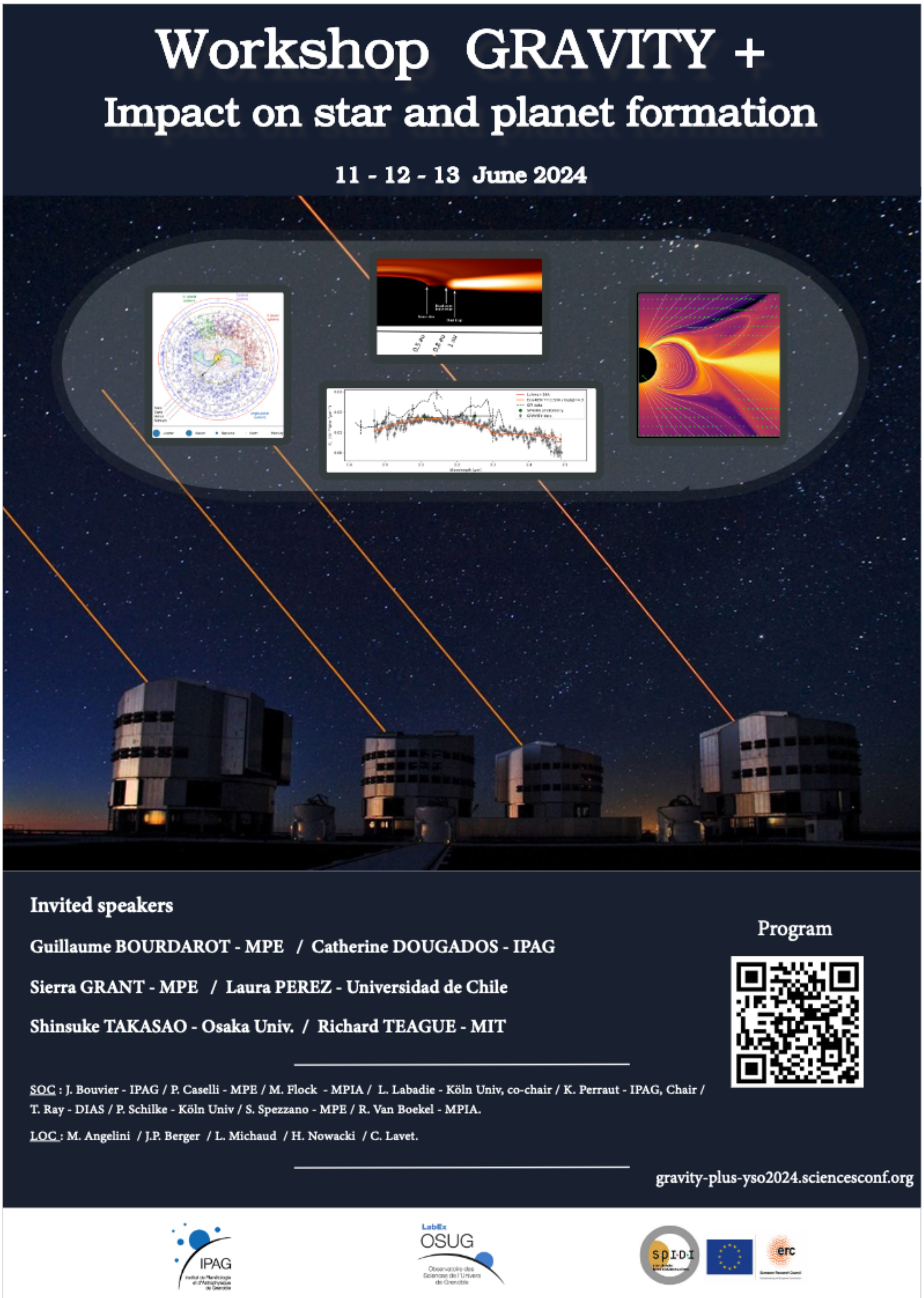
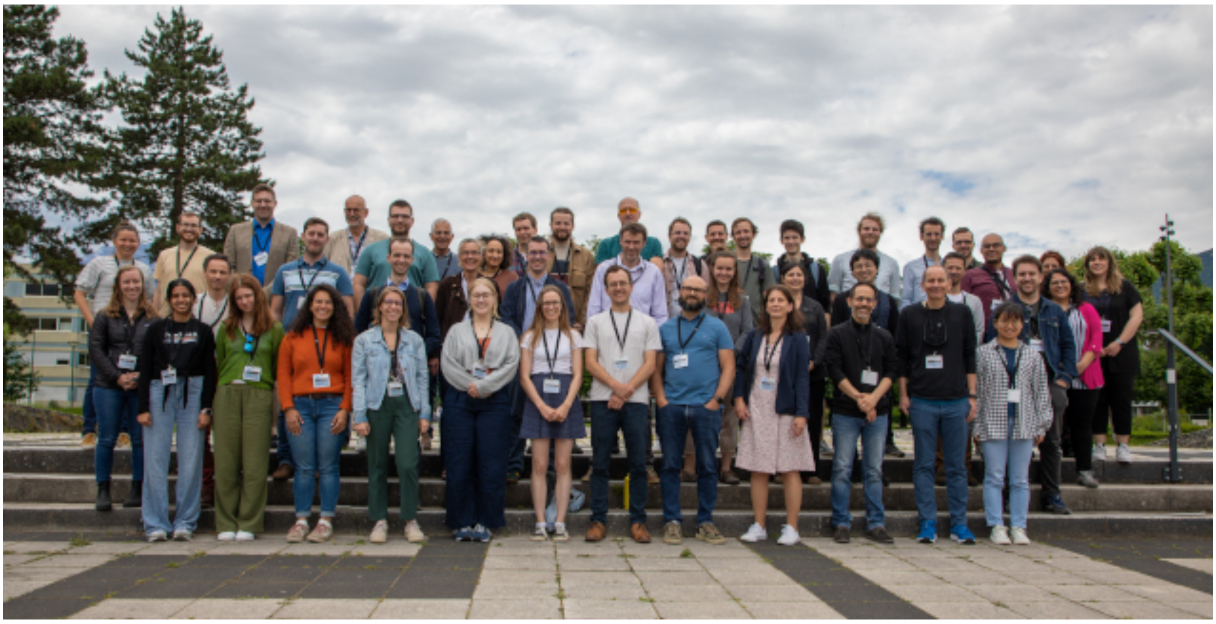


