Tuesday, 17th September			
Session 1			
10:00	Registration Opens		
10:45	Welcome		
11:00	MAJORS: Massive, Active, JCMT-Observed Regions of Star Formation	David Eden	Slides
11:20	Understanding the Star Formation Efficiency in Dense Gas with the CAFFEINE ArTeMiS survey	Michael Mattern	Slides
11:40	Dense gas tracers in giant molecular filaments in and between spiral arms	Orsolya Fehér	Slides
12:00	Semi-confined supernovae in HII region bubbles and its implications on molecular cloud evolution	Cheryl Lau	Slides
12:20-12:40	A zoomed view of molecular cloud evolution under the impact by multiple supernovae	Masato Kobayashi	Slides
13:00	Lunch		
Session 2			
14:00	HII Region Feedback: A Study of Magnetic Fields in the Hub-Filament System G34.26+0.15	Zacariyya Khan	Slides
14:20	Latest Results From The JCMT BISTRO Survey	Derek Ward-Thompson	Slides
14:40	Interstellar Magnetic Fields: From Star Formation to Galaxy Evolution	Kate Pattle	Slides
15:00	Characterising Magnetic Field Properties During the Formation of Star Cluster Progenitors	Ria Ramkumar	Slides
15:20	Poster Session		
15:30	Coffee Break		
Session 3			
16:00	Star Formation with the SKA	Tyler Bourke	Slides
16:20	Investigating the Role of Magnetic Fields on the Formation of High-Mass Cores	Katerina Klos	Slides
16:40	Minihalos and the Milky Way's Metallicity Floor	Britton Smith	Slides
17:00	The persistence of high-altitude non-equilibrium diffuse ionized gas in simulations of star-forming galaxies	Lewis McCallum	Slides
18:30	Pizza Night at the Planetarium		

Wednesday, 18th September			
Session 1			
10:00	Turbulent fragmentation in molecular clouds	Fumitaka Nakamura	Slides
10:20	Filaments and Star Formation in a Cold Clump	Larry Morgan	Slides
10:40	Structure and Kinematics of Magnetized Filaments in Giant Molecular Clouds	Melika Gorgianeh	Slides
11:00	Coffee Break		
Session 2			
11:30	Star cluster formation and feedback in different galactic environments	Ahmad Ali	Slides
11:50	Origin and dynamics of protostar clusters	Xiuyu Cai	Slides
12:10	Long-term evolution and dissolution of young stellar clusters	Megan Allen	Slides
12:30	Massive Protoclusters at 1.3 mm: Initial Results from the ALMA EGO-10 Survey	Michael Logue	Slides

12:50	Lunch		
Session 3			
14:00	Star formation structures in the nearby Milky Way	Andrew Wilson	Slides
14:20	Determining the physical parameters of the interstellar medium	Kyriakos Trakakis	Slides
14:40	The SARAO MeerKAT 1.3 GHz Galactic Plane Survey	Mark Thompson	Slides
19:00	Conference Dinner at Uluru		

Thursday, 19th September			
Session 1			
11:00	Determining the star formation rate in Central Molecular Zone Clouds E/F using JWST imaging	Rebecca Houghton	Slides
11:20	What controls the star formation at the center of the MilkyWay? Cosmic Adventure of Cloud E/F	Rojita Buddhacharya	
11:40	Sagittarius B2 gas kinematics: a pilot study in preparation for the advent of ACES (ALMA CMZ Exploration Survey)	Khang Minh Nguyen	Slides
12:00	The JCMT/BISTRO Sub-millimetre Magnetic Field of the Galactic Centre	Janik Karoly	Slides
12:20	ALMA spatial filtering responsible for shallowing the slopes of core mass functions (CMFs) in distant clouds	Gwenllian Williams	Slides
12:40	Investigating massive star formation with ALMAGAL: fragmentation of dense clumps, compact source catalog	Alessandro Coletta	Slides
13:00	Lunch		
Session 2			
14:00	The formation of multiples in small-N subclusters	Hannah Ambrose	Slides
14:20	Search for evidence of episodic accretion from 4-year GASTON data	Jixuan Zhou	Slides
14:40	Disc fragmentation and binary formation in massive protoclusters: the earliest stages of massive binary formation as seen by ALMA	Claudia Cyganowski	Slides
15:00	The JWST/NIRISS Deep Spectroscopic Survey for Young Brown Dwarfs and Free-Floating Planets in the NGC1333 Young Cluster	Ray Jayawardhana	Slides
15:20	Coffee		
19:00	Public Talk: How to take a picture of a black hole	Derek Ward-Thompson	
19:45	Pink Floyd Planetarium Show		

Tuesday, 17th September
Session 1

David Eden
MAJORS: Massive, Active, JCMT-Observed Regions of Star Formation
Multiple large-scale Galactic Plane surveys have attempted to determine what impact features of Galactic structure are having on the star-formation process. However, all of these studies have found that the dominant scale on which star formation efficiency is regulated is that of individual molecular clouds. As a result, if we are to determine the physics that regulates star formation efficiency, we need to look at individual molecular clouds, and in particular the dense gas as that appears to be the cause of the regulation. When star-forming regions are observed in dense-gas tracers, they can be linked by empirical star-formation laws than span from individual regions to ULRIG, starburst systems.

I will, therefore, introduce MAJORS (Massive, Active, JCMT-Observed Regions of Star Formation), which will observe over 100 of the highest mass star-forming regions observable from the JCMT in HCN and HCO+ J=3-2. This survey is designed to determine the role dense gas plays in star formation, and I will explain how we will hope to achieve this, as well as presenting the initial data and science results.

Michael Mattern
Understanding the Star Formation Efficiency in Dense Gas with the CAFFEINE ArTeMiS survey
Submillimeter continuum observations with high sensitivity of the Herschel satellite space mission have revolutionized our understanding of the link between the structure of the cold interstellar medium (ISM) and the star formation (SF) process. In particular, the Gould Belt Survey of nearby (d < 0.5 kpc) molecular star-forming clouds was able to resolve physical scales that are critical to reveal the fragmentation of the clouds towards the formation of dense prestellar cores. However, due to limited resolution, Herschel observations cannot resolve these scales in more distant and significantly more massive star-forming regions.

To solve this problem, we used the ArTeMiS receiver at the APEX telescope to conduct a survey of about 80 massive clouds in a range of 0.5 to 3.0 kpc from the Sun, called CAFFEINE (Core And Filament Formation/ Evolution In Natal Environments). The 350 micron and 450 micron dust continuum observations provide a resolution of 8 Au and 10 Au, respectively, which is a factor 4 higher than for standard Herschel column density maps. We use this data to correct saturation in the Herschel observations and combine both to compose novel multi-resolution column density maps, which provide the excellent sensitivity of Herschel and the high resolution of CAFFEINE. These exceptional data products allow us to extend the research performed on the Gould Belt survey to more distant star-forming clouds. This includes regions with a dense gas reservoirs (Av > 100 mag) larger by one order of magnitude compared to Gould Belt clouds.

