THE STAR FORMATION NEWSLETTER

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

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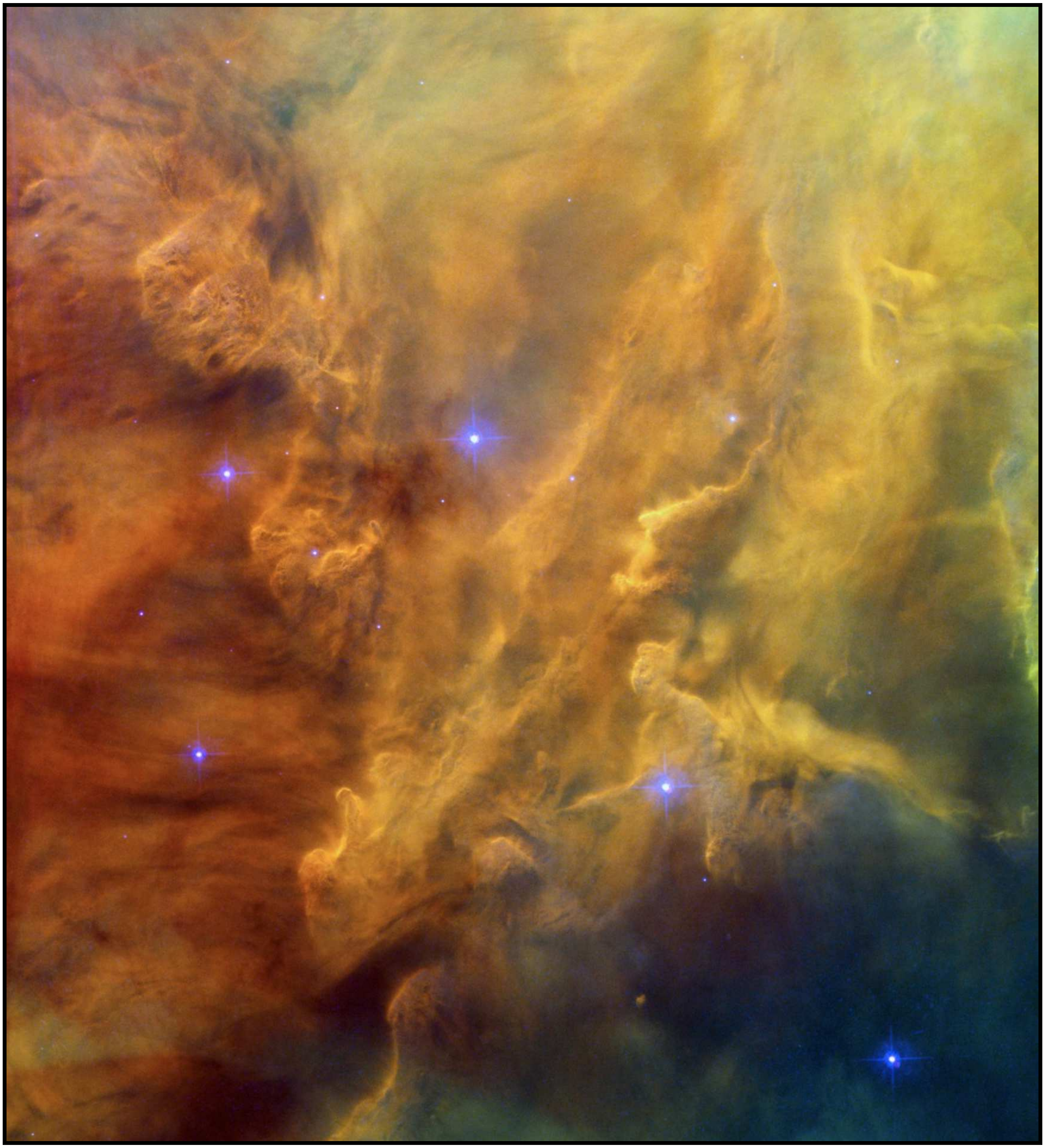

The Star Formation Newsletter

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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An excerpt from an HST image of Messier 8. 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

Abstracts of recently accepted papers

The role of molecular filaments in the origin of the prestellar core mass function and stellar initial mass function

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Context: The origin of the stellar initial mass function (IMF) is one of the most debated issues in astrophysics.
Aims: Here, we explore the possible link between the quasi-universal filamentary structure of star-forming molecular clouds and the origin of the IMF.
Methods: Based on our recent comprehensive study of filament properties from *Herschel* Gould Belt survey observations (Arzoumanian et al.), we derive, for the first time, a good estimate of the filament mass function (FMF) and filament line mass function (FLMF) in nearby molecular clouds. We use the observed FLMF to propose a simple toy model for the origin of the prestellar core mass function (CMF), relying on gravitational fragmentation of thermally supercritical but virialized filaments.
Results: We find that the FMF and the FLMF have very similar shapes and are both consistent with a Salpeter-like power-law function ($\mathrm{d}N/\mathrm{dlog}M_{\mathrm{line}} \propto M_{\mathrm{line}}^{-1.5\pm0.1}$) in the regime of thermally supercritical filaments ($M_{\mathrm{line}} > 16\,M_{\odot}/\mathrm{pc}$). This is a remarkable result since, in contrast, the mass distribution of molecular clouds and clumps is known to be significantly *shallower* than the Salpeter power-law IMF, with $\mathrm{d}N/\mathrm{dlog}M_{\mathrm{cl}} \propto M_{\mathrm{cl}}^{-0.7}$.
Conclusions: Since the vast majority of prestellar cores appear to form in thermally transcritical or supercritical filaments, we suggest that the prestellar CMF and by extension the stellar IMF are at least partly inherited from the FLMF through gravitational fragmentation of individual filaments.

Accepted by Astronomy and Astrophysics Letters

http://arxiv.org/pdf/1907.13448

The Transition from a Lognormal to a Power-law Column Density Distribution in Molecular Clouds: An Imprint of the Initial Magnetic Field and Turbulence

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We introduce a theory for the development of a transitional column density Σ_{TP} between the lognormal and the power-law forms of the probability distribution function (PDF) in a molecular cloud. Our turbulent magnetohydrodynamic simulations show that the value of Σ_{TP} increases as the strength of both the initial magnetic field and turbulence increases. We develop an analytic expression for Σ_{TP} based on the interplay of turbulence, a (strong) magnetic field, and gravity. The transition value Σ_{TP} scales with $\mathcal{M}_0^2$, the square of the initial sonic Mach number, and β_0, the initial ratio of gas pressure to magnetic pressure. We fit the variation of Σ_{TP} among different model clouds as a function of $\mathcal{M}_0^2\beta_0$, or equivalently the square of the initial Alfvénic Mach number $\mathcal{M}_{\mathrm{A0}}^2$. This implies that the transition value

$\Sigma_{\rm TP}$ is an imprint of cloud initial conditions and is set by turbulent compression of a magnetic cloud. Physically, the value of $\Sigma_{\rm TP}$ denotes the boundary above which the mass-to-flux ratio becomes supercritical and gravity drives the evolution.

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https://arxiv.org/pdf/1907.09783

The Concentration and Growth of Solids in Fragmenting Circumstellar Disks

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Due to the gas rich environments of early circumstellar disks, the gravitational collapse of cool, dense regions of the disk form fragments largely composed of gas. During formation, disk fragments may attain increased metallicities as they interact with the surrounding disk material, whether through particle migration to pressure maxima or through mutual gravitational interaction. In this paper, we investigate the ability of fragments to collect and retain a significant solid component through gas-particle interactions in high-resolution 3D self-gravitating shearing box simulations. The formation of axissymmetric perturbations associated with gravitational instabilities allows particles of intermediate sizes to concentrate through aerodynamic drag forces. By the onset of fragmentation, the mass of local particle concentrations within the fragment are comparable to that of the gas component and the sebsequent gravitational collapse results in the formation of a solid core. We find that these cores can be up to several tens of Earth masses, depending on grain size, before the fragment center reaches temperatures which would sublimate solids. The solid fraction and total mass of the fragment also depend on the metallicity of the young parent protoplanetary disk, with higher initial metallicities resulting in larger fragments and larger solid cores. Additionally, the extended atmospheres of these soon-to-be gas giants or brown dwarfs are occasionally enriched above the initial metallicity, provided no solid core forms in the center and are otherwise lacking in heavier elements when a core does form.