Book of abstracts



GRAVITY+ Workshop - Impact on star and planet formation

Day 1: Tuesday, 11 June 2024

9:00 (45')	Welcome and coffee
9:45 (15')	Welcome speech
	Session 1: **"From Gravity to Gravity+"**
10:00 (25'+5')	**Invited Talk - Catherine DOUGADOS** **The yield of the Gravity YSO survey and beyond**
10:30 (25'+5')	**Invited talk - Guillaume BOURDAROT** **The Gravity+ project**
11:00 (30')	**Discussion and Q&A on "Observing with Gravity+"**
11:30 (60')	*Poster flash presentations*
12:30 (90')	Lunch
	Session 2: **"Disk structure and evolution"**
14:00 (25'+5')	**Invited Talk - Laura PEREZ** **Disk structure and evolution**
14:30 (15'+5')	*I. CODRON - Characterising the inner region of protoplanetary discs using MIRC-X, PIONIER, and GRAVITY*
14:50 (15'+5')	*L. LABADIE - Tracing the time-variable asymmetric disk structure in the inner disk of a Herbig Be star: results and perspectives*
15:10 (30')	Coffee and posters
15:40 (15'+5')	*Y. BOUAROUR - The First High Resolution Interferometric Survey in K-band of High Mass YSOs*
16:00 (15'+5')	*E. DI FOLCO - Comparative disk structures in a young binary star system*
16:20 (50')	**Round table on session 2**
17:20 (40')	**JMMC hands-on session**
18:00	End of Day 1

Day 2: Wednesday, 12 June 2024

	Session 3: **"Star-disk and disk-planet interaction"**
9:30 (25'+5')	**Invited Talk - Shinsuke TAKASAO** **Accretion and wind structures just around an accreting star**
10:00 (15'+5')	*H. NOWACKI - Towards real-time magnetospheric accretion monitoring with VLTI/GRAVITY+*
10:20 (15'+5')	*A. LABDON - Interferometry view of accretion outbursts*
10:40 (15'+5')	*G.-D. MARLEAU - Accreting planetary-mass-objects at medium to high-resolution*
11:00 (30')	Coffee and posters
11:30 (15'+5')	*E. KOUMPIA - A VLTI view of the star/disc interface around Massive Young Stellar Objects*
11:50 (15'+5')	*E. BORDIER - Hints of inward migration during the formation of massive multiples revealed by GRAVITY*
12:10 (60')	**Round table on session 3**
13:10 (80')	Lunch
	Session 4: **"Dust and gas chemistry in disks"**
14:30 (25'+5')	**Invited Talk - Sierra GRANT** **Probing the gas and dust in the planet-forming zones of disks using ground- and space-based observations**
15:00 (15'+5')	*B. LOPEZ - Pursuing the YSO surveys in a panchromatic approach. Context of the GRAVITY+ infrastructure upgrades and of the MATISSE Wide capability*
15:20 (15'+5')	*E. GAIDOS - The Dynamic, Chimeric Inner Disk of PDS 70*
15:40 (30')	Coffee and posters
16:10 (50')	**Round table on session 4**
17:00	End of Day 2
17:30	**Cocktail at Cosmocité**

Day 3: Thursday, 13 June 2024

	Session 5: **"Complementary surveys and large programs"**
9:30 (25'+5')	**Invited Talk - Richard TEAGUE** **The Outer Regions of Protoplanetary Disks**
10:00 (15'+5')	*T. GARDNER -Star and Planet Formation with BIFROST at VLTI*
10:20 (15'+5')	*S. KRAUS - CHARA imaging survey of Herbig Ae/Be stars*
10:40 (15'+5')	*A. PAIXÃO DE SOUSA - Unraveling NIR Variability in Young Accreting Stars with SPIRou/CFHT*
11:00 (30')	Coffee
11:30 (60')	**Round table on session 5**
12:30 (90')	Lunch
	Session 6: **"Preparing future steps"**
14:00 (25'+5')	Wrap-up on the talks
14:30 (90')	**General discussion: observing programs, modeling & analysis tools, community coordination (staffing and funding)**
16:00	Coffee and end of the workshop

Table of contents

From Gravity to Gravity+

The GRAVITY+ Project

Guillaume Bourdarot * [1]

[1] Max Planck Institut for Extraterrestrial Physics – Germany

The GRAVITY+ project will provide a major upgrade of the Very Large Telescope Interferometer, by increasing by orders of magnitude the sky-coverage, sensitivity and high-contrast capabilities previously accessible with VLTI. At the heart of the upgrade is the implementation on all 8m telescope of state-of-the-art Adaptive Optics and Laser Guide Stars, improved vibration control and wide off-axis fringe tracking. This improvement will have profund implications on the sample of objects and the observing capabilities previously accessible with infrared interferometry. The LGS operation will allow for the first time the observation of red, embedded objects (R< 19), giving access to regions of star formation never observed with infrared interferometry, while the overall improvement will increase the sensitivity of existing objects up to K

*Speaker

The yield of the Gravity YSO survey and beyond

Catherine Dougados * [1]

[1] Institut de Planétologie et d'Astrophysique de Grenoble – Univ. Grenoble Alpes, CNRS – France

In this talk, I will review the main highlights obtained in the context of the YSO GRAVITY GTO program, including results from statistical studies of the inner dusty disks, detailed constraints on the gaseous component at the star/inner disk scale and evidence for inner disk structure. Pioneering results from image reconstruction and time monitoring studies will be also presented. The power of combined GRAVITY/MATISSE and GRAVITY/SPIROU analysis will be illustrated in a few examples. These results will be put in context of the most recent numerical modeling of the star inner disk systems. Finally, I will present promising prospects for GRAVITY+ in synergy with future/existing instrumentation like JWST and ELT instruments.

