


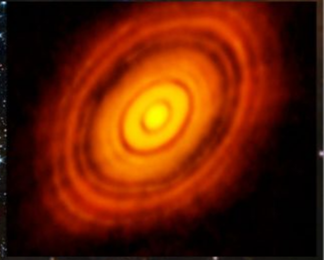

4th Meeting on Star Formation

Star Formation Studies in India

S. N. BOSE NATIONAL CENTRE FOR BASIC SCIENCES 1986

1894-1974

बिज्ञानेन परिपश्यन्ति धीराः

S.N. Bose National Centre For Basic Sciences

Salt Lake, Kolkata - 700 106

January 08 -11, 2024

Contents

About

Broad Topics

1. Molecular Clouds
2. Interstellar Medium and Feedback
3. Magnetic Fields in SFR
4. Planet Formation and Exoplanets
5. Stellar Clusters
6. Extra-galactic star formation
7. Instrumentation

Scientific Organizing Committee (SOC)

Devendra K. Ojha (Chair)	Anandamayee Tej	Bhaswati Mookerjea
Jessy Jose	Liton Majumdar	Lokesh K. Dewangan
Maheswar Gopinathan	Sarita Vig	Saurabh Sharma
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Local Organizing Committee (LOC)

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Rajib Kumbhakar	Soumita Chakraborty	Sudip Pramanik

Timetable

IT: Invited Talk (15+5 min), CT: Contributed Talk (10+5 min)

Day 1: Monday, 08 January 2024

09:30–09:35	**Welcome Address**		
09:35–09:45	**Opening Remark by Director, SNBNCBS**		
09:45–09:55	**Welcome Remark by SOC Chair**		
Session I: Star-forming Filaments			
Chairs: Sarita Vig and Santosh Joshi			
10:00–10:20	IT	**Devendra K. Ojha** TIFR, Mumbai	Disk-mediated accretion bursts in low- and high-mass young stellar objects
10:20–10:40	IT	**Saurabh Sharma** ARIES, Nainital	Role of filaments in the formation of stars in the NGC 2316 star cluster
10:40–10:55	CT	**Veena V S** Max Planck Institute for Radio Astronomy, Germany	Star Formation in Extreme Environments: A 200 pc High Velocity Cloud in the Galactic Centre
10:55–11:45	**Group Photo + Poster Viewing + Tea Break**		
11:45–12:00	CT	**Kshitiz Mallick** ARIES, Nainital	Exploring High-mass star formation at the junction of filaments in Sh2-112
12:00–12:15	CT	**Jyotirmoy Dey** IIST, Thiruvananthapuram	G18.148–0.283: a case study of the cloud-cloud collisions as a mechanism for high-mass star formation

12:15–12:30	CT	**Arup Kumar Maity** PRL, Ahmedabad	Origin of Hub-Filament Systems through Cloud-Cloud Collision
12:30–12:45	CT	**Sonu Tabitha Paulson** TIFR, Mumbai	Investigating the Earliest Stages of High-Mass Star Formation
12:45–13:00	CT	**Arun Seshadri** IIST, Thiruvananthapuram	Multiwavelength investigation of the star-forming complex G12.79+0.43
13:00–14:15	**Lunch at Basundhara Building**		
Session II: Interstellar Medium and Feedback			
Chairs: Neelam Panwar and Lokesh Dewangan			
14:15–14:35	IT	**Bhaswati Mookerjea** TIFR, Mumbai	PDRs: The irradiated neutral ISM
14:35–14:55	IT	**Maheswar Gopinathan** IIA, Bengaluru	Rocket effect in molecular clouds near O-type stars
14:55–15:10	CT	**Nirupam Roy** IISc, Bangalore	Fire burn, and cauldron bubble: Missing supernova remnants and prospect of detecting them at low radio frequency
15:10–15:25	CT	**Mridusmita Buragohain** University of Hyderabad	Observational search of PAHs footprints using SUBARU/COMICS telescope
15:25–15:40	CT	**Aayushi Verma** ARIES, Nainital	Exploring Stellar Cluster and Feedback-driven Star Formation in the Galactic Midinfrared Bubble [HKS2019] E70
15:40–15:55	CT	**Sudeshna Patra** IISER Tirupati	The role of metallicity on the mass-luminosity conversion factor derived from dense gas
15:55–16:25	**Tea Break**		
Session III: Planet formation and Exoplanets			

Chair: Anandamayee Tej			
16:25–16:45	IT	**Abhijit Chakraborty** PRL, Ahmedabad	Discovery of two exoplanets with extreme densities with PARAS: TOI4603b and TOI1789b
16:45–17:05	IT	**Jessy Jose** IISER, Tirupathi	Proto-planetary disk evolution: Role of external factors
17:05–17:25	IT	**Liton Majumdar** NISER, Bhubaneswar	Constraining the initial conditions for the formation of extra-solar planets and their atmospheres
17:25–17:40	CT	**Swastik Chowbay** IIA, Bengaluru	The Search for Planet around LkCa 15 protoplanetary disk
20:00–21:30	**Dinner at Basundhara Building**		
End of Day 1			

Day 2: Tuesday, 09 January 2024

Session IV. Star formation at high resolution			
Chairs: Bhaswati Mookerjea and Maheswar Gopinathan			
09:30–09:50	IT	**Anandamayee Tej** IIST, Thiruvanandthapuram	Perspectives on high-mass star formation: Results from the ATOMS survey
09:50–10:10	IT	**Lokesh Dewangan** PRL, Ahmedabad	Unearthing the hidden structures in star-forming regions: Results from JWST
10:10–10:30	IT	**Manoj P.** TIFR, Mumbai	Investigating Protostellar Accretion and Outflow: JWST NIRSpec and MIRI IFU Mapping of Young Protostars Across the Mass Spectrum

10:30–10:50	IT	**Jagadheep Pandian** IIST, Thiruvanandthapuram	The physics of high-mass star formation: a fragmentation study of ATLASGAL dust clumps
10:50–12:15	**Poster Viewing + Tea Break**		
12:20–12:40	IT	**Somnath Dutta** IAA, Academia Sinica, Taiwan	Episodic Accretion in Protostars - An ALMA Survey of Molecular Jets in the Orion Molecular Cloud
12:40–12:55	CT	**Sabyasachi Pal** Midnapore City College, West Bengal	Study of possible glycine precursor molecules towards the hot molecular core G10.47+0.03
12:55–13:10	CT	**Anindya Saha** IIST, Thiruvananthapuram	Study of fragmentation and multiscale gas dynamics in two protoclusters with ALMA: Deciphering the driving mechanism for high mass star formation – gravity or turbulence
13:10–14:15	**Lunch Break at Basundhara Building**		
14:15–14:30	CT	**Naval Kishor Bhadari** PRL, Ahmedabad	Dynamics of the inner environment of a hub-filament system hosting massive young stellar object W42-MME
14:30–14:45	CT	**Arijit Manna** Midnapore City College, West Bengal	Detection of phosphorus nitride and other complex organic molecules towards the high-mass protostar IRAS 18089–1732
Session V. Instrumentation			
Chair: Sreeja S Kartha			

14:45–15:05	IT	**Joe P. Ninan** TIFR, Mumbai	Pushing the boundaries of star and planet formation by developing new spectrographs
15:05–15:20	CT	**Arun Surya** IIA, Bengaluru	Design advancement of MOIS : A configurable slit multi-object infrared spectrograph and wide field imager
15:20–15:35	CT	**Supriyo Ghosh** University of Hertfordshire, UK	An actively controlled fibre-fed optical spectrograph EXOhSPEC
15:35–16:00	**Tea Break**		
16:00–17:15	**Bose Colloquium by Prof. Dipankar Banerjee**		
19:30–21:30	**Confernce Dinner at Staddle**		
End of Day 2			

Day 3: Wednesday, 10 January 2024

Session VI. Pre-main Sequence Stars and Variability			
Chair: Mousumi Das			
09:30–09:50	IT	**Sarita Vig** IIST, Thiruvanandthapuram	Non-thermal emission from massive protostellar jets
09:50–10:05	CT	**Arpan Ghosh** ARIES, Nainital	Monitoring of episodically accreting Young Stellar Objects
10:05–10:20	CT	**Shridharan Baskaran** CHRIST (Deemed to be University)	Disentangling the two sub-populations of early Herbig Be stars using VLT/X-shooter spectra
10:20–10:35	CT	**Nidhi Sabu** CHRIST (Deemed to be University), Bangalore	Evaluation of varying mass accretion rate with mass in PMS stars

10:35–11:45	**Poster Viewing + Tea Break**		
Session VII. Stellar clusters			
Chair: Blesson Mathew			
11:45–12:05	IT	**Yogesh Joshi** ARIES, Nainital	Photometric, kinematic and variability study in the young and intermediate-age open clusters
12:05–12:25	IT	**Manash R. Samal** PRL, Ahmedabad	Formation and early evolution of star clusters: the case of FSR 655 and NGC 2516
12:25–12:40	IT	**Neelam Panwar** ARIES, Nainital	Multi-wavelength Studies of Young Star Clusters and HII regions
12:40–12:55	CT	**Ranjan Kumar** PRL, Ahmedabad	An investigation of the formation channels of blue straggler stars in the Galactic globular cluster M68
12:55–13:10	CT	**Harmeen Kaur** Kumaun University Nainital	Structural morphology and star formation scenario in young star clusters
13:10–14:30	**Lunch Break**		
14:30–18:00	**Open for Excursion**		
End of Day 3			

Day 4: Thursday, 11 January 2024

Session VIII. Magnetic fields in star-forming regions			
Chair: Jessy Jose			
09:30–09:50	IT	**Eswariah Chakali** IISER, Tirupathi	The interplay between magnetic fields, turbulence, and gravity and its significance

09:50–10:05	CT	**Piyali Saha** NAOJ, Japan	Magnetic Fields in Massive Star-forming Regions (MagMaR) unveiled by ALMA
10:05–10:20	CT	**Ram Kesh Yadav** NARIT, Thailand	Witnessing Star Formation in Galactic Bubble and Filamentary Systems
10:20–10:50	**Tea Break**		
Session IX. Extra-galactic star formation			
Chair: Soumen Mondal			
10:50–11:10	IT	**Mousumi Das** IIA, Bengaluru	The Rules of Star formation in Galaxies : from Small Scales to Large Complexes
11:10–11:30	IT	**Sreeja S Kartha** CHRIST, Bengaluru	Harmony of the Cosmos: unveiling the interwoven threads of star formation and galactic evolution in secular and environmental contexts
11:30–11:45	CT	**Ananta Charan Pradhan** NIT, Rourkela	Tracing star formation in void and filament galaxies
11:45–12:00	CT	**Susmita Barman** University of Hyderabad	Effect of high-mass stars on the properties of ISM in N44 of the LMC
12:00–12:15	CT	**Souvik Manna** SNBNCBS, Kolkata	Observation of Radio Continuum Halos of 8 Nearby Large Galaxies using uGMRT
12:15–13:00	**Discussion and Conclusion of the conference**		
	Chair: Devendra K. Ojha		
13:00–14:30	**Lunch Break**		
End of the conference			

List of Abstracts – Talks

Day 1: Monday, 08 January 2024

Session I: Star-forming Filaments

[S1-I01] **Disk-mediated accretion bursts in low- and high-mass young stellar objects**

Devendra K. Ojha IT

Tata Institute of Fundamental Research (TIFR), Mumbai

Understanding how stars form within the Universe is one of the fundamental questions in modern astrophysics and is central to many other fields. In this talk, I will briefly describe the current astrophysical understanding of the formation of low-mass (Sun-like) and high-mass ($>$ 8 Msun) stars out of the interstellar medium in the Milky Way, based on our long-term monitoring observations of a few rare type of eruptive young low-mass young stellar objects (e.g., FUors, EXors, etc) and from our ongoing investigation of high-mass star formation at the periphery of Galactic H II regions.

[S1-I01] **Role of filaments in the formation of stars in the NGC 2316 star cluster.**

***Saurabh Sharma**, Aayushi Verma, Kshitiz Mallick, Lokesh Dewangan, Harmeen Kaur, D K Ojha* IT

ARIES, Nainital

We present a multiwavelength detailed analysis of the star-forming region NGC 2316, showing signatures of recent star formation. We have performed a deep optical/NIR photometric analysis of this region. The archival MIR/FIR/radio data has been used to study the distribution of gas(cold/warm/ionized)/dust in the region. We have found a small elongated near-infrared cluster embedded in the nebulosity of this region. This cluster hosts a couple of massive stars (B1.5V) and YSOs, and is located at a distance of 1.3 kpc at the tip of a filamentary structure/dust-gas lane. Both ends of this filamentary structure/dust-gas lane host the core of YSOs. The nearby region of the cluster shows the signature of feedback from the massive star. We have studied the velocity/intensity profile of the molecular gas along the filamentary structures in the region and found evidence of two separate elongated filamentary structures interacting in the region. We have also found the longitudinal flow of matter along the network of filaments and towards the NGC 2316 cluster. Thus, the cluster might be a gravity well for the material and, is a site of recent massive star formation. The filaments also show the formation of low-mass YSOs along their structure. This confirms the active role of filaments in the recent star formation in the NGC 2316 region.

[S1-CO1] **Star Formation in Extreme Environments: A 200 pc High Velocity Cloud in the Galactic Centre**

***Veena V S**, W. Kim, P. Schilke, K. M. Menten, M. C. Sormani, W. E. Banda-Barragan, D. Riquelme, G. A. Fuller, F. Wyrowski, A. Sanchez-Monge* CT

Max Planck Institute for Radio Astronomy

The Galactic Centre (GC) is the most extreme environment in the Milky Way hosting high energy feedback processes and contains the central molecular zone (CMZ), the largest reservoir of molecular gas in the Galaxy. There exists an extended and high velocity molecular gas structure in the GC known as the 200 pc expanding molecular ring (EMR) believed to have its origins in the non-circular motions driven by the Galactic bar. Despite its significance, the EMR remains largely unexplored owing to the fact that many observational studies of the GC region do not extend enough in latitude or do not have the high sensitivity needed to detect low level emission. Using the SEDIGISM CO survey, we investigated the detailed kinematics of a giant filament within the EMR region. Our findings reveal intriguing signatures of cloud-cloud collisions with the CMZ, shedding light on the dynamic processes at play. Additionally, our detailed molecular line survey spanning the frequency range 30-350 GHz uncovers the rich chemistry within the filament. These molecular components hold the keys to understanding the complex chemical makeup of this unique region. The evidence of massive star formation within this high velocity (V_{lsr} >100 km/s) filament adds a new layer of complexity to our understanding of this enigmatic structure. This presentation will offer a comprehensive look at our findings, shedding light on a previously unexplored realm of our Milky Way.

[S1-CO2] **Exploring High-mass star formation at the junction of filaments in Sh2-112**

Kshitiz Mallick CT

Aryabhatta Research Institute of Observational Sciences, Nainital

Sh2-112 is an optically visible region powered by an O8V type massive star BD+45 3216, and hosts two interesting sources: G083.7962+03.3058 and G083.7071+03.2817, classified as H II region and young stellar object, respectively. ^{13}CO(3–2) channel map of the region shows the molecular cloud to have filamentary extensions directed away from the massive star, which also seems to be at the edge of a cavity like structure. Multiple molecular cloud protrusions into this cavity structure, host local peaks of emission. We present a brief overview of Sh2-112 region, using high resolution CO molecular transitions from JCMT archive, placing the results in the context of high-mass star formation at the junction of filaments.

[S1-C03] **G18.148–0.283: a case study of the cloud-cloud collisions as a mechanism for high-mass star formation**

Jyotirmoy Dey**,**Jagadheep D. Pandian, Dharam Vir Lal CT

IIST, Thiruvananthapuram

Understanding high-mass (M $\geq 8M_{\odot}$) star-forming regions is essential for gaining insights into the processes that shape galaxies and the origin of the most massive and influential stars in the universe. These regions are typically found within massive molecular clouds of cold, dense gas and dust. While both high-mass and low-mass star formation processes share commonalities, such as the role of molecular clouds as birthplaces, their formation processes differ drastically due to various reasons such as the deeply embedded locations, shorter life span, higher radiation pressure of high-mass stars, etc. Recently, collisions between molecular clouds have gained significant interest as one of the many formation processes of high-mass star-forming regions. These collisions involve the interaction of two distinct molecular clouds, often leading to the compression of gas and dust, which can trigger the formation of high-mass stars. Here, We present the results obtained from a multi-wavelength study of the high-mass star-forming region or H II region, G18.148–0.283, using the *upgraded Giant Metre-wave Radio Telescope* (uGMRT) at 1350 MHz along with other archival data. In this study, we have gathered enough evidence to suggest that this H II region is one of the sites of a cloud-cloud collision in our Galaxy, which includes the detection of a velocity gradient of approximately 10 km/s across the radio continuum peaks using spectral line (H169α and H170α) observations. This finding again matches with the ^{12}CO (J=3–2) molecular line data from the COHRS survey, which reveals the presence of two velocity components corresponding to two distinct molecular clouds. Moreover, we have observed mid-infrared absorption and far-infrared emission, establishing the presence of a filamentary infrared dark cloud, the extent of which includes G18.148–0.283.

