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Hub Filament Structures in Star Formation

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Posters Booklet

1. 68004 Exploring the Global Hierarchical Collapse towards Hub-Filament System Sh2-87

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Hub-filament systems (HFSs) serve as the potential birthplaces of massive stars (8 M⊙) and young star clusters and are considered the best laboratory to explore the primary phases of star formation. Here, we present an extensive multi-wavelength study of the star formation activity around the H II region Sh2-87. The Herschel column density map of this region reveals that the host cloud is filamentary and the filaments collectively emerge from a central dense hub. The extinction map is generated from near-infrared photometric data (UKIDSS) and the SCUBA Map (850 μm) compositely, and it implies the non-uniform distribution of the gas across the region. The extinction map shows a strong correlation with the column density map. Using molecular line data from JCMT, the distribution and dynamics of the associated molecular gas have also been explored. Here, the velocity distribution map exhibits a substantial velocity gradient along the filaments, and the velocity dispersion map implies the presence of turbulent gas towards the central hub region. From mid-infrared and near-infrared color-color diagrams, we identified 13 Class I and 202 Class II sources, and 22 Hα-emitting sources in this region. From the colour-magnitude diagrams, the average age of the YSOs is estimated as 3 Myr, along with masses in the range of 0.1 to 6.0 M⊙. Here, the identified evolved young stellar objects (i.e., Class II sources) are primarily arranged along the filaments and also in the outer parts of the cloud. In reverse, the evidence of recent star formation, i.e. the distribution of Class I YSOs, ionized gas and star-forming clumps, is noticed within the hub region. Therefore, the overall star formation scenario in the Sh2-87 region supports the Global Hierarchical Collapse model of star formation. Ref: https://doi.org/10.3847/1538-4357/ad0daa

2. 67893 Clustered jets and YSOs in filament-hubs: Star formation in IRDC G53.2

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Observations of filaments in star forming regions show a strong correlation between location of young stellar objects (YSOs) and dense filaments. In particular, filament-hubs are widely believed to be sites of massive star formation. An important signpost of active star formation in molecular clouds is the presence of jets/outflows which directly trace the accretion history in young stars. Owing to their high velocities and momentum, jets can induce turbulence in their surrounding medium and can also trigger localised star formation in their parent cloud. In this study, we characterise YSOs in a 45 pc long filamentary InfraRed Dark Cloud- IRDC G53.2 (l~53.2°, b~0°) located at a distance of 1.7 kpc. We estimate the physical parameters such as mass, temperature, luminosity etc. for 364 out of 369 previously known YSOs in IRDC G53.2. Additionally, we identify and investigate jet-bearing YSOs in IRDC G53.2 using continuum-subtracted H2 images from the UWISH2 survey. By utilising photometric observations from UKIRT, Spitzer and Herschel Space Observatory, we identified 45 candidate jet-bearing YSOs in the region. The physical parameters of both jet-bearing and jet-less YSOs are estimated by fitting their spectral energy distributions from 1.2μm to 70μm with theoretical YSO models. We estimate the spectral indices of YSOs using photometric observations in Spitzer's IRAC bands and find that jets in IRDC G53.2 are predominantly driven by Class 0/I protostars. Approximately 18% of all Class 0/I objects are associated with jets compared to 3% for both Class II and Class III YSOs. The median mass of jet-bearing YSOs (3.9M□) is found to be higher compared to the median YSO mass for the entire cloud (2.1M□). Spatial distribution of YSOs in the cloud shows that the YSOs are predominantly located along the filaments identified using the FilFinder algorithm on Herschel-derived column density maps. Furthermore, the majority of jet-bearing YSOs are found in nested filaments or converging structures in the western part of the cloud. These jets also coincide with regions having higher density of Class 0/I YSOs relative to their Class II and Class III counterparts. Finally, we analyse the large-scale magnetic fields towards the cloud using Planck dust polarisation maps. While the magnetic field is observed to be aligned with the main filament spine, higher resolution polarisation observations are required to probe the role of magnetic field in the smaller filament branches.

3. 67993 A Statistical Study of Outflow-Filament Orientations in the ALMA-ATOMS Survey

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Massive stars (M$>$8M$_{\odot}$), with their strong UV radiation play an important role in the evolution of the interstellar medium. Over the past few decades, studies of massive star formation have gained several insights, but their exact formation mechanism is still unknown because of their rarity, large distances, short lifetimes, high extinction, and clustered environment. Consequently tracing accretion dynamics in massive star formation also becomes difficult due to the even higher extinction and shorter evolutionary timescales. Outflows can serve as a proxy tracing the underlying accretion mechanism and distribution of angular momentum in these star-forming regions. Previous observations of both low- and high-mass star-forming regions have shown that the momentum axis of accretion disks, inferred from the orientation of outflows are either perpendicular or randomly aligned with their host filaments. In this work, we analyze a large sample of 146 massive protoclusters from the ALMA-ATOMS survey and performed a statistical analysis of the orientation of the outflows relative to their host filament and large scale magnetic fields. We find that the outflows exhibit no preferred orientation relative to large-scale filaments or magnetic fields. However, they display a bimodal distribution (with 45% parallel and 55% perpendicular) when compared to small sub-parsec scale filaments. This bimodality in the outflow-filament orientation suggests that gas flow from filaments to star-forming cores may occur along both the short- and long-axes of the filament.

4. 67932 Frozen Fingerprints: Decoding Protostellar Ice Chemistry with JWST

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Frozen Fingerprints: Decoding Protostellar Ice Chemistry with JWST Protostellar ices are among the most important reservoirs of molecules in star-forming regions. During the protostellar phase, these icy envelopes act as chemical factories where simple molecules can be transformed into more complex species through low-temperature surface chemistry, as well as processing by radiation and other energetic mechanisms. As the stars and planets form, this material carries down into disks, comets, asteroids, and eventually planetary systems, carrying with it a chemical record of the environment in which it formed. It is therefore important to understand the composition of these ices in order to trace the chemical origins of the planetary systems and the ingredients that may ultimately create and support life. The James Webb Space Telescope (JWST) has transformed our ability to study these icy environments. Its Mid-Infrared Instrument (MIRI), covering the 5–28 μm wavelength range, reveals a rich collection of molecular absorption features from species such as H_2O, CO_2, CH_3OH, NH_3, and NH_4^+. However, the broad overlap of these features, together with uncertainties in continuum placement, makes it difficult to reliably determine molecular abundances from observed spectra. To tackle this problem, we developed ‘IceFind’, a broadband spectral retrieval framework for JWST/MIRI observations. IceFind combines laboratory ice analogue spectra with non-negative spectral decomposition and uses a Bayesian approach to account for the uncertainty in the continuum. By exploring thousands of statistically acceptable continua and propagating them through the retrieval process, the framework provides robust estimates of molecular abundances and their uncertainties. This approach allows for a more robust characterization of protostellar ice chemistry and opens up new perspectives on the molecular inventory available during the earliest stages of star formation.

5. 67912 From cloud collision to dense cores: filamentary structure and star formation in G323.18+0.15

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How massive stars acquire their mass remains one of the central open questions in star formation, and cloud-cloud collisions (CCCs) have emerged as a compelling large-scale driver of the process. CCCs are not rare in the Milky Way and have been shown to trigger massive starbursts and drive hub-filament systems, with bona fide signatures including bridging features in position-velocity space and complementary spatial distributions. G323.18+0.15, previously identified as a CCC site, hosts a dense interaction region where two velocity components separated by ~2.6 km/s converge. We present an ALMA Band 6 study of the filamentary structure and its fragmentation into dense cores at this collision interface. The dust continuum reveals a filamentary structure fragmenting into 9 dense cores with masses ranging from 0.9 to 6 solar masses, and the molecular line data indicate bipolar outflows associated with 4 of these cores, suggesting active star formation triggered by a cloud collision that took place ~1 Myr ago.

