in the Small Magellanic Cloud. By examining the spatial distribution of YSOs and PMS stars, as well as their disk properties, we assess how far-ultraviolet radiation from massive OB stars at the cluster center influences disk formation and survival in a low-metallicity regime. Additionally, we explore whether star formation is propagating outward from the cluster center into the H II region, driven by feedback from OB stars. In this talk, we present a preliminary census of the emerging stellar populations in NGC 602 and their connection to the gas and dust distribution into the interstellar medium (ISM) of this cluster.

3D MHD simulations of runaway pulsars in core-collapse supernova remnants

Dominique Meyer
ICE/CSIC Barcelona

Pulsars are one of the possible final stages in the evolution of massive stars. If a supernova explosion is anisotropic, it can give the pulsar a powerful "kick", propelling it to supersonic speeds. The resulting pulsar wind nebula is significantly reshaped by its interaction with the surrounding medium as the pulsar moves through it. First, the pulsar crosses the supernova remnant, followed by the different layers of circumstellar medium formed during different stages of the progenitor star's evolution. We aim to investigate how the evolutionary history of massive stars shapes the bow shock nebulae of runaway "kicked" pulsars, and how these influences in turn affect the dynamics and non-thermal radio emission of the entire pulsar remnant. We perform three-dimensional magnetohydrodynamic simulations using the PLUTO code to model the pulsar wind nebula generated by a runaway pulsar in the supernova remnant of a red supergiant progenitor, and derive its non-thermal radio emission. The supernova remnant and the pre-supernova circumstellar medium of the progenitor strongly confine and reshape the pulsar wind nebula of the runaway pulsar, bending its two side jets inwards and giving the nebula an arched shape for an observer perpendicular to the jets and the propagation direction. We perform the first classical 3D model of a pulsar moving through its progenitor's ejecta and circumstellar medium, inducing a bending of its polar jet that turns into characteristic radio synchrotron signature. The circumstellar medium of young runaway pulsars has a significant influence on the morphology and emission of pulsar wind nebulae, which comprehension requires the detailed understanding of the evolutionary history of the progenitor star.

A Galactic Eclipse: The SMC is forming stars in two, superimposed structures

Claire Murray
Space Telescope Science Institute

The structure and dynamics of our most massive satellites, the LMC and SMC, have long confounded us. These systems have markedly different interstellar conditions than the Milky Way, and are located at close enough proximity for individual stars and interstellar structures to be resolved, which makes them exciting laboratories for conditions at higher redshift. However, fundamental questions about their evolutionary history and present-day structure remain open. In this talk, I will discuss new insights into the 3D structure of the SMC from the Galactic Australian Square Kilometre Array Pathfinder (GASKAP), a high-resolution survey of neutral hydrogen (HI) in the MCs as well as the kinematics of young, massive, embedded stars traced by precise velocity constraints from Gaia and APOGEE. By comparing the average dust extinction toward these stars, we show that the SMC is composed of two structures with distinct stellar and gaseous chemical compositions and similar gas mass separated by ~5 kpc along the line of sight. I will discuss the implications of these results in the context of the history of the Magellanic System and our understanding of ISM physics at low metallicity.

JWST Photometry and Spectra Reveal Dust and Ice in the Magellanic Clouds

Isha Nayak
NASA Goddard Space Flight Center

We present JWST near- and mid-infrared imaging and spectroscopic observations of the low-metallicity star-forming regions, NGC 346, in the Small Magellanic Cloud (SMC) and N79, in the Large Magellanic Cloud (LMC). Both regions within the Magellanic Clouds have metallicities analogous to that of cosmic noon, the era of intense star formation in the early Universe ($z \sim 2$). We use NGC 346 and N79 as local laboratories to test theories of early star and planet formation. JWST is able to resolve details which are not attainable for galaxies observed at $z \sim 2$, giving us a unique opportunity to study early-stage star formation in our very own backyard. By imaging with NIRCam and MIRI, we reach photometric depths over 10 magnitudes below Spitzer and 2 magnitudes below HST at comparable wavelengths, detecting sources with masses as low as $\sim 0.3\ M_\odot$. Using a combination of NIRCam and MIRI photometry, as well as fitting to model SEDS, we detected and characterize 200 YSOs in NGC 346, the most intense star-forming region in the SMC. Similarly, we characterize over 1500 YSOs in N79, host to newly discovered super star cluster (SSC) H72.97-69.39. We use color magnitude diagrams to separate the young stellar objects from the red giant branch and asymptotic giant branch stellar populations. The emission and absorption lines taken with MRS for over a dozen YSOs in the Magellanic Clouds include fine-structure, molecular hydrogen, and polyaromatic hydrocarbon. We detect ice absorption features for two of the YSOs in the LMC, and for the first time, mid-IR ice absorption features in one of the YSOs in the SMC. Hydrogen recombination lines indicate these protostars have accretion rates as high as $0.02\ M_\odot$ per year. We compare our JWST observations to ALMA, HST, and Chandra observations to present a clearer picture of how star formation is taking place within the Magellanic Clouds, a proxy to how star formation took place at $z \sim 2$.

High-Altitude Clouds in the Solar Neighborhood: Connecting 3D Dust Maps and HI Gas Kinematics

Theo O'Neill
Center for Astrophysics | Harvard & Smithsonian

The exchange of gas between galaxies' disks and halos is a key driver of galactic evolution, with inflows from the circumgalactic medium sustaining star formation in the disk and feedback-driven outflows from the interstellar medium recycling gas into the halo. Studies of the Milky Way's disk-halo interface have traditionally identified inflowing and outflowing gas incompatible with disk rotation on the basis of radial velocity, leading to the well-known categories of intermediate- and high-velocity clouds (IVCs and HVCs). Recent progress in mapping the 3D structure of the Solar Neighborhood presents an opportunity to search for local anomalous-velocity clouds at the disk-halo interface. In this work, we identify individual dust clouds in a parsec-resolution 3D dust map of the Solar Neighborhood using a new topological structure identification method. By analyzing these clouds' vertical distribution, we isolate a sample of "high-altitude" clouds located beyond the disk. We evaluate the morphological similarity between these dust clouds and HI gas to evaluate probable cloud kinematics, and construct a complete sample of local high-altitude clouds with resolved 3D structures and known radial velocities. We evaluate how these clouds fit into the established IVC/HVC framework, and discuss future prospects for linking cloud origins to past stellar feedback events.

Linking radio dispersion measure and optical extinction using pulsars hosted in globular clusters

Cristina Pallanca
University of Bologna

Globular clusters (GCs) are old, coeval, chemically homogeneous and dynamically active stellar systems. Their populations allow for highly precise estimates of key parameters such as distance and optical extinction caused by the foreground dust.

Moreover, they are the main furnaces of exotic binary systems, including millisecond pulsars (MSPs). Recent advancements in radio astronomy, thanks to facilities like MeerKAT and FAST, have led to a surge in new MSP detections in Galactic GCs, bringing the total number of GCs with precise radio dispersion measure (DM) estimates, linked to free electrons in the interstellar medium, to 45. While, in principle, optical extinction and DM are not expected to be correlated, since they originate from cold and hot phases of the interstellar medium, our study challenges this assumption.
In this talk, we first demonstrate that DM does not correlate with distance, contrary to commonly thought. Instead, we uncover a strong and unexpected correlation between DM and optical extinction. We also explore the implications of this finding, discussing the advantages and complementarity of our approach in predicting DM compared to commonly adopted Galactic free-electron models. This is particularly relevant for poorly studied regions, such as the outer Galactic halo and the innermost Galactic Bulge.

Finally, we discuss potential future developments. These include considering different extinction laws (e.g., values of Rv different from 3.1 in the Galactic Bulge), converting 3D Galactic dust maps into 3D DM maps, extending our method to extragalactic sources (such as the Magellanic Clouds), and assessing its impact on distance estimates for fast radio bursts.

Dust as a Tracer of Gas and Stellar Feedback

Deb Pathak
The Ohio State University

I will present recent high-resolution measurements of ISM structure, radiation feedback, and PAH fractions in nearby galaxies based on mid-infrared emission and optical spectroscopy from the PHANGS JWST and MUSE surveys. JWST mid-IR images reveal complex substructure that simultaneously traces the distribution of dust and gas as well as heating from young stars. We measure the distribution functions (PDFs) of this mid-IR emission and show a common behavior where star-forming regions form a power-law tail while diffuse emission exhibits a log-normal distribution, which we argue traces the underlying gas column density distribution. Within the star-forming regions, we combine JWST, MUSE, and HST to measure the strength of dynamical feedback mechanisms, including a first-ever estimate of the strength of total IR reprocessed radiation pressure in a large (~18,000) set of HII regions. We find that the IR pressure term is of order 5-10% of the UV radiation pressure from young stars, and that both terms are typically subdominant relative to thermal pressure from photoionization heating. Finally, we will share new results on the contribution of old stars to the gravitational potential of HII regions and molecular clouds, and on the variation in PAH abundance observed by JWST in the diffuse ISM of more than 70 nearby galaxies.

Dissecting the spectral energy distributions of emerging star clusters

Alex Pedrini
Stockholm University

Young star clusters form embedded in dusty gas clouds, with feedback from massive stars driving their emergence over a few million years. This process is now captured in unprecedented detail by JWST IR capabilities which enable us to detect and study thousands of emerging young star clusters (eYSCs) at few parsecs scales.
I will present an overview of the census of eYSCs detected in the FEAST (Feedback in Emerging extrAgalactic Star ClusTer) sample of nearby galaxies: M51, M83, NGC628, NGC4449 and the interacting systems NGC4490/85. I will show the NIR colors of these populations, characterised by hot dust and PAH-3.3μm emission, absent in HST-detected young star clusters. I will discuss the challenges of studying their spectral energy distributions (SEDs) with currently available models. Our analysis combines a wide range of filters, both from JWST and archival HST data. They span the SED of clusters from the UV to the NIR, including narrowband filters that recover hydrogen recombination line emission (direct tracers of the presence of massive stars). We observe a flux excess at 1.5-2.5 μm that cannot be fitted by current models and affects the recovered physical properties of eYSCs. This excess may arise from a combination of phenomena that are not included in the models, such as contributions from hot dust in protostellar disks and from pre-main-sequence stars. The latter might be important for low mass clusters, where stochasticity effects in the initial mass function sampling become significant. These findings highlight the need for caution when interpreting SED analyses of eYSCs now accessible in the local Universe, and emphasize the necessity of improved models to address this discrepancy.

Using quasars as lighthouses for the ISM fog

Alexander Plavin
Black Hole Initiative, Harvard University

The insterstellar medium affects radio emission by scattering it, an effect which is most apparent for very compact sources such as quasars. The very long baseline radio interferometry (VLBI) technique can perform direct measurements of their sub-milliarcsecond structure. In this talk, I'll present our recent results on massive studies of these scattering effects. We measure the scattering-induced broadening in thousands of quasars, using them as lighthouses that shine through the ISM. This enables us to both map the Galactic scattering over the whole sky using archival surveys data, and to probe regions of specific interest with dedicated observations. I'll discuss the comparison of radio scattering of extragalactic source to other observational tracers of the ISM. These measurements of scattering-induced structure let us constrain the characteristics of the screen, including its turbulence properties and relevant lengthscales.