[S1-C04] **Origin of Hub-Filament Systems through Cloud-Cloud Collision**

***Arup Kumar Maity*, Prof. Yasuo Fukui, Mr. Rin Yamada, Dr. Hayakawa Takahiro, and Dr. Lokesh Dewangan**

CT

Physical Research Laboratory

While massive star-forming regions (MSFRs) are commonly associated with hub-filament systems (HFSs) and the sites of cloud-cloud collision (CCC), the connection between HFS and CCC has been notably absent in the existing literature. Our recent investigations on Galactic MSFRs, such as the W31 complex and AFGL 5180, have revealed concurrent indications of HFSs and CCCs, suggesting the intriguing possibility that CCCs may play a role in forming HFSs. In this context, we conducted an extensive examination of a shock-compressed layer, utilizing numerical magneto- hydrodynamic simulations data from Inoue et al. 2018, 70(SP2), S53(1-11). These simulations involve the collision of molecular clouds at a relative velocity of approximately 10 km/s with a spatial resolution of roughly 2500 AU. Our preliminary findings indicate the expansion of the shock-compressed layer in terms of increased width and density over time. Following the collision, the turbulent and non-uniform cloud undergoes compression due to the shock wave and magnetic fields, resulting in the rapid development of filamentary structures within the compressed interface. We observed the emergence of a complex network of filaments with multiple junctions, becoming more concentrated toward the central region in the later stages of the evolution. Interestingly, filament collisions are unlikely to be responsible for forming hub-filament systems in our current setup. Furthermore, gravity, while not the exclusive driving force behind the formation of this intricate network of filaments, plays a significant role in increasing the line-mass of the filaments and the total mass of the hubs. This effect, in turn, promotes the formation of massive stars. As a result, our initial observations suggest that a combined influence of turbulence, gravity, and magnetic fields within colliding clouds contributes to creating HFSs and, subsequently, the birth of massive stars. During this presentation, I will share these early research outcomes.

[S1-CO5] **Investigating the Earliest Stages of High-Mass Star Formation**

Sonu Tabitha Paulson ***,K.K. Mallick and D. K. Ojha*** CT

Tata Institute of Fundamental Research, Mumbai

High-mass stars play a critical role in shaping the evolution of galaxies, as they enrich the interstellar medium through stellar winds and supernovae. Understanding the formation of these stars is vital for refining models of galaxy formation and evolution. To shed light on the early stages of high-mass star formation, we can utilize interstellar masers, particularly the class II methanol masers at 6.7 GHz, which are exclusively observed in massive star-forming regions. Our study focuses on exploring the various aspects of massive star formation using 6.7 GHz methanol masers as indicators. Firstly, we employ maser emissions to study star formation on larger scales. Since 6.7 GHz masers are associated with early stages of high-mass star formation, searching for regions abundant in these maser detections, allows us to investigate relatively young star-forming sites. We analyse such a star forming region-Bubble N59- which harbours almost 8 6.7 GHz methanol masers, numerous compact HII regions, massive clumps, filaments, and bright rims. To characterize the N59 region comprehensively, we utilize multiwavelength data obtained from various surveys. Our molecular study uncovers two distinct molecular clouds in the region, which, although spatially close, occupy different regions in velocity space. We also propose that the feedback from the H_{II} regions has led to the formation of prominent Bright Rimmed Clouds (BRC) within our region of interest. Secondly, we investigate how massive stars gain mass by analysing maser bursts. Since there has been strong evidence that maser flares are driven by accretion bursts, tracing for maser flaring events helps us track the episodic accretion in massive stars. We present the case of the most recent maser flaring event associated with G23.39+0.19 and the follow up observations using Indian facilities such as TIRSPEC and TANSPEC to study the associated massive young stellar object and determine whether the maser flares are indeed linked to accretion burst.

[S1-C06] **Multiwavelength investigation of the star-forming complex G12.79+0.43**

Arun Seshadri ***,Sarita Vig, Veena V S*** CT

Indian Institute of Space Science and Technology (IIST)

We present a multi-wavelength investigation of the region towards RCW 155, spanning $24' \times 24'$. The optical image towards this region shows nebulae towards the west, east and south, also seen as bright emission in mid-infrared Spitzer images. The far-infrared emission mapped using Herschel images show filamentary structures towards the centre, as well as emission in the periphery. Column density and dust temperature maps have been generated by pixel-by-pixel fitting of the modified blackbody function to the far-infrared spectral energy distribution. The column density is seen to be lying within the range $6.5 \times 10^{19} - 7.3 \times 10^{22}$ cm^{-2}, while the dust temperature is seen to be within 15 – 28 K. Two IRAS objects 18092-1742 and 18090-1732 lie to the south and north respectively, towards which the infrared emission is seen to peak. The molecular line analysis using ^{13}CO and C^{18}O data from the SEDIGISM survey indicate the presence of two prominent cloud components along the line of sight. Radio interferometry observations were carried out for the region from GMRT in band-4, which shows the presence of faint nebulous emission towards the central region. In addition, we observe radio emission from the H$_{\text{II}}$ regions associated with the IRAS sources. By assimilating these results, we aim to decipher the intricate star formation process in the region, shedding light on the potential triggered star formation.

[S1-P01] **Kinematical study of high-mass star formation in Hub-Filament systems**

***Saurav Sen**, Bhaswati Mookerjea, Rolf Guesten, C. H. Ishwara Chandra* **PS**
TATA INSTITUTE OF FUNDAMENTAL RESEARCH, MUMBAI

Current observation suggests that star formation occurs along ubiquitus filaments, with massive stars forming in the densest regions where several filaments converge, called hubs. Identification of such hub-filament systems (HFSs) in the large-scale survey observations followed by a methodical analysis of the dynamics of the molecular material is a robust approach toward the study of the formation of massive young stellar objects. We present the results of our recent study of the dust continuum, molecular line and radio continuum emission from an HFS identified in Herschel 250 micron images. The newly obtained GMRT data at 750 and 1260 GHz suggest the presence of three intensity peaks that match well with far-infrared sources in Herschel dust continuum maps. The observed radio continuum flux from the H II region indicates the presence of massive young stars, O8.5V or later, establishing the region as a site for massive star formation.To understand mass accretion and the role of filaments in forming massive stars within the hub, we observed the J=2-1 transition of CO and its isotopes using the APEX Chile. The column density map from dust continuum and integrated C^{18}O(2–1) emission are consistent, showing N(H$_2$) values of $\sim 10^{23}$cm^{-2} toward the hub. CO data unveil a complex velocity structure with multiple overlapping components. To identify velocity-coherent structures (filaments), we decomposed spectra into Gaussian components at all positions and grouped them in position-position-velocity space using a friends-of-friends algorithm. Analysis of velocity gradients along the identified velocity-coherent filaments reveals signatures of mass accretion, consistent with other massive star-forming HFSs.

[S1-P02] **Evidence of Global Hierarchical Collapse towards Hub-Filament System Sh2-87**

Siddhartha Biswas ***,Soumen Mondal, Ariful Hoque, Alik Panja, Tapas Baug, Ramkrishna Das*** PS

S.N.Bose National Centre for Basic Sciences

Hub-filament systems (HFSs) are considered as one of the potential birthplaces of massive stars ($\geq 8M_{\odot}$) and young star clusters and they serve as the best laboratory to investigate the primitive phases of star formation. Here, we present a comprehensive multi-wavelength study on the star formation activity in the H II region Sh2-87. From the Herschel column density map, it was found that the host cloud is filamentary in nature, and together they formed a central dense hub. The extinction map generated using near-infrared photometric data and the SCUBA Map (850 μm) implies the non-uniform distribution of the cloud. The extinction map is strongly correlated with the column density map. From various color-color diagrams, we identified 13 Class I and 202 Class II sources, and 22 Hα emitting sources in this region. From the color-magnitude diagram, their average age is estimated as 3 Myr with masses in the range of 0.1 to 6.0 $M_{\odot}$. The identified evolved young stellar objects (YSOs) i.e., Class II sources are incipiently aligned along the filaments and in the outer parts of the cloud whereas the evidence of recent star formation, i.e. the presence of Class I YSOs, ionized gas and star-forming clumps, is observed in the hub region. Hence the overall star formation scenario in the Sh2-87 region corresponds to the Global Hierarchical Collapse model of star formation.

[S1-P03] **Multiwavelength Investigation of Star Formation activity towards the Galactic Cloud G13.89-0.47**

***Sangeetha K K**, Dr. VEENA V S* PS

University of Kerala Kariavattom campus

It is still unclear how the physical processes that lead to the formation and evolution of massive stars work. Despite the fact that there are countless research and surveys that have examined the chemistry and physical conditions of a large sample of high mass star forming regions. The main advantage of studying individual regions is that, unlike large surveys that only glance at a few general characteristics of these regions, it allows one to fully understand the various aspects of a given region, such as the star formation activity, physical characteristics, chemistry, kinematics, etc. We use multiwavelength observations from infrared to radio wavelengths to comprehend many aspects of massive star formation since our goal is to understand the star formation activity. METHOD: we start our study with warm dust emission towards this region because IRDCs have been found to be dark structures against nebulous mid-infrared emission. We analyze YSO population and its distribution across the cloud and finally the distribution of ionized gas emission is analyzed to identify the locations of star-forming flurries. we have constructed a ratio map of [4.5 μm /3.6 μm]. The [4.5]/ [3.6] ratio map towards the source. To locate YSO sources we employed the [5.8]- [8.0] versus [3.6]- [4.5] color-color diagram for the sources detected in all IRAC bands. To get an idea about massive stars around the region, G13.89-0.47 we used radio continuum image from NVSS survey. RESULTS From the mid infrared maps we could see the bright emission at the centre surrounded by dark patches in 3.6 and 4.5 μm image clearly; and those dark patches represents infrared cloud. Moreover, there are more point sources can be found in 3.6 and 4.5 μm as they are shorter wavelengths and hence represents emission from warmer dust and from stellar photosphere of main sequence stars instead of 5.8 and 8.0 from which only warmer dust emission can be seen. There is flux ratio excess towards the centre of the region. The morphology is arc like structure. So, this could indicate the presence of protostellar outflows. Also, we can infer that the [4.5]/ [3.6] ratio is $\sim$1.5 or larger for jets and outflows, whereas outside this region infrared average flux ratio is in the range of 1 like stellar sources. Here among the spitzer source G13.89-0.47, we find that 414 sources are detected in all four IRAC bands. from the color–color diagram, a total of 56 YSO candidates are detected. Of these, 23 are Class I sources, 16 are Class II sources, and 17 are reddened Class I /II sources. Lymann continuum photon rate shows that the region contains a B0.5 Star. CONCLUSION In this work we have investigated the star formation activity in the region G13.89-0.47 located at a distance of 1.9 kpc. Here we used different data sets obtained from various archives as well as the techniques used to study star formation in the region. Data's associated with study collected from spitzer space telescope and NVSS survey. Here we have used continuum archival data at infrared and radio bands. As a continuation of the thesis work, we intend to use spectral line data to investigate the structure and kinematics of the molecular cloud associated with this region and to extend our study into a large region.

[S1-P04] **Exploring the Dynamics of a Hub-Filament System in the Region G41.194-0.163**

***Shehu Usman Muhammad**, Dr. Tapas Baug* PS

S.N. National Centre for Basic Sciences, Kolkata, India

We have identified a hub-filament system associated with the formation of massive stars in a region located at a distance of 4.5 kpc, with coordinates of longitude 41.194 and latitude -0.1632. Through simultaneous observations of ^{12}CO, ^{13}CO, and C^{18}O lines, the region contains two main velocity components. The first component reveals the presence of four distinct and elongated filaments converging at a hub, with velocities between 50 and 70 kms^{-1}. The second component, at approximately 78 kms^{-1}, also shows hub-filament structures, each characterized by separate velocity components. The observed velocity gradient in the system indicates a global gas motion, with an increasing velocity dispersion towards the hub, suggesting the presence of turbulence. In the Herschel column density N(H_2) map, filaments with higher aspect ratios (length/diameter) and lower N(H_2) values ($\sim 1 - 2.4 \times 10^{22} cm^{-2}$) are identified, while the central hub exhibits a lower aspect ratio and higher N(H_2) values ($\sim 3.5 - 6.010^{22} cm^{-2}$). The hub also contains the 6.7 GHz methanol maser. Utilizing Spitzer and UKIDSS photometric data, we have identified infrared-excess young stellar objects (YSOs) and observed their groups transitioning from Class I to Class III.

Session II: Interstellar Medium and Feedback

[S2-I01] **PDRs: The irradiated neutral ISM**

Bhaswati Mookerjea **IT**
Tata Institute of Fundamental Research, Mumbai

Feedback of massive stars on their environment regulates the physical conditions and sets the emission characteristics in the interstellar medium (ISM), influences the star formation activity through molecular cloud dissolution and compression processes, and drives the evolution of the ISM in galaxies. The massive stars control the radiative energy budget of the ISM and its emission characteristics, with the extreme UV photons forming HII regions and the far-UV photons creating Photo Dissociation Regions (PDRs), a layer of warm, atomic and molecular gas that separates the ionized gas from the surrounding molecular cloud material. Thus, the photodissociated gas bears the signature of the dynamical evolution of the ambient interstellar medium impacted by the mechanical and radiative feedback due to the massive stars. In this talk, I will present some results from our studies of Galactic PDRs using the fine-structure transitions of singly ionized carbon at 158 micron and atomic oxygen at 63 and 145 micron, that reveal a three-dimensional view of the PDRs. While the [CII] and [OI] lines have been used for studying the PDRs for quite some time, this talk will show how the availability of velocity-resolved spectra has changed the narrative recently.

[S2-I02] **Rocket effect in molecular clouds near O-type stars**

Maheswar Gopinathan **IT**
IIA, Bengaluru

The effect of ionizing radiation from O-type stars on the surrounding ISM has been subject to several pioneering works in which the “rocket effect” of the asymmetrically off-streaming gas would cause a small cloud to accelerate away from the ionizing source while losing mass. In my talk, I will discuss evidence of the rocket effect in molecular clouds near massive stars and its implications in star formation in and around HII regions.

[S2-C01] **Fire burn, and cauldron bubble: Missing supernova remnants and prospect of detecting them at low radio frequency**

Nirupam Roy

CT

IISc

Apart from influencing the ISM properties, supernovae and supernova remnants are closely related to the star formation process in a galaxy. The (core collapse) supernova rate is directly related to the number of massive stars, and hence the star formation in a galaxy. The feedback from supernova explosions, on the other hand, may as well affect the star formation rate in a galaxy by compressing and cooling the gas. There is a clear difference between the number of observed and expected supernova remnants in our Galaxy, giving rise to the missing supernova puzzle. In this talk, I will present some interesting results related to this discrepancy based on recent radio surveys of the Galactic plane as well as multiwavelength data. I will discuss prospects of low radio frequency imaging and polarimetry to get a consensus on the Galactic supernova remnant population from a low frequency survey of the Milky Way Galactic plane, and present the results from the recent pilot observations of the Metrewave Galactic Plane with the uGMRT (MeGaPluG) Survey.

[S2-C02] **Observational search of PAHs footprints using SUBARU/COMICS telescope**

***Mridusmita Buragohain**, Takashi Onaka, Itsuki Sakon, and Amit Pathak* **CT**
UNIVERSITY OF HYDERABAD

Polycyclic Aromatic Hydrocarbons (PAHs) have found a noteworthy place in the family of possible interstellar organics as revealed by their spectral footprints, particularly observed in the mid-infrared wavelength range starting from 3 to 20 μm (Allamandola et al., 1989; Tielens, 2008; Li, 2020). The observed emission bands in these wavelengths are popularly known as "Aromatic Infrared Bands (AIBs)" as suggested by nature of the carriers. PAHs are mostly apolar or weakly polar, hence rotational spectroscopy, which is the usual method of identification of a molecule, is rather difficult. The nearest comparable confirmed species to PAH is benzonitrile (c-C6H5CN), which was detected through rotational transitions, and may be considered as a precursor for PAH formation in the ISM (McGuire et al., 2018). A recent detection of two isomers of small PAHs (naphthalene) with a CN group by McGuire et al. (2021) have encouraged the community to search for more varieties of PAHs and their characteristic features. PAH features may vary in terms of width, intensity and profile from one astronomical source to another. In this work, I am discussing PAH features observed towards MWC1080 (A Herbig Ae/Be star) obtained using SUBARU/COMICS that operates in the wavelength range of $\sim$ 7-25 μm. Spatially resolved features extracted from different sections of the target have been discussed here and any variations in PAH features have been looked for. These kind of observations help to prioritise goals for the very powerful James Webb Space Telescope (JWST) that offers higher sensitivity as well as resolution and could be used to make powerful observations, which are unattainable by previous observations.

