The Star Formation Newsletter

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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.

Newsletter Archive
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Cover Picture

The Orion Nebula Cluster has formed at northern tip of the Orion A or L1641 cloud. The cover picture shows a composite of an optical image from the Digitized Sky Survey 2 together with a large map of submillimeter emission from cool dust in the giant molecular cloud. This map was obtained with the ESO-operated Atacama Pathfinder Experiment (APEX) in Chile.

Image courtesy the European Southern Observatory.

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
As you probably have noticed, there have been few of the short articles in the 'My Favorite Object' and 'Perspective' series during the last half year. This is due to a large workload, which has left me little time to take care of this part of the editorial work on the Newsletter. I am therefore pleased to welcome Dr. Anna Faye McLeod as a new Associate Editor with responsibility for these two series of articles. Anna is a Research Associate at the School of Physical and Chemical Sciences of the University of Canterbury, New Zealand. Her research interests focus on feedback from massive stars, galactic and extragalactic HII regions, and Herbig-Haro flows, and you can see some of her recent work in a Letter to Nature (Feb 15 issue) describing the discovery and analysis of a collimated Herbig-Haro jet in the Large Magellanic Cloud. Anna will be soliciting articles for the Newsletter, but if you think you have a good object or subject for these articles, do not hesitate to contact Anna at anna.mcleod@canterbury.ac.nz with your suggestions.
Similar complex kinematics within two massive, filamentary infrared dark clouds
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Infrared dark clouds (IRDCs) are thought to be potential hosts of the elusive early phases of high-mass star formation. Here we conduct an in-depth kinematic analysis of one such IRDC, G034.43+00.24 (Cloud F), using high sensitivity and high spectral resolution IRAM-30m N₂H⁺ (1–0) and C¹⁸O (1–0) observations. To disentangle the complex velocity structure within this cloud we use Gaussian decomposition and hierarchical clustering algorithms. We find that four distinct coherent velocity components are present within Cloud F. The properties of these components are compared to those found in a similar IRDC, G035.39−00.33 (Cloud H). We find that the components in both clouds have: high densities (inferred by their identification in N₂H⁺), trans-to-supersonic non-thermal velocity dispersions with Mach numbers of ~1.5–4, a separation in velocity of ~3 km s⁻¹¹, and a mean red-shift of ~0.3 km s⁻¹ between the N₂H⁺ (dense gas) and C¹⁸O emission (envelope gas). The latter of these could suggest that these clouds share a common formation scenario. We investigate the kinematics of the larger-scale Cloud F structures, using lower-density-tracing ¹³CO (1–0) observations. A good correspondence is found between the components identified in the IRAM-30m observations and the most prominent component in the ¹³CO data. We find that the IRDC Cloud F is only a small part of a much larger structure, which appears to be an inter-arm filament of the Milky Way.

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On the diversity and statistical properties of protostellar discs
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We present results from the first population synthesis study of protostellar discs. We analyse the evolution and properties of a large sample of protostellar discs formed in a radiation hydrodynamical simulation of star cluster formation. Due to the chaotic nature of the star formation process, we find an enormous diversity of young protostellar discs, including misaligned discs, and discs whose orientations vary with time. Star-disc interactions truncate discs and produce multiple systems. Discs may be destroyed in dynamical encounters and/or through ram-pressure stripping, but reform by later gas accretion. We quantify the distributions of disc mass and radii for protostellar ages up to ~10⁵ yrs. For low-mass protostars, disc masses tend to increase with both age and protostellar mass. Disc radii range from of order ten to a few hundred au, grow in size on timescales < 10⁴ yr, and are smaller around lower-mass protostars. The radial surface density profiles of isolated protostellar discs are flatter than the minimum mass solar nebula model, typically scaling as Σ ∝ r⁻¹. Disc to protostar mass ratios rarely exceed two, with a typical range of M_d/M_∗ = 0.1 – 1 to ages < 10⁴ yrs and decreasing thereafter. We quantify the relative orientation angles of
circumstellar discs and the orbit of bound pairs of protostars, finding a preference for alignment that strengths with decreasing separation. We also investigate how the orientations of the outer parts of discs differ from the protostellar and inner disc spins for isolated protostars and pairs.

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Animation available at: [http://www.astro.ex.ac.uk/people/mbate/Animations/](http://www.astro.ex.ac.uk/people/mbate/Animations/)

### Magnetic fields at the onset of high-mass star formation

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**Context:** The importance of magnetic fields at the onset of star formation related to the early fragmentation and collapse processes is largely unexplored today.

**Aims:** We want to understand the magnetic field properties at the earliest evolutionary stages of high-mass star formation.

**Methods:** The Atacama Large Millimeter Array is used at 1.3 mm wavelength in full polarization mode to study the polarized emission and by that the magnetic field morphologies and strengths of the high-mass starless region IRDC 18310-4.

