THE STAR FORMATION NEWSLETTER

An electronic publication dedicated to early stellar/planetary evolution and molecular clouds

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The Star Formation Newsletter

The Star Formation Newsletter is a vehicle for fast distribution of information of interest for astronomers working on star and planet formation and molecular clouds. You can submit material for the following sections: *Abstracts of recently accepted papers* (only for papers sent to refereed journals), *Abstracts of recently accepted major reviews* (not standard conference contributions), *Dissertation Abstracts* (presenting abstracts of new Ph.D dissertations), *Meetings* (announcing meetings broadly of interest to the star and planet formation and early solar system community), *New Jobs* (advertising jobs specifically aimed towards persons within the areas of the Newsletter), and *Short Announcements* (where you can inform or request information from the community). Additionally, the Newsletter brings short overview articles on objects of special interest, physical processes or theoretical results, the early solar system, as well as occasional interviews.

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Cover Picture

The large bow shock HH 216 in M16 is seen here in an HST image. The shock is driven by a source embedded at the tip of one of the many elephant trunks in this region.

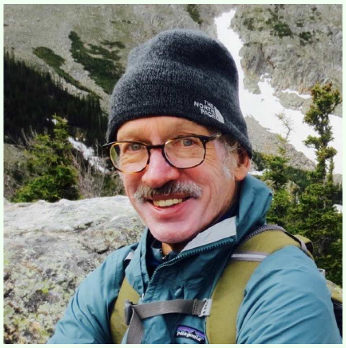
Image courtesy STScI.

Submitting your abstracts

Latex macros for submitting abstracts and dissertation abstracts (by e-mail to reipurth@ifa.hawaii.edu) are appended to each Call for Abstracts. You can also submit via the Newsletter web interface at http://www2.ifa.hawaii.edu/star-formation/index.cfm

Paul Harvey

in conversation with Bo Reipurth



Q: *Your PhD from 1974 dealt with infrared and microwave variability of infrared stars. How did you choose that subject?*

A: Like so many things in life, it was pretty much an accident. As an undergrad at Wesleyan University, I had experimented with making telescope mirrors from a stretched mylar film with a vacuum behind it. My advisor suggested I get in touch with Bob Leighton when I arrived at Caltech for grad school, and Bob said something to the effect of, "Well, I'm not experimenting with spinning epoxy mirrors anymore, but Gerry Neugebauer is using one to make an infrared survey of the sky". So I went to talk to Gerry, and he said something to the effect of, "Well, our sky survey is done and we have found all these red giant stars that are associated with OH masers. A good project would be to see if there is a correlation between the infrared variability and the OH maser variability". This was the era of the Vietnam War, and I needed Caltech to write a letter to my draft board saying that I was doing important research!

Q: *You then built a far-infrared photometer for the Kuiper Airborne Observatory.*

A: In between, I also built some instrumentation for my PhD thesis because Neugebauer said, "You can't get a PhD in physics without building some instrumentation". So I made the first photometer at Caltech for 1.4mm photometry, using the Palomar 200-inch in twilight. When I graduated and went to the University of Arizona as a postdoc, Bill Hoffmann was in the process of moving there from Goddard in NYC, and had gotten a small grant to build a photometer for the KAO. He asked if I'd be interested in working on that as well as helping with upgrading his balloon gondola and that sounded great. After that, we ended up creating new, improved versions of the instrument every three years or so until the KAO was retired in 1995. In a typical year we were awarded enough observing time to support two or three series of flights in different seasons to be able to observe most parts of the Milky Way, including eventually, the southern parts. Flying on the KAO was an interesting combination of excitement and stress. We worked with a large number of great people, but the stress came from using state-of-the-art equipment that did not always choose to function when we needed it to. If something went wrong in flight with either our equipment or the observatory's, there were 20 people in the air and another 20-40 on the ground "watching over our shoulders". The KAO, though, provided a unique platform to obtain routine observations with, for that era, high spatial resolution. It enabled us to spatially resolve individual proto-stars and map dust density gradients through simultaneous multi-color photometry.

Q: *In the late 1970s you and your collaborators published a series of papers on high spatial resolution far-infrared observations of a number of star forming regions. What were your overall conclusions?*

A: To put this into perspective, you will have to remember that this was in the pre-IRAS days, and even when IRAS flew, its spatial resolution at 60 and 100 microns was pretty low! So I think our observations were important to establish the total luminosity of the obscured young stars, and compare it to the UV luminosity as inferred from the radio continuum emission. With the spatial resolution of the KAO we were able to see far-ir emission from dust associated directly with ionized gas as well as dust that was heated by objects too young or too low in luminosity to ionize significant amounts of gas. The spatial resolution also allowed us to infer the presence of circumstellar disks around two young stars, in NGC 2264 and in the Rosette Nebula, from a comparison of the far-ir optical depth relative to that in the near-ir.

Q: *In the mid-1980s you wrote several papers on the NGC 6334 region. What is special about this particular star forming region?*

A: Well, to be blunt, it was bright, so it was easy to map, and for the KAO it was important to have a collection of objects around the sky to piece together a flight-plan that would get you home after 7 1/2 hours, while observing detectable objects most of the time! I also got some observing time at the IRTF for 1-20 micron observations to follow up after our KAO 50-100 micron observing. We were able to spatially resolve a number of structures in the three most luminous OB star-forming clusters here. We found several infrared bipolar nebulae. We interpreted the near-infrared nebulae as reflection nebulae and the far-ir emission as cool dust, both consistent with structure indicative of circumstellar disks close to the exciting stars.

Q: *About 10 years ago you carried out a series of studies* *of the Serpens star forming region at mid- and far-infrared wavelengths with Spitzer.*

A: This was a part of the Spitzer "From Cores to Planet-Forming Disks" Legacy Project (c2d) led by Neal Evans at UT. This was yet another "accident" in my career. Early in the planning we talked about who wanted to be in charge of which region to be observed. Since I had already suggested that I would handle the software and processing for source extraction, I thought it would make some sense to test it on a region as close to the Galactic Plane as possible and toward the center of the Galaxy to see what the problems would be with a high density of sources. Serpens fit that requirement perfectly, as well as being a region where I had made a few observations with the KAO. This was my first experience with relatively large-scale infrared imaging in multiple, simultaneous colors, and it was great fun producing the various false-color images that were possible from our observations. We were able to successfully identify 235 YSOs out of more than 200,000 sources detected, and to study their energy distributions, luminosities, and spatial distribution.

Q: *You have also used FORCAST onboard SOFIA. What are the strengths of that instrument and what did you learn?*

A: For me the value of FORCAST is that the longest wavelength filter around 37 microns is long enough that one is beginning to look at the same dust as that emitting strongly at 50-100 microns, but with much better angular resolution than possible with Spitzer or the KAO. My first proposal was to work with the team on some star-forming region where that resolution would be useful in separating closely spaced sources. In the end we chose Sharpless 140, a region that I had observed many times with the KAO. The combination of our SOFIA data with high resolution ground-based data from ESO made it possible to determine the luminosities of the individual young stars much more reliably. I had also hoped to continue using FORCAST to attempt observing some lunar occultations in the mid-infrared. I made some preliminary test observations of the dark limb of the Moon to see how feasible the project was, but the pointing stability at the time was not sufficiently good to enable the required sensitivity.

Q: *You were involved in the Herschel mission and among other topics studied cold dust in the disks of brown dwarfs.*

A: I became interested in this area when I realized that we were detecting very low luminosity young stars in our Spitzer c2d observations. That led to a Spitzer PI proposal to try to go very deep in a few areas to try to find very young brown dwarfs. In many areas our sensitivity was limited by Spitzer's modest angular resolution together with the presence of diffuse background emission. So I hoped to improve on these kinds of observations with Herschel's big increase in angular resolution. I submitted an open-time Key Project proposal to perform a fairly large survey of known BD's in star-forming regions, but that was turned down. So I took a large chunk of my guaranteed time (as a Mission Scientist) together with a big contribution from Thomas Henning's guaranteed time on the PACS team to observe a subset of the original planned set of BD's. I think our paper was the first large study of far-infrared emission from young BD's. Since most of the mass in circumstellar disks is in the outer, coolest, parts of the disks, these observations and the accompanying modeling allowed much more accurate estimates of the total disk masses, as well as placed limits on the structure of the disks. This added to the growing understanding that even sub-stellar objects were formed with surrounding disks, presumably by the same processes that more massive, hydrogen-burning stars were formed. Although there is a very wide range of disk masses seen around young stars, the evidence suggested that there is a rough proportionality between the mass of a disk and the mass of the central star.

Q: *In a recent study you used Herschel to study circumstellar disks in the R CrA surroundings. What were the results?*

A: This proposal was a small, open-time program that was aimed at enlarging our data set on very low luminosity stars and BD's. The proposal had a larger set of objects than just these in R CrA, but the remaining objects were not observed before Herschel's cryogens were depleted. We did manage to detect all 5 observed objects with S/N of 4-20 at 70 microns, and used radiative transfer modeling to estimate the dust and gas masses in the disks around the stars/BD's. Our analysis of their spectral energy distributions supported the conclusions of our previous study that the star-disk mass ratio for brown dwarfs extends the T Tauri relation to much lower masses.

Q: *You led a team in a Herschel and CSO study of the Auriga-California dark cloud which, despite being comparable in size and mass to the Orion GMC, has a much smaller population of young stars. What do you think were the most important conclusions from that study?*

A: The Auriga-California molecular cloud is an interesting contrast to the Orion Molecular Cloud. They both have similar masses, but very different star formation rates, especially for massive stars. We suggested that the main observable difference in the clouds is that the amount of gas mass in higher density clumps is significantly higher in the OMC than in the AMC. This, of course, just pushes the question back one step to what has created this difference?

Abstracts of recently accepted papers

Search for Alignment of Disk Orientations in Nearby Star-Forming Regions: Lupus, Taurus, Upper Scorpius, ρ Ophiuchi, and Orion

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Spatial correlations among proto-planetary disk orientations carry unique information on physics of multiple star formation processes. We select five nearby star-forming regions that comprise a number of proto-planetary disks with spatially-resolved images with ALMA and HST, and search for the mutual alignment of the disk axes. Specifically, we apply the Kuiper test to examine the statistical uniformity of the position angle (PA: the angle of the major axis of the projected disk ellipse measured counter-clockwise from the north) distribution. The disks located in the star-forming regions, except the Lupus clouds, do not show any signature of the alignment, supporting the random orientation. Rotational axes of 16 disks with spectroscopic measurement of PA in the Lupus III cloud, a sub-region of the Lupus field, however, exhibit a weak and possible departure from the random distribution at a 2σ level, and the inclination angles of the 16 disks are not uniform as well. Furthermore, the mean direction of the disk PAs in the Lupus III cloud is parallel to the direction of its filament structure, and approximately perpendicular to the magnetic field direction. We also confirm the robustness of the estimated PAs in the Lupus clouds by comparing the different observations and estimators based on three different methods including sparse modeling. The absence of the significant alignment of the disk orientation is consistent with the turbulent origin of the disk angular momentum. Further observations are required to confirm/falsify the possible disk alignment in the Lupus III cloud.

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Studying star-forming processes at core and clump scales: the case of the young stellar object G29.862−0.0044

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Massive molecular clumps fragment into cores where star formation takes place, hence star-forming studies should be done at different spatial scales. Using near-IR data obtained with Gemini, data of CH_3OCHO and CH_3CN from the ALMA database, observations of HCN, HNC, HCO^+, and C_2H carried out with ASTE, and CO data from public surveys, we perform a deep study of the YSO G29.86−0.004 at core and clump spatial scales. The near-IR emission shows two nebulosities separated by a dark lane, suggesting a typical disk-jets system, but highly asymmetric. They are likely produced by scattered light in cavities carved out by jets on an infalling envelope of material, which also present line emission of H_2 and [FeII]. The presence of the complex molecular species observed with ALMA confirms that we are mapping a hot molecular core. The CH_3CN emission concentrates at the position of the dark lane and it

appears slightly elongated from southwest to northeast in agreement with the inclination of the system as observed at near-IR. The morphology of the CH_3OCHO emission is more complex and extends along some filaments and concentrates in knots and clumps, mainly southwards the dark-lane, suggesting that the southern jet is encountering a dense region. The northern jet flows more freely, generating more extended features. This is in agreement with the red-shifted molecular outflow traced by the ^{12}CO J=3–2 line extending towards the northwest and the lack of a blue-shifted outflow. This configuration can be explained by considering that the YSO is located at the furthest edge of the molecular clump along the line of sight, which is consistent with the position of the source in the cloud mapped in the $C^{18}O$ J=3–2 line. The detection of HCN, HNC, HCO^+, and C_2H allowed us to characterize the dense gas at clump scales, yielding results that are in agreement with the presence of a high-mass protostellar object.

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A Machine Learning model to infer planet masses from gaps observed in protoplanetary disks

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Observations of bright protoplanetary disks often show annular gaps in their dust emission. One interpretation of these gaps is disk-planet interaction. If so, fitting models of planetary gaps to observed protoplanetary disk gaps can reveal the presence of hidden planets. However, future surveys are expected to produce an ever-increasing number of protoplanetary disks with gaps. In this case, performing a customized fitting for each target becomes impractical owing to the complexity of disk-planet interaction. To this end, we introduce DPNNet (Disk Planet Neural Network), an efficient model of planetary gaps by exploiting the power of machine learning. We train a deep neural network with a large number of dusty disk-planet hydrodynamic simulations across a range of planet masses, disk temperatures, disk viscosities, disk surface density profiles, particle Stokes numbers, and dust abundances. The network can then be deployed to extract the planet mass for a given gap morphology. In this work, first in a series, we focus on the basic concepts of our machine learning framework. We demonstrate its utility by applying it to the dust gaps observed in the protoplanetary disk around HL Tau at 10 au, 30 au, and 80 au. Our network predict planet masses of 80 $M_{\rm Earth}$, 63 $M_{\rm Earth}$, and 70 $M_{\rm Earth}$, respectively, which are comparable to other studies based on specialized simulations. We discuss the key advantages of our DPNNet in its flexibility to incorporate new physics, any number of parameters and predictions, and its potential to ultimately replace hydrodynamical simulations for disk observers and modelers.

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LEGO II: A 3 mm molecular line study covering 100 pc of one of the most actively star-forming portions within the Milky Way Disc

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The current generation of (sub)mm-telescopes has allowed molecular line emission to become a major tool for studying the physical, kinematic, and chemical properties of extragalactic systems, yet exploiting these observations requires a detailed understanding of where emission lines originate within the Milky Way. In this paper, we present 60 arcsec (~ 3 pc) resolution observations of many 3mm-band molecular lines across a large map of the W49 massive star-forming region ($\sim 100 \times 100$ pc at 11 kpc), which were taken as part of the "LEGO" IRAM-30m large project. We find that the spatial extent or brightness of the molecular line transitions are not well correlated with their critical densities, highlighting abundance and optical depth must be considered when estimating line emission characteristics. We explore how the total emission and emission efficiency (i.e. line brightness per H_2 column density) of the line emission vary as a function of molecular hydrogen column density and dust temperature. We find that there is not a single region of this parameter space responsible for the brightest and most efficiently emitting gas for all species. For example, we find that the HCN transition shows high emission efficiency at high column density (10^{22} cm^{-2}) and moderate temperatures (35 K), whilst e.g. N_2H^+ emits most efficiently towards lower temperatures (10^{22} cm^{-2}; <20 K). We determine $X_{\mathrm{CO}(1-0)} \sim 0.3 \times 10^{20}\,\mathrm{cm}^{-2}\,(\mathrm{K\,km\,s}^{-1})^{-1}$, and $\alpha_{\mathrm{HCN}(1-0)} \sim 30\,\mathrm{M}_\odot\,(\mathrm{K\,km\,s}^{-1}\,\mathrm{pc}^2)^{-1}$, which both differ significantly from the commonly adopted values. In all, these results suggest caution should be taken when interpreting molecular line emission.