MOBStIRS: Mass-loss rates for OB Stars driving IR Bow Shocks

Matthew Povich
Cal Poly Pomona

Over the past decade, we have been developing and refining a novel method for measuring mass-loss rates of massive, OB-type stars using infrared stellar-wind bow shock nebulae. These nebulae form in the shock front preceding a star moving with supersonic velocity relative to the ambient interstellar medium (ISM), where swept-up interstellar dust is heated by the intense stellar radiation field, producing bright mid-IR emission. The standoff distance, R0, between the star and the bow shock is set by momentum flux balance between the stellar wind and ram pressure of the ambient ISM. R0 is sensitive to the stellar mass-loss rate. The Milky Way Project: MOBStIRS enlisted several hundred students via the Zooniverse online citizen science platform to measure R0 and two other projected shape parameters for 764 cataloged IR bow shocks. MOBStIRS incorporated 1528 JPEG cutout images produced from Spitzer GLIMPSE and MIPSGAL survey data. Measurements were aggregated to compute shape parameters for each bow shock. The derived nebular morphologies agree well with hydrodynamic simulations of bow shocks driven by the winds of OB stars moving at 10 - 40 km/s with respect to the ambient ISM. Most stars show space velocities at the lower end of this range, suggesting that the bulk of our sample is not comprised of runaway OB stars. Slightly more than half of MOBStIRS bow shocks are asymmetric, indicating anisotropic stellar winds and/or ISM clumping on sub-pc scales. Further work comparing the sizes, shapes, and orientations of bow shock nebulae with stellar proper motions derived from Gaia astrometry may yield new insights on local ISM flows, potentially revealing deviations from circular rotation, for example caused by champagne flows from H II regions or streaming motions along spiral arms.

Propagating Star Formation in Sco-Cen: Cluster Chains as Tracers of Stellar Feedback

Sebastian Ratzenboeck
University of Vienna

The Scorpius-Centaurus (Sco-Cen) OB association, the closest and best-studied OB association, provides a unique view of the interplay between young stars and the ISM. Using the Significance Mode Analysis (SigMA) clustering algorithm on Gaia DR3 data, we identified 37 stellar groups, recovering rich populations and distinguishing clusters with velocity differences as small as 0.5 km s^{-1} at densities as low as 0.01 sources pc^{-3}. Isochronal age-dating reveals four bursts of star formation, about 5 Myr apart, with the most significant at ∼15 Myr producing most of Sco-Cen's stellar content, including clusters large enough to have hosted supernova progenitors.
We find that star and ISM interactions, particularly feedback-driven expansion, may have played a crucial role in structuring and sustaining star formation in the region. Our results show that star formation propagates inside-out in 100-pc-long spatially connected chains, where older, massive clusters in Sco-Cen's center give rise to younger, smaller ones on its outskirts. Our analysis supports a scenario in which the energetic output of the massive clusters from the 15 Myr starburst—through supernovae, winds, and radiation pressure—compressed and accelerated molecular gas, driving successive cluster formation episodes. We estimate that 40% of Sco-Cen's stars formed through feedback-driven triggered star formation, with the majority located within cluster chains.
Cluster chains emerge as a new and potentially ubiquitous mode of triggered star formation in OB associations, linking the stellar and ISM components of galactic ecosystems. Future work will leverage high-resolution spectroscopy and next-generation surveys to probe the chemical evolution and feedback dynamics within these chains, shedding light on molecular cloud fragmentation and stellar enrichment.

The Emerging Properties of Our Immediate Interstellar Medium and its Impact on Stars and Planets

Seth Redfield
Wesleyan University

Our immediate interstellar environment, the local interstellar medium (LISM), is not only the screen through which we observe the rest of the Universe, it also directly interacts with the outflowing solar wind and the resulting heliospheric properties may impact the planets in our solar system. The interaction of stellar winds with their surrounding interstellar medium is common for all stars and our Sun-LISM interaction is the gold standard by which we can study this kind of relationship in detail. In the era of evaluating planetary habitability, the study of the LISM will be critical in order to measure the intrinsic stellar extreme ultraviolet (EUV) emission and particle flux impacting their exoplanets. These emissions shape the structure and chemistry of planetary atmospheres. The LISM is a complex and rich environment within the currently quiet and rarefied Local Bubble. In many ways, measuring the properties of this closest interstellar material is more challenging than distant clouds, and requires high spectral resolution observations in the ultraviolet (UV) along sight lines to nearby stars. I will present recent observing campaigns of the LISM targeted at mapping the morphology of the LISM, including in the direction that the Sun has travelled over the last 1Myr. This stretches back to roughly when we think these clouds may have formed and provide a prediction for how the heliosphere responded to changes in the ISM in our recent past and near future. These programs measure several properties of the gas, including its temperature, turbulence, dust depletion, and ionization. I will share new HST spectra probing the collision and interaction of neighboring LISM clouds precisely at the solar location. UV observations at the edge of our solar system by the New Horizons spacecraft have also provided a unique view of the ISM directly surrounding the Sun. The study of the LISM may at first seem provincial, but it shares the same volume of the Galaxy with well-studied stars and the intriguing Earth-like exoplanets we will be intensely studying in the future. Our proximity allows us to study the complexity of the LISM in detail and apply that to more distant ISM environments.

Multi-wavelength insights into the recycled material from AGB Stars

Maryam Saberi
University of Oslo

Low- to intermediate-mass stars eject a significant fraction of their material during the asymptotic giant branch (AGB) phase through strong stellar winds. This process plays a crucial role in shaping the chemical composition and evolution of the interstellar medium (ISM) and galaxies. In this talk, I will present our ALMA observations of a sample of AGB stars, focusing on their contributions to the Galactic fluorine budget and the role of S-process in shaping the titanium isotopic ratio. Additionally, I will share preliminary results from our analysis of the impact of internal UV radiation on the chemical composition of the inner outflow of the AGB star R Leo. I will conclude by emphasizing the importance of multi-wavelength observations in studying the chemical composition of AGB outflows, enabling us to more accurately constrain the physical and chemical conditions within these regions and better quantify the recycled material from AGB stars to the ISM.

Extended Lyman Alpha haloes as probes of ionizing radiation escape near and far

Alberto Saldana-Lopez
Stockholm University

While the nature of the inner, multi-phase interstellar medium (ISM) and its evolution with look-back time has been studied in detail in the last decade, much is yet to know about the outer envelope between such ISM and the Cosmic Web. This circumgalactic medium (CGM) plays an important role in the evolution of galaxies, acting as the most immediate gas reservoir for star-formation, regulating the cooling and heating processes as well as contributing to the galaxy chemical enrichment and metal mixing.

In this work, we study the interplay between the cold gas in the CGM and the star-formation at ISM scales, using the LaCOS survey. LaCOS (the Lyman-alpha and Continuum Origins Survey) assembles a sample of 42 star-forming galaxies at z=0.3 with rich archival spectroscopic data, including ionizing continuum observations with HST/COS. The five-band observing strategy of LaCOS probe the physical extent of the Ly-a in the CGM at HST resolution, with the UV and rest-optical continua tracing the stellar populations and dust extinction in a 2D resolved fashion. We focus on the connection between the extent of the diffuse CGM and other physical properties. Interestingly, galaxies that do not emit copious amounts of ionizing radiation also show extended Ly-a haloes, consistent with a scenario in which the ionizing photons are absorbed by the neutral HI gas within the CGM. By comparing the sizes of nearby Ly-a haloes with other existing samples at lower and higher redshifts, LaCOS offers an observational benchmark towards the characterisation of Ly-a haloes with JWST during the Epoch of Reionization, where the compact Ly-a morphologies may indicate a high fraction of leaking ionizing radiation to the intergalactic medium.

Where do stars explode in the interstellar medium?

Sumit Sarbadhicary
Johns Hopkins University

The physics of stellar feedback is arguably our largest uncertainty in the understanding of galaxy evolution. Particularly contentious is the question of where stars explode with respect to gas clouds in the interstellar medium (ISM), which plays a major role in how efficiently supernovae (SNe) drive turbulence in the ISM vs outflows in order to regulate star-formation. Addressing this from modern observations is urgently needed by the field, and nearby galaxies offer are the ideal laboratories for this purpose, since one gets the most detailed observations of the multi-phase gas ISM, and supernova sites from historical supernovae or their progenitor stellar population (e.g. red supergiants, Wolf-Rayet stars).

In this talk, I will present the first set of direct observational constraints on where stars explode from ongoing high-resolution surveys of nearby galaxies with JWST, HST, VLA, ALMA and VLT/MUSE. We find that at least 50% of core-collapse supernovae occurred outside molecular clouds, implying that their environments were cleared by pre-supernova/prior-supernova explosions, leading to supernova energy deposition in the lower density atomic ISM. With a survey of red-supergiants and Wolf-Rayet stars in M33, we find that this fraction exploding outside molecular clouds has a mass-dependence, with 44% for stars > 30 Msun, and 72% for stars 8-30 Msun. Independently with JWST, we find that about 20-40% of supernova remnants show direct evidence of interaction with dense gas/molecular clouds in the infrared. I will discuss how these empirical measurements of SN fractions interacting with dense vs diffuse gas are a novel observational anchor for stellar feedback models that underpin hydrodynamical simulations of galaxy formation, and ongoing expansion of this work to a sample of nearly 80 star-forming galaxies.

Expanding Horizons in Stellar Dust Formation

Melissa Shahbandeh
Space Telescope Science Institute

Supernovae, the cataclysmic endpoints of massive stars, are more than dramatic cosmic events–they serve as alchemists of the universe, forging and dispersing the dust that shapes galaxies, stars, and planets. While AGB stars were traditionally considered the primary dust producers, the discovery of ancient, massive dust reservoirs predating their formation shifted the focus to core-collapse supernovae (CCSNe). With JWST's unparalleled observational capabilities, we are now uncovering the profound role of these stellar explosions in building the universe's dust inventory. This presentation examines JWST’s remarkable observations of CCSNe, following the transformation from molecular dust precursors to substantial dust masses decades after explosion. Highlights include NIRSpec and MIRI detections of CO and SiO during the early stages of dust formation and late-stage MIRI insights into significant dust production in select supernovae. These findings, revealing dust masses comparable to historical benchmarks, provide a transformative view of supernovae as architects of cosmic evolution in the era of multi-messenger astronomy.

Characterizing the PAH emission in the PN NGC 7027: Spectral variations revealed by JWST

Charlotte Smith-Perez
The University of Western Ontario

In the cosmic carbon cycle, Polycyclic Aromatic Hydrocarbons (PAHs) and related species play a key role. They are thought to form in the outflows of dying carbon-rich stars, and are subsequently subjected to chemical processing due to changing physical and chemical conditions in the outflows. The end products of this processing will eventually be incorporated into the interstellar medium (ISM). However, despite their strong and ubiquitous infrared emission, many aspects of their formation and chemical evolution remain unclear. Given their importance in heating of the neutral ISM (and thus setting the thermal balance in proto-planetary disks), the emission of galaxies, and the amount of interstellar carbon they can account for, understanding how pristine complex hydrocarbons in circumstellar environments transition to PAHs in the ISM is key to our understanding of the carbon life cycle and unraveling their role in star- and planet-formation.