Accepted by ApJ

http://arxiv.org/pdf/1907.01290

OH maser emission in the THOR survey of the northern Milky Way

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Context: OH masers trace diverse physical processes, from the expanding envelopes around evolved stars to star-forming regions or supernovae remnants. Providing a survey of the ground-state OH maser transitions in the northern hemisphere inner Milky Way facilitates the study of a broad range of scientific topics.
Aims: We want to identify the ground-state OH masers at $\sim$18 cm wavelength in the area covered by "The HI/OH/Recombination line survey of the Milky Way (THOR)". We will present a catalogue of all OH maser features and their possible asso-

ciated environments.
Methods: The THOR survey covers longitude and latitude ranges of $14.3^\circ < l < 66.8^\circ$ and $b < \pm 1.25^\circ$. All OH ground state lines $^2\Pi_{3/2}$(J=3/2) at 1612 (F=1-2), 1665 (F=1-1), 1667 (F=2-2) and 1720 MHz (F=2-1) have been observed, employing the Very Large Array (VLA) in its C configuration. The spatial resolution of the data varies between 12.5″ and 19″, the spectral resolution is $1.5\,\mathrm{km\,s^{-1}}$, and the rms sensitivity of the data is $\sim$10 mJy beam^{-1} per channel.
Results: We identify 1585 individual maser spots (corresponding to single spectral features) distributed over 807 maser sites (regions of size $\sim 10^3 - 10^4$ AU). Based on different criteria from spectral profiles to literature comparison, we try to associate the maser sites with astrophysical source types. Approximately 51% of the sites exhibit the double-horned 1612 MHz spectra typically emitted from the expanding shells of evolved stars. The separations of the two main velocity features of the expanding shells typically vary between 22 and $38\,\mathrm{km\,s^{-1}}$. In addition to this, at least 20% of the maser sites are associated with star-forming regions. While the largest fraction of 1720 MHz maser spots (21 out of 53) is associated with supernova remnants, a significant fraction of the 1720 MHz maser spots (17) are also associated with star-forming regions. We present comparisons to the thermal ^{13}CO(1–0) emission as well as to other surveys of class II CH_3OH and H_2O maser emission. The catalogue attempts to present associations to astrophysical sources where available, and the full catalogue is available in electronic form.
Conclusions: This OH maser catalogue presents a unique resource of stellar and interstellar masers in the northern hemisphere. It provides the basis for a diverse range of follow-up studies from envelopes around evolved stars to star-forming regions and Supernova remnants.

Accepted by Astronomy and Astrophysics

http://www.mpia.de/homes/beuther/papers.html

First detections of H13CO+ and HC15N in the disk around HD 97048: Evidence for a cold gas reservoir in the outer disk

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Observations of different molecular lines in protoplanetary disks provide valuable information on the gas kinematics, as well as constraints on the radial density and temperature structure of the gas.With ALMA we have detected H13CO+ (J=4-3) and HC15N (J=4-3) in the HD 97048 protoplanetary disk for the first time.We compare these new detections to the ringed continuum mm-dust emission and the spatially resolved CO (J=3-2) and HCO+ (J=4-3) emission. The radial distributions of the H13CO+ and HC15N emission show hints of ringed sub-structure whereas, the optically thick tracers, CO and HCO+, do not. We calculate the HCO+/H13CO+ intensity ratio across the disk and find that it is radially constant (within our uncertainties). We use a physio-chemical parametric disk structure of the HD 97048 disk with an analytical prescription for the HCO+ abundance distribution to generate synthetic observations of the HCO+ and H13CO+ disk emission assuming LTE. The best by-eye fit models require radial variations in the HCO+/H13CO+ abundance ratio and an overall enhancement in H13CO+ relative to HCO+. This highlights the need to consider isotope selective chemistry and in particular low temperature carbon isotope exchange reactions. This also points to the presence of a reservoir of cold molecular gas in the outer disk (T <10 K, R > 200 au). Chemical models are required to confirm that isotope-selective chemistry alone can explain the observations presented here. With these data, we cannot rule out that the known dust substructure in the HD 97048 disk is responsible for the observed trends in molecular line emission, and higher spatial resolution observations are required to fully explore the potential of optically thin tracers to probe planet-carved dust gaps. We also report non-detections of H13CO+ and HC15N in the HD 100546 protoplanetary disk.

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Fragmentation, rotation, and outflows in the high-mass star-forming region IRAS 23033+5951. A case study of the IRAM NOEMA large program CORE

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The formation process of high-mass stars ($> 8\,M_{\odot}$) is poorly constrained, particularly the effects of clump fragmentation creating multiple systems and the mechanism of mass accretion onto the cores. We study the fragmentation of dense gas clumps, and trace the circumstellar rotation and outflows by analyzing observations of the high-mass ($\sim 500\,M_{\odot}$) star-forming region IRAS 23033+5951. Using the Northern Extended Millimeter Array (NOEMA) in three configurations and the IRAM 30m single-dish telescope at 220 GHz, we probe the gas and dust emission at an angular resolution of ∼0.45 arcsec, corresponding to 1900 au. In the millimeter (mm) continuum emission, we identify a protostellar cluster with at least four mm-sources, where three of them show a significantly higher peak intensity well above a signal-to-noise ratio of 100. Hierarchical fragmentation from large to small spatial scales is discussed. Two fragments are embedded in rotating structures and drive molecular outflows, traced by ^{13}CO (2–1) emission. The velocity profiles across two of the cores are similar to Keplerian but are missing the highest-velocity components close to the center of rotation, which is a common phenomena from observations like these, and other rotation scenarios are not excluded entirely. Position–velocity diagrams suggest protostellar masses of ~ 6 and $19\,M_{\odot}$. Rotational temperatures from fitting CH_3CN ($12_K - 11_K$) spectra are used for estimating the gas temperature and thereby also the disk stability against gravitational fragmentation, utilizing Toomre's Q parameter. Assuming that the candidate disk is in Keplerian rotation about the central stellar object and considering different disk inclination angles, we identify only one candidate disk as being unstable against gravitational instability caused by axisymmetric perturbations. The dominant sources cover different evolutionary stages within the same maternal gas clump. The appearance of rotation and outflows of the cores are similar to those found in low-mass star-forming regions.

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http://www.mpia.de/homes/beuther/bosco2019.pdf

High-Resolution Near Infrared Spectroscopy of HD 100546: IV. Orbiting Companion Disappears on Schedule

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HD 100546 is a Herbig Ae/Be star surrounded by a disk with a large central region that is cleared of gas and dust (i.e., an inner hole). High-resolution near-infrared spectroscopy reveals a rich emission spectrum of fundamental rovibrational CO emission lines whose time variable properties point to the presence of an orbiting companion within the hole. The Doppler shift and spectroastrometric signal of the CO v=1-0 P26 line, observed from 2003 to 2013, are consistent with a source of excess CO emission that orbits the star near the inner rim of the disk. The properties of the excess emission are consistent with those of a circumplanetary disk. In this paper, we report follow up observations that confirm our earlier prediction that the orbiting source of excess emission would disappear behind the near side of the inner rim of the outer disk in 2017. We find that while the hotband CO lines remained unchanged in 2017, the v=1-0 P26 line and its spectroastrometric signal returned to the profile observed in 2003. With these new observations, we further constrain the origin of the emission and discuss possible ways of confirming the presence of an orbiting planetary companion in the inner disk.