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High Resolution Infrared Spectroscopy of Hot Molecular Gas in AFGL 2591 and AFGL 2136: Accretion in the Inner Regions of Disks Around Massive Young Stellar Objects

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We have performed a high resolution 4-13 μm spectral survey of the hot molecular gas associated with the massive protostars AFGL 2591 and AFGL 2136, utilising the Echelon-Cross-Echelle-Spectrograph (EXES) on-board the Stratospheric Observatory for Infrared Astronomy (SOFIA), and the iSHELL instrument and Texas Echelon Cross Echelle Spectrograph (TEXES) on the NASA Infrared Telescope Facility (IRTF). Here we present results of this survey with analysis of CO, HCN, C_2H_2, NH_3 and CS, deriving the physical conditions for each species. Also from the IRTF, iSHELL data at 3 μm for AFGL 2591 are presented that show HCN and C_2H_2 in emission. In the EXES and TEXES data, all species are detected in absorption, and temperatures and abundances are found to be high (600 K and 10^{-6}, respectively). Differences of up to an order of magnitude in the abundances of transitions that trace the same ground state level are measured for HCN and C_2H_2. The mid-infrared continuum is known to originate in a disk, hence we attribute the infrared absorption to arise in the photosphere of the disk. As absorption lines require an outwardly decreasing temperature gradient, we conclude that the disk is heated in the mid-plane by viscous heating

due to accretion. We attribute the near-IR emission lines to scattering by molecules in the upper layers of the disk photosphere. The absorption lines trace the disk properties at 50 AU where a high temperature gas-phase chemistry is taking place. Abundances are consistent with chemical models of the inner disk of Herbig disks.

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CMZoom: Survey Overview and First Data Release

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We present an overview of the *CMZoom* survey and its first data release. *CMZoom* is the first blind, high-resolution survey of the Central Molecular Zone (CMZ; the inner 500 pc of the Milky Way) at wavelengths sensitive to the precursors of high-mass stars. *CMZoom* is a 550-hour Large Program on the Submillimeter Array (SMA) that mapped at 1.3 mm all of the gas and dust in the CMZ above a molecular hydrogen column density of 10^{23}cm^{-2} at a resolution of $\sim$3′′ (0.1 pc). In this paper, we focus on the 1.3 mm dust continuum and its data release, but also describe *CMZoom* spectral line data which will be released in a forthcoming publication. While *CMZoom* detected many regions with rich and complex substructure, its key result is an overall deficit in compact substructures on 0.1 - 2 pc scales (the compact dense gas fraction: CDGF). In comparison with clouds in the Galactic disk, the CDGF in the CMZ is substantially lower, despite having much higher average column densities. CMZ clouds with high CDGFs are well-known sites of active star formation. The inability of most gas in the CMZ to form compact substructures is likely responsible for the dearth of star formation in the CMZ, surprising considering its high density. The factors responsible for the low CDGF are not yet understood but are plausibly due to the extreme environment of the CMZ, having far-reaching ramifications for our understanding of the star formation process across the cosmos.

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Birth of convective low-mass to high-mass second Larson cores

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Stars form as an end product of the gravitational collapse of cold, dense gas in magnetized molecular clouds. This fundamentally multi-scale scenario occurs via the formation of two quasi-hydrostatic Larson cores and involves complex physical processes, which require a robust, self-consistent numerical treatment. The primary aim of this study is to understand the formation and evolution of the second hydrostatic Larson core and the dependence of its properties on the initial cloud core mass. We used the PLUTO code to perform high-resolution, one- and two-dimensional radiation hydrodynamic (RHD) core collapse simulations. We include self-gravity and use a grey flux-limited diffusion approximation for the radiative transfer. Additionally, we use for the gas equation of state density- and temperature-dependent thermodynamic quantities (heat capacity, mean molecular weight, etc.) to account for effects such as dissociation of molecular hydrogen, ionisation of atomic hydrogen and helium, and molecular vibrations and rotations. Properties of the second core are investigated using one-dimensional studies spanning a wide range of initial cloud core masses from 0.5 $M_{\odot}$ to 100 $M_{\odot}$. Furthermore, we expand to two-dimensional (2D) collapse simulations for a selected few cases of 1 $M_{\odot}$, 5 $M_{\odot}$, 10 $M_{\odot}$, and 20 $M_{\odot}$. We follow the evolution of the second core for $\geq$ 100 years after its formation, for each of these non-rotating cases. Our results indicate a dependence of several second core properties on the initial cloud core mass. Molecular cloud cores with a higher initial mass collapse faster to form bigger and more massive second cores. The high-mass second cores can accrete at a much faster rate of $\approx 10^{-2} M_{\odot}\ yr^{-1}$ compared to the low-mass second cores, which have accretion rates as low as $10^{-5} M_{\odot}\ yr^{-1}$. For the first time, owing to a resolution that has not been achieved before, our 2D non-rotating collapse studies indicate that convection is generated in the outer layers of the second core, which is formed due to the gravitational collapse of a 1 $M_{\odot}$ cloud core. Additionally, we find large-scale oscillations of the second accretion shock front triggered by the standing accretion shock instability (SASI), which has not been seen before in early evolutionary stages of stars. We predict that the physics within the second core would not be significantly influenced by the effects of magnetic fields or an initial cloud rotation. In our 2D RHD simulations, we find convection being driven from the accretion shock towards the interior of the second Larson core. This supports an interesting possibility that dynamo-driven magnetic fields may be generated during the very early phases of low-mass star formation.

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FAUST I. The hot corino at the heart of the prototypical Class I protostar L1551 IRS5

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The study of hot corinos in Solar-like protostars has been so far mostly limited to the Class 0 phase, hampering our understanding of their origin and evolution. In addition, recent evidence suggests that planet formation starts already during Class I phase, which, therefore, represents a crucial step in the future planetary system chemical composition. Hence, the study of hot corinos in Class I protostars has become of paramount importance. Here we report the discovery of a hot corino towards the prototypical Class I protostar L1551 IRS5, obtained within the ALMA Large Program FAUST. We detected several lines from methanol and its isopotologues ($^{13}CH_3OH$ and CH_2DOH), methyl formate and ethanol. Lines are bright toward the north component of the IRS5 binary system, and a possible second hot corino may be associated with the south component. The methanol lines non-LTE analysis constrains the gas temperature (∼100 K), density ($\geq 1.5\times10^8$ cm^{-3}), and emitting size (∼10 au in radius). All CH_3OH and $^{13}CH_3OH$ lines are optically thick, preventing a reliable measure of the deuteration. The methyl formate and ethanol relative abundances are compatible with those measured in Class 0 hot corinos. Thus, based on the present work, little chemical evolution from Class 0 to I hot corinos occurs.

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Estimation of the Gould Belt scale height from T Tauri type stars in the Gaia DR2 catalogue

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We analyze the spatial and kinematic properties of a large sample of young T Tauri type stars in a 500 pc radius solar neighborhood, closely related to the Gould belt. The following parameters of the exponential density distribution have been determined: the average $(z_G)_\odot = -25 \pm 5$ pc and scale height $h_G = 56 \pm 6$ pc. We propose a method of excluding background stars from the samples, which are located at large heights with respect to the symmetry plane of the Gould belt. We discovered that the expansion effect for the entire star system, $K_G = 6 \pm 1$ km s^{-1} kpc^{-1}, is determined mainly by the dynamics of the Scorpius-Centaurus association. We show that the angular velocity of the residual intrinsic rotation of the Gould belt can reach $\Omega_G = 6.9 \pm 0.2$ km s^{-1} kpc^{-1} and that this rotation is opposite to the galactic rotation.

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Self-scattering in protoplanetary disks with dust settling

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Scattering of re-emitted flux is considered to be at least partially responsible for the observed polarisation in the (sub-)millimetre wavelength range of several protoplanetary disks. Although the degree of polarisation produced by scattering is highly dependent on the dust model, early studies investigating this mechanism relied on the assumption of single grain sizes and simple density distribution of the dust. However, in the dense inner regions where this mechanism is usually most efficient, the existence of dust grains with sizes ranging from nanometres to millimetres has been confirmed. Additionally, the presence of gas forces larger grains to migrate vertically towards the disk midplane, introducing a dust segregation in the vertical direction. Using polarisation radiative transfer simulations, we analyse the dependence of the resulting scattered light polarisation at 350 micron, 850 micron, 1.3 mm, and 2 mm on various parameters describing protoplanetary disks, including the effect of dust grain settling. We find that the different disk parameters change the degree of polarisation mostly by affecting the anisotropy of the radiation field, the optical depth, or both. It is therefore very challenging to deduce certain disk parameter values directly from polarisation measurements alone. However, assuming a high dust albedo, it is possible to trace the transition from optically thick to optically thin disk regions. The degree of polarisation in most of the considered disk configurations is lower than what is found observationally, implying the necessity to revisit models that describe the dust properties and disk structure.

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The dichotomy of atmospheric escape in AU Mic b

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Here, we study the dichotomy of the escaping atmosphere of the newly discovered close-in exoplanet AU Mic b. On one hand, the high EUV stellar flux is expected to cause a strong atmospheric escape in AU Mic b. On the other hand, the wind of this young star is believed to be very strong, which could reduce or even inhibit the planet's atmospheric escape. AU Mic is thought to have a wind mass-loss rate that is up to 1000 times larger than the solar wind mass-loss rate ($\dot{M}_\odot$). To investigate this dichotomy, we perform 3D hydrodynamics simulations of the stellar wind–planetary atmosphere interactions in the AU Mic system and predict the synthetic Ly-α transits of AU Mic b. We systematically vary the stellar wind mass-loss rate from a 'no wind' scenario to up to a stellar wind with a mass-loss rate of 1000 $\dot{M}_\odot$. We find that, as the stellar wind becomes stronger, the planetary evaporation rate decreases from 6.5×10^{10} g/s to half this value. With a stronger stellar wind, the atmosphere is forced to occupy a smaller volume, affecting transit signatures. Our predicted Ly-α absorption drops from $\sim 20\%$, in the case of 'no wind' to barely any Ly-α absorption in the extreme stellar wind scenario. Future Ly-α transits could therefore place constraints not only on the evaporation rate of AU Mic b, but also on the mass-loss rate of its host star.

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Ubiquitous NH_3 supersonic component in L1688 coherent cores

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Context. Star formation takes place in cold dense cores in molecular clouds. Earlier observations have found that dense cores exhibit subsonic non-thermal velocity dispersions. In contrast, CO observations show that the ambient large-scale cloud is warmer and has supersonic velocity dispersions.
Aims. We aim to study the ammonia (NH_3) molecular line profiles with exquisite sensitivity towards the coherent cores in L1688 in order to study their kinematical properties in unprecedented detail.
Methods. We used NH_3 (1,1) and (2,2) data from the first data release (DR1) in the Green Bank Ammonia Survey (GAS). We first smoothed the data to a larger beam of $1'$ to obtain substantially more extended maps of velocity dispersion and kinetic temperature, compared to the DR1 maps. We then identified the coherent cores in the cloud and analysed the averaged line profiles towards the cores.
Results. For the first time, we detected a faint (mean NH_3 (1,1) peak brightness <0.25 K in $T_{\rm MB}$), supersonic component towards all the coherent cores in L1688. We fitted two components, one broad and one narrow, and derived the kinetic temperature and velocity dispersion of each component. The broad components towards all cores have supersonic linewidths ($\mathcal{M}_S \geq 1$). This component biases the estimate of the narrow dense core component's velocity dispersion by ≈28% and the kinetic temperature by ≈10%, on average, as compared to the results from single-component fits.
Conclusions. Neglecting this ubiquitous presence of a broad component towards all coherent cores causes the typical single-component fit to overestimate the temperature and velocity dispersion. This affects the derived detailed physical structure and stability of the cores estimated from NH_3 observations.

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The hierarchical fragmentation of filaments and the role of sub-filaments

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Recent observations have revealed the presence of small fibres or sub-filaments within larger filaments. We present a numerical fragmentation study of fibrous filaments investigating the link between cores and sub-filaments using hydrodynamical simulations performed with the moving-mesh code Arepo. Our study suggests that cores form in two environments: (i) as isolated cores, or small chains of cores, on a single sub-filament, or (ii) as an ensemble of cores located at the junction of sub-filaments. We term these *isolated* and *hub* cores respectively. We show that these core populations are statistically different from each other. Hub cores have a greater mean mass than isolated cores, and the mass distribution of hub cores is significantly wider than isolated cores. This fragmentation is reminiscent of parsec-scale hub-filament systems, showing that the combination of turbulence and gravity leads to similar fragmentation signatures on multiple scales, even within filaments. Moreover, the fact that fragmentation proceeds through sub-filaments suggests that there exists no characteristic fragmentation length-scale between cores. This is in opposition to earlier theoretical works studying fibre-less filaments which suggest a strong tendency towards the formation of quasi-periodically spaced cores, but in better agreement with observations. We also show tentative signs that global collapse of filaments preferentially form cores at both filament ends, which are more massive and dense than other cores.

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Anomalous Extinction toward NGC 1938

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Intrigued by the extended red giant clump (RC) stretching across the colour-magnitude diagram of the stars in a 50×50 pc^2 region of the Large Magellanic Cloud (LMC) containing the clusters NGC 1938 and NGC 1939, we have studied the stellar populations to learn about the properties of the interstellar medium (ISM) in this area. The extended RC is caused by a large and uneven amount of extinction across the field. Its slope reveals anomalous extinction properties, with $A_V/E(B-V) \simeq 4.3$, indicating the presence of an additional grey component in the optical contributing about 30% of the total extinction in the field and requiring big grains to be about twice as abundant as in the diffuse ISM. This appears to be consistent with the amount of big grains injected into the surrounding ISM by the about 70 SN II explosions estimated to have occurred during the lifetime of the $\sim$ 120 Myr old NGC 1938. Although this cluster appears today relatively small and would be hard to detect beyond the distance of M 31, with an estimated initial mass of $\sim$ 4800 M$_\odot$ NGC 1938 appears to have seriously altered the extinction properties in a wide area. This has important implications for the interpretation of luminosities and masses of star-forming galaxies, both nearby and in the early universe.

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RW Aur B: a modest UX Ori type companion of the famous primary

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The secondary of the famous young binary RW Aur is much less studied than the primary. To compensate this shortcoming, we present here the results of $UBVRIJHK$ photometric, VRI polarimetric and optical spectral observations of RW Aur B. The star demonstrates chaotic brightness variations in the optical band with irregular short ($\sim$ 1 day) dimmings with an amplitude ΔV up to $1.3^{\rm m}$. The dimmings are accompanied with an increase in the linear polarization (up to 3 per cent in the I band), presumably due to the scattering of the stellar radiation by dust in the circumstellar disc that means that RW Aur B can be classified as a UX Ori type star. We concluded that the observed excess emission at $\lambda \lesssim 0.45$ μm and longward ≈ 2 μm as well as a variability of fluxes and profiles of H I, He I and Na I D emission lines are due to the accretion process. At the same time, emission components of Ca II lines indicate that RW Aur B has a powerful chromosphere. Assuming the solar elemental abundances, we found the following parameters of the star: $T_{\rm eff} = 4100 - 4200\,$K, $A_{\rm V} = 0.6 \pm 0.1$ (out of the dimming events), $L_* \approx 0.6\ L_\odot$, $R_* \sim 1.5\ R_\odot$, $M \sim 0.85$ M$_\odot$, $\dot{M}_{\rm acc} < 5 \times 10^{-9}$ M$_\odot$ yr^{-1}. Finally, we discuss possible reasons for the different levels of the accretion activity of RW Aur binary components and present arguments in favour of the fact that they are gravitationally bound.

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Hunting for Runaways from the Orion Nebula Cluster

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We use Gaia DR2 to hunt for runaway stars from the Orion Nebula Cluster (ONC). We search a region extending 45° around the ONC and out to 1 kpc to find sources that overlapped in angular position with the cluster in the last ∼10 Myr. We find $\sim 17,000$ runaway/walkaway candidates satisfy this 2D traceback condition. Most of these are expected to be contaminants, e.g., caused by Galactic streaming motions of stars at different distances. We thus examine six further tests to help identify real runaways, namely: (1) possessing young stellar object (YSO) colors and magnitudes based on Gaia optical photometry; (2) having IR excess consistent with YSOs based on 2MASS and WISE photometry; (3) having a high degree of optical variability; (4) having closest approach distances well constrained to within the cluster half-mass radius; (5) having ejection directions that avoid the main Galactic streaming contamination zone; and (6) having a required radial velocity (RV) for 3D overlap of reasonable magnitude (or, for the 7% of candidates with measured RVs, satisfying 3D traceback). Thirteen sources, not previously noted as Orion members, pass all these tests, while another twelve are similarly promising, except they are in the main Galactic streaming contamination zone. Among these 25 ejection candidates, ten with measured RVs pass the most restrictive 3D traceback condition. We present full lists of runaway/walkaway candidates, estimate the high-velocity population ejected from the ONC and discuss its implications for cluster formation theories via comparison with numerical simulations.