We present the first high spatial resolution study of the spectral characteristics of the 5-20 micron PAH emission in a circumstellar environment. We use JWST MIRI/MRS observations of the young, hot, carbon-rich planetary nebula, NGC 7027. Illuminated by a single star, NGC 7027 provides an ideal laboratory to investigate the evolution of the PAH family shortly after their formation. We report significant variations in the PAH emission across the nebula, both in terms of relative intensity and spectral profiles. In particular, we observe spectral variability in the 7.7 micron complex and identify unique spectral profiles in the 12–13 micron region. Combined with variation in the PAH ionization fraction, these results imply modifications of the PAH family in terms of molecular structure and charge within the planetary nebula NGC 7027. These results advance our understanding of PAH processing and evolution, and provides critical insight into how complex hydrocarbons formed in the outflow of AGB stars, evolve into the carriers of the PAH emission typically seen in star-forming regions in our Milky Way and beyond.

RAENBOW: Reconstructing AGB ENvelopes by Bridging Observations across Wavelengths

Sundar Srinivasan
National Autonomous University of Mexico

The enrichment and recycling of the interstellar medium (ISM) by asymptotic giant branch (AGB) stars is a crucial process in the chemical evolution of galaxies. It is therefore critical to understand the properties and evolution of circumstellar material in AGB outflows. However, models have so far struggled to integrate data tracing both dust and gas across multiple wavelengths. Infrared spectra provide information about material closer to the star, and long-wavelength observations are required to study the cold dust and extended gas and probe earlier epochs of mass loss. While facilities such as Spitzer and JWST have obtained spectra for AGB stars in many Local Group galaxies and beyond, mapping at (sub)-mm and radio wavelengths is only feasible for Galactic targets.

In this talk, I will describe the simultaneous modeling of the circumstellar gas and dust. In the Milky Way, I exploit CO line and continuum observations from the Nearby Evolved Stars Survey (NESS; https://evolvedstars.space), including data from the JCMT, ALMA, and Nobeyama facilities, which probe the cold, extended component of the envelope. I will also demonstrate the application to IR spectra from Spitzer and JWST of extragalactic sources, sensitive to the hot inner envelope. These complementary approaches combine to reveal a more holistic picture of the history of mass loss.

Our approach aligns seamlessly with the symposium's focus on multi-wavelength integration, as circumstellar envelopes are best studied across IR (for dust), (sub)-mm (for gas), and optical/UV (for scattered light) wavelengths. By modeling stars, gas, and dust simultaneously, we adopt an innovative method that captures the coupled dynamics, chemistry, and radiative transfer of these components, often treated separately in other studies. The analysis uses publicly-available codes and our procedure is reproducible. Ultimately, our work provides new insights into the interaction between AGB stars and their surrounding ISM, shedding light on how these systems enrich and transform their host galaxies.

Detection of protostellar outflows in ALMA-IMF: top-heavy CMFs and high-mass prestellar cores

Maxime Valeille-Manet
Institut de Planetologie et d'Astrophysique de Grenoble

Investigate the origin of the IMF by studying the evolution of the CMF in massive protoclusters is the main goal of the ALMA-IMF large program. To better understand the formation of high-mass stars, it is also necessary to identify the youngest precursors of massive stars (M > 8 M_⊙), even before collapse (so-called prestellar cores), within high-mass star-forming regions.

Using a new automatized method for systematically detecting outflows from protostellar cores, we search high-mass prestellar cores in the ALMA-IMF survey, i.e. cores without significant outflowing emission. For this, we rely on the CO(2-1) and SiO(5-4) lines. This outflow detection method also allows us to study prestellar and protostellar CMFs and to compare them with the canonical IMF.

Building prestellar and protostellar samples with huge statistics, we found that protostellar CMFs are top-heavy, i.e. with a larger proportion of high-mass cores compared to the IMF, while the prestellar ones are much steeper (Nony, Valeille-Manet et al in prep; Pouteau et al 2023; Nony et al 2023; Pouteau et al 2022).

We then show that 30 cores with a mass greater than 8 M_⊙ are such good prestellar candidates in the ALMA-IMF survey (Valeille-Manet et al. accepted). They cover a mass range from 8 to 54 M_⊙, with 12 cores more massive than 16 M_⊙ that will most certainly form a high-mass star in the future.

We can then derive statistical lifetimes in several bins of mass with short lifetimes below 105 yr for the most massive cores. But on the other hand, the obtained lifetimes are relatively large with values of the order of 10 x T_ff, suggesting the need of a support against gravity to prevent the cores to collapse on a free-fall time as expected.

Using the DCN(3-2) and 13CS(5-4) lines, we studied the turbulence in the 12 most massive prestellar core candidates and found supersonic turbulence in all the cores (Valeille-Manet et al in prep). A Virial analysis reveals that additional magnetic field strengths between 5 and 50 mG would be needed for around 2/3 of the 12 cores to justify their long lifetimes.

PHANGS-JWST: Do spiral arms even matter?

Thomas Williams
University of Oxford

Since JWST launched as 2021's best Christmas present to astronomers, it has been changing our view of galaxy evolution. Its excellent angular resolution and much improved sensitivity over previous generations of space telescopes have allowed us to see the interstellar medium in much more detail than we ever could before. Leading the charge on full-disc mapping of nearby galaxies (those where we can resolve stellar clusters at JWST's resolution) are the PHANGS team, who mapped 19 galaxies in their Cycle 1 proposal and are now hard at work on another 55 galaxies observed during Cycle 2. This, combined with a bevy of data from other telescopes (most notably ALMA and MUSE) allows us to answer long-standing questions, like "how important are spiral arms, really?"

I will present work from the early PHANGS-JWST observations, studying spurs in the Phantom Galaxy, NGC628. These fluffy features join the arms of this prototypical spiral galaxy together, and with JWST's keen eye the distinction between "grand design" and "flocculent" spirals becomes significantly less clear-cut. Combining JWST, ALMA, and MUSE we can study the star formation rate, molecular gas content, and ultimately star-formation efficiency (the ratio of SFR to molecular gas mass) at very high resolution. We find that a) the star formation efficiency is nearly identical to in the spiral arms, and b) the stars must be forming in the spurs, rather than forming and then drifting from the spiral arms. This paints a picture of spiral arms merely acting to gather gas, rather than being instrumental in enhancing how efficiently stars are forming. This is in agreement with simulations and earlier observations of M51. The prevalence of spurs in the JWST imaging is indicative that much more star formation may happen outside of spiral arms than we previously thought.

As a bonus, I will also present a brief overview of the PHANGS-JWST data processing pipeline. I have led development of a tailored pipeline for producing large mosaics of extended sources (pjpipe). This pipeline is simple to run, but highly flexible to different imaging setups. Given the nature of this conference, pjpipe is likely to be very useful for many in the audience!

The Si K Edge Gas and Dust Optical Depths Toward the Galactic Bulge

Jun Yang
University of Massachusetts – Amherst

Knowledge of the dust content in interstellar matter is important to our understanding of the composition and evolution of the interstellar medium. The Chandra High Energy Transmission Grating (HETG) Spectrometer provides a unique opportunity to measure X-ray absorption of interstellar dust and its compositions through the X-ray edge absorption structure. We measure gas and dust optical depths at Si K toward nine bright low-mass x-ray binaries in the Galactic Bulge with very high-precision and pileup-free spectra. We include a likely instrumental feature affecting the Si K edge structure in our analysis. While gas optical depths grow consistently with broadband hydrogen-equivalent columns, the dust optical depths do not. Calculations including dust self-shielding show that the observed dust optical depths can be explained by variations in dust grain columns between various lines of sight. At least three grain column regimes can be identified toward the Galactic Bulge. While grain sizes define the self-shielding effect, variations in grain size distributions do not seem relevant. This shows that the gas-to-dust optical depth ratio toward sources in the Galactic Bulge is not homogeneous. The dust optical depths also roughly correlate with molecular hydrogen columns. Lowly ionized Si K contributions toward the Galactic Bulge were detected but are very small. We also find Si xiii absorption with velocity widths of 800–1100 km s−1, which we attribute to the circumbinary medium.

From massive O-stars to young Brown Dwarfs ‚Äì the effects of feedback in the Small Magellanic Cloud

Peter Zeidler
Space Telescope Science Institute

NGC 602, a young star cluster located in the Small Magellanic Cloud (SMC), is a rare nearby low-metallicity example of massive star formation in isolation. Even with its unfavorable location in the wing of the SMC, a remote low gas-density region, the O and B-star rich cluster shows a high star formation rate, comparable to well-studied regions in the Milky Way. Despite the rareness in the Local Group, star formation in galactic streams is a common phenomenon at high redshifts and in interacting galaxies. The low-metallicity ISM of the SMC is the closest stellar laboratory with conditions similar to the Cosmic Noon. The synergy of our dataset, ranging from FUV spectra of the OB star population to optical MUSE IFU spectroscopy, and multi-epoch HST and JWST NIRCam and MIRI photometry, allows us to study the stellar population from the most massive member, an O3 star, down to and below the hydrogen burning limit, together with the gas and dust surrounding NGC 602. This includes the very young (<0.5 Myr), deeply embedded YSO population. The formation and evolution of the YSOs, their envelopes, and protoplanetary disks on the Eastern ridge is highly impacted by the FUV radiation and winds of the numerous cluster OB stars while on the Western ridge these pro-cesses are dominated by one single star, Sk183, the O3 star. Utilizing the exquisite sensitivity and spatial resolution of JWST, we discovered the first popula-tion of 64 young, sub-Solar metallicity Brown Dwarf candidates between 50 to 87 Jupiter masses outside the Milky Way, co-located with the rich cluster pre-main-sequence in three “stream-like” features from the North and East toward the central cluster. With these data we characterize in detailed how star and star cluster formation occur in low-density galactic streams and how feed-back processes impact the young population across all masses under low-metallicity conditions.

A Deep High-Angular Resolution 3D Dust Map of the Southern Galactic Plane

Catherine Zucker
Center for Astrophysics | Harvard & Smithsonian

3D dust mapping epitomizes how stars and the interstellar medium (ISM) can be harnessed together to advance our understanding of both. We can leverage the colors of stars to infer stellar properties (distance, reddening, and stellar type), the key ingredients necessary to construct the 3D spatial distribution of the dusty ISM. These new 3D models of the ISM in turn provide the global context for star formation in the Milky Way. We present a new 3D dust map of the southern Galactic plane built primarily on photometry for a billion stars from the DECaPS2 survey and the brutus stellar inference framework. Our map is unique in two respects. First, unlike most maps of the solar neighborhood (tied explicitly to Gaia), we extend significantly deeper into the Galactic plane (up to distances of 10 kpc from the Sun), revealing hitherto undetected structure in the inner Galaxy. And second, due to our incredibly high stellar density, we achieve an angular resolution of 1', an order of magnitude better than existing 3D dust maps and on par with the 2D Herschel dust emission maps. We will review what we have learned from this new deep, high-angular resolution 3D dust map and preview how this method can be extended in the era of LSST and Roman to provide bird's eye views of the Milky Way's ISM at unprecedented scales.