In the talk I will present examples of the multi-resolution column density maps and show how they are important to analyze dependency of star formation efficiency (SFE) and gas (surface) density. In particular, we test two SF models with different predictions for high density regions. Our results indicate that the SFE stays constant for column densities above 10^22 cm^-2.

Orsolya Fehér
Dense gas tracers in giant molecular filaments in and between spiral arms
Studying giant molecular filaments associated with galactic spiral arm or inter-arm structures allows us to study the interstellar material and its dense, potentially star forming phase on scales comparable to those that are being resolved towards extragalactic clouds these days. Two large filaments detected in the 13CO/C18O CHIMPS survey, one in the Sagittarius arm and one in the inter-arm, were mapped with dense gas tracers HCN(1-0), HCO+(1-0), and N2H+(1-0) using the IRAM 30m telescope. I will present maps of the observed emission and the ratios of different species (e.g. N2H+/HCN, HCN/CO), and compare these to the results seen towards galactic giant molecular clouds (e.g. Pety+ 2017, Kauffmann+2017, Tafalla+2023) and extragalactic environments (e.g. Jimenez-Donaire+2023, Stuber+2023). I will expand on the environmental dependence of these molecular emitters in the two filaments, determine what local densities the different species may trace effectively, and discuss angular coverage and beam-filling. The results will also be compared to the theoretical work of Priestley+2023a,b using NEATH which post-processes thermodynamical simulations with a full time-dependent chemical network. In short, N2H+ seem to be the only tracer

that only exists in substantial quantities in gas with high densities (Feher+2024) and several of our often-used "dense gas mass fraction" parameters may be heavily influenced by many scale- and environment-dependent factors, as well as the local chemistry and excitation of the particular tracers.

Cheryl Lau
Semi-confined supernovae in HII region bubbles and its implications on molecular cloud evolution
Galactic-scale simulations often employ sub-grid models to incorporate stellar feedback. In particular, the energy and momentum injections from supernovae (SNe) are of fundamental importance. Outflows and turbulence driven by SNe largely shape the kinematic properties of molecular clouds and thus the star formation process. To construct sub-grid models for SNe, a thorough knowledge of their coupling efficiency with the ISM is required. Most of the current SN models are 1-D such that it is easier to account for the complexity of the local environment. However, results from small-scale simulations revealed that the release of energy from SNe are typically non-isotropic. Pre-SN feedback, such as photoionization, carves cavities and low-density channels in the molecular cloud within which the SN detonates. The SN energy then escapes preferentially through the channels into the outer environment, departing from the behaviour described by the standard 1-D models. In this talk, I will present our novel approach for modelling a semi-confined SN within an HII region cavity. I will illustrate how their coupling efficiencies with the ISM differ to that of a 1-D spherical blast, and what it implies about their ability to regulate star formation in the molecular clouds.

Masato Kobayashi
A zoomed view of molecular cloud evolution under the impact by multiple supernovae
Recent observations suggest that bubble structures ubiquitously exist in the the interstellar medium (ISM) across the Universe, from the vicinity of our Solar system to nearby star-forming galaxies. The bubble expansions, driven by HII regions, supernovae, and superbubbles, significantly influence the dynamical and thermal states of pre-existing molecular clouds in their neighboring ISM. In particular, the impact by multiple supernovae is important to understand molecular cloud evolution, because recent theoretical studies suggest that the lifetime of molecular clouds is typically long enough to experience many compressions by multiple supernovae.

To understand the supernova's impact, we start from our simulations of a stratified galactic disk ("Simulating the Life-Cycle of molecular Clouds, a.k.a. SILCC project) and perform zoomed simulations toward a molecular cloud on a 100 pc scale. we employ controlled setups where (1) the zoomed cloud has no nearby supernova, (2) it has a single supernova at 25 pc distance, and (3) it has 6 supernovae at 25 pc distance. Our results show that multiple supernovae enhance the turbulent motions to the > 10 km/s level on a spatial scale of 1 - 100 pc, but this continues for a relatively short timescale of ~ 2 Myr.

We also perform a synthetic observation in 12CO rotational transition lines to reveal the observational signature of these turbulent motion. Our results indicate that, even in the most ideal limit where we can observe all the faint emission, 12CO(1-0) emission traces only 25 percent of the total turbulent energy in this cloud, because of the lack of the CO abundance inside the supernova remnants and in turbulent diffuse volumes. The CO rotational lines thus tend to trace the turbulent motion within/between filaments triggered by multiple supernovae.
In this presentation, we will also explore the capability to detect those turbulent enhancement in ALMA, IRAM 30m, as well as in other CO lines in JCMT (CLOGS, CHORS, CHIMPS2 programs), CCAT-prime etc.

We will also present more detailed statistics of high density clumps and their turbulent motion in molecular clouds to discuss the implication to the subsequent star formation.

Session 2

Zacariyya Khan
HII Region Feedback: A Study of Magnetic Fields in the Hub-Filament System G34.26+0.15
Hub-filament Systems are molecular clouds that host massive star-formation, often containing multiple high-mass stars within their central hubs. However, the physics of the fragmentation and collapse of hub-filament systems is poorly understood at present, especially the role played by magnetic fields. G34.26+0.15 is a hub-filament cloud at a distance of 3.3kpc and is part of the W48

complex. Its dense central hub contains multiple ultra-compact HII regions which have been extensively studied, indicative of massive star formation. We present an analysis of the magnetic field structure across the cloud, inferred from observations of polarised dust emission at 850um, taken using the Submillimetre Common-User Bolometer Array-2 (SCUBA-2) and its polarimeter POL-2, mounted on the JCMT. The alignment of the magnetic field to filaments in G34.26+0.15 shows that, although some filaments appear to be undergoing gravitational in-fall towards the hub, a substantial portion of the cloud appears to have been altered by an expanding HII region. This intense form of feedback appears to have reshaped the magnetic field and material in the cloud, potentially even triggering further massive star formation.

Derek Ward-Thompson
Latest Results From The JCMT BISTRO Survey
The submillimetre continuum emission from dust grains is polarised because the grains tend towards alignment perpendicular to B-field lines. For asymmetric particles with some ability to be magnetized, a series of relaxation processes brings the grains towards their lowest energy rotation state. This is with the longest axis perpendicular to the field. We are currently using this method to measure the B-field orientation in numerous Galactic star-forming regions in a large-scale project on the James Clerk Maxwell Telescope (JCMT) known as BISTRO (B-fields In Star-forming Region Observations). The BISTRO Project overall is comprised of three Large Programs, BISTRO-1, 2 & 3, which were each awarded 224 hours of Band 1 & 2 weather with SCUBA-2 and POL-2. This talk reports on progress in all three projects together, since the same team is working on all. In this talk I will present some of the latest results from the BISTRO Project.