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ACRONYM IV: Three New, Young, Low-mass Spectroscopic Binaries

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As part of our search for new low-mass members of nearby young moving groups (YMG), we discovered three low-mass, spectroscopic binaries, two of which are not kinematically associated with any known YMG. Using high-resolution optical spectroscopy, we measure the component and systemic radial velocities of the systems, as well as their lithium absorption and Hα emission, both spectroscopic indicators of youth. One system (2MASS J02543316−5108313, M2.0+M3.0) we confirm as a member of the 40 Myr old Tuc-Hor moving group, but whose binarity was previously undetected. The second young binary (2MASS J08355977−3042306, K5.5+M1.5) is not a kinematic match to any known YMG, but each component exhibits lithium absorption and strong and wide Hα emission indicative of active accretion, setting an upper age limit of 15 Myr. The third system (2MASS J10260210−4105537, M1.0+M3.0) has been hypothesized in the literature to be a member of the 10 Myr old TW Hya Association (TWA), but with our measured systemic velocity, shows the binary is in fact not part of any known YMG. This last system also has lithium absorption in each component, and has strong and variable Hα emission, setting an upper age limit of 15 Myr based on the lithium detection.

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A survey for variable young stars with small telescopes: III – Warm spots on the active star V1598Cyg

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Magnetic spots on low-mass stars can be traced and characterised using multi-band photometric light curves. Here we analyse an extensive data set for one active star, V1598Cyg, a known variable K dwarf which is either pre-main sequence and/or in a close binary system. Our light curve contains 2854 photometric data points, mostly in V, R_c, I_c, but also in U, B and Hα, with a total baseline of about 4yr, obtained with small telescopes as part of the HOYS project. We find that V1598Cyg is a very fast rotator with a period of 0.8246 days and varying amplitudes in all filters, best explained as a signature of strong magnetic activity and spots. We fit the photometric amplitudes in V, R_c, I_c and use them to estimate spot properties, using a grid-based method that is also propagating uncertainties. We verify the method on a partial data set with high cadence and all five broad-band filters. The method yields spot temperatures and fractional spot coverage with typical uncertainties of 100 K and 3–4%, respectively. V1598Cyg consistently exhibits spots that are a few hundred degrees warmer than the photosphere, most likely indicating that the light curve is dominated by chromospheric plage. The spot activity varies over our observing baseline, with a typical time scale of 0.5–1yr, which we interpret as the typical spot lifetime. Combining our light curve with archival data, we find a six year cycle in the average brightness, that is probably a sign of a magnetic activity cycle.

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Aluminum-26 Enrichment in the Surface of Protostellar Disks Due to Protostellar Cosmic Rays

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The radioactive decay of aluminum-26 (^{26}Al) is an important heating source in early planet formation. Since its discovery, there have been several mechanisms proposed to introduce ^{26}Al into protoplanetary disks, primarily through contamination by external sources. We propose a local mechanism to enrich protostellar disks with ^{26}Al through irradiation of the protostellar disk surface by cosmic rays accelerated in the protostellar accretion shock. We calculate the ^{26}Al enrichment, [^{26}Al/^{27}Al], at the surface of the protostellar disk in the inner AU throughout the evolution of low-mass stars, from M-dwarfs to proto-Suns. Assuming constant mass accretion rates, $\dot{m}$, we find that irradiation by MeV cosmic rays can provide significant enrichment on the disk surface if the cosmic rays are not completely coupled to the gas in the accretion flow. Importantly, we find that low accretion rates, $\dot{m} < 10^{-7}\ M_\odot\ \mathrm{yr}^{-1}$, are able to produce canonical amounts of ^{26}Al, [^{26}Al/^{27}Al] $\approx 5 \times 10^{-5}$. These accretion rates are experienced at the transition from Class I- to Class II-type protostars, when it is assumed that calcium-aluminum-rich inclusions condense in the inner disk. We conclude that irradiation of the inner disk surface by cosmic ray protons accelerated in accretion shocks at the protostellar surface may be an important mechanism to produce ^{26}Al. Our models show protostellar cosmic rays may be a viable model to explain the enrichment of ^{26}Al found in the Solar System.

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Disk Evolution Study Through Imaging of Nearby Young Stars (DESTINYS): A close low mass companion to ET Cha

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To understand the formation of planetary systems, one needs to understand the initial conditions of planet formation, i.e. the young gas-rich planet forming disks. Spatially resolved high-contrast observations are of particular interest, since substructures in disks, linked to planet formation, can be detected and close companions or even planets in formation embedded in the disk can be revealed. In this study we present the first result of the DESTINYS survey (Disk Evolution Study Through Imaging of Nearby Young Stars). DESTINYS is an ESO/SPHERE large program that aims at studying disk evolution in scattered light, mainly focusing on a sample of low-mass stars ($<1\ M_\odot$) in nearby ($\sim$200 pc) star-forming regions. In this particular study we present the observations of the ET Cha (RECX 15) system, a nearby 'old' classical T Tauri star (5–8 Myr, $\sim$100 pc), which is still strongly accreting. We use SPHERE/IRDIS in *H*-band polarimetric imaging mode to obtain high contrast images of the ET Cha system to search for scattered light from the circumstellar disk as well as thermal emission from close companions. We additionally employ VLT/NACO total intensity archival data taken in 2003. We report here the discovery of a low-mass (sub)stellar companion with SPHERE/IRDIS to ET Cha. We are estimating the mass of this new companion based on photometry. Depending on the system age it is a 5 Myr, 50 $M_{\rm Jup}$ brown dwarf or an 8 Myr, 0.10 $M_\odot$ M-type pre-main-sequence star. We explore possible orbital solutions and discuss the recent dynamic history of the system. Independent of the precise companion mass we find that the presence of the companion likely explains the small size of the disk around ET Cha. The small separation of the binary pair indicates that the disk around the primary component is likely clearing from the outside in, explaining the high accretion rate of the system.

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CS Cha B: A disc-obscured M-type star mimicking a polarised planetary companion

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Context. Direct imaging provides a steady flow of newly discovered giant planets and brown dwarf companions. These multi-object systems can provide information about the formation of low-mass companions in wide orbits and/or help us to speculate about possible migration scenarios. Accurate classification of companions is crucial for testing formation pathways.
Aims. In this work we further characterise the recently discovered candidate for a planetary-mass companion CS Cha b and determine if it is still accreting.
Methods. MUSE is a four-laser-adaptive-optics-assisted medium-resolution integral-field spectrograph in the optical part of the spectrum. We observed the CS Cha system to obtain the first spectrum of CS Cha b. The companion is characterised by modelling both the spectrum from 6300 Å to 9300 Å and the photometry using archival data from the visible to the near-infrared (NIR).
Results. We find evidence of accretion and outflow signatures in Hα and OI emission. The atmospheric models with the highest likelihood indicate an effective temperature of 3450$\pm$50 K with a $\log g$ of 3.6$\pm$0.5 dex. Based on evolutionary models, we find that the majority of the object is obscured. We determine the mass of the faint companion with several methods to be between 0.07 $M_\odot$ and 0.71 $M_\odot$ with an accretion rate of $\dot{M} = 4 \times 10^{-11\pm0.4}$ Myr^{-1}.
Conclusions. Our results show that CS Cha B is most likely a mid-M-type star that is obscured by a highly inclined disc, which has led to its previous classification using broadband NIR photometry as a planetary-mass companion. This shows that it is important and necessary to observe over a broad spectral range to constrain the nature of faint companions.

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ALMA Observations of Young Eruptive Stars: continuum disk sizes and molecular outflows

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We present Atacama Large Millimeter/submillimeter Array (ALMA) 1.3 mm observations of four young, eruptive star-disk systems at $0\farcs4$ resolution: two FUors (V582 Aur and V900 Mon), one EXor (UZ Tau E) and one source with an ambiguous FU/EXor classification (GM Cha). The disks around GM Cha, V900 Mon and UZ Tau E are resolved. These observations increase the sample of FU/EXors observed at sub-arcsecond resolution by 15%. The disk sizes and masses of FU/EXors objects observed by ALMA so far suggest that FUor disks are more massive than Class 0/I disks in Orion and Class II disks in Lupus of similar size. EXor disks in contrast do not seem to be distinguishable from these two populations. We reach similar conclusions when comparing the FU/EXor sample to the Class I and Class II disks in Ophiuchus. FUor disks around binaries are host to more compact disks than those in single-star systems, similar to non-eruptive young disks. We detect a wide-angle outflow around GM Cha in ^{12}CO emission, wider than typical Class I objects and more similar to those found around some FUor objects. We use radiative transfer models to fit the continuum and line data of the well-studied disk around UZ Tau E. The line data is well described by a keplerian disk, with no evidence of outflow activity (similar to other EXors). The detection of wide-angle outflows in FUors and not in EXors support to the current picture in which FUors are more likely to represent an accretion burst in the protostellar phase (Class I), while EXors are smaller accretion events in the protoplanetary (Class II) phase.

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On the orbital evolution of binaries with circumbinary discs

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Circumbinary discs are generally thought to take up angular momentum and energy from the binary orbit over time through gravitational torques mediated by orbital resonances. This process leads to the shrinkage of the binary orbit over time, and is important in a variety of astrophysical contexts including the orbital evolution of stellar binaries, the migration of planets in protoplanetary discs, and the evolution of black hole binaries (stellar and supermassive). The merger of compact object binaries provides a source of gravitational waves in the Universe. Recently, several groups have reported numerical simulations of circumbinary discs that yield the opposite result, finding that the binary expands with time. Here we argue that this result is primarily due to the choice of simulation parameters, made for numerical reasons, which differ from realistic disc parameters in many cases. We provide physical arguments, and then demonstrate with 3D hydrodynamical simulations, that thick (high pressure, high viscosity) discs drive sufficient accretion of high angular momentum material to force binary expansion, while in the more realistic case of thin (low pressure, low viscosity) discs there is less accretion and the binary shrinks. In the latter case, tides, which generally transfer angular momentum and energy from the more rapidly rotating object (the binary) to the less rapidly rotating object (the disc), are the dominant driver of disc-binary evolution. This causes the binary to shrink. We therefore conclude that for common circumbinary disc parameters, binaries with non- extreme mass ratios are expected to shrink over time. Expansion of the binary can occur if the disc viscosity is unusually high, which may occur in the very thick

discs encountered in e.g. circumplanetary discs, super-Eddington AGN, or the outer regions of passive protostellar discs that are heated by the central protostar. We also provide discussion of the impact that some simplifications to the problem, that are prevalent in the literature and made usually for numerical convenience, have on the disc-binary evolution.

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Ubiquitous velocity fluctuations throughout the molecular interstellar medium

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The density structure of the interstellar medium (ISM) determines where stars form and release energy, momentum, and heavy elements, driving galaxy evolution. Density variations are seeded and amplified by gas motion, but the exact nature of this motion is unknown across spatial scale and galactic environment. Although dense star-forming gas likely emerges from a combination of instabilities, convergent flows, and turbulence, establishing the precise origin is challenging because it requires quantifying gas motion over many orders of magnitude in spatial scale. Here we measure the motion of molecular gas in the Milky Way and in nearby galaxy NGC 4321, assembling observations that span an unprecedented spatial dynamic range (10^{-1}–10^3 pc). We detect ubiquitous velocity fluctuations across all spatial scales and galactic environments. Statistical analysis of these fluctuations indicates how star-forming gas is assembled. We discover oscillatory gas flows with wavelengths ranging from 0.3–400 pc. These flows are coupled to regularly-spaced density enhancements that likely form via gravitational instabilities. We also identify stochastic and scale-free velocity and density fluctuations, consistent with the structure generated in turbulent flows. Our results demonstrate that ISM structure cannot be considered in isolation. Instead, its formation and evolution is controlled by nested, interdependent flows of matter covering many orders of magnitude in spatial scale.

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The Outburst of the Young Star Gaia19bey

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We report photometry and spectroscopy of the outburst of the young stellar object Gaia19bey. We have established the outburst light curve with archival Gaia "G", ATLAS "Orange", ZTF r-band and Pan-STARRS "$rizy$"-filter photometry, showing an outburst of $\approx$ 4 years duration, longer than typical EXors but shorter than FUors. Its pre-outburst SED shows a flat far-infrared spectrum, confirming the early evolutionary state of Gaia19bey and its similarity to other deeply embedded young stars experiencing outbursts. A lower limit to the peak outburst luminosity is $\approx 182\ L_\odot$ at an assumed distance of 1.4 kpc, the minimum plausible distance. Infrared and optical spectroscopy near maximum light showed an emission line spectrum, including H I lines, strong red Ca II emission, other metal emission lines, infrared CO bandhead emission, and a strong infrared continuum. Towards the end of the outburst, the emission lines have all but disappeared and the spectrum has changed into an almost pure continuum spectrum. This indicates a cessation of magnetospheric accretion activity. The near-infrared colors have become redder as Gaia19bey has faded, indicating a cooling of the continuum component. Near the end of the outburst, the only remaining strong emission

lines are forbidden shock-excited emission lines. Adaptive optics integral field spectroscopy shows the H_2 1–0 S(1) emission with the morphology of an outflow cavity and the extended emission in the [Fe II] line at 1644 nm with the morphology of an edge-on disk. However, we do not detect any large-scale jet from Gaia19bey.

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Migrating Low-Mass Planets in Inviscid Dusty Protoplanetary Discs

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Disc-driven planet migration is integral to the formation of planetary systems. In standard, gas-dominated protoplanetary discs, low-mass planets or planetary cores undergo rapid inwards migration and are lost to the central star. However, several recent studies indicate that the solid component in protoplanetary discs can have a significant dynamical effect on disc-planet interaction, especially when the solid-to-gas mass ratio approaches unity or larger and the dust-on-gas drag forces become significant. As there are several ways to raise the solid abundance in protoplanetary discs, for example through disc winds and dust-trapping in pressure bumps, it is important to understand how planets migrate through a dusty environment. To this end, we study planet migration in dust-rich discs via a systematic set of high-resolution, two-dimensional numerical simulations. We show that the inwards migration of low-mass planets can be slowed down by dusty dynamical corotation torques. We also identify a new regime of stochastic migration applicable to discs with dust-to-gas mass ratios $\gtrsim$0.3 and particle Stokes numbers $\gtrsim$0.03. In these cases, disc-planet interaction leads to the continuous development of small-scale, intense dust vortices that scatter the planet, which can potentially halt or even reverse the inwards planet migration. We briefly discuss the observational implications of our results and highlight directions for future work.

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Large-scale CO spiral arms and complex kinematics associated with the T Tauri star RU Lup

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While protoplanetary disks often appear to be compact and well-organized in millimeter continuum emission, CO spectral line observations are increasingly revealing complex behavior at large distances from the host star. We present deep ALMA maps of the J=2–1 transition of ^{12}CO, ^{13}CO, and C^{18}O, as well as the J=3–2 transition of DCO$^+$, toward the T Tauri star RU Lup at a resolution of $\sim$0.″3 ($\sim$50 au). The CO isotopologue emission traces four major components of the RU Lup system: a compact Keplerian disk with a radius of $\sim$120 au, a non-Keplerian "envelope-like" structure surrounding the disk and extending to $\sim$260 au from the star, at least five blueshifted spiral arms stretching up to 1000 au, and clumps outside the spiral arms located up to 1500 au in projection from RU Lup. We comment on potential explanations for RU Lup's peculiar gas morphology, including gravitational instability, accretion of material onto the disk, or perturbation by another star. RU Lup's extended non-Keplerian CO emission, elevated stellar accretion rate, and unusual photometric variability suggest that it could be a scaled-down Class II analog of the outbursting FU Ori systems.

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Multiwavelength investigation of extended green object G19.88−0.53: Revealing a protocluster

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A multiwavelength analysis of star formation associated with the extended green object, G19.88−0.53 is presented in this paper. With multiple detected radio and millimetre components, G19.88−0.53 unveils as harbouring a protocluster rather than a single massive young stellar object. We detect an ionized thermal jet using the upgraded Giant Meterwave Radio Telescope, India, which is found to be associated with a massive, dense and hot ALMA 2.7 mm core driving a bipolar CO outflow. Near-infrared spectroscopy with UKIRT-UIST shows the presence of multiple shock-excited H_2 lines concurrent with the nature of this region. Detailed investigation of the gas kinematics using ALMA data reveals G19.88−0.53 as an active protocluster with high-mass star forming components spanning a wide evolutionary spectrum from hot cores in accretion phase to cores driving multiple outflows to possible UCHII regions.

