Unstable and Time-Variable Accretion Flows from Core to Disk to Star

October 15–17, 2025
Canadian Institute for Theoretical Astrophysics (CITA)

Day 1 – Wednesday, October 15, 2025

Arcs, Cavities, and Outflows in Magnetized Collapse

Speaker: Shantanu Basu

Affiliation: Canadian Institute for Theoretical Astrophysics (CITA)

Abstract: The ALMA-era of star formation studies has revealed many irregular structures in the near-protostellar environment. I review recent three-dimensional nonideal MHD simulations that reveal surprising new insights into the role of magnetic fields and magnetic field dissipation in creating outflows, arcs, and cavities on scales of hundreds to thousands of au. Magnetic fields are responsible for a complex inflow-outflow structure around a protostar, including effects of pseudodisk winds and expanding cavities driven by the magnetic interchange instability. I discuss the role of these effects in creating a complex circumstellar structure as well as possibly leading to a termination of mass infall.

Attempting to find the origin of accretion bursts starting at ISM scales

Speaker: Rajika Kuruwita

Affiliation: Heidelberg Institute for Theoretical Studies/Australian National University

Abstract: I present preliminary work attempting to find the origin of some accretion bursts starting from ISM scales. Previous models of accretion burst phenomena like FUors have limited the mass available to drive the burst to the circumstellar disc of the bursting star. However, outbursting young stars are embedded within molecular clouds that they interact with and accrete from. From moderate resolution (25au) simulations of clustered star formation with high cadence (2yr) sink particle accretion data, I search for candidates that look like they might be experiencing an outburst. This is done by cross-correlating a step function with a moving window over the accretion profile of all sink particles. Zoom-in simulations were run on the candidates to achieve a resolution of a few au. I found that all candidates had multiple good matches when cross-correlating with the step function. This is because all candidates happened to be in binary star systems, and the step function was not matching 'bursting' events, but rather dramatic accretion suppression events that occur at periastron. Post-suppression, the accretion rate of the candidates increases quickly over multiple orders of magnitude to the pre-suppression accretion rate. A resolution study of a candidate shows that this accretion suppression is resolved. On closer inspection at periastron, the circumstellar material of the candidate is stripped away due to ram pressure from the fast orbital velocities. Shortly after periastron, the

candidate accretes mass rapidly in a Bondi-Hoyle-Lyttleton fashion. The circumstellar material is replenished from streamer accretion and accretion from the ambient star-forming medium. The candidate accretion rate returns to pre-suppression rates. My question to the audience is, is this a plausible physical mechanism of dramatic accretion variability? What accretion rates can we expect from BHL accretion? And can we possibly test this observationally?

Complex Envelopes in the Earliest Phases of Star Formation and Their Implications

Speaker: Kazuki Tokuda

Affiliation: Kagawa University

Abstract: Understanding how protostars acquire their mass, how magnetic flux is redistributed, and why protostellar disks exhibit such a wide range of sizes and substructures are central problems in star-formation studies. Using ALMA, we have conducted targeted observations of very young sources, including Class 0 VeLLOs. These data reveal complex morphologies on multiple spatial scales: arc/ring-like structures extending over several thousand au in the envelope, as well as spike-like features attached to the disk on scales of only a few au. Some of the structures have appeared in our series of observations since the ALMA Cycle 0 era (Tokuda et al. 2014), but their origin remained unclear. By comparing the ALMA data with recent non-ideal MHD calculations, we find that the observed structures are explained if the interchange instability, a form of magnetic buoyancy, operates near the disk edge. In this picture, magnetized material becomes locally buoyant and is displaced outward, leaving behind residual magnetic fields and density enhancements that manifest as arcs/rings in the envelope and narrow, spike-like protrusions at the disk periphery. The associated re-organization and outward transport of magnetic flux can fundamentally alter the inner magnetic topology, potentially easing the magnetic-flux problem and setting the protostellar disk size.