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Polarization reversal of scattered thermal dust emission in protoplanetary disks at submillimetre wavelengths

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Investigation of the polarized light of protoplanetary disks is key for constraining dust properties, disk morphology, and embedded magnetic fields. However, different polarization mechanisms and the diversity of dust grain shapes and compositions lead to ambiguities in the polarization pattern. The so-called self-scattering of thermal, re-emitted radiation in the infrared and millimetre and submillimetre wavelengths is discussed as a major polarization mechanism. If the net flux of the radiation field is in the radial direction, it is commonly assumed that the polarization pattern produced by scattering in a protoplanetary disk shows concentric rings for disks seen in face-on orientation. We show that a change of 90° of the polarization vector orientation may occur and mimic the typical pattern of dichroic emission of dust grains aligned by a toroidal magnetic field in disks seen close to face-on. Furthermore, this effect of polarization reversal is a fast-changing function of wavelength and grain size, and is thus a powerful tool to constrain grain composition and size distribution present in protoplanetary disks. In addition, the effect may also provide unique constraints for the disk inclination, especially if the disk is seen close to face-on.

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http://arxiv.org/pdf/1907.02705
https://www.aanda.org/articles/aa/pdf/2019/07/aa35169-19/aa35169-19.html

NH_3 Observations of the S235 Star Forming Region: Dense Gas in Inter-core Bridges

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Star formation is thought to be driven by two groups of mechanisms; spontaneous collapse and triggered collapse. Triggered star formation mechanisms further diverge into cloud-cloud collision (CCC), "collect and collapse" (C&C) and shock induced collapse of pre-existing, gravitationally stable cores, or 'radiation driven implosion' (RDI). To evaluate the contributions of these mechanisms and establish whether these processes can occur together within the same star forming region we performed mapping observations of radio frequency ammonia, and water maser emission lines in the S235 massive star forming region. Via spectral analyses of main, hyperfine and multi-transitional ammonia lines we explored the distribution of temperature and column density in the dense gas in the S235 and S235AB star forming region. The most remarkable result of the mapping observations is the discovery of high density gas in inter-core bridges which physically link dense molecular cores that house young proto-stellar clusters. The presence of dense gas implies the potential for future star formation within the system of cores and gas bridges. Cluster formation implies collapse and the continuous physical links, also seen in re-imaged archival CS and ^{13}CO maps, suggests a common origin to the molecular cores housing these clusters, i.e the structure condensed from a single, larger parent cloud, brought about by the influence of a local expanding HII region. An ammonia absorption feature co-locating with the center of the extended HII region may be attributed to an older gas component left over from the period prior to formation of the HII region. Our observations also detail known and new sites of water maser emission, highlighting regions of active ongoing star formation.

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Forming Pop III binaries in self-gravitating discs: how to keep the orbital angular momentum

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The disk fragmentation is a possible process leading to the formation of Population III stellar binary systems. However, numerical simulations show diverse fates of the fragments; some evolve into stable binaries and others merge away with a central star. To clarify the physics behind such diversity, we perform a series of three dimensional hydrodynamics simulations in a controlled manner. We insert a point particle mimicking a fragment in a self-gravitating disk, where the initial mass and position are free parameters, and follow the orbital evolution for several tens of orbits. The results show great diversity even with such simple experiments. Some particles shortly merge away after migrating inward, but others survive as the migration stalls with the gap-opening in the disk. We find that our results are well interpreted postulating that the orbital angular momentum is extracted by (i) the gravitational torque from the disk spiral structure, and (ii) tidal disruption of a gravitationally-bound envelope around the particle. Our analytic evaluations show the processes (i) and (ii) are effective in an outer and inner part of the disk respectively. There is a window of the gap-opening in the middle, if the envelope mass is sufficiently large. These all agree with our numerical results. We further show that the binaries, which appear for the "survival" cases, gradually expand while accreting the disk gas. Our theoretical framework is freely scalable to be applied for the present-day star and planet formation.

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Cometary compositions compared with protoplanetary disk midplane chemical evolution. An emerging chemical evolution taxonomy for comets

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With a growing number of molecules observed in many comets, and an improved understanding of chemical evolution in protoplanetary disk midplanes, comparisons can be made between models and observations that could potentially constrain the formation histories of comets. A χ^2-method was used to determine maximum likelihood surfaces for 14 different comets that formed at a given time (up to 8 Myr) and place (out to beyond the CO iceline) in the pre-solar nebula midplane. This was done using observed volatile abundances for the 14 comets and the evolution of volatile abundances from chemical modelling of disk midplanes. Considering all parent species (ten molecules) in a scenario that assumed reset initial chemistry, the χ^2 likelihood surfaces show a characteristic trail in the parameter space with high likelihood of formation around 30 AU at early times and 12 AU at later times for ten comets. This trail roughly traces the vicinity of the CO iceline in time. The formation histories for all comets were thereby constrained to the vicinity of the CO iceline, assuming that the chemistry was partially reset early in the pre-solar nebula. This is found, both when considering carbon-, oxygen-, and sulphur-bearing molecules (ten in total), and when only considering carbon- and oxygen-bearing molecules (seven in total). Since these 14 comets did not previously fall into the same taxonomical categories together, this chemical constraint may be proposed as an alternative taxonomy for comets. Based on the most likely time for each of these comets to have formed during the disk chemical evolution, a formation time classification for the 14 comets is suggested.

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http://arxiv.org/pdf/1907.11255

Interstellar Glycolaldehyde, Methyl Formate, and Acetic Acid I: A Bi-modal Abundance Pattern in Star Forming Regions

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The relative column densities of the structural isomers methyl formate, glycolaldehyde, and acetic acid are derived for a dozen positions towards the massive star-forming regions MM1 and MM2 in the NGC 6334I complex, which are separated by ∼4000 AU. Relative column densities of these molecules are also gathered from the literature for 13 other star-forming regions. In this combined dataset, a clear bi-modal distribution is observed in the relative column densities of glycolaldehyde and methyl formate. No such distribution is evident with acetic acid. The two trends are comprised of star-forming regions with a variety of masses, suggesting that there must be some other common parameter that is heavily impacting the formation of glycolaldehyde. This is indicative of some demonstrable differentiation in these cores; studying the abundances of these isomers may provide a clue as to the integral chemical processes ongoing in a variety of protostellar environments.

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A Survey for New Members of Taurus from Stellar to Planetary Masses

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We present a large sample of new members of the Taurus star-forming region that extend from stellar to planetary masses. To identify candidate members at substellar masses, we have used color-magnitude diagrams and proper motions measured with several wide-field optical and infrared (IR) surveys. At stellar masses, we have considered the candidate members that were found in a recent analysis of high-precision astrometry from the Gaia mission. Using new and archival spectra, we have measured spectral types and assessed membership for these 161 candidates, 79 of which are classified as new members. Our updated census of Taurus now contains 519 known members. According to Gaia data, this census should be nearly complete for spectral types earlier than M6–M7 at $A_J < 1$. For a large field encompassing ~72% of the known members, the census should be complete for $K < 15.7$ at $A_J < 1.5$, which corresponds to ~5–13 $M_{\rm Jup}$ for ages of 1–10 Myr based on theoretical evolutionary models. Our survey has doubled the number of known members at greater or equal to M9 and has uncovered the faintest known member in M_K, which should have a mass of ~3–10 $M_{\rm Jup}$ for ages of 1–10 Myr. We have used mid-IR photometry from the Spitzer Space Telescope and the Wide-field Infrared Survey Explorer to determine whether the new members exhibit excess emission that would indicate the presence of circumstellar disks. The updated disk fraction for Taurus is ~0.7 at less than or equal to M3.5 and ~0.4 at >M3.5.