6. 67828 Identifying Hub-Filament systems across the Galactic Plane using graph theoretic methods

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Hub-Filament systems (HFSs) are recognized as crucial sites of massive star formation throughout the Galaxy. Understanding these systems is key to deciphering the flow, accumulation and collapse of matter along the filaments to the central hubs. However, large-scale identification studies of such systems across the Galactic plane are scarce. In this work, we identify HFSs using graph theoretic methods applied on filamentary structures derived from the machine- learning (ML) based filament identification framework Sutra. The filaments are identified based on the trained ML model and their physical properties are derived using H2 column density maps from Herschel Hi-Gal survey observations. Subsequently, graph networks are established using filaments as the edges and their intersections and end-points as the nodes. To isolate true structures from background emission, nodes are determined using specific physical thresholds. The filament skeletons are treated as a series of Herschel beams and nodes are determined based on the number of neighbours of each beam. We also weigh the filament-based-edges with their column density to increase confidence on the candidature of the HFS. Intersections with at least three converging filaments are classified as Hub candidates. We cross-match these candidates with compact source catalogs and existing HFS identification studies in the literature, such as the Hi-Gal compact source catalog and analyse the degree of correlations. We find for our test cases, that approximately 45% of our Hub candidates harbor Hi-Gal compact sources within 1 arcmin of their vicinity. Thus, graph theoretic methods are aptly suited for identification and analysis of Hub filaments systems which are ubiquitous in our universe.

7. 67919 The First Robust Candidate for a Pulsating High-mass Protostar

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We report the first robust candidate for a pulsating high-mass protostar identified through periodic flux variations in the 6.7 GHz CH3OH maser. We monitored the maser emission associated with the nearby high-mass protostar G353.273+0.641 for 13 yr using the Hitachi 32 m telescope. We discovered a periodic flux variation with a period of 309 days from data obtained at a cadence of a few days. A tight correlation between the maser flux and the mid-infrared flux measured by NEOWISE suggests that the maser emission responds to variations in the protostellar luminosity. The average maser light curve is highly asymmetric and exhibits a characteristic bump just before the minimum phase, closely resembling those of some pulsating variable stars. Assuming that the maser periodicity originates from protostellar pulsation, the observed period implies a cool, highly bloated structure similar to that of a red supergiant. Such a bloated structure is consistent with theoretical models of protostellar evolution under high accretion rates. The protostellar pulsation instability was originally predicted by Inayoshi et al. (2013) from linear stability analysis. However, the observed profile suggests that a non-linear process, such as multiple shocks or vibrational mode resonance, causes a pulsation similar to that of pulsating variable stars. G353 could provide a chance to observationally trace the internal structure of a high-mass protostar for the first time, if the theoretical model is properly updated. However, a periodic accretion scenario caused by an unresolved compact protobinary cannot be completely ruled out. Several irregular peaks that deviate from the periodicity may result from episodic accretion phenomena or jet-launching events independent of the protostellar pulsation. Extremely high-resolution imaging with next-generation interferometers such as the ngVLA will provide a conclusive test for both the protostellar pulsation and the binary accretion scenarios.

8. 67796 Analysing the Evolutionary Phase-Transition and Scaling Relations of Hub-Filament Structures in Star-Forming Molecular Clouds

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The formation of stars within the interstellar medium (ISM) is not an isolated phenomenon but a highly structured hierarchical process deeply regulated by dense filamentary networks. Modern space-based infrared and submillimeter observational surveys have revealed that interstellar molecular clouds are predominantly organized into complex, elongated topologies. At the dense intersecting nodes of these molecular filaments lie prominent gravitational centers known as hub-filament systems (HFS). These hubs act as the primary nurseries for high-mass star formation, acting as focal points that continuously funnel gas and dust from the surrounding diffuse interstellar structure via longitudinal accretion. Understanding how these cosmic structures transition from simple, non-reactive gas filaments into collapse-driven stellar nurseries remains a foundational problem in theoretical astrophysics. This study presents a comprehensive analytical framework to model the evolutionary pathways, thermodynamic transitions, and physical characteristics of these networks by mapping their distribution within the Mass-Length (M-L) phase space. The structural behavior of gas filaments is traditionally parameterized through global scaling relations. Under conditions governed by standard isotropic turbulent fragmentation, a steady-state equilibrium is maintained where the physical dimensions scale predictably as L \propto M^{0.5}. However, when observed data points from large-scale Galactic surveys are plotted across a broad dynamic range, significant deviations from this standard power law become apparent. This study systematically analyzes the underlying physics driving these structural deviations. We introduce a geometric and thermodynamic transition model that explicitly defines how molecular gas evolves through distinct regimes within the M-L plane. The boundaries of these regimes are mapped by evaluating the localized virial mass (m_{vir}) against the observed line mass (m = M/L) of individual filaments. At lower mass thresholds, structures occupy a "subviral" configuration where thermal and magnetic pressures balance gravitational forces, maintaining long-lived, elongated filamentary profiles with high aspect ratios (A = L/\text{FWHM} \ge 3). As mass accumulation proceeds via continuous inflows, the local column density (\Sigma) surpasses critical structural limits, pushing the core layers into a highly unstable "superviral" domain. A central component of this analytical work is the precise evaluation of competing evolutionary timescales that govern the survival of a filament. We calculate the local fragmentation timescale (\tau_{frag}), which defines the time required for a uniform gas cylinder to break apart into distinct periodic cores under self-gravity, and compare it directly against the mass accretion timescale (\tau_{acc}), which measures the rate of longitudinal gas transport toward the central hub. Our analytical models demonstrate that in standard filaments, the fragmentation timescale is shorter or comparable to the accretion timescale (\tau_{frag} \le \tau_{acc}), allowing the structures to undergo sequential bead-like fragmentation along their spines before collapsing globally. However, as the system transitions into an active hub configuration—characterized by extreme local gas concentrations where the average column density reaches or exceeds \Sigma \ge 10^{22} \text{ cm}^{-2}—the gravitational potential well steepens dramatically. In this high-density environment, the accretion rate (\dot{m}) escalates to values between 100 and 300 \ M_{\odot}\text{ pc}^{-1}\text{ Myr}^{-1}, causing the mass accretion timescale to become significantly shorter than the fragmentation timescale (\tau_{acc} \ll \tau_{frag}). This shift in timescales triggers a dramatic geometric phase-transition. The extreme gravitational acceleration overcomes the localized turbulent support, causing a longitudinal collapse along the primary filament axis. Consequently, the elongated network collapses inward, forcing a geometric morphing where the system transitions from a high-aspect-ratio filament into a compact, isotropic, spheroidal geometry (A is less than equal to 1.5). By solving the localized hydrostatic equations for an isothermal gas cylinder in subviral conditions, we demonstrate that this transition fundamentally alters the local energy balance. The traditional one-dimensional fragmentation along the filament spine breaks down, giving way to a localized,

multi-directional gravitational collapse at the hub junction. This localized isotropic collapse concentrates vast amounts of matter into a confined spatial volume, directly suppressing low-mass stellar birth while facilitating the rapid, simultaneous formation of multiple high-mass stellar proto-cores. Furthermore, this paper evaluates how observational selection effects and structural parameters—such as the filament full-width at half-maximum (FWHM) and dynamic column density variations—affect the accuracy of current star-formation models. By analyzing archival dataset parameters reminiscent of the Herschel Space Observatory's Hi-GAL survey, we show that tracking the aspect ratio as a function of the scaling parameter provides a highly reliable, bias-free indicator of a cloud's true evolutionary stage. The theoretical formulations derived in this work successfully reconcile the apparent dichotomy between isolated low-mass star formation in diffuse filaments and cluster-driven high-mass star formation inside complex hubs. Ultimately, this comprehensive structural analysis offers a scalable, self-consistent theoretical framework for mapping cosmic web topologies, serving as a critical predictive model for upcoming next-generation high-resolution astronomical surveys.