The characterisation of eruptive variable YSOs in the time-domain era

Speaker: Carlos Contreras Pena

Affiliation: Seoul National University

Abstract: The detection of large accretion outbursts in young stellar objects provides support to the idea that stars gain most of their mass during short-lived episodes of high accretion. The universality of episodic accretion, as well as its potential impact on stellar and planetary formation are still under debate. Improvement on the statistics of the members of the eruptive class is needed to better understand the episodic accretion phenomenon and its universality across different mass regimes and environments. Eruptive variable YSOs (a.k.a FUors/EX Lupi-type) are a relatively rare class of objects. However, thanks to dedicated time-domain surveys across a wide wavelength range, the members of the eruptive variable class have increased by a factor of 3-4 over the last decade. In this talk, I will present a summary of the characteristics of this variability class, the methods used to detect and confirm their classification, as well as the lessons we have learned from decades-long monitoring of large samples of YSOs.

Go with the Flow: Probing the Dynamics During Protostar and Disc Formation

Speaker: Asmita Bhandare

Affiliation: USM, LMU

Abstract: Stars like our Sun and their planet-forming discs are born through the gravity-dominated collapse of cold, dense fragments within molecular clouds. In this talk, I will share insights from numerical simulations that follow the transition of an isolated molecular cloud core to hydrostatic cores with a surrounding disc. I will present results on gas–dust interactions in the earliest stages of disc formation. The main takeaway is that a very young disc is extremely dynamic and shows complex hydrodynamical gas features. Data from our 2D radiation hydrodynamic simulations reveal transient dust traps and a thermal-pressure-driven outflow that transports material from sub-au regions in embedded discs. These mechanisms offer efficient pathways for thermal reprocessing during pre-stellar core collapse. I will also briefly discuss ongoing experiments that examine the effects of streamlined infall in these nascent stages.

Magnetic field and its influence on protostellar disk formation

Speaker: Yisheng Tu

Affiliation: University of Michigan

Abstract: Magnetic fields are observed throughout all stages of star and disk formation, from molecular cloud cores to protoplanetary disks. Their influence is expected to be significant, yet their precise role remains poorly understood. Using non-ideal magnetohydrodynamic simulations with Athena++, we investigate how magnetic fields shape the formation and early evolution of stars and circumstellar disks. Our models follow the collapse of a molecular cloud core through star and disk formation. In the absence of initial turbulence, the system develops the well-known pseudodisk—a flat, rapidly infalling midplane structure. With turbulence, however, the pseudodisk fragments into three-dimensional, sheetlet-like structures, which we term "gravo-magneto-sheetlets" since they arise from the interplay of gravity and magnetic fields. These sheetlets dominate the transport of mass, angular momentum, and magnetic flux through the protostellar envelope, with the relative contributions regulated by the strength of non-ideal MHD effects that decouple gas and magnetic fields. Within the newly formed disk, magnetic fields remain crucial, typically dominating angular momentum transport over gravitational torques. To connect with observations, we are developing a method to infer magnetic field strength in infalling sheetlets from kinematic signatures and dust polarization. This technique provides an indirect probe of magnetic fields in collapsing protostellar cores and constrains the magnetic flux inherited by forming disks.

Accretion History from Core Collapse to Disk Evolution: Implications for Planetesimal Formation

Speaker: Indrani Das

Affiliation: Academia Sinica Institute of Astronomy and Astrophysics (ASIAA)