[S2-C03] **Exploring Stellar Cluster and Feedback-driven Star Formation in the Galactic Midinfrared Bubble [HKS2019] E70**

Aayushi Verma ***,Saurabh Sharma, Kshitiz K. Mallick, Lokesh Dewangan, Devendra K. Ojha, Ram Kesh Yadav, Rakesh Pandey, Arpan Ghosh, Harmeen Kaur, Neelam Panwar, and Tarak Chand*** CT

Aryabhatta Research Institute of Observational Sciences (ARIES), Nainital

We will comprehensively analyze the Galactic mid-infrared bubble [HKS2019] E70 (hereafter E70) with a multiwavelength approach to understand its physical environment and star formation scenario. A small (radius $\sim$1.7 pc) stellar cluster inside the E70 bubble was spotted, and its distance is estimated as 3.26 $\pm$ 0.45 kpc. This cluster is found to be embedded within the molecular cloud and hosting massive stars and young stellar objects (YSOs), pointing towards the ongoing active star formation in the region. The spectral type of the brightest star (hereafter M1) of the E70 cluster is estimated as O9V and a circular ring/shell of gas and dust is identified around it. The diffuse radio emission inside this ring/shell, the excess pressure exerted by the massive star M1 at the YSO's core, and the distribution of photodissociation regions, a class I YSO, and two ultracompact H II regions on the rim of this ring/ shell suggest positive feedback of the massive star M1 in the region. A low-density shell-like structure in the ^{12}CO(J = 1—0) was identified in the molecular emission along the perimeter of the E70 bubble. The velocity structure of the ^{12}CO emission suggests that the feedback from the massive star appears to have expelled the molecular material, and the subsequent swept-up material appears as the E70 bubble.

[S2-C04] **The role of metallicity on the mass-luminosity conversion factor derived from dense gas**

Sudeshna Patra ***,Neal Evans, Jessy Jose***

CT

IISER Tirupati

Metals are ubiquitous in the present-day interstellar medium, throughout the galaxies and play a crucial role in shaping the destiny of fundamental processes in star formation, such as gas cooling, condensations, fragmentations, stellar evolution, and dust formation. The radial gradient of metallicity in the Milky Way results in a decrease in the abundance of metals towards the outer regions, rendering it a suitable model for low metallicity galaxies. There is increasing acknowledgement that the conversion of CO luminosity into mass is not expected to be uniform in all environments, and a major contributor to the difference in the conversion factor is the variation in metallicity. Also, the role of traditional dense gas tracers (HCN, HCO+) in the extreme environments is one of the interesting topics in astronomy. However, the effect of metallicity on the mass-luminosity conversion factor from dense gas (HCN, HCO+) is still unexplored. While studies of nearby galaxies with low metallicity are used to understand these facts, the outer Galaxy is closer and offers clearer observations of molecular clouds. Therefore, it serves as a bridge between studies of star formation within our Galaxy and beyond. We aim to study this aspect in the Milky Way, we have selected total 18 outer Galaxy clouds (among them 7 clouds are previously studied by Patra et al. [2022]), and combine those with 6 inner Galaxy clouds studied by Evans et al. [2020], and 2 Solar neighborhood clouds Orion A, Ophiuchus studied by Yun et al. [2021]. This combined sample provides a statistically significant number for comparing environments within the inner and outer Galaxy, as well as the solar neighborhood. We are using the molecular data (HCN, HCO+, ^{13}CO, ^{12}CO) from TRAO and FCRAO telescopes, and 1.1 mm dust continuum emission from BGPS. We have incorporated metallicity correction in the mass estimation processes, utilizing both the hydrogen column density map and analysis derived from BGPS. We have found a clear trend that L(HCO+)/L(HCN) is increasing towards the low metallicity region, this result is consistent with the results from LMC studies. In our preliminary findings, we observed that the mass-luminosity conversion factor for HCN is three times higher in the Outer Galaxy compared to the Inner Galaxy when correcting for metallicity in the estimation of dense gas mass.

[S2-P01] **Optical and Near IR Spectroscopic study of five Carbon Rich Planetary Nebulae using TANSPEC and TIRSPEC**

Atul Kumar Singh*, *Rahul Anand*, *Arpan Ghosh*, *Saurabh Sharma*, *Shantanu Rastogi

PS

Deen Dayal Upadhyaya Gorakhpur University

Using TANSPEC and TIRSPEC, we have obtained spectrum of 5 Planetary Nebula. TANSPEC is optical to near infrared spectrograph having spectral coverage from 0.55 to 2.5 microns, were as TIRSPEC is infrared spectrograph having spectral coverage of 1 to 2.5 microns. We have analyzed line profile of the source and compared with previously published spectra of these objects. Comparing the line profile shapes with the existing theoretical predication, we have tried to interpret the physical processes that are responsible for the current evolution of these objects.

Session III: Planet formation and Exoplanets

[S3-I01] **Discovery of two exoplanets with extreme densities with PARAS: TOI4603b and TOI1789b**

Abhijit Chakraborty IT

PRL, Ahmedabad

I discuss the curious cases of two exoplanets TOI4603b and TOI1789b with nearly similar radii but opposite extreme densities, one is of about 14g/cc while the other is about 0.3g/cc respectively. Both were TESS candidates and were finally discovered by PARAS coupled to the PRL 1.2m telescope at Mt.Abu, India.

[S3-I02] **Proto-planetary disk evolution: Role of external factors**

Jessy Jose IT

IISER-Tirupathi

Proto-planetary disks around young stellar objects are the building blocks of planets and is one of the fundamental outcomes of the star formation process. The evolution of proto-planetary disks is known to be largely depend on the environmental factors such as the external UV radiation field, underlying stellar density and metallicity. In this talk, I will present our recent analysis of proto-planetary disk properties of a large number of star-forming regions evolving under diverse environmental conditions using high sensitive observations. Our deepest survey samples a large population of young stellar objects of wide stellar parameters such as extreme low-mass brown-dwarfs, broad metallicity range and extended evolutionary time scale of up to 100 Myr. Various evolutionary aspects and the role of environmental factors will be discussed.

[S3-I03] **Constraining the initial conditions for the formation of extra-solar planets and their atmospheres**

Liton Majumdar IT

National Institute of Science Education and Research (NISER), Bhubaneswar, Odisha 752050, India

One of the most exciting developments in astronomy and astrophysics is the discovery of planets around stars other than our own Sun, termed as 'Exoplanets.' The discoveries of these exoplanets have unveiled astonishing diversity in their physical characteristics, including masses, temperatures, radii, orbital properties, and their host stars. Protoplanetary disks serve as the sites where these exoplanets form. Observations of these sites, where exoplanets are born, reveal a wide range of temperatures, densities, and the distribution of various molecules. The Atacama Large Millimeter/submillimeter Array (ALMA) has ushered in a new era in the study of protoplanetary disks, enabling us to explore the physics and chemistry of the outer regions of these disks. With the arrival of the James Webb Space Telescope (JWST), we can now delve much deeper into the inner regions of the disks and also investigate icy volatiles in colder regions. The combined contributions of these two instruments can provide us with greater clarity on the formation of exoplanets and the chemical inventory they inherit from protoplanetary disks. Here, I will introduce how modeling and observing protoplanetary disks can bridge the gap between our theoretical understanding of exoplanet formation and its connection to atmospheres.

[S3-C01] **The Search for Planet around LkCa 15 protoplanetary disk**

Swastik Chowbay[1]**, *Myriam Benisty*[2] *Zahed Wahhaj*[3] *Saksham Arora*[4]** CT

[1]Indian Institute of Astrophysics
[2]Institut de Planetologie et d Astrophysique de Grenoble, France
[3]European Southern Observatory, Chile
[4]University of Potsdam, Germany

In this study, we present K-band imaging and polarimetry of the young disk system, LkCa 15. Leveraging near-simultaneous reference star difference imaging, or "star-hopping," we unveil the true intensity of the disk without the interference of self-subtraction effects for the first time. Our primary objectives are to identify potential new giant planets beyond 0.1″ separations and to analyze the disk's morphology to understand its interactions with the existing planets. Through radiative transfer modeling, we align the near-infrared imaging with polarimetric data and further integrate sub-millimeter imaging data from ALMA. We model our LkCa 15 portoplanetary disk using three grain components consisting of submicron, micron and sub-millimeter sized grains. Our results indicate a highly flared region in the inner-part of the disk with notable features with a very strong forward scattering. We also analysed the K-band inverse polarimetric map, no new planets were found outside of a 12 au separation.However, based on contrast curve estimates, we have established an upper mass limit for potential companions that might be present in LkCa 15. In conclusion, we are able to constrain the disk morphology using the three component radiative transfer modelling and also estimate the upper limits for the companion mass that might be present in this system at different separations from the host star.

[S3-P01] **Physics and Chemistry at Planet-forming Scales: The Ringworld Revisited**

Parashmoni Kashyap**, **Liton Majumdar, Anne Dutrey, Stéphane Guilloteau **PS**
National Institute of Science Education and Research (NISER), Bhubaneswar

Exoplanets form and acquire their compositions within disks around young stars, and the outcome of this process is intimately linked to the chemistry and structure of the disk. The midplane of the protoplanetary disk is the region where exoplanets are born. However, tracing the midplane region is challenging due to very high density and opacity. Through high-resolution and highly sensitive observations from the Atacama Large Millimeter/submillimeter Array (ALMA), we have, for the first time, resolved molecular emissions from regions closer to the midplane of the GG Tau A protoplanetary disk, renowned for its spectacular ring of dust and gas. Utilizing ALMA band 7 molecular line observations of N2H+ and DCO+, alongside state-of-the-art in-house disk modeling packages, we have constrained the CO snowline and the location of the midplane. Our results show that we have detected strong emissions from the molecules N2H+ and DCO+. The best-fitting models suggest that N2H+ emission comes from a region much closer to the midplane than DCO+ emission. The radial distribution of N2H+ emission is characterized by a single Gaussian structure. In contrast, DCO+ emission exhibits a double Gaussian structure, implying that some emissions originate from the midplane, while others come from the intermediate layer of the protoplanetary disk. Additionally, we have successfully constrained the CO snowline to be around 250 AU. These new constraints on the location of the mid-plane of the GG Tau A disk help us in understanding planet-forming scales in ringworlds.

[S3-P02] **Physical properties and composition of dust in protostellar envelopes: insights into star and planet formation**

Rupam Kundu**, **Himanshu Tyagi**, **Mayank Narang**, **Bihan Banerjee**, **Manoj Puravankara

PS

Indian Institute of Science Education and Research Berhampur

Protostars, the earliest phases of star and planet formation, serve as natural laboratories, offering insights into the processes that shaped our solar system. This phase involves the condensation of interstellar dust and gas into stars and planets. However, the dust within our solar system's planetary bodies exhibits distinct physical and chemical properties compared to the interstellar medium (ISM). Unraveling the evolutionary journey of dust—when and how it evolves—remains a fundamental inquiry. The protostellar phase is the most important phase in the accretion processes and it sets the initial conditions for planet formation. The envelope of a protostar contains different types of materials, among which the silicates are one of the most important, which in turn play a significant role later during the formation of the planetary system around the central star. We have analysed the Spitzer IRS spectra of several hundred protostars from the nearby ($>$500 pc) star forming regions to study composition and physical properties of various dust species by modelling the silicate spectral features at 10 and 20 micron. Additionally, we explore the influence of protostellar evolution, luminosity, and environmental factors on the dust properties and composition. We will present our results and discuss the future implications of our findings for the understanding of stellar and planetary system formation.

[S3-P03] **Unveiling the Atmospheric Secrets of Super-Earth Exoplanets in the JWST Era**

Priyankush Ghosh **, *Liton Majumdar*** PS

National Institute of Science Education and Research, Bhubaneswar

Until recently, we have been able to discover a whole realm of planetary diversity with the detection of planets beyond our solar system. With the advent of the James Webb Space Telescope (JWST), we have entered a new era in which we are not only confined to detect exoplanets but also characterize their atmospheres, which is a crucial step in understanding the formation of the solar system itself. In this talk, I will discuss Nitrogen and Sulfur based chemistry of an ultra-short-period exoplanet 55 Cancri e, which is currently a JWST GO target. I will introduce our state-of-the-art forward model which couples radiative transfer under radiative-convective equilibrium with photo-chemical kinetics and explains the constraints on the physical structure of the atmosphere and its chemistry due to variation of initial elemental abundances and eddy diffusivities. This would further be complimented by the simulated transmission and emission spectra of the atmosphere of 55 Cancri e and the potential detectability of its modeled spectroscopic signatures. Having the information on the composition would tell us the possible location and environment in which such types of planets are likely to have formed. These studies will be helpful in: (1) guiding the future observers to interpret the physics and chemistry of exoplanet atmospheres, (2) assessing the type of exoplanets to look for when searching for particular atoms/molecules, and (3) determining the type of systematics a telescope would need for observing particular spectroscopic features.

[S3-P04] **From Protoplanetary Disks to Sun-like Planetary Systems: The Cosmic Tale Unveiled Using C/O and Isotopic Ratios**

Prathap Rayalacheruvu **,** ***Liton Majumdar*** **PS**

National Institute of Science Education and Research, Bhubaneswar

Protoplanetary disks are the birthplaces of planets like our Earth. Understanding the physical and chemical processes in disks help us understand the planet-formation processes. Isotopic studies of the solar system objects and other star and planet-forming regions unveil a new picture of the evolutionary processes undergone by planetary bodies right from the molecular clouds to planetary systems like our solar system. Also, the chemical gradients of C/O ratios observed in disks offer an explanation about the formation pathways and chemical inventory available for planets like gas giants. The observational data from facilities like Atacama Large Millimeter/submillimeter Array (ALMA), Square Kilometre Array (SKA) and James Webb Space Telescope makes it possible to measure isotopic abundances and C/O ratios in disks that are in various stages of their evolution, thanks to the high sensitivity observations. To understand how planetary bodies acquire such specific composition and how they evolve spatially and temporally more in detail, we require gas-grain chemical models that are coupled with radiative transfer. In this talk, we will showcase a state-of-art gas-grain chemical code that models the chemical ratios of H, C, O and N including their isotopes measured in different planetary bodies of our solar system and in other planetary systems. We will also show the possibility to constrain planetary formation and evolution using measured and modeled isotopic ratios.

Day 2: Tuesday, 09 January 2024

Session IV. Star formation at high resolution

[S4-I01] Perspectives on high-mass star formation: Results from the ATOMS survey

Anandmayee Tej IT

Indian Institute of Space Science and Technology, Trivandrum

The ATOMS (ALMA Three-millimeter Observations of Massive Star-forming regions) survey has observed a large sample of active star-forming regions with ALMA. With high-resolution and sensitivity, the continuum and molecular line data have revealed many interesting results that have deepened our understanding of high-mass star formation. The talk will give a brief overview of the survey and discuss some of the interesting results published.

[S4-I02] Unearthing the hidden structures in star-forming regions: Results from JWST

Lokesh Kumar Dewangan IT

Physical Research Laboratory

High-resolution and high-sensitivity near-infrared (NIR) and mid-infrared (MIR) observations from the James Webb Space Telescope (JWST) allow the study of the dust and gaseous structures around embedded protostars. This can enable us to gain a better understanding of physical processes taking place in star-forming sites. The existing JWST infrared images (resolution $\sim$0.07-0.7 arcsec) have been examined to study the bubble wall of NGC 3324, an ionized knot HH 216 in the Eagle Nebula (M16), and the massive protostar G11P1 in Galactic 'Snake' IRDC G11.11-0.12. The analysis of the JWST images along with the other multi-wavelength data has revealed several new findings in these sites. Our findings include the discovery of intertwined/entangled sub-structures towards the bubble wall of NGC 3324 below a physical scale of 4500 AU. High-resolution images reveal entangled ionized structures (below 3000 AU) of HH 216. Hierarchical structures in G11P1 are inferred in the Atacama Large Millimeter/submillimeter Array (ALMA) 1.16 mm continuum map and the JWST images. For the first time, the JWST infrared images reveal one infrared-dark hub-filament system candidate (extent $\sim$0.55 pc) around G11P1. The important findings and their implications for understanding the ongoing physical processes in the sites will be presented in the talk.