*Speaker

Disk structure and evolution

Tracing the time-variable asymmetric disk structure in the inner disk of a Herbig Be star: results and perspectives

Lucas Labadie * [1], Valerio Ganci , Karine Perraut , Gravity Collaboration

[1] Institute for Astrophysics of the University of Cologne – Germany

The deployment of the second generation VLTI instruments GRAVITY and MATISSE (with CHARA in the northern hemisphere) has permitted us to map with increased accuracy the inner _˜0.1-1au regions of protoplanetary disks around young stars at a milliarcsecond spatial resolution not attainable with other facilities. These inner regions are highly interesting for at least two reasons: they host complex morphological features that can possibly be connected to planet formation; the relatively short orbital timescale at such stellocentric distances allows to follow time variable features within months to years. Hence, monitoring these inner regions with interferometry offers a unique opportunity to probe short timescale aspects of disc evolution.

In this contribution, we address the question of the inner disk's morphological time variability with the case of the _˜0.5Myr Herbig Be stars HD98922. Herbig Be sources are interesting as their disks are found to be rarer, less massive and with a shorter lifetime in comparison to less massive Herbig Ae or T Tauri stars. We have compiled a dataset acquired with PIONIER and GRAVITY to monitor with 33 snapshots over a period of 11 years the variations in the interferometric visibilities and, more importantly, the closure phase signal that traces spatial asymmetries in the brightness distribution. Our analysis reveals a dynamical inner disk that can be modeled by a crescent-like structure – also seen in other Herbig stars – orbiting the central star seemingly slower than Keplerian. In addition, we observe that the compact Br-gamma line emission traced with the high-spectral resolution mode of GRAVITY is off-centered from the star and likely orbits the central star as well. We find a discontinuous radial structure of the dusty disk and discuss these results in the context of a low-mass companion or a disk wind shaping the inner disk.

This result confirms the probable strong morphological variability of the inner disk even around more massive objects. This opens the door to important complementary observing programs that will be discussed in this contribution: this involves the comparison to mid-infrared high-resolution observations with MATISSE, but also extending these studies to earlier phases of Herbig Be stars and for which the level of embeddedness will require the capabilities of Gravity+.

*Speaker

The First High Resolution Interferometric Survey in K-band of High Mass YSOs

Youcef Bouarour * [1]

[1] University College Dublin – Ireland

Circumstellar disks are crucial for high-mass star formation; however, our understanding of the geometry and physical properties of the innermost regions of disks around massive stars is limited due to their rarity, considerable distance and embedded nature. In this poster, I will present the first K-band high spectral and high spatial resolution study of a sample of High Mass Young Stellar Objects (HMYSOs), observed with VLTI/GRAVITY. We use geometrical modelling to derive the characteristic sizes of the K-band continuum and hot gas emission for this sample of HMYSOs. The sample populates the existing continuum emission size-luminosity diagram and is placed for the first time in the (Brγ) emission size-luminosity diagram. Their locations are directly compared to those of the Herbig AeBe stars. Additionally, we explore the origin of the hot gas emission (Brγ) by studying the displacements of its photocentre.

*Speaker

Characterising the inner region of protoplanetary discs using MIRC-X, PIONIER, and GRAVITY

Isabelle Codron * [1], Stefan Kraus [1], Aaron Labdon [2]

[1] University of Exeter – United Kingdom
[2] European Southern Observatory – Chile

In the last 10 years, protoplanetary disc observations have revealed a wide variety of substructures including gaps, asymmetries and misalignments/warps that are often interpreted as signposts of planet formation. These enormous advancements thanks to instruments like SPHERE and ALMA have, however, been very biased towards the outer regions of protoplanetary discs. In contrast, we still know little about the inner region of discs even though constraining their structure and evolution is fundamental to understanding how and when the ubiquitous close-in planets form. This knowledge gap is quickly being filled thanks to optical interferometry instruments such as MIRC-X at CHARA, and PIONIER and GRAVITY at the VLTI, which allow us to resolve these small scales. In this talk, I will present new MIRC-X and PIONIER observations of HD143006, a disc known to have shadows and asymmetries in its outer disk. My observations resolve and constrain the orientation of this system's inner disc, revealing a best-fit misalignment of the inner/outer disc of 45∘ and thus confirming the origin of the shadows seen in scattered light images. I will also present the first detailed characterisation of the inner regions of 4 further Herbig discs from GRAVITY data, as well as preliminary results on the origin of the asymmetries seen in their non-zero closure phases.

*Speaker

Comparative disk structures in a young binary star system

Emmanuel Di Folco * [1], Anne Dutrey [2], Edwige Chapillon [3], Stéphane Guilloteau [2]

[1] LAB – Université Bordeaux, CNRS : UMR5804 – France
[2] LAB – University of Bordeaux, CNRS UMR5804 – France
[3] IRAM , University of Bordeaux – IRAM – France

Although a large fraction of stars in our Galaxy consist of binary or higher order multiple systems, only a small number has been probed at high spatial resolution to reveal their disk structure. We report on the detection of HD35187AB, a rare 10Myr-old Herbig Ae double star, initially classified as a young debris disk, where tidal truncation may affect the disk evolution and shape the young stellar system. We combined IR and millimeter observations with VLTI/PIONIER, MATISSE and NOEMA instruments to determine the multiple disk structure from the analysis of the gaseous and dusty components. Hints of dynamical interactions are searched for to solve the discrepancy between their IR and mm morphologies. Many more binary or triple disk systems will be within reach with the increase in sensitivity of the VLTI instruments GRAVITY+ and MATISSE/GRA4MAT. Comparative studies of single versus multiple young star systems will make it possible to bring observational constraints on planet formation in such dynamically active environments.

*Speaker

Our view of planet-forming disks in the era of ALMA

Laura Perez * [1]

[1] Universidad de Chile – Chile

The high-resolution imaging capabilities of ALMA in the sub-millimeter regime allow us to study in astonishing detail the distribution of gas and solid material in planet-forming disks: the disks of gas and dust that orbit young stars during their formation. In this talk, I will discuss how do we trace the different disk components, how recent ALMA observations have characterized the underlying substructure of these protoplanetary disks, and how observing their substructures at multiple wavelengths allow us to infer disk properties. Finally, I will present recent results on searches for embedded planets that may cause the observed features in disks. All of these results gives us new insights into planet-forming disks in the era of ALMA.