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Circumbinary disk inner radius as a diagnostic for disk–binary misalignment

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We investigate the misalignment of the circumbinary disk around the binary HD 98800 BaBb with eccentricity $e \approx 0.8$. Kennedy et al. (2019) observed the disk to be either at an inclination of 48° or polar aligned to the binary orbital plane. Their simulations showed that alignment from 48° to a polar configuration can take place on a shorter timescale than the age of this system. We perform hydrodynamical numerical simulations in order to estimate the cavity size carved by the eccentric binary for different disk inclinations as an independent check of polar alignment. Resonance theory suggests that torques on the inner parts of a polar disk around such a highly eccentric binary are much weaker than in the coplanar case, indicating a significantly smaller central cavity than in the coplanar case. We show that the inferred inner radius (from carbon monoxide measurements) of the accretion disk around BaBb can exclude the possibility of it being mildly inclined with respect to the binary orbital plane and therefore confirm the polar configuration. This study constitutes an important diagnostic for misaligned circumbinary disks, since it potentially allows us to infer the disk inclination from observed gas disk inner radii.

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Dust Transport and Processing in Centrifugally Driven Protoplanetary Disk Winds

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There is evidence that protoplanetary disks—including the protosolar one—contain crystalline dust grains on spatial scales where the dust temperature is lower than the threshold value for their formation through thermal annealing of amorphous interstellar silicates. We interpret these observations in terms of an extended, magnetocentrifugally driven disk wind that transports grains from the inner disk—where they are thermally processed by the stellar radiation after being uplifted from the disk surfaces—to the outer disk regions. For any disk radius r there is a maximum grain size $a_{\rm max}(r)$ that can be uplifted from that location: grains of size $a \ll a_{\rm max}$ are carried away by the wind, whereas those with $a \lesssim a_{\rm max}$ reenter the disk at larger radii. A significant portion of the reentering grains converge to—and subsequently accumulate in—a narrow region just beyond $r_{\max}(a)$, the maximum radius from which grains of size a can be uplifted. We show that this model can account for the inferred crystallinity fractions in classical T Tauri and Herbig Ae disks and for their indicated near constancy after being established early in the disk evolution. It is also consistent with the reported radial gradients in the mean grain size, crystallinity, and crystal composition. In addition, this model yields the properties of the grains that remain embedded in the outflows from protoplanetary disks and naturally explains the inferred persistence of small grains in the surface layers of these disks.

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Fragmentation of Filamentary Cloud Permeated by Perpendicular Magnetic Field II. Dependence on the Initial Density Profile

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We examine the linear stability of a filamentary cloud permeated by a perpendicular magnetic field. The initial magnetic field is assumed to be uniform and perpendicular to the cloud axis. The model cloud is assumed to have a Plummer-like density profile and to be supported against the self-gravity by turbulence. The effects of turbulence are taken into account by enhancing the effective pressure of a low density gas. We derive the effective pressure as a function of the density from the condition of the hydrostatic balance. It is shown that the model cloud is more unstable against radial collapse, when the radial density slope is shallower. When the magnetic field is mildly strong, the radial collapse is suppressed. If the displacement vanishes in the region very far from the cloud axis, the model cloud is stabilized completely by a mildly strong magnetic field. If rearrangement of the magnetic flux tubes is permitted, the model cloud is unstable even when the magnetic field is extremely strong. The stability depends on the outer boundary condition as in case of the isothermal cloud. The growth rate of the rearrangement mode is smaller when the radial density slope is shallower.

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Formation of rocky and icy planetesimals inside and outside the snow line: Effects of diffusion, sublimation and back-reaction

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It is important to clarify where and when rocky and icy planetesimals are formed in a viscously evolving disk. We wish to understand how local runaway pile-up of solids occurs inside or outside the snow line. We assume an icy pebble contains micron-sized silicate grains that are uniformly mixed with ice and are released during the ice sublimation. Using a local one-dimensional code, we solve the radial drift and the turbulent diffusion of solids and the water vapor, taking account of their sublimation/condensation around the snow line. We systematically investigate effects of back-reactions of the solids to gas on the radial drift and diffusion of solids, scale height evolution of the released silicate particles, and possible difference in effective viscous parameters between that for turbulent diffusion ($\alpha_{\rm tur}$) and that for the gas accretion rate onto the central star ($\alpha_{\rm acc}$). We study the dependence on the ratio of the solid mass flux to the gas ($F_{\rm p/g}$). We show that the favorable locations for the pile-up of silicate grains and icy pebbles are the regions in the proximity of the water snow line inside and outside it, respectively. We found that runaway pile-ups occur when both the back-reactions for radial drift and diffusion are included. In the case with only the back-reaction for

the radial drift, no runaway pile-up is found except for extremely high pebble flux, while the condition of streaming instability can be satisfied for relatively large $F_{\rm p/g}$ as found in the past literatures. If the back-reactions for radial diffusion is considered, the runaway pile-up occurs for reasonable value of pebble flux. The runaway pile-up of silicate grains that would lead to formation of rocky planetesimals occurs for $\alpha_{\rm tur} \ll \alpha_{\rm acc}$, while the runaway pile-up of icy pebbles is favored for $\alpha_{\rm tur} \sim \alpha_{\rm acc}$.

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New constraints on the dust and gas distribution in the LkCa 15 disk from ALMA

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We search a large parameter space of the LkCa 15's disk density profile to fit its observed radial intensity profile of ^{12}CO (J = 3–2) obtained from ALMA. The best-fit model within the parameter space has a disk mass of 0.1 $M_\odot$ (using an abundance ratio of $^{12}\rm CO/H_2 = 1.4 \times 10^{-4}$ in mass), an inner cavity of 45 AU in radius, an outer edge at ∼600 AU, and a disk surface density profile follows a power-law of the form $\rho_r \propto r^{-4}$. For the disk density profiles that can lead to a small reduced χ^2 of goodness-of-fit, we find that there is a clear linear correlation between the disk mass and the power-law index γ in the equation of disk density profile. This suggests that the ^{12}CO disk of LkCa 15 is optically thick and we can fit its ^{12}CO radial intensity profile using either a lower disk mass with a smaller γ or a higher disk mass with a bigger γ. By comparing the ^{12}CO channel maps of the best-fit model with disk models with higher or lower masses, we find that a disk mass of ∼0.1 $M_\odot$ can best reproduce the observed morphology of the ^{12}CO channel maps. The dust continuum map at 0.87 mm of the LkCa 15 disk shows an inner cavity of the similar size of the best-fit gas model, but its out edge is at ∼200 AU, much smaller than the fitted gas disk. Such a discrepancy between the outer edges of the gas and dust disks is consistent with dust drifting and trapping models.

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Dusty disk winds at the sublimation rim of the highly inclined, low mass YSO SU Aurigae

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T Tauri stars are low-mass young stars whose disks provide the setting for planet formation. Despite this, their structure is poorly understood. We present new infrared interferometric observations of the SU Aurigae circumstellar environment that offer resolution that is three times higher and a better baseline position angle coverage than previous observations. We aim to investigate the characteristics of the circumstellar material around SU Aur, constrain the disk geometry,The CHARA array offers unique opportunities for long baseline observations, with baselines up to 331 m. Using the CLIMB three-telescope combiner in the K-band allows us to measure visibilities as well as closure phase. We undertook image reconstruction for model-independent analysis, and fitted geometric models such as Gaussian and ring distributions. Additionally, the fitting of radiative transfer models constrain the physical parameters of the disk. For the first time, a dusty disk wind is introduced to the radiative transfer code TORUS to model protoplanetary

disks. Our implementation is motivated by theoretical models of dusty disk winds, where magnetic field lines drive dust above the disk plane close to the sublimation zone. Image reconstruction reveals an inclined disk with slight asymmetry along its minor-axis, likely due to inclination effects obscuring the inner disk rim through absorption of incident star light on the near-side and thermal re-emission and scattering of the far-side. Geometric modelling of a skewed ring finds the inner rim at 0.17 ± 0.02 au with an inclination of $50.9 \pm 1.0°$ and minor axis position angle $60.8 \pm 1.2°$. Radiative transfer modelling shows a flared disk with an inner radius at 0.18 au which implies a grain size of $0.4\,\mu$m assuming astronomical silicates and a scale height of 15.0 au at 100 au. Among the tested radiative transfer models, only the dusty disk wind successfully accounts for the K-band excess by introducing dust above the mid-plane.