[S4-I03] **Investigating Protostellar Accretion and Outflow: JWST NIRSpec and MIRI IFU Mapping of Young Protostars Across the Mass Spectrum**

Manoj Puravankara IT

TIFR, Mumbai

The Investigating Protostellar Accretion (IPA) is a medium-sized cycle 1 GO program that has obtained NIRSpec and MIRI MRS IFU observations of five deeply embedded protostars with luminosities ranging from 0.2 to 10000 $L_{\odot}$ and masses of 0.12 to 10 $M_{\odot}$. We will present our program's complete dataset for all five sources for the first time: NIRSpec and MIRI MRS spectral imaging in the 2.9-28 micron range, with a spectral resolution of R $\sim$ 1000-3000 and a spatial resolution down to scales as small as 30 au. Our infrared spectral (line and continuum) maps with exquisite spatial resolution reveal previously unseen details of the interaction between accretion-driven jets and outflows and the innermost envelope of the protostars. Collimated ionic (seen in [Fe II], [Ne II]) with velocities $\sim$100 km/s are detected in all sources. We report the discovery of collimated jet in the lowest mass and luminosity source, even in the quiescent accretion phase, with a measured accretion rate of $\sim 10^{-9}$ $M_{\odot}$/year and an associated mass loss rate of $\sim 10^{-10}$ $M_{\odot}$/year. Some of the outflow knots show emission from CO and H2, indicating the presence of molecules in primarily atomic/ionic jets. Gas phase CO emissions appear to arise from jet/outflow shocks, in addition to inner protostellar disks. Cavity walls are well delineated in scattered light; interestingly, wide-angled outflows traced by molecular hydrogen show opening angles much smaller than that of the cavity walls, suggesting they are well inside the cavity. The composition and the spatial distribution of various ice species in the higher luminosity sources show evidence for thermal processing. We will discuss how the measured properties of the jets and outflows and their interactions with the protostellar stellar environment vary based on protostellar mass and luminosity.

[S4-I04] **The physics of high-mass star formation: a fragmentation study of ATLASGAL dust clumps**

***Jagadheep D. Pandian*, R. Chatterjee, T. Csengeri, J. P. Williams, F. Wyrowski and K. M. Menten**

IT

Indian Institute of Space Science and Technology (IIST)

The rarity of high-mass star forming regions, the rapid timescale for high-mass star formation and the clustered environment in which they form makes the study of high-mass star formation more difficult compared to low-mass counterparts. The smaller number of high-mass star forming regions has the additional effect of larger distances to these regions, requiring observations of high angular resolution and sensitivity to study these regions. The completion of unbiased surveys of the Galactic plane from submillimeter to mid-infrared wavelengths has revolutionized observational studies of high-mass star formation. The spectral energy distributions of the sources from submillimeter to mid-infrared can be used to identify high-mass star forming cores at different evolutionary stages. In this talk, I will discuss the study of fragmentation of high-mass clumps selected from the ATLASGAL survey by observing them at high angular resolution using the Submillimeter Array. The observed properties of fragmentation can help discriminate between the two leading theories of high-mass star formation, namely core accretion and competitive accretion. The core accretion theory postulates that massive stars form from individual high-mass cores with there being a direct relation between the mass of the core and that of the star. In contrast, according to the competitive accretion theory, a high-mass clump fragments into a large number of Jeans mass fragments followed by competitive accretion of gas from the clump reservoir. The results of the study of fragmentation of ATLASGAL clumps casts doubt on the initial fragmentation as predicted by the competitive accretion theory.

[S4-I05] **Episodic Accretion in Protostars - An ALMA Survey of Molecular Jets in the Orion Molecular Cloud**

Somnath Dutta IT

Indian Institute of Space Science and Technology (IIST)

Protostellar outflows and jets are almost ubiquitous characteristics during the mass accretion phase, and encode the history of stellar accretion, complex-organic molecule (COM) formation, and planet formation. Episodic jets are likely connected to episodic accretion through the disk. Despite the importance, the studies on episodic accretion and ejection links have not been done yet in a systematic fashion at high-sensitivity and high-resolution observations. To explore episodic accretion mechanisms and the chronologies of episodic events, we investigated 42 fields containing protostars with ALMA observations of CO, SiO, and 1.3 mm continuum emission. We detected SiO emission in the 50% fields, where majority of them are driving confirmed molecular jets with high abundances of SiO. Jet velocities, mass-loss rates, mass-accretion rates, and periods of accretion events are found to be dependent on the driving forces of the jet (e.g., bolometric luminosity, envelope mass). We determine mean periods of ejection events of 20-175 years for our sample, which are likely anti-correlated with the envelope mass. The observed periods of outburst/ejection are much shorter than the freeze-out time scale of the simplest COMs like CH_3OH, suggesting that episodic events could affect the ice-gas balance inside and around the snowline.

[S4-C01] **Study of possible glycine precursor molecules towards the hot molecular core G10.47+0.03**

***Sabyasachi Pal**, Arijit Manna* CT

Department of Physics and Astronomy, Midnapore City College, Paschim Medinipur, West Bengal, India 721129

Amino acids are essential for the synthesis of proteins. Amino acids contain both amine (R-NH_2) and carboxylic acid (R-COOH) functional groups, which help to understand the possible formation mechanism of life in the universe. Among the 20 types of amino acids, glycine (NH_2CH_2COOH) is known as the simplest non-essential amino acid. In the last 40 years, all surveys of NH_2CH_2COOH in the interstellar medium, especially in the star-formation regions, have failed at the millimeter and sub-millimeter wavelengths. We aim to identify the possible precursors of NH_2CH_2COOH because it is highly challenging to identify NH_2CH_2COOH in the interstellar medium. Many laboratory experiments have suggested that methylenimine (CH_2NH), methanamine (CH_3NH_2), cyanamide (NH_2CN), and aminoacetonitrile (NH_2CH_2CN) play a key role as possible precursors of NH_2CH_2COOH in the star-formation regions via gas-phase and grain surface chemical reactions. After spectral analysis using the local thermodynamic equilibrium (LTE) model, we successfully identified the rotational emission lines of CH_2NH, NH_2CN, and NH_2CH_2CN towards the hot molecular core G10.47+0.03 using the Atacama Large Millimeter/Submillimeter Array. The estimated column densities of CH_2NH, NH_2CN, and NH_2CH_2CN towards G10.47+0.03 are $(3.40\pm0.2)\times10^{15}$ cm^{-2}, $(6.60\pm0.1)\times10^{15}$cm^{-2}, and $(9.10\pm0.7)\times10^{15}$ cm^{-2} with a rotational temperature of 218.70 ± 20 K, 201.2 ± 3.3 K, and 122 ± 8.8 K, which is estimated from the rotational diagram. The fractional abundances of CH_2NH, NH_2CN, and NH_2CH_2CN with respect to H_2 towards G10.47+0.03 are 2.61×10^{-8}, 5.076×10^{-8}, and 7.01×10^{-8}. We found that the derived abundances of CH_2NH, NH_2CN, and NH_2CH_2CN agreed fairly well with the existing three-phase warm-up chemical modelling abundance. We found that CH2NH is likely formed via neutral-neutral gas-phase reactions of CH_3 and NH radicals towards G10.47+0.03. Similarly, NH_2CN and NH_2CH_2CN are created via the neutral-neutral reaction between ammonia (NH_3) and cyanide (CN) on the grain surfaces and the reaction between radical CH_2CN and NH_2 on the grain surface of G10.47+0.03.

[S4-C02] **Study of fragmentation and multiscale gas dynamics in two protoclusters with ALMA: Deciphering the driving mechanism for high mass star formation – gravity or turbulence.**

Anindya Saha CT

Indian Institute of Space Science and Technology

Massive stars play a crucial role in the dynamical and chemical evolution of their environment by feeding the ambient interstellar medium (ISM) with material and radiation. They influence the surrounding ISM, especially during its formation stages and late evolutionary phases. Despite this, most aspects of the formation mechanism of high-mass stars, particularly the processes involved in the initial stages, are far less understood in contrast to low-mass counterparts. Observationally, it is challenging to probe the early stages of high-mass star formation due to short evolutionary time scales, formation in clusters at large distances, and high extinction in complex and embedded environments. To overcome this, in-depth, high-resolution interferometric studies of star-forming regions in both core and clump scales are essential. In this talk, I will give a brief overview of our study of two protoclusters, G12.42+0.50 and G19.88-0.53, using ALMA data from the ATOMS survey, where we investigated fragmentation and multiscale gas kinematics in them using continuum and spectral line data.

[S4-C03] **Dynamics of the inner environment of a hub-filament system hosting massive young stellar object W42-MME**

***Naval Kishor Bhadari**, Lokesh Kumar Dewangan (PRL), Arup Kumar Maity (PRL)*

CT

PRL, Ahmedabad, India

Recent observations suggest that massive star formation (MSF) involves the simultaneous onset of various physical processes, primarily driven by turbulence and gravity across scales of molecular clouds (>10 pc) down to cores ($\leq$0.1 pc). This points to a multi-scale accretion process in MSF. Investigating the role of gravity and turbulence in the early stages of star formation, including massive stars, is one of the hot topics in star formation research. In this context, we analyzed the fragmentation and dynamics of dense gas structures down to $\sim$2000 AU scale in the inner environment of a central hub within a hub-filament system hosting a massive young stellar object (MYSO) W42-MME. We utilized the high-resolution $(0''.31 \times 0''.25)$ Atacama Large Millimetre/submillimetre Array (ALMA) dust continuum and molecular line data. We performed a dendrogram analysis of H13CO+(4-3) line data to study multi-scale structures and their spatio-kinematic properties. Our results reveal 19 dense structures, including 12 leaves and 7 branches. These structures exhibit transonic-supersonic gas motions (1<M<5) with overvirial states (αvir $\geq$ 2). The non-thermal velocity dispersion-size relation (δnt-L) of dendrogram structures shows a weak negative correlation, while the velocity dispersion across the sky (δVlsr) correlates positively with structure size (L). Velocity structure function (S2(l)1/2) analysis of H13CO+ data reveals strong power-law dependences with lag (l) up to a scale length of $\leq$6000 au. The mass-size (M-R) relation of dendrogram structures shows a positive correlation with a power-law index of 1.73 $\pm$ 0.23, and the leaf L17 hosting W42-MME meets the mass-size conditions for MSF. Blue asymmetry is observed in the H12CO+ (4-3) line profiles of most of the leaves, indicating infall. Overall, our findings provide observational support for the hierarchical and chaotic collapse scenario in the vicinity of MYSO W42-MME, emphasizing the role of gravity-driven turbulence. This presentation aims to provide a comprehensive discussion of these observational findings and a broad overview of MSF in W42 region.

[S4-C04] **Detection of phosphorus nitride and other complex organic molecules towards the high-mass protostar IRAS 18089–1732**

Arijit Manna*, *Sabyasachi Pal, Tapas Baug CT

Department of Physics and Astronomy, Midnapore City College, Paschim Medinipur, West Bengal, India 721129

In the interstellar medium (ISM), phosphorus (P) is one of the essential chemical compounds for the building blocks of life, and it is necessary for many biochemical reactions. Recent multiple spectral line investigations confirm the presence of P-bearing molecules, specifically PN and PO, in the high-mass star formation regions, but their formation mechanism is still unknown. The P-bearing molecule phosphorus nitride (PN) is found in several high-mass star-forming regions, but it is poorly studied in the highly dense high-mass protostars and hot molecular cores. In this article, we present the identification of the rotational emission line of PN with transition J = 3–2 towards a high-mass protostar IRAS 18089–1732 using the 7-m Atacama Compact Array (ACA) of the Atacama Large Millimeter/submillimeter Array (ALMA). The estimated column density of PN towards the IRAS 18089–1732 is $(7.20 \pm 0.2) \times 10^{12}$ cm^{-2} with an excitation temperature of 150$\pm$62 K. The fractional abundance of PN relative to H_2 towards the IRAS 18089–1732 is $(9.0 \pm 0.5) \times 10^{212}$. The existing two-phase warm-up chemical model indicates that PN is formed towards IRAS 18089–1732 via the gas-phase neutral-neutral reaction between PO and N in the warm-up stage. Additionally, we also detect the rotational emission lines of nitrogen-bearing molecules ethyl cyanide (C_2H_5CN), cyanoacetylene (HC_3N) and oxygen-bearing molecule methyl formate (CH_3OCHO) towards the IRAS 18089–1732. We claim that (C_2H_5CN), and (HC_3N) are formed via the hydrogenation of the radical CH_2CH_2CN and the reaction between C_2H_2 and CN on the grain surface of IRAS 18089–1732. Similarly, (CH_3OCHO) is created via the reaction between radical CH_3O and radical HCO on the grain surface of IRAS 18089–1732.

[S4- P01] **IPA on the Rocks: JWST Unveils the Building Blocks of Planetary Systems**

***Himanshu Tyagi**, Manoj Puravankara, Mayank Narang, Will Rocha, Nashanty Brunken, Sam Federman, Adam Rubinstein, Tom Megeath, Dan Watson, Rob Gutermuth, Ewine F. van Dishoeck, and the IPA team* PS

Tata Institute of Fundamental Research

Protostars, representing the earliest stages of star formation, are essential to understand because they set the initial conditions of protoplanetary disks (birth-places of planets) by regulating the physical and chemical properties of their natal envelope. The composition of dust and ice in the envelope, shaped by the energetic processes driven by the protostar, serves as the fundamental building material for planets and complex organic molecules (potential precursors of life). Protostars are best studied at wavelengths > 3 microns, as their dense natal envelopes result in significant extinction in the optical and UV. Investigating protostellar accretion across the mass spectrum (IPA) is a JWST Cycle 1 GO program to study protostars in a broad luminosity range of 0.1-10,000 solar luminosity using NIRSpec IFU and MIRI MRS (from 2.8 to 28 micron). With JWST's unprecedented sensitivity, angular resolution, and IFU capabilities, studying the diverse composition of ice and dust and their spatial distribution in protostellar envelopes is now possible. We will present the ice and dust inventory of five protostars observed by the IPA program. We have decomposed the chemical species contributing to the opacity in various ice and dust absorption features. For the first time, we have generated distribution maps of the volatile ice species in the vicinity of the protostar. These findings suggest the occurrence of past thermal processing of ice species, even in cases involving very low-luminosity protostars, thereby indicating possible episodic accretion-induced heating. We will discuss our results and their implications for star and planet formation.

[S4-P02] **Characterizing the inner protoplanetary disks with JWST MIRI-MRS spectra**

Bihan Banerjee **, *Vinod Chandra Pathak*, *Manoj Puravankara*, *Himanshu Tyagi*, *Mayank Narang***

PS

PRL, Ahmedabad, India

Protoplanetary disks surrounding pre-main-sequence stars are the birthplaces of planetary systems. Multi-wavelength observations of the material (gas and dust) in these disks provide important constraints on the mass distribution, dynamical state, physical conditions, and evolution of these disks, thus helping us understand the planet formation process in greater detail. Mid-infrared spectra, in particular, provide insights into the physics and chemistry of the inner disk, the terrestrial planet-forming region. This work focuses on the detailed investigation of 25 protoplanetary disks surrounding T Tauri stars, using publicly available data from the James Webb Space Telescope (JWST) MIRI Medium Resolution Spectrometer (program ids: 1584, 1640, 2025, 1282). We have independently and uniformly reduced the data using the latest JWST pipeline and extracted the spectra from the stage 3 data cubes. We find the disk spectra are diverse in nature and extremely rich in gas lines. We have identified various molecular transitions like CO_2, H_2O, C_2H_2, HCN, OH, and CO in these protoplanetary disks. Many of the observed lines are detected for the first time with JWST. Assuming LTE conditions, we have uniformly modeled these molecular lines to obtain the column density, emitting area, and temperature of the emitting region, thus constraining the physical conditions in terrestrial planet-forming regions in protoplanetary disks. We will discuss how the physical conditions of the disks derived from the JWST spectra depend on the host star properties and the disk morphology revealed by ALMA observations, and connect it with the predictions from the planet formation theory.

[S4-P03] **HC3N as Outflow Tracer**

Ariful Hoque , ***TAPAS BAUG***

PS

S. N. Bose National Centre For Basic Sciences

Protostellar outflows are ubiquitous in both Low and High mass star formation. Outflows are considered as a signpost of active star formation. On passing through molecular clouds, outflows cause shock within molecular gas which can be traced using tracers which are sensitive to shock. Molecular gas tracers like, HC3N (Cyanoacetylene) are generally known to trace dense regions of molecular clouds, since they tend to be destroyed by ultraviolet radiation in low density environments.In this study, we identified outflows towards 146 active star forming regions of the ATOMS survey using HC3N (J=11-10) tracer. We have identified possible outflow candidates towards 30 star forming regions, out of which 20 sources have shown strong outflow characteristics. Commonly known outflow tracers like, CO, SiO can trace outflows at velocities 20-200 km/s and it is difficult to separate outflow components using these tracers at low velocities because of the cloud dynamics. On the other hand, HC3N (J=11-10) because of low abundance and high critical column density can trace outflows at lower velocities ($\sim$4-30 km/s) where most of the outflow mass is concentrated. Details of this study will be presented.