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Distortion of Magnetic Fields in the Dense Core SL42 (CrA-E) in the Corona Australis Molecular Cloud Complex

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Detailed magnetic field structure of the dense core SL42 (CrA-E) in the Corona Australis molecular cloud complex was investigated based on near-infrared polarimetric observations of background stars to measure dichroically polarized light produced by magnetically aligned dust grains. The magnetic fields in and around SL42 were mapped using 206 stars and curved magnetic fields were identified. On the basis of simple hourglass (parabolic) magnetic field modeling, the magnetic axis of the core on the plane of sky was estimated to be $40^\circ \pm 3^\circ$. The plane-of-sky magnetic field strength of SL42 was found to be 22.4 ± 13.9 μG. Taking into account the effects of thermal/turbulent pressure and the plane-of-sky magnetic field component, the critical mass of SL42 was obtained to be $M_{\rm cr} = 21.2 \pm 6.6$ M$_\odot$, which is close to the observed core mass of $M_{\rm core} \approx 20$ M$_\odot$. We thus conclude that SL42 is in a condition close to the critical state if the magnetic fields lie near the plane of the sky. Since there is a very low luminosity object (VeLLO) toward the center of SL42, it is unlikely this core is in a highly subcritical condition (i.e., magnetic inclination angle significantly deviated from the plane of sky). The core probably started to collapse from a nearly kinematically critical state. In addition to the hourglass magnetic field modeling, the Inoue & Fukui (2013) mechanism may explain the origin of the curved magnetic fields in the SL42 region.

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Molecular Cloud Cores with High Deuterium Fraction: Nobeyama Single-Pointing Survey

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We present the results of a single-pointing survey of 207 dense cores embedded in Planck Galactic Cold Clumps distributed in five different environments (λ Orionis, Orion A, B, Galactic plane, and high latitudes) to identify dense cores on the verge of star formation for the study of the initial conditions of star formation. We observed these cores in eight molecular lines at 76-94 GHz using the Nobeyama 45-m telescope. We find that early-type molecules (e.g., CCS) have low detection rates and that late-type molecules (e.g., N_2H^+, c-C_3H_2) and deuterated molecules (e.g., N_2D^+, DNC) have high detection rates, suggesting that most of the cores are chemically evolved. The deuterium fraction (D/H) is found to decrease with increasing distance, indicating that it suffers from differential beam dilution between the D/H pair of lines for distant cores (>1 kpc). For λ Orionis, Orion A, and B located at similar distances, D/H is not significantly different, suggesting that there is no systematic difference in the observed chemical properties among these three regions. We identify at least eight high D/H cores in the Orion region and two at high latitudes, which are most likely to be close to the onset of star formation. There is no clear evidence of the evolutionary change in turbulence during the starless phase, suggesting that the dissipation of turbulence is not a major mechanism for the beginning of star formation as judged from observations with a beam size of 0.04 pc.

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3D structure of HII region Sh2-235 from tunable-filter optical observations

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We present observations of the Hα, Hβ, [SII] $\lambda\lambda 6716, 6731$ and [NII] $\lambda 6583$ emission lines in the galactic HII region Sh2-235 with the Mapper of Narrow Galaxy Lines (MaNGaL), a tunable filter at the 1-m telescope of the Special Astrophysical Observatory of the Russian Academy of Sciences. We show that the HII region is obscured by neutral material with $A_{\rm V} \approx 2-4$ mag. The area with the highest $A_{\rm V}$ is situated to the south-west from the ionizing star and coincides with a maximum detected electron density of $\gtrsim$300 cm^{-3}. The combination of these results with archive *AKARI* far-infrared data allows us to estimate the contribution of the front and rear walls to the total column density of neutral material in S235, and explain the three-dimensional structure of the region. The HII region consist of a denser, more compact portion deeply embedded in the neutral medium and the less dense and obscured gas. The front and rear walls of the HII region are inhomogeneous, with the material in the rear wall having a higher column density. We find a two-sided photodissociation region in the dense clump S235 East 1, illuminated by a UV field with $G_0 = 50-70$ and 200 Habing units in the western and eastern parts, respectively.

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The PDR structure and kinematics around the compact HII regions S235A and S235C with [CII], [13CII], [OI] and HCO+ line profiles

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The aim of the present work is to study structure and gas kinematics in the photodissociation regions (PDRs) around the compact H II regions S235 A and S235 C. We observe the [C II], and [O I] line emission, using SOFIA/upGREAT and complement them by data of HCO$^+$ and CO. We use the [^{13}C II] line to measure the optical depth of the [C II] emission, and find that the [C II] line profiles are influenced by self-absorption, while the [^{13}C II] line remains unaffected by these effects. Hence, for dense PDRs, [^{13}C II] emission is a better tracer of gas kinematics. The optical depth of the [C II] line is up to 10 in S235 A. We find an expanding motion of the [C II]-emitting layer of the PDRs into the front molecular layer in both regions. Comparison of the gas and dust columns shows that gas components visible neither in the [C II] nor in low-J CO lines may contribute to the total column across S235 A. We test whether the observed properties of the PDRs match the predictions of spherical models of expanding H II region + PDR + molecular cloud. Integrated intensities of the [^{13}C II], [C II] and [O I] lines are well-represented by the model, but the models do not reproduce the double-peaked [C II] line profiles due to an insufficient column density of C$^+$. The model predicts that the [O I] line could be a more reliable tracer of gas kinematics, but the foreground self-absorbing material does not allow using it in the considered regions.

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CO Depletion in Protoplanetary Disks: A Unified Picture Combining Physical Sequestration and Chemical Processing

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The gas-phase CO abundance (relative to hydrogen) in protoplanetary disks decreases by up to 2 orders of magnitude from its ISM value $\sim 10^{-4}$, even after accounting for freeze-out and photo-dissociation. Previous studies have shown that while local chemical processing of CO and the sequestration of CO ice on solids in the midplane can both contribute, neither of these processes appears capable of consistently reaching the observed depletion factors on the relevant timescale of 1−3 Myr. In this study, we model these processes simultaneously by including a compact chemical network (centered on carbon and oxygen) to 2D $(r + z)$ simulations of the outer $(r > 20$ au) disk regions that include turbulent diffusion, pebble formation, and pebble dynamics. In general, we find that the CO/H_2 abundance is a complex function of time and location. Focusing on CO in the warm molecular layer, we find that only the most complete model (with chemistry and pebble evolution included) can reach depletion factors consistent with observations. In the absence of pressure traps, highly-efficient planetesimal formation, or high cosmic ray ionization rates, this model also predicts a resurgence of CO vapor interior to the CO snowline. We show the impact of physical and chemical processes on the elemental (C/O) and (C/H) ratios (in the gas and ice phases), discuss the use of CO as a disk mass tracer, and, finally, connect our predicted pebble ice compositions to those of pristine planetesimals as found in the Cold Classical Kuiper Belt and debris disks.

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Unifying low and high mass star formation through density amplified hubs of filaments: The highest mass stars ($>100M_\odot$) form only in hubs

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Context: Star formation takes place in giant molecular clouds, resulting in mass-segregated young stellar clusters composed of Sun-like stars, brown dwarves, and massive O-type(50-100 Msun) stars.
Aims: To identify candidate hub-filament systems (HFS) in the Milky-Way and examine their role in the formation of the highest mass stars and star clusters.
Methods: Filaments around ∼35000 HiGAL clumps that are detected using the DisPerSE algorithm. Hub is defined as a junction of three or more filaments. Column density maps were masked by the filament skeletons and averaged for HFS and non-HFS samples to compute the radial profile along the filaments into the clumps.
Results: ∼3700(11%) are candidate HFS of which,∼2150 (60%) are pre-stellar,∼1400(40%) are proto-stellar. All clumps with $L>10^4$ Lsun and $L>10^5$ Lsun at distances respectively within 2kpc and 5kpc are located in the hubs of HFS. The column-densities of hubs are found to be enhanced by a factor of ∼2 (pre-stellar sources) up to ∼10 (proto-stellar sources).
Conclusions: All high-mass stars preferentially form in the density enhanced hubs of HFS. This amplification can drive the observed longitudinal flows along filaments providing further mass accretion. Radiation pressure and feedback can escape into the inter-filamentary voids. We propose a "filaments to clusters" unified paradigm for star formation, with the following salient features: a) low-intermediate mass stars form in the filaments slowly (10^6yr) and massive stars quickly (10^5yr) in the hub, b) the initial mass function is the sum of stars continuously created in the HFS with all massive stars formed in the hub, c) Feedback dissipation and mass segregation arise naturally due to HFS properties,

and c) explain age spreads within bound clusters and formation of isolated OB associations.

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The dependence of episodic accretion on eccentricity during the formation of binary stars

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Context: Episodic accretion has been observed in short-period binaries, where bursts of accretion occur at periastron. The binary trigger hypothesis has also been suggested as a driver for accretion during protostellar stages.
Aims: Our goal is to investigate how the strength of episodic accretion bursts depends on eccentricity.
Methods: We investigate the binary trigger hypothesis in longer-period ($> 20\,\mathrm{yr}$) binaries by carrying out three-dimensional magnetohydrodynamical (MHD) simulations of the formation of low-mass binary stars down to final separations of $\sim$10 AU, including the effects of gas turbulence and magnetic fields. We ran two simulations with an initial turbulent gas core of one solar mass each and two different initial turbulent Mach numbers, $\mathcal{M} = \sigma_v/c_s = 0.1$ and $\mathcal{M} = 0.2$, for 6500 yr after protostar formation.
Results: We observe bursts of accretion at periastron during the early stages when the eccentricity of the binary system is still high. We find that this correlation between bursts of accretion and passing periastron breaks down at later stages because of the gradual circularisation of the orbits. For eccentricities greater than $e = 0.2$, we observe episodic accretion triggered near periastron. However, we do not find any strong correlation between the strength of episodic accretion and eccentricity. The strength of accretion is defined as the ratio of the burst accretion rate to the quiescent accretion rate. We determine that accretion events are likely triggered by torques between the rotation of the circumstellar disc and the approaching binary stars. We compare our results with observational data of episodic accretion in short-period binaries and find good agreement between our simulations and the observations.
Conclusions: We conclude that episodic accretion is a universal mechanism operating in eccentric young binary-star systems, independent of separation, and it should be observable in long-period binaries as well as in short-period binaries. Nevertheless, the strength depends on the torques and hence the separation at periastron.

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The large-scale magnetic field of the eccentric pre-main-sequence binary system V1878 Ori

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We report time-resolved, high-resolution optical spectropolarimetric observations of the young double-lined spectroscopic binary V1878 Ori. Our observations were collected with the ESPaDOnS spectropolarimeter at the Canada-France-Hawaii Telescope through the BinaMIcS large programme. V1878 Ori A and B are partially convective intermediate mass weak-line T Tauri stars on an eccentric and asynchronous orbit. We also acquired X-ray observations at periastron and outside periastron.
Using the least-squares deconvolution technique (LSD) to combine information from many spectral lines, we clearly detected circular polarization signals in both components throughout the orbit. We refined the orbital solution for

the system and obtained disentangled spectra for the primary and secondary components. The disentangled spectra were then employed to determine atmospheric parameters of the two components using spectrum synthesis. Applying our Zeeman Doppler imaging code to composite Stokes *IV* LSD profiles, we reconstructed brightness maps and the global magnetic field topologies of the two components. We find that V1878 Ori A and B have strikingly different global magnetic field topologies and mean field strengths. The global magnetic field of the primary is predominantly poloidal and non-axisymmetric (with a mean field strength of 180 G). while the secondary has a mostly toroidal and axisymmetric global field (mean strength of 310 G). These findings confirm that stars with very similar parameters can exhibit radically different global magnetic field characteristics. The analysis of the X-ray data shows no sign of enhanced activity at periastron, suggesting the lack of strong magnetospheric interaction at this epoch.

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Protostellar collapse: the conditions to form dust rich protoplanetary disks

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Dust plays a key role during star, disk and planet formation. Yet, its dynamics during the protostellar collapse remains a poorly investigated field. Recent studies seem to indicate that dust may decouple efficiently from the gas during these early stages. We aim to understand how much and in which regions dust grains concentrate during the early phases of the protostellar collapse, and see how it depends on the properties of the initial cloud and of the solid particles. We use the multiple species dust dynamics solver of the grid-based code RAMSES to perform various simulations of dusty collapses. We perform hydrodynamical and MHD simulations where we vary the maximum grain size, the thermal-to-gravitational energy ratio and the magnetic properties of the cloud. We simulate the simultaneous evolution of ten neutral dust grains species with grain sizes varying from a few nm to a few hundredth of microns. We obtain a significant decoupling between the gas and the dust for grains of typical sizes a few 10 microns. This decoupling strongly depends on the thermal-to-gravitational energy ratio, the grain sizes or the inclusion of a magnetic field. With a semi-analytic model calibrated on our results, we show that the dust ratio mostly varies exponentially with the initial Stokes number at a rate that depends on the local cloud properties. We find that larger grains tend to settle and drift efficiently in the first-core and in the newly formed disk. This can produce dust-to-gas ratios of several times the initial value. Dust concentrates in high density regions and is depleted in low density regions. The size at which grains decouple from the gas depends on the initial properties of the clouds. Since dust can not necessarily be used as a proxy for gas during the collapse, we emphasize on the necessity of including the treatment of its dynamics in collapse simulations.

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The Molecular Clouds associated with the HII Regions/Candidates between $l = 207.7°$ and $l = 211.7°$

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Using the PMO-13.7 m millimeter telescope at Delingha in China, we have conducted a large-scale simultaneous survey of ^{12}CO, ^{13}CO, and C^{18}O $J = 1 - 0$ emission toward the sky region centered at l=209.7°, b=−2.25° with a coverage of 4.0° × 4.5°. The majority of the emission in the region comes from the clouds with velocities lying in the range from −3 km s^{-1} to 55 km s^{-1}, at kinematic distances from 0.5 kpc to 7.0 kpc. The molecular clouds in the region are concentrated into three velocity ranges. The molecular clouds associated with the ten HII regions/candidates are identified and their physical properties are presented. Massive stars are found within Sh2-280, Sh2-282, Sh2-283, and BFS54, and we suggest them to be the candidate excitation sources of the HII regions. The distributions of excitation temperature and line width with the projected distance from the center of HII region/candidate suggest that the majority of the ten HII regions/candidates and their associated molecular gas are three-dimensional structures, rather than two-dimensional structures.

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Steady Wind-Blown Cavities within Infalling Rotating Envelopes: Application to the Broad Velocity Component in Young Protostars

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Wind-driven outflows are observed around a broad range of accreting objects throughout the Universe, ranging from forming low-mass stars to super-massive black holes. We study the interaction between a central isotropic wind and an infalling, rotating, envelope, determining the steady-state cavity shape formed at their interface under the assumption of weak mixing. The shape of the resulting wind-blown cavity is elongated and self-similar, with a physical size determined by the ratio between wind ram pressure and envelope thermal pressure. We compute the growth of a warm turbulent mixing-layer between the shocked wind and the deflected envelope, and calculate the resultant broad line profile, under the assumption of a linear (Couette-type) velocity profile across the layer. We then test our model against the warm broad velocity component observed in CO J=16–15 by *Herschel*/HIFI in the protostar Serpens-Main SMM1. Given independent observational constraints on the temperature and density of the dust envelope around SMM1, we find an excellent match to all its observed properties (line profile, momentum, temperature) and to the SMM1 outflow cavity width for a physically reasonable set of parameters: a ratio of wind to infall mass-flux $\simeq 4\%$, a wind speed $v_{\rm w} \simeq 30$ km/s, an interstellar abundance of CO and H_2, and a turbulent entrainment efficiency consistent with laboratory experiments. The inferred ratio of ejection to disk accretion rate, $\simeq 6-20\%$, is in agreement with current disk wind theories. Thus, the model provides a new framework to reconcile the modest outflow cavity widths in protostars with the large observed flow velocities. Being self-similar, it is applicable over a broader range of astrophysical contexts as well.