**Results:** The polarized emission is clearly detected in four sub-cores of the region. In general it shows a smooth distribution, also along elongated cores. Estimating the magnetic field strength via the Davis-Chandrasekhar-Fermi method and following a structure function analysis, we find comparably large magnetic field strengths between ~0.6 and 3.7 mG. Comparing the data to spectral line observations, the turbulent-to-magnetic energy ratio is low, indicating that turbulence does not significantly contribute to the stability of the gas clump. A mass-to-flux ratio around the critical value 1.0 – depending on column density – indicates that the region starts to collapse which is consistent with the previous spectral line analysis of the region.

**Conclusions:** While this high-mass region is collapsing and thus at the verge of star formation, the high magnetic field values and the smooth spatial structure indicate that the magnetic field is important for the fragmentation and collapse process. This single case study can only be the starting point for larger sample studies of magnetic fields at the onset of star formation.

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[http://www.mpia.de/homes/beuther/papers.html](http://www.mpia.de/homes/beuther/papers.html)

### K2 reveals pulsed accretion driven by the 2 Myr old hot Jupiter CI Tau b

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CI Tau is a young (~2 Myr) classical T Tauri star located in the Taurus star forming region. Radial velocity observations indicate it hosts a Jupiter-sized planet with an orbital period of approximately 9 days. In this work, we
analyze time series of CI Tau’s photometric variability as seen by K2. The lightcurve reveals the stellar rotation period to be \(\sim 6.6\) d. Although there is no evidence that CI Tau b transits the host star, a \(\sim 9\) d signature is also present in the lightcurve. We believe this is most likely caused by planet-disk interactions which perturb the accretion flow onto the star, resulting in a periodic modulation of the brightness with the \(\sim 9\) d period of the planet’s orbit.

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Pebble isolation mass — scaling law and implications for the formation of super-Earths and gas giants

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The growth of a planetary core by pebble accretion stops at the so called pebble isolation mass, when the core generates a pressure bump that traps drifting pebbles outside its orbit. If the isolation mass is very small, then gas accretion is protracted and the planet remains at a few Earth masses with a mainly solid composition. For larger values of the pebble isolation mass, the planet might be able to accrete gas from the protoplanetary disc and grow into a gas giant. Previous works have determined a scaling of the pebble isolation mass with cube of the disc aspect ratio. Here we expand on previous measurements and explore the dependency of the pebble isolation mass on all relevant parameters of the protoplanetary disc. We use 3D hydrodynamical simulations to measure the pebble isolation mass and derive a simple scaling law that captures the dependence on the local disc structure and the turbulent viscosity parameter \(\alpha\). We find that small pebbles, coupled to the gas, with Stokes number \(\tau_f < 0.005\) can drift through the partial gap at pebble isolation mass. However, as the planetary mass increases, particles must be decreasingly smaller to penetrate through the pressure bump. Turbulent diffusion of particles, however, can lead to an increase of the pebble isolation mass by a factor of two, depending on the strength of the background viscosity and on the pebble size. We finally explore the implications of the new scaling law of the pebble isolation mass on the formation of planetary systems by numerically integrating the growth and migration pathways of planets in evolving protoplanetary discs. Compared to models neglecting the dependence of the pebble isolation mass on the -viscosity, our models including this effect result in larger core masses for giant planets. These larger core masses are more akin to the core masses of the giant planets in the Solar System.

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Sulphur monoxide exposes a potential molecular disk wind from the planet-hosting disk around HD 100546

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Sulphur-bearing volatiles are observed to be significantly depleted in interstellar and circumstellar regions. This missing sulphur is postulated to be mostly locked up in refractory form. With ALMA we have detected sulphur monoxide (SO), a known shock tracer, in the HD 100546 protoplanetary disk. Two rotational transitions: \(J = 7_7 - 6_6\) (301.286 GHz) and \(J = 7_8 - 6_7\) (304.078 GHz) are detected in their respective integrated intensity maps. The stacking of these transitions results in a clear 5\(\sigma\) detection in the stacked line profile. The emission is compact but is spectrally resolved and the line profile has two components. One component peaks at the source velocity and the other is blue-shifted by 5 km s\(^{-1}\). The kinematics and spatial distribution of the SO emission are not consistent with that
expected from a purely Keplerian disk. We detect additional blue-shifted emission that we attribute to a disk wind. The disk component was simulated using LIME and a physical disk structure. The disk emission is asymmetric and best fit by a wedge of emission in the north east region of the disk coincident with a ‘hot-spot’ observed in the CO $J = 3 – 2$ line. The favoured hypothesis is that a possible inner disk warp (seen in CO emission) directly exposes the north-east side of the disk to heating by the central star, creating locally the conditions to launch a disk wind. Chemical models of a disk wind will help to elucidate why the wind is particularly highlighted in SO emission and whether a refractory source of sulphur is needed. An alternative explanation is that the SO is tracing an accretion shock from a circumplanetary disk associated with the proposed protoplanet embedded in the disk at 50 au. We also report a non-detection of SO in the protoplanetary disk around HD 97048.