Session V: Instrumentation

[S5-I01] **Pushing the boundaries of star and planet formation by developing new spectrographs.**

Joe P. Ninan IT

TIFR, Mumbai

Astronomers have a rich tradition of building new instruments to push the discovery space. In this talk, I shall talk about two extreme precision radial velocity spectrographs we built for exoplanet science, and how they helped us in discovering new planets that push the current theories on understanding planet and star formation. I shall also talk about one of the ongoing TIFR-ARIES collaboration to build a novel spectrograph, which will be the fastest spectrograph for ultra broad band spectroscopy survey in the world. This instrument, dubbed TA-MOONS will be a next generation instrument on DOT, that will have the unique capability to observe up to 8 targets anywhere in the 12 arc min diameter field of view in the ultra broad band wavelength range of 380 nm to 2.5 micron simultaneously. I shall update on the status of this project and what the star formation community can expect from this instrument.

[S5-C01] **Design advancement of MOIS : A configurable slit multi-object infrared spectrograph and wide field imager**

Arun Surya ***, Manoj Puravankara, Bhaswati Mookerjea, Satheesha Poojary, Savio L. D. Costa, Mayank Narang, Pankaj Madhwani, A. P. K. Kutty, Shailesh Bhagat, Harshit Shah, Bihan Banerjee, Sanjay Gharat, Rajesh Jadhav, Vikas Kurhade, Jayendra S. Parmar, Himashu Tyagi (TIFR)*** CT

Indian Institute of Astrophysics

MOIS is a multi-object configurable slit spectrograph designed to be used with the 3.6 Devasthal Optical Telescope (DOT). It will cover the near-infrared wavelength band of 0.97 - 2.37 microns and have a spectroscopic field of view of 9' $\times$ 3' arc minutes and an imaging field of view of 9.6' diameter . MOIS is being designed as a precursor to a future multi-object spectrograph for the planned National Large Optical Telescope (NLOT) in India. MOIS is currently designed with a modular configurable slit unit of 5 slits created by 10 bars moving pair-wise in opposition. The slit unit can be upgraded independently to increase the multiplexing capability. The design had unique challenges of adequate thermal isolation and cooling of the slits units to $\sim$120 K and wide-field camera design for the f/9 beam of the telescope. During the latest phase we have made progress in optimising the design with off the shelf components and also developing opto-mechanical solutions to some of the assemblies. We have also built an extensive raw data simulator that was used to understand the sensitivity of the instrument together with an observation planning simulator. We will discuss these aspects in the talk.

[S5-C02] **An actively controlled fibre-fed optical spectrograph EXOhSPEC**

Supriyo Ghosh ***, EXOhSPEC team*** CT

University of Hertfordshire, UK

EXOplanet High resolution SPECtrograph (EXOhSPEC) is an actively controlled fibre-fed optical spectrograph based on off-the-shelf components. The main objective of this project is to develop a cost-effective, small and efficient high-resolution spectrograph for measuring radial velocities for extra-solar planets. A prototype of this instrument is currently under development at the University of Hertfordshire, United Kingdom. With the current configuration of this instrument, we can achieve a spectral resolution of > 70,000 and a precision of 4 m/s. However, we are constantly envisaging new methodologies for improving the performance and stabilisation of the spectrograph. In this presentation, I present our latest several promising developments including modal noise mitigation using optical agitation, fibre tapering for achieving efficient focal reduction, temperature stabilisation and control of optical path length concerning temperature and pressure variation in an unsealed enclosure and Fabry-Perot metalon for precise calibration.

[S5-P01] **pyTANSPEC-1.0.0: A Major upgrade to TANSPEC pipeline, with the capability to reduce Low-Resolution mode spectra**

Varghese Reji**, **Joe Ninan**, **Supriyo Ghosh**, **Arpan Ghosh**, **Koshvendra Singh**, **Devendra K Ojha PS

TIFR Mumbai

The TANSPEC (TIFR-ARIES Near Infrared Spectrograph) is widely used by the astronomy community on the 3.6m Devasthal Optical Telescope. This is a unique instrument that can conduct spectral studies and photometry in the wavelength range of 0.6-2.5 microns. For spectroscopy, TANSPEC offers two resolution modes: high-resolution mode (R $\sim$2500) and low-resolution high throughput mode (R $\sim$100-350). pyTANSPEC is the pipeline, a semi-automated Python package designed to reduce and wavelength calibrate the High-Resolution spectra from the 2D frames taken with TANSPEC. Wavelength calibration is performed using argon and neon spectra, taken immediately after the exposure of the science target. The spectral lines which are not blended are then reidentified during the reduction process for wavelength calibration. However, this method is effective only in the high-resolution mode, slit s0.5, as spectral line identification in other slits and low-resolution modes are not possible due to the blending of lines. Here, we present an updated version of pyTANSPEC, version 1.0.0, which can now reduce Low-Resolution Spectra. It also has the capability of wavelength calibration for all slits in both low and high-resolution modes, as well as flux calibration for both low and high-resolution modes. Instead of reidentifying spectral lines, the new version uses template matching algorithm for wavelength calibration, which is faster and more precise. Additionally, a feature for flux calibration has also been added to the pipeline with instrument response curves for both resolution modes. Since wide slits of High-resolution mode and Low-resolution mode are useful for studying different astronomical objects such as nebulae, galaxies, exoplanet atmospheres, etc., this updated version of the pipeline will provide more opportunities to astronomers in the country.

Day 3: Wednesday, 10 January 2024

Session VI: Pre-main Sequence Stars and Variability

[S6-I01] **Non-thermal emission from massive protostellar jets**

Sarita Vig IT

Indian Institute of Space science and Technology (IIST)

Stars are born deeply ensconced in dense clouds of interstellar medium. Protostellar jets launched in the early evolutionary phase of these young stellar objects are targets of intense scrutiny, to understand the properties of the protostellar systems. We have investigated a few jets from massive embedded protostars through their interaction with the ambient medium, in radio and infrared wavebands and we trace emission from shocked regions where the jet impacts the medium. Our results from GMRT, India, at low radio frequencies have confirmed the presence of non-thermal synchrotron emission from these jets, unlike measurements at higher radio frequencies that usually trace thermal free-free emission. We assimilate the observed emission measurements within a numerical model that we have developed, which incorporate the effects of both thermal and non-thermal emission, to understand the properties of the jets and ambient medium in the vicinity.

[S6-C01] **Monitoring of episodically accreting Young Stellar Objects**

Arpan Ghosh, Saurabh, J.P. Ninan, D.K. Ojha, Koshvendra Singh, Aayushi Verma, Tarak Chand Sahu CT

Aryabhatta Research Institute of Observational Sciences

Spectro-photometric monitoring of eruptive Young Stellar Objects (YSOs) in the last few years have contributed significantly towards understanding of the episodic accretion phenomenon.These objects are highly embedded and therefore obscured in the visible wavelengths. Continuous multi-band photometric monitoring helps in the study of color-color evolution by disentangling the effects of variability due to change in extinction or accretion change. Spectroscopic monitoring both at optical and near infrared (NIR) wavelengths presents a wealth of information about the evolution of these sources. Evolution of the spectroscopic features associated with the accretion process helps us to understand about the type of ongoing accretion process in these systems. The lines associated with a molecular outflow or disc wind during the active and the quiescent phases help in understanding of their connection to the accretion process, thereby, helping in further understanding of these episodic outbursts. We have been continuously monitoring these sources with spectro-photometrically both in the optical and NIR regimes using Indian facilities like HCT and DOT and in this platform we wish to show our results from our monitoring.

[S6-C02] **Disentangling the two sub-populations of early Herbig Be stars using VLT/X-shooter spectra**

Shridharan Baskaran *, B. Mathew, R. Arun, T. B. Cysil, A. Subramaniam, P. Manoj, G. Maheswar, and T. P. Sudheesh* CT

CHRIST (Deemed to be University)

Early Herbig Be (HBe) stars are massive, young stars accreting through the boundary layer mechanism. However, given the rapid (<2 Myr) evolution of early Herbig stars to the main-sequence phase, studying the evolution of the circumstellar medium around these stars can be a cumbersome exercise. In this work, we study the sample of early (B0–B5) HBe stars using the correlation between Hα emission strength and near–infrared excess, complemented by the analysis of various emission features in the X-shooter spectra. We segregate the sample of 37 early HBe stars based on the median values of Hα equivalent width (EW) and near–infrared index (n(J-H)) distributions. The stars with |Hα EW| >50Å and n(J-H) >–2 are classified as intense HBe stars and stars with |HαEW| <50Å and n(J-H) <–2 as weak HBe stars. Using the VLT/X–shooter spectra of five intense and eight weak HBe stars, we visually checked for the differences in intensity and profiles of various HI and metallic emission lines commonly observed in Herbig stars. We propose that the intense HBe stars possess an inner disk close to the star (as apparent from the high near-infrared excess) and an active circumstellar environment (as seen from the high Hα EW value and presence of emission lines belonging to FeII, CaII,OI, and [OI]). However, for weak HBe stars, the inner disk has cleared, and the circumstellar environment appears more evolved than for intense HBe stars. Furthermore, we compiled a sample of $\sim$58 000 emission-line stars published in Gaia DR3 to identify more intense HBe candidates. We plan to perform high-resolution spectroscopic studies of the intense HBe stars to understand the evolution of the inner (approximately a few au) disk during the Boundary Layer (BL) accretion process.

[S6-C03] **Evaluation of varying mass accretion rate with mass in PMS stars**

Nidhi Sabu CT
CHRIST (Deemed to be University), Bangalore

Characterized by the presence of accreting circumstellar disks and infrared excess, the study of pre-main sequence (PMS) stars offers valuable insights into the formative stages of star, mass accretion process, and planetary systems. In this study, we systematically explores a sample of 379 PMS stars identified through the Large Sky Area Multi-Object Fiber Spectroscopic Telescope (LAMOST) survey and evaluates the interdependencies of mass accretion rates with stellar mass. From the investigation, we found that the correlation between mass accretion rates and stellar mass has been characterized by power-law relationships, $\dot{M}_{acc} \propto M_{\star}^{3.08^{+0.21}_{-0.64}}$ and $\dot{M}_{acc} \propto M_{\star}^{1.43\pm0.26}$ for the high and low mass PMS stars, respectively. However, in this work, notable discrepancies in the power-law relation are observed for high-mass PMS stars, at a turnover mass of 4.62 Msun. This observation extends to the identification and characterization of Intermediate Mass T Tauri stars (IMTTS), a distinct classification within the PMS category. Among the stars under scrutiny, 36 stars are confirmed to be IMTTS, showcasing spectral features ranging from A9 to G0, with an age span spanning from 1.2 to 12 Myr. Moreover, we explore the potential existence of a comparable turnover point in the low-mass regime and draw comparisons with other turnover points within the comprehensive mass spectrum of PMS stars.

[S6-P01] **Accretion Funnel Reconfiguration during an Outburst in a Young Stellar Object: EX Lupi**

Koshvendra Singh **, *Joe P. Ninan, Marina M Romanova, David A. H. Buckley, Devendra K. Ojha, Arpan Ghosh, Andrew Monson, Malte Schramm, Saurabh Sharma, Daniel E. Reichart, Joanna Mikolajewska, Juan Carlos Beamin, J. Borissova, Valentin D. Ivanov, Vladimir V. Kouprianov, Franz-Josef Hambsch and Andrew Pearce*** PS

Accretion Funnel Reconfiguration during an Outburst in a Young Stellar Object: EX Lupi

In this talk, I will present our first discovery of migration of the magnetic accretion funnel footprint during a period of enhanced accretion onto a young stellar object (YSO), EX Lupi. This phenomenon was predicted by dipolar magnetic field MHD simulations more than a decade ago. EX Lupi is the prototype of a class of young stellar objects (YSOs), EXors, that undergo repetitive outbursts (brightness increase by a few to a hundred) on the time scales of a few months to years. Though EX Lupi has a long history of recorded and well-studied outbursts since the 1940s, the most recent 2022's outburst could be observed by us as well as other astronomers around the globe at an unprecedented cadence. We observed spectroscopically with HRS on 10-m SALT, SA and photometrically with LCRO, TMMT and CTIO. This data, along with the other publicly available data from ASAS-SN, TESS and AAVSO, enables accurate modelling of the accretion funnel footprint. I shall present how our analysis shows that the hotspot, the footprint of disk-mediated accretion onto the star, moved azimuthally ahead on the stellar surface by $\sim 112^{\circ} \pm 5^{\circ}$, along the star's rotation during the March 2022 outburst. The hotspot also moved down to lower latitude by $\sim 10^{\circ}$. Our 3-dimensional MHD simulations support the hotspot's movement over the stellar surface during the state of high accretion rate. The hotspot held on to its new location even after the completion of the outburst, leading us to hypothesise a heated and thickened inner disk during the outburst. Our further analysis showed the pre-outburst azimuthally concentrated hotspot gains a temperature gradient during the outburst and gets azimuthally spread. These results also have broader implications on the other compact accreting sources.

[S6-P02] **Approaching the End of Protoplanetary Disk Evolution: A Blind Survey of Young Stellar Clusters within the Solar Vicinity**

Gregory Mathews Ben, Jessy Jose PS

Indian Institute of Science Education and Research Tirupati

Investigating the evolution of protoplanetary disks surrounding young stellar objects (YSOs) is paramount for understanding the mechanisms underlying star and planet formation. We chose 32 clusters(within 500 pc) in the age range of 1-100 Myrs, whose membership is based on Gaia DR2, to understand when the disk dissipation comes to a stop. The Age and mass information of the sources were obtained through SED fitting, conducted using VOSA, and by employing PARSEC 1.2 isochrones. The IR data was obtained from 2MASS and WISE catalogs, and we employed three methods to identify disks across the different wavelength regimes(1.1- 22μm). We find that disk-fraction consistently decreases as stellar systems age, a trend observed across all wavelengths. However, there is an increase in the time scale of disk decay as wavelength increases. The different wavelength regime corresponds to different disk radii: short wavelengths(1.2-4μm) for disk radii within 0.01-1AU, 12μm for 0.03-5AU, and 22μm for disk radii in the range 0.3-60AU. This indicates that dust particles at larger radii evolve at a slower pace. In contrast to shorter wavelengths, we observed 12μm and 22μm excess sources at relatively older ages, $\approx$ 50 Myr. These sources may represent evolved disks, such as debris or transitional disks. Based on the optical spectra obtained from LAMOST DR8, we calculated the H-alpha equivalent widths(EW) to identify possible accretors in our sample. We derived the mass accretion rate based on the EW and found that the accretors in our sample are all within $\approx$10 Myr, indicating no accretion observed beyond this age. We also perform a simulation-based analysis using D'Alessio models to determine the disk structure in the 12μm and 22μm range; focusing on the degree of dust settling and disk wall height.

[S6-P03] **Photometric study of an open cluster Be65**

Tarak Chand*, *Saurabh Sharma*, *Ajay Kumar Singh

Aryabhtta Research Institute of observational sciencES (ARIES), Nainital

PS

We have conducted an extensive (∼8 year-long) optical photometric survey of a young open cluster Berkeley 65 (Be65), using the 1.3m Devasthal fast optical telescope. This long term photometric data will be used to study the evolution of low mass stars through their long term multi-band photometric light-curve characteristics. We have successfully identified 88 stars as variable stars within Be65. Among them, 67 stars show periodicity in their light curves, while 21 stars are showing irregular behaviour. The periodic variables have periods of a few hours to a few days and amplitude between a few tens of milli-mag to a few hundred milli-mags. Using the color-magnitude and color-color diagrams, we have estimated the extinction, distance, and age of the Be65 cluster as 2.85±0.05 mag, 2.0±0.1 kpc and 160 Myrs, respectively. In this presentation, we will be discussing the individual characteristics of the variables we have identified in the Be65 cluster.