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ATOMS: ALMA Three-millimeter Observations of Massive Star-forming regions - I. Survey description and a first look at G9.62+0.19

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The ATOMS, standing for ALMA Three-millimeter Observations of Massive Star-forming regions, survey has observed 146 active star-forming regions with ALMA band 3, aiming to systematically investigate the spatial distribution of various dense gas tracers in a large sample of Galactic massive clumps, to study the roles of stellar feedback in star formation, and to characterize filamentary structures inside massive clumps. In this work, the observations, data analysis, and example science of the ATOMS survey are presented, using a case study for the G9.62+0.19 complex. Toward this source, some transitions, commonly assumed to trace dense gas, including CS J = 2-1, HCO^+ J = 1-0, and HCN J = 1-0, are found to show extended gas emission in low-density regions within the clump; less than 25 per cent of their emission is from dense cores. SO, CH_3OH, $H^{13}CN$, and HC_3N show similar morphologies in their spatial distributions and reveal well the dense cores. Widespread narrow SiO emission is present (over $\sim$1 pc), which may be caused by slow shocks from large-scale colliding flows or HII regions. Stellar feedback from an expanding HII region has greatly reshaped the natal clump, significantly changed the spatial distribution of gas, and may also account for the sequential high-mass star formation in the G9.62+0.19 complex. The ATOMS survey data can be jointly analysed with other survey data, e.g. MALT90, Orion B, EMPIRE, ALMA_IMF, and ALMAGAL, to deepen our understandings of 'dense gas' star formation scaling relations and massive protocluster formation.

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ATOMS: ALMA three-millimeter observations of massive star-forming regions - II. Compact objects in ACA observations and star formation scaling relations

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We report studies of the relationships between the total bolometric luminosity (L_{bol} or L_{TIR}) and the molecular line luminosities of J = 1 - 0 transitions of $H^{13}CN$, $H^{13}CO^+$, HCN, and HCO^+ with data obtained from ACA observations in the 'ATOMS' survey of 146 active Galactic star-forming regions. The correlations between Lbol and molecular line luminosities $L'_{\rm mol}$ of the four transitions all appear to be approximately linear. Line emission of isotopologues shows as large scatters in L_{bol}-$L'_{\rm mol}$ relations as their main line emission. The $\log(L_{bol}/L'_{\rm mol})$ for different molecular line tracers have similar distributions. The L_{bol}-to-$L'_{\rm mol}$ ratios do not change with galactocentric distances (R_{GC}) and clump masses (Mclump). The molecular line luminosity ratios (HCN-to-HCO^+, $H^{13}CN$-to-$H^{13}CO^+$, HCN-to-$H^{13}CN$, and HCO^+-to-$H^{13}CO^+$) all appear constant against Lbol, dust temperature (T_d), M_{clump}, and R_{GC}. Our studies suggest that both the main lines and isotopologue lines are good tracers of the total masses of dense gas in Galactic molecular clumps. The large optical depths of main lines do not affect the interpretation of the slopes in star formation relations. We find that the mean star formation efficiency (SFE) of massive Galactic clumps in the 'ATOMS' survey is reasonably consistent with other measures of the SFE for dense gas, even those using very different tracers or examining very different spatial scales.

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The Dynamic Proto-atmospheres around Low-Mass Planets with Eccentric Orbits

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Protoplanets are able to accrete primordial atmospheres when embedded in the gaseous protoplanetary disk. The formation and structure of the proto-atmosphere are subject to the planet–disk environment and orbital effects. Especially, when planets are on eccentric orbits, their relative velocities to the gas can exceed the sound speed. The planets generate atmosphere-stripping bow shocks. We investigate the proto-atmospheres on low-mass planets with eccentric orbits with radiation-hydrodynamics simulations. A 2D radiative model of the proto-atmosphere is established with tabulated opacities for the gas and dust. The solutions reveal large-scale gas recycling inside a bow shock structure. The atmospheres on eccentric planets are typically three to four orders of magnitude less massive than those of planets with circular orbits. Overall, however, a supersonic environment is favorable for planets to keep an early stable atmosphere, rather than harmful, due to the steady gas supply through the recycling flow. We also quantitatively explore how such atmospheres are affected by the planet's relative velocity to the gas, the planet mass, and the background gas density. Our time-dependent simulations track the orbital evolution of the proto-atmosphere with the planet–disk parameters changing throughout the orbit. Atmospheric properties show oscillatory patterns as the planet travels on an eccentric orbit, with a lag in phase. To sum up, low-mass eccentric planets can retain small proto-atmospheres despite the stripping effects of bow shocks. The atmospheres are always connected to and interacting with the disk gas. These findings provide important insights into the impacts of migration and scattering on planetary proto-atmospheres.

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Implementation of stellar heating feedback in simulations of star cluster formation: effects on the initial mass function

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Explaining the initial mass function (IMF) of stars is a long-standing problem in astrophysics. The number of complex mechanisms involved in the process of star cluster formation, such as turbulence, magnetic fields and stellar feedback, make understanding and modeling the IMF a challenging task. In this paper, we aim to assert the importance of stellar heating feedback in the star cluster formation process and its effect on the shape of the IMF. We use an analytical subgrid model to implement the radiative feedback in fully three-dimensional magnetohydrodynamical (MHD) simulations of star cluster formation, with the ultimate objective of obtaining numerical convergence on the IMF. We compare a set of MHD adaptive-mesh-refinement (AMR) simulations with three different implementations of the heating of the gas: 1) a polytropic equation of state (EOS), 2) a spherically symmetric stellar heating feedback, and 3) our newly developed polar heating model that takes into account the geometry of the accretion disc and the resulting shielding of stellar radiation by dust. For each of the three heating models, we analyse the distribution of stellar masses formed in ten molecular cloud simulations with different realizations of the turbulence to obtain a statistically representative IMF. We conclude that stellar heating feedback has a profound influence on the number of stars formed and plays a crucial role in controlling the IMF. We find that the simulations with the polar heating model achieve the best convergence on the observed IMF.

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Ejection of close-in super-Earths around low-mass stars in the giant impact stage

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Earth-sized planets were observed in close-in orbits around M dwarfs. While more and more planets are expected to be uncovered around M dwarfs, theories of their formation and dynamical evolution are still in their infancy. We investigate the giant impact growth of protoplanets, which includes strong scattering around low-mass stars. The aim is to clarify whether strong scattering around low-mass stars affects the orbital and mass distributions of the planets. We perform *N*-body simulation of protoplanets by systematically surveying the parameter space of the stellar mass and surface density of protoplanets. We find that protoplanets are often ejected after twice or three times close-scattering around late M dwarfs. The ejection sets the upper limit of the largest planet mass. Adopting the surface density scaling linearly with the stellar mass, we find that as the stellar mass decreases less massive planets are formed in orbits with higher eccentricities and inclinations. Under this scaling, we also find that a few close-in protoplanets are generally ejected. The ejection of protoplanets plays an important role in the mass distribution of super-Earths around late M dwarfs. The mass relation of observed close-in super-Earths and their central star mass is well reproduced by ejection.

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MHD accretion-ejection: jets launched by a non-isotropic accretion disk dynamo. I. Validation and application of selected dynamo tensorial components

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Astrophysical jets are launched from strongly magnetized systems that host an accretion disk surrounding a central object. The origin of the jet launching magnetic field is one of the open questions for modeling the accretion-ejection process. Here we address the question how to generate the accretion disk magnetization and field structure required for jet launching. Applying the PLUTO code, we present the first resistive MHD simulations of jet launching including a non-scalar accretion disk mean-field $\alpha^2\Omega$-dynamo in the context of large scale disk-jet simulations. Essentially, we find the α_ϕ-dynamo component determining the amplification of the poloidal magnetic field, which is strictly related to the disk magnetization (and, as a consequence, to the jet speed, mass and collimation), while the α_R and α_θ-dynamo components trigger the formation of multiple, anti-aligned magnetic loops in the disk, with strong consequences on the stability and dynamics of the disk-jet system. In particular, such loops trigger the formation of dynamo inefficient zones, which are characterized by a weak magnetic field, and therefore a lower value of the magnetic diffusivity. The jet mass, speed and collimation are strongly affected by the formation of the dynamo inefficient zones. Moreover, the θ-component of the α-dynamo plays a key role when interacting with a non-radial component of the seed magnetic field. We also present correlations between the strength of the disk toy dynamo coefficients and the dynamical parameters of the jet that is launched.

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MHD accretion-ejection: jets launched by a non-isotropic accretion disk dynamo. II. A dynamo tensor defined by the disk Coriolis number

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Astrophysical jets are launched from strongly magnetized systems that host an accretion disk surrounding a central object. Here we address the question how to generate the accretion disk magnetization and field structure required for jet launching. We continue our work from Paper I (Mattia & Fendt 2020a) considering a non-scalar accretion disk mean-field $\alpha^2\Omega$-dynamo in the context of large scale disk-jet simulations. We now investigate a disk dynamo that follows analytical solutions of mean-field dynamo theory, essentially based only on a single parameter, the Coriolis number. We thereby confirm the anisotropy of the dynamo tensor acting in accretion disks, allowing to relate both the resistivity and mean-field dynamo to the disk turbulence. Our new model recovers previous simulations applying a purely radial initial field, while allowing for a more stable evolution for seed fields with a vertical component. We also present correlations between the strength of the disk dynamo coefficients and the dynamical parameters of the jet that is launched, and discuss their implication for observed jet quantities.

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The magnetic obliquity of accreting T Tauri stars

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Classical T Tauri stars (CTTS) accrete material from their discs through their magnetospheres. The geometry of the accretion flow strongly depends on the magnetic obliquity, i.e., the angle between the rotational and magnetic axes. We aim at deriving the distribution of magnetic obliquities in a sample of 10 CTTSs. For this, we monitored the radial velocity variations of the HeIλ5876Å line in these stars' spectra along their rotational cycle. He I is produced in the accretion shock, close to the magnetic pole. When the magnetic and rotational axes are not aligned, the radial velocity of this line is modulated by stellar rotation. The amplitude of modulation is related to the star's projected rotational velocity, $v \sin i$, and the latitude of the hotspot. By deriving $v \sin i$ and HeIλ5876 radial velocity curves from our spectra we thus obtain an estimate of the magnetic obliquities. We find an average obliquity in our sample of 11.4° with an rms dispersion of 5.4°. The magnetic axis thus seems nearly, but not exactly aligned with the rotational axis in these accreting T Tauri stars, somewhat in disagreement with studies of spectropolarimetry, which have found a significant misalignment ($> 20°$) for several CTTSs. This could simply be an effect of low number statistics, or it may be due to a selection bias of our sample. We discuss possible biases that our sample may be subject to. We also find tentative evidence that the magnetic obliquity may vary according to the stellar interior and that there may be a significant difference between fully convective and partly radiative stars.

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Massive Stars in Molecular Clouds Rich in High-energy Sources: The Bridge of G332.809−0.132 and CS 78 in NGC 6334

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Detections of massive stars in the direction of the H II region CS 78 in NGC 6334 and of G332.809−0.132 are here presented. The region covered by the G332.809−0.132 complex coincides with the RCW 103 stellar association. In its core (40′ in radius), approximately 110 OB candidate stars ($K_s < 10$ mag and $0.4 < A_{K_s} < 1.6$ mag) were identified using 2MASS, DENIS, and GLIMPSE data. This number of OB stars accounts for more than 50% of the observed number of Lyman continuum photons from this region. Medium-resolution K-band spectra were obtained for seven

early types, including one WN 8 star and one Ofpe/WN 9 star; the latter is located near the RCW 103 remnant and its luminosity is consistent with a distance of about 3 kpc. The area analyzed encloses 9 of the 34 OB stars previously known in RCW 103, as well as IRAS 16115−5044, which we reclassify as a candidate luminous blue variable. The line of sight is particularly interesting, crossing three spiral arms; a molecular cloud at −50 (with RCW 103 in the Scutum-Crux arm) and another at −90 km s^{-1} (in the Norma arm) are detected, both rich in massive stars and supernova remnants. We also report the detection of a B supergiant as the main ionizing source of CS 78, 2MASS J17213513−3532415. Medium-resolution H and K band spectra display H I and He I lines, as well as Fe II lines. By assuming a distance of 1.35 kpc, we estimate a bolometric magnitude of −6.16, which is typical of supergiants.

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Searching for debris discs in the 30 Myr open cluster IC 4665

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Context. Debris discs orbiting young stars are key to understand dust evolution and the planetary formation process. We take advantage of a recent membership analysis of the 30 Myr nearby open cluster IC 4665 based on the Gaia and DANCe surveys to revisit the disc population of this cluster.
Aims. We aim to study the disc population of IC 4665 using Spitzer (MIPS and IRAC) and WISE photometry.
Methods. We use several colour-colour diagrams with empirical photospheric sequences to detect the sources with an infrared excess. Independently, we also fit the spectral energy distribution (SED) of our debris disc candidates with the Virtual Observatory SED analyser (VOSA) which is capable of automatically detecting infrared excesses and provides effective temperature estimates.
Results. We find six candidates debris disc host-stars (five with MIPS and one with WISE) and two of them are new candidates. We estimate a disc fraction of 24±10% for the B–A stars, where our sample is expected to be complete. This is similar to what has been reported in other clusters of similar ages (Upper Centaurus Lupus, Lower Centaurus Crux, the β Pictoris moving group, and the Pleiades). For solar type stars we find a disk fraction of 9±9%, lower than that observed in regions with comparable ages.
Conclusions. Our candidates debris disc host-stars are excellent targets to be studied with ALMA or the future James Webb Space Telescope (JWST).

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Dynamical traceback age of the β Pictoris moving group

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Context. The β Pictoris moving group is one of the most well-known young associations in the solar neighbourhood and several members are known to host circumstellar discs, planets, and comets. Measuring its age with precision is basic to study several astrophysical processes such as planet formation and disc evolution which are strongly age dependent.
Aims. We aim to determine a precise and accurate dynamical traceback age for the β Pictoris moving group.
Methods. Our sample combines the extremely precise Gaia DR2 astrometry with ground-based radial velocities measured in an homogeneous manner. We use an updated version of our algorithm to determine dynamical ages. The new approach takes into account a robust estimate of the spatial and kinematic covariance matrices of the association

to improve the sample selection process and to perform the traceback analysis.
Results. We estimate a dynamical age of $18.5^{+2.0}_{-2.4}$ Myr for the β Pictoris moving group. We investigated the spatial substructure of the association at birth time and we propose the existence of a core of stars more concentrated. We also provide precise radial velocity measurements for 81 members of β Pic, including ten stars with the first determination of their radial velocities.
Conclusions. Our dynamical traceback age is three times more precise than previous traceback age estimates and, more important, for the first time, reconciles the traceback age with the most recent estimates of other dynamical, lithium depletion boundary, and isochronal ages. This has been possible thanks to the excellent astrometric and spectroscopic precisions, the homogeneity of our sample, and the detailed analysis of binaries and membership.

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An APEX survey of outflow and infall toward the youngest protostars in Orion

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We aim to characterize the outflow properties of a sample of early Class 0 phase low-mass protostars in Orion, which were first identified by the *Herschel* Space Observatory. We also look for signatures of infall in key molecular lines. Maps of CO J=3-2 and J=4-3 toward 16 very young Class 0 protostars were obtained using the Atacama Pathfinder EXperiment (APEX) telescope. We searched the data for line wings indicative of outflows and calculated masses, velocities, and dynamical times for the outflows. We used additional HCO^+, $H^{13}CO^+$, and NH_3 lines to look for infall signatures toward the protostars. We estimate the outflow masses, forces, and mass-loss rates based on the CO J=3-2 and J=4-3 line intensities for eight sources with detected outflows. We derive upper limits for the outflow masses and forces of sources without clear outflow detections. The total outflow masses for the sources with clear outflow detections are in the range between 0.03 and 0.16 $M_\odot$ for CO J=3-2 and between 0.02 and 0.10 $M_\odot$ for CO J=4-3. The outflow forces are in the range between 1.57×10^{-4} and 1.16×10^{-3} $M_\odot$ km s^{-1} yr^{-1} for CO J=3-2 and between 1.14×10^{-4} and 6.92×10^{-4} $M_\odot$ km s^{-1} yr^{-1} for CO J=4-3. Nine protostars in our sample show asymmetric line profiles indicative of infall in HCO^+, compared to $H^{13}CO^+$ or NH_3. The outflow forces of the protostars in our sample show no correlation with the bolometric luminosity, unlike those found by some earlier studies for other Class 0 protostars. The derived outflow forces for the sources with detected outflows are similar to those found for other, more evolved, Class 0 protostars, suggesting that outflows develop quickly in the Class 0 phase.