Abstract: Understanding the early stages of star formation is the key to explain how stars and planets form and evolve. This yet remains one of the most challenging frontiers in the field, as it requires disentangling the physical processes across a wide range of spatial and temporal scales. In the first half of my talk, I will present the results from the numerical exploration of the magnetized gravitational collapse of a prestellar cloud core, using global nonideal magnetohydrodynamic (MHD) simulations, encompassing a wider range of EOSs in form of $P(\rho) \sim \rho^{\Gamma}$, that provides insights on constraining the choice of EOSs, which in turn, facilitates necessary cooling in allowing star formation. Our numerical results, complemented by the magnetized virial theorem, reveal that the collapse model with a Γ no stiffer than 4/3 allows the dynamical core collapse to happen continuously where a point-mass-like protostar forms and steadily builds up its mass from the infalling envelope, with a mass accretion rate of the order of c^3/G. At this stage, the collapse becomes fully dynamical, progressing from the inside out, with material accreting through pseudodisks. Whereas, the collapse models with a stiffer than 4/3 fail to ensure sufficient cooling for allowing the direct mass growth of the central point-mass-like protostar, thus delaying the mass infall. These results may provide a new perspective on the concept of direct mass infall onto the central protostar during the earliest stages of collapse, a key physical process that drives the protostar's mass growth. During accretion through a protoplanetary disk (PPD), young stellar objects (YSOs) are observed to undergo episodic and powerful accretion events, known as FUor or EXor outbursts, that drive protostar's mass growth. In the second half of my talk, I will present results on the long-term PPD evolution, occurrence of accretion bursts, dust dynamics, and prospects for first-generation planetesimal formation in gravitationally unstable disks with episodically triggered magnetorotational instability (MRI) from global thin-disk MHD simulations of low-mass YSOs, with comparisons to intermediate-mass YSOs. Within the inner disk, dust rings form due to the radially varying efficiency of mass transport by gravitational instability and are susceptible to streaming instability (SI). In the early disk evolution, frequent MRI bursts may impede the feasibility of planetesimal formation via SI, even though the inner disk is prone to develop SI. In later stages—particularly for intermediate-mass YSOs—SI becomes inefficient as increasing dust drift and an extended inner dead zone reduce dust concentrations below SI threshold. Low-mass YSOs seem to be less affected by these adverse effects. This study may highlight how episodic accretion shapes PPD evolution across stellar masses, which may explain the relative dearth of planets around stars more massive than 3 Msun, in contrast with their abundance around low-mass stars.

Star Formation in Filamentary Hierarchies

Speaker: Ralph Pudritz

Affiliation: McMaster University

Abstract: Recent advances in the design of MHD codes as well as vast improvements in computer architecture are enabling a new generation of multi-scale simulations of star formation. Simulations, theory, and now observations (JWST) reveal that the interstellar medium is organized as a filamentary hierarchy from kpc down to subpc scales. Our own multiscale galactic MHD simulations, using the RAMSES code, of flocculent and NGC628 like spiral galaxies undergoing supernova feedback elucidate filament formation, dynamics, and accretion flows down to sub pc scales (Zhao et al. 2024, Pillsworth et al 2025a,b; Koletic et al. 2025 submitted). I will discuss these and our latest results (achieving resolution down of 200 AU), and what these are telling us about the connection between filamentary hierarchies, accretion flows, and variability down to disk scales.

Day 2 – Thursday, October 16, 2025

Formation and evolution of embedded disks toward planet formation

Speaker: Nagayoshi Ohashi

Affiliation: Academia Sinica Institute of Astronomy and Astrophysics (ASIAA)

Abstract: It is well known that disks are formed around young stellar objects during the star

formation process. Even though these disks are formed as by-products of star formation, they play essential roles in star and planet formation. In particular, disks around Class II sources, often called protoplanetary disks, have attracted more attention because they are believed in the main planet-formation phase. In contrast, disks around embedded protostars, which are younger and more embedded than Class II disks, have attracted less attention. Recent researches, however, suggest importance of embedded disks for planet formation, requiring more systematic study of embedded disks. We have therefore carried out the ALMA large program "Embedded disks in early planet formation (eDisk)", observing 19 protostars in nearby star forming regions in 1.3 mm continuum at a resolution of 0.04" and in molecular lines such as CO isotopologues at a resolution of 0.1". In this presentation, I will review observational results of the eDisk program, with emphasis on more recent demographic results.