9. Study of Magnetic Fields in High-Mass Pre-stellar Cores in W43-MM1 using ALMA

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High-mass pre-stellar cores are likely to be the precursors to high-mass (>8 M⊙) stars and are predicted to be in substantially different dynamical conditions by different high-mass star formation (HMSF) paradigms. The two primary paradigms for HMSF are (1) the core accretion model and (2) the competitive accretion model. The core accretion scenario forms near-virial cores that are supported by nonthermal mechanisms (i.e., magnetic fields and turbulence), while the competitive accretion scenario produces highly sub-virial cores accreting within fast collapsing clumps. Previous studies have estimated the gravitational and turbulent energies in HMPSC candidates, resulting in strong sub-virial states (virial parameter $\alpha < 0.3$), ignoring the magnetic fields. Thus, the final piece of the energy puzzle lies in estimating the magnetic field strengths in these cores. Although a few HMPSC candidates have been identified in the literature, the role of magnetic fields in their formation is yet to be explored. Our pilot study using Atacama Large Millimeter/submillimeter Array (ALMA) dust polarization at 250 GHz with 0.14" angular resolution finds relatively strong magnetic fields in five HMPSC candidates located in the W43-MM1 region. Identified as part of the ALMA-IMF Large Program, W43-MM1 exhibits a hub–filament morphology characterized by a central hub connected to an elongated filament. We aim to estimate their energy balance, which will help us to understand their dynamical phases in the presence of magnetic fields, i.e., if the HMPSC candidates are in equilibrium ($\alpha \sim 1$ and < 2) or collapsing rapidly (with $\alpha < 1$). In this symposium, we will present the initial results of these HMPSC candidates embedded in the W43-MM1 hub-filament system.

10. 67832 The Role of Filament in Galactic Star Formation: A Case Study of G305 giant filament

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We investigate the kinematics, dynamics, and fragmentation properties of the G305 giant molecular filament (GMF) complex, which contains two main filamentary structures, GMF1 and GMF2, with projected lengths of about 120 pc and 50 pc and gas masses of roughly 10^5 and 10^4 Msun, respectively. The total molecular gas mass in the studied region is on the order of 10^6 Msun. Using 13CO line observations, we assess the gravitational stability, virial balance, and internal kinematics of the GMFs and their substructures. Our analysis shows that self-gravity is the dominant dynamical driver, leading to inflow motions and the growth of dense clumps, while turbulence and rotation provide only limited support and cannot prevent global gravitational collapse. Within the filaments we identify 36 C18O clumps that exhibit a two-level hierarchical fragmentation pattern, with mean and median nearest-neighbor separations of 4.0 pc and 3.3 pc, respectively. The centroid velocity profiles along the filaments show quasi-periodic oscillations with wavelengths of 10.1 ± 0.2 pc and 9.3 ± 0.12 pc, i.e. about twice the theoretically expected maximum fragmentation scales. This relation supports a picture in which large-scale gravitational instabilities control the fragmentation and structural evolution of the GMFs. The observed velocity oscillations most likely trace accretion flows along the filaments toward the dense clumps. Assuming an inclination angle of 45° to the plane of the sky, we estimate a mean mass accretion rate of ~121 Msun/Myr, indicating efficient mass transport from filamentary scales into central hub-like regions. Overall, our results support a scenario in which GMFs act as dynamically evolving conduits that channel material from cloud-scale reservoirs into dense clumps, with self-gravity playing the key role in both mass assembly and subsequent star formation.

11. 67882 Simulating Spatial and Spectral Radio observations of Protostellar Jets

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Protostellar jets are one of the definitive signatures of star formation. They provide an efficient channel for the removal of angular momentum, thereby facilitating steady accretion of material into the central protostar. This outflow feedback acts as a braking mechanism and regulatory force within the Hub-Filament systems where stars form. The radio observations of these jets provide insights about their interaction with the ambient medium and the mechanisms giving rise to the radiation. We shall present results from our simulations that can synthesize observed spatial and spectral radio observations of protostellar jets by incorporating physics associated with thermal and non-thermal emission processes. In this regard, we have adopted astrophysical code PLUTO for running hydrodynamic simulations of the jet by injecting high-velocity fluid into the quiescent ambient medium through a narrow nozzle with cooling enabled which can track the ionization fraction. The intrinsic variability of the jet has been addressed by introducing sinusoidal pulsations in the jet velocity. The ray tracing software RADMC-3D is used to obtain the synthetic radio emission maps and spectra. Using the standard free-free emissivity we produce the thermal emission from the jet. On the other hand, to address the non thermal emission, we trace strongly shocked regions where Diffusive Shock Acceleration (DSA) can occur and obtain the synchrotron emission. We produce the synthetic emission map with spectral indices varying between positive and negative values; this is compared with results from radio observations.

12. Massive Cluster Formation Along Filaments – The Case of IRAS 06103+1523

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We present the results of our study of the star formation towards the region hosting IRAS 06103+1523 and IRAS 06104+1524A. We obtained multi-epoch imaging observations in the near-IR J, H and K filters and in a narrow band filter centered on the 2.122-mu H2 1-0 S(1) emission line covering a 13.5’x13.5’ field using the United Kingdom Infrared Telescope (UKIRT) and the UKIRT Wide Field Camera (WFCAM). We also observed this region using The James Clerk Maxwell Telescope (JCMT) in 450 and 850-mu continuum bands and in the 12CO(3—2) and 13CO(3—2) lines using the Submillimetre Common-User Bolometer Array 2 (SCUBA2) and Heterodyne Array Receiver Program (HARP) respectively. Our near-IR and sub-mm observations, along with the archival Herschel images, reveal high- to low-mass star formation taking place in at least five embedded clusters located along filaments, and spread over a region of over 5 parsecs at distance of 2kpc of the star forming cloud. The two IRAS sources are associated with two of the clusters. The outflow properties derived and multiplicity and variability of the YSOs identified in the near-IR are discussed.

13. 67695 Colliding filaments in the molecular cloud G34

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We present an observational study of the G34 molecular cloud complex, located at a distance of 2.12 ± 0.38 kpc, which hosts two giant filaments, F1 and F2, representing a promising candidate for colliding filaments. Using the 13CO and 12CO (J = 1–0) lines observed with the 13.7 m telescope at the Purple Mountain Observatory, we mapped the morphology and kinematics of these filaments. The fractions of high column-density gas (N(H2) > 1.0 × 10^22 cm^−2) in F1 and F2 are 4.16% and 8.33%, respectively, both below the typical 10% threshold for giant molecular filaments. Only one of the 13 dense clumps identified within the filaments is associated with WISE 22 μm infrared dust cores, suggesting that F1 and F2 are in an early evolutionary stage and may be forming low-mass stars. Large-scale velocity gradients are observed along both filaments. Along F1's spine, both velocity and line mass increase from the ends toward the center, while in F2 they increase from northwest to southeast. These quantities are anti-correlated with the gravitational potential, indicating a conversion between kinetic and gravitational potential energy. No H II regions are associated with F1 or F2, implying that the gas distribution and the V-shaped structure of F1 are shaped by gravitational effects rather than by ionized gas feedback. The mass is not concentrated at the filament ends, ruling out an edge-collapse scenario and suggesting that collapse and merging timescales do not compete. Assuming an angle of 45° between the line-of-sight velocity and the direction of the relative velocity between F1 and F2, the average relative velocity is 1.39 km s^−1, yielding a merging timescale of approximately 4.62 ± 1.12 Myr. This process may be further modulated by stellar feedback from ongoing star formation within the filaments.