Kate Pattle
Interstellar Magnetic Fields: From Star Formation to Galaxy Evolution
Recent advances in submillimetre dust emission polarimetry are revolutionizing our understanding of the magnetic fields which thread the interstellar media of the Milky Way and other galaxies. In this talk I will discuss the insights which we are gaining into the energy balance, dynamics and evolution of the magnetized interstellar medium, on size scales ranging from nearby star-forming regions to the disc and superwind of the starburst galaxy M82, from recent observations made with the POL-2 polarimeter on the James Clerk Maxwell Telescope (JCMT). I will discuss how we can infer the dynamic importance of magnetic fields from observations of magnetic field geometries in the dense interstellar medium, and the emerging evidence for how the interaction between magnetic fields, protostellar outflows and stellar feedback may influence star formation efficiency on both small and large scales.

Ria Ramkumar
Characterising Magnetic Field Properties During the Formation of Star Cluster Progenitors
Gravity, turbulence, and magnetic fields are thought to be the three main factors influencing star formation. In Peretto et al. 2023 the gravity and turbulence in a sample of star-forming clumps and their parent molecular clouds were investigated. The findings of this study were that clumps are dynamically decoupled from their parent molecular clouds - this result might indicate that the star formation process has a preferred spatial and/or density scale on which it occurs. It is unknown as to the physical reason why this decoupling may take place. I have begun research into the magnetic field counterpart of the Peretto et al. 2023 study, aiming to observe whether the dynamical decoupling is accompanied by a decoupling in the properties of the magnetic field at the different spatial scales of cloud and clump. I present my research comparing the magnetic fields of a sample of infrared dark clouds and their parent molecular clouds using dust polarisation data from JCMT POL-2 and Planck respectively. It is found that the direction of the magnetic field within the small-scale dense clumps tends to differ from the direction of the magnetic field in the large-scale more diffuse clouds for all samples. From investigations into the magnetic field strength, the magnetic field strength in the clumps appears to be lower than the value of magnetic field strength required to hold the clump up from collapse, while for the clouds the values are comparable. These results seem to imply that the star-forming clumps are indeed magnetically decoupled from their parent molecular clouds, in accordance with the findings of Peretto et al. 2023.

Posters

Kotora Sasaki

Simulation and Observational Data Analysis for Understanding the Structural Evolution of Molecular Clouds

Star formation occurs in molecular clouds, which are clumps of molecular gas. However, the detailed evolutionary process of the structure of molecular clouds leading to star formation has not yet been clarified.

In this study, we investigate the structural evolution in molecular clouds by analyzing self-gravity hydrodynamic simulations of molecular cloud evolution using the Dendrogram, which is often used in observational studies. The simulation data are stored in three-dimensional space consisting of line-of-sight velocity, position, and position, respectively, in the same way as the observational data. The analysis is performed on the integrated intensity plots and the three-dimensional scatter plots, respectively. The observed data of the FUGIN project are also analyzed using Dendrogram, and compared with the simulations.

As a result of the analysis of the simulation, it was confirmed that the outermost structure among the structures identified in the integrated intensity diagram shrinks due to self-gravity. The inner structures were found to repeatedly increase and decrease in size, mass, and virial parameters. From the analysis of three-dimensional scatter plots, it is found that the size, mass, and virial parameters of each identified structure repeatedly increase and decrease. On the other hand, relatively large structures were observed to emerge and grow as time progresses. As for the analysis of the observed data, it is found that the size, mass, and virial parameters of the structures increase and decrease repeatedly as in the simulations.

These results suggest that the structure of evolving molecular clouds shrinks due to self-gravity as a whole, while small-scale structures grow into larger-scale structures in the interior. In the process of the growth of small-scale structures into large-scale structures, there is a possibility that star formation is enhanced due to collisions between structures.

Matt Cusack

The Fragmentation of Molecular Clouds in Starburst Envrionments

It is accepted that star formation rates in the earlier universe far exceeded those found today. As a consequence, the majority of stars in the Milky Way, and the wider universe, formed in environments more akin to starbursts than to the present galaxy. Simulations of star formation have thus far neglected this fact and seek to replicate the star formation seen in nearby regions. In this work we vary the interstellar radiation field and cosmic ray ionisation rate in numerical simulations of molecular clouds. These simulations model clouds embedded in high star formation environments. We find evidence for significant changes in the fragmentation behaviour of these clouds. Extreme environments produce fewer, but more massive, clumps that form a top-heavy core mass function. These clumps subsequently fragment into larger groups of sink particles that also follow a top-heavy mass function. We present a picture where starburst clouds fragment less over large (pc) scales, but more over small (kAU) scales, and produce a modified system mass function. Our results imply that the majority of models of star formation may not be representative of much of the historical star formation in the universe.

Janik Karoly

Magnetic Fields in the Massive Star-Forming Region IRAS 16562-3959

We present observations of the massive star-forming region IRAS 16562-3959 observed with ALMA Band 6 as part of the Magnetic Fields in Massive Star-forming Regions (MagMaR) project. IRAS 16562-3959 is an incredibly complex region with a dust ring cavity surrounding the massive protostar driving multiple outflows including a radio jet and massive outflow observed by Hubble. There are multiple dusty filaments and cores in the vicinity of this dust ring and massive protostar. The magnetic field is incredibly well-ordered but complex across the whole region. The magnetic field follows the outflow cavity wall in areas but also shows the characteristic hourglass pinching in four dusty cores. Some of these dusty cores are chemically evolved as well suggesting additional protostars may have already formed in this region and indicating a previously dynamically-important magnetic field.

Larry Morgan

Star Formation in the Galactic Bar Dust Lanes

Dust lane features within galaxy bars are thought to mediate the flow of material from the disk to the nucleus, fueling the extreme environment found within the inner regions of galaxies. A recent pilot study using the GBT, targeting the midpoint of the Milky Way,Äôs Galactic Bar Dust Lanes, detected widespread dense gas in multiple molecular tracers, spatially coincident with 250 micron dust continuum at compact and extended scales. Strong indications of star-forming activity, including water and ammonia (3,3) maser emission, imply ongoing formation in this highly dynamic environment. Here I will present these results and detail the ongoing BARFLYS project, a 3-year, 200 hr Large Project on the GBT to target Ammonia (1,1) and (2,2) molecular emission across the full 11.5 square degree extent of the Milky Way dust lanes. I will include the coverage of this legacy survey, details of the observational set up, outline the questions we aim to address with this dataset, and a timeline of when data products are expected to be released to the public.