[S6-P04] **YSO jets in Galactic plane: The molecular cloud complexes Vulpecula OB1 and IRDC G53.2**

***Manish Chauhan*, Manash Samal, Anandmayee Tej, Dirk Froebrich** PS

Space Applications Centre, ISRO, Ahmedabad

Jets and outflows are ubiquitous in star forming regions and are early tracers of formation of star. Using data from the UKIRT Wide Field Infrared Survey for H2 (UWISH2) at 2.12 micron, 127 outflows are identified in molecular cloud complexes Vulpecula OB1 and IRDC G53.2 covering 12 square degrees of the Galactic plane. 79 young stellar objects (YSOs) are identified as driving source candidates using multi-wavelength datasets from 1.2 to 70 micron. Out of the 79 driving source candidates, $\sim$82% are likely Class 0/I protostars, 16% are Class II YSOs and the remaining 2% are Class III YSOs. The identified outflows have a median lobe length of 0.22 pc and 0.17 pc for outflows in Vulpecula OB1 and IRDC G53.2, respectively. A typical ejection frequency of $\sim$1.2 kyr is observed based on the knot spacing in outflows suggesting an intermediate type between the FU-Ori and EX-Ori type of eruptions in both cloud complexes. Physical parameters of driving source candidates are identified by fitting the observed spectral energy distributions (SEDs) to theoretical SEDs obtained from radiative transfer modelling. Estimates of the outflow mass suggest that the outflows identified in this study are predominantly driven by intermediate mass stars. Various observed trends between the outflow properties and the corresponding driving sources, and various interesting outflows and star forming sites, including sites of triggered star formation and protocluster forming clump with clusters of jets, are discussed. The obtained sample of jet-bearing protostars will be highly beneficial to gain deeper understanding on the accretion and ejection mechanisms of young stars with future high-resolution observations.

[S6-P05] **Influence of radiative feedback in Bright-Rimmed Cloud (BRC) 44**

Rishi C*, *Neelam Panwar

PS

Junior Research Fellow

Star-forming regions (SFRs) are ideal candidates to understand different mechanisms involved in star formation. SFRs may harbor bright-rimmed clouds (BRCs), which are remnant molecular clouds possibly undergoing triggered star formation due to radiative feedback from the high-mass stars. To investigate the role of high-mass stars on the star-formation activity in BRCs, we studied a nearby region, BRC 44 (distance $\sim$ 1 kpc), which is part of HII region sh2-145. To obtain a census of young stellar objects (YSOs) in this region, we exploited infrared (IR) data from the 2MASS, TIRCAM-II mounted on the 3.6m DOT, Spitzer-IRAC, and MIPS. A total of 35 YSOs were identified through the Spitzer-IRAC and MIPS observations. Using 2MASS/ TIRCAM-II near-IR (NIR) data, an additional number of YSOs is recovered. To constrain the evolutionary status and mass of these YSOs, we used the NIR color-magnitude diagram, which revealed that these are low-mass stars at a very young age. The spatial distribution and the kinematics of the YSOs indicate that these may have been formed due to the high-mass stars in the adjacent HII region.

Session VII: Stellar Clusters

[S7-I01] **Photometric, kinematic and variability study in the young and intermediate-age open clusters**

Yogesh Joshi IT

ARIES, Nainital

There are more than 3000 open clusters known in the Galaxy but not all are well studied. With the advent of new technologies and recent space missions, new star clusters are being detected in the bulk but their detailed study is still lacking. At Nainital, we have initiated a long-term program to study some of the young and intermediate-age open clusters. Having the kinematic data available for these clusters through GAIA and long-term photometric data through our small 1-m size telescopes, we have embarked upon their kinematic and variability study as well. Furthermore, large sample of open clusters can be used to probe star formation and Galactic structure in the solar neighbourhood. In this talk, I will present results of few open clusters which we have studied in recent times under this project.

[S7-I02] **Formation and early evolution of star clusters: the case of FSR 655 and NGC 2516**

Manash Samal IT

Physical Research Laboratory

A significant fraction of stars are known to form in clustered environments, however, some fraction of these end up in bound clusters. In particular, we yet to understand the scarcity of massive young clusters in our Galaxy despite the fact that our Galaxy is host to many massive clouds. In this talk, I shall review some of the evolution and dissolution processes of star clusters and present two case studies, highlighting how a massive embedded cluster cloud potentially ends up being a low-mass open cluster after only a fraction of its members lifetime.

[S7-I03] **Multi-wavelength Studies of Young Star Clusters and HII regions**

Neelam Panwar IT

ARIES, Nainital

Young star clusters are ideal sites to study the formation and evolution of different mass objects in the same environment. In this talk, I will present the results of our recent studies based on the deep optical and infrared investigation of a sample of young clusters and associated HII regions. Furthermore, I will discuss the 4Kx4K CCD Imagers mounted on the 3.6-m DOT and their potential for studying star formation in young star clusters and HII regions.

[S7-CO1] **An investigation of the formation channels of blue straggler stars in the Galactic globular cluster M68**

Ranjan Kumar ***,Ananta C. Pradhan, M. Parthasarathy, Sonika Piridi, Santi Cassisi, Devendra K. Ojha, Abhisek Mohapatra, and Jayant Murthy*** CT

Astronomy and Astrophysics Division, Physical Research Laboratory, Navrangpura, Ahmedabad - 380009, Gujarat, India

Globular clusters (GCs) are old-dense stellar environment that host a rich fraction of binary stellar populations. Blue straggler (BS) stars are the byproduct of the multiple (binary/triple) stellar systems present in the dense stellar environment of GCs. There are two formation channels proposed for BS stars in globular clusters - (i) they are formed as a consequence of the mass transfer/merger in binary/triple stellar systems. (ii) They are formed when a direct collision occurs in the dense stellar environments. The number and nature of BS stars affects the dynamical evolution of a cluster. Here, I present a detailed investigation of the formation channels of BS stars and their evolutionary status in a dense Galactic GC M68 using UV/optical observations of AstroSat/UVIT and HST/WFC3 filters. We found a total of 66 BS stars in the cluster. We derived their bolometric luminosities (L_{bol}), effective temperature (Teff), surface gravity, radius, mass, and age using their observed spectral energy distribution (SED) in the range of 3.12-24.25 $L_{\odot}$, 5,750-9,000 K, 1.5-4.5 dex, 0.93-3.76 $R_{\odot}$, 0.84-1.26 $M_{\odot}$ and 1.5-10.0 Gyr, respectively. The BS stars of M68 show two groups in the T_{eff} vs. Lbol plot: one towards bluer/hotter end with an average age of 3-6 Gyr and the other one towards redder/cooler end with an average age of 6-10 Gyr. This suggests the presence of both the formation scenarios (direct collision and mass-transfer/merger) of BS stars in the cluster. The radial distribution of BS stars suggests that the massive and young BS stars are situated at the core of the cluster and formed through the direct collision process whereas the older and less massive BS stars are distributed over the entire cluster and formed through the mass-transfer/merger events in the cluster.

[S7-C02] **Structural morphology and star formation scenario in young star clusters**

Harmeen Kaur **, *Alok Durgapal, Saurabh Sharma, Lokesh Dewangan*** **CT**
Kumaun University, Nainital

Young open clusters are idiosyncratic for astrophysical research. Their study has played a significant role in developing an understanding of the Galactic structure. Most of the stars formed in a clustered environment more or less simultaneously from the same giant molecular cloud (GMCs) spanning a wide range of stellar mass within a relatively small volume of space. The explicate characteristic of embedded cluster is its intimate physical association with interstellar gas and dust (cold/warm). The degree of their being embedded in molecular gas is related to their evolutionary state. Hence, the distribution of embedded clusters imprints the fractal structure of the GMCs from which they born. The initial mass function (IMF) is the most fundamental output of the star formation process. Examining the universality of the IMF among young stellar clusters is one of the intricate subject in modern astrophysics. One of the important question in the field of star formation is the role of stellar feedback on the subsequent star formation process. The evolution of H_{II} regions can trigger a new generation of stars at their peripheries, with environmental conditions that may affect the IMF, disk evolution and star formation efficiency. In this work we study the stellar content and star formation processes in the young open clusters. We used multiwavelength data sets to study the large scale environment of the young open clusters.

[S7-P01] **GAIA DR3 view on GUM 31**

Renjithmon A A PS

MAHATMA GANDHI UNIVERSITY, KERALA

The study aims to characterize the Gum 31 H II region located near Carina Nebula complex using Gaia EDR3 astrometric data. The region is known to be associated with young stellar objects (YSOs), making it an intriguing target for investigation. By analyzing Spitzer data, we identified 21 YSOs in close proximity to Gum 31. Leveraging the Gaia DR3 astrometric data and distances of these known YSOs, we determined the median distance and proper motion of the region. Our analysis yielded an estimated distance of 2626.52 $\pm$ 300 parsecs, which is consistent with previous studies. Employing the estimated parameters, we further identified 286 co-moving members within the Gum 31 region. To gain additional insights into the population, we constructed a Gaia Color-Magnitude diagram, providing valuable information on the properties of the region's members. Subsequently, we focused on identifying Hα emission sources among both the co-moving stars and YSOs. This allowed us to identify the sources with the highest emission within the selected YSOs and co- moving stars,we made another color magnitude diagram using both emission and absorption of YSOs and co-moving stars. We will use the Gaia data to identify multiple populations and test the cloud-cloud collision scenario for the formation of the region.

[S7-P02] **Photometric and Kinematic Analysis of a Young Open Cluster NGC 2345**

Kuldeep Belwal ***, D. Bisht, Mohit Singh Bisht, Geeta Rangwal, Ashish Raj, Arvind Dattatray, R. K. S. Yadav, B. C. Bhatt*** PS

Indian Centre for Space Physics, 466 Barakhola Singabari road Netai Nagar, Kolkata 700099

We present a comprehensive photometric and kinematic analysis of NGC 2345 to gain insights into the cluster's properties and evolution. We used CCD UBV, 2MASS, and Gaia DR3 data to derive the cluster's fundamental parameters, including age, distance, reddening, etc., based on color-magnitude and color-color diagrams. Our analysis suggests that this is a relatively young cluster with an estimated age of approximately 78 million years and located at a distance of roughly 2.811 kpc. We have done a mass function study using only actual members with a membership probability higher than 60 percent. We found the relaxation time is almost double than its age which indicates that NGC 2345 is not dynamically relaxed. We also computed the cluster's galactic orbit, eccentricity, and orbital parameters better to understand its motion within our Milky Way galaxy.

[S7-P03] **Kinematic and photometric study of NGC 6793 open cluster**

Ranjana Jaiswal[1]***, Dr. Apara Tripathi***[1]***, Saurabh Sharma***[2]***, Professor Shantanu Rastogi***[1] PS

[1]Deen Dayal Upadhyaya Gorakhpur University, Civil Lines 273009, Gorakhpur, Uttar Pradesh [2]ARIES,Nainital

We present photometric and kinematic analysis of young age open cluster NGC6793 using UBV(RI) data and Gaia DR3 archival data. Structural and fundamental parameters such as cluster center and cluster extent ,reddening, age and distance of the cluster are estimated in this study. The color magnitude diagram shows a bright , well defined pre main sequence region and some interstellar dust component which show there is star forming region due to influence of O and B type of star in cluster.

[S7-P04] **Deep Near Infrared Photometric Analysis of Open Cluster Teutsch 76**

Vikalp Sharma ***, Dr. Saurabh Sharma, Dr. Arpan Ghosh, Mr. Tarak Chand, Ms. Aayushi Verma*** PS

Hansraj College, University of Delhi

The study of open clusters present in molecular clouds and H II regions helps us understand the triggering factors of star formation, and its evolutionary track, and match the theoretical frameworks with our observations and data. We have performed a detailed study of an open cluster Teutsch 76 (T76) located in the Sharpless region(Sh 2-141 HII region) inside a mid-infrared(MIR) bubble seen by the WISE MIR band image. We have used the deep near-infrared(NIR) data taken from the TANSPEC instrument installed on the 3.6m Devasthal optical telescope(DOT), along with this we have used the proper motion data from the latest Gaia data release 3 and deep photometric data from Pan-STARRS 1 survey. We have found that T76 has a Circular Morphology with a central density concentration and the center of the cluster is located at αJ2000: 22h28m46s.68, δJ2000: +61$^\circ 38' 0.1''.2$, the probable reason for this can be the star formation process due to its location near an HII cloud. The radius of the cluster was found to be 45$'$(1.24pc) and 24 stars were found to be highly probable members within this radius. We have found the cluster is located at a distance of 5.7 $\pm$ 1 kpc and the age of the cluster is found to be 50 $\pm$ 10Myr. We have calculated the mass function for the cluster in the mass range of 1.3 $\leq$ M/M$_\odot$ $\leq$ 2.249 using the PS1 data and found the value to be Γ = -1.69. The cluster is not showing any significant mass segregation and is currently ongoing dynamic relaxation.

[S7-P05] **Deep near-infrared imaging of a young embedded star cluster BDS2003-52**

***Mamta**, Saurabh Sharma* PS

Aryabhatta Research Institute of Observational Sciences

In this work, we will present a deep near-infrared (NIR) study of an embedded cluster BDS2003-52 using the TANSPEC instrument mounted on the 3.6-meter Devasthal Optical Telescopes (DOT). Present calibrated data can detect sources up to the faint limit (S/N$>$10) of J$\sim$20 mag. Deep NIR data is used to study the structure, stellar population, dynamical state, etc. of this embedded cluster. We have found that the shape of this cluster is elongated and is small in size (r$\sim$2$'$). From our observations, we have found that most of the stellar population in this cluster has low mass (<2 solar mass). This cluster is found to be located within a bubble of gas and dust. The cluster's center coincides with the peak in the distribution of ionized gas, which indicates the possibility of a massive star impacting its nearby surrounding region. Present NIR data along with multi-wavelength archival data from 2MASS/UKDSS, Spitzer/WISE, Herschel, PMO, NVSS, etc. are used to study the star formation history of this cluster.

[S7-P06] **The stellar population of h and χ Persei: Cluster properties, membership, and the IMF towards low mass end**

***Govind Bhat D**, Dr. Jessy Jose, Estelle Moraux* PS

Indian Institute of Science Education and Research, Tirupati

h and chi (NGC 869 and NGC 884) Persei are the largest, brightest, densest, and nearest open cluster of fairly massive stars, a double cluster known in our Milky Way Galaxy. Open clusters are exceptional observatories of star formation and evolution and significant tools for studying the composition and development of the Galactic disc. The Double Cluster has an extraordinarily high density of evolved stars, including red supergiants, B giants/supergiants, and early B-type dwarfs. No previous study has addressed the fainter cluster members. Hence, the first critical step in their inquiry is to create a membership list of the double cluster and to further classify the list into members of h and chi Persei down to the brown dwarf mass limit. The Initial Mass Function (IMF) explains the mass distribution of stellar and sub-stellar objects formed in a particular volume of space, generally in a single episode, usually as a part of a stellar association or cluster. This study aims to produce this double cluster's Initial Mass Function (IMF) towards the low mass end. Apart from the Gaia data, an analysis is done using the deepest photometric observations from the CFHT (Canada France Hawaii Telescope), Hawaii, USA. The data from the instruments MegaCam and WIRCam in I (Optical), Y, J, H, and K (Infrared) bands is used for the analysis. The CFHT data goes as deep as a magnitude level of 12- 21 in J, which is the deepest survey of the region so far. Various methods, such as Color-Magnitude diagram analysis and spectral Energy Distribution analysis(SED analysis), are being employed to obtain the membership estimation that will be presented. Various Machine learning techniques (eg. Random Forest, Gaussian Mixture Model) are also applied for further analysis of the fainter members.

[S7-P07] **A Statistical and Multiwavelength Photometric Analysis of a Young Embedded Star Cluster: IC 1590**

***Ali Hasan Sheikh**, Dr. Biman J. Medhi* PS
Dept of Physics, Gauhati University

Open clusters are the important stellar systems that provide valuable insights into the formation and evolution of stars. We will present a statistical and multiwavelength photometric study of young open cluster IC 1590 using Gaia data release (DR2, EDR3 and DR3) and 2MASS NIR (JHKs) data. We used Gaia Data Release (DR2, EDR3 and DR3) and the 2MASS JHKs data to investigate the young open cluster IC 1590 and understand its properties and characteristics. We used Gaia astrometry data to identify cluster members based on their proper motions and parallaxes and and separate them from the field stars using ensemble-based unsupervised machine learning techniques. By combining Gaia data and 2MASS photometry data, we used color-magnitude diagrams (CMDs) to study the cluster's stellar population and identify any unique features such as the presence of main-sequence(MS), pre-main sequence(PMS), age, metalicity, distance, LF and MF of the cluster. We also generate extinction map of the cluster using PNICER technique. We analyse the 2MASS NIR color-color diagram to classify the pre-main sequence (PMS) and main sequence (MS) population. We also perform orbit analysis using Gaia data. This combined Gaia and 2MASS-based study of an open cluster showcases the abilty of multiwavelength study to understand the properties of open clusters.

[S7-P08] **Rocket Effect near Young Open Clusters**

***Arun Roy**, Maheswar Gopinathan, Blesson Mathew, Shridharan Baskaran* PS
Indian Institute of Astrophysics

Cavity structures in star-forming regions arise from the pressure exerted by OB-type stars, propelled by their winds and ionizing radiation. Ionization fronts give rise to H II regions and bright rims at cavity boundaries. These regions undergo acceleration due to the 'rocket effect.' In our study, we examined the kinematics of 18 young open clusters containing O-type stars. We identified stars in the outer regions of the clusters with an expansion velocity directed radially outward, indicating signatures of the rocket effect. Our investigation yields compelling results on the rocket effect in young clusters hosting O-type stars, contributing to an enhanced understanding of kinematics in star formation around hot stars and galaxies.