ALMA 2D Super-resolution Imaging Survey of Ophiuchus Class I/Flat spectrum/II Disks. I. Discovery of New Disk Substructures

Speaker: Ayumu Shoshi

Affiliation: Kyushu University

Abstract: This study focuses on Class I, flat-spectrum (FS), and Class II disks in the Ophiuchus molecular cloud, a nearby active star-forming region with numerous young stellar objects, to unveil signs of substrate formation in these disks. We employ two-dimensional super-resolution imaging based on sparse modeling for ALMA archival Band 6 continuum data, achieving images with spatial resolutions comparable to a few au (0".01–0".02) for 78 dust disks, all of which are spatially resolved. In our sample, we confirm that approximately 30%–40% of the disks exhibit substrates, and we identify new substrates in 15 disks (four Class I, seven Class FS, and four Class II objects). Their dust disk radii, Rdust, range from 5 to 179 au, with a median radius of 27 au. We confirmed that similar radius distributions between Class I and II disks, which is consistent with the disk evolution models that incorporate MHD disk winds or radial dust drift. Compared to the eDisk sample in terms of bolometric temperature, Tbol, our targets are in a later accretion phase. By combining our targets with the eDisk sample, we confirm that substrate detection in a viable dataset is restricted to objects where Tbol exceeds 200-300 K and the dust disk radius, Rdust, is larger than 30 au. Analyzing molecular line emission data around these objects will be crucial for further constraining the evolutionary stages of disks and understanding when and how substrates form.

Accretion Outbursts in Three-Dimensional Self-Gravitating Disks

Speaker: Han-Gyeol Yun

Affiliation: Seoul National University

Abstract: The concept of episodic accretion was first proposed to explain the observed protostellar luminosity distribution in star-forming regions. More recently, variability in YSOs has provided direct evidence for episodic accretion during the early stages of stellar evolution. However, the driving mechanism behind episodic accretion remains under debate. In this talk, we present our recent progress on hydrodynamical simulations of three-dimensional self-gravitating disks with an infalling envelope, which exhibit FU Ori–type accretion outbursts triggered by the combination of Gravitational Instability and Magneto-Rotational Instability.

Modeling Episodic Accretion in Protoplanetary Disks: From Mechanisms to Disk Evolution

Speaker: Kundan Kadam

Affiliation: Space Research Institute, Austrian Academy of Sciences

Abstract: The classical picture of low mass star formation begins with the collapse of an isolated magnetically supercritical cloud core under its own gravity. From the residual angular momentum of the cloud, a centrifugally supported circumstellar disk inevitably forms surrounding the protostar, which evolves viscously into protoplanetary disk. The micrometer sized interstellar dust grows in the environment of this disk to form planetesimals and eventually, planetary systems. However, in reality, the picture of star and planet formation is not as straightforward and several time-dependent phenomena with a rich diversity of physics make this process much more complex. In this talk, I will present my work related to modeling unstable accretion of disks surrounding young stars, from a theoretical point of view. I will talk about how the paradigm of disk accretion is changing to favor magnetic disk winds, the physics of FU Orionis-type accretion events, how mass ejection is linked with episodic accretion, the long-term behavior of the disk with respect to such unstable accretion. I will also talk about the impact of such powerful outbursts on disk substructure and early planet formation as well as some new results on the disk chemistry with respect to its ice reservoir and snow line evolution.

Chemical Consequences of Episodic Accretion in Protostellar Systems

Speaker: Jeong-Eun Lee

Affiliation: Seoul National University

Abstract: Episodic accretion in young stellar objects has recently emerged as a key driver of rapid and profound chemical evolution in star- and planet-forming environments. During accretion bursts, the sudden rise of protostellar luminosity elevates dust and gas temperatures, triggering sublimation of icy mantles, releasing abundant volatile species, and initiating complex organic chemistry in the gas phase. The same bursts can also induce crystallization of silicate grains at temperatures above 900 K, linking protostellar environments with the crystalline components observed in comets. As the system cools back to quiescence, recondensation and mantle reformation occur, raising fundamental questions about whether chemical changes are transient resets or cumulative enrichments. A major challenge lies in the mismatch between burst timescales (years to decades) and chemical relaxation timescales (hundreds to thousands of years), complicating the interpretation of molecular abundances observed at any given epoch. Multi-epoch observations with facilities such as ALMA and JWST, combined with time-dependent astrochemical modeling, now allow us to trace these processes directly. In this talk, I will review key issues in the chemistry of episodic accretion, focusing on the diagnostics of molecular ices and complex organics, the formation and transport of crystalline silicates, and the implications for the initial chemical composition of planetary systems.