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Unified simulations of planetary formation and atmospheric evolution II: Rapid disk clearing by photoevaporation yields low-mass super-Earth atmospheres

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Super-Earths possess low-mass H_2/He atmospheres (typically less than 10% by mass). However, the origins of super-Earth atmospheres have not yet been ascertained. We investigate the role of rapid disk clearing by photoevaporation during the formation of super-Earths and their atmospheres. We perform unified simulations of super-Earth formation and atmospheric evolution in evolving disks that consider both photoevaporative winds and magnetically driven disk winds. For the growth mode of planetary cores, we consider two cases in which planetary embryos grow with and without pebble accretion. Our main findings are summarized as follows. (i) The time span of atmospheric accretion is shortened by rapid disk dissipation due to photoevaporation, which prevents super-Earth cores from accreting massive atmospheres. (ii) Even if planetary cores grow rapidly by embryo accretion in the case without pebble accretion, the onset of runaway gas accretion is delayed because the isolation mass for embryo accretion is small. Together with rapid disk clearing, the accretion of massive atmospheres can be avoided. (iii) After rapid disk clearing, a number of high-eccentricity embryos can remain in outer orbits. Thereafter, such embryos may collide with the super-Earths, leading to efficient impact erosion of accreted atmospheres. We, therefore, find that super-Earths with low-mass H_2/He atmospheres are naturally produced by *N*-body simulations that consider realistic disk evolution.

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Solving grain size inconsistency between ALMA polarization and VLA continuum in the Ophiuchus IRS 48 protoplanetary disk

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The protoplanetary disk around Ophiuchus IRS 48 shows an azimuthally asymmetric dust distribution in (sub-)millimeter observations, which is interpreted as a vortex, where millimeter/centimeter-sized particles are trapped at the location of the continuum peak. In this paper, we present 860 μm ALMA observations of polarized dust emission of this disk. The polarized emission was detected toward a part of the disk. The polarization vectors are parallel to the disk minor axis, and the polarization fraction was derived to be 1–2%. These characteristics are consistent with models of self-scattering of submillimeter-wave emission, which indicate a maximum grain size of $\sim$100 μm. However, this is inconsistent with the previous interpretation of millimeter/centimeter dust particles being trapped by a vortex. To explain both, ALMA polarization and previous ALMA and VLA observations, we suggest that the thermal emission at 860 μm wavelength is optically thick ($\tau_{\rm abs} \sim 7.3$) at the dust trap with the maximum observable grain size of $\sim$100 μm rather than an optically thin case with $\sim$cm dust grains. We note that we cannot rule out that larger dust grains are accumulated near the midplane if the 860 μm thermal emission is optically thick.

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The Origin of Massive Stars: The Inertial–Inflow Model

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We address the problem of the origin of massive stars, namely the origin, path and timescale of the mass flows that create them. Based on extensive numerical simulations, we propose a scenario where massive stars are assembled by large-scale, converging, inertial flows that naturally occur in supersonic turbulence. We refer to this scenario of massive-star formation as the *Inertial-Inflow Model*. This model stems directly from the idea that the mass distribution of stars is primarily the result of *turbulent fragmentation*. Under this hypothesis, the statistical properties of the turbulence determine the formation timescale and mass of prestellar cores, posing definite constraints on the formation mechanism of massive stars. We quantify such constraints by the analysis of a simulation of supernova-driven turbulence in a 250-pc region of the interstellar medium, describing the formation of hundreds of massive stars over a time of approximately 30 Myr. Due to the large size of our statistical sample, we can say with full confidence that *massive stars in general do not form from the collapse of massive cores, nor from competitive accretion*, as both models are incompatible with the numerical results. We also compute synthetic continuum observables in Herschel and ALMA bands. We find that, depending on the distance of the observed regions, estimates of core mass based on commonly-used methods may exceed the actual core masses by up to two orders of magnitude, and that there is essentially no correlation between estimated and real core masses.

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High-resolution spectroscopic monitoring observations of FU Orionis-type object, V960 Mon

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We present the results of high-resolution ($R \geq 30,000$) optical and near-infrared spectroscopic monitoring observations of a FU Orionis-type object, V960 Mon, which underwent an outburst in 2014 November. We have monitored this object with the Bohyunsan Optical Echelle Spectrograph (BOES) and the Immersion GRating INfrared Spectrograph (IGRINS) since 2014 December. Various features produced by a wind, disk, and outflow/jet were detected. The wind features varied over time and continually weakened after the outburst. We detected double-peaked line profiles in the optical and near-infrared, and the line widths tend to decrease with increasing wavelength, indicative of Keplerian disk rotation. The disk features in the optical and near-infrared spectra fit well with G-type and K-type stellar spectra convolved with a kernel to account for the maximum projected disk rotation velocity of about 40.3±3.8 km s^{-1} and 36.3±3.9 km s^{-1}, respectively. We also report the detection of [S II] and H_2 emission lines, which are jet/outflow tracers and rarely found in FUors.

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The accretion history of high-mass stars: An ArTéMiS pilot study of Infrared Dark Clouds

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The mass growth of protostars is a central element to the determination of fundamental stellar population properties such as the initial mass function. Constraining the accretion history of individual protostars is therefore an important aspect of star formation research. The goal of the study presented here is to determine whether high-mass (proto)stars gain their mass from a compact (< 0.1 pc) fixed-mass reservoir of gas, often referred to as dense cores, in which they are embedded, or whether the mass growth of high-mass stars is governed by the dynamical evolution of the parsec-scale clump that typically surrounds them. To achieve this goal, we performed a 350μm continuum mapping of 11 infrared dark clouds, along side some of their neighbouring clumps, with the ArTéMiS camera on APEX. By identifying about 200 compact ArTéMiS sources, and matching them with *Herschel* Hi-GAL 70μm sources, we have been able to produce mass vs. temperature diagrams. We compare the nature (i.e. starless or protostellar) and location of the ArTéMiS sources in these diagrams with modelled evolutionary tracks of both core-fed and clump-fed accretion scenarios. We argue that the latter provide a better agreement with the observed distribution of high-mass star-forming cores. However, a robust and definitive conclusion on the question of the accretion history of high-mass stars requires larger number statistics.

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A protostellar system fed by a streamer of 10,500 au length

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Binary formation is an important aspect of star formation. One possible route for close-in binary formation is disk fragmentation. Recent observations show small scale asymmetries (<300 au) around young protostars, although not always resolving the circumbinary disk, are linked to disk phenomena. In later stages, resolved circumbinary disk observations (<200 au) show similar asymmetries, suggesting the origin of the asymmetries arises from binary-disk interactions. We observed one of the youngest systems to study the connection between disk and dense core. We find for the first time a bright and clear streamer in chemically fresh material (Carbon-chain species) that originates from outside the dense core (>10,500 au). This material connects the outer dense core with the region where asymmetries arise near disk scales. This new structure type, 10× larger than those seen near disk scales, suggests a different interpretation of previous observations: large-scale accretion flows funnel material down to disk scales. These results reveal the under-appreciated importance of the local environment on the formation and evolution of disks in early systems and a possible initial condition for the formation of annular features in young disks.

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Carina High-contrast Imaging Project for massive Stars (CHIPS). I. Methodology and proof of concept on QZ Car (HD93206)

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Massive stars like company. However, low-mass companions have remained extremely difficult to detect at angular separations (ρ) smaller than 1" (1000-3000 au considering typical distance to nearby massive stars) given the large brightness contrast between the companion and the central star. Constraints on the low-mass end of the companions mass-function for massive stars are however needed, for example to help distinguishing between various scenarios for the formation of massive stars. To obtain statistically significant constraint on the presence of low-mass companions beyond the typical detection limit of current surveys (Δmag$\leq$5 at $\rho\leq$1"), we initiated a survey of O and Wolf-Rayet stars in the Carina region using the SPHERE coronagraphic instrument on the VLT. In this first paper, we aim to introduce the survey, to present the methodology and to demonstrate the capability of SPHERE for massive stars using the multiple system QZ Car. High-contrast imaging techniques, such as angular- and spectral-differential imaging techniques as well as PSF-fitting, were applied to detect and measure the relative flux of companions in each spectral channel of the instrument. We detected 19 sources around the QZ Car system with detection limits of 9 mag at ρ>200 mas for IFS and as faint as 13 mag at $\rho > 1".8$ for IRDIS (corresponding to sub-solar masses for potential companions). All but two are reported here for the first time. Based on this proof of concept, we showed that VLT/SPHERE allows us to reach the sub-solar mass regime of the companion mass function. This paves the way for this type of observation with a large sample of massive stars to provide novel constraints on the multiplicity of massive stars in a region of the parameter space that has remained inaccessible so far.

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Torques felt by solid accreting planets

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The solid material of protoplanetary discs forms an asymmetric pattern around a low-mass planet ($M_{\rm p} \leq 10\ M_{\rm Earth}$) due to the combined effect of dust-gas interaction and the gravitational attraction of the planet. Recently, it has been shown that although the total solid mass is negligible compared to that of gas in protoplanetary discs, a positive torque can be emerged by a certain size solid species. The torque magnitude can overcome that of gas which may result in outward planetary migration. In this study, we show that the accretion of solid species by the planet strengthens the magnitude of solid torque being either positive or negative. We run two-dimensional, high-resolution (1.5K $\times$ 3K) global hydrodynamic simulations of an embedded low-mass planet in a protoplanetary disc. The solid material is handled as a pressureless fluid. Strong accretion of well-coupled solid species by a $M_{\rm p} < 0.3\ M_{\rm Earth}$ protoplanet results in the formation of such a strongly asymmetric solid pattern close to the planet that the positive solid torque can overcome that of gas by two times. However, the accretion of solids in the pebble regime results in increased magnitude negative torque felt by protoplanets and strengthened positive torque for Earth-mass planets. For $M_{\rm p} \geq 3\ M_{\rm Earth}$ planets the magnitude of the solid torque is positive, however, independent of the accretion strength investigated. We conclude that the migration of solid accreting planets can be substantially departed from the canonical type-I prediction.

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Autonomous Gaussian decomposition of the Galactic Ring Survey. II. The Galactic distribution of ^{13}CO

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Knowledge about the distribution of CO emission in the Milky Way is essential to understanding the impact of the Galactic environment on the formation and evolution of structures in the interstellar medium. However, our current insight as to the fraction of CO in the spiral arm and interarm regions is still limited by large uncertainties in assumed rotation curve models or distance determination techniques. In this work we use the Bayesian approach from Reid et al. (2016, 2019), which is based on our most precise knowledge at present about the structure and kinematics of the Milky Way, to obtain the current best assessment of the Galactic distribution of ^{13}CO from the Galactic Ring Survey. We performed two different distance estimates that either included (Run A) or excluded (Run B) a model for Galactic features, such as spiral arms or spurs. We also included a prior for the solution of the kinematic distance ambiguity that was determined from a compilation of literature distances and an assumed size-linewidth relationship. Even though the two distance runs show strong differences due to the prior for Galactic features for Run A and larger uncertainties due to kinematic distances in Run B, the majority of their distance results are consistent with each other within the uncertainties. We find that the fraction of ^{13}CO emission associated with spiral arm features ranges from 76% to 84% between the two distance runs. The vertical distribution of the gas is concentrated around the Galactic midplane, showing full-width at half-maximum values of ~ 75 pc. We do not find any significant difference between gas emission properties associated with spiral arm and interarm features. In particular, the distribution of velocity dispersion values of gas emission in spurs and spiral arms is very similar. We detect a trend of higher velocity dispersion values with increasing heliocentric distance, which we, however, attribute to beam averaging effects caused by differences in spatial resolution. We argue that the true distribution of the gas emission is likely more similar to a combination of the two distance results discussed, and we highlight the importance of using complementary distance estimations to safeguard against the pitfalls of any single approach. We conclude that the methodology presented in this work is a promising way to determine distances to gas emission features in Galactic plane surveys.

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Recombination Lines and Molecular Gas from Hypercompact HII regions in W51 A

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We present a detailed characterization of the population of compact radio-continuum sources in W51 A using subarcsecond VLA and ALMA observations. We analyzed their 2-cm continuum, the recombination lines (RL's) H77α and H30α, and the lines of H_2CO ($3_{0,3}$–$2_{0,2}$), H_2CO ($3_{2,1}$–$2_{2,0}$), and SO (6_5–5_4). We derive diameters for 10/20 sources in the range $D \sim 10^{-3}$ to $\sim 10^{-2}$ pc, thus placing them in the regime of hypercompact HII regions (HC HII's). Their continuum-derived electron densities are in the range $n_e \sim 10^4$ to 10^5 cm^{-3}, lower than typically considered for HC HII's. We combined the RL measurements and independently derived n_e, finding the same range of values but significant offsets for individual measurements between the two methods. We found that most of the sources in our sample are ionized by early B-type stars, and a comparison of n_e vs D shows that they follow the inverse relation previously derived for ultracompact (UC) and compact HII's. When determined, the ionized-gas kinematics is always (7/7) indicative of outflow. Similarly, 5 and 3 out of the 8 HC HII's still embedded in a compact core show evidence for expansion and infall motions in the molecular gas, respectively. We hypothesize that there could be two different types of hypercompact ($D < 0.05$ pc) HII regions: those that essentially are smaller, expanding UC HII's; and those that are also hyperdense ($n_e > 10^6$ cm^{-3}), probably associated with O-type stars in a specific stage of their formation or early life.

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Prebiotic precursors of the primordial RNA world in space: Detection of NH_2OH

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One of the proposed scenarios for the origin of life is the *primordial RNA world*, which considers that RNA molecules were likely responsible for the storage of genetic information and the catalysis of biochemical reactions in primitive cells, before the advent of proteins and DNA. In the last decade, experiments in the field of prebiotic chemistry have shown that RNA nucleotides can be synthesized from relatively simple molecular precursors, most of which have been found in space. An important exception is hydroxylamine, NH_2OH, which, despite several observational attempts, it has not been detected in space yet. Here we present the first detection of NH_2OH in the interstellar medium towards the quiescent molecular cloud G+0.693-0.027 located in the Galactic Center. We have targeted the three groups of transitions from the J=2−1, 3−2, and 4−3 rotational lines, detecting 5 transitions that are unblended or only slightly blended. The derived molecular abundance of NH_2OH is $(2.1\pm0.9)\times10^{-10}$. From the comparison of the derived abundance of NH_2OH and chemically related species, with those predicted by chemical models and measured in laboratory experiments, we favor the formation of NH_2OH in the interstellar medium via hydrogenation of NO on dust grain surfaces, with possibly a contribution of ice mantle NH_3 oxidation processes. Further laboratory studies and quantum chemical calculations are needed to completely rule out the formation of NH_2OH in the gas phase.

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The Role of Outflows, Radiation Pressure, and Magnetic Fields in Massive Star Formation

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Stellar feedback in the form of radiation pressure and magnetically-driven collimated outflows may limit the maximum mass that a star can achieve and affect the star-formation efficiency of massive pre-stellar cores. Here we present a series of 3D adaptive mesh refinement radiation-magnetohydrodynamic simulations of the collapse of initially turbulent, massive pre-stellar cores. Our simulations include radiative feedback from both the direct stellar and dust-reprocessed radiation fields, and collimated outflow feedback from the accreting stars. We find that protostellar outflows punches holes in the dusty circumstellar gas along the star's polar directions, thereby increasing the size of optically thin regions through which radiation can escape. Precession of the outflows as the star's spin axis changes due to the turbulent accretion flow further broadens the outflow, and causes more material to be entrained. Additionally, the presence of magnetic fields in the entrained material leads to broader entrained outflows that escape the core. We compare the injected and entrained outflow properties and find that the entrained outflow mass is a factor of $\sim$3 larger than the injected mass and the momentum and energy contained in the entrained material are $\sim$25% and $\sim$5% of the injected momentum and energy, respectively. As a result, we find that, when one includes both outflows and radiation pressure, the former are a much more effective and important feedback mechanism, even for massive stars with significant radiative outputs.

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The one that got away: A unique eclipse in the young brown dwarf Roque 12

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We report the discovery of a deep, singular eclipse of the bona fide brown dwarf Roque 12, a substellar member of the Pleiades. The eclipse was 0.65 mag deep, lasted 1.3 h, and was observed with two telescopes simultaneously in October 2002. No further eclipse was recorded, despite continuous monitoring with Kepler/K2 over 70 d in 2015. There is tentative (2σ) evidence for radial velocity variations of 5 kms^{-1}, over timescales of three months. The best explanation for the eclipse is the presence of a companion on an eccentric orbit. The observations constrain the eccentricity to $e > 0.5$, the period to $P > 70\,d$, and the mass of the companion to $\sim 0.001 - 0.04\,M_{\odot}$. In principle it is also possible that the eclipse is caused by circum-sub-stellar material. Future data releases by Gaia and later LSST as well as improved radial velocity constraints may be able to unambiguously confirm the presence of the companion. This would turn the system into one of the very few known eclipsing binary brown dwarfs with known age.