*Speaker

VLTI multi-wavelength characterization of the exozodiacal dust around β Pictoris

Philippe Priolet * [1,2], Jean-Charles Augereau [1,2], Julien Milli [1,2]

[1] Université Grenoble Alpes – Ministère de l'Enseignement Supérieur et de la Recherche Scientifique, Ministère de l'Éducation nationale et de la Jeunesse – France
[2] Institut de Planétologie et d'Astrophysique de Grenoble – observatoire des sciences de l'univers de Grenoble, Centre National de la Recherche Scientifique - CNRS – France

The presence of hot dust in the inner regions of exoplanetary systems is common, with a detection rate of about 20% around nearby AFGK stars from near-infrared interferometric surveys. These exozodiacal dust clouds, or exozodi, are extrasolar analogues to the Solar System zodiacal cloud, although the dust density is several orders of magnitude higher and the spatial distribution might differ. Excessive amounts of exozodiacal dust could affect the imaging of habitable planets in the future (notably an exo-Earth), justifying the interest of space agencies in this subject (e.g. https://exoplanets.nasa.gov/exep/exopag/sag/ Study Analysis Group 23, NASA Exoplanet Program). The most likely mechanism to explain the presence of short-lived dust in these inner regions is the inward scattering of exocomets from an outer Kuiper-like belt by a chain of (low-mass) exoplanets. Since the discovery of its edge-on debris disk in 1984, Beta Pictoris has become a laboratory for studies on planet formation and planet-disk interactions, especially around the outer disk (from around 50 au to 1000 au). Nevertheless, the inner region (< 4 au) remains fairly unconstrained. VLTI/PIONIER observations first revealed the presence of a small circumstellar emission in the H-band (accounting for 1-2% of the stellar flux) which is likely due to hot dust in the inner regions of the system. This emission was shown to be variable in time, and may be associated with the inflow of exocomets detected in transit and radial velocity data. To investigate the spatial distribution of this hot dust, its variability and its spectral energy distribution across a wide spectral range, we obtained PIONIER (H-band), GRAVITY (K-band) and MATISSE (L, M & N-bands) interferometric data. In this contribution, we present the ongoing analysis of these datasets and the methods developed to extract spatial information on the hot dust distribution.

*Speaker

The Mulitplicity of Massive Young Stellar Objects

Maria Koutoulaki * [1]

[1] University of Leeds – United Kingdom

The question of the formation of massive stars, particularly massive binaries, is still very open. More than 90%, and perhaps all, high-mass main sequence stars are found in binary systems. In contrast, close massive binaries are responsible for some of the most energetic phenomena in the Universe. To understand massive stars and their evolution, it is therefore essential to find out how they formed in binary or multiple systems and how these primordial binaries evolve into the Main Sequence systems observed. This requires studying them at the earliest possible stages; however, data on young massive binary systems is sparse. We are conducting a project to determine the Multiplicity of Young MAssive Stars (MULTYMASS) at all scales. The project uses methods ranging from spectroscopy, interferometry (large program with gravity-wide, imaging), and proper motion studies to imaging (H-, K-bands). I will give an overview of the project and the results obtained so far. These indicate that the binarity of massive stars is already large at a young stage, while mass ratios are close to one rather than randomly sampled from the Initial Mass Function.

*Speaker

Shadows and spiral arcs in the Protoplanetary Disc HD 139614

Katie Milsom * [1], Tim Harries [1], Simon Lance [1]

[1] University of Exeter – United Kingdom

We present scattered light images of HD 139614 taken using GPI and SPHERE. Previous scattered light observations of HD 139614 show various azimuthally asymmetric features such as a broad shadow across _˜2/3 of the outer disc, an inner bright ring at _˜100-160 mas, and three arc-like features. We have shown that two of the arc-like features around the disc may be spiral in nature and that the azimuthal brightness distribution of the inner ring shows temporal variability on the timescale of months. Variable shadows, such as in HD 139614, are likely caused by a warp in the inner disc. We are working on modelling the temporal variation of warps in protoplanetary discs by combining 1-d warp propagation theory with ray-tracing and Monte Carlo scattered-light models.

*Speaker

Using the scattered light and millimeter-band disk images to distinguish between FU Orionis-type outburst mechanisms

Eduard Vorobyov * [1], Aleksandr Skliarevskii [2]

[1] Department of Astrophysics, University of Vienna – Austria
[2] Southern Federal University – Russia

FU Orionis-type objects are characterized by episodic increases in luminosity by orders of magnitude. These luminosity bursts affect disk dynamics and chemistry, and play an important role in star and planet formation. Yet, the mechanisms behind these energetic events are not firmly established. Using numerical hydrodynamic simulations coupled with radiative transfer models, we demonstrate that scattered light and mm-band images of protoplanetary disks undergoing luminosity outbursts bear distinct features that can be used to distinguish between different triggering mechanisms of outbursts.

*Speaker

Scrutinising the ubiquity of substructure with compact discs

James Miley * [1]

[1] Universidad de Santiago de Chile [Santiago] – Chile

Substructures in the density distribution of protoplanetary discs are intimately linked to the planet formation process and are now ubiquitous in high resolution mm observations. "Compact" discs however are faint, radially compact discs that appear to be structure-less. Concerningly, these objects appear to comprise the majority in nearby star forming regions (_˜ 60% in Lupus, 62% in Taurus). Due to a historical bias towards observations of more extended, brighter objects, it remains unclear as to whether their lack of structure is due to observational limits or a true physical difference. High resolution mm data is beginning to show evidence of substructure on smaller scales in these discs, but these scales ($\leq$ 5 au) evade the resolving capability of mm interferometry. In this talk I will present high resolution observations of compact discs at mm wavelengths and review the current evidence for substructure in the compact disc population on as-yet-unseen scales beyond our grasp. In this context I will discuss how our upcoming GRAVITY+ observations can begin to unlock study of the density distribution in the inner regions of protoplanetary discs and how they can compliment our understanding of the cool outer regions or protoplanetary discs.

*Speaker

Star-disk and disk-planet interaction

A VLTI view of the star/disc interface around Massive Young Stellar Objects.