Posters

Silicate Dust Grain Properties in the Gas-Rich Absorption Systems of Diverse Galaxies

Monique Aller
Georgia Southern University Res. & Svc. Foundation, Inc

Although dust grains comprise a small fraction of the ISM mass, they can play a critical role in providing the necessary ingredients for new star formation, while revealing chemical enrichment from previous stellar generations. Quasar absorption systems (QASs) are a valuable tool to probe dust grain properties in the interstellar and circumgalactic media of gas-rich galaxies, which imprint dust and gas absorption features in the spectra of distant, background AGNs. Such QASs allow investigations into dust grains in galaxies with diverse masses, morphologies, and evolutionary histories, and can probe varied internal environments, ranging from diffuse interstellar regions to dense molecular clouds. We present results from ongoing programs utilizing archival Spitzer Infrared Spectrograph (IRS) and JWST-MIRI spectra, covering the 10 and/or 18 micron silicate features, to investigate silicate dust grain properties in QASs at $0<z<2$. Our spectral measurements allow us to place constraints on the silicate dust grain compositions, morphologies, and crystallinities. We summarize our current results regarding the similarities and differences between the silicate dust grains in diverse systems. For some systems with available data, we discuss these silicate grain properties in relation to galaxy properties, and compare with information about the carbonaceous dust grains and gas properties, such as depletions. A better understanding of the diversity of silicate dust grain properties in individual systems, and the connections between the silicate and carbonaceous dust grains, in relation to galactic gas properties, may help to inform models of the evolution of dust and metals in galaxies, as well as future observational studies with facilities such as JWST. We acknowledge support from NASA grants NNX17AJ26G and 80NSSC20K0887, and an STScI grant for JWST-GO-02155.

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Optical Polarization and Reddening of Dust and Magnetic Structure in 3-Dimensions Towards ζ Ophiuchi

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University of Wyoming

The O9.5IV star ζ Ophiuchi (d = 182 pc), and its surrounding material, represents a well-studied sight line, with decades worth of spectroscopic observations of the star itself. Some of these data have suggested the presence of discrete clouds of dust along this single line of sight, but previous studies have been limited to observing the superposition of the many possible features present due to a lack of sufficiently accurate distances to observed targets. With the addition of Gaia DR3 parallactic distances, we can now decompose the structure of the ambient B-field and the dust reddening as a function of distance. We present V band polarimetry (from the Wyoming Infrared Observatory) and E(B-V) color excesses of 25 background dwarf stars within 50' of ζ Oph and with Gaia DR3 distances of 36–1176 pc. These data allow us to decompose our observations into two discrete B field components, at 86–127 pc and 252–287 pc, of similar polarization percentage but rotated approximately 60° from one another. The polarization angle of the farther magnetic component also aligns with 12 micron dust striations visible in the WISE field image. This indicates that we can use this line-of-sight decomposition to constrain the location of specific dust populations that may be responsible for observed polarizations. We use these same decomposition techniques to probe how the polarization efficiency, P/E(B-V), changes along our line of sight. We find that the farther group of aligned grains also contains super-Serkowski efficiencies (> 9 %/mag), providing more insight into how the structure of magnetic fields and their surrounding dust impacts the polarization efficiency. The combination of the polarizations, reddenings, and distances allows us to form a more detailed 3-dimensional picture of dust behavior and magnetic structure within this small sight line than ever before.

Constraints on the efficiency of the PE heating in a molecular ridge of the metal-poor LMC

Leo Belloir

Commissariat a l'Energie Atomique (CEA)

The Large Magellanic Cloud (LMC) provides a unique laboratory to understand the interaction between the interstellar medium (ISM) and massive star formation, in a galaxy with a low metallicity. The LMC's proximity to our Galaxy permits observation of its dusty and gaseous infrared emission at a parsec-scale resolution, thereby enabling study of interstellar properties at the scale of a molecular cloud. The SOFIA Legacy Program (LMC+) [1] has observed the [CII] λ158 µm and [OIII] λ88 µm lines in the southern molecular ridge at a resolution of 2.5 pc. These new observations provide access to the dominant cooling lines in the neutral and ionised ISM, enabling investigation of the major heating and cooling mechanisms in the three massive star-forming regions, N158, N159 and N160. In neutral regions, the main mechanism responsible for the gas heating is the photoelectric effect. This process consists in the ejection of an electron from a dust grain after the absorption of a UV photon.

The objective of this work is to combine data acquired by the SAGE [2] survey with Spitzer (3.6 to 70 microns), the HERITAGE [3] survey with Herschel (100 to 250 microns), and new data from SOFIA, with the aim of creating maps of dust properties and constraining the efficiency of the photoelectric heating of the gas in this region. To that end, we have homogenized our multi-wavelength maps to an optimal, common resolution and pixel grid. We took particular care in the estimate of the non-Gaussianity of our uncertainties and their correlations. The spatially-resolved spectral energy distribution of each pixel was then fitted with the hierarchical Bayesian code, HerBIE [4], using the THEMIS dust model [5,6]. One of the originality of our work is that the modeling we perform allows us to compare the efficiency of the photoelectric heating to the actual mass of its carriers, and not only to their luminosity. Our results confirm that the photoelectric heating is dominated by the smallest grains. In addition, the overall efficiency of the heating appears reduced, because of the lower abundance of these grains, relative to the gas, in the LMC.

References

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Squeezing Orbits: Accretion-Induced Orbital Tightening

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The kinematics of young stellar clusters hold critical clues about the dynamical states of their parent molecular clouds. Decades ago, Lynden-Bell demonstrated that violent relaxation during collapse results in a system with velocity dispersion independent of particle mass. In contrast, astronomers frequently expect that, if collisional relaxation occurs, energy equipartition between stars should happen, where massive stars exhibit smaller velocity dispersions than their lower-mass counterparts. Recently, we have found that stellar clusters such as Orion and the Lagoon Nebula clusters, as well as in numerical simulations of collapsing clouds, produce clusters where, indeed, the stars have constant velocity dispersion. However, turbulence-supported clouds tell a more complex story: massive newborn stars exhibit larger velocity dispersions than low-mass stars. Through an analysis of turbulent numerical simulations, I will demonstrate that this phenomenon arises as a consequence of a phenomenon we call "accretion-induced orbital tightening", where massive stars form in denser, more crowded regions within turbulence-supported clouds, allowing them to accrete mass more efficiently while simultaneously interacting with nearby stars, increasing their velocity dispersion. In contrast, low-mass stars, which accrete less vigorously and tend to be more isolated, are not able to increase with the same intensity their velocity dispersion.

The Resolved Structure of a Low Metallicity Photodissociation Region

Ilyse Clark
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Photodissociation Regions (PDRs) are key to understanding the radiative feedback processes that shape the interstellar matter in galaxies. One important type of PDR sits at the interface between HII regions and molecular clouds, where far-ultraviolet (FUV) radiation from massive stars heats gas and dust and dissociates molecules. Photochemical models predict that the C/CO transition occurs deeper in the PDR compared to the H/H2 transition in low-metallicity environments due to reduced dust shielding, increasing the extent of CO-dark H2 gas. This prediction has been difficult to test outside the Milky Way due to the lack of high-spatial resolution observations tracing H2 and CO. We present high-resolution observations of N13, an edge-on, low-metallicity PDR in the Small Magellanic Cloud (SMC), resolving the ionization front, H2 dissociation front, and the C/CO transition for the first time in an extragalactic environment. Using JWST near-infrared spectroscopy of H2 vibrational lines and ALMA 12CO (2-1), (3-2), and [CI] (1-0) data, we measure the separation between the H/H2 and C/CO boundaries as 0.049±0.001 pc (0".162±0".001), defining the spatial extent of the CO-dark H2 layer. Comparing these results with plane-parallel PDR models, we find that a constant-pressure model reproduces the observed structure more accurately than a constant-density one. Overall we find that the PDR model does well at predicting the extent of the CO-dark H2 layer in N13, set mainly by the ratio of extinction to column density (AV/NH). This work illustrates the potential of high-resolution, multi-wavelength observations to disentangle the effects of low-metallicity environments on PDR structure, providing a critical benchmark for testing PDR models.

Analyzing Stellar and Interstellar Contributions to Polarization for Hot Stars

Christiana Erba
Space Telescope Science Institute

Linear polarimetry is a valuable technique for examining or constraining the geometry of an unresolved source. For hot stars, which exhibit asphericity due phenomena like binarity, rapid rotation, and wind structure, linear polarization can provide insight into the geometry of their circumstellar environments. However, contributions from interstellar polarization introduce challenges to the interpretation of intrinsic stellar polarization. In this poster, we review techniques for separating the interstellar contribution from the stellar signal for massive star astronomy. We characterize interstellar polarization with distance using recent catalogs of starlight polarization and consider polarimetric variability across spectral features. This study can aid efforts for spectropolarimetry in the age of new flagship missions like Habitable Worlds Observatory, and future instrumentation such as the Ultraviolet spectropolarimeter concepts like Polstar and Pollux.

Stirring the Pot: Spiral-Arm-Induced Star Formation and ISM Enrichment in NGC 628

James Garland
University of Toronto

Spiral arms are the primary sites of star formation in disk galaxies. Recent observations and simulations provide a dynamical perspective on spiral structure, revealing its significant influence on the enrichment, flow, and mixing of the ISM. These studies suggest that spiral arms drive subtle radial and azimuthal trends in ISM properties, such as gas-phase metallicity. Although challenging to observe, these effects serve as powerful probes of the mechanisms and behavior of spiral structure. We leverage the high spatial resolution (∼1–40 pc) and spectral resolution (R = 5000) of the Star formation, Ionized Gas, and Nebular Abundances Legacy Survey (SIGNALS) to investigate these fine chemical fluctuations. Our study examines 4,285 emission-line regions in the face-on, grand-design spiral galaxy NGC 628. Using flux measurements from eight nebular emission lines in the 3640–6860 Å range, we precisely estimate chemical abundances across the entire galactic disk. To quantify spiral structure, we employ machine learning models trained on morphologically classified galaxy images. We present spatial maps of the gas-phase metallicity of NGC 628 and highlight azimuthal trends that shed light on the nature and influence of its spiral arms. Expanding our methodology to a broader sample of galaxies will offer deeper insights into spiral structure and its role in galactic evolution.

The impact of evolved stars on their environment, and vice versa

Steve Goldman
Space Telescope Science Institute

Evolved stars are complex and hard to model. Dense outflows, dust production, variability, convection, and changing chemistry complicate our understanding of their output and evolution, and so we rely heavily on observations. Using data from mainly the near- and mid-infrared, we have identified the largest stellar dust producers in nearby galaxies. This includes the massive PHAT dataset in M31, as well as the handfuls of stars that contribute the bulk of the dust in metal-poor dwarf galaxies. Our ability to calculate the net impact of evolved stars has been limited by a variety of unknowns. For evolved stars these largely come down to the dust properties and assumed circumstellar geometry. This talk will discuss how we are measuring stellar feedback in nearby galaxies, the limitations of our dust budget calculations, and how future observations and theoretical work can improve on these estimates.

Extinction Curve in the Local Group: Evidence for ISM Dust Grain Grown

Karl Gordon
Space Telescope Science Institute

Ultraviolet through mid-infrared dust extinction curves provide an efficient probe of dust grain sizes and compositions. Combining recent new results in the SMC and M31 with existing work in the LMC and Milky Way, there is strong evidence that the large variation in extinction curves seen is likely due to dust grain grown in the ISM itself. Extinction curves in these galaxies vary significantly between having moderately rising extinction with wavelength and strong 2175 A bumps to having no 2175 A bump and strongly rising extinction. Correlations between UV extinction properties, gas-to-dust ratios, small carbonaceous grain IR emission measurements, and ALMA CO indicate that dust grain growth is happening in the ISM itself. The combined extinction behavior paints a picture of a family of curves more dependent on local conditions and less on the overall galaxy properties (e.g., metallicity).