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The lithium-rotation connection in the 125 Myr-old Pleiades cluster

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The evolution of lithium abundance over a star’s lifetime is indicative of transport processes operating in the stellar interior. We revisit the relationship between lithium content and rotation rate previously reported for cool dwarfs in the Pleiades cluster. We derive new LiI 670.8 nm equivalent width measurements from high-resolution spectra obtained for low-mass Pleiades members. We combine these new measurements with previously published ones, and use the Kepler/K2 rotational periods recently derived for Pleiades cool dwarfs to investigate the lithium-rotation connection in this 125 Myr-old cluster. The new data confirm the correlation between lithium equivalent width and stellar spin rate for a sample of 51 early K-type members of the cluster, where fast rotating stars are systematically lithium-rich compared to slowly rotating ones. The correlation is valid for all stars over the (J-Ks) color range 0.50-0.70 mag, corresponding to a mass range from about 0.75 to 0.90 M⊙, and may extend down to lower masses. We argue that the dispersion in lithium equivalent widths observed for cool dwarfs in the Pleiades cluster reflects an intrinsic scatter in lithium abundances, and suggest that the physical origin of the lithium dispersion pattern is to be found in the pre-main sequence rotational history of solar-type stars.

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The dense cores and filamentary structure of the molecular cloud in Corona Australis. Herschel SPIRE and PACS observations from the Herschel Gould Belt Survey

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We present a catalogue of prestellar and starless cores within the Corona Australis molecular cloud using photometric data from the Herschel Space Observatory. At a distance of $d \sim 130$ pc, Corona Australis is one of the closest star-forming regions. Herschel has taken multi-wavelength data of Corona Australis with both the SPIRE and PACS photometric cameras in a parallel mode with wavelengths in the range 70 µm to 500 µm. A complete sample of starless and prestellar cores and embedded protostars is identified. Other results from the Herschel Gould Belt Survey have shown spatial correlation between the distribution of dense cores and the filamentary structure within the molecular clouds. We go further and show correlations between the properties of these cores and their spatial distribution within the clouds, with a particular focus on the mass distribution of the dense cores with respect to their filamentary proximity. We find that only lower-mass starless cores form away from filaments, while all of the higher-mass prestellar cores form in close proximity to, or directly on the filamentary structure. This result supports the paradigm that prestellar cores mostly form on filaments. We analyse the mass distribution across the molecular cloud, finding evidence that the region around the Coronet appears to be at a more dynamically advanced evolutionary stage to the rest of the clumps within the cloud.

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The radio outburst from a massive (proto)star: When accretion turns into ejection
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Recent observations of the massive young stellar object S255 NIRS 3 have revealed a large increase in both methanol maser flux density and IR emission, which have been interpreted as the result of an accretion outburst, possibly due to instabilities in a circumstellar disk. This indicates that this type of accretion events could be common in young/forming early-type stars as well as in their lower-mass siblings and supports the idea that accretion onto the star may occur in a non-continuous way.

As accretion and ejection are believed to be tightly associated phenomena, we wished to confirm the accretion interpretation of the outburst in S255 NIRS 3 by detecting the corresponding burst of the associated thermal jet. We monitored the radio continuum emission from S255 NIRS 3 at four bands using the Karl G. Jansky Very Large Array. The millimeter continuum emission was also observed with both the Northern Extended Millimeter Array of IRAM and the Atacama Large Millimeter and submillimeter Array. We have detected an exponential increase of the radio flux density from 6 to 45 GHz starting right after July 10, 2016, namely ~13 months after the estimated onset of the IR outburst. This is the first ever detection of a radio burst associated with an IR accretion outburst from a young stellar object. The flux density at all observed centimeter bands can be reproduced with a simple expanding jet model. At millimeter wavelengths we infer a marginal flux increase with respect to literature values and we show this is due to free-free emission from the radio jet. Our model fits indicate a significant increase of the jet opening angle and ionized mass loss rate with time. For the first time, we can estimate the ionization fraction in the jet and conclude that this must be low (<14%), lending strong support to the idea that the neutral component is dominant in thermal jets. Our findings strongly suggest that recurrent accretion+ejection episodes may be the main route to the formation of massive stars.

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Binary energy source of the HH 250 outflow and its circumstellar environment

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Herbig-Haro flows are signposts of recent major accretion and outflow episodes. We aim to determine the nature and properties of the little-known outflow source HH 250-IRS, which is embedded in the Aquila clouds. We have obtained adaptive optics-assisted \(L\)-band images with the NACO instrument on the Very Large Telescope (VLT), together with \(N\)– and \(Q\)–band imaging with VISIR also on the VLT. Using the SINFONI instrument on the VLT we carried out \(H\)– and \(K\)–band integral field spectroscopy of HH 250-IRS, complemented with spectra obtained with the SpeX instrument at the InfraRed Telescope Facility (IRTF) in the \(JHKL\) bands. Finally, the SubMillimeter Array (SMA) interferometer was used to study the circumstellar environment of HH 250-IRS at 225 and 351 GHz with CO (2-1) and CO (3-2) maps and 0.9 mm and 1.3 mm continuum images. The HH 250-IRS source is resolved into a binary with 0.53 arcsec separation, corresponding to 120 AU at the adopted distance of 225 pc. The individual components show heavily veiled spectra with weak CO absorption indicative of late-type stars. Both are Class I sources, but their spectral energy distributions between 1.5 \(\mu m\) and 19 \(\mu m\) differ markedly and suggest the existence of a large cavity around one of the components. The millimeter interferometric observations indicate that the gas mainly traces a circumbinary envelope or disk, while the dust emission is dominated by one of the circumstellar envelopes. HH 250 IRS is a new addition to the handful of multiple systems where the individual stellar components, the circumstellar disks and a circumbinary disk can be studied in detail, and a rare case among those systems in which a Herbig-Haro flow is present.