Day 4: Thursday, 11 January 2024

Session VIII. Magnetic field Star-forming regions

[S8-I01] The interplay between magnetic fields, turbulence, and gravity and its significance

Eswaraiha Chakali IT

IISER-Tirupathi

The magnetic fields contribute a significant amount of pressure—as much as turbulence does—and more than thermal energy to the diffuse interstellar medium. These factors and gravity collaborate in a complex way to govern the rate and efficiency of star formation. Stars form due to the gravitational collapse of fragmented, dense cores that lie along the ridges of the molecular cloud filaments. Investigating how each agent's contribution varies as a function of density and spatial scale is crucial to fully understanding the role of magnetic fields. The wide-field and sensitive polarimeters enable us to trace across the cloud, encompassing all densities and spatial scales. We will review the methods to probe a detailed magnetic field map, ways to estimate the strength of a magnetic field and the implications based on the comparison among the energies of the magnetic field, turbulence, and magnetic fields. We will discuss the results based on the multi-wavelength polarization observations of various sources, such as low-mass star-forming filamentary clouds, massive dense cores in and around bipolar HII regions, massive clumps with energetic outflows, and dark globules. We will also briefly discuss the results obtained based on the HINSA Zeeman experiment with the FAST telescope.

[S8-C01] **Magnetic Fields in Massive Star-forming Regions (MagMaR) unveiled by ALMA**

Piyali Saha CT

National Astronomical Observatory of Japan (NAOJ)

High-mass stars play a critical role in the physical and chemical evolution of their immediate surroundings as well as the galaxies, although the detailed mechanism of their birth is still unclear. A complete understanding of high-mass star formation necessitates the investigation of one of the most elusive energy components: magnetic field (B-field). Several observational properties in high-mass star-forming regions are frequently explained invoking B-fields, despite the lack of direct evidence of their presence or their importance with respect to turbulence and gravity. Some efforts have been attempted to address the importance of B-fields by observing statistically significant samples, for example, with Submillimeter Array (SMA) and Combined Array for Research in Millimeter-wave Astronomy (CARMA). In recent years, the Atacama Large Millimeter/submillimeter Array (ALMA) offers us excellent resolution, sensitivity, through which we can probe the size-scales of the star-forming regions that have never been explored before. Here, we introduce the first survey of B-fields in high-mass star-forming regions using ALMA: Magnetic Fields in Massive Star-forming Regions (MagMaR). In MagMaR, 30 high-mass star-forming regions have been observed at 1.2 mm, resulting in $\sim 0.3''$ resolution ($\sim$1000 au). A large diversity of B-field morphologies is detected in this survey, which we have catagorized as follows: (1) "simple" spiral- or hourglass-like, with no/little fragmentation; (2) filamentary, with B-field vectors sometimes parallel to the aligned fragmentation; (3) complex B-field morphology with highly clustered fragmentation. The initial findings of the survey and the results of some case studies will be presented in this conference.

[S8-C01] **Witnessing Star Formation in Galactic Bubble and Filamentary Systems**

Ram Kesh Yadav CT

National Astronomical Research Institute of Thailand (NARIT)

In recent decades, advancements in space-based and ground-based observatories have increasingly shifted the focus of star formation studies towards Bubble and Filamentary systems, structures believed to be cradles of stellar birth. This presentation will unveil some recent findings from these environments, shedding light on their pivotal role in the origin of stars and how they reshape our understanding of the star formation process. Additionally, I will discuss the future of these studies in light of the advent of new facilities.

[S8-P01] **Galactic 'Snake' IRDC G11.11-0.12: New Findings from SOFIA and JWST**

Omkar Jadhav**, **Lokesh Kumar Dewangan**, **Naval Kishor Bhadari**, **Arup Kumar Maity PS

Physical Research Laboratory, IIT Gandhinagar

Numerous observational investigations have demonstrated that Infrared Dark Clouds (IRDCs) are important sites for studying the birth of massive stars and embedded protostars. IRDCs appear as absorption features against the galactic background in mid-infrared images. Magnetic fields are thought to play a crucial role in the mass accretion and stability of IRDCs. However, the exact role of magnetic fields in the early stages of star formation including massive stars remains unclear. The present work focuses on one of the well-studied IRDCs, which is Galactic 'Snake' IRDC G11.11-0.12 (hereafter, cloud G11). We have examined the existing SOFIA HAWC+ 214 μm polarimetric data toward G11, allowing us to study the plane of sky (POS) magnetic field (B-field) morphology. Overall, the POS magnetic field orientations are found to be perpendicular to the cloud G11. Moreover, a noticeable change in the position angle is found towards the center compared to the rest of the cloud. A ring-like structure is also investigated in the B-field orientations, and is located between the central and southern region of the cloud G11. We generated a POS B-field map using the Davis-Chandrasekhar-Fermi Method and computed mass-to-flux ratios, revealing both subcritical and supercritical regions in the cloud. However, embedded protostars are found toward the entire cloud. Interestingly, dust condensations hosting previously known high mass protostellar candidates p1 and p6 seem to be subcritical and supercritical, respectively. On the basis of the energy balance calculations, p6 is found to be in a more evolved state than p1. Our analysis of the cloud's Position-Position-Velocity map revealed large-scale periodic velocity oscillations. On comparison with the existing Gravitationally Induced (GI) core collapse model, it was observed that the detected oscillations arise from a combination of the kinematics associated with the GI core collapse model and the oscillation of large-scale physical filaments. The existing JWST near-infrared images reveal a hub-filament configuration (below 10000 AU) around p1 and p6, where new embedded sources are investigated, which are not detected in the existing highly sensitive IR surveys like VVV. In this presentation, I will provide a more thorough analysis of our findings.

[S8-P02] **Magnetically regulated massive star-formation in Cep A**

Sandhyarani Panigrahy **, *Dr. Eswaraiah Chakali*** **PS**

IISER Tirupati

To understand the role of magnetic fields in massive star formation, we have conducted sub-mm dust polarization observations with JCMT SCUBA2/POL-2 towards a massive clump, Cep A. From the analysis, we found that the polarization fraction (P) decreases with the μm continuum intensity (I) with an index of α = -0.65$\pm$ 0.03, indicating a better alignment of dust grains with the magnetic field (B-field). Notably, the dust grain alignment seems to be more pronounced in the direction of the precessing jet originating from the HW2 protostar, owing to the mechanical alignment of dust grains (MAD). The offset angle map of B-field and Gravity suggests a good alignment between magnetic and gravitational fields in the N-S direction, while they mismatch in the E–W direction, likely influenced by outflows originating from the central protostar. We have produced the maps of B-field strength, mass-to-flux ratio criticality (λ), and the Alfvenic-Mach number (MA) for Cep A. These analyses suggested that Cep A is magnetically sub-critical and turbulently sub-Alfvenic. Furthermore, from the sinω map, we deduced that the uniform B-field acts as a localized agent directing the flow of matter towards the gravitational potential well, facilitating accretion flows from the outskirts to the cloud center, thereby fueling the formation of massive stars.

[S8-P03] **FAST HINSA Zeeman Observations of PGCC G89.75-2.16**

Ujwal Reddy P **, *Dr. Eswaraiah Chakali*, *Dr. Tao Chung-Ching*, *Dr. Ningyu Tang*, *Dr. Di Li*** **PS**

IISER Tirupati

The Zeeman effect allows us to study the line-of-sight magnetic field in the interstellar medium. The most common tracers are HI, OH, and CN. However, at densities where the transition from sub-critical to super-critical occurs, these tracers do not provide sufficient information to study the magnetic field. To overcome this, we employ the H$_{\rm I}$ Narrow Self Absorption (HINSA) tracer, which probes a small amount of H$_{\rm I}$ in cloud envelopes that are cold and have transition densities. We have made use of the Five-hundred-meter Aperture Spherical Telescope (FAST) to conduct the sensitive Zeeman splitting observations of HINSA from one of the PGCCs with a strong HINSA absorption feature. PGCCs, the targets of our observations, are dense, cold clouds that host the pristine physical conditions governing the star formation process. In this talk, I will present our results of measuring the magnetic field strength towards PGCC G89.75-2.16 with the help of radiative transfer equations.

[S8-P04] **Understanding the importance of magnetic fields in the "collect and collapse" model of star formation: a case study towards S104 using JCMT SCUBA2/POL2**

***Rohit Chaudhary*, Eswaraiah Chakali, Manash R Samal, Vineet Rawat, and Sandhyarani Panigrahy** PS

PhD Student

We present the results based on the sub-mm polarization observations conducted with JCMT SCUBA2/POL2 data towards the S104 region. We have delineated the magnetic field (B-field) morphology in the clumps formed as a consequence of the "collect and collapse mode of triggered star formation". We aim to understand the relative importance of B-field in comparison to turbulence, gravity, and electron thermal pressure. The analyses show both parallel and perpendicular B-field patterns with respect to the direction of the I-front. The power-law fit over intensity versus polarization data yields an index of α =- 0.65$\pm$ 0.06, suggesting efficiently aligned dust grains across various depths of a massive clump in S104. This implies that the observed polarized dust emission traces B-field morphology even in the denser parts of the clump. We estimate the B-field strength by making use of the DCF method and structure function analyses. We will present the results based on the comparison between the magnetic, turbulent, gravitational, and electron thermal pressures. We will then discuss the importance of B-field in governing the stability of the clump based on the virial analysis. We will finally compare the observed B-field morphology with that based on the MHD simulations.

[S8-P05] **Role of Magnetic Fields in Star Formation - Quantum Mechanics Perspective**

Parike Madhu Krishna, Bingsati Roy PS

Department of Physics and Electronics, School of Sciences, JAIN deemed to be University, #34, 1st Cross, JC Road, Near Ravindra Kalakshetra, Bangalore - 560027

This work presents a pioneering exploration into the role of magnetic fields in star formation from a quantum mechanical standpoint. Employing the principles of quantum physics, we investigate the fundamental interactions between magnetic fields and the quantum dynamics of particles within the intricate environments of molecular clouds. By delving into the quantum nature of magnetic field alignment, we aim to elucidate the quantum harmonies that govern the delicate dance of star formation. Through theoretical analyses and quantum simulations, we uncover the quantum mechanical nuances influencing the stability, collapse, and subsequent emergence of stellar structures within magnetic fields. This quantum-centric perspective offers a novel lens for comprehending the enigmatic processes that underlie the cosmic genesis of stars.

[S8-P06] **Role of Magnetic Fields in Star Formation - Quantum Mechanics Perspective**

***Bingsati Roy**, Parike Madhu Krishna* PS

Department of Physics and Electronics, School of Sciences, JAIN deemed to be University, #34, 1st Cross, JC Road, Near Ravindra Kalakshetra, Bangalore - 560027

This work presents a pioneering exploration into the role of magnetic fields in star formation from a quantum mechanical standpoint. Employing the principles of quantum physics, we investigate the fundamental interactions between magnetic fields and the quantum dynamics of particles within the intricate environments of molecular clouds. By delving into the quantum nature of magnetic field alignment, we aim to elucidate the quantum harmonies that govern the delicate dance of star formation. Through theoretical analyses and quantum simulations, we uncover the quantum mechanical nuances influencing the stability, collapse, and subsequent emergence of stellar structures within magnetic fields. This quantum-centric perspective offers a novel lens for comprehending the enigmatic processes that underlie the cosmic genesis of stars.

Session IX: Extra-galactic star formation

[S9-I01] **The Rules of Star formation in Galaxies : from Small Scales to Large Complexes**

Mousumi Das IT

IIA, Bengaluru

Star formation in galaxies is known to depend on several factors, including disk and gas surface densities, disk shear, the presence of bars and spiral arms and interactions with companion galaxies. In this presentation I will briefly discuss these effects and show using examples that the stellar disk properties and gas availability are the most important parameters for supporting star formation in galaxies. I will use recent UVIT studies of massive galaxies and dwarf galaxies to illustrate how commonly known correlations such as the Kennicutt-Schmidt law and star forming main sequence, are really an outcome of these two dependencies.

[S9-I02] **Harmony of the Cosmos: unveiling the interwoven threads of star formation and galactic evolution in secular and environmental contexts**

Sreeja S Kartha IT

CHRIST (Deemed to be University)

Star formation, a fundamental astrophysical process, actively shapes the evolution and aesthetics of galaxies across the cosmos. Within galaxies, expansive celestial nurseries emerge, where the gravitational pull orchestrates the convergence of gas and dust, sparking the intricate ballet of star formation. The fate of these stellar nurseries is intricately woven through the interplay of diverse physical forces such as turbulence, magnetic fields, and radiation. A thorough understanding of the factors steering star formation is essential for a holistic comprehension of the broader panorama of galaxy evolution. We explore how the interplay of secular and environmental factors shapes the regulation of star-formation rates and, in turn, the evolution of galaxies. Employing the multiwavelength data, primarily from UVIT onboard AstroSat, our investigation extends to galaxies in diverse settings, including isolated fields, groups, and clusters. The discussion delves into the influence of internal factors like bars and density waves, along with external factors such as interactions and mergers.

[S9-C01] **Tracing star formation in void and filament galaxies**

Ananta Charan Pradhan, Divya Pandey, Kanak Saha CT

National Institute Technology Rourkela

We have observed small portions of the large-scale structures (LSSs) of the Universe, i.e., the voids and filaments situated 300 Mpc from us, using Ultraviolet Imaging Telescope (UVIT)/AstroSat. We detected a sample of void and filament galaxies in UV. We calculated their star formation rates and colors, modeled spectral energy distribution (SED) using multi-band fluxes, and dissected their structural properties. Our analysis reveals a dominant fraction of bluer galaxies over the red ones in the void region probed while we detected an equal number of star-forming and non star-forming galaxies in filaments. The large-scale environment weakly impacts the ongoing star formation in void galaxies. In comparison, our study on the filament galaxies confirms the influence of the environment on their evolution. We studied the star formation properties of a massive void galaxy, I Zw 81, and found that the nuclear region of the galaxy comprising the bar shows signs of strong far- and near-UV emission, while there is a dearth of recent star formation at the galactic outskirts. We inferred that bar and minor mergers-like interactions enhance the gas inflow and drive star formation in the center of I Zw 81.

[S9-CO2] **Effect of high-mass stars on the properties of ISM in N44 of the LMC**

Susmita Barman**, **Naslim Neelamkodan**, **Suzanne C. Madden**, **Marta Sewilo**, **Francisca Kemper**, **Kazuki Tokuda**, **Soma Sanyal**, **Toshikazu Onishi**, **Kisetsu Tsuge**, and **Batool Ilyas

CT

University of Hyderabad

The N44 superbubble, one of the brightest star-forming regions in the Large Magellanic Cloud (LMC), is easily recognized by its compact H II regions along the main shell rim in a Hα map. This work presents the impact of high-mass star on Interstellar medium (ISM) properties in a massive star forming region, N44 of the LMC. Previous studies show the OB star association in N44 was created approximately 5 Myrs ago by a colliding H I flow. The H II regions (N44 C, N44 D1) showed expansion velocities of about 20 km/s, which is due to the strong radiation pressure from the central ionizing stars. We use 13CO(3-2) and 12CO(3-2) emission recorded with Atacama Submillimeter Telescope Experiment (ASTE) to present the morphology, column density, mass, and velocity distribution of the molecular gas in the N44 CD molecular cloud in the LMC. We determine the total H2 mass of this clump to be $\sim 1.9 \times 10^4 M_\odot$ with radius $\sim$4.3 pc, which exceeds the mass requirements previously suggested for massive star cluster forming region. In the PV diagram, which is taken at the intersection of these velocity components, we detect an inverted V-shaped gas distribution. Further we used the CLOUDY spectral synthesis code to reveal the physical properties which are governing the H II region of hot stars. Using the integral field optical spectroscopic data made with Multi-Unit Spectroscopic Explorer (MUSE), we conduct a thorough investigation of N44 C and N44 D1 region. We characterize the spatial distribution of emission line geometry and the physical conditions by comparing these findings to the photoionization models generated by CLOUDY. A spherically symmetric ionization-bounded model with a partial covering factor, which is appropriate for a blister H II region, can well reproduce the observed geometry and most of the diagnostic line ratios in N44 D1. Similarly, in N44 C we apply a low-density and optically thin model based on the observational signatures. Our modeling results show that the ionization structure and physical conditions of N44 D1 are mainly determined by the radiation from an O5 V star. However, local X-rays, possibly from supernovae or stellar wind, play a key role. In N44 C, the main contribution is from three ionizing stars.