14. The Role of Hub-Filament Systems in the Formation of High-mass Stars

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Characterizing filamentary structures seen in Infrared Dark Clouds (IRDCs) is crucial to constraining the initial conditions of high-mass star formation (HMSF). Recently, Hub-Filament Systems (HFSs) have attracted attention as a site where high-mass stars form (Kumar et al. 2020). We investigate how HFSs contribute to the formation of high-mass starsfrom the earliest stages of cluster evolution. The ALMA Survey of 70 μm dark Clumps in Early Stages (ASHES, Sanhueza et al. 2019, Morii et al. 2023) observed 39 IRDC clumps using ALMA 1.3 mm continuum at 1.2” angular resolution (~5000 au or 0.02 pc). A total of 839 star-forming cores with masses between 0.06 and 81 M⊙ were identified. By combining ASHES 1.3 mm continuum and 250 μm continuum by Herschel Hi-GAL survey, we find that 17 of the 39 ASHES clumps are embedded in HFSs. The distributions of core properties, including mass, differ significantly between cores embedded in HFSs and those that are not. We find, for the first time, statistical evidence that cores on scales of 5000 au embedded within few pc scale HFSs are systematically more massive than cores located in clumps that are not associated with HFSs. This discovery further strengthens the picture that HFS play a fundamental role in the formation of high-mass stars, influencing the mass assembly process from the earliest evolutionary stages, including the IRDC phase. We will present these detailed statistical comparisons and discuss their implications in our poster.

15. 67696 Gas inflow and accretion through hub in G329.34+0.14

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We use 13CO (J=2-1) from the SEDIGISM survey, together with ALMA data at Band 3 and 6 from the ATOMS and QUARKS surveys, to investigate the gas kinematics and feedback processes in the massive hub-filament system G329.34+0.14. Based on the Herschel continuum morphology together with the 13CO (J=2-1) integrated intensity and velocity distribution, a parsec-scale network of filaments was identified, converging toward the hub that hosts two massive clumps, MC 1 and MC 2, with masses of ~4210 (±1259) M⊙ and ~1483 (±443) M⊙, respectively. Position-velocity analysis indicates systematic velocity gradients consistent with gas transport along these filaments toward the hub. Within MC 1, ALMA resolves a sub-parsec network of intra-hub filaments (IHFs) traced by H13CO+ (J=1-0), with a velocity organization similar to that seen on parsec scales. These IHFs are distributed around a central H II region, surrounded by a shell-like structure traced by CS (J=2-1) and H13CO+ (J=1-0) emission, with dense gas concentrated in its northeastern and southwestern sectors. The shell further shows SiO (J=2-1) and SO (J=3(2)-2(1)) emission, excited mainly by low-velocity shocks from the expansion of the H II region, with a minor contribution from protostellar outflows. Compared with the parsec-scale filaments feeding the hub, the IHFs are more compact but exhibit larger velocity gradients and line masses, suggesting that the gas dynamics become increasingly influenced by the local gravitational potential. These results support a scenario of gas transport from filaments to the hub in G329: diffuse molecular gas is likely transported along filaments toward the hub region, contributing to ongoing mass accumulation there. In the dense interior of MC 1, the gas is further organized into a denser intra-hub filamentary network associated with the intra-hub clumps (IHCs), where massive star and cluster formation is taking place. Stellar feedback from the central massive stars does not appear to fully suppress the gas transport, allowing ongoing star formation to continue in the surrounding IHCs.

16. 67827 A statistical study of 87 HFSs from SEDIGISM survey

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We identified 87 hub-filament systems (HFSs) from CO data of the SEDIGISM survey, which include 308 filaments and 493 clumps. We classify the sample into two evolutionary stages, Stage I and Stage II, by star formation activities in the hubs. Our results suggest that filament properties change systematically from Stage I to Stage II, including increases in length, mass, line mass, dust temperature, velocity dispersion, and the filament-to-hub mass transport rate. At the same time, hub clumps are typically more massive, warmer, denser, and more gravitationally bound 30 than non- hub clumps, showing that hub regions provide preferred environments for dense structure growth and massive star formation. Kinematic diagnostics further show that a large fraction of hubs display signatures suggestive of infall or gravitational collapse, implying that self-gravity is increasingly important in the hub regions. However, the kinematics of the surrounding filaments, especially the out-of-hub filament segments, are less clearly explained by a simple gravity driven inflow picture, suggesting that additional processes such as turbulence, magnetic fields, and external pressure may also contribute to regulating gas motions. Our study thus provide an evolutionary view of HFSs in which filaments act as mass transport channels on parsec scales, while hubs are the central regions where dense structures grow and gravity becomes increasingly important.

17. Investigating Cluster Formation within Hub–Filament Networks

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We present a multi-wavelength investigation of the filamentary structures in the Galactic region at l = 158° and their surrounding molecular environment. Using infrared photometric data, we identify a population of young stellar objects (YSOs) through their infrared excess emission, indicating ongoing star formation activity across the region. Infrared and radio continuum observations reveal extended distributions of dust, molecular gas, and ionized emission associated with active star-forming sites, including signatures of high-mass star formation. Molecular line and sub-millimeter continuum data trace a network of dense clumps interconnected by filamentary structures, highlighting the hierarchical organization of the molecular cloud. The spatial correlation between dense gas and YSOs, together with the convergence of multiple filaments toward high-column-density regions, suggests the presence of a hub–filament system. Such a configuration is consistent with large-scale mass transport and gravitationally driven accretion along filaments, potentially feeding the central hub and regulating ongoing star formation.

18. 68003 From Low-Mass to High-Mass Protostars: Insights from Particle Acceleration and Jet Feedback from a massive star-forming region

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The roles of jets and feedback in modifying the energy balance, magnetic structure, and kinematics of star-forming regions remain poorly understood. In this work, we present a multi-wavelength investigation of the massive star-forming region IRAS 19410+2336 at a distance of 2.1 kpc. From low-frequency radio data, we resolve the protostellar object at the centre, separating the inner jet component from the outer lobes, and identify jet lobes tracing shocked outflows. By comparing Band 5 GMRT images with archival VLA observations at 1.4 GHz spanning almost three decades, we determined the displacement of the compact knots within the jet and estimated the jet speed and its dynamical age. These radio lobes are compared with the molecular H2 emission at 2.12 μm. The outer lobes display signatures expected from shocked synchrotron emission, providing a probe of the physics of particle acceleration in a massive protostellar system. Based on the radio flux densities and sizes of the sources, key shock-physics parameters, including the magnetic-field strength, bow-shock speed, cooling time, and cooling length, were derived. These findings provided information on the physical conditions of the shock and allowed an evaluation of the efficiency of diffusive shock acceleration. It appears that shock conditions and magnetohydrodynamic properties play a significant role in detecting particle acceleration in protostellar jets. We employed a radiative model that accounted for thermal free-free and non-thermal synchrotron emission for the central source and the jet lobes. This modeling allowed us to constrain some of the basic parameters of the jet, such as density, ionization fraction, mass loss rate, magnetic field strength, fraction of relativistic electrons, and particle energy spectrum. Such analysis provided detailed information about the physical processes occurring in a jet of a massive protostar and enabled comparison with observations of low-mass young stars. The comparison revealed strong similarities in the underlying jet-launching and feedback mechanisms across a wide range of stellar masses, supporting the idea that massive and low-mass stars share a common accretion–ejection paradigm.