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The ionizing source of the bipolar HII region S106: a close massive binary

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S106 is one of the best known bipolar HII regions, thoroughly studied and modelled at infrared, submillimeter and millimeter wavelengths, and it is one of the nearest examples of the late stages of massive star formation in which the newly formed star that ionizes it is still surrounded by vast amounts of gas and dust. However, little is known about its heavily obscured central source, S106IR. The possible binarity of the central source is investigated, which is considered to be likely given the high binarity fraction among massive stars. We have carried out visible and near-infrared photometric monitoring looking for short-term variability, with special interest in that related to the presence of a close binary companion to S106IR that may produce periodic eclipses or tidal distortion of the shape of the members of the system. A periodic variability of S106IR in the \(J\) band is found with a period of 5.0 days and an amplitude of about 0.1 mag. The light curve displays a slow rise from minimum to maximum followed by a steep decrease, and can be well reproduced by a close binary system composed of two stars with different luminosity orbiting each other in an elliptical orbit of moderate eccentricity. S106IR also shows hints of short-term variability possibly related to accretion. We also report variability of four other stars previously classified as members of the S106 cluster, all of which are strong X-ray emitters. The newly discovered close binarity of S106IR adds a new element to the modeling of the nebula and to the understanding of the dynamics of the gas around the ionizing source, which suggests that the components of the binary are accreting via a circumbinary disk. Binarity also helps to explain the apparent mismatch between the spectral type of the ionizing source inferred from the nebular spectrum and its high brightness at near-infrared wavelengths.

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The embedded ring-like feature and star formation activities in G35.673-00.847

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Rings and gaps in the disc around Elias 24 revealed by ALMA

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We present Atacama Large Millimeter/sub-millimeter Array (ALMA) Cycle 2 observations of the 1.3 mm dust continuum emission of the protoplanetary disc surrounding the T Tauri star Elias 24 with an angular resolution of ~0′′2 (~28 au). The dust continuum emission map reveals a dark ring at a radial distance of 0′′47 (~65 au) from the central star, surrounded by a bright ring at 0′′58 (~81 au). In the outer disc, the radial intensity profile shows two inflection points at 0′′71 and 0′′87 (~99 and 121 au respectively). We perform global three-dimensional smoothed
particle hydrodynamic gas/dust simulations of discs hosting a migrating and accreting planet. Combining the dust density maps of small and large grains with three dimensional radiative transfer calculations, we produce synthetic ALMA observations of a variety of disc models in order to reproduce the gap- and ring-like features observed in Elias 24. We find that the dust emission across the disc is consistent with the presence of an embedded planet with a mass of $\sim 0.7 M_J$ at an orbital radius of $\sim 60$ au. Our model suggests that the two inflection points in the radial intensity profile are due to the inward radial motion of large dust grains from the outer disc. The surface brightness map of our disc model provides a reasonable match to the gap- and ring-like structures observed in Elias 24, with an average discrepancy of $\sim 5\%$ of the observed fluxes around the gap region.

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The structure and spectrum of the accretion shock in the atmospheres of young stars

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The structure and spectrum of the accretion shock have been self-consistently simulated for a wide range of parameters typical for Classical T Tauri Stars (CTTS). Radiative cooling of the shocked gas was calculated, taking into account the self-absorption and non-equilibrium (time-dependent) effects in the level populations. These effects modify the standard cooling curve for an optically thin plasma in coronal equilibrium, however the shape of high-temperature ($T > 3 \times 10^5$ K) part of the curve remains unchanged. The applied methods allow us to smoothly describe the transition from the cooling flow to the hydrostatic stellar atmosphere. Thanks to this approach, it has been found that the narrow component of He II lines is formed predominantly in the irradiated stationary atmosphere (hotspot), i.e. at velocities of the settling gas $< 2$ km s$^{-1}$. The structure of the pre-shock region is calculated simultaneously with the heated atmosphere. The simulation shows that the pre-shock gas produces a noticeable emission component in He II lines and practically does not manifest itself in He I lines ($\lambda\lambda 5876, 10830$ Å). The UV spectrum of the hotspot is distorted by the pre-shock gas, namely numerous red-shifted emission and absorption lines overlap each other forming a pseudo-continuum. The spectrum of the accretion region at high pre-shock densities $\sim 10^{14}$ cm$^{-3}$ is fully formed in the in-falling gas and can be qualitatively described as a spectrum of a star with an effective temperature derived from the Stefan-Boltzmann law via the full energy flux.