Session 3

Tyler Bourke

Measuring Magnetic Field Strengths in Star Forming Regions via the Zeeman Effect

Magnetic (B) fields are important in the regulation of star formation. Quantifying this requires measurements of the field strength. Most measurements are from indirect methods such as dust polarisation and thus are subject to biases and uncertainties. The only way to directly measure field strengths is via the Zeeman effect in some atomic and molecular transitions, but the effect is subtle for the typical field strengths in molecular clouds, and as a result detections are few. Indirect measurements of field strength support the view that B fields are important in the evolution of star-forming molecular clouds, with clouds/cores being marginally supercritical, but direct measurements using the Zeeman effect are sorely needed to put these claims on a solid footing. To make significant progress on this problem requires a multi-faceted approach, undertaking Zeeman observations with a toolkit of spectral lines toward different types of star-forming regions (prestellar/protostellar, high/low mass, ...) across a range of frequencies with different radio telescopes, combined with dust polarisation observations and chemical and radiative transfer modelling, to fully understand the conditions in which the field strength is measured and hence infer the degree of importance of the B field. In this presentation I will give examples of the types of Zeeman observations that can and are being undertaken now with the fantastic sensitivity provided by SKA precursors such MeerKAT, FAST, and ASKAP that will increase the number of field strength detections in Galactic star-forming regions, and a plan for future observations with these and other facilities leading into the explosion of measurements enabled by SKA and ngVLA. This presentation is a call to bring together interested parties to form a Z-Team, as this ambitious program will require a team effort on many fronts to succeed.

Katerina Klos

Investigating the Role of Magnetic Fields on the Formation of High-Mass Cores

For over three decades, the question , “how do massive stars obtain their mass?” has been a topic of debate. Radiation pressure and outflows from high-mass protostars (M > 10 Msun) are thought to stifle the flow of accreting matter, preventing them from attaining higher masses. This contradicts observations of young stellar clusters, in which stars up to several hundred solar masses have been detected (e.g., R136). Furthermore, environments hosting high-mass stars show distinct characteristics not seen in regions containing solely lower-mass objects. High-mass stars are almost exclusively found in clusters, often displaying evidence of primordial mass segregation.

The effects of magnetic fields on the formation of high-mass cores are investigated using the Smoothed Particle Magnetohydrodynamic (SPMHD) code PHANTOM. The collapse of five Mc = 1000 Msun, Rc = 1 pc, clumps are simulated, for a range of initial cloud mass-to-flux ratios. Of interest are to what degree do magnetic support can reliably support a massive core against fragmentation, and over what timescales. Are the range of magnetic field strengths required for support realistic when compared to fields in real star forming regions, and how reliably the Initial Mass Function is recreated? We also investigate the morphologies of identified cores, and the orientation of structures with magnetic fields.

Britton Smith

Minihalos and the Milky Way's Metallicity Floor

The prevalence of light element enhancement in metal-poor stars could be interpreted as a metallicity floor for the Milky Way at Z ~ 10^-3.5 Zsun. In this talk, we present a case that this metallicity floor is set by the ability of metal-enriched minihalos (i.e., dark matter halos too small to cool via H Lyman-

alpha) to form stars in the radiatively intense environment of the Milky Way at Cosmic Dawn (i.e., redshifts 10-20). We use a cosmological simulation to identify the physical processes that determine when star formation occurs in these
small systems. With this information, we create a model capable of reproducing the density and chemo-thermal evolution within minihalos and then apply it to a scenario of intense photo-dissociating radiation akin to the early history of the Milky Way. We find that minihalos exposed to this environment require metal-enrichment to roughly the level of the observed metallicity floor in order to form stars. When combined with mechanisms for suppressing iron enrichment (for example, faint supernovae from Population III stars), this provides a plausible explanation for the Galaxy's population of carbon-enhanced metal-poor stars.

Lewis McCallum
The persistence of high altitude non-equilibrium diffuse ionized gas in simulations of star-forming galaxies
Widespread, high altitude, diffuse ionized gas with scale heights of around a kiloparsec is observed in the Milky Way and other star-forming galaxies. Numerical radiation-magnetohydrodynamic simulations of a supernova-driven turbulent interstellar medium show that gas can be driven to high altitudes above the galactic mid-plane, but the degree of ionization is often less than inferred from observations. For computational expediency, ionizing radiation from massive stars is often included as a post-processing step assuming ionization equilibrium. We extend our simulations of an Milky Way-like interstellar medium to include the combined effect of supernovae and photoionization feedback from mid-plane OB stars and a population of hot evolved low mass stars. The diffuse ionized gas has densities below 0.1 cm^-3, so recombination time-scales can exceed millions of years. Our simulations now follow the time-dependent ionization and recombination of low density gas. The long recombination time-scales result in diffuse ionized gas that persists at large altitudes long after the deaths of massive stars that produce the vast majority of the ionized gas. The diffuse ionized gas does not exhibit the large variability inherent in simulations that adopt ionization equilibrium. The vertical distribution of neutral and ionized gas is close to what is observed in the Milky Way. The volume filling factor of ionized gas increases with altitude resulting in the scale height of free electrons being larger than that inferred from H\alpha,Äâemission, thus reconciling the observations of ionized gas made in H-alpha and from pulsar dispersion measurements.

Wednesday, 18th September
Session 1

Fumitaka Nakamura
Turbulent fragmentation in molecular clouds
Stars form from dense cores within molecular clouds, but the process by which these cores form remains uncertain. We compare two popular scenarios for core formation,Äîgravitational fragmentation and turbulent fragmentation. By analyzing Herschel images, we identified dense cores in molecular clouds and measured their masses and separations. Our findings indicate that both core mass and separations are smaller than the predictions of gravitational fragmentation. Additionally, the density probability distribution functions (PDFs) of the cores closely follow log-normal distributions which are reproduced by supersonic turbulence. Therefore, we propose that turbulent fragmentation is the primary mechanism for core formation in molecular clouds. This is consistent with observations that most cores in nearby clouds, such as Orion and Rho Ophiuchi, are pressure-confined rather than gravitationally bound.

Larry Morgan
Filaments and Star Formation in a Cold Clump
Close to Sh2-205, an HII region that has developed out of the northern edge of the local arm, G148.0+0.1 is a Planck Galactic Cold Clump (PGCC) - quiescent, cold collections of gas of low temperature, column density, and star formation efficiency (Eden et al, 2019). While they are home to conditions expected to be conducive to star formation (i.e. dust temperatures of 6 - 20 K), their YSO content is low, averaging half that of IRDCs. PGCCs are also found to be roughly on the threshold of virial stability, with 51% of a sample of 96 cores found to be likely collapsing (Zhang et al, 2016).

I will present GBT/Argus 13CO/C18O observations of this region, which forms part of a filamentary structure and is potentially the result of the expansion of an older HII region. These observations show an excellent example of the complexity and dynamical structure of the ISM, with additional multi-wavelength archival observations exhibiting a hierarchy of filamentary structure ranging from the scale of spiral arms to GMC filaments from which HII regions may form, potentially compressing the ISM to form further filaments, in which these PGCCs (and other structures) now exist, exhibiting filamentary structure at even smaller scales and becoming sites of potential future star formation.