Using JWST to Map CO Ice in a Star Forming Filament

Savannah Gramze
University of Florida

Astronomers' fundamental tool for measuring mass column density in different environments is CO gas emission, but in cold, dark clouds, much of the mass is locked away in ice. We present JWST results from observations of a star forming filament associated with the 3 kpc arm. This filament is backlit by the Galactic Center, which has allowed us to construct a high resolution extinction map with measured extinctions exceeding A_v = 85. Using the CO ice feature covered by the F466N band, we create a map of CO ice column density of the filament. Using the extinction map, CO ice column density map, and archival CO observations, we examine the efficacy of standard CO X-factor measurements of mass in star forming gas. We find that more than 50% of the CO is locked away in ice at large column densities in the filament. This shows that systematic corrections are needed for mass measurements in the Milky Way and nearby galaxies at high column densities.As the Sun and other stars wander through the inhomogeneous interstellar medium, pressure balance will shrink or expand their astrospheres leading to changes in the cosmic ray flux incident on their planets and perhaps to conditions for habitability. The 15 local partially ionized clouds lie inside of the Local Bubble created by recent supernova events, and the clouds are likely produced by shocks or instabilities in the shock waves produced by supernovae. These clouds, which can be studied in great detail by virtue of their proximity, are likely prototypes for warm gas clouds elsewhere in the galaxy and beyond.

Interactions between young stars and molecular clouds

Aashish Gupta
University of Virginia

The traditional picture of star formation suggests that the collapse of spherical protostellar cores forms protostars, surrounded by planet-forming disks. However, stars form in turbulent giant molecular clouds, where the initial conditions for star and disk formation cannot be represented as isolated spheres. Observations and simulations show that the star formation is highly asymmetrical, with material usually falling onto protostellar systems via elongated channels or "streamers". The recent detections of infalling streamers around Class II systems, which were expected to be isolated, suggest that young stars can gravitationally capture nearby cloudlets of gas. To systematically study the impact of such an infall of material on protostellar systems, we developed a novel code TIPSY (Trajectory of Infalling Particles in Streamers around Young stars). Analysis of streamers using TIPSY has allowed us to understand their role in increasing the mass budget available to form planets, inducing accretion outbursts, and misaligning planet-forming disks. Furthermore, initial results from ALMA large-program DECO (Disk-Exoplanet C/Onnection) show that at least 40% of Class II systems are interacting with surrounding clouds. Our results strongly suggest that studying interactions between young stellar systems and their surrounding gas is important for a comprehensive understanding of star and planet formation.

Constraining the star-forming past and future of the MonR2 GMC

Robert Gutermuth
University of Massachusetts – Amherst

Understanding when and how high- and low-mass stars are formed from molecular gas is vital for modeling a wide range of astrophysical phenomena, from galaxy evolution to the incidence of planets that may host life. Recent MHD simulations like STARFORGE that employ reasonable feedback recipes can successfully trace a full, finite star-forming lifetime of a synthetic molecular cloud. To reap the most benefit from these new capabilities and facilitate future advancements, new constraints on the star formation process must be derived for nearby clouds. What constraints on the star-formation history of a cloud can we extract from the present state of a cloud's gas and stellar content? How is feedback likely to influence the formation of the next generation of protesters? We will present a prototype analysis where we capture the star formation history of the MonR2 giant molecular cloud via the union of archival Spitzer, 2MASS, Herschel, LMT, and Gaia data. IR and mm-wave surveys have successfully taken censuses of the early-stage young stellar content of entire clouds. In contrast, our ability to identify substantial fractions of the diskless pre-main sequence stellar content, the long-term archive of star formation in a cloud, is limited by the coverage of X-ray and spectroscopic surveys to date. To address this, we will demonstrate the results of a Random Forest Classifier analysis that isolates substantial populations of diskless members over entire clouds with Spitzer and Gaia data in combination. With all of these catalogs, we have reasonably large samples of the entire stellar content life cycle over entire molecular clouds: prestellar dense gas cores, protostars, and pre-main sequence stars with and without circumstellar disks. Such a census of the stellar content facilitates estimation of the present star-forming age and total stellar content of the cloud. We will constrain the long-term star formation rate of the cloud from this analysis and compare it to star formation rates derived from the more recent past as traced by the protostars alone. Finally, we will use a new map of radiative feedback strength derived from mid- and far-IR imaging with a machine learning technique (denoising diffusion probabilistic models) to explore how the dense gas cores that will form the next generation of protostars are impacted in regions in strong feedback.

Star Formation in the Perseus Molecular Cloud: IC 348, NGC 1333 and Friends

Priya Hasan
Maulana Azad National Urdu University, Hyderabad, India

The Perseus molecular cloud is a nearby (~300 pc) area of size 6 by 2 degrees and includes the young star-forming clusters IC 348 and NGC 1333, both of age 1-3 Myr lying within 300 pc of the Sun. With Himalyan Chandra Telescope observations of IC~348 and NGC~1333, coupled with Spitzer, WISE, and 2MASS data, we compile a catalog of YSOs in the region. We use this catalog to crossmatch with Gaia DR3 data to produce a control sample. We then use machine learning techniques, DBSCAN, OPTICS, and HDBSCAN, to identify a new population of YSOs. We classified these objects using 2MASS and WISE data to study their distribution and the progress of star formation in Serpens using the kinematical data from Gaia DR3 to study this large region.

Populations of massive stars at low metallicity

Calum Hawcroft
Space Telescope Science Institute

Hot, massive stars which host strong radiatively-driven outflows, are essential components of stellar populations, giving rise to prominent spectral features in the UV composite spectrum, and setting key mechanical, chemical and energetic feedback properties. Massive stars become more extreme at low metallicity and, thanks to pioneering observations of young, metal-poor stellar populations both locally and at high redshifts with HST and JWST, we are at a key moment to reassess our understanding of the impact of massive stars in stellar populations throughout the universe.

To this end, we have updated the population synthesis code Starburst99 with a comprehensive set of evolutionary tracks (GENEC) and a new complementary grid of atmosphere (FASTWIND) models which extend our modelling capability to metallicities representative of star-forming regions in the Milky Way, LMC, SMC, IZw18 and the early universe. These models also increase the upper mass limit from 120 to 300 solar masses and include the effects of rotation. Additionally, we update the feedback prescriptions, informed by the latest results from combined UV and optical spectroscopic analyses from large (>100 OB stars) surveys in the LMC and SMC from XShootU and our new study of 10 O-type stars in Sextans A (results from which will also be highlighted).

Here I will present the latest results from the new version of Starburst99, focusing on new predictions of the integrated diagnostics and properties of stellar populations, such as the wind luminosity, ionising fluxes and chemical yields and the impact of metallicity, very massive stars and rotation on these predictions.

An integral partner to star formation: the dust filament network (DFN) in PHANGS-JWST galaxies

Jake Hoffman
Johns Hopkins University

We present analysis of the dust filament network (DFN) and its link to star formation activity in 19 nearby disk galaxies of the PHANGS-JWST Cycle 1 Treasury program. JWST/MIRI observations reveal pervasive substructure throughout the dusty ISM; an intricate tracery of bubbles and filaments resulting from both star formation feedback and dynamical influences. These data provide an opportunity to quantify the physical properties of such ISM structures at scales of 10-30 pc, and specifically correlate them with the products of star formation. We introduce FilPHANGS, a new method for multi-scale identification and characterization of filaments, which we apply to starlight subtracted F770W images of the 7.7-micron PAH feature. We compare measured observables of filament line mass, aspect ratio, and hierarchical nesting characteristics to analogous quantities derived from state-of-the-art numerical galaxy simulations (also analyzed with FilPHANGS). We employ PHANGS catalogs of young clusters and HII regions from HST, and embedded cluster candidates from JWST/NIRCAM, to quantify the occupation statistics of star formation sites with the DFN. We also illustrate that FilPHANGS can be used to map filamentary dust lanes such as will be vividly revealed in wide-field Roman Vis-NIR imaging of the local galaxy population.

Mapping the Cosmic-Ray Ionization Rate in the Local ISM

Nick Indriolo
Space Telescope Science Institute

Chemical complexity in the molecular interstellar medium (ISM) is driven by fast ion-molecule reactions. This network of chemical reactions requires a source of ionization, and as molecular gas is generally well-shielded from ionizing UV photons, cosmic rays provide the dominant source of ionization in such environments. The impact of cosmic rays on atomic and molecular hydrogen is parameterized as the cosmic-ray ionization rate (CRIR; number of ionizations per atom/molecule per unit time), which serves as an important input variable in astrochemical modeling. We use observations of H3+, a molecule with very simple formation and destruction pathways, in combination with advanced 3D chemical modeling to infer the CRIR in diffuse molecular gas along sight lines toward bright, early type stars. Until recently, it was impossible to constrain the location of the absorbing gas along a sight line, but with Gaia extinction maps we can now link molecular absorption features to physical complexes of dust and gas in the local (2 kpc) ISM. This has allowed us to begin creating the first 3D map of CRIRs in the solar neighborhood, and to investigate correlations with properties such as location, gas density, distance from proposed cosmic-ray acceleration sites, and more. Here, I will present the results of our recent H3+ survey using IRTF/iSHELL, which has more than doubled the number of sight lines where we have precision estimates of the CRIR, and enabled the investigation of spatial variations in the cosmic-ray flux.

Revealing the Role of Earlier Generations in Guiding Cloud Evolution in Circinus

Ronan Kerr
University of Toronto

Young associations provide a record of star formation that lasts long after the dispersal of the natal cloud. Through the SPYGLASS program, I am revealing the diversity of dynamical processes and patterns that guide the formation and evolution of nearby young associations. My recent work on the Circinus Complex reveals that stellar populations near the Circinus Molecular Cloud host an age gradient, with progressively younger populations found further from the region's center. By comparing Circinus to analogous STARFORGE simulations, I show that the region's formation can be explained solely by triggered star formation in a shell driven by feedback from its central cluster, with the observed age and velocity gradients induced by differences in the exposure of gas overdensities to stellar feedback. This idea is supported by gas dynamics, as the Cir-E cloud shows convergent velocities consistent with a collision between an interloping cloud and material from the feedback-driven shell. This collision appears to drive Cir-E's morphology, as that cloud is denser and less filamentary compared to the largely unperturbed Cir-W cloud. Massive stellar populations often accompany star-forming clouds in young association surveys, so our findings in Circinus demonstrate the importance of these populations in contextualizing gas dynamics.