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VLBA Determination of the Distance to Nearby Star-forming Regions. VIII. The LkH\(\alpha\) 101 cluster

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The LkH\(\alpha\) 101 cluster takes its name from its more massive member, the LkH\(\alpha\) 101 star, which is an $\sim 15 M_\odot$ star whose true nature is still unknown. The distance to the LkH\(\alpha\) 101 cluster has been controversial for the last few decades, with estimated values ranging from 160 to 800 pc. We have observed members and candidate members of the LkH\(\alpha\) 101 cluster with signs of magnetic activity, using the Very Long Baseline Array, in order to measure their trigonometric parallax and, thus, obtain a direct measurement of their distances. A young star member, LkH\(\alpha\) 101
VLA J043001.15+351724.6, was detected at four epochs as a single radio source. The best fit to its displacement on the plane of the sky yields a distance of $535 \pm 29$ pc. We argue that this is the distance to the LkHα 101 cluster.

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A spectroscopic survey of the youngest field stars in the solar neighborhood. II. The optically faint sample

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Star formation in the solar neighborhood is mainly traced by young stars in open clusters, associations, and in the field, which can be identified, for example, by their X-ray emission. The determination of stellar parameters for the optical counterparts of X-ray sources is crucial for a full characterization of these stars. This work extends the spectroscopic study of the RasTyc sample, obtained by the cross-correlation of the TYCHO and ROSAT All-Sky Survey catalogs, to stars fainter than $V = 9.5$ mag and aims to identify sparse populations of young stars in the solar neighborhood. We acquired 625 high-resolution spectra for 443 presumably young stars with four different instruments in the northern hemisphere. The radial and rotational velocity ($v \sin i$) of our targets were measured by means of the cross-correlation technique, which is also helpful to discover single-lined (SB1), double-lined spectroscopic binaries (SB2), and multiple systems. We used the code ROTFIT to perform an MK spectral classification and to determine the atmospheric parameters ($T_{\text{eff}}$, log $g$, [Fe/H]) and $v \sin i$ of the single stars and SB1 systems. For these objects, we used the spectral subtraction of slowly rotating templates to measure the equivalent widths of the Hα and Li i 6708 Å lines, which enabled us to derive their chromospheric activity level and lithium abundance. We made use of Gaia DR1 parallaxes and proper motions to locate the targets in the Hertzsprung-Russell (HR) diagram and to compute the space velocity components of the youngest objects. We find a remarkable percentage (at least 35 %) of binaries and multiple systems. On the basis of the lithium abundance, the sample of single stars and SB1 systems appears to be mostly ($\sim 60 \%$) composed of stars younger than the members of the UMa cluster. The remaining sources are in the age range between the UMa and Hyades clusters ($\sim 20 \%$) or older ($\sim 20 \%$). In total, we identify 42 very young (PMS-like) stars, which lie above or very close to the Pleiades upper envelope of the lithium abundance. A significant percentage ($\sim 12 \%$) of evolved stars (giants and subgiants) is also present in our sample. Some of these stars ($\sim 36 \%$) are also lithium rich ($A(\text{Li}) > 1.4$).

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A Model for Protostellar Cluster Luminosities and the Impact on the CO-H$_2$ Conversion Factor

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We construct a semi-analytic model to study the effect of far-ultraviolet (FUV) radiation on gas chemistry from embedded protostars. We use the Protostellar Luminosity Function (PLF) formalism of Offner & McKee (2011) to calculate the total, FUV, and ionizing cluster luminosity for various protostellar accretion histories and cluster sizes. We compare the model predictions with surveys of Gould Belt star-forming regions and find the Tapered Turbulent Core model matches best the mean luminosities and the spread in the data. We combine the cluster model with the photo-dissociation region astrochemistry code, 3D-PDR, to compute the impact of the FUV luminosity from embedded
protostars on the CO to H$_2$ conversion factor, $X_{\text{CO}}$, as a function of cluster size, gas mass and star formation efficiency. We find that $X_{\text{CO}}$ has a weak dependence on the FUV radiation from embedded sources for large clusters due to high cloud optical depths. In smaller and more efficient clusters the embedded FUV increases $X_{\text{CO}}$ to levels consistent with the average Milky Way values. The internal physical and chemical structure of the cloud are significantly altered, and $X_{\text{CO}}$ depends strongly on the protostellar cluster mass for small efficient clouds.

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BANYAN. XI. The BANYAN Σ multivariate Bayesian algorithm to identify members of young associations within 150 pc

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BANYAN Σ is a new Bayesian algorithm to identify members of young stellar associations within 150 pc of the Sun. It includes 27 young associations with ages in the range ~1–800 Myr, modelled with multivariate Gaussians in 6-dimensional XYZUVW space. It is the first such multi-association classification tool to include the nearest sub-groups of the Sco-Cen OB star-forming region, the IC 2602, IC 2391, Pleiades and Platais 8 clusters, and the ρ Ophiuchi, Corona Australis, and Taurus star-formation regions. A model of field stars is built from a mixture of multivariate Gaussians based on the Besançon Galactic model. The algorithm can derive membership probabilities for objects with only sky coordinates and proper motion, but can also include parallax and radial velocity measurements, as well as spectrophotometric distance constraints from sequences in color-magnitude or spectral type-magnitude diagrams.