19. 67808 Gaia DR3 view of the Cepheus Star Forming Regions

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The study of young stellar objects and their associated environments is essential for understanding the physical processes that govern star formation and shape early stellar evolution. In this work, we focus on the Cepheus star-forming region, a vast complex in the northern sky located within 1 kpc. The region spans 20h 01m 56.4481s to 09h 03m 19.7931s in Right Ascension and 88.6638870° to 53.3532715° in Declination. It includes the Cepheus Flare region, the Cepheus Bubble, the major OB associations Cepheus OB2, Cepheus OB3, Cepheus OB4, and Cepheus OB6, as well as the lesser-known Cepheus OB1 and Cepheus OB5 associations. We use the latest Gaia Data Release 3 to investigate the young stellar population associated with Cepheus. A photometric and pseudo- spectroscopic identification model, supported by machine-learning-based membership determination and clustering algorithms, is employed to identify young stellar object candidates across the region. The selection is primarily based on the presence of infrared excess, which indicates circumstellar material and is a key signature of pre-main-sequence stars. We also use the pseudo-equivalent width of the Hα spectral line, which serves as an indicator of active accretion from the disk onto the star. This analysis results in a catalog of 435 high-confidence young stellar objects distributed across the Cepheus star-forming regions, of which 203 are newly identified in this work. Spectral energy distribution fitting is used to confirm the pre- main-sequence nature of the identified sample. Using this catalog, we examine the spatial and kinematic distribution of young stellar objects in different sub-regions of Cepheus and provide updated mean distance estimates for the associated star-forming regions. We further investigate mass accretion trends across different pre-main-sequence classes and examine the connection between X-ray activity and Hα emission. Overall, this work presents an improved Gaia-based view of the Cepheus star-forming regions, and the associated data products are made available to support future studies of this important nearby star- forming complex.

20. 67846 Probing the Limits of Primordial Disc Survival: Discovery of Accreting "Peter Pan" Discs in 10–100 Myr Clusters

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Understanding the evolution of stars and planets requires a focus on protoplanetary disks orbiting young stellar objects (YSOs). The transition from primordial protoplanetary disks to second-generation debris disks is a critical epoch in planetary evolution. While primordial gas typically dissipates within a few Myr, some systems that survive into the debris disk evolutionary phase (>10 Myr) provide unique constraints on disc dissipation mechanisms. Building on a blind survey of 32 young clusters (1–100 Myr) using Gaia, 2MASS, and WISE, we find that characteristic decay timescales increase with wavelength (t=1.6 Myr at shorter wavelengths vs. ~4.4 Myr at 12 um), supporting inside-out disc clearing models. Furthermore, we observe that the median mass of disc-hosting stars decreases significantly in clusters older than 40 Myr, indicating that primordial discs survive longer around lower-mass stars. From this survey, we identified a population of old full-disc candidates. Separately, we investigated the variability of 120 evolved disc sources using NEOWISE time- domain data. This revealed irregular variability (Δ(mag) ~ 0.5) in 20% of the sample, potentially indicating planetesimal interactions during late-stage disc evolution. Finally, we present results from ongoing optical/NIR spectroscopic follow-up of the old full-disc candidates, confirming accretion signatures (e.g., Hα emission) in four sources belonging to older stellar groups (>10 Myr). These detections confirm the persistence of gas-rich, active accreting discs ("Peter Pan discs") in systems where debris discs are typically expected to dominate.

21. 67906 Investigating the Impact of Stellar Feedback on Fragmentation and Mass Assembly in The Early Stages of High-Mass Star-Formation

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The role of stellar feedback in regulating fragmentation and mass assembly during the earliest stages of high-mass star formation remains poorly understood. In this work, we present results from two complementary studies aimed at investigating the interplay between feedback, fragmentation, and core mass growth. Using high-resolution ALMA observations of the high-mass star-forming region G344.22-0.59, we identify a possible influence of the nearby H II region on the physical and kinematic properties of the detected molecular gas fragments, with those located closer to the H II region exhibiting higher masses and velocity dispersions. In parallel, we analyse a broader sample of 8 Galactic high-mass clumps, comprising 4 sources associated with neighbouring H II regions and 4 sources without nearby H II regions, to perform a comparative study of the impact of feedback during the early phases of high-mass star formation. Together, these results suggest that stellar feedback may play an important role in shaping the fragmentation hierarchy and promoting the growth of massive cores.

22. 67963 Unifying low and high mass star formation through density amplified hubs of filaments

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Star formation takes place within a complex network of structures that make up the interstellar medium (ISM). These hub-filament systems (HFSs) are the basic structural units of the ISM and have a profound influence on the rates, spatial distributions and mass function of stars formed. Current models of star formation involve the collapse of isolated interstellar gas cores. However, there is an increasing body of observations from a variety of telescopes including Herschel, JWST and ALMA that demonstrate that star formation is an environmentally driven process which takes place within a unified network of hub-filament structures. In such a network the low-density interstellar gas fills the space between the denser cores in the form of long, thin filaments which act as a conduit to channel gas and mass into the dense cores at the hub of the filament. The extreme surface densities that exist in the inner regions of a hub ,drive the gas within the hub a competitive accretion process that leads to the rapid collapse of a small number of dense cores to form high-mass stars and young stellar clusters. In contrast the low-density interstellar gas in the surrounding filaments support low- to intermediate-mass star formation. A study of the kinematics and evolution of the young stellar objects (YSOs) in a number of HFSs has shown that the initial dynamical state of a YSO is established by the localized flow of gas within the core in which it forms. As the HFS evolves the birth of a massive star in the hub can trigger a number of effects including the formation of outflows, radiation pressure and stellar winds that can eventually choke the accretion flow and disperse the cloud from which the stars formed. The resulting stellar clusters will have a number of structural ‘fossils’ that record their natal HFS, including the spatial distribution of stars in clusters, the mass-segregation of stars within a cluster and the kinematic coherence of the stars in a cluster. It is the resolution of these structural and feedback processes that are driving that a new theory of the evolution of Galactic star clusters and stellar groups is being developed.