Evgenia Koumpia * [1]

[1] ESO – Chile

With steady observational advances, the formation of massive stars is being understood in more detail. Numerical models are converging on a scenario where accretion discs play a key role. Also, binarity appears to be an inevitable outcome. Indeed, the vast majority of massive stars are found in binaries (up to 100%). Our understanding of the geometry and physical properties of the innermost regions of discs around massive stars and their associated binarity is sparse due to the rarity of such objectsand the observational challenges, including the lack of adequate diagnostic lines in the near-IR.

In this talk, I will present the first systematic study towards a sample of Massive Young Stellar Objects (MYSOs) as observed with long-baseline near-infrared K-band interferometry on VLTI (GRAVITY, AMBER). Geometrical models are employed to derive the characteristic size of the 2μm continuum and ionised gas emission towards this sample of MYSOs and investigate binarity. MYSOs are placed in a luminosity-size diagram for the first time, and their location is directly compared to their low and intermediate-mass counterparts. In addition, the investigation on the origin of the ionised gas emission (Brγ) points towards a disc-wind interaction. I will also present the first statistics on young high-mass binarity tracing 2-300 au separations and directly compare them to their pre-main and main sequence equivalents, reporting an increasing fraction with evolution.

Finally, we detect and spatially resolve the Na I doublet and He I transitions at au-scales towards an MYSO for the first time. The new observations in combination with our geometric models allowed us to probe the smallest -au- scales of accretion/ejection around an MYSO. We find that Na I originates in the disc at smaller radii than the dust disc and is more compact than any of the other spatially resolved diagnostics (Brγ, He I, and CO). Our findings suggest that Na I can be a new powerful diagnostic line in tracing the warm star/disc accreting interface of forming (massive) stars, while the similarities between He I and Brγ point towards an accretion/ejection origin of He I.

*Speaker

Hints of inward migration during the formation of massive multiples revealed by GRAVITY

Emma Bordier * [1]

[1] II. Physikalisches Institut [Köln] – Germany

The high incidence of close multiples in main sequence massive stars questions the way they form. Recent observational evidence from the very young HII region M17 suggests that massive stars are formed at large separations and migrate inward in a few Myrs. Detecting companions within the expected size of the accretion disk would then place important constraints on the pairing mechanism of massive stars. Our recent VLTI/GRAVITY observations of six young O stars in M17 revealed that multiplicity is set early during the formation of massive stars with more than 2 companions on average. We will present the observational constraints that arise from the modelling of the interferometric observables and their implications in the framework of massive star formation. In addition, these observations revealed the presence of an exotic system composed of an inner main sequence binary surrounded by an outer pre-main sequence tertiary with an extended dusty structure much like a protostellar disc. Such a configuration would suggest that high-order massive multiples could be formed via sequential star formation. We aim to discuss the possibility of observing many more young massive stars and monitoring such exotic objects with the current and future capabilities of GRAVITY+.

*Speaker

Accreting planetary-mass-objects at medium to high-resolution

Gabriel-Dominique Marleau * [1]

[1] Universität Duisburg-Essen – Germany

I present recent spectroscopic observations of low-mass accretors including PDS70b, Delorme 1 (AB)b, and TWA27B and others with VLT/MUSE, SOAR/TripleSpec, or JWST/NIRSpec. These exquisite data reveal structures in the shape of hydrogen emission lines seen at these embedded or (semi-)isolated accretors. This yields tentalising clues about the physical processes associated with the accretion, with support for both shock-emission and magnetospheric-accretion models. I also present 2.5D radiation-hydrodynamical simulations of the accretion onto gas giants and what this implies for their detectability through spectroscopy and direct imaging.

*Speaker

Accretion and wind structures just around an accreting star

Shinsuke Takasao * [1]

[1] Osaka University – Japan

Many exoplanets have been identified within the inner regions of protoplanetary disks, underscoring the critical nature of investigating these inner disk structures. The configuration of the innermost disk is profoundly influenced by interactions between the star and the disk, necessitating a comprehensive grasp of mass transport mechanisms. We have conducted 3D magnetohydrodynamic (MHD) simulations focused on magnetospheric accretion to delineate the flow patterns surrounding the star. Our simulations reveal a variety of wind types, including stellar winds, magnetospheric ejections, and disk winds. Notably, we identify disk winds as comprising both (intermittent) conical disk winds and turbulent winds. The turbulent winds, unique to three-dimensional settings, are found to play a crucial role in mitigating stellar spin-up. Additionally, our simulations indicate magnetic heating at the base of the magnetospheric accretion flows, potentially contributing to hydrogen Br-gamma emissions. In this talk, we will briefly review recent studies of star-disk interaction and explore the observational implications of our findings.

*Speaker

Towards real-time magnetospheric accretion monitoring with VLTI/GRAVITY+

Hugo Nowacki * [1], Karine Perraut [1], Evelyne Alecian [1], Jean-Baptiste Le Bouquin [1], Anthony Soulain [1]

[1] Université Grenoble Alpes – IPAG Grenoble – France

Among the solar-mass Classical T Tauri Stars (CTTS), some are strong accretors (Macc _˜ a few 10ˆ-7 Msun/yr). These objects are still poorly understood (and studied). Yet they represent a unique opportunity to study and test the magnetospheric accretion phenomenon in a sustained regime (_˜100 times larger than in CTTS) along with every accretion-related phenomena from the inner disc (stellar/disc wind, jet launching, etc...). Following the successful example of the CTTS DoAr44 (Bouvier et al. 2020a, b), we obtained unique results in the multi-technique observation of the strong accretor S CrA N that I will present in this communication. I will also show how they represent a first glance at the exciting perspectives brought by the upcoming VLTI/GRAVITY+.
The power of the multi-technique observation we led on S CrA N resides in the cross-constraints brought by two techniques.
With GRAVITY observations, we reveal the sublimation front of its dusty disk in the K-band continuum. We also probe the accretion flows at its natural scales by means of differential interferometric quantities obtained at a cadence of an hour timescale, with a precision of a few stellar radii. While such a temporal resolution is currently reachable for strong accretors only, it will be feasible for a sample of CTTS large enough to be statistically significant with GRAVITY+ and its sensitivity increase. This change of paradigm will enable the magnetospheric accretion phenomenon to be modeled and understood like never before.
With CFHT/ESPaDOnS observations, we study the topology of the magnetic field of S CrA N along with accretion-related emission lines. Such an optical spectro-polarimetric study gives unique insights on the high-energy processes linked to magnetospheric accretion/ejection. Among them, the accretion regime of the star (for instance) provides a mean of direct interpretation of the interferometric models. Combining GRAVITY+ with spectro-polarimeters such as ESPaDOnS and SPIRou, the study of star-disk interactions could even extend to class I protostars.
GRAVITY+ will be a game changer for studying star-disk interactions in a more representative sample of CTTS with a unique temporal resolution. New targets could encompass class I sources that will be observed for the first time with near-infrared interferometry. If the study of strongly accreting CTTS – such as S CrA N – gives some hints of what an embedded, strongly accreting source may look like, reaching new sensitivity limits might open new exciting perspectives.