BANYAN Σ benefits from an analytical solution to the Bayesian marginalization integrals that makes it more accurate and significantly faster than its predecessor BANYAN II. A contamination versus hit rate analysis is presented and demonstrates that BANYAN Σ achieves a better classification performance than other moving group classification tools, especially in terms of cross-contamination between young associations. An updated list of bona fide members in the 27 young associations, augmented by the Gaia-DR1 release, are presented. This new tool will make it possible to analyze large data sets such as the upcoming Gaia-DR2 to identify new young stars. IDL and Python versions of BANYAN Σ are made available with this publication.

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Distributed star formation throughout the Galactic Center cloud Sgr B2

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We report ALMA observations with resolution \( \sim 0'5 \) at 3 mm of the extended Sgr B2 cloud in the Central Molecular Zone (CMZ). We detect 271 compact sources, most of which are smaller than 5000 AU. By ruling out alternative possibilities, we conclude that these sources consist of a mix of hypercompact HII regions and young stellar objects (YSOs). Most of the newly-detected sources are YSOs with gas envelopes which, based on their luminosities, must contain objects with stellar masses \( M_\star \gtrsim 8 M_\odot \). Their spatial distribution spread over a \( \sim 12 \times 3 \) pc region demonstrates that Sgr B2 is experiencing an extended star formation event, not just an isolated ‘starburst’ within the protocluster regions. Using this new sample, we examine star formation thresholds and surface density relations in Sgr B2. While all of the YSOs reside in regions of high column density \( (N(H_2) \gtrsim 2 \times 10^{23} \text{ cm}^{-2}) \), not all regions of high column density contain YSOs. The observed column density threshold for star formation is substantially higher than that in solar vicinity clouds, implying either that high-mass star formation requires a higher column density or that any star formation threshold in the CMZ must be higher than in nearby clouds. The relation between the surface density of gas and stars is incompatible with extrapolations from local clouds, and instead stellar densities in Sgr B2 follow a linear \( \Sigma_\star = \Sigma_{\text{gas}} \) relation, shallower than that observed in local clouds. Together, these points suggest that a higher volume density threshold is required to explain star formation in CMZ clouds.

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**An ALMA study of the Orion Integral Filament: I. Evidence for narrow fibers in a massive cloud**

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Are all filaments bundles of fibers? To address this question, we have investigated the gas organization within the paradigmatic Integral Shape Filament (ISF). We combined two new ALMA Cycle 3 mosaics with previous IRAM 30m observations to produce a high-dynamic range \( N_2H^+ (1-0) \) emission map of the ISF tracing its high-density material and velocity structure down to scales of 0.009 pc. From the analysis of the gas kinematics, we identify a total of 55 dense fibers in the central region of the ISF. Independently of their location, these fibers are characterized by transonic internal motions, lengths of \( \sim 0.15 \) pc, and masses per-unit-length close to those expected in hydrostatic equilibrium. The ISF fibers are spatially organized forming a dense bundle with multiple hub-like associations likely shaped by the local gravitational potential. Within this complex network, the ISF fibers show a compact radial emission profile with
a median FWHM of 0.035 pc systematically narrower than the previously proposed universal 0.1 pc filament width. Our ALMA observations reveal complex bundles of fibers in the ISF, suggesting strong similarities between the internal substructure of this massive filament and previously studied lower-mass objects. The fibers show identical dynamic properties in both low- and high-mass regions, and their widespread detection suggests a preferred organizational mechanism of gas in which the physical fiber dimensions (width and length) are self-regulated depending on their intrinsic gas density. Combined with previous works, we identify a systematic increase of the surface density of fibers as a function of the total mass per-unit-length in filamentary clouds. Based on this empirical correlation, we propose a unified star-formation scenario where the observed differences between low- and high-mass clouds emerge naturally from the initial concentration of fibers.

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On the Rotation of Supermassive Stars
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Supermassive stars born from pristine gas in atomically-cooled haloes are thought to be the progenitors of supermassive black holes at high redshifts. However, the way they accrete their mass is still an unsolved problem. In particular, for accretion to proceed, a large amount of angular momentum has to be extracted from the collapsing gas. Here, we investigate the constraints stellar evolution imposes on this angular momentum problem. We present an evolution model of a supermassive Population III star including simultaneously accretion and rotation. We find that, for supermassive stars to form by accretion, the accreted angular momentum has to be about 1% of the Keplerian angular momentum. This tight constraint comes from the ΩΓ-limit, at which the combination of radiation pressure and centrifugal force cancels gravity. It implies that supermassive stars are slow rotators, with a surface velocity less than 10 – 20% of their first critical velocity, at which the centrifugal force alone cancels gravity. At such low velocities, the deformation of the star due to rotation is negligible.