PDRs4All: Decoding the spectral properties of PAHs and Very Small Grains in the Orion Bar

Baria Khan
The University of Western Ontario

Photodissociation regions (PDRs) within the interstellar medium are significant habitats for polycyclic aromatic hydrocarbons (PAHs) - a ubiquitous and resilient family of organic molecules. The dynamic interplay of ultraviolet radiation, excitation and processing of PAHs greatly helps in sculpting PDR environments and contributing to PDR physics and chemistry. PAHs are thus important components of PDRs. We present JWST's Early-Release Science Program, PDRs4All's observations of a prototypical PDR, the Orion Bar, which reveal the complexity of PAH signatures in the form of mid-infrared, broad aromatic infrared bands (AIBs), in exquisite detail. In particular, the 10–15 micron AIBs largely originate from the out-of-plane bending of C-H groups located on the edges of PAHs, and are thus excellent tracers of their molecular skeletons. We investigate the spectral diversity, morphology and interrelationships of a cohort of these AIBs across the PDR, to infer the edge structures of their carrier PAHs. This study reveals that the PAH family in the Orion Bar consists of members with structures that are rich in solo and trio edge hydrogens, with labile hydrogens that are lost near the PDR surface via photoprocessing. We further find that the 11.2, 12.0 and 12.7 micron AIBs have sub-components that are carried by another population of carbonaceous AIB carriers in the Orion Bar, the Very Small Grains (VSGs). These labile carriers undergo photolysis as they are advected through the PDR toward its surface and exposed to an increasingly stronger radiation field. This work provides insight into the power of JWST to decipher the photochemical evolution of PAH and VSG populations within diverse astronomical environs, through their complex spectral emission signatures.

Resolved Stellar Populations in PHANGS-HST Galaxies

Hwihyun Kim
International Gemini Observatory/NSF NOIRLab

Abstract: Observations of resolved stellar populations provide critical insights into the interplay between star formation, chemical enrichment, and the interstellar medium (ISM) across diverse galactic environments. The PHANGS-HST Treasury Survey focuses on nearby galaxies at distances of 4.5-20 Mpc, allowing the detection of individual stars in various evolutionary phases. Here, we present our approach for selecting stellar candidates from PSF-fitting photometric catalogs in the HST NUV, U, V, B, and I bands, focusing on their photometric properties and connections to their host galaxy environments. Our analysis includes resolved stellar populations within the interstellar bubbles of the Phanom Galaxy, NGC 628, providing a direct link between stellar feedback and the surrounding gas and dust structures. These data refine our understanding of star formation histories and ISM-driven feedback processes. Further analysis incorporating PHANGS-JWST observations will be discussed, probing massive young stars (including embedded sources), evolved stars (RGB and AGB candidates), and those in between.

Untangling Interstellar Extinction of Cepheids to Refine the Extragalactic Distance Scale

Wilma Kiviaho
Observatoire de Paris

Cepheid variables serve as fundamental standard candles for calibrating the extragalactic distance scale. The high-precision parallaxes from Gaia now enable a sub-percent calibration of the Period-Luminosity (PL) relation for Milky Way (MW) Cepheids. However, interstellar extinction remains the main source of uncertainty, as the Cepheids' variability complicates direct reddening measurements.

We present a novel approach to estimate extinction by leveraging non-variable field stars in the neighborhood of Cepheids. Using medium-high-resolution VLT/FLAMES spectroscopic observations, we determine the stellar parameters (Teff, log g, [M/H]) of these stars. Combining these parameters with multi-band photometry (Gaia, 2MASS, etc.) and ATLAS9 atmosphere models, we derive their individual color excesses E(B-V). This results in a high-resolution 3D extinction map, from which we interpolate the Cepheid reddening.

By refining extinction corrections, we will improve the calibration of the MW Cepheid PL relation, leading to more precise extragalactic distance measurements and an enhanced determination of the Hubble constant, H0.

Exploring Star Formation and Multi-Phase Gas in a Brightest Cluster Galaxy with JWST, MUSE, and ALMA

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We provide a comprehensive multi-phase study of the interstellar medium (ISM), and circumgalactic medium (CGM) of the brightest cluster galaxy (BCG) in MACS1931-26, a cool-core cluster at z~0.35. This galaxy hosts a radio-loud active galactic nucleus (AGN) and a massive molecular gas reservoir, extending over 30 kpc in a tail-like structure, likely responsible for the galaxy's enhanced star formation. We present new JWST MIRI observations revealing the spatially resolved distribution and kinematics of warm molecular gas—traced by rotational H2 lines—along with ionized gas, and dust tracing polycyclic aromatic hydrocarbons (PAHs). By combining these warm (100−1000 K) H2 observations with cold (10−50 K) H2 traced by ALMA CO measurements, we probe an extensive temperature range of the molecular phase. Our analysis reveals a consistent warm-to-cold gas mass ratio across the ISM core (1.0%+\-0.3%) and CGM tail (1.3%+/-0.8%), suggesting dynamic coupling between molecular gas components despite varying heating mechanisms. We investigate these mechanisms in the ionized phase, where detections of the AGN-tracing [S IV]10.54um line, combined with radio continuum data, suggest the jet's potential role in heating and shocking gas. Additionally, we use PAH features and Halpha emission from MUSE data to trace shock-induced star formation. Ultraviolet radiation from these regions and several star-forming clumps may also influence gas excitation. Finally, we compare observed optical/infrared diagnostic ratios to predictions from photoionization and shock modeling to quantify the relative contributions of different heating mechanisms. Our findings indicate that it is necessary to consider multiple mechanisms to fully explain the heating of both gas phases. By analyzing the CGM across a range of temperatures, ionization states, and wavelengths, we provide new insights into feedback, the baryon cycle, and the roles of shocks and turbulence in the heating and cooling of the multiphase CGM.

Astrospheres as Shields: Habitability in the Interstellar Medium

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Astrospheres, the extended regions of plasma and magnetic fields formed by stellar winds as they interact with the interstellar medium (ISM), play a crucial role in shielding planetary systems from the harsh galactic environment. However, astrospheres are not static; they are shaped by the competition of stellar wind pressure and external forces, including ram pressure from ISM flows, thermal pressure from surrounding gas, and magnetic pressure from interstellar magnetic fields. When these pressures become significant, the astrosphere can contract dramatically, potentially exposing planets to the direct influence of galactic cosmic rays and interstellar gas, which can alter planetary climates.

In this work, we investigate the frequency and conditions of such "descreening events," wherein the astrosphere contracts below the orbital radius of a planet, leaving it vulnerable to ISM conditions. Using high-resolution simulations indicative of the solar neighborhood from the TIGRESS framework, we model astrosphere variability over a range of stellar parameters. Our findings suggest that descreening events may not be rare occurrences and occur frequently over stellar lifetimes, particularly in regions of dense ISM. These events could play a pivotal role in determining planetary habitability, influencing atmospheric conditions, surface radiation levels, and overall climate stability. By quantifying the occurrence of astrospheric shrinkage and its impact, our study provides new insights into the dynamic interplay between stars, their environments, and the potential for life beyond our solar system.

Compact Obscured Star Clusters in the Nearby Starburst Galaxy NGC 253

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At a distance of 3.5 Mpc, the galaxy NGC 253 is the nearest example of a nuclear starburst. A majority of the star formation activity in this galaxy is concentrated in the central region of the galaxy within deeply embedded, massive star clusters. This innermost region was previously inaccessible due to the extreme visual extinction, however, with the advent of ALMA, these massive clusters and the physics governing them are now able to be investigated with high-resolution. In the present day universe, the formation and evolution of massive star clusters is rare, however, it is believed to be a common mode of star formation in the early Universe. Thus, these nearby clusters provide critical insight into the nature of star formation over cosmic time and the starburst phase of galactic evolution. In this work, we leverage high resolution observations from ALMA to study the molecular emission from individual cluster regions in order to analyze the evolution and impact these clusters have on their surroundings over their lifetimes. We compare observations of multiple lines from several abundant dense gas tracers (HCN and HC3N), examining emission from both lower-energy rotationally-excited transitions which trace less dense gas in the cluster environment and higher-energy vibrationally-excited transitions from the dense and dusty inner cores. By comparing the gas motions in these two regions, we isolate signatures of both gas outflow and inflow on cluster-scales that allow us to better understand the life cycle of massive star clusters and how they contribute to large-scale winds that shape the evolution of entire galaxies.

Empirical measures of the inhomogeneity of the local ISM and effects on astrospheres

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Analysis of high resolution HST/STIS ultraviolet spectra of 113 stars show the complex structure of interstellar absorption within 100 pc of the Sun. Kinematic inhomogeneity is structured in the form of clouds, each with flows characterized its own velocity vector, that are roughly similar to the direction from the recent supernovae in the Sco-Cen Association. The clouds are partially ionized with mean temperatures in the range of 3,000 K to almost 10,000 K, but within the LIC and presumably other nearby clouds there are large temperature differences with length scales smaller than 5,000 au. These differences interpreted as temperatures may not be entirely thermal, but include variable amounts of supra-thermal components. Neutral hydrogen densities cannot be directly measured, but indirect methods infer typical mean neutral hydrogen densities of about 0.1 cm^{-3}. Neutral hydrogen column densities can be directly measured. Typical neutral hydrogen column densities through the LIC and other clouds are about 1x10^{18} cm^{-2}, indicating that the LIC and other nearby clouds extend to only 3-5 pc. However there are number of sight lines with neutral hydrogen column densities 2-6 times larger. We have explored possible explanations for these high sight lines. Swaczyna et al. (2022) argued that there is a region where the LIC and G clouds clouds overlap with locally higher density and regions perpendicular to the axis separating the LIC and G clouds with high column densities. They showed that the high column densities to AD Leo and HD 82556 fit this explanation. We show that 7 sight lines lie within 10 degrees of the perpendicular direction. We also argue that high sight lines may also be explained by the overlap of other clouds, by shocks, and by shells produced by supernova events (Zucker et al. 2024).

As the Sun and other stars wander through the inhomogeneous interstellar medium, pressure balance will shrink or expand their astrospheres leading to changes in the cosmic ray flux incident on their planets and perhaps to conditions for habitability. The 15 local partially ionized clouds lie inside of the Local Bubble created by recent supernova events, and the clouds are likely produced by shocks or instabilities in the shock waves produced by supernovae. These clouds, which can be studied in great detail by virtue of their proximity, are likely prototypes for warm gas clouds elsewhere in the galaxy and beyond.

Massive Star Cluster Formation and Early Evolution

Mordecai-Mark Mac Low
American Museum of Natural History

The initial conditions of massive stellar clusters are enshrouded in the high-density gas from which they form. Stellar dynamicists often assume clusters start as monolithic symmetric distributions, while star cluster formation modelers usually form aggregates of stars rather than individual stars to reduce computational cost. I present models of star cluster formation from gas clouds of 3,000 to a million solar masses simulated with the Torch framework that begin to move beyond these simplifying assumptions. This framework uses AMUSE to combine the Flash magnetohydrodynamics code with the PeTar N-body code and SeBa stellar evolution model (although other N-body and stellar evolution models can be substituted). We individually track all stars exceeding four solar masses in clusters formed in initially spherical, turbulent clouds with sub-virial velocity dispersions consistent with observed regions of massive cluster formation. We follow mechanical and radiative feedback from stars exceeding 20 solar masses. Non-spherically symmetric star formation occurs as a natural consequence of the turbulent initial conditions. We find high star formation efficiencies ranging from 32% at 10,000 solar masses to 85% at a million solar masses. These models may help explain the unusual properties of the most massive clusters. Stars in our models of massive clusters initially form in subclusters that then interact dynamically. At late times, subclusters falling into the potential well can be accelerated out, producing an anisotropic distribution of runaway stars. This subcluster ejection scenario represents a novel third channel for producing runaways beyond binary supernovae and dynamical ejections of single stars. These models produce a fraction of runaways smaller than observed, which we attribute to our unrealistically symmetric initial gas clouds. To move to more self-consistent gas initial conditions we use our newly developed capability to take a region from a whole galaxy model using a Voronoi mesh and map it onto the Flash AMR grid. I will also report on ultraviolet escape fractions from these clusters to examine whether they support the idea of feedback-free cluster formation at high surface density. We have further developed the machinery to examine how elemental yields from individual stars are mixed into star-forming gas within and beyond subclusters.