This presentation will focus on an analysis of the multi-scale 'nesting-doll' structure of this region, with speculation on the relevance to star formation and star formation efficiency in the Milky Way.

Melika Gorgianeh
Structure and Kinematics of Magnetized Filaments in Giant Molecular Clouds
Observations of nearby molecular clouds have revealed intricate web-like patterns of filamentary structures that are embedded with rich populations of pre- and proto-stellar cores. However, despite the ubiquity of star-forming filaments, the overall rate of Galactic star formation remains relatively inefficient, with only ~1% of the gas within clouds forming stars for each cloud free-fall time (e.g., Krumholz & Tan 2007). It has been predicted that magnetic fields may play an important role in the structure, kinematics, and star formation activity of filaments and clumps, as the general effects of B-fields are to suppress collapse and fragmentation. Therefore, a thorough understanding of the evolving behaviours of these filaments, when subjected to magnetic fields, is important for potentially explaining the star formation rates of galaxies.

With this motivation, magnetohydrodynamic (MHD) simulations have been carried out of self-gravitating dense gas in a galactic disk environment over a period of 4 Myrs, from scales of 1kpc down to resolutions of ~.1pc i.e., extending the work of Van Loo et al. (2015) and Butler et al. (2015).From these simulations a sample of giant, ‚à°50pc long filaments were chosen for analysis, with the same structures identified in galactic disks, with mean B-fields ranging from 0 (unmagnetized) to 80 uG. In particular, we have examined their structural and kinematic properties, including their mass per unit lengths, dispersion in mass per unit lengths, filament densities, dense gas fractions, rms lateral widths, and velocity gradients. These properties are compared to those of observed giant filaments. In addition to the above, the morphology and topology of the B-fields are investigated. By doing so, we to seek to understand the preferential orientation of the magnetic fields with respect to the filaments, as this could potentially have profound implications on the structures that are able to form within them. Furthermore, assessment of the correlation between the magnitude of the line-of-sight B-field component and the gas density (Crutcher et al. 2010), may provide insight into the subcritical or supercritical nature of filaments, and thus allow for a clearer evaluation of how magnetic fields may dominate over filament support during collapse.

Session 2

Ahmad Ali
Star cluster formation and feedback in different galactic environments
Star formation takes place in giant molecular clouds (GMCs), with most stars forming in clusters or associations. How clusters/associations form is still an open problem, as is the cause of differences in their properties. For instance, Young Massive Clusters (YMCs; masses > 10^4 Msun; ages ~1 Myr) are not as common in the Milky Way (MW) as they are in starburst galaxies. The YMCs that are found in our Galaxy are typically found near the Galactic Centre or bar.

We investigate how the formation of such clusters depends on galactic environment using smoothed particle hydrodynamics simulations. We extract 10^6 Msun GMC complexes from a MW-like galaxy model, enhance the resolution, and re-run the region with improved methods to track star formation and stellar feedback. This includes ray-traced photoionization which is not possible on galactic scales. We retain galactic potentials and cloud-cloud interactions, which are usually neglected in standard, isolated cloud models.

We model GMC complexes from the bar, inner spiral arm, outer spiral arm, and inter-arm region. We find that the relation between star formation rate surface density and gas surface density follows the

Kennicutt-Schmidt power law 1.3, with the bar region lying higher up the relation. The inter-arm is 2-3x less star-forming for the same gas surface density as the arm regions. We also find that the bar and inner arm produce smaller, denser, faster-rotating clusters on average, whereas the outer arm and inter-arm regions produce larger clusters more similar to associations.

Xiuyu Cai
Origin and dynamics of protostar clusters
Most stars are believed to form in protostar clusters. Herschel observations of nearby molecular clouds (Gould Belt survey: HGBS) have shown that prestellar cores and protostars form mainly along filament networks. Young stellar objects (YSOs) are expected to decouple from their parent filaments at some point in their evolution. However, the timescale on which this decoupling occurs is uncertain. Here we explore the origin and dynamics of protostar clusters by using Gaia optical 2D proper motion data of Class II/III YSOs in combination with Herschel column density maps. In addition, we use millimeter N2H+(1-0) molecular line data from the IRAM 30m telescope to constrain the line-of-sight velocities of prestellar cores.
We estimate the 3D velocity dispersions of YSOs and cores in several nearby clouds from Gaia 2D proper motions and IRAM 1D radial velocities, respectively. We then compare the YSO-YSO velocity dispersion to both the virial velocity dispersion of YSOs and the core-core velocity dispersion in the same regions. We also compare the spatial distribution of prestellar cores and Class I/II YSOs with respect to their parent filaments in the same molecular clouds. Our analysis of both the velocity dispersion and spatial distribution of prestellar cores and YSOs suggests that prestellar cores are still well coupled to their filaments, while YSOs progressively decouple from their parent filaments during the Class I stage, on a timescale of about 1 - 2 x10^5 yr.

Megan Allen
Long-term evolution and dissolution of young stellar clusters
Stars will typically spend the first few million years of their lives in their natal star-forming regions. The initial densities in these regions often mean young stars are much more likely to experience the effects of close encounters, massive star stellar winds and potentially even nearby supernovae. Therefore, understanding the dynamical evolution of star-forming regions is key to understanding star (and planet) formation and it tells us much about the stars' early lives. However, the dissolution of star-forming regions into the Galactic disc is much less well understood. Does the dissolution rate depend more on the initial mass, density or virial state of the star-forming region? Using N-body simulations of the first 100Myr of a star-forming region, we aim to understand the effects of various factors on star cluster dissolution. In particular, we focus on the effects of an external tidal field on star-forming regions of varying radii, mass, density and initial degree of spatial and kinematic substructure. In this talk I will present the results from a suite of simulations, and discuss the implications of these regions' evolution on star formation, and the young planetary systems that form simultaneously with the stars.

Michael Logue
Massive Protoclusters at 1.3 mm: Initial Results from the ALMA EGO-10 Survey
Massive stars dominate the physics and chemistry of the interstellar medium on galactic scales, and characteristically form in clustered environments. Thus, characterising young massive 'protoclusters' is crucial to advancing our understanding of the formation of high-mass stars and the formation and evolution of stellar clusters. Sensitive, high-resolution millimetre-wavelength ALMA observations now enable these systems to be studied in unprecedented detail. I will present initial results from the 1.3 mm ALMA EGO-10 imaging survey, which targets ten GLIMPSE Extended Green Objects (EGOs) , massive protostars with active outflows, traced by extended 4.5 um emission in Spitzer images. The 1.5 x 1.5 ALMA mosaics reveal rich protoclusters associated with all ten target EGOs. With a mean spatial resolution of 2500 x 1900 AU, we identify a total of 569 millimetre continuum cores, with between 13 and 136 cores in each region. Using Minimum Spanning Trees (MSTs), we find the Q value for these mm protoclusters ranges from 0.5 to 0.93, with a mean of 0.74 - consistent with young, subclustered regions overall. A notable feature of the EGO-10 sample is the wealth of available high-resolution multi-wavelength data. Combining our results with published Very Large Array (VLA) centimetre continuum observations, we find a positive correlation between the total centimetre continuum luminosity of a protocluster and the Q parameter, consistent with protoclusters evolving from subclustered to centrally-condensed distributions as they age and supporting ‚Äòclump-fed‚Äô models of massive star formation. Correlating our core catalogue with VLA maser positions,

we find that only 5% of cores host H_2O masers and 2% host 6.7 GHz CH_3OH masers, and that many high-mass protostars traced by 6.7 GHz CH_3OH masers are forming in highly clustered locales, defined as >10 millimetre cores within r=10,000 AU.