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The stellar IMF from Isothermal MHD Turbulence
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We address the turbulent fragmentation scenario for the origin of the stellar initial mass function (IMF), using a large set of numerical simulations of randomly driven supersonic MHD turbulence. The turbulent fragmentation model successfully predicts the main features of the observed stellar IMF assuming an isothermal equation of state without any stellar feedback. As a test of the model, we focus on the case of a magnetized isothermal gas, neglecting stellar feedback, while pursuing a large dynamic range in both space and timescales covering the full spectrum of stellar masses from brown dwarfs to massive stars. Our simulations represent a generic 4 pc region within a typical Galactic molecular cloud, with a mass of 3000 Msun and an rms velocity 10 times the isothermal sound speed and 5 times the average Alfven velocity, in agreement with observations. We achieve a maximum resolution of 50 au and a maximum
duration of star formation of 4.0 Myr, forming up to a thousand sink particles whose mass distribution closely matches the observed stellar IMF. A large set of medium-size simulations is used to test the sink particle algorithm, while larger simulations are used to test the numerical convergence of the IMF and the dependence of the IMF turnover on physical parameters predicted by the turbulent fragmentation model. We find a clear trend toward numerical convergence and strong support for the model predictions, including the initial time evolution of the IMF. We conclude that the physics of isothermal MHD turbulence is sufficient to explain the origin of the IMF.

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Where can a Trappist-1 planetary system be produced?

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We study the evolution of protoplanetary discs that would have been precursors of a Trappist-1 like system under the action of accretion and external photoevaporation in different radiation environments. Dust grains swiftly grow above the critical size below which they are entrained in the photoevaporative wind, so although gas is continually depleted, dust is resilient to photoevaporation after only a short time. This means that the ratio of the mass in solids (dust plus planetary) to the mass in gas rises steadily over time. Dust is still stripped early on, and the initial disc mass required to produce the observed 4 $M_\odot$ of Trappist-1 planets is high. For example, assuming a Fatuzzo & Adams (2008) distribution of UV fields, typical initial disc masses have to be >30% of the stellar (which are still Toomre Q stable) for the majority of similar mass M dwarfs to be viable hosts of the Trappist-1 planets. Even in the case of the lowest UV environments observed, there is a strong loss of dust due to photoevaporation at early times from the weakly bound outer regions of the disc. This minimum level of dust loss is a factor two higher than that which would be lost by accretion onto the star during 10 Myr of evolution. Consequently even in these least irradiated environments, discs that are viable Trappist-1 precursors need to be initially massive (>10% of the stellar mass).

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Evolution of Magnetic Fields in Collapsing Star-forming Clouds under Different Environments

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In nearby star-forming clouds, amplification and dissipation of the magnetic field are known to play crucial roles in the star-formation process. The star-forming environment varies from place to place and era to era in galaxies. In the present study, amplification and dissipation of magnetic fields in star-forming clouds are investigated under different environments using magnetohydrodynamics (MHD) simulations. We consider various star-forming environments in combination with the metallicity and the ionization strength, and prepare prestellar clouds having two different mass-to-flux ratios. We calculate the cloud collapse until protostar formation using ideal and non-ideal (inclusion and exclusion of Ohmic dissipation and ambipolar diffusion) MHD calculations to investigate the evolution of the magnetic field. We perform 288 runs in total and show the diversity of the density range within which the magnetic field effectively dissipates, depending on the environment. In addition, the dominant dissipation process (Ohmic dissipation or ambipolar diffusion) is shown to strongly depend on the star-forming environment. Especially, for the primordial case, magnetic field rarely dissipates without ionization source, while it efficiently dissipates when very weak ionization sources exist in the surrounding environment. The results of the present study help to clarify star formation in various environments.
Probing Episodic Accretion in Very Low Luminosity Objects
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Episodic accretion has been proposed as a solution to the long-standing luminosity problem in star formation; however, the process remains poorly understood. We present observations of line emission from N$_2$H$^+$ and CO isotopologues using the Atacama Large Millimeter/submillimeter Array (ALMA) in the envelopes of eight Very Low Luminosity Objects (VeLLOs). In five of the sources the spatial distribution of emission from N$_2$H$^+$ and CO isotopologues shows a clear anti-correlation. It is proposed that this is tracing the CO snow line in the envelopes: N$_2$H$^+$ emission is depleted toward the center of these sources in contrast to the CO isotopologue emission which exhibits a peak. The positions of the CO snow lines traced by the N$_2$H$^+$ emission are located at much larger radii than those calculated using the current luminosities of the central sources. This implies that these five sources have experienced a recent accretion burst because the CO snow line would have been pushed outwards during the burst due to the increased luminosity of the central star. The N$_2$H$^+$ and CO isotopologue emission from DCE161, one of the other three sources, is most likely tracing a transition disk at a