Spatially-resolved TRGB JWST CMDs as a tool to measure fossil stellar metallicity gradients

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We use archival JWST/NIRCam images in the F115W, F150W, and F200W filters to measure the Tip of the Red Giant Branch (TRGB) magnitudes across the disk of the late-type spiral galaxy NGC 628. In this exploratory study, we demonstrate how the metallicity-dependence of TRGB magnitudes in the near-infrared (NIR) filters can be exploited by making use of the theoretical isochrones to determine metallicities of the fossil 10 Gyr old population over kiloparsec scales without being affected by the age-metallicity-reddening degeneracy. We obtain a smooth metallicity gradient that decreases from Z=0.003 in the central regions to Z=0.002 in the external parts, with a typical error on Z of 0.0002. The extinction variation across the disk caused by the diffuse interstellar dust is spiky with a median value of Av=0.1 mag. We propose that the large bubbles in the disks of galaxies offer dust-free lines of sight for measuring the TRGB magnitudes, and hence the distance to galaxies, to an accuracy that is as good as that of the halo populations. Using the Phantom Void, we obtain a TRGB distance modulus of 29.83±0.05 for NGC 628, which agrees well with the most recent PNLF measurement of 29.89-0.09+0.06 for this galaxy.

Investigating protostellar accretion driven feedback with JWST

Tom Megeath
University of Toledo

Accretion driven feedback by protostars plays an important role in the baryonic cycles of matter between stars and gas, both by shaping the initial mass function of stars and by lowering the star formation efficiency of molecular clouds. JWST can now study this feedback on 100-5000 au scales through IFU imaging of deeply embedded, Class 0 protostars. We present results of the JWST program Investigating Protostellar Accretion, which targets five protostars with masses of 0.12 to 12 Msun and luminosities of 0.2 to 10,000 Lsun . These are bipolar sources observed at 60-80 degree inclinations, and thus ideal targets for observing the interactions between accretion driven outflows and infalling envelopes. With 2.9-27 micron NIRSpec+MIRI spectra and spatial resolutions as high as 80 au, we examine the outflow properties vs the masses of the emerging stars. The low to intermediate mass protostars show collimated jets with velocities of ~150 km s-1 traced in ionic fine structure lines, with molecules in the jets primarily localized to knots. The cavities carved by the outflows - as delineated in the IFU data by the scattered light continuum - are much wider than the jets. Filling the cavities is a ~20 km s-1, wide angle wind traced primarily.in molecules such as molecular hydrogen. From the estimated mass loss rates and gas velocities, we find that both the jets and winds have similar momentum flows, but the winds are likely more important in halting infalling gas due to their wide angle nature. We also give a brief preview of the ongoing HEFE program on JWST, a 175 hour program to study protostellar feedback in the massive Orion Integral Shaped Filament with NIRSpec, MIRI and NIRCam.

The Distance to the Magellanic Stream: Constraints from Optical Absorption along Stellar Sightlines

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The Magellanic Stream (MS) is a large structure of neutral and ionized gas in the circumgalactic medium of the Milky Way (MW), spanning over 200 degrees across the sky. It originates from tidal and hydrodynamical interactions between the Magellanic Clouds as they orbit the MW. The MS is crucial for understanding galaxy evolution, as it carries a significant gas reservoir that could fuel future star formation in the MW, particularly evident from gas accreting onto the MW disk from the Leading Arm. However, the timing and likelihood of this gas settling onto the Galactic disk remain uncertain, with distance of the MS to the MW disk being a key factor. Despite its importance, direct observational constraints on the MS distance remain unexplored. In this study, we analyze VLT/UVES spectra of five blue horizontal branch (BHB) stars in the MW halo, located near two regions of the stream's trailing tip (Group 1 and Group 2), with the aim of detecting CaII and NaI absorption features at the stream's location. However, no CaII or NaI absorption features are detected in any of the spectra. We also perform a stacked analysis using SNR-weighted mean spectra from stars in both regions, but the stacked profile reveals no CaII or NaI signals. The observed CaII absorption strength is significantly lower than predicted by extragalactic studies. From these meaningful non-detections, we establish the first observational lower limit of 20 kpc (robust) and tentative lower limits of 42 kpc and 55 kpc for the two regions of the stream. The stacked profiles further refine these limits to 23 kpc and 38 kpc for the same two regions, respectively. These first observational constraints on the stream's distance represent an important step forward in refining models of the Magellanic Clouds orbiting around the MW.

Characterizing Surface Density and Potential Fluctuations of the Interstellar Medium

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The interstellar medium (ISM) plays an important role in shaping the structure of our Galaxy: in addition to being the birthplace of stars, ISM substructures have the capacity to significantly perturb stellar orbits. Presently, despite their far-reaching influence in stellar dynamics, these fluctuations and their effects have only been studied with models that do not capture realistic properties of the ISM. Analytic models (e.g. isotropically distributed spherical clouds) are tractable but highly idealized, while global computational models (MHD coupled to N-body) have low resolution and often lack key ISM physics. In this work, we bridge this gap by quantitatively characterizing the ISM structure in state-of-the-art MHD simulations, providing a key physical input to stellar dynamical modeling. The TIGRESS-NCR framework we employ includes self-consistent star formation and feedback (ray-tracing radiation and supernovae), as well as nonequilibrium chemistry and cooling, and resolves scales down to 2 pc. We measure the one-point and two-point spatial statistics as well as additional spatio-temporal features of the surface density and gravitational potential fluctuations. We find that in both solar neighborhood and inner-galaxy conditions, the surface density fluctuation field follows an approximately log-normal pdf and the power spectrum of the log-density contrast is well-approximated as an isotropic power law with an exponent of ∼-2.8; the power spectrum of the linear density contrast is also well-approximated as an isotropic power law, with an exponent of ∼ -2.3. Additionally, we compare the potential fluctuations to simplified models of thin disks populated with the corresponding surface density fluctuations. Ultimately, our characterizations provide convenient parametrizations for incorporating the influence of a realistic ISM in dynamical studies, and offer comparisons for multi-wavelength observational data.

Determining the Properties of the Cold, Dense LISM Clouds that the Sun may have Recently Encountered

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Wesleyan University

As stars pass through the interstellar medium (ISM), their astrospheres, or heliosphere in the case of the Sun, expand or contract depending upon the density of surrounding ISM. While cold, dense clouds are rare in the local interstellar medium (LISM), the Local Ribbon of Cold Clouds (LRCC) has garnered considerable attention in recent years due to its unusual ring structure and because our Sun may have passed through it 2-3 Myr ago, drastically compressing the heliosphere, and potentially driving atmospheric changes on Earth. We present new high-resolution (R > 80,000) optical spectra, obtained by MAROON-X on Gemini North, of 85 nearby (< 100 pc) stars in the direction of the LRCC. We model the LISM absorption due to Na I and K I in order to measure new velocities, Doppler parameters, column densities, metallicities, and temperatures for the LRCC. These measurements help us to constrain the distances, structures, boundaries, and properties of the LRCC in order to help confirm or refute the existence of a ring structure and assess its origins, as well as test the claim that the Sun encountered the LRCC. This study will also be vital in the broader context of understanding how the LISM impacts the heliosphere, planetary atmospheres, and potentially Earth's biosphere. We acknowledge support for this project through the Gemini Observatory programs GN-2024A-Q-114 and GN-2025A-Q-216.

Spectral Decomposition of the Aromatic Infrared Bands in Photodissociation Regions

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We will discuss recent developments for the PAHFIT spectral decomposition tool, and its application to JWST spectra from two programs: the PDRs4All ERS observations of the Orion Bar photodissociation region (PDR), and the GTO observations of NGC7023. The IFU spectra of the Orion Bar and NGC7023 are of very high signal-to-noise across the wavelength range (1-28 um), revealing the numerous sub-features of the bright aromatic infrared bands (AIBs, PAHs) in a spatially and spectrally resolved manner. The Python version of PAHFIT was developed as one of the products to be delivered to the community by the PDRs4All collaboration. Alongside this new version of PAHFIT, we present an updated "science pack", which defines the AIBs and continuum components to be included in a fit. We have updated the central wavelengths and FWHMs for the AIBs based on fits to the PDRs4All template spectra. The new science pack enables PAHFIT to perform decompositions at a level of detail suitable for JWST spectra of similar depth. We apply PAHFIT to spectra of a star forming ring in the center of the NGC7469 galaxy, demonstrating the applicability of this science pack to extragalactic objects. As an example use case, we present two simple diagnostics derived from the PAHFIT results, that describe shape variations shape of the 3.3 um and 5.7 um profiles. In ongoing work on NGC7023, individual fits of all spaxels reveal the spatial distribution of the AIB sub-components. A preliminary conclusion is that the 16.4 and 17.4 um features exhibit distinct spatial distributions. We explore which other features have spatial distributions similar to to either 16.4 or 17.4 um, or a mix of both.

DH~Cephei, a massive O+O binary system at the core of the young cluster NGC~7380

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DH~Cephei, a massive O+O binary system at the core of the young cluster NGC~7380, serves as a critical laboratory for studying feedback between massive stars and the interstellar medium (ISM). Using high-precision BVR-band polarimetry with the DiPol-2 instrument, we detected phase-locked polarization variations at half the 2.11-day orbital period, tracing a symmetric circumstellar envelope sculpted by binary interactions. Simultaneously, polarization measurements of 14 neighboring cluster stars revealed foreground interstellar dust aligned at $\theta \sim 55^\circ$--85°, consistent with the empirical $P \leq 9 \times E(B-V)\%$ law. By disentangling interstellar and intrinsic polarization components, we constrained the binary's orbital inclination ($i = 46^\circ^{+11^\circ}_{-46^\circ}$), orientation ($\Omega = 105^\circ \pm 55^\circ$), and clockwise orbital motion. The phase-dependent variability, attributed to light scattering in a wind-driven envelope, yields a system mass-loss rate of $3.4 \times 10^{-7} \, M_\odot \, \mathrm{yr}^{-1}$, highlighting the role of stellar winds in shaping circumstellar material. Our results demonstrate how polarimetry bridges stellar dynamics and ISM studies, offering insights into dust alignment mechanisms, wind-ISM interactions, and the influence of massive binaries on clustered environments. This work underscores the power of multi-band polarimetry in unraveling the complex interplay between stars and their surrounding medium.