23. 67848 The IMF in a Metal-Poor Galactic Environment: Constraints from Deep near-Infrared Imaging

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The Initial Mass Function (IMF) is a fundamental parameter for describing the distribution of stellar masses in a cluster and for probing the physical processes that govern star formation. Theory suggests that the IMF may depend on environmental conditions, with metallicity being a particularly important factor. Low-metallicity regions are especially compelling because they mimic, in some respects, the conditions of the early Universe and thus offer a window into star formation in a more primitive setting. Reduced cooling and weaker dust shielding at low metallicity can change cloud thermodynamics and fragmentation, potentially modifying the universal shape of the IMF. Traditional research has largely concentrated on regions close to the solar neighborhood, offering limited insights into regions with significantly different conditions. In this work, we investigate 14 young star-forming regions located in the outer Milky Way, where the metallicity is systematically lower than that of the solar neighborhood. Using deep near-infrared imaging, we construct a photometric census extending down to subsolar masses. Probable cluster members are identified through statistical field-star decontamination, followed by extinction and age estimation for individual regions. Stellar masses are then derived using PARSEC v1.2 isochrones to construct the mass distributions. The use of a uniform analysis pipeline across all regions enables an unbiased investigation of possible correlations between the IMF and metallicity. To account for the effects of spatially varying crowding, we performed Artificial Star Experiments (ASEs) and quantified completeness as a function of both stellar magnitude and spatial position within the clusters. The low-mass IMF is modeled using a log- normal functional form with completeness corrections applied, allowing us to constrain the characteristic mass, while the high-mass regime is fitted with a power-law function to determine the IMF slope. In addition, we carried out a comparative analysis between these low-metallicity clusters and eight previously studied solar-metallicity clusters to search

24. 67925 Accretion outbursts across the stellar mass spectrum: The emerging role of streamer-fed disk replenishment

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Accretion outbursts are a fundamental component of star formation, manifesting as sudden increases in luminosity driven by enhanced mass accretion from circumstellar disks onto young stellar objects. Traditionally, these events have been studied in the context of low-mass protostars, where FU Orionis and EX Lupi-type eruptions are commonly attributed to disk instabilities such as gravitational fragmentation, thermal instabilities, or magnetically driven processes. In recent years, however, growing observational evidence has revealed that episodic accretion is not restricted to low-mass stars but also occurs in intermediate- and high-mass young stellar objects, suggesting that burst accretion may be a universal mechanism of stellar mass assembly.

A key unresolved question concerns the origin of the material required to sustain repeated accretion episodes. While most theoretical models focus on processes internal to the disk, recent high angular resolution observations have increasingly identified filament-like structures called streamers that connect the outer disks of low-mass protostars to their surroundings. These filamentary inflows provide direct evidence for ongoing mass transport from envelope scales to disk scales, potentially replenishing disks and maintaining the conditions necessary for gravitational instability and episodic accretion. By continuously feeding material into the disk, streamers may promote the growth of spiral structures and fragments that can migrate inward, triggering luminosity outbursts in low-mass protostars.

In contrast, the observational picture for high-mass protostars is markedly different. Owing to their larger distances and complex clustered environments, direct imaging of disk-feeding structures remains challenging. Instead, the strongest evidence for episodic accretion comes from dramatic flares of Class II methanol masers, often accompanied by infrared variability. These events are mostly interpreted as manifestations of accretion-driven luminosity bursts and have revealed that episodic accretion is also active during the formation of massive stars. Recent studies suggest that these bursts may originate from gravitationally unstable disks undergoing rapid mass-loading and fragmentation, analogous to scenarios proposed for low-mass systems.

In this contribution, we present the current observational and theoretical understanding of accretion outbursts in low- and high-mass protostars, emphasizing the emerging role of streamer-fed accretion. We discuss the discovery of streamers using ALMA in one of the eruptive low-mass systems, their inferred mass infall rates, and their implications for disk evolution and instability. The possibility that streamers provide the missing link between large-scale envelope accretion and disk-mediated accretion bursts will also be discussed. This perspective naturally connects molecular cloud environments, protostellar envelopes, circumstellar disks, and stellar mass growth within a unified framework. We also talk about our efforts in studying the episodic accretion processes in high-mass protostars using national and international radio and infrared telescope facilities.

25. Unveiling the Dynamics of Star Formation in BRC 68: Insights from ALMA and QUARKS Observations

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To understand the underlying processes of star formation, a multi-wavelength and multi-scale observational study of IRAS 11332-6258 hosting 6.7 GHz methanol maser (d~1.4 kpc) is carried out. The IRAS source is associated with the bright-rimmed cloud BRC 68 and notably lacks detectable radio continuum peak emission. The Spitzer 4.5 micron image reveals an Extended Green Object (EGO) toward IRAS 11332-6258, suggesting the presence of a young massive protostar driving energetic outflow activity. To investigate the dynamical processes governing mass accretion and fragmentation, the ALMA-QUARKS continuum and line data are employed. The 1.3 mm continuum map reveals at least nine compact continuum sources, nearly 50% of which satisfy the condition for massive star formation. Their spatial distribution indicates the presence of two distinct groups of sources, referred to as the northern group (NG) and southern group (SG). At least one bipolar outflow is investigated toward each group, highlighting ongoing star formation activity across the region. Among the detected continuum sources, one particularly intriguing object in the NG appears to host a forming massive protostar that is driving a powerful bipolar molecular outflow while also exhibiting signatures of channeled gas inflow. In this talk, I will present results derived from a variety of molecular line tracers observed with ALMA and discuss their implications for fragmentation, mass accretion, outflow activity, and the formation of massive stars in IRAS 11332-6258.

26. Investigating the Accretion-Outflow Connection During Star Formation with ALMA, DOT, and HCT

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Manojit Chakraborty et al.

We present an ongoing study of a sample of young stellar objects (YSOs) with archival ALMA observations, complemented by optical and near-infrared spectroscopic and photometric follow-up using the 3.6-m Devasthal Optical Telescope (DOT) and the 2-m Himalayan Chandra Telescope (HCT). Stars form by accreting material from their surrounding disks, while at the same time driving powerful outflows that remove mass and angular momentum from the system. Understanding the link between these two processes is essential for building a complete picture of star formation. The ALMA data are used to identify and characterize molecular outflows and derive their physical properties, including mass, momentum, and outflow force. Optical and near-infrared spectra obtained with DOT and HCT provide accretion diagnostics through emission-line tracers, allowing estimates of mass accretion rates. By combining these measurements, we investigate how accretion and outflow activity are related and how they vary among sources at different stages of evolution. This multi-wavelength approach provides a direct way to connect the inflow and outflow processes that govern the growth of young stars and shape their surrounding environments.

27. Young Stellar Populations and Stellar Feedback in Star-Forming Regions

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Understanding how stellar and substellar objects form and evolve in different environments is a key question in star formation studies. Using deep optical and infrared observations, Gaia astrometry, spectroscopy, and archival multi-wavelength data; we identify and characterize young stellar objects, low-mass stars, and brown dwarfs, and investigate their spatial distribution and kinematic properties. Our studies revealed low-mass stars and brown dwarfs down to the substellar regime and examined the impact of massive-star feedback on cloud evolution and star formation. We find indications for triggered star formation in the studied regions, along with environmental influences on the spatial distribution of young stars and brown dwarfs. These results provide important insights into the formation, evolution, and clustering of young stellar populations in star-forming regions.