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Effects of infall and outflow on massive star-forming regions

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A total of 188 high-mass outflows have been identified from a sample of 694 clumps from the Millimetre Astronomy Legacy Team 90 GHz survey, representing a detection rate of approximately 27%. The detection rate of outflows increases from the protostellar stage to the H II stage, but decreases again at the photodissociation (PDR) stage suggesting that outflows are being switched off during the PDR stage. An intimate relationship is found between outflow action and the presence of masers, and water masers appear together with 6.7 GHz methanol masers. Comparing the infall detection rate of clumps with and without outflows, we find that outflow candidates have a lower infall detection rate. Finally, we find that outflow action has some influence on the local environment and the clump itself, and this influence decreases with increasing evolutionary time as the outflow action ceases.

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The GeV emission in the field of the star-forming region W30 revisited

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We present a detailed study of the γ-ray emission from the direction of the star-forming region W30 based on a decade of the Fermi Large Area Telescope data in the 0.3–300 GeV photon energy range. The morphological and spectral analyses allow us to resolve the γ-ray emission into two extended structures from different origins. One of them mostly overlaps with the supernova remnant (SNR) G8.7−0.1 and has a soft spectrum that resembles with the spectra of other middle-aged SNRs interacting with molecular clouds. The other shows remarkable spatial and spectral consistency with the TeV emission from HESS J1804−216, and its spectrum could be naturally explained by inverse Compton scattering of electrons like a number of TeV gamma-ray emitting pulsar wind nebulae. Thus we attribute this source to the nebula around the pulsar PSR J1803−2137.

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Compact Disks in a High Resolution ALMA Survey of Dust Structures in the Taurus Molecular Cloud

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We present a high-resolution ($\sim 0.''12$, ~ 16 au, mean sensitivity of 50 μJy beam^{-1} at 225 GHz) snapshot survey of 32 protoplanetary disks around young stars with spectral type earlier than M3 in the Taurus star-forming region using Atacama Large Millimeter Array (ALMA). This sample includes most mid-infrared excess members that were not previously imaged at high spatial resolution, excluding close binaries and highly extincted objects, thereby providing a more representative look at disk properties at 1–2 Myr. Our 1.3 mm continuum maps reveal 12 disks with prominent dust gaps and rings, 2 of which are around primary stars in wide binaries, and 20 disks with no resolved features at the observed resolution (hereafter smooth disks), 8 of which are around the primary star in wide binaries. The smooth disks were classified based on their lack of resolved substructures, but their most prominent property is that they are all compact with small effective emission radii ($R_{\rm eff,95\%} < 50$ au). In contrast, all disks with $R_{\rm eff,95\%}$ of at least 55 au in our sample show detectable substructures. Nevertheless, their inner emission cores (inside the resolved gaps) have similar peak brightness, power law profiles, and transition radii to the compact smooth disks, so the primary difference between these two categories is the lack of outer substructures in the latter. These compact disks may lose their outer disk through fast radial drift without dust trapping, or they might be born with small sizes. The compact dust disks, as well as the inner disk cores of extended ring disks, that look smooth at the current resolution will likely show small-scale or low-contrast substructures at higher resolution. The correlation between disk size and disk luminosity correlation demonstrates that some of the compact disks are optically thick at millimeter wavelengths.

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Characterization of Ring Substructures in the Protoplanetary Disk of HD 169142 from Multi-Wavelength ALMA Observations

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We present a detailed multi-wavelength characterization of the multi-ring disk of HD 169142. We report new ALMA observations at 3 mm and analyze them together with archival 0.89 and 1.3 mm data. Our observations resolve three out of the four rings in the disk previously seen in high-resolution ALMA data. A simple parametric model is used to estimate the radial profile of the dust optical depth, temperature, density, and particle size distribution. We find that the multiple ring features of the disk are produced by annular accumulations of large particles, probably associated with gas pressure bumps. Our model indicates that the maximum dust grain size in the rings is $\sim$ 1 cm, with slightly flatter power-law size distributions than the ISM-like size distribution ($p \sim 3.5$) found in the gaps. In particular, the inner ring ($\sim$ 26 au) is associated with a strong and narrow buildup of dust particles that could harbor the necessary conditions to trigger the streaming instability. According to our analysis, the snowlines of the most important volatiles do not coincide with the observed substructures. We explore different ring formation mechanisms and find that planet-disk interactions are the most likely scenario to explain the main features of HD 169142. Overall, our multi-wavelength analysis provides some of the first unambiguous evidence of the presence of radial dust traps in the rings of HD 169142. A similar analysis in a larger sample of disks could provide key insights on the impact that disk substructures have on the dust evolution and planet formation processes.

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Observational constraints on dust disk sizes in tidally truncated protoplanetary disks in multiple systems in the Taurus region

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The impact of stellar multiplicity on the evolution of planet-forming disks is still the subject of debate. Here we present and analyze disk structures around 10 multiple stellar systems that were included in an unbiased, high spatial resolution survey of 32 protoplanetary disks in the Taurus star-forming region with ALMA. At the unprecedented spatial resolution of $\sim$0.12" we detect and spatially resolve the disks around all primary stars, as well as those around eight secondary and one tertiary stars. The dust radii of disks around multiple stellar systems are smaller than those around single stars in the same stellar mass range and in the same region. The disks in multiple stellar systems have also a steeper decay of the mm-continuum emission at the outer radius than disks around single stars, suggestive of the impact of tidal truncation on the shape of the disks in multiple systems. However, the observed ratio between the dust disk radii and the observed separation of the stars in the multiple systems is consistent with analytic predictions of the effect of tidal truncation only if the eccentricities of the binaries are rather high (typically >0.5), or if the observed dust radii are a factor of two smaller than the gas radii, as is typical for isolated systems. Similar high resolution studies targeting the gaseous emission from disks in multiple stellar systems are required to resolve this question.

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Massive stars in the young cluster VVV CL074

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We obtained K-band spectroscopy of the brightest members of the cluster VVV CL074 in order to identify the massive star population. We also determined the stellar properties of the cluster's massive stars to better quantify the evolutionary sequences linking different types of massive stars. We collected integral field spectroscopy of selected fields in the cluster VVV CL074 with SINFONI on the ESO/VLT. We performed a spectral classification based on the K-band spectra and comparison to infrared spectral atlases. We determined the stellar parameters of the massive stars from analysis with atmosphere models computed with the code CMFGEN. We uncover a population of 25 early-type (OB and Wolf-Rayet) stars, 19 being newly discovered by our observations out of which 15 are likely cluster members. The cluster's spectrophotometric distance is 10.2±1.6 kpc, placing it close to the intersection of the galactic bar and the Norma arm, beyond the galactic center. This makes VVV CL074 one the farthest young massive clusters identified so far. Among the massive stars population, three objects are Wolf-Rayet stars, the remaining are O and B stars. From the Hertzsprung-Russell diagram we find that most stars have an age between 3 and 6 Myr according to the Geneva evolutionary tracks. WN8 and WC8-9 stars are the descendants of stars with initial masses between 40 and 60 $M_{\odot}$. The massive star population of VVV CL074 is very similar to that of the cluster DBS2003-179 and to a lesser extent to that of the Quintuplet cluster, indicating the same age. The central cluster of the Galaxy is ∼3 Myr older. From the comparison of the massive stars populations in these four clusters, one concludes that galactic stars with an initial mass in the range 40 to 60 $M_{\odot}$ likely go through a WN8-9 phase.