The Hidden Lives of Star Clusters: Using 3.3 µm PAH emission to detected dust-embedded star clusters

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The earliest stages of star and cluster formation are hidden within dense cocoons of gas and dust, limiting their detection at optical wavelengths. With the unprecedented infrared capabilities of JWST, we can now observe dust-enshrouded star formation with ~10 pc resolution out to ~20 Mpc. Early findings from PHANGS-JWST suggest that 3.3 µm polycyclic aromatic hydrocarbon (PAH) emission can identify star clusters in their dust-embedded phases. Here, we extend this analysis to 19 galaxies from the PHANGS-JWST Cycle 1 Treasury Survey, providing the first characterization of compact sources exhibiting 3.3 µm PAH emission across a diverse sample of nearby star-forming galaxies. We identified 1816 compact 3.3 µm PAH emitters across the 19 galaxies, of which only $\lesssim$10% were previously identified in the PHANGS-HST catalogs, yielding 1645 new objects. These sources are predominantly located in dust lanes, spiral arms, rings, and galaxy centers, with ~87% showing concentration indices similar to optically detected star clusters. Comparison with the PHANGS-HST catalogs suggests that PAH emission fades within ~3 Myr. The Hα equivalent width of PAH emitters is 1–2.8 times higher than that of young PHANGS-HST clusters, providing evidence that PAH emitters are on average younger.

The environmental influence on star and planet formation

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Most of the stars and planets in the Milky Way formed in large clusters, with environmental factors present, including high interstellar gas and dust densities and moderate to high levels of UV radiation. Due to their proximity, the nearest star forming regions of Taurus and Lupus have been heavily favoured observationally. Crucially however, these environmental factors are significantly reduced or entirely absent in nearby low-mass star forming regions (SFR)s.

NGC 3603 is a giant Galactic SFR in the Milky Way, representing one of the most massive clusters in the Galaxy. Studying young stars in regions like this allows us to assess how star and planet formation proceeds in a dense clustered environment with high levels of UV radiation. Employing multi-object spectroscopy with the JWST NIRSpec MSA, we have identified a population of accreting PMS sources in NGC 3603 based on the presence of hydrogen emission lines in their NIR spectra. We have spectrally classified the sources, and determined their mass and age from stellar isochrones and evolutionary tracks. Our sources span a range of masses from 0.5 to 7 $M_\odot$. Twelve of these accreting sources have ages consistent with ≥ 10 Myrs, with four having ages of ≥ 15 Myrs. This is significantly older than the expected disk survival timescales for a region like NGC 3603. We have determined the mass accretion rate of the sources, which spans 5 orders of magnitude, and have shown that these accretion rates are systematically higher for a given stellar mass than for a comparative sample taken from low-mass SFRs. Finally, we have discovered an environmental relationship between the accretion rate and the density of interstellar molecular gas as traced by nebular H2 emission. This unique result suggests that mass accretion onto the central star may be influenced by the interstellar medium.

Resolving physical conditions in the Trifid Nebula with SDSS-V LVM

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The chemical abundance of the interstellar medium (ISM) sets the initial conditions for star formation and provides a probe of chemical galaxy evolution models. Since metals act as coolants in the gas, we can obtain the gas abundances of HII regions by measuring the electron temperature through emissionlines. If the electron temperature is not homogeneous across an HII region due to winds, shocks or different ionizing sources, then the abundances of any integrated HII region would be systematically underestimated. In our study, we use the SDSS-V Local Volume Mapper (LVM) to spatially map the physical conditions of the Trifid Nebula (M20) at approximately 0.24 pc resolution. This HII region is ionized by the single O7.5 V star HD 164492A, making it the ideal laboratory for probing spherical symmetries inside a single Strömgren Sphere. Using the different emission lines measured with LVM (e.g. Hydrogen recombination lines and collisional excited lines: [OII]3727,29; [OIII]4363; [OII]4650; [SII]4069; [SII]4076; [OIII]5007; [NII]5755; [SIII]6312; [NII]6584; [SII]6717,31; [OII]7320, [OII]7330; [SIII]9531) we compute spatially resolved maps of electron densities, temperatures, and ionic abundances. There we find internal variations and gradients in electron density that may result from ionization fronts. The electron temperature and the total oxygen abundance however look quite homogeneous. Moreover, we compare these spatially resolved properties with equivalent measurements of the integrated Trifid Nebula and find no significant variations between integrated and spatially resolved conditions in this rather simple HII region. The LVM will finally observe around 260 such regions, providing a systematic overview of how unresolved nebular structures impact our integrated (extragalactic) prescriptions, especially in more complex ionized structures.

A Portrait of the Triangulum: Advancing a New Frontier of Galaxy Evolution with Resolved Stars

Adam Smercina
Space Telescope Science Institute

We are in an exciting new frontier, where JWST and HST operate simultaneously, providing combined access to resolved stellar populations in large, individual nearby galaxies for transformative galaxy evolution science. I will discuss some of the first panchromatic HST+JWST resolved population science in large galaxies, focusing on the Triangulum Galaxy, M33, as well as a brand new survey of the nearby starburst M82. In M33, the PHATTER survey has used HST to reveal its stellar populations in never-before-seen detail, leading to the discovery of a newly-discovered central bar and possible evidence of a stellar halo. Even more recently, JWST's exceptional combination of angular resolution and sensitivity in the infrared has provided a new view of M33, revealing its central stellar populations and dusty ISM at high resolution, including large star-forming regions like NGC 595 and its dense nuclear star cluster. These observations are not only a powerful early demonstration of JWST's ability to study stellar populations in nearby galaxies, but will also provide unprecedented, novel insight into the evolution of this already well-studied nearby galaxy. Building on this insight into JWST's efficacy for resolved star science at high densities, I will lastly introduce a brand new JWST survey of M82 that will, for the first time, reveal the crowded and dust-obscured stellar populations in its starbursting disk to deep limits.

Tracing turbulence with young stars

Ben Velguth
UMass Amherst

The interstellar medium (ISM) is turbulent on all scales from the diffuse interstellar phases to the dense star-forming gas. Various methods have been developed to measure turbulence in the ISM based on gas observations, but they often suffer from projection uncertainties that arise from limited position and velocity measurements. My group developed a new method to probe the turbulent kinematics of the ISM using stars as tracers. We study the motions of young stars in four nearby star-forming regions: Orion, Ophiuchus, Perseus, and Taurus. We use the full 6-dimensional measurements of positions and velocities provided by the APOGEE and Gaia surveys. We compute the velocity structure functions (VSFs) of the stars and find that the motions of young stars in all diffuse groups exhibit strong characteristics of turbulence. The VSFs of all four regions show a generally consistent scaling of turbulence consistent with Larson's relation. They also show variations and features that can be attributed to local energy injection from supernovae. We analyze H-alpha gas kinematics in these four regions from the Wisconsin H-Alpha Mapper. In regions with recent supernova activities, the H-alpha VSFs show higher amplitudes compared to the VSFs of stars and of CO from the literature, suggesting preferential energy injection into the warmer face from supernovae. With the next Sloan Digital Sky Survey V (SDSS-V) Data Release (DR19), we will be able to expand our study to a total of 20 star-forming regions in the Milky Way, covering diverse environments and star formation rates. Our study provides unique insights into ISM turbulence that is complementary to traditional gas kinematics analysis.

Power Spectra of the Diffuse Interstellar Emission with JWST/NIRCam

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CNRS / STScI

Since its launch in 2021, JWST is providing a wealth of spectacular images of the diffuse interstellar medium. These images are not only beautiful, they also allow us to study spatial scales never reached before at near/mid-infrared wavelength. In our case, we have observed the diffuse emission in the surroundings of Merope in the Pleiades at 3.3 microns with JWST/NIRCam. The observations may be used to characterize statistically the Interstellar Medium down to scale of 20 AU. However, there is a large statistical contamination due to point and compact sources (stars and galaxies), which prevent us to directly compute statistics on the diffuse emission. To remove stars, we constructed the empirical Point Spread Function using a hundred stars visible in the image. To remove the statistical impact of galaxies, we used a multi-scale filtering.

With all these sources removed, we were able to obtain the power spectrum of what we thought to be the Galactic interstellar matter. In practice, there are still residuals due to faint sources. To get rid of this component we used three self-consistent methods: 1 - a background subtraction using an off-position (taken further from Merope, with the same observation parameters) ; 2 - a statistical separation based on the angular anisotropy of the diffuse emission ; 3 - a multicomponent power law fitting using MCMC.

We find that the power spectrum of the diffuse matter is well fitted by a power law with no break and a spectral index of -3.5. We place this result in the context of previous studies, in particular the "Big Power Law" [Chepurnov & Lazarian 2010] of interstellar turbulence. Our work fills in intermediate scales between the larger scales probed by imaging of dust and gas emission and the smaller scales probed by interstellar scintillations of pulsars radio emission.

Connecting High Resolution Star Forming Simulations to Observables

Tobin Wainer
University of Washington

Most stars form in the gravitational collapse of giant molecular clouds, where several stars are born from the same cloud in a single event. Observationally, gravitationally bound stellar clusters are the long lasting remnants of this formation. However, the initial cloud conditions, and physical processes which cause stars to remain gravitationally bound remain highly uncertain, causing a disconnect between the best star formation models and the observational remnants. In this work, we seek to bridge this gap by examining the 3D radiative magnetohydrodynamical STARFORGE simulations, which fully account for both stellar feedback, and gravitational evolution with extremely high resolution. In this simulation suite, we investigate the necessary conditions which result in a gravitationally bound cluster, and how viewing angle affects our ability to observationally determine what is a 'cluster'. We also examine the embedded stage of cluster formation, describing timescales stars emerge from their natal clouds, and what is observable during these periods.

The Effect of Feedback on our Ability to Age-date Star Clusters in Nearby PHANGS Galaxies

Brad Whitmore
Space Telescope Science Institute

Feedback from young star clusters plays an important role in controlling the evolution from giant molecular clouds to star clusters to HII regions to the dispersal of the parent cloud. This dispersal controls the gas consumption rate and hence the evolution of the galaxy as a whole. Age dating star clusters provides the clocks that can be used to determine these rates. We might hope that the addition of new JWST observations would improve the accuracy of our age estimates for star clusters. However, to date this new data has introduced more uncertainty than precision. Most current SED modeling codes incorporate infrared emission by assuming energy balance between the UV light of young stars and the re-emission in the infrared by dust. While this works well for an integrated population in a large region of a galaxy, it may not be appropriate for the small region around a star cluster due to the outflow from feedback that removes the gas and dust in only a few million years. As part of our effort to improve our age-dating, we have developed a set of empirical HST+JWST SED templates for star clusters. A key result is the finding that essentially all star clusters with strong PAH and infrared continuum emission have ages of 5 My or younger, in contrast to energy balance models that imply older ages.

What Drives R(V) Variation in Dust Extinction Curves? A New Perspective from PAHs in 3D Dust Mapping

Catherine Zucker

Max Planck Institute for Astronomy

The R(V) variation of dust extinction curves is traditionally attributed to changes in grain size distribution. From the first three-dimensional full-sky dust R(V) map (Zhang & Green 2025), we find a surprising anti-correlation between R(V) and A(V) in the translucent ISM. R(V) rises only in higher-density ISM such as star-forming regions. We find present theoretical and observational evidence that this trend arises from polycyclic aromatic hydrocarbons (PAHs). Growth of PAHs in molecular clouds strengthens the 2175 Angstrom feature and causes R(V) to decrease. R(V) variation from larger grains (silicates) is ruled out due to the mass budget available in gas phase. Our discovery suggests the in-situ growth of PAHs. We also discuss possibilities for verifying our hypothesis with infrared and ultraviolet spectroscopic data.