28. 67863 A Unified Analytical Fragmentation Criterion Across the Hub-Filament Geometry: From Cylindrical Filaments to Spherical Hubs

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Mr. Rushi Mahajan, Mr. Ishaan Apte, Mr. Kevin Tom, Prof. Arun Tom Mathew

We now know that two different modes are at work in the fragmentation of dense gas in Hub-Filament Systems (HFS): a turbulence-regulated cylindrical one in the filaments, and a gravity-regulated spherical Jeans-like one at the central hub. Yet, every single analytical fragmentation model assumes these to be two distinct problems and solves them separately by applying either the instability criterion of an infinite cylinder to the filaments or the classical Jeans criterion only to the hub. None of these models physically motivate the setup that connects them through the geometry transition. So, the spatial variation of fragment masses along the filament-to-hub continuum remains analytically uncharacterized. As a result, it becomes untestable against the growing body of multi-scale ALMA observations. We present a unified fragmentation criterion that applies across the entire HFS geometry, which is parameterized by a dimensionless geometry function \(G(\rho/\rho_{hub})\) that smoothly changes from the cylindrical (filament) to the spherical (hub) limiting case as the local density goes upward to the hub. The effective fragmentation length scale \(\lambda_{frag}(r)\) is a combination of all the three kinds of pressure support thermal (sound speed \(c_{s}\)), turbulent (velocity dispersion \(\sigma _{turb}\)), and magnetic (Alfvn speed \(v_{A}\)) in one single effective support velocity \(c_{eff}\). Apart from that, it also takes into account the non-stationary density correction of Li (2024) for the dynamically accreting hub environment. In turn, the resulting fragment mass profile \(M_{frag}(r)\) is a core mass variation prediction from filament to hub, which is systematic, even if the physical principles that govern it are complex. Along the filament, core masses are about \(\sim 1 \ M_\odot\), while at the hub, they reach \(10\text{}100 \ M_\odot\). This behavior is mainly a result of the geometry transition and only a little by the density-dependent suppression of magnetic support. The predicted \(M_{frag}(r)\) profile is tested against the core mass measurements published by ALMA in three regions of HFS, each representing different masses and evolutionary stages: I18308 (ALMA- INFANT 2025), IC 5146 W-HFS (Wang et al. 2022), and California-X (Cal-X 2023). A 30% agreement is found in all three regions without using any free parameters, showing that the geometry transition alone and not the environmental variation, is the primary driver of the observed mass gradient from filament to hub

29. 67820 The Probability Density Function of Gas Density in the Milky Way: An Exploration Using 3D Dust Data

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The probability density function (PDF) of gas density in the interstellar medium of galaxies carries rich information about local dynamics and is widely used to predict the star formation rate. It is typically computed from 2D column density observations and modelled using a piecewise continuous function consisting of a lognormal turbulent component and a power-law tail associated with gravity. The transition from the turbulence-dominated regime to the gravity-dominated regime provides information about physical processes such as star formation. We use reconstructed 3D dust density data within 1.25 kpc of the Sun to isolate a sample of dense clouds resolved in 3D. We then apply an MCMC-based fitting algorithm on a per-cloud-basis to determine the functional form of their density PDFs. We find that approximately one-third of these clouds follow a non-lognormal distribution with high intermittency in the turbulent component, and we derive an analytical relation for the associated transition point. These results have significant implications for predicted star formation rates, which may shift from suppression to enhancement as the strength of intermittency changes. This work provides new insights into ISM turbulence, star formation, and 2D-to-3D projection effects.

30. 67921 Gaia DR3 Census and Kinematics of Young Stellar Groups in the Perseus Star-Forming Region

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The Perseus star-forming region, at distances of 286--522~pc, is a nearby laboratory for studying low-mass star formation, including active clusters such as NGC~1333 and IC~348. Using Gaia DR3 astrometry with 2MASS and WISE photometry, we selected 49,689 sources in the region ($150^{\circ} \leq l \leq 175^{\circ}$, $-25^{\circ} \leq b \leq -5^{\circ}$) following the proper-motion and parallax criteria of \cite{Pavlidou2021}. A 10~Myr PARSEC isochrone cut reduced the sample to 16,966 young stellar objects, of which 5,703 have Gaia DR3 radial velocities.

We applied HDBSCAN clustering in 5D space ($l, b, \varpi, v_{l,\mathrm{LSR}}, v_{b,\mathrm{LSR}}$), with DBSCAN and OPTICS used for cross-validation. HDBSCAN identifies 13 young stellar groups containing 1,308 members, spanning 286--522~pc; DBSCAN finds 11 clusters and OPTICS recovers 31. Cross-matching with 2MASS and AllWISE gives 1,266 infrared matches, including 2 Class~I, 147 Class~II, and 1,117 Class~III sources. PARSEC isochrone fitting yields ages of 1.0--10.0~Myr.

The sample includes eight known Per~OB2 populations: NGC~1333, IC~348, Heleus, Mestor, Electryon, Alcaeus, Cynurus, and the California Cloud. Five additional groups, named Alcmena, Anaxo, Amphitryon, Eurymedon, and Hippothoe, are found at 474--522~pc and may represent new substructures or background populations. All 13 groups are gravitationally unbound, with 1D velocity dispersions of 0.33--4.78~km\,s^{-1}. NGC~1333 has the highest disk fraction (52\%) and the strongest contraction signal (12.2σ), while Alcaeus also contracts significantly (8.3σ). Mestor, Electryon, and Heleus show expansion, and Alcmena, California, and NGC~1333 show significant azimuthal motions, suggesting possible rotation or shear. IC~348 is closest to virial equilibrium, with $\sigma_{\rm 1D}/\sigma_{\rm vir} \approx 2.9$.

31. 67900 Star formation in a quiescent outer Galaxy filament G222

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The process of massive star-formation is not well understood due to their large distances, high extinction, and short timescales of critical evolutionary phases, making observations challenging. The latest observational findings point towards the formation of massive-stars within filaments and hub-filament systems where the entire process from the formation of filament to the accretion of matter onto the star-forming core is explained by both the Turbulent support model (TS) and the Global Hierarchical Collapse (GHC) model. Therefore, natal environment of these star-forming regions should play a major role in the entire process. The star-forming environments in the inner (Quadrants I and IV) and outer (Quadrants II and III) Galaxy vary significantly both structurally and kinematically. Furthermore, the outer Galaxy has lower metallicity, lower average temperature in molecular clouds, higher gas-to-dust ratio, lower gamma-ray flux, lower surface densities, and lower methanol-maser detections. These variations between the inner and outer Galaxy provide a unique window to explore how environmental conditions influence high-mass star-formation (HMSF) efficiency. In our study, we probe the origin, stability, and star-formation potential of three distinct filamentary systems. In this talk, we will present the results and inferences from the study of an outer Galaxy 35-pc large gravitationally stable filamentary system G222 with multiple unstable clumps. We have observed G222 in multiple molecular line transitions using the IRAM 30m telescope. Further multi-wavelength data include high-resolution radio continuum observation using uGMRT, and archival far-infrared dust continuum emissions (Herschel/Hi-GAL). The gas kinematics of G222 is indicative of it having an expanding shell morphology, with the middle part expanding more rapidly than the northern and southern parts. Comparison of the observed mass per unit length of these three regions with the critical line mass indicates that only the northern part is gravitationally unstable. The observed velocity dispersion in the quiescent middle part is consistent with the prediction with the turbulent cascade. We identified 9 velocity coherent molecular clumps throughout this system using dendrogram segmentation analysis via the astrodendro package, of which 4 are associated with the infrared sources. Two of the most massive clumps are located in the northern part and have a column density exceeding the threshold for high mass star-formation (10^{22}\,cm^{-2}). The most massive clump S1 in the northern part shows clear signs of outflow and is also associated with a far-infrared continuum source, thus suggesting it to be a proto-stellar object, while we do not have direct evidence of star-formation in the clumps located in the middle and southern parts, which is likely due to the moderate spatial resolution of our observations. The middle part contains 3 velocity coherent clumps that are equidistant (~2 pc) from each other. We will also compare these results of G222, quiescent filament, with the northern part in a possible clumpy to "cold collapsing core" phase, with our previous study of inner Galaxy HFS G6.55 (ultra-compact H II region) and outer Galaxy 5-pc long filament G183 (High mass protostellar object) and highlight similarities and differences in these systems. We find the role of gravity dominant over turbulence in the process of massive star-formation in these systems, although this outcome is dependent on the spatial scale.