The (in)stability of the inner disk: A universal outburst mechanism?

Speaker: Michael Cecil

Affiliation: Max Planck Institute for Astronomy (MPIA)

Abstract: The inner regions of protoplanetary disks are prone to various forms of instabil-

ities on both small and large scales. Heating by the protostellar irradiation produces a hot, gaseous, ionised region close to the star in which the magnetorotational instability (MRI) can be permanently maintained. Behind the dust sublimation front, the temperature quickly decreases, making thermal ionisation inefficient enough to shut down the MRI, thereby producing the MRI-dead zone. The dynamics and long-term temporal evolution of these transitions in the inner disk have proven challenging to understand and model. I will present radiation-hydrodynamic models of these elusive regions and discuss their evolution over thousands of years. Our simulations indicate that the inner dead zone becomes periodically unstable due to the activation of the MRI just beyond the dead zone's inner edge. These instabilities manifest as outbursts of accretion onto the central star, raising the accretion rate by several orders of magnitude compared to the quiescent stage. The burst is substructured into multiple reflares, establishing accretion variability on both large and small timescales. I will discuss the triggering, evolution, and consequences of this outburst scenario, as well as potential contributions to stellar mass assembly, and analyse the dependence of accretion variability on disk physics and parameters. While our models were designed for isolated disks without infall, this bursting mechanism has the potential of being universally applicable to Class 0/I/II objects in various environments. However, the occurrence, scales and periodicity of the instability are sensitively influenced by many different properties of the disk and the star, such as stellar luminosity, viscous efficiency (alpha-parameter), dust and gas opacities and non-ideal MHD effects, potentially allowing for a large range of burst magnitudes and timescales. Several open questions concerning this mechanism still remain and need to be addressed in the future. Among those, the interplay between the inner disk's evolution and other variability mechanisms occurring in young, high-mass disks (such as gravitational instability, infall, magnetospheric variability) seems to be the most pressing issue in the context of Class 0/I YSOs. The harmonisation of observationally derived signatures of outbursting YSOs with inner disk simulations remains a challenging endeavour as well. Reliable statistical compilations, as well as multi-epoch measurements of a variety of variable accreters, will be crucial in assessing the viability of theoretically predicted bursting mechanisms.

Star-disk connection: roles of stellar-scale processes

Speaker: Shinsuke Takasao

Affiliation: Musashino

Abstract: Stellar-scale processes play crucial roles in the evolution of protoplanetary disks. Ionizing radiation from stars, such as EUV and X-rays, significantly contributes to disk gas dispersal. In addition, star–disk interactions shape the density structure of the innermost disk regions, potentially influencing the orbital evolution of short-period planets. These processes collectively define the inner boundary conditions of protoplanetary disks. To investigate their properties, we have been conducting both theoretical and numerical studies. We are developing models of stellar ionizing radiation that incorporate detailed magnetic heating in stellar coronae, and we are performing 3D MHD simulations to study star–disk interactions across different evolutionary stages. In this presentation, I will introduce our approach and highlight recent findings.

Measuring the accretion on young stars

Speaker: Eleonora Fiorellino

Affiliation: Alma Mater Università di Bologna

Abstract: Measuring accretion luminosity on young stars remains a major challenge. Recent PENELLOPE data confirm statistical agreement between established methodologies, but they also reveal significant measurement differences when analyzing individual sources. We have built our current understanding of protostellar accretion by extrapolating from Classical T Tauri Stars (CTTSs). But given the new spectroscopic results and ongoing debates about fundamental differences (e.g., boundary layer vs. magnetospheric accretion), how do these findings affect our ability to measure accretion in protostars? In this talk, I will set up the discussion for possible pathways and self-consistent methods to constrain protostellar accretion, aiming to reconcile the existing discrepancies and advance the field.