[S9-C03] **Observation of Radio Continuum Halos of 8 Nearby Large Galaxies using uGMRT**

Souvik Manna CT

S.N. Bose National Centre for Basic Sciences, Kolkata

Magnetic fields are believed to play a crucial role at various stages of the star formation process—from the fragmentation of clouds at the few kiloparsec scales to the final collapse of gas into stars. Besides, Cosmic Ray Electron (CRE) propagation is coupled to several physical processes, like turbulence and outflows, which are directly related to the star-formation activity. Low radio-frequency observations below 1 GHz are unique tracers of magnetic fields and CRE because synchrotron emission, which traces both the components, dominates at these frequencies. However, most studies on nearby galaxies have been carried out at frequencies above 1GHz. We began the Metrewavelength survey of Local Volume Large galaxies(MLVL), a GMRT survey of 46 nearby galaxies at 400MHz at linear resolutions below 1 kpc. We observed 8 galaxies using the upgraded GMRT (uGMRT) at 400MHz with an angular resolution of $\sim$10 arcsec. The achieved sensitivities of these observations range from $\approx$15 to 50 μJy/beam which is $\approx 3-4$ times lower than the previous observations at these frequencies. For 3 galaxies with moderate inclination angles, significant diffuse emissions are seen for the first time. Detected radio halos in the vertical direction are 50%, 30%, and 75% larger in uGMRT maps than compared to the JVLA observations at 1.5 GHz for 3 edge-on galaxies - NGC4096, NGC4594, and NGC4631 respectively. For these 3 galaxies, significantly larger halos are also detected along the galaxy disk. For NGC3623 and NGC4594, we detected elongated radio disks which was not seen before. We also fitted an exponential function to the flux densities along different cross-cuts and found a significantly smoother distribution at 400MHz uGMRT images than compared to the high-frequency images. Using archival LOFAR maps at 144MHz and JVLA maps at 1.5GHz, we made spectral index maps and found steepening of the spectrum up to a value of -1.5 in the halo regions of all the galaxies.

[S9-P01] **Secular evolution of galaxies : a star formation perspective**

Ujjwal Krishnan**, **Sreeja S Kartha**, **Robin Thomas**, **Akhil Krishna R PS

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The evolutionary trajectory of galaxies in the local Universe is significantly shaped by secular processes, characterized by the gradual rearrangement of energy and mass. Secular evolution is driven by various morphological components such as active galactic nuclei, bars, oval discs, and spiral structures. Advances in high-resolution imaging telescopes provide a unique opportunity to delve into the star-forming properties of nearby galaxies at resolved scales. Since the UV flux is a direct indicator of the star formation in galaxies, the UltraViolet Imaging Telescope (UVIT) onboard AstroSat enables us to characterize the star-forming knots in the nearby galaxies (within angular scales less than 1.4”). Integration of UV images with high-resolution multiwavelength data from dedicated observatories like ALMA and MUSE enhances our comprehension of the gas-star formation cycle. To elucidate the secular evolution of galaxies, we focus on a sample of barred spiral galaxies hosting active galactic nuclei in their centers – NGC 1672, NGC 4321, and NGC 7496 – in the nearby Universe. The selection is based on the availability of UVIT and auxiliary datasets. Identification and characterization of star-forming regions within these galaxies are performed using UVIT images and auxiliary data covering the electromagnetic spectrum from submillimeter to infrared. Systematic exploration of the evolutionary mechanism affecting star formation involves quantifying star formation rate, star formation efficiency, and star formation history on resolved scales. Extensive analysis of each morphological component reveals that stellar feedback and the presence of active galactic nuclei play pivotal roles in regulating the gas-star formation cycle in the nearby Universe. Our results provide valuable insights into the complex interplay influencing the evolution of galaxies in a secular context.

[S9-P02] **Investigating the Impact of Ram Pressure Stripping on Star Formation in NGC 4254**

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Ram pressure stripping can strip out gas from a galaxy. Galaxies undergoing ram pressure stripping in clusters are an excellent opportunity to study the effects of the environment on star formation activity. Studying the star formation properties allows us to gain valuable insights into the galaxy's evolutionary processes as well. We probe NGC 4254 entering the Virgo cluster. This galaxy is starting to undergo ram pressure stripping. We aim to understand the UV star formation activity in the galaxy, thereby acquiring a profound understanding of the evolution of NGC 4254. The UltraViolet Imaging Telescope (UVIT) onboard AstroSat, having a superior spatial resolution of 1.4" offers an opportunity to characterise the star-forming regions in the galaxy. Star formation rates are estimated and correlated in light of the multiwavelength data. We observed the radial and spatial distribution of the star formation rates. The star formation efficiency of the galaxy exhibits an interesting trend, with higher efficiencies observed in the spiral arms rather than the central regions of the galaxy. We probed the reason for the observed trends and thus, concluded on the effect of ram pressure stripping on the star formation properties of NGC 4254.

[S9-P03] **Probing Star Formation in AGN-hosting Galaxies: Insights from UVIT Observations**

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The study of star formation is pivotal in unravelling the evolution of galaxies, offering insights from cosmic noon to late-stage galaxies. One of the tracers of star formation is ultraviolet (UV) emission, which can effectively pinpoint stellar populations aged between 10 to 100 million years along with other optical, infrared and mm band tracers. While UV light is often obscured by dust, proper corrections for extinction can yield better estimate on the emitted radiation. The pioneering observations from GALEX paved the way for UV studies in this domain, and the UVIT instrument aboard AstroSat, India's first mult-wavelemgth astronomical observatory has made substantial contributions. Its exceptional angular resolution empowers investigations on smaller scales over large field of view than previously possible. We have been carrying out a systematic investigation of the star formation properties of galaxies hosting active galactic nuclei (AGN) mostly Seyferts with redshifts lesser than 0.01, characterized by sizes exceeding 2 arcminutes, employing UVIT. Its remarkable angular resolution has enabled the detection of star-forming clumps with sizes ranging from 30 pc to several hundred pc, contingent on the sources' redshift. We have meticulously analyzed the stellar properties of these clumps. Furthermore, our investigation involved the estimation of extinction using the UV slope method, revealing intriguing radial variations in some galaxies while displaying constancy in others. The UV colour information we gathered, has provided valuable insights into the distribution of stellar ages throughout these galaxies. Moreover, by examining the flux data, we have discerned the distribution of star formation rates. Our findings of the concentration of star formation near the centers of most Seyfert galaxies suggest the positive impact of the central AGN on its nearby ISM. This comprehensive study using UVIT has enriched our understanding of star formation processes in galaxies hosting AGN and their intricate interplay with dust and other galactic properties. Details of these results will be presented.

[S9-P04] **Dynamical lineage of field ultra-diffuse galaxies**

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Ultra diffuse galaxies (UDGs) constitute a class of galaxies with very low stellar central surface brightness yet relatively large stellar extent given their dynamical mass in the dwarf regime. These galaxies have been observed in all possible environments in the universe, the effect of their local habitat being reflected upon their structure and kinematics. In particular, UDGs found in the field environment have dwarf-like dark matter halo; they are HI-rich and actively star-forming as indicated by their blue color. Morphological similarities between field UDGs and other low luminosity samples, as suggested by spectroscopic observations, may possibly indicate their evolutionary link which in turn may reveal crucial insight into the dynamics and evolution of field UDGs. In this study, we investigate the common dynamical origin of field UDGs with other low luminosity field galaxies, namely the low surface brightness galaxies (LSBs) and the dwarf irregulars (dIrrs). First, by obtaining the possible scaling relations for LSBs and dIrrs and superposing the data for UDGs on them, we observe that UDGs follow the scaling relations for dIrrs more closely, specifically in terms of (i) central stellar surface density vs exponential stellar disk scale length, (ii) stellar vs HI-mass, and (iii) stellar vs dynamical mass scaling relations. Further, we construct distribution function-based stellar-dynamical models of these galaxies constructed from stellar photometry and HI 21cm radio-synthesis observational data already available in the literature. Comparing the modelled radial-to-vertical velocity dispersion ratios and rotational velocity-to-total stellar velocity dispersion ratios of these galaxies, we note that UDGs and dIrrs have similar stellar kinematics than LSBs. Finally, we conduct principal component analysis incorporating some structural and kinematical parameters as obtained from the modelling. We observe that for UDGs and dIrrs the variance in the data is mainly explained by the total HI-mass, while the ratio of radial-to-vertical velocity dispersion dominates the same in LSBs. We therefore conclude that field UDGs and dIrrs possibly share a common dynamical lineage.

[S9-P05] **Deciphering the young star-forming regions in NGC 4571: A UVIT-SDSS-ALMA study**

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We present a multi-wavelength study of the nearby flocculent galaxy NGC 4571 using multi-band observations taken from the Ultra-Violet Imaging Telescope (UVIT) in the F154W and N263M filters, the Sloan Digital Sky Survey (SDSS) in the g and r filters and the Atacama Large Milimeter/Submilimeter Array (ALMA). With the superior spatial resolution of UVIT (1 pixel $\sim$ 30.2 pc), we identified 368 bright young star-forming regions in the UVIT FUV and NUV bands within the galaxy with their radii between $\sim$ 55 - 240 pc. These regions were found to be clumpy in nature and located throughout the galaxy. We observe a gradient of younger and less massive sources with increasing radial distance. We observe the majority of star formation activity to have occurred between 200 and 400 Myr, with little residual activity. The masses of the identified regions span a range between $10^3 - 10^6$ $M_\odot$. We also notice the youngest sources to distinctly trace the flocculent arms of the galaxy. We derived the radial surface brightness profiles in the UV and optical bands, the radial UV F154W - N263M and the optical g - r color profiles, and the radial SFR density profile of the galaxy, all of which provide further evidence for galaxy-wide star formation. We estimate the star formation rate of the galaxy to be $\sim$ 0.220798 $\pm$ 0.002388 $M_\odot$ / yr. We also studied the associations of these clumps with the ALMA-detected Giant Molecular Clouds (GMCs). We find 153 such SFC-GMC associations with the maximum cross-matching radius being 10 arcsec ($\sim$ 720 pc) We observe these SFC-GMC associations to be located throughout the galaxy, predominantly tracing the flocculent arms of the galaxy.

[S9-P06] **Influence of AGN on the star formation properties in the nearby active galaxy NGC 1566**

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Active Galactic Nuclei (AGN) and their jets can influence the star formation activities of the host galaxy via radiation energy or mechanical outflows. This energy may quench (negative AGN feedback) or enhance the star formation (positive AGN feedback). This feedback, in turn, can affect the activity of AGN. However, observational evidence for such feedback effects is very limited. We have initiated the study of AGN feedback in one of the nearby active galaxies, NGC 1566. We utilized optical and UV observations to derive various star formation properties. We used UV observations from UltraViolet Imaging Telescope (UVIT) onboard AstroSat and Galaxy Evolution Explorer (GALEX) to derive the radial dependence of the UV SFR density and spatially resolved FUV-NUV magnitude diagrams to infer the star formation properties. We will also present the initial results from our study on the spatially resolved optical spectroscopic data from Multi-Unit Spectroscopic Explorer (MUSE).

[S9-P07] **Identification of lopsided galaxies using Convolutional Neural Network**

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The non-axisymmetric features in disc galaxies including bars and spiral arms are fundamentally important in driving their secular evolution. Yet another promiscuous non-axisymmetric feature in the galactic disc is the large-scale asymmetry in the distribution of stars and gas, commonly referred to as lopsidedness. However, their formation and evolution are not very well understood. Quantitatively, lopsidedness is the normalised amplitude of the non-zero m=1 mode in the Fourier decomposition of the surface brightness distribution of the galaxy. About 30 % of the galactic disc shows global lopsidedness. In this work, we aim to augment their relatively sparse sample size by new identifications from the updated catalogs from the more recent surveys, using machine learning methods. To implement the same, we train the publicly-available ALEXNET, a convolutional neural network model for binary classification of galaxies into lopsided and non-lopsided galaxies. For training the neural network, we selected 40 galaxies images from the Sloan Digital Sky Survey Data Release 12 from Bournaud et al., 2005. After deprojecting the galaxy images to face-on view, we obtained the value of for each galaxy. Based upon the above-calculated value and the threshold well-adopted in the literature, we labelled the galaxies as lopsided and not lopsided. Our trained model achieved an accuracy of almost 90 % on the validation set. We aim to further improve our testing accuracy by expanding the training set for our model, allowing the model to learn more efficiently.

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Useful Information

Talks will be held at the **Silver Jubilee Hall** of Main building. It is situated on the second floor of the Main building and has independent access from the rest of the building (through stairs and lifts located at the ground floor).

Tea breaks will be offered in front of the main entrance of the conference hall. **Lunches** will be offered in the **Basudhara dinning hall.**

The **poster session** will be held on the **First floor of Bhagirathi Guest House**.

Wi-Fi will be available during the conference.

The **conference dinner** will be held at the **Staddle**, at Salt Lake City, Kolkata.

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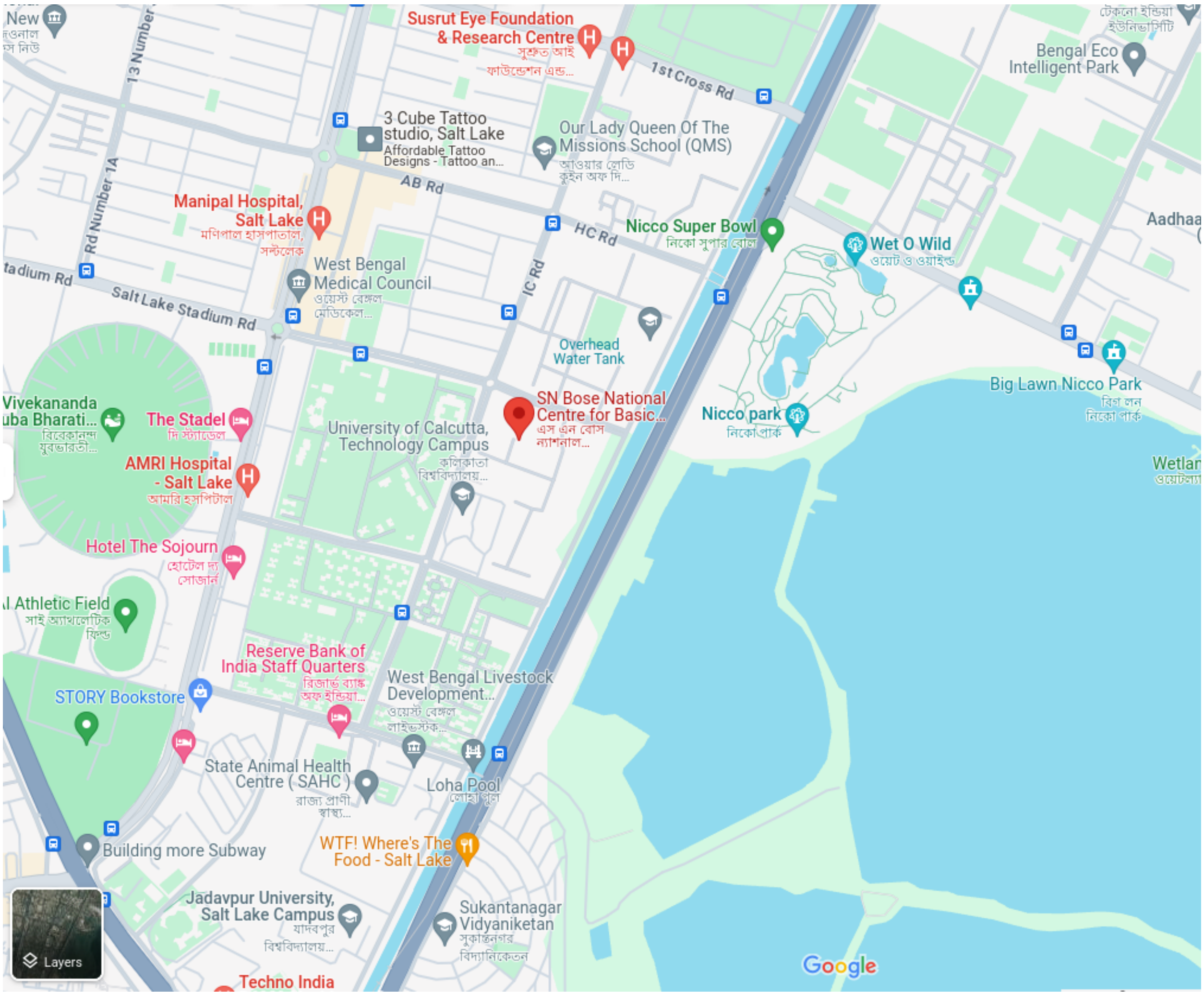
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