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The importance of magnetic fields for the initial mass function of the first stars

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Magnetic fields play an important role for the formation of stars in both local and high-redshift galaxies. Recent studies of dynamo amplification in the first dark matter haloes suggest that significant magnetic fields were likely present during the formation of the first stars in the Universe at redshifts of 15 and above. In this work, we study how these magnetic fields potentially impact the initial mass function (IMF) of the first stars. We perform 200 high-resolution, three-dimensional (3D), magnetohydrodynamic (MHD) simulations of the collapse of primordial clouds with different initial turbulent magnetic field strengths as predicted from turbulent dynamo theory in the early Universe, forming more than 1100 first stars in total. We detect a strong statistical signature of suppressed fragmentation in the presence of strong magnetic fields, leading to a dramatic reduction in the number of first stars with masses low enough that they might be expected to survive to the present-day. Additionally, strong fields shift the transition point where stars go from being mostly single to mostly multiple to higher masses. However, irrespective of the field strength, individual simulations are highly chaotic, show different levels of fragmentation and clustering, and the outcome depends on the exact realization of the turbulence in the primordial clouds. While these are still idealized simulations that do not start from cosmological initial conditions, our work shows that magnetic fields play a key role for the primordial IMF, potentially even more so than for the present-day IMF.

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Dark dust and UVES search of single-cloud sightlines in the ISM

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The precise characteristics of clouds and the nature of dust in the diffuse interstellar medium can only be extracted by inspecting the rare cases of single-cloud sightlines. In our nomenclature such objects are identified by interstellar lines, such as K I, that show at a resolving power of $\lambda/\Delta\lambda \sim 75,000$ one dominating Doppler component that accounts for more than half of the observed column density. We searched for such sightlines using high-resolution spectroscopy towards reddened OB stars for which far-UV extinction curves are known. We compiled a sample of 186 spectra, 100 of which were obtained specifically for this project with UVES. In our sample we identified 65 single-cloud sightlines, about half of which were previously unknown. We used the CH/CH^+ line ratio of our targets to establish whether the sightlines are dominated by warm or cold clouds. We found that CN is detected in all cold ($CH/CH^+ > 1$) clouds, but is frequently absent in warm clouds. We inspected the WISE ($3 - 22\,\mu$m) observed emission morphology around our sightlines and excluded a circumstellar nature for the observed dust extinction. We found that most sightlines are dominated by cold clouds that are located far away from the heating source. For 132 stars, we derived the spectral type and the associated spectral type-luminosity distance. We also applied the interstellar Ca II distance scale, and compared these two distance estimates with GAIA parallaxes. These distance estimates scatter by $\sim 40\,\%$. By comparing spectral type-luminosity distances with those of GAIA, we detected a hidden dust component that amounts to a few mag of extinction for eight sightlines. This dark dust is populated by $\gtrsim 1\mu$m large grains and predominately appears in the field of the cold interstellar medium

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Effect of grain size distribution and size-dependent grain heating on molecular abundances in starless and pre-stellar cores

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We present a new gas-grain chemical model to constrain the effect of grain size distribution on molecular abundances in physical conditions corresponding to starless and pre-stellar cores. We simultaneously introduce grain-size dependence for desorption efficiency induced by cosmic rays (CRs) and for grain equilibrium temperatures. The latter were calculated with a radiative transfer code via custom dust models built for the present work. We explicitly tracked of ice abundances on a set of grain populations. We find that the size-dependent CR desorption efficiency affects ice abundances in a highly nontrivial way that depends on the molecule. Species that originate in the gas phase, such as CO, follow a simple pattern in which the ice abundance is highest on the smallest grains and these are the most abundant in the distribution. Some molecules, such as HCN, are instead concentrated on large grains throughout the time evolution; others, such as N_2, are initially concentrated on large grains, but at late times on small grains because of grain-size-dependent competition between desorption and hydrogenation. Most of the water ice is on small grains at high medium density ($n(H_2)$ higher than $10^6\,cm^{-3}$), where the water ice fraction, with respect to the total water ice reservoir, can be as low as $\sim 10^{-3}$ on large (upwards of 0.1 μm) grains. Allowing the grain equilibrium temperature to vary with grain size induces strong variations in relative ice abundances in low-density conditions in which the interstellar radiation field and in particular its ultraviolet component are not attenuated. Our study implies consequences not only for the initial formation of ices preceding the starless core stage, but also for the relative ice abundances on the grain populations going into the protostellar stage. In particular, if the smallest grains can lose their mantles owing to grain-grain collisions as the core is collapsing, the ice composition in the beginning of the protostellar stage could be very different than in the pre-collapse phase because the ice composition depends strongly on the grain size.

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CO-to-H_2 Conversion and Spectral Column Density in Molecular Clouds: The Variability of $X_{\rm CO}$ Factor

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Analyzing the Galactic plane CO survey with the Nobeyama 45-m telescope, we compared the spectral column density (SCD) of $N_{\rm H_2}$ calculated for ^{12}CO (J=1-0) line using the current conversion factor $X_{^{12}{\rm CO}}$ to that for ^{13}CO (J=1-0) line under LTE (local thermal equilibrium) assumption in M16 and W43 regions. Here, SCD is defined by $dN_{\rm H_2}/dv$ with $N_{\rm H_2}$ and v being the column density and radial velocity, respectively. It is found that the $X_{^{12}{\rm CO}}$ method significantly under-estimates the H_2 density in a cloud or region, where SCD exceeds a critical value ($\sim 3 \times 10^{21}$ [H_2 cm^{-2} (km s^{-1})$^{-1}$]), but over-estimates in lower SCD regions. We point out that the actual CO-to-H_2 conversion factor varies with the H_2 column density or with the CO-line intensity: It increases in the inner and opaque parts of molecular clouds, whereas it decreases in the low-density envelopes. However, in so far as the current $X_{^{12}CO}$ is used combined with the integrated ^{12}CO intensity averaged over an entire cloud, it yields a consistent value with that calculated using the ^{13}CO intensity by LTE. Based on the analysis, we propose a new CO-to-H_2 conversion relation, $N^*_{\rm H_2} = \int X^*_{\rm CO}(T_{\rm B}) T_{\rm B}\, dv$, where $X^*_{\rm CO}(T_{\rm B}) = (T_{\rm B}/T^*_{\rm B})^\beta X_{^{12}{\rm CO}}$ is the modified spectral conversion factor as a function of the brightness temperature, $T_{\rm B}$, of the ^{12}CO (J=1-0) line, and $\beta \sim 1-2$ and $T^*_{\rm B} = 12-16$ K are empirical constants obtained by fitting to the observed data. The formula corrects for the over/under estimation of the column density at low/high-CO line intensities, and is applicable to molecular clouds with $T_{\rm B} \geq 1$ K (^{12}CO (J=1-0) line rms noise in the data) from envelope to cores at sub-parsec scales (spatial resolution).

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Possible Time Correlation Between Jet Ejection and Mass Accretion for RW Aur A

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For the active T-Taur star RW Aur A we have performed long-term (∼10 yr) monitoring observations of (1) jet imaging in the [Fe II] 1.644 μm emission line using Gemini-NIFS and VLT-SINFONI; (2) optical high-resolution spectroscopy using CFHT-ESPaDOnS; and (3) V-band photometry using the CrAO 1.25-m telescope and AAVSO. The latter two observations confirm the correlation of time variabilities between (A) the Ca II 8542 Å and O I 7772 Å line profiles

associated with magnetospheric accretion, and (B) optical continuum fluxes. The jet images and their proper motions show that four knot ejections occurred at the star over the past ~15 years with an irregular interval of 2-6 years. The time scale and irregularity of these intervals are similar to those of the dimming events seen in the optical photometry data. Our observations show a possible link between remarkable ($\Delta V < -1$ mag.) photometric rises and jet knot ejections. Observations over another few years may confirm or reject this trend. If confirmed, this would imply that the location of the jet launching region is very close to the star ($r \leq 0.1$ au) as predicted by some jet launching models. Such a conclusion would be crucial for understanding disk evolution within a few au of the star, and therefore possible ongoing planet formation at these radii.

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The Excitation Conditions of CN in TW Hya

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We report observations of the cyanide anion, CN, in the disk around TW Hya covering the N=1–0, N=2–1 and N=3–2 transitions. Using line stacking techniques, 24 hyperfine transitions are detected out of the 30 within the observed frequency ranges. Exploiting the super-spectral resolution from the line stacking method reveals the splitting of hyperfine components previously unresolved by laboratory spectroscopy. All transitions display a similar emission morphology, characterized by an azimuthally symmetric ring, peaking at ≈45 au ($0\farcs75$), and a diffuse outer tail extending out to the disk edge at ≈200 au. Excitation analyses assuming local thermodynamic equilibrium (LTE) yield excitation temperatures in excess of the derived kinetic temperatures based on the local line widths for all fine structure groups, suggesting assumptions of LTE are invalid. Using the 0D radiative transfer code RADEX, we demonstrate that such non-LTE effects may be present when the local H_2 density drops to 10^7 cm^{-3} and below. Comparison with models of TW Hya find similar densities at elevated regions in the disk, typically $z/r \gtrsim 0.2$, consistent with model predictions where CN is formed via vibrationally excited H_2 in the disk atmospheric layers where UV irradiation is less attenuated.

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A wide survey for circumstellar disks in the Lupus complex

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Previous star formation studies have, out of necessity, often defined a population of young stars confined to the proximity of a molecular cloud. Gaia allows us to examine a wider, three-dimensional structure of nearby star forming regions, leading to a new understanding of their history. We present a wide-area survey covering 494 square degrees of the Lupus complex, a prototypical low-mass star forming region. Our survey includes all known molecular clouds in this region as well as parts of the Upper Scorpius (US) and Upper Centaurus Lupus (UCL) groups of the Sco-Cen complex. We combine Gaia DR2 proper motions and parallaxes as well as ALLWISE mid-infrared photometry to select young stellar objects (YSOs) with disks. The YSO ages are inferred from Gaia color-magnitude diagrams, and their evolutionary stages from the slope of the spectral energy distributions. We find 98 new disk-bearing sources. Our new sample includes objects with ages ranging from 1 to 15 Myr and masses ranging from 0.05 to 0.5 solar masses , and consists of 56 sources with thick disks and 42 sources with anemic disks. While the youngest members are concentrated in the clouds and at distances of 160 pc, there is a distributed population of slightly older stars that

overlap in proper motion, spatial distribution, distance, and age with the Lupus and UCL groups. The spatial and kinematic properties of the new disk-bearing YSOs indicate that Lupus and UCL are not distinct groups. Our new sample comprises some of the nearest disks to Earth at these ages, and thus provides an important target for follow-up studies of disks and accretion in very low mass stars, for example with ALMA and ESO-VLT X-Shooter.

Accepted by Astronomy and Astrophysics

http://arxiv.org/pdf/2007.14102

Giant planet formation models with a self-consistent treatment of the heavy elements

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We present a new numerical framework to model the formation and evolution of giant planets. The code is based on the further development of the stellar evolution toolkit Modules for Experiments in Stellar Astrophysics (MESA). The model includes the dissolution of the accreted planetesimals/pebbles, which are assumed to be made of water ice, in the planetary gaseous envelope, and the effect of envelope enrichment on the planetary growth and internal structure is computed self-consistently. We apply our simulations to Jupiter and investigate the impact of different heavy-element and gas accretion rates on its formation history. We show that the assumed runaway gas accretion rate significantly affect the planetary radius and luminosity. It is confirmed that heavy-element enrichment leads to shorter formation timescales due to more efficient gas accretion. We find that with heavy-element enrichment Jupiter's formation timescale is compatible with typical disks' lifetimes even when assuming a low heavy-element accretion rate (oligarchic regime). Finally, we provide an approximation for the heavy-element profile in the innermost part of the planet, providing a link between the internal structure and the planetary growth history.

Accepted by EPSC-DPS Joint Meeting

http://arxiv.org/pdf/2007.13577

Measurements of the Ca II infrared triplet emission lines of pre-main-sequence stars

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We investigated the chromospheric activity of 60 pre-main-sequence (PMS) stars in four molecular clouds and five moving groups. It is considered that strong chromospheric activity is driven by the dynamo processes generated by the stellar rotation. In contrast, several researchers have pointed out that the chromospheres of PMS stars are activated by mass accretion from their protoplanetary disks. In this study, the Ca II infrared triplet (IRT) emission lines were investigated utilizing medium- and high-resolution spectroscopy. The observations were conducted with Nayuta/MALLS and Subaru/HDS. Additionally, archive data obtained by Keck/HIRES, VLT/UVES, and VLT/X-Shooter was used. The small ratios of the equivalent widths indicate that Ca II IRT emission lines arise primarily in dense chromospheric regions. Seven PMS stars show broad emission lines. Among them, four PMS stars have more than one order of magnitude brighter emission line fluxes compared to the low-mass stars in young open clusters. The four PMS stars have a high mass accretion rate, which indicates that the broad and strong emission results from a large mass accretion. However, most PMS stars exhibit narrow emission lines. No significant correlation was found between the accretion rate and flux of the emission line. The ratios of the surface flux of the Ca II IRT lines to the stellar bolometric luminosity, $R'_{\rm IRT}$, of the PMS stars with narrow emission lines are as large as the largest $R'_{\rm IRT}$ of the low-mass stars in the young open clusters. This result indicates that most PMS stars, even in the classical T Tauri star stage, have chromospheric activity similar to zero-age main-sequence stars.

Accepted by PASJ

http://arxiv.org/pdf/2007.09315

Cloud-cloud collision as drivers of the chemical complexity in Galactic Centre molecular clouds

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G+0.693-0.03 is a quiescent molecular cloud located within the Sagittarius B2 (Sgr B2) star-forming complex. Recent spectral surveys have shown that it represents one of the most prolific repositories of complex organic species in the Galaxy. The origin of such chemical complexity, along with the small-scale physical structure and properties of G+0.693-0.03, remains a mystery. In this paper, we report the study of multiple molecules with interferometric observations in combination with single-dish data in G+0.693-0.03. Despite the lack of detection of continuum source, we find small-scale (0.2 pc) structures within this cloud. The analysis of the molecular emission of typical shock tracers such as SiO, HNCO, and CH_3OH unveiled two molecular components, peaking at velocities of 57 and 75 km s^{-1}. They are found to be interconnected in both space and velocity. The position-velocity diagrams show features that match with the observational signatures of a cloud-cloud collision. Additionally, we detect three series of class I methanol masers known to appear in shocked gas, supporting the cloud-cloud collision scenario. From the maser emission we provide constraints on the gas kinetic temperatures (∼30-150 K) and H_2 densities (10^4-10^5 cm^{-2}). These properties are similar to those found for the starburst galaxy NGC253 also using class I methanol masers, suggested to be associated with a cloud-cloud collision. We conclude that shocks driven by the possible cloud-cloud collision is likely the most important mechanism responsible for the high level of chemical complexity observed in G+0.693-0.03.

Accepted by MNRAS

http://arxiv.org/pdf/2007.14362

Fragmentation of star-forming filaments in the X-shape Nebula of the California molecular cloud

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Context. Dense molecular filaments are central to the star formation process, but the detailed manner in which they fragment into prestellar cores is not yet well understood.
Aims. Here, we investigate the fragmentation properties and dynamical state of several star-forming filaments in the X-shape Nebula region of the California molecular cloud, in an effort to shed some light on this issue.
Methods. We used multi-wavelength far-infrared images from *Herschel* and the *getsources* and *getfilaments* extraction methods to identify dense cores and filaments in the region and derive their basic properties. We also used a map of $^{13}CO(2-1)$ emission from the Arizona 10m Submillimeter Telescope (SMT) to constrain the dynamical state of the

filaments.
Results. We identified 10 filaments with aspect ratios $AR > 4$ and column density contrasts $C > 0.5$, as well as 57 dense cores, including 2 protostellar cores, 20 robust prestellar cores, 11 candidate prestellar cores, and 24 unbound starless cores. All 10 filaments have roughly the same deconvolved FWHM width, with a median value 0.12 ± 0.03 pc, independently of their column densities ranging from $< 10^{21}\,\mathrm{cm}^{-2}$ to $> 10^{22}\,\mathrm{cm}^{-2}$. Two star-forming filaments (# 8 and # 10) stand out in that they harbor quasi-periodic chains of dense cores with a typical projected core spacing of ∼0.15 pc. These two filaments have thermally supercritical line masses and are not static. Filament 8 exhibits a prominent transverse velocity gradient, suggesting that it is accreting gas from the parent cloud gas reservoir at an estimated rate of $\sim 40 \pm 10\ M_\odot$ Myr^{-1} pc^{-1}. Filament 10 includes two embedded protostars with outflows and is likely at a somewhat later evolutionary stage than filament 8. In both cases, the observed (projected) core spacing is similar to the filament width and significantly shorter than the canonical separation of ~ 4 times the filament width predicted by classical cylinder fragmentation theory. Projection effects are unlikely to explain this discrepancy. We suggest that continuous accretion of gas onto the two star-forming filaments, as well as geometrical bending of the filaments, may account for the observed core spacing.
Conclusions. Our findings suggest that the characteristic fragmentation lengthscale of molecular filaments is quite sensitive to external perturbations from the parent cloud, such as gravitational accretion of ambient material.