Day 3 – Friday, October 17, 2025

The ALPPS project, first results (virtual talk)
Speaker: Paulo Cortes

Affiliation: NRAO

Abstract: The ALMA Perseus Polarization Survey (ALPPS) is an ALMA program designed to investigate the role of magnetic fields at high angular resolutions in the one of the most studied star forming regions, the Perseus molecular cloud. In this presentation, we report the first ALPPS results, focusing on the SVS13A protobinary system and its circumbinary disk. Our full-Stokes ALMA observations at $\sim 0^{''}.3$ and 870 μm, complemented with molecular line data from $C^{17}O(J = 3 \rightarrow 2)$, $C^{18}O(J = 2 \rightarrow 1)$, and $DCN(J = 3 \rightarrow 2)$ at resolutions between $\sim$ 01 and $\sim$ 03, reveal a remarkable magnetic morphology. The data resolve both a previously identified dust spiral and an infalling streamer, capturing their spatial and kinematic structure from scales of > 300 au down to the circumbinary disk.

Using alignment measure (AM) maps and histograms comparing the plane-of-sky magnetic field with local intensity and velocity gradients, we find a strong peak in the AM distribution (AM $\simeq 1$), indicating alignment between the magnetic field, the dust emission, and the gas velocity field—consistent with grain alignment by magnetic fields. From the polarization data we estimate a plane-of-sky magnetic field strength of $B_{\mathrm{pos}} \sim 1.1 \pm 0.6$ mG and a kinetic-to-magnetic energy ratio of 0.5 ± 0.4, suggesting a magnetically regulated flow. The derived Alfvénic Mach number map shows $\mathcal{M}_{\mathrm{A}} < 1$ along the streamer, indicating sub-Alfvénic infalling motions.

These results provide the first observational evidence for a magnetically sub-Alfvénic streamer channeling material from the envelope onto a protostellar disk, illustrating how magnetic fields can facilitate rather than impede accretion in forming binary systems.

Probing 100–10,000-au Scales in a Class 0 Protostar Driving Three Outflows
Speaker: Yuki Okoda

Affiliation: NRC-HAA

Abstract: Recent observations of protoplanetary systems reveal that about one-third of young stars have spin axes misaligned with their protoplanetary disks (Biddle et al. 2025). The origin of this misalignment may lie in the earliest stages of star formation as well; in particular, variability in outflow direction may contribute to the effect. The multiple outflows from the single Class 0 protostar IRAS 153983359 was reported with ALMA observations. Three outflows appear to have been launched along distinct position angles. The northeast-southwest outflow is known to be primary traced by 12CO, CCH, H2CO and so on (e.g., Oya et al. 2014; Vazzano et al. 2021), and the northwest-southeast outflow was reported with some shock tracers (Okoda et al. 2021a). On the other hand, the north–south outflow was recently reported in 12CO with ACA observation (Sai et al. 2024). To understand the third outflow more and large-scale gas distribution, we conducted ALMA Band 3 observations targeting several molecular lines. We detect SiO emission along the three directions with line widths as narrow as 1–2 kms^{-1}. Part of CCH and CN emission is extended along the north–south axis. CCH, together with HCN and $H^{13}CO$, appears to trace the north-south outflow cavity wall. Thus, the chemical characteristics in the north-south outflow is successfully found with our observation. The S-shape emission in CCH is seen at northeast and southwest, which looks like connecting to the primary outflow, while NHD exhibits an extended, likely large envelope distribution. These distributions will further be discussed.

Multifaceted Views of Magnetically Interplaying Inflow and Outflow in Protostellar Systems

Speaker: Hsien Shang

Affiliation: Institute of Astronomy and Astrophysics, Academia Sinica, Taiwan (ASIAA)

Abstract: A plethora of new, enigmatic phenomena in the innermost parts of protostellar systems, associated with jets and outflows, have been revealed by ALMA and JWST. These jets and outflows, along with the streamers from their magnetically collapsing prenatal envelopes, are integral parts of the physical processes that assemble the systems. We review the characteristics of these enigmatic, powerful phenomena that constitute telltale signs of the underlying fundamental physics revealed by generations of radio and optical telescopes. The unprecedented revelation of the fine, nested kinematic and morphological structures is consistent with theoretically predicted features of magnetized bubbles blown by magnetized winds from the innermost regions and the pseudo-disks formed inside the large magnetically supported envelopes. The ubiquitous systematics of the coupled and nested velocity and emission components finds a natural explanation in the unique combination of jet–outflow–envelope systems. Tomographic projections of morphological and kinematic structures naturally connect to high-angular resolution and high-sensitivity observations of the magnetically interacting inflow and outflow, enriched by chemical diversity.Further steps involving combined physical processes and microphysics are needed to connect the infall/outflow and accretion/ejection phenomena.