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Substructures in the Keplerian disc around the O-type (proto-)star G17.64+0.16

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We present the highest angular resolution (20x15mas - 44x33au) atacama Large Millimeter/sub-millimeter Array (ALMA) observations that are currently possible of the proto-O-star G17.64+0.16 in Band 6. The Cycle 5 observations with baselines out to 16 km probe scales <50 au and reveal the rotating disc around G17.64+0.16, a massive forming O-type star. The disc has a ring-like enhancement in the dust emission that is especially visible as arc structures to the north and south. The Keplerian kinematics are most prominently seen in the vibrationally excited water line, H2O $\nu_2 = 1$ (E_u = 3461.9 K). The mass of the central source found by modelling the Keplerian rotation is consistent with 45±10 $M_\odot$. The $H_{30}\alpha$ (231.9 GHz) radio-recombination line and the SiO (5-4) molecular line were detected at up to the $\sim 10\sigma$ level. The estimated disc mass is 0.6-2.6 $M_\odot$ under the optically thin assumption. Analysis of the Toomre Q parameter in the optically thin regime indicates that the disc stability is highly dependent on temperature. The disc currently appears stable for temperatures >150 K; this does not preclude that the substructures formed earlier through disc fragmentation.

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IC 4665 DANCe I. Members, empirical isochrones, magnitude distributions, present-day system mass function, and spatial distribution

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Context. The study of star formation is extremely challenging due to the lack of complete and clean samples of young, nearby clusters, and star forming regions. The recent Gaia DR2 catalogue complemented with the deep, ground based COSMIC DANCe catalogue offers a new database of unprecedented accuracy to revisit the membership of clusters and star forming regions. The 30 Myr open cluster IC 4665 is one of the few well-known clusters of this age and it is an excellent target where to test evolutionary models and study planetary formation.
Aims. We aim to provide a comprehensive membership analysis of IC 4665 and to study the following properties:

empirical isochrones, distance, magnitude distribution, present-day system mass function, and spatial distribution.
Methods. We use the Gaia DR2 catalogue together with the DANCe catalogue to look for members using a probabilistic model of the distribution of the observable quantities in both the cluster and background populations.
Results. We obtain a final list of 819 candidate members which cover a 12.4 magnitude range ($7 < J < 19.4$). We find that 50% are new candidates, and we estimate a conservative contamination rate of 20%. This unique sample of members allows us to obtain a present-day system mass function in the range of 0.02–6 $M_{\odot}$, which reveals a number of details not seen in previous studies. In addition, they favour a spherically symmetric spatial distribution for this young open cluster.
Conclusions. Our membership analysis represents a significant increase in the quantity and quality (low-contamination) with respect to previous studies. As such, it offers an excellent opportunity to revisit other fundamental parameters such as the age.

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What is wrong with steady accretion discs?

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In a standard, steady, thin accretion disc, the radial distribution of the dissipation of the accretion energy is determined simply by energy considerations. Here we draw attention to the fact that while the (quasi-)steady discs in dwarf novae in outburst are in agreement with the expected emission distribution, the steady discs in the nova-like variables are not. We note that essentially the only difference between these two sets of discs is the time for which they have been in the high viscosity, high accretion rate state. In such discs, the major process by which angular momentum is transported outwards is MHD turbulence. We speculate that such turbulence gives rise to corona-like structures (here called magnetically controlled zones, or MCZs) which are also able to provide non-negligible angular momentum transport, the magnitude of which depends on the spatial scale L of the magnetic field structures in such zones. For short-lived, high accretion rate discs (such as those in dwarf novae) we expect $L \sim H$ and the MCZ to have little effect. But, with time (such as in the nova-like variables) an inverse cascade in the MHD turbulence enables L, and the net effect of the MCZ, to grow. We present a simple toy model which demonstrates that such ideas can provide an explanation for the difference between the dwarf novae and the nova-like variable discs.

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Ambipolar diffusion and the molecular abundances in prestellar cores

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We investigate differences in the molecular abundances between magnetically super- and sub-critical prestellar cores, performing three-dimensional non-ideal magnetohydrodynamical (MHD) simulations with varying densities and magnetic field strengths, and post-processing the results with a time-dependent gas-grain chemical code. Most molecular species show significantly more central depletion in subcritical models, due to the longer duration of collapse. However, the directly observable quantities — the molecule to hydrogen column density ratios — are generally too similar for observational data to discriminate between models. The profiles of N_2H^+ and HCO^+ show qualitative differences between supercritical and subcritical models on scales of 0.01 pc, which may allow the two cases to be distinguished. However, this requires knowledge of the hydrogen column density, which is not directly measureable, and predicted line intensity profiles from radiative transfer modelling are similar for these molecules. Other commonly observed

species, such as HCN and CH_3OH, have line intensity profiles which differ more strongly between models, and so are more promising as tracers of the mechanism of cloud collapse.

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Probing CO and N_2 Snow Surfaces in Protoplanetary Disks with N_2H^+ Emission

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Snowlines of major volatiles regulate the gas and solid C/N/O ratios in the planet-forming midplanes of protoplanetary disks. Snow surfaces are the 2D extensions of snowlines in the outer disk regions, where radiative heating results in an increasing temperature with disk height. CO and N_2 are two of the most abundant carriers of C, N and O. N_2H^+ can be used to probe the snow surfaces of both molecules, because it is destroyed by CO and formed from N_2. Here we present Atacama Large Millimeter/submillimeter Array (ALMA) observations of N_2H^+ at $0.2''$-$0.4''$ resolution in the disks around LkCa 15, GM Aur, DM Tau, V4046 Sgr, AS 209, and IM Lup. We find two distinctive emission morphologies: N_2H^+ is either present in a bright, narrow ring surrounded by extended tenuous emission, or in a broad ring. These emission patterns can be explained by two different kinds of vertical temperature structures. Bright, narrow N_2H^+ rings are expected in disks with a thick Vertically Isothermal Region above the Midplane (VIRaM) layer (LkCa 15, GM Aur, DM Tau) where the N_2H^+ emission peaks between the CO and N_2 snowlines. Broad N_2H^+ rings come from disks with a thin VIRaM layer (V4046 Sgr, AS 209, IM Lup). We use a simple model to extract the first sets of CO and N_2 snowline pairs and corresponding freeze-out temperatures towards the disks with a thick VIRaM layer. The results reveal a range of N_2 and CO snowline radii towards stars of similar spectral type, demonstrating the need for empirically determined snowlines in disks.

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High sensitivity maps of molecular ions in L1544: I. Deuteration of N_2H^+ and HCO^+ and first evidence of N_2D^+ depletion

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Context. The deuterium fraction in low-mass prestellar cores is a good diagnostic indicator of the initial phases of star formations, and it is also a fundamental quantity to infer the ionisation degree in these objects.
Aims. With the analysis of multiple transitions of N_2H^+, N_2D^+, $HC^{18}O^+$and DCO^+we are able to determine the molecular column density maps and the deuterium fraction in $N_2H^+$and HCO^+toward the prototypical prestellar core L1544. This is the preliminary step to derive the ionisation degree in the source.
Methods. We use a non-local thermodynamic equilibrium (non-LTE) radiative transfer code, combined with the molecular abundances derived from a chemical model, to infer the excitation conditions of all the observed transitions, which allows us to derive reliable maps of each molecule's column density. The ratio between the column density of a deuterated species and its non-deuterated counterpart gives the searched deuteration level.
Results. The non-LTE analysis confirms that, for the analysed molecules, higher-J transitions are characterised by excitation temperatures $\approx 1-2\,$K lower than the lower-J ones. The chemical model that provides the best fit to the observational data predict the depletion of $N_2H^+$and to a lesser extent of N_2D^+in the innermost region. The peak values for the deuterium fraction that we find are $D/H_{N_2H^+} = 0.26^{+0.15}_{-0.14}$ and $D/H_{HCO^+} = 0.035^{+0.015}_{-0.012}$, in good agreement with previous estimates in the source.