Session 3

Andrew Wilson
Star formation structures in the nearby Milky Way
We present the results from a refined version of our Bayes classifier for identifying low mass young stellar objects, Wilson et al (2023, MNRAS 521 354). We have widened the footprint to +/-5.5 degrees in Galactic longitude and extended it fainter to Gaia G<20. Our base data set benefits from an improved quality cut on the Gaia data, giving a cleaner view of star formation by removing distant sources that have been scattered into the solar neighbourhood by spurious parallax measurements. Our enlarged footprint covers 2100 square degrees of the Northern Galactic Plane out to 2 kpc, doubling the size of our original input catalogue to 16 million sources.

Our updated classifier exploits the improved mid-infrared photometry of CatWISE, complemented by an update to the probabilistic Gaia DR3 match of Wilson & Naylor (2018, MNRAS 481 2148). We have refined our variability model, improving its ability to discriminate YSOs from other types of variable source.

We have analysed the distribution of 13,000 high confidence YSOs. Their spatial location traces out known star forming regions and indicates new groupings of young stars. Using the 5-dimensions available from Gaia DR3 of sky coordinates, parallaxes and proper motions, we are able to identify connected groups of YSOs. We see extended halos around known star forming associations such as Cep OB3b, implying they are larger than previously understood. We also see evidence of filamentary structures across tens of parsecs, giving support to the filamentary models of star formation. On the largest scales we see star forming regions joined together in structures stretching for hundreds of parsecs at locations consistent with the Local Arm. Thus, the low mass YSOs we identify, provide structural detail to large star formation complexes and spiral arms.

Kyriakos Trakakis
Determining the physical parameters of the interstellar medium
Star formation is the most important baryonic process in astrophysics, crucial for shaping and evolving galaxies. Despite its significance, star formation remains a somewhat elusive phenomenon, and the influence of environmental factors on it is not fully understood. Our primary objective is to develop a method to calculate the excitation temperature, optical depth, and column density of the interstellar medium in star-forming molecular clouds. We achieve this by analyzing observations of carbon monoxide (CO), an excellent tracer for the primary observable component of molecular clouds, where star formation occurs. Specifically, we use emission lines from different rotational transitions of the CO molecule (J=3-2 and J=1-0 dipole transitions so far) and three isotopologues: 12CO, 13CO, and C18O. Our analysis will utilize previously unexamined data from the Mopra and James Clerk Maxwell Telescopes, enabling us to calculate the mass of molecular gas in the Galactic Plane and estimate the amount of molecular hydrogen in the inner star-forming regions of the Galaxy.

Mark Thompson
The SARAO MeerKAT 1.3 GHz Galactic Plane Survey
I will outline the recent SARAO MeerKAT 1.3 GHz Galactic Plane Survey (SMGPS), which is the deepest and highest fidelity radio survey of the Milky Way to be carried out. I will describe some of the results of SMGPS and its future potential for star formation studies.

Thursday, 19th September
Session 1

Rebecca Houghton
Determining the star formation rate in Central Molecular Zone Clouds E/F using JWST imaging
The Central Molecular Zone (CMZ) in the Milky Way is the most extreme star-forming environment in the Galaxy. The pressures, gas densities, magnetic fields, and temperatures are orders of magnitudes higher than in local star-forming regions, making star formation in the CMZ more similar to that of the early Universe than the present day Solar neighbourhood. Additionally, due to its

proximity, the CMZ is the only such extreme environment where detecting young stars and resolving gas on protostellar scales is possible. In spite of the large amount of dense molecular gas in the CMZ that is available for star formation, the overall star formation rate (SFR) in this region is an order of magnitude lower than expected from Milky Way cloud scaling relations.

I have used JWST NIRCam and MIRI imaging to study Cloud E/F; an extremely massive and compact giant molecular cloud in the CMZ that has strong signs of early star formation. JWST can detect Young Stellar Objects (YSOs) at this distance down to 0.1 Lsun, and by counting the number of YSOs in the cloud, we can put the most robust estimates to date on the SFR in this region. I present the results of our YSO study of the cloud, including a discussion of the completeness of our sample due to the high column densities present in the Galactic Centre. I will show how we have combined our findings with JWST-resolution ALMA data to study the environmental dependence of YSOs in GC clouds, and will conclude with an overview of our proposed follow-on studies.

Rojita Buddhacharya
What controls the star formation at the center of the MilkyWay? Cosmic Adventure of Cloud E/F
The Milky Way's central molecular zone (CMZ) presents an extreme environment for star formation, hosting the nearest supermassive black hole, young star clusters, and dense molecular gas clouds. Despite this rich environment, the CMZ perplexes astronomers by producing fewer stars than expected based on dense gas scaling relations. The ALMA CMZ Exploration Survey (ACES) aims to address this paradox and uncover the governing factors of star formation at the heart of the Milky Way by constructing a detailed, multi-scale picture of the physical and kinematic structure within the inner 100 pc of the Milky Way, down to individual star-forming cores using high-resolution and high-sensitivity ALMA data.

I present the initial results on the kinematics and dynamics of Cloud E/F, an extremely massive and dense molecular cloud situated between two regions with contrasting star formation scenarios: the Brick and Sgr B2. The Brick shows no signs of star formation, while Sgr B2 accounts for approximately 50% of all present-day CMZ star formation. I have compared the kinematics from the ALMA data to JWST data for Cloud E/F aiming to identify and pinpoint areas of star formation, and the possible causes of relatively low star formation in Cloud E/F. Additionally, my project addresses the question: "Where is the sonic gas in Cloud E/F?"

Khang Minh Nguyen
Sagittarius B2 gas kinematics: a pilot study in preparation for the advent of ACES (ALMA CMZ Exploration Survey)
Star formation in and around the Central Molecular Zone (CMZ) has been one of astronomy‚Äôs most well-studied fields. And yet, there currently lacks a spatially contiguous & homogeneous observational effort for the entirety of the CMZ. Hence, creating a significant gap of knowledge in connecting the star formation physics between global and small-scale processes within the Galactic Centre in one uniform picture. The ALMA CMZ Exploration Survey (ACES) programme aims to bridge this vital gap by observing across the board from global (~100pc) to protostellar core (~0.05pc) scales for all of the CMZ. This allows us to quantify physical processes occurring across these spatial scales and be able to determine the locality, intensity and timescales for star formation and feedback physics within the CMZ.