Time-variable, asymmetric in- and out-flows at envelope scales

Speaker: Hector G. Arce

Affiliation: Yale University

Abstract: We present results from an ongoing survey of the environment surrounding a large sample of protostars at different evolutionary stages in the Orion A molecular cloud. This study uses recently obtained multi-line ALMA data that probes the kinematics and distribution of the gas at envelope scales (out to 10,000 au from protostars). Maps of molecular outflow momentum, energy, and instantaneous mass ejection rate of jet-like flows reveal clear fluctuations in outflow kinematic properties which are not clearly detected in conventional outflow maps. We suspect these are indicative of time-variation in the outflow/accretion process. The molecular line maps also reveal a wide range of irregular structures at envelope scales, and at various stages of protostellar evolution, including asymmetric (infalling) dense envelopes, candidate infall streamers, outflow-induced cavities of various shapes and sizes, and drastically nonuniform outflow lobes. Our preliminary results support the conclusion that protostellar outflows have a direct impact on the mass-assembling process, and that the natal sites of individual low-mass star formation are far more dynamic and irregular than commonly accepted theoretical paradigms.

Optical-IR (OIR) Studies of Jets/Winds and FUors to Test Theories of Mass Accretion Processes

Speaker: Michihiro Takami

Affiliation: Institute of Astronomy and Astrophysics, Academia Sinica, Taiwan (ASIAA)

Abstract: Jets and winds close to young stellar objects (YSOs) have been extensively studied to understand their role in removing angular momentum from the circumstellar disk, and therefore allowing mass accretion to occur. In the first half of the talk, I will present our recent studies using Subaru, Gemini, VLT, and Keck telescopes about their complexities (jet knots, wide-angled wind, stationary shocks: Takami+ 2020, 2023a; Uyama, Takami+ 2022; Chou, Takami+ 2025), and summarize what we need to clarify in the near future in order to test the theories of their physical link with disk accretion. On the other hand, it has been suggested that accretion outbursts like FU Ori-type outbursts play an important role for many young stars to develop their masses. In the second half of my talk, I will summarize our recent understanding based on near-IR imaging observations that hint at the accretion processes via gravitational instabilities in disks or via accretion streamers. I will then explain how the observations using Subaru and ELT 39-m would be able to yield a breakthrough for better understanding (Takami+ 2023b, 2025).

Bowshocks driven by the molecular jet of an outbursting protostar

Speaker: Guillermo Blazquez-Calero

Affiliation: Institute of Astrophysics of Andalucia

Abstract: In this talk, I will present high-angular and high-spectral resolution ALMA CO observations of the molecular jet from the outbursting protostar SVS 13. Thanks to the high sensitivity of these data, we are able to resolve faint shell structures in the intermediate high-velocity regime ($\sim$30–100 km/s), which are connected to the extremely high-velocity (¿100 km/s) jet knots at their apex. The morphology and kinematics of these shells are in excellent agreement with predictions from an analytical bowshock model. This strongly supports the interpretation that jet knots provide a fossil record of ejection variability, further reinforced by the temporal coincidence of the most recent knot with the documented optical/IR photometric outburst of SVS 13 around 1990. These findings imply that accretion outbursts should be accompanied by changes in ejection speed, since variations in jet mass flux alone would not produce the observed internal shocks nor the observed bowshocks. Also, the fast material expelled during outbursts must be launched in a highly collimated direction, within $\sim$5 deg. This sets interesting constraints on the physical mechanism in the disk that drive outbursts at

timescales of several decades.