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The Massive Star-Forming Regions Omnibus X-Ray Catalog, Third Installment

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We offer to the star formation community the third installment of the Massive Star-forming Regions (MSFRs) Omnibus X-ray Catalog (MOXC3), a compilation of X-ray point sources detected in 50 archival Chandra/ACIS observations of 14 Galactic MSFRs and surrounding fields. The MOXC3 MSFRs are NGC 2264, NGC 6193, RCW 108-IR, Aur OB1, DR15, NGC 6231, Berkeley 87, NGC 6357, AFGL 4029, h Per (NGC 869), NGC 281, Onsala 2S, G305, and RCW 49 (Wd 2); they have distances of 0.7 kpc to 4.2 kpc. Most exhibit clumped or clustered young stellar populations; several contain at least two distinct massive young stellar clusters. The total MOXC3 catalog includes 27,923 X-ray point sources. We take great care to identify even the faintest X-ray point sources across these fields. This allows us to remove this point source light, revealing diffuse X-ray structures that pervade and surround MSFRs, often generated by hot plasmas from massive star feedback. As we found in MOXC1 and MOXC2, diffuse X-ray emission is traceable in all MOXC3 MSFRs; here we perform spectral fitting to investigate the origins of selected diffuse regions. Once again, MOXC3 shows the value of high spatial resolution X-ray studies of MSFRs enabled by Chandra.

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WISE Discovery of Mid-infrared Variability in Massive Young Stellar Objects

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We systematically investigate the mid-infrared (MIR; $\lambda > 3$ μm) time variability of uniformly selected ~ 800 massive young stellar objects (MYSOs) from the Red MSX Source (RMS) survey. Out of the 806 sources, we obtain reliable 9-year-long MIR magnitude variability data of 331 sources at the 3.4 μm (W1) and 4.6 μm (W2) bands by cross-matching the MYSO positions with *ALLWISE* and *NEOWISE* catalogs. After applying the variability selections using *ALLWISE* data, we identify 5 MIR-variable candidates. The light curves show various classes, with the periodic, plateau-like, and dipper features. Out of the obtained two color-magnitude diagram of W1 and W1−W2, one shows "bluer when brighter and redder when fainter" trends in variability, suggesting change in extinction or accretion rate. Finally, our results show that G335.9960−00.8532 (hereafter, G335) has a periodic light curve, with a $\approx$ 690-day cycle. Spectral energy density model fitting results indicate that G335 is a relatively evolved MYSO; thus, we may be witnessing the very early stages of a hyper- or ultra-compact HII region, a key source for understanding MYSO evolution.

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Thermal Infrared Imaging of MWC 758 with the Large Binocular Telescope: Planetary Driven Spiral Arms?

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Theoretical studies suggest that a giant planet around the young star MWC 758 could be responsible for driving the spiral features in its circumstellar disk. Here, we present a deep imaging campaign with the Large Binocular Telescope with the primary goal of imaging the predicted planet. We present images of the disk in two epochs in the L' filter (3.8 μm) and a third epoch in the M' filter (4.8 μm). The two prominent spiral arms are detected in each observation, which constitute the first images of the disk at M', and the deepest yet in L' ($\Delta L' = 12.1$ exterior to the disk at 5σ significance). We report the detection of a S/N$\sim$3.9 source near the end of the Sourthern arm, and, from the source's detection at a consistent position and brightness during multiple epochs, we establish a $\sim$90% confidence-level that the source is of astrophysical origin. We discuss the possibilities that this feature may be a) an unresolved disk feature, and b) a giant planet responsible for the spiral arms, with several arguments pointing in favor of the latter scenario. We present additional detection limits on companions exterior to the spiral arms, which suggest that a $\lesssim$4 $M_{\rm Jup}$ planet exterior to the spiral arms could have escaped detection. Finally, we do not detect the companion candidate interior to the spiral arms reported recently by Reggiani et al. (2018), although forward modelling suggests that such a source would have likely been detected.

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Orbital Evolution of a Circumbinary Planet in a Gaseous Disk

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Sub-Jupiter classed circumbinary planets discovered in close-in binary systems have orbits just beyond the dynamically unstable region, which is determined by the eccentricity and mass ratio of the host binary stars. These planets are assumed to have formed beyond the snow line and migrated to the current orbits rather than forming *in situ*. We propose a scenario in which a planet formed beyond the snow line and migrated to the inner edge of the circumbinary disk, which was within the unstable area, and then moved to the current orbit through outward transportation. This outward transportation is driven by the balance of orbital excitation of the central stars inside the gravitationally unstable region and damping by the gas-drag force. We carried out N-body simulations with a dissipating circumbinary protoplanetary disk for binary systems with different eccentricities and mass ratios. Planets are more likely to achieve a stable orbit just beyond the unstable region in less eccentric binary systems. This result is not as sensitive to mass ratio as it is to eccentricity. These dependencies are consistent with the data from observed binary systems hosting circumbinary planets. We find CBPs' orbits close to the instability boundaries are explained by our orbital evolution scenario.

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Northern Galactic Molecular Cloud Clumps in Hi-GAL: Clump and Star Formation within Clouds

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We investigate how the properties of Galactic giant molecular clouds (GMCs) and their denser substructures (clumps) correlate with the local star formation rate. We trace clouds using the ^{12}CO (3–2) transition, as observed by the CO High Resolution Survey (COHRS). We identify their constituent clumps using thermal dust emission, as observed by the Herschel infrared GALactic plane survey (Hi-GAL). We estimate star formation rates in these clouds using 70 μm emission. In total, we match 3,674 clumps to 473 clouds in position-position-velocity space spanning the Galactic longitude range $10^\circ < \ell < 56^\circ$. We find that more massive clouds produce more clumps and more massive clumps.

These clumps have average number densities an order of magnitude greater than their host clouds. We find a mean clump mass fraction of $0.20^{+0.13}_{-0.10}$. This mass fraction weakly varies with mass and mass surface density of clouds, and shows no clear dependence on the virial parameter and line width of the clouds. The average clump mass fraction is only weakly dependent upon Galactocentric radius. Although the scatter in our measured properties is significant, the star formation rate for clouds is independent of clump mass fraction. However, there is a positive correlation between the depletion times for clouds and clump mass fraction. We find a star formation efficiency per free fall time of $\epsilon_{\rm ff} = 0.15\%$ for GMCs but $\epsilon_{\rm ff} = 0.37\%$ for clumps.

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Dissertation Abstracts

The physics and chemistry of envelopes and disks around young protostars

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Important clues about the formation of our own Solar System are revealed by studying other young sources that are currently forming. The study of low-mass protostars in different evolutionary stages is, therefore, essential to link their physical and chemical evolution to what we know about the Solar System. In particular, low-mass protostars are associated with disks, where planets form. Very little is known about the initial physical and chemical conditions for planet formation and the relationship between the physical and chemical structures of embedded disks. Therefore, the study of the physics and chemistry at small scales may provide important clues about how the material falls from the envelope to the disk and accretes from the disk into the protostar and what is the physico-chemical link between deeply embedded stages and the onset of planet formation. The goal of this thesis is to study the physics and chemistry at play at small scales (disk scales) towards low-mass protostars in order to constrain the mass flow and identify the physical and chemical processes that dominate at these scales. The study of the formation and evolution of disks is challenging since they are embedded in the parental cloud and are relatively small in size ($\leq$700 AU), requiring observations with high sensitivity and angular resolution. For this, we observe a sample of Class I protostars using the Atacama Large Millimeter/submillimeter Array (ALMA) and the Submillimeter Array (SMA) to characterise their physical and chemical structures. Class I sources have been chosen since disks are expected to have been formed at this stage and because they serve as a link between the deeply embedded Class 0 sources and the emergence of protoplanetary disks. The results from these studies are presented in three papers (published in international journals). We find an empirical linear correlation between the bolometric luminosity and the mass accretion rate, suggesting that more massive protostars accrete material with a higher accretion rate. The mean mass accretion estimated for a sample of 13 Class I sources is 2.4×10^{-7} $M_{\odot}$ yr^{-1}. This value is lower than the expected if the accretion is constant in time and rather points to a scenario of accretion occurring in bursts. In addition, this low mass accretion rate provides observational evidence that a typical protostar will spend most of its lifetime in a quiescent state of accretion. The formation and evolution of the disk are reflected on the chemical structure of the envelope, from large to small scales. The disk shields material beyond its extent where cold temperature tracers are