We present preliminary results of an ongoing pilot study into the gas kinematics/dynamics of Sagittarius B2 (Sgr B2), the most active molecular clouds within the CMZ dust ridge, using legacy ALMA HC3N data. The key goals are to 1) dissect and characterise any existing three-dimensional hierarchical structures within Sgr B2 in order to better understand its star formation activities, and 2) preparing for follow-up analysis using ACES data of Sgr B2 when it becomes analysis-ready.

Stevie King
Isolating The Central Molecular Zone Using Fourier Filtering Techniques
Accurately determining the properties of the Central Molecular Zone (CMZ) poses a complex challenge for astronomers due to significant contamination from the Galactic Spiral Arms, through which we observe. In position-velocity space, the CMZ is characterised by signals exhibiting high velocity dispersion, while the Spiral Arms show extensive spatial dispersion. To address this obstacle, we have developed a novel method utilising Fourier transform and filtering techniques to effectively

separate these signals.

We apply these methods to the 12CO & 13CO J = 3 - 2 data obtained as part of the CHIMPS2 survey, and the 13CO & C18O J = 2 - 1 data obtained as part of the SEDIGISM survey. By transforming the data to the frequency domain and applying band-pass filtering techniques, we isolate the distinct frequency components associated with the CMZ and Spiral Arms.

Preliminary results demonstrate the efficacy of our method in distinguishing between the CMZ and Spiral Arm signals, showing promise for enhancing our understanding of the structure and dynamics of these regions and allowing for direct comparison of their properties from single data sets. Additionally, we can obtain preliminary measurements of the newly isolated Spiral Arm's physical properties.

This method shows potential as a robust tool for astronomers to analyse complex galactic environments, facilitating more accurate interpretations of observational data.

Janik Karoly
The JCMT/BISTRO Sub-millimetre Magnetic Field of the Galactic Centre
We present the first parsec-scale sub-millimetre map of the Central Molecular Zone (CMZ) in the Galactic Centre. The 850 micron data were taken using the sub-millimetre camera SCUBA-2 and its associated polarimeter POL-2 on the James Clerk Maxwell Telescope (JCMT) as part of the B-fields In STar-forming Regions Observations (BISTRO) large program. With a beam size of 14.6 arcseconds, we resolve the 0.6 pc scale magnetic fields. We find incredibly ordered large-scale magnetic fields in the individual molecular clouds such as the 20 km/s cloud, the Dust Ridge, the Brick, Sagittarius C and Sagittarius B2. There is an overall trend of magnetic fields on the order of mG in these molecular clouds, which give roughly transcritical mass-to-flux ratios and Alfvenic mach numbers, suggesting magnetic fields may play an important role on the individual cloud scale in providing general support against star-formation. This would help answer the key question of why the star formation rate in the CMZ is so low despite its massive abundance of gas and dust. We also investigate any large-scale coherence of the magnetic field. There have been proposed orbital structures for the material around the Galactic Centre which could influence, or be influenced by, a large-scale magnetic field.

Session 2

Gwenllian Williams
ALMA spatial filtering responsible for shallowing the slopes of core mass functions (CMFs) in distant clouds
Many studies have been dedicated over the years to understanding whether the initial mass function (IMF) of stars is inherited from the mass function of their parent cores in star forming clouds or not. To this aim, we present new ALMA 1.3mm observations of SDC13, an infrared dark hub-filament system at 3.6kpc distance. Following core extraction from the 1arcsec~0.02pc resolution continuum image, we find a prestellar core mass function (CMF) with slope -0.82+/-0.02. This is shallower than the canonical Salpeter-like slope of -1.35 typically found in nearby low-mass star forming regions such as Aquila. To act as a control cloud, we produce synthetic ALMA 1.3mm observations of Aquila with the same observational setup as the SDC13 data, and place it at the 3.6kpc distance of SDC13. Applying the same techniques, we find a synthetic prestellar CMF towards Aquila with slope -0.92+/-0.03. Given the Aquila CMF prior to its processing through the ALMA simulator is known to be Salpeter-like, we suggest the spatial filtering of the ALMA 12m array is responsible for shallowing the CMF. Assuming that devoid of these systematics the slope would have been consistent with Salpeter, and given that the very same systematics are at play towards SDC13, we suggest that the SDC13 CMF could also be consistent with Salpeter. This would imply a static core evolution rather than a dynamic clump-fed scenario. Finally, a consistent re-analysis of literature ALMA 1.3mm observations towards W43-MM1 (a high-mass star forming ridge 5.5kpc away at the end of the Galactic bar) yields a steep prestellar CMF of -1.54+/-0.03. Using the same logic as before, this slope would steepen further were it evaluated devoid of the ALMA systematics. We therefore suggest that rather than producing top-heavy protostellar CMFs, that the extreme local conditions present within W43-MM1 leads to a bottom-heavy prestellar CMF.

Alessandro Coletta

Investigating massive star formation with ALMAGAL: fragmentation of dense clumps, compact source catalog, physical analysis and evolution of the core population

The physical mechanisms behind the fragmentation of high-mass dense clumps into compact star-forming cores and the properties of these cores are fundamental topics heavily investigated in current astrophysical research. The ALMAGAL survey (PI: S.Molinari, P.Schilke, C.Battersby, P.Ho) provides the opportunity to study this process with an unprecedented level of detail and statistical significance, featuring high-angular resolution 1.4 mm ALMA observations of 1013 massive dense clumps at various Galactic locations with a uniformly high average spatial resolution of 1400 au (down to 800 au). These clumps cover a wide range of distances (2 - 8 kpc), masses (10^2 x 10^4 Msun), surface densities (0.1 x 10 g cm^,àí2), and evolutionary stages (luminosity over mass ratio indicator 0.05 < L/M < 450).

In this talk we present the first extensive analysis of the full ALMAGAL sample data (Coletta et al. to be submitted). In detail, we present the catalog of compact sources (cores) obtained with the CuTEx (Curvature Thresholding Extractor) algorithm from continuum images of the full ALMAGAL clump sample combining ACA-7m and 12m ALMA arrays. We characterize and discuss the revealed fragmentation properties and the photometric and estimated physical parameters of the core population. The ALMAGAL compact

source catalog includes 6348 cores detected in 844 clumps (83% of the total), with a number of fragments per clump between 1 and 49 (median of 5). Estimated core diameters are mostly within 800 - 3000 au (median of 1700 au). We assigned core temperatures based on the L/M of the hosting clump, obtaining core masses from 0.002 to 345 Msun (complete above 0.23 Msun), showing a good correlation with the core radii (M ~ R^2.6).