*Speaker

Interferometry view of accretion outbursts

Aaron Labdon * [1]

[1] European Southern Observatory [Santiago] – Chile

Accretion outbursts in young stars come in many different forms, most notably long term FUor an short term EXor outbursts. Such outbursts have a profound effect on the dusk structure and composition, which in turn greatly impacts planet formation. It is now thought thar most young stars will go though an outburst phase, meaning our undrrstanding of these mechanisms must improve. In this talk, I will present an interferometry view of the inner disk of 4 FUor objects and explore how the outburst has effected the thermal and spatial structure of the disk. This includes evidence of boundary layer accretion and viscous heating in the inner disks of these unusual objects.

*Speaker

What shapes the angular momentum evolution of accreting, low-mass stars?

Lukas Gehrig * [1], Eric Gaidos [1,2], Manuel Güdel [1], Eduard Vorobyov [3]

[1] University of Vienna [Vienna] – Austria
[2] University of Hawaii – United States
[3] University of Vienna [Vienna] – Austria

The origin of the angular momentum distribution of low-mass stars (< 1 Msun) at young ages is still unclear. Even in very young clusters (_˜1 Myr), a significant spread is observed in rotational periods, ranging from less than 1 day to around 10 days.

We carried out a suite of simulations of coupled star-disk systems to explain this dispersion and relate it to key stellar and disk properties, starting from a stellar seed until the disk dissolves. Using the MESA stellar evolution code and a hydrodynamic disk model we can combine the effects of stellar evolution, accretion, stellar winds, the magnetic star-disk interaction, and photoevaporation. We show that different phenomena dominate the stellar spin evolution during different evolutionary stages of the star-disk system. During the embedded phase, the history of strong accretion combined with the resulting stellar feedback shapes the stellar spin evolution. With decreasing accretion rates during the T Tauri phase, the magnetic star-disk interaction and photoevaporation become increasingly important.

These results highlight two points that are vital to understanding and explaining stellar spin evolution. First, the importance of the interaction between the star and the disk; and second, the inclusion of the whole star-disk evolution history from the embedded phase until the disk dissipates.

*Speaker

The JWST/MIRI-MRS spectrum of CT Cha b

Elena Kokoulina * [1]

[1] STAR Institute - University of Liège – Belgium

The origin of the observed diversity of exoplanet systems is still a matter of debate. High spectral resolution imaging can help us in our understanding of the physical and chemical properties of imaged exoplanets.
The wide-orbit planet-mass companion CT Cha b observed with JWST/MIRI MRS is a perfect candidate for constraining theories of giant planet formation. Moreover, the previously measured high mass accretion rate of CT Cha b together withthe high extinction is a strong indication for the presence of a circumplanetary disk signatures of which may be probed with a MIR spectrum. I will show a spectrum of CT Cha b obtained after subtracting the PSF of the star. I will then present a comparison of the extracted spectrum with planet atmosphere models, and test the presence of a circumplanetary disk.

*Speaker

Is HD45677 a close binary?

Joel Sanchez-Bermudez [1,2], Prakruti Sudarshan * [1], Wolfgang Brandner [1], Mario Flock [1]

[1] Max Planck Institute for Astronomy – Germany
[2] Universidad Nacional Autónoma de México = National Autonomous University of Mexico – Mexico

HD45677 is an FSCMa type object, around an unclassified B(e) intermediate mass star. Previous continuum interferometric observations with PIONIER, GRAVITY (H-K bands) and MATISSE (L-M bands) have shown the disk structure to be highly asymmetric, and with an inner cavity. We present recent observations of the disk with GRAVITY along with new reductions of PIONIER show orbital motion of a dusty feature in thermal emission. The claim is further backed up by Brγ imaging that shows high velocity deviations at the location of this dusty feature indicative of a possible secondary companion. We present a simple hydrodynamical model of a binary star-disk system to explain the observations and provide constraints to the temperature of the cavity and an upper limit on the binary mass ratio.

*Speaker

Dust and gas chemistry in disks

The Dynamic, Chimeric Inner Disk of PDS 70

Gaidos Eric * [1]

[1] University of Hawaii at Manoa – United States

PDS 70 is a key system in studies of disk evolution and planet formation, but while its outer disk and two directly-imaged giant planets have been intensely scrutinized, much less is known about the _˜10 au-wide inner disk which is only marginally resolved by ALMA. Infrared and sub-mm observations show the inner disk to be gas-poor, with low CO, but detectable CO2, and H2O. We present new and archival data showing the system to be highly variable on day- to year-long timescales, including evolution between dipper-like and "scalloped" periodic variability in the optical, and the near-disappearance of infrared emission from the innermost disk for about one year. We model the disk's SED as a warm (< 600K) component and hot (_˜1200K) component and explain this variability in terms of the motion of the disk inner edge relative to the co-rotation radius and the dust sublimation point, resulting in gas-bearing dust being ejected along magnetic field lines, trapped at the co-rotation radius, or completely vaporizing exterior to the disk edge. This variabiity is driven by variability in the large-scale stellar magnetic field and/or accretion. We propose that this inner disk is a hybrid mixture of outer disk gas, depleted by trapping of solids (including CO ice) at a pressure bump, leaking across the gap, plus dust, H2O, and CO2 from evaporating/disintegrating/colliding planetesimals that are stirred by protoplanets within the inner disk. This means that observations of material close to the star can probe the products of ongoing planet formation in this system.