Accepted by Astronomy & Astrophysics

https://arxiv.org/pdf/2002.05984

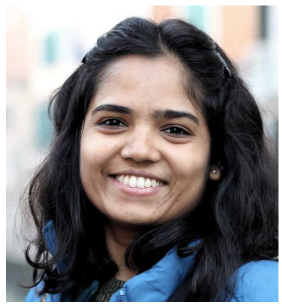
Abstract submission deadline

The deadline for submitting abstracts and other submissions is the first day of the month. Abstracts submitted after the deadline will appear in the following month's issue.

Dissertation Abstracts

Numerical simulations of star and disc formation

Asmita Bhandare



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Ph.D dissertation directed by: Prof. Dr. Thomas Henning

Ph.D degree awarded: June 2020

Magnetized, cold, dense molecular cloud cores provide the birth environment for stars, discs, and planets. The multi-scale scenario of low-mass star formation occurs via the formation of two quasi-hydrostatic cores. Furthermore, the conservation of angular momentum can lead to the formation of a disc around the second core (i.e. the forming protostar). During these early stages of star formation, magnetically driven outflows and jets can be launched from the first and second cores, respectively. Star, disc, and outflow formation involve complex physical processes, which require a robust, self-consistent numerical treatment.

In this thesis, we use numerical simulations to probe the gravitational collapse scenario that involves the transition of an isolated molecular cloud core to a hydrostatic core with a surrounding disc. We use the *PLUTO* code to perform radiation (magneto-)hydrodynamic (MHD) collapse simulations, using one- and two-dimensional (2D) grids. We include the effects of self-gravity and a grey flux-limited diffusion approximation for the radiative transfer. Additionally, we use for the gas equation of state density- and temperature-dependent thermodynamic quantities to account for the dissociation, ionisation, and molecular vibrations and rotations.

Our spherically symmetric simulations span seven orders of magnitude in spatial scale. We survey a wide range of initial low- to high-mass ($0.5 - 100\ M_\odot$) molecular cloud cores, yielding the largest parameter scan so far. Our results highlight the dependence of the first and second hydrostatic core properties on the initial cloud core properties. These simulations indicate that in the high-mass regime, the first hydrostatic cores do not have enough time to form due to large accretion rates.

We further expand our studies to three different sets of 2D simulations using axial and midplane symmetry. First, we perform 2D simulations for non-rotating molecular cloud cores with masses of 1 $M_\odot$, 5 $M_\odot$, 10 $M_\odot$, and 20 $M_\odot$.

For each of these cases, we use an unprecedented resolution to model the evolution of the second core for ≥ 100 years after its formation. For the first time, we demonstrate that convection is generated in the outer layers of the second core. This supports the intriguing possibility that dynamo-driven magnetic fields may be generated during the earliest phases of star formation. Following which, for the 1 $M_\odot$ case, we analyse the effects of solid-body rotation on the properties of the hydrostatic cores and disc formation. In this model, the first hydrostatic core evolves into a more oblate, pseudo-disc like structure and a sub-au disc starts forming after the formation of the second core. Finally, we explore the effects of ideal and non-ideal (including Ohmic resistivity) MHD during the collapse of rotating molecular cloud cores. We investigate the dependence of molecular outflows and disc formation on the initial cloud core mass, rotation, resistivity, and magnetic field strength. We find the presence of magnetically driven outflows launched from both first and second cores in the resistive models. We also reveal ongoing disc formation in some of our resistive simulations.

In conclusion, we use detailed thermodynamical modelling to quantify the properties of the hydrostatic cores, outflows, and discs for collapse scenarios with a wide range of initial cloud core properties. The models presented herein will serve as the foundation for follow-up studies that link these theoretical insights with observational signatures.

http://www.ub.uni-heidelberg.de/archiv/28554

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The Origin of Complex Organic Molecules in Star Forming Regions

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Ph.D dissertation directed by: Jes K. Jørgensen

Ph.D degree awarded: June 2020

Complex organic molecules (COMs, i.e. molecules with six or more atoms with at least one carbon) are present in the gas around young stars in the earliest stages of their evolution. Similar molecules are also found in meteorites and comets in our Solar System. Their formation may be closely related to the physical processes that led to the formation of the Solar System. Thus, it is important to study the chemistry of COMs around young protostars to understand how these molecules are formed, how they can form prebiotic molecules, such as amino acids, and investigate whether they potentially could be important for the origin of life elsewhere. In this thesis, the inventory of oxygen-bearing COMs towards a young protostellar binary is studied and their chemical formation and evolution discussed.

The low-mass Class 0 protostellar binary IRAS 16293–2422, located in the ρ Ophiuchus molecular cloud, has been observed with the Atacama Large Millimeter/submillimeter Array (ALMA) as part of the "Protostellar Interferometric Line Survey (PILS)". This well-studied source is characterised by its great molecular richness and their high abundance, especially in the innermost region of the envelope of each protostar, the so-called "hot corinos". The abundances of the oxygen-bearing COM were derived from their spectral features towards both components of the binary system.

The comparison between the molecular abundances found towards two binary components and the spatial extent of the emission from different molecules suggests that the hot corino region has a layered structure in terms of its molecular composition. This layer-structure seems to be correlated with the desorption temperatures of the different species, i.e. that the molecules having a higher desorption temperature are located in the inner layers of the hot corino (closer to the central protostar), compared to molecules with lower desorption temperatures.

The PILS observations allowed for several new detections of molecules in the interstellar medium, some of which are reported in this thesis. These include CHD_2OCHO, a variant of methyl formate (CH_3OCHO) where two hydrogen atoms are substituted by deuterium. The D/H ratio measured for CHD_2OCHO is systematically higher than those estimated for the singly-deuterated isotopologues of methyl formate, CH_2DOCHO and CH_3OCDO, suggesting that the deuteration enhancement is inherited from their precursor species.

The detection of molecules containing three carbon atoms, C_3-species, towards IRAS 16293B, such as propenal (C_2H_3CHO), propanal (C_2H_5CHO), methyl acetylene (CH_3CCH), propene (C_3H_6), and trans-ethyl methyl ether (t-$C_2H_5OCH_3$), made the study of their formation possible. We compared the observed abundances of these C_3-species to those predicted by a three-phase chemical model, NAUTILUS, coupled to a 1D hydrodynamical model of an infalling protostellar envelope. The simulations could reproduce all the abundances of the observed C_3-species, as well as those of other COMs, within one order of magnitude. Comparisons between simulations suggest that radical-radical additions and successive hydrogenation contribute equally to the formation of C_2H_3CHO and C_2H_5CHO. Also, a systematic over-production of molecules of the form C_3H_x suggests that the chemical networks lack consumption channels for those species, which could be related to the chemistry of polycyclic aromatic hydrocarbons (PAHs).

The detailed velocity structure and distribution of ^{13}CO emission in the Galactic plane

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Ph.D dissertation directed by: Jouni Kainulainen

Ph.D degree awarded: July 2020

Studying the detailed velocity structure of molecular gas in our Galaxy is of fundamental importance for understanding structure formation in the interstellar medium. Knowledge about the detailed gas kinematics is moreover essential to map the distribution and dynamics of the molecular gas in the Milky Way.

In this thesis I use the method of spectral decomposition to analyse the ^{13}CO (1–0) observations of the Galactic Ring Survey (GRS). I developed the GaussPy+ package, specifically designed for the fully automated decomposition of large Galactic plane surveys, to fit the ~ 2.3 million spectra of this large emission line data set. After extensive validation of the algorithm using synthetic spectra and a GRS test field, I use GaussPy+ to fit the entire data set of the GRS, resulting in ~ 4.6 million Gaussian fit components.

These decomposition results provide a new way to analyse the dynamics of the molecular gas over a wide extent of the Galactic plane and study how its velocity structure looks like and varies at Galactic to sub-cloud scales. I find that the velocity dispersion of the gas is increased in the midplane and towards the inner Galaxy, and establish that the integrated emission of the velocity components correlates well with the complexity of the gas emission and the amount of dust emission along the line of sight. Moreover, I uncover qualitatively similar fluctuations in the centroid velocities of the gas components throughout the entire GRS data set, and demonstrate how the fitted linewidths enable the separation of blended gas emission features that originate from nearby regions and far distances.

Finally, I use a Bayesian approach to obtain the current best assessment of the Galactic distribution of ^{13}CO. As prior information, I use the presently most precise knowledge about the structure and kinematics of the Milky Way and an extensive compilation of distances from literature. I perform two different distance calculations that either include or exclude a prior for a model of Galactic features, which allows me to characterise possible biases of the distance estimates and establish more reliable limits on the ^{13}CO distribution. I establish that the majority (76% to 84%) of the ^{13}CO emission is associated with spiral arm features. However, I do not find significant differences between the gas emission properties associated with spiral arm and interarm features.

I conclude that the decomposition results provide a wealth of data enabling new and unexplored ways to interpret the detailed gas velocity structure of large Galactic plane surveys. The methodology and results presented in this thesis allowed for a homogeneous study of the dynamics and distribution of the molecular gas over a large fraction of the Galactic disk. As demonstrated in this work, the information extracted from the detailed gas kinematics and its combination with complementary tracers of the interstellar medium has enormous potential to further our knowledge about the physical processes and mechanisms shaping the interstellar medium.

https://archiv.ub.uni-heidelberg.de/volltextserver/28635/1/Riener_PhD_thesis.pdf

New Jobs

51 Pegasi b Fellowship

The 51 Pegasi b Fellowship Program sponsored by the Heising-Simons Foundation provides an opportunity for promising recent doctoral scientists to conduct novel theoretical, experimental, or observational research in planetary astronomy. The fellowship program supports postdoctoral fellows to advance our fundamental understanding of planet formation and evolution, solar system science, planetary atmospheres, protoplanetary disks, exoplanet science, or other closely related topics. The fellowship program recognizes early-career investigators of significant potential and provides them with the opportunity to conduct independent research at a selected host institution.

The Foundation anticipates awarding six to eight fellowships this year. The Heising-Simons Foundation is committed to diversity, equity, and inclusion within its community. Thus, we particularly welcome applications from individuals who belong to groups that have been historically underrepresented in planetary sciences and astronomy such as women, persons with disabilities, racial and ethnic minorities, gender and sexual minorities, and others who may contribute to diversification of the field.

Awarded postdoctoral fellows are expected to carry out a strong, coherent research program. Each recipient will receive a three-year grant of up to 375,000 dollars to cover salary, benefits, highly-flexible discretionary spending (e.g., travel, child care, personal computers, etc.), and indirect costs.

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California Institute of Technology; University of California, Berkeley; Cornell University; University of California, Los Angeles; Harvard University / Harvard-Smithsonian; University of California, Santa Cruz; Massachusetts Institute of Technology; University of Chicago; Pennsylvania State University; University of Michigan; Princeton University; University of Texas, Austin; University of Arizona; Yale University;

Application Deadline: Friday, October 2, 2020

Apply Here: http://www.51pegasib.org

Meetings

Threats from the surroundings:

An e-workshop on the importance of environment for the evolution of protoplanetary discs and formation of planets

On-line on November 10-12 2020

Website: https://www.eso.org/sci/meetings/2020/tfts2020.html
Conference email: tfts2020@eso.org

Short Scientific Rationale:
Growing evidence indicates that protoplanetary discs (and by extension, forming planets) are significantly affected by the environment in which they form. In particular, the presence of massive stars and the dynamical history of clusters and associations impacts the evolution of discs and can lead to photoevaporation, truncation, and chemical enrichment. We therefore need to move beyond the picture of planet-forming discs as isolated systems. This e-workshop aims to bring together the community to share our current understanding of the different ways that the environment shapes disc evolution and planet formation, to shape the future direction of research in this regard through new ideas and collaborations.

Invited speakers: Reiter, Megan (UK Astronomy Technology Centre) Akeson, Rachel (IPAC Caltech) Ndugu, Nelson (Mbarara University Of Science And Technology) Winter, Andrew (MPIA Heidelberg) Kim, J. Serena (University of Arizona) Coleman, Gavin (Queen Mary University of London) Lugaro, Maria (Konkoly Observatory) Guzmn, Viviana (Pontificia Universidad Catolica de Chile) Vazan, Allona (Hebrew University of Jerusalem/Open University of Israel)

Invited discussion leaders: Rosotti, Giovanni (Leiden University) Pfalzner, Susanne (Max Planck fr Radioastronomie, Bonn) Facchini, Stefano (ESO Garching) Mordasini, Christoph (University of Bern) Drazkowska, Joanna (USM Munich) Clarke, Cathie (IoA Cambridge)

SOC: Manara, Carlo F. (ESO) Petr-Gotzens, Monika (ESO) Ansdell, Megan (NASA) Haworth, Thomas (Queen Mary University of London) Lichtenberg, Tim (Oxford University)

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The meeting will be fully online (see https://www.eso.org/sci/meetings/2020/tfts2020/online.html). In order to facilitate the discussion, the number of talking participants will be limited to about 60 persons, selected by the SOC based on scientific relevance to the topic, considering all career stages and reflecting diversity.
All other participants will be able to observe and ask questions via chat.

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Important Deadlines
Abstract submission: September 15, 2020
Programme release: October 13, 2020

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Summary of Upcoming Meetings

Check the websites of these meetings for the latest information on how they are affected by Covid-19

Star Formation in Different Environments 2020
24 - 28 August 2020, Quy Nhon, Vietnam
http://icisequynhon.com/conferences/sfde/

IMPRS Summer School: Planet Formation in Protoplanetary Disks
31 Aug - 4 Sept 2020, Heidelberg, Germany
https://www.imprs-hd.mpg.de/Summer-School

Planetary Science: The Young Solar System
6 - 12 September 2020, Quy Nhon, Vietnam
http://www.icisequynhon.com/conferences/planetary_science/

Conditions and Impact of Star Formation - Across Times and Scales
28 September - 2 October 2020, Chile
https://astro.uni-koeln.de/symposium-star-formation-2020.html

From Clouds to Planets II: The Astrochemical Link
28 September - 2 October 2020, Berlin, Germany
https://events.mpe.mpg.de/event/12/

Threats from the Surroundings – VIRTUAL MEETING
10 - 12 November 2020
http://www.eso.org/sci/meetings/2020/tfts2020.html

Five Years after HL Tau: A New Era in Planet Formation – VIRTUAL MEETING
7 - 11 December 2020
https://www.eso.org/sci/meetings/2020/hltau2020.html

Protostars & Planets VII
1 - 7 April 2021, Kyoto, Japan
http://www.ppvii.org

Gordon Conference on Origins of Solar Systems
19 - 25 June 2021, MA, USA
https://www.grc.org/origins-of-solar-systems-conference/2021

Cool Stars, Stellar Systems, and the Sun 21
Summer 2021, Toulouse, France
https://coolstars21.github.io/

Star Formation: From Clouds to Discs - A Tribute to the Career of Lee Hartmann
16 - 19 August 2021, Malahide, Ireland
https://www.dias.ie/cloudstodiscs/

Chemical Processes in Solar-type Star Forming Regions
13 - 17 September 2021, Torino, Italy
https://sites.google.com/inaf.it/aco-conference

Wheel of Star Formation: A conference dedicated to Prof. Jan Palouš
20 - 24 September 2020, Prague, Czech Republic
https://janfest2020.asu.cas.cz

The Physics of Star Formation: From Stellar Cores to Galactic Scales
∼June - July 2022, Lyon, France
http:/staratlyon.univ-lyon1.fr/en