We evaluated the variation of the core mass function (CMF) with evolution as traced by the clump L/M, finding a clear, robust shift among CMFs within subsamples at different stages. This finding suggests that the CMF shape is not constant throughout the star formation process but rather builds with evolution, with higher core masses reached at later stages. We found that all cores within a clump grow in mass on average with evolution, while a population of possibly newly formed lower-mass cores is present throughout. The number of fragments increases with core masses, at least until the most massive core reaches 10 Msun, when fragmentation appears to be halted.

More generally, our results favor a clump-fed scenario for high-mass star formation, in which cores form as low-mass seeds and then gain mass while further fragmentation occurs.

Hannah Ambrose

The formation of multiples in small-N subclusters

We explore the relative percentages of binary systems and higher-order multiples that are formed within a small subcluster of N stars, by pure stellar dynamics. The subcluster is intended to represent the fragmentation products of a single, relatively isolated star-forming core. Initially the stars have random positions, and masses drawn from a log-normal distribution. For Sun-like primaries, the best fit to the observed percentages of singles, binaries, triples and higher-order systems (quadruples, quintuples, etc.) is obtained if a typical core spawns between 4 and 5 stars, specifically a distribution of N with mean u_N~4.4. This best fit is obtained when 50\% of the internal kinetic energy of the subcluster is invested in ordered rotation and 50\% in isotropic Maxwellian velocities. There is very little dependence on other factors, for example mass segregation, or the width of the mass distribution.

Jixuan Zhou

Search for evidence of episodic accretion from 4-year GASTON data

Massive stars play an important role in chemical enhancement of ISM and star formation in the galaxies. How they form and gain their mass is still a mystery and poorly understood. Episodic accretion, which means the accretion rate is low most of the time and accretion burst occurs occasionally, has been proposed to solve the luminosity problem for low-mass protostars. It has been observed in FUors and LUors and in numerical hydrodynamical simulations for both low- and high-mass protostars. However, due to the rarity of massive stars, few observations of burst from high-mass protostars have been found, and their accretion histories are still poorly constrained. As part of the IRAM 30 m GASTON large programme, a 2 deg^2 region in the Galactic plane was observed at 1.15 mm and 2mm, with angular resolutions of 11” and 18”, respectively. The whole observation lasted 4 years and the GP field was observed for 11 times. After a careful run-to-run calibration process, we extracted ~2000 compact sources, and built the light curves for ~300 of those (i.e. with the highest signal-to-noise ratio across enough runs). We finally identified 8 variable candidates with significant flux variations at both wavelengths. Those sources spread a range of evolutionary stages, from infrared-dark clumps to compact HII regions. One of the candidate G24.33+0.14 has been confirmed as a busting protostellar object in the mid-infrared, validating the method we developed for the search of millimetre variables. We discuss about the expected detection rate based on the simulations and the feasibility of variability detection at millimeter wavelength.

Session 3

Katharine Johnston

Resolving the disk-jet accretion connection for forming massive stars

Since the discovery of dust-continuum and maser-line outbursts from a handful of massive forming stars, there has been an accompanying burst of scientific interest in variable accretion onto MYSOs. Recent observations of highly structured and unstable disks around MYSOs have provided a possible mechanism to explain their episodic accretion. An additional record of their recent accretion history can be derived from observations of jets. We observed six MYSOs with ionized jets with both ALMA and e-MERLIN to resolve the accretion and jet structures down to a matched resolution of ~40mas (~100au). Our original aim was to compare these two sets of observations to look for trends in the jet and circumstellar properties and structure, to observationally confirm whether there is a connection between unstable disks with sub-structure and episodic jets with knots, thus establishing that unstable disks are a route to the production of accretion bursts. However, although we have only clearly resolved a jet towards the outbursting source S255 IR NIRS3, our observations of its associated disk and those in the other observed ALMA fields show interesting and unexpected results.

Claudia Cyganowski

Disc fragmentation and binary formation in massive protoclusters: the earliest stages of massive binary formation as seen by ALMA

High-mass stars (>8 Msun) are distinguished by their very high multiplicity fraction, with >90% of main-sequence O and early B stars having at least one companion. In contrast to recent progress in observational studies of low-mass multiple formation, there remains a lack of observational evidence capturing the earlier stages of high-mass binary formation -- before the protostars are evolved enough to ionize their surroundings or excite hot core line emission. I will present high-resolution (<160 au/0.05") ALMA observations of the high-mass prestellar core candidate G11.92-0.61 MM2, which reveal that this source is in fact a protobinary system with a projected separation of 505 au. The compact binary components, MM2E and MM2W, have 1.3 mm brightness temperatures that imply internal heating (Tb>60K) and drive a highly asymmetric bipolar molecular outflow, both clear indications that they contain deeply embedded protostars. However, their cm-mm SEDs are consistent with pure dust emission (no free-free contribution) and no compact line emission from the binary is detected in our high-resolution 1.3 mm ALMA observations. MM2E and MM2W have similar 1.3 mm brightness temperatures and integrated flux densities, suggesting that their mass ratio is likely close to one; overall, the super-Alfvenic models of Mignon-Risse et al. (2021) agree well with the observed properties of the MM2E/MM2W protobinary, suggesting that this system may be forming in an environment with a weak magnetic field. New 0.02" (~70 AU)-resolution ALMA observations resolve disk-like structures associated with MM2E and MM2W but show no additional multiplicity. I will also present initial results on our recent discovery of another example of a similar, early-stage protobinary system in 0.27" (~360 AU)-resolution ALMA observations of NGC6334IV, taken as part of the CoCCoA astrochemistry survey of high-mass star-forming regions.

Ray Jayawardhana

The JWST/NIRISS Deep Spectroscopic Survey for Young Brown Dwarfs and Free-Floating Planets in the NGC1333 Young Cluster

The discovery and characterization of free-floating planetary-mass objects (FFPMOs) is fundamental to our understanding of star and planet formation. Here we report results from an extremely deep spectroscopic survey of the young star cluster NGC1333 using NIRISS/WFSS on the James Webb Space Telescope. The survey is photometrically complete to K 21, and includes useful spectra for objects as faint as K 20.5. The observations cover 19 known brown dwarfs, for most of which we confirm spectral types using NIRISS spectra. We discover six new candidates with L-dwarf spectral types that are plausible planetary-mass members of NGC1333, with estimated masses between 5-15 MJup. One, at 5 MJup, shows clear infrared excess emission and is a good candidate to be the lowest mass object known to have a disk. We do not find any objects later than mid-L spectral type. Our findings put the fraction of FFPMOs in NGC1333 at10 % of the number of cluster members. This is significantly more than expected from the typical stellar log-normal mass function. The paucity of Jupiter-mass objects, despite the survey,Äôs unprecedented sensitivity, suggests that our observations reach the lowest mass objects formed like stars in NGC1333. We also search for wide binaries in our images and report a young brown dwarf with a planetary-mass companion.