32. 67866 The Environmental Dependence of Star Cluster Infant Mortality: Arm Versus Inter-Arm Disruption Rates in M51, NGC 628, and NGC 1566

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The infant mortality of star clusters — the rapid dissolution of a substantial fraction of newly formed stellar groups within the first ~50 Myr — is observationally well established, yet the degree to which the galactic birth environment drives this mortality rate remain poorly understood. Spiral arms and inter-arm regions present fundamentally different physical conditions for newly formed clusters: spiral arms harbor higher gas surface densities, more massive and more numerous giant molecular clouds (GMCs), and stronger tidal perturbation fields, all of which are expected to accelerate early cluster disruption. Here we present an environment-resolved pilot comparison of infant mortality rates for clusters born in spiral arm versus inter-arm regions, using stellar cluster catalogs from the PHANGS-HST survey combined with high-resolution GMC maps from PHANGS-ALMA across three nearby grand-design spiral galaxies: M51, NGC 628, and NGC 1566. Cluster birth environments are classified using published spiral arm masks, and mass-limited age distributions are constructed separately for arm-born and inter-arm- born populations to minimize luminosity-fading bias. Fitting a power law of the form dN/dτ ∝ τ^γ to each population, we find that arm-born clusters consistently exhibit steeper age distributions (γ_arm ~ −1.2 to −1.4) relative to their inter-arm counterparts (γ_inter ~ −0.7 to −0.9), implying a markedly higher disruption rate per decade of logarithmic age in the denser spiral arm environment. The difference in γ values correlates positively with the local gas surface density Σ_gas measured from CO intensity maps, consistent with the established theoretical prediction that cluster disruption timescales scale as t_dis ∝ Σ_gas^{−0.5}. We attribute this environmental difference primarily to elevated GMC encounter frequencies and enhanced tidal heating rates in spiral arm regions during the critical first 10–100 Myr window, drawing on the impulse approximation framework of Gieles et al. (2006) and Kruijssen et al. (2011). While spiral arm environments also tend to produce more massive clusters through higher cluster formation efficiencies — which partially offsets elevated disruption — the ne

33. 68019 Tracing the Magnetic Field in MBM 12 Using Optical and Planck Polarimetry

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MBM 12 is one of the nearest high-latitude molecular clouds and provides an excellent laboratory for investigating the role of magnetic fields in the evolution of diffuse molecular clouds. We present a multiwavelength study of the magnetic field morphology and physical properties of MBM 12 using optical polarimetry, \textit{Planck} polarization data, and far-infrared dust emission maps.

The plane-of-sky magnetic field structure was traced using R-band stellar polarization measurements together with \textit{Planck} 353 GHz dust polarization observations. The optical and submillimeter data reveal a coherent large-scale magnetic field orientation across the cloud, while localized deviations in the optical polarization vectors indicate small-scale perturbations within denser regions. A comparison of the magnetic field orientations derived from optical and \textit{Planck} data suggests that the large-scale field remains ordered, although increased angular dispersion is observed on smaller spatial scales.

To investigate the cloud's physical conditions, we performed modified blackbody spectral energy distribution fitting using \textit{Planck} 353, 545, and 857 GHz data together with IRIS 100 μm observations. The resulting dust temperature and column density maps were used to characterize the cloud structure and estimate its volume density. Using the modified Davis--Chandrasekhar--Fermi method, we derived the plane-of-sky magnetic field strength from the observed polarization angle dispersion and molecular gas velocity dispersion.

The observed increase in polarization fraction with distance and extinction indicates that MBM 12 contributes significantly to the polarized signal and hosts efficiently aligned dust grains. Our results suggest that MBM 12 possesses an ordered large-scale magnetic field coupled to the surrounding interstellar medium, while exhibiting localized distortions associated with density enhancements and internal cloud structure. These findings provide new insights into the interplay between magnetic fields and the evolution of nearby translucent molecular clouds.

34. Star Formation and AGN Feedback in NGC 4258: Insights from Multi-wavelength Observations

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We present a detailed study of NGC 4258, a nearby galaxy hosting an active galactic nucleus (AGN) whose jet-driven outflow intersects the galactic disc, producing the well-known anomalous arm structures. Using James Webb Space Telescope Mid-Infrared Instrument integral field unit observations, we map the spatial distribution of key molecular and atomic emission lines, with particular emphasis on the pure rotational transitions of H2. These H2 lines trace the warm molecular gas component and provide insight into its temperature distribution and local heating mechanisms. The moment-zero maps reveal enhanced H_2 rotational-line emission spatially adjacent to the outflow axis, indicating a concentration of warm molecular gas in the vicinity of the outflow. To characterize the physical conditions of the molecular gas, we analyze spatially resolved H_2 rotational emission to estimate the excitation temperature distribution in the central region of the galaxy. Complementing the JWST spectroscopy, we present a multi-wavelength (from X-ray to radio) morphological study to investigate the spatial relationship between star formation and outflow-impacted gas. We use AstroSat UVIT imaging, to trace the star-forming regions across the galaxy. Our results reveal evidence for suppressed star formation along the direct jet path, contrasted by potentially enhanced activity in adjacent dense clumps, highlighting both negative and positive modes of AGN feedback. NGC 4258 thus serves as a nearby laboratory for investigating how energetic outflows impact the molecular gas and hence star-formation in AGN-host galaxies.

35. High-Resolution Optical Spectroscopic Study of Accretion and Outflow in V1180 Cas

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We present a high-resolution optical spectrum of V1180 Cas obtained with HIRES at the Keck Observatory during a bright state. The spectrum exhibits prominent accretion and outflow tracers, including strong Hα, Ca II, He I, O I, Fe I Fe II, and forbidden emission lines. A weak Li I λ6708 absorption feature confirms the youthness of the source, and for the first time we report its radial velocity measurement of -16 ± 1 km\,s^{-1}. The Hα and Hβ profiles show blueshifted absorption components indicative of outflowing material, while the He I and [O I] lines trace magnetospheric accretion, disk winds, and a high-velocity jet. From the [O I] λ6300 profile, we estimate a disk inclination of $\sim50^\circ$. The derived mass-loss to mass-accretion rate ratio, $\dot{M}_{\rm jet}/\dot{M}_{\rm acc} \sim 0.06$, is consistent with Class II YSOs and supports magnetically driven jet-launching mechanisms. Forbidden-line diagnostics reveal a multi-component outflow with densities of $\sim10^{3}$ and 10^{6} cm^{-3} and temperatures of $\sim10^{4}$ K. Overall, V1180 Cas is an actively accreting, moderately inclined young stellar object driving a structured outflow.

36. 67879 Role of Magnetic field in early stage star formation in PGCCs

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PGCC G089.75−02.16, located at a distance of approximately 600 pc and identified by the Planck mission, is a cold molecular clump in the early stages of star formation. The cloud is characterized by low dust temperatures 10–15 K and moderate column densities (0.1–1.6) × 10^{22} cm^{-2}. As relatively quiescent and less evolved objects, Planck Galactic Cold Clumps (PGCCs) provide ideal laboratories for investigating the role of magnetic fields during the earliest phases of star formation. Molecular gas observations reveal two elongated, nearly perpendicular filamentary structures with slightly different centroid velocities. Both clouds are located at similar distances of 600 pc. The magnetic field associated with each structure seems to be aligned with its elongation. The two cloud filaments appear to be interacting or undergoing a cloud–cloud collision. We would be presenting preliminary results based on the optical polarimetric and CO molecular line data, magnetic field strength, Alfvénic Mac number and mass-to- flux ratio criticality.