*Speaker

Probing the gas and dust in the planet-forming zones of disks using ground- and space-based observations

Sierra Grant * [1]

[1] Max-Planck Institute for extraterrestrial Physics – Germany

Most planets are expected to form within the inner 10 au of protoplanetary disks. Constraining the disk structure, the composition of the gas, and the evolution of this region is vital for understanding the formation of these planets. Several observational tools are available for studying this region; wide spectral coverage observations from space and high spectral and spatial resolution observations from the ground offer unique pathways to probe the inner disk. In this talk, I will highlight what we are learning about inner disk chemistry with JWST and describe how we can build a comprehensive picture of the inner disk structure and composition by combining JWST observations with VLTI-GRAVITY(+) and VLT-CRIRES+.

*Speaker

Pursuing the YSO surveys in a panchromatic approach. Context of the GRAVITY+ infrastructure upgrades and of the MATISSE Wide capability

Bruno Lopez [*] [1]

[1] + A. Matter et al., Observatoire de la Cote d'Azur – CNRS : UMR7293 – France

Protoplanetary disks around young stars as well as debris disks around Main Sequence stars constitute two major scientific cases of the VLTI/MATISSE instrument at the interface with planetology. Our contribution to the foreseen workshop is based on the 3 first years of operation of MATISSE. A survey of a hundred young stars has been undertaken with MATISSE in the mid-IR, in parallel to the surveys carried out in the near IR with PIONIER and GRAVITY, and in the millimeter domain with ALMA. With a milliarcsecond angular resolution and an access to the gas and dust spectral signatures of the mid-IR, MATISSE makes it possible to study the inner regions of the discs (_˜ 0.5 - 10 au) along 2 main axes: 1) detection and study of fine structures (gaps, spirals, dust concentrations) unattainable until now and 2) characterization of the composition and physical properties of the primordial planet building blocks. We will present the current status of the MATISSE GTO survey on young stellar objects and debris disks, and give a view of the achieved first results. Moreover, we will propose to exploit the GRAVITY+ infrastructure upgrades and the MATISSE Wide capability under preparation : a) to extend the YSO observations to faint and embbeded sources and b) to carry out a joint YSO survey with the GRAVITY+ and PIONIER teams & instruments. Such a joint survey program will allow a better synchronization of observations, important for variable sources, and the establishment of a multi-spectral database required nowadays for performing fine radiative transfer modellings and interpretation.

[*]Speaker

Modeling GRAVITY(+) data with ProDiMo

Jelke Bethlehem * [1]

[1] MPE – Germany

With the introduction of GRAVITY it has become possible to study the gas and dust properties of the inner region (< 0.5 AU) of protoplanetary disks around Herbig and TTauri stars. Physical/chemical models for disks exist but few take the innermost dust-free part in consideration. This research is aimed at creating proper simulations for gravity data using the protoplanetary disk model called ProDiMo including the dust-free inner disk. We will show the first results of simulating CO-overtone gravity data for disk models.

*Speaker

Complementary surveys and large programs

Unraveling NIR Variability in Young Accreting Stars with SPIRou/CFHT

Alana Paixão De Sousa * [1], Jerome Bouvier [1], Evelyne Alecian [1], Catherine Dougados [1], Silvia Alencar [2], J-F Donati [3]

[1] Institut de Planétologie et d'astrophysique de Grenoble – Centre National d´tudes Spatiales [Toulouse], observatoire des sciences de l'univers de Grenoble, Centre National d´tudes Spatiales [Toulouse], Centre National d´tudes Spatiales [Toulouse], Centre National d'Études Spatiales [Toulouse] – France

[2] Universidade Federal de Minas Gerais – Brazil

[3] Univ. de Toulouse – CNRS – France

Accreting T Tauri stars exhibit photometric and spectroscopic variability across various timescales, ranging from seconds to decades, which can be attributed to different physical phenomena. The observed variability provides valuable insights into the underlying processes occurring within the circumstellar environment. We aim to analyze the variability patterns of the Bry and HeI (10830, A) line profiles in the complete sample of accrediting young stars observed by SPIRou / CFHT. The targets consist of Class II stars, as part of the SLS consortium, and Class I stars, as part of the PROMETHEE project. The analysis primarily involves measuring the near-infrared excess along the YJHK bands to understand its origin and timescale variability. Additionnaly, we aim to characterize the average profile shape and its variance over timescales ranging from days to months. Special attention has been given to studying the potential evolution of the accretion and/or ejection processes over a span of a few years. We discuss the implications of these results for the accretion and ejection mechanisms in young stars, exploring their connection with the stellar magnetic field.

*Speaker

The Outer Regions of Protoplanetary Disks

Richard Teague * [1]

[1] MIT – United States

Our understanding of the outer regions of protoplanetary disks, those beyond 10au, has improved significantly over the last decade thanks primarily to the introduction of ALMA. Sub-mm interferometric observations have provided us a glimpse of the physical, chemical and dynamical conditions in which we beleive gas giant planets will be forming, allowing rare opportunities to test models of planet formation. In this talk I will discuss the progress we have made in characterizing these outer regions of the disk and discuss what next steps are necessary to translate what we know down to the smaller scales of the terrestrial planet forming region.

*Speaker

Star and Planet Formation with BIFROST at VLTI

Tyler Gardner * [1]

[1] University of Exeter – United Kingdom

BIFROST is an upcoming short wavelength, high spectral resolution combiner for the VLTI as part of the ASGARD suite of instruments. BIFROST will study a range of important topics from stellar to planetary science. I will discuss how this instrument will probe the architecture of binary and planet systems by measuring spin-orbit alignments. This is a crucial diagnostic in the study of star and planet formation channels in discs. BIFROST will also increase our knowledge of the inner regions of YSOs, by extending the methods of current VLTI instruments to shorter wavelengths. The Y/H/J bands and high spectral resolution will provide a richer spectrum for studying accretion and ejection processes in discs. With an off-axis mode, BIFROST can also search for differential phase signals from protoplanets to study accretion in circumplanetary discs.