detected, such as DCO^+. Furthermore, the non detection of CH_3OH suggests that material from the inner envelope follows the flattened structure of the disk and, since less material is exposed to high temperatures, desorption of complex-organic molecules is not efficient. In addition, compact emission and large line widths of warm SO_2 emission are consistent with the presence of accretion shocks produced at the interface between the inner envelope and the disk surface. Class I sources show a physical and chemical link between deeply embedded Class 0 sources and more evolved Class II sources. The gas column density decreases as the system evolves, which is reflected in the emission of high-density tracers such as CO isotopologues. The formation and evolution of the disk, together with the increase of the outflow-opening angle as the system evolves, allow the UV radiation from the central protostar to reach the surface layers of the disk, promoting the photodissociation of molecules and enhancing the abundance of others, for example, CN. On the other hand, the chemistry of Class 0 sources can be preserved, to some extent, in Class II sources mainly towards the disk midplane and beyond its extension, where the shielding is efficient.

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New Jobs

Applications Now Accepted for 51 Pegasi b Fellowships (with U. Michigan as a potential Host Institution)

Now is a great time to study exoplanets at the University of Michigan! We are pleased to announce that the University of Michigan is an approved Host Institution for the 51 Pegasi b Fellowship Program, sponsored by the Heising-Simons Foundation. Applications are due September 20, 2019. More information can be found at:

https://www.hsfoundation.org/programs/science/51-pegasi-b-fellowship/

The University of Michigan is home to several research groups focused on planet formation, exoplanet science, and solar system exploration, utilizing theoretical, numerical, and observational methods, including the development of novel instrumentation. Potential faculty hosts include Fred Adams, Ted Bergin, Nuria Calvet, Lia Corrales, Elena Gallo, Lee Hartmann, Michael Meyer, John Monnier, Emily Rauscher, as well as others. We also anticipate that additional post-doctoral research positions in the areas of planet formation and exoplanets will be advertised this fall.

The University of Michigan hosts a vibrant astrophysics research community within the Departments of Astronomy and Physics, as well as significant expertise in planetary sciences within the Earth & Environmental Sciences and Climate & Space Sciences Departments. We have a particular strength in the interrelated study of stars, planets, and their formation. Postdoctoral researchers in our department can apply as PI to any of our telescope facility partnerships, currently including the Magellan Telescopes in Chile, the MDM Observatory in Arizona, the CHARA Interferometer, the SWIFT space telescope, and the NOEMA mm array. Significant computing resources are available through the Department and through the University of Michigan. The Michigan Institute for Research in Astrophysics funds cross-disciplinary efforts, including a series of intellectually stimulating conferences, and conversations on inclusion and equity, while the Michigan Institute for Data Science advances cross-cutting data science methodology and applications relevant to solving fundamental research problems in planetary science.

The University of Michigan is recognized as a top academic employer and Ann Arbor, Michigan is routinely celebrated for its high quality of life. We are a department that values diversity, equity, and inclusion as essential to scientific excellence and encourage applications from those with identities underrepresented in astronomy.

Please share this information with potentially interested persons, and do not hesitate to contact individual members of the scientific staff to learn more about research opportunities in planetary science or visit our website at https://lsa.umich.edu/astro.

51 Pegasi Fellowship Opportunities at Cornell University

The Department of Astronomy at Cornell University encourages early career researchers in astronomy and planetary sciences to apply to the 51 Pegasi b Fellowship. Cornell University is among the fourteen host institutions for this planetary astronomy focused postdoctoral fellowship. Deadline: September 20th

Diversity and inclusion are a part of Cornell University's heritage. 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. Our inclusive community of scholars, students, and staff impart an uncommon sense of larger purpose, and contribute creative ideas to further the university's mission of teaching, discovery, and engagement.

For more information, please contact Nikole Lewis (nkl35@cornell.edu)

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Meetings

NAOJ Science Workshop II: Planet Formation Workshop 2019

November 25th-28th, 2019, Tokyo, Japan

In the last few years, our field has been dramatically developing especially achieved by ALMA and other fascinating telescopes. This workshop aims at sharing and discussing the latest understandings of planet formation and protoplanetary disks as well as numerical and theoretical developments in this field. We especially expect active participation from the East Asia for learning this excitingly developing field and finding a new network in geographically close collaborators, while participation from any countries and regions are welcome. In addition, we encourage early-stage researchers such as master and Ph.D. students and postdocs to join this workshop.

INVITED SPEAKERS:
Chris Ormel (University of Amsterdam → Tsinghua Univ., China)
Gregory J. Herczeg (KIAA, China)
Kenji Furuya (Tsukuba Univ., Japan)
Min-Kai Lin (ASIAA, Taiwan)
Satoshi Okuzumi (Tokyo Tech., Japan)
Woojin Kwon (KASI, Korea)
Xue-Ning Bai (Tsinghua Univ., China)
Ya-Wen Tang (ASIAA, Taiwan)

TOPICS:
Formation of protoplanetary disks
Evolution of protoplanetary disks
Disk observations
Evolution of solids in disks
Formation of planetary system
Debris disks

IMPORTANT DATES:
Registration open: currently open
Abstract submission deadline: September 1st, 2019
Announcement of program: mid of September, 2019
Registration deadline: October 25th, 2019
Workshop dates: November 25th-28th, 2019

Contact: planet-formation-workshop2019@th.nao.ac.jp

Organizers: Akimasa Kataoka (Chair), Takahiro Ueda (Co-Chair), Hideko Nomura, Shinsuke Takasao, Takashi Tsukagoshi, Misako Tatsuuma

http://th.nao.ac.jp/meeting/planet-formation-workshop2019/

Summary of Upcoming Meetings

Orion Uncovered
26 - 30 August 2019 Leiden, The Netherlands
https://sites.google.com/view/OrionLeiden2019

Understanding the Nearby Star-forming Universe with JWST
26 - 30 Aug 2019 Courmayeur, Italy
http://www.stsci.edu/institute/conference/unsfjwst2019

Celebrating the first 40 Years of Alexander Tielens' Contribution to Science: The Physics and Chemistry of the ISM
2 - 6 september 2019, Avignon, France https://tielens2019.sciencesconf.org

From Gas to Stars: The Links between Massive Star and Star Cluster Formation
16-20 September 2019 York, UK
https://starformmapper.org/final-conference/

Crete III - Through dark lanes to new stars - Celebrating the career of Prof. Charles Lada
23 - 27 September 2019 Crete, Greece
http://crete3.org

The UX Ori type stars and related topics
30 September - 4 October 2019 St. Petersburg, Russia
http://uxors-2019.craocrimea.ru

First Stars VI
1 - 6 March 2020 Concepcion, Chile
http://www.astro.udec.cl/FirstStarsVI/

Linking Dust, Ice, and Gas in Space
19 - 24 April 2020, Capri, Italy
http://frcongressi.net/ecla2020.meet

COOL STARS 21: Cambridge Workshop on Cool Stars, Stellar Systems and the Sun
22 -26 June 2020, Toulouse, France
https://coolstars21.github.io/

The Physics of Star Formation: From Stellar Cores to Galactic Scales
29 June - 3 July 2020 Lyon, France
https://cral.univ-lyon1.fr

Planet Formation Workshop 2019
25 - 28 November Tokyo, Japan
http://th.nao.ac.jp/meeting/planet-formation-workshop2019/