*Speaker

CHARA imaging survey of Herbig Ae/Be stars

Stefan Kraus * [1], John Monnier , Isabelle Codron , Benjamin Setterholm , Ibrahim Noura

[1] University of Exeter, Astrophysics Group – United Kingdom

Combining the light from all six CHARA telescopes simultaneously, the MIRC-X and MYSTIC instruments achieve the image sharpness of a 330m telescope and have been built to image time-variable structures in the inner region of protoplanetary discs. In this talk, we will summarise our observing campaign on Herbig Ae/Be stars and present infrared interferometric images obtained from the dust sublimation zone, where the disc undergoes a dramatic transition from a dust+gas composition to a purely gaseous disc. Our survey is uniquely suited to search for planet-induced structures in the inner few astronomical units of these discs. For some objects, we detect temporal variability and are producing first movies of the inner disk environment. We co-schedule our MIRC-X runs with photometric/spectroscopic monitoring, with the goal to link accretion rate variations or occultation events to structural changes in the inner disc. We will highlight potential synergies with the GRAVITY+ survey on young stars.

*Speaker

Young Stellar Objects in the turbulent environment of the supermassive black hole Sgr A*

Florian Peißker * [1], Lucas Labadie [1], Alexis Matter [2]

[1] 1. Physikalisches Institut, Universität zu Köln – Germany
[2] Observatoire de la Côte d'Azur – Institut National des Sciences de l'Univers, Centre National de la Recherche Scientifique – France

According to stellar migration timescales in dense clusters, no young stellar objects (YSOs) in the Nuclear Star Cluster in the vicinity of the supermassive black hole Sgr A* at the center of our Galaxy would be detected (Morris 1993).
However, even younger objects than OB stars have been reported in the regions around SgrA*. First proposed by Eckart+2004, several candidate Young Stellar Objects are detected in the dense and embedded IRS 13 cluster located about 0.1 pc away from Sgr A* (Peißker+2023c). This finding follows the identification of a population of bipolar outflow sources (Yusef-Zadeh+2017) and the observation of the first massive YSO in the "inner parsec" (Peißker+2023b). Radio and sub-mm observations (Yusef-Zadeh+2013, Moser+2017) suggest that these results are only the tip of the iceberg. Primarily observed at VLT's resolution with NACO and/or SINFONI, many of the YSOs in the central region of our Galaxy would benefit from observations at higher resolution to characterize sizes and morphological properties of the continuum and line emission, which may reveal different trends for sources close to the energetic environment of Sgr A* than for those in the solar neighborhood. This would provide new insight into the influence of environmental conditions on the evolution of YSOs. We present a first attempt to observe and resolve a source in the IRS 13 cluster using the MATISSE instrument and CIAO during a recent technical run and discuss the nature of this object. In this context, we identify a population of candidate YSOs in the immediate vicinity of SgrA*, whose faintness would take advantage of the new capabilities of Gravity+ in terms of sensitivity and sky coverage. In the close vicinity of SgrA*, we will be able to study the possible imprint of putative stellar or black hole outflows with some of the candidate YSOs such as X3 and X7 (Muzic+2010, Peißker+2021a, 2023b).

*Speaker

Characterising the magnetic fields of the class I protostars

Lisa Drouglazet * [1]

[1] Université Grenoble Alpes – Institut de Planétologie et d'Astrophysique – France

Magnetism is known to play a key role in the evolutionary processes of protostars. Specifically, it significantly influences the star-disk interaction and it also governs the angular momentum of the system. While extensive research has focused on exploring magnetic fields in both pre- and post-protostellar phases of star formation, our understanding of magnetic properties during the proto-stellar phase remains limited.
To complete our vision, we will investigate the magnetic fields of protostars during the embedded phase of stellar formation. A set of near-infrared spectropolarimetric data were obtained with the new instrument SPIRou (Donati et al 2020). By analysing the polarized data of class I and flat-spectrum protostars, magnetic fields can be detected and characterised.

In this poster I will present preliminary results for a small sample of protostars.

*Speaker

The IMAGER program in Gildas: imaging 100 000 channels with ALMA & NOEMA

Emmanuel Di Folco * [1], Stéphane Guilloteau [1], Edwige Chapillon [2], Thierry Jacq [1]

[1] Laboratoire d'Astrophysique de Bordeaux – OASU – France
[2] Institut de RadioAstronomie Millimétrique – OSUG – France

IMAGER is an interferometric imaging package in the GILDAS environment, tailored for usage simplicity and efficiency for multi-spectral data sets. It is optimized for ALMA and NOEMA data sets. Efficiency is obtained through parallel programming and extensive use of Memory. IMAGER comes with a powerful PIPELINE, which simplifies mutliple spectral line processing. IMAGER is distributed as a standalone precompiled LINUX container, as a Macports package, and also available as a " contrib " package with GILDAS. It was developed in Bordeaux as part of the INSU Service National d'Observation ALMA-IRAM. Installation information, documentation and tutorials are available on a dedicated website https://imager.oasu.u-bordeaux.fr, supported and maintained by the Observatoire Aquitaine des Sciences de l'Univers.

*Speaker

List of participants

- Alecian Evelyne
- Amblard Benjamin
- Anghel Simon
- Augereau Jean-Charles
- Baruteau Clément
- Bethlehem Jelke
- Bordier Emma
- Bouarour Youcef
- Bourdarot Guillaume
- Bouvier Jerome
- Brandner Wolfgang
- Cecil Michael
- Codron Isabelle
- Desgrange Célia
- Di Folco Emmanuel
- Dougados Catherine
- Drouglazet Lisa
- Eric Gaidos
- Flock Mario
- Gardner Tyler
- Gehrig Lukas
- Grant Sierra
- Kokoulina Elena
- Koumpia Evgenia
- Koutoulaki Maria

- Kraus Stefan
- Kurtovic Nicolas
- Labadie Lucas
- Labdon Aaron
- Lopez Bruno
- Ma Jie
- Malbet Fabien
- Marleau Gabriel-Dominique
- Matter Alexis
- Melon Fuksman David
- Merand Antoine
- Milsom Katie
- Nowacki Hugo
- Ostertag Dominik
- Paixão De Sousa Alana
- Peißker Florian
- Perez Laura
- Perraut Karine
- Priolet Philippe
- Schilke Peter
- Soulain Anthony
- Spezzano Silvia
- Sudarshan Prakruti
- Takasao Shinsuke
- Teague Richard