CO and dust properties in the TW Hya disk from high-resolution ALMA observations
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We analyze high angular resolution ALMA observations of the TW Hya disk to place constraints on the CO and dust properties. We present new, sensitive observations of the $^{12}$CO J=3–2 line at a spatial resolution of 8 AU (0′′14). The CO emission exhibits a bright inner core, a shoulder at r ≈ 70 AU, and a prominent break in slope at r ≈ 90 AU. Radiative transfer modeling is used to demonstrate that the emission morphology can be reasonably reproduced with a $^{12}$CO column density profile featuring a steep decrease at r ≈ 15 AU and a secondary bump peaking at r ≈ 70 AU. Similar features have been identified in observations of rarer CO isotopologues, which trace heights closer to
the midplane. Substructure in the underlying gas distribution or radially varying CO depletion that affects much of the disk’s vertical extent may explain the shared emission features of the main CO isotopologues. We also combine archival 1.3 mm and 870 μm continuum observations to produce a spectral index map at a spatial resolution of 2 AU. The spectral index rises sharply at the continuum emission gaps at radii of 25, 41, and 47 AU. This behavior suggests that the grains within the gaps are no larger than a few millimeters. Outside the continuum gaps, the low spectral index values of $\alpha \approx 2$ indicate either that grains up to centimeter size are present, or that the bright continuum rings are marginally optically thick at millimeter wavelengths.

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The Extraordinary Outburst in the Massive Protostellar System NGC6334I-MM1: Emergence of Strong 6.7 GHz Methanol Masers

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We report the first sub-arcsecond VLA imaging of 6 GHz continuum, methanol maser, and excited-state hydroxyl maser emission toward the massive protostellar cluster NGC6334I following the recent 2015 outburst in (sub)millimeter continuum toward MM1, the strongest (sub)millimeter source in the protocluster. In addition to detections toward the previously known 6.7 GHz Class II methanol maser sites in the hot core MM2 and the UCHII region MM3 (NGC6334F), we find new maser features toward several components of MM1, along with weaker features $\sim 1''$ north, west, and southwest of MM1, and toward the non-thermal radio continuum source CM2. None of these areas have heretofore exhibited Class II methanol maser emission in three decades of observations. The strongest MM1 masers trace a dust cavity, while no masers are seen toward the strongest dust sources MM1A, 1B and 1D. The locations of the masers are consistent with a combination of increased radiative pumping due to elevated dust grain temperature following the outburst, the presence of infrared photon propagation cavities, and the presence of high methanol column densities as indicated by ALMA images of thermal transitions. The non-thermal radio emission source CM2 ($2''$ north of MM1) also exhibits new maser emission from the excited 6.035 and 6.030 GHz OH lines. Using the Zeeman effect, we measure a line-of-sight magnetic field of $+0.5$ to $+3.7$ mG toward CM2. In agreement with previous studies, we also detect numerous methanol and excited OH maser spots toward the UCHII region MM3, with predominantly negative line-of-sight magnetic field strengths of $-2$ to $-5$ mG and an intriguing south-north field reversal.

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V2492 Cygni: Optical BVRI variability during the period 2010-2017

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Results from BVRI photometric observations of the young stellar object V2492 Cyg collected during the period from August 2010 to December 2017 are presented. The star is located in the field of the Pelican Nebula and it was discovered in 2010 due to its remarkable increase in the brightness by more than 5 mag in R-band. According to the first hypothesis of the variability V2492 Cyg is an FUor candidate. During subsequent observations it was reported that the star shows the characteristics inherent to EXor- and UXor-type variables. The optical data show that during the whole time of observations the star exhibits multiple large amplitude increases and drops in the brightness. In the beginning of 2017 we registered a significant increase in the optical brightness of V2492 Cyg, which seriously exceeds the maximal magnitudes registered after 2010.

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Dust Coagulation Regulated by Turbulent Clustering in Protoplanetary Disks
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The coagulation of dust particles is a key process in planetesimal formation. However, the radial drift and bouncing barriers are not completely resolved, especially for silicate dust. Since the collision velocities of dust particles are regulated by turbulence in a protoplanetary disk, the turbulent clustering should be properly treated. To that end, direct numerical simulations (DNSs) of the Navier Stokes equations are requisite. In a series of papers, Pan & Padoan used a DNS with the Reynolds number \( Re \sim 1000 \). Here, we perform DNSs with up to \( Re = 16100 \), which allow us to track the motion of particles with Stokes numbers of \( 0.01 < St < 0.2 \) in the inertial range. By the DNSs, we confirm that the rms relative velocity of particle pairs is smaller by more than a factor of two, compared to those by Ormel & Cuzzi (2007). The distributions of the radial relative velocities are highly non-Gaussian. The results are almost consistent with those by Pan & Padoan or Pan et al. at low-\( Re \). Also, we find that the sticking rates for equal-sized particles are much higher than those for different-sized particles. Even in the strong-turbulence case with \( \alpha \)-viscosity of \( 10^{-2} \), the sticking rates are as high as \( \geq 50\% \) and the bouncing probabilities are as low as \( \sim 10\% \) for equal-sized particles of \( St \lesssim 0.01 \). Thus, the turbulent clustering plays a significant role for the growth of cm-sized compact aggregates (pebbles) and also enhances the solid abundance, which may lead to the streaming instability in a disk.

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Explaining the luminosity spread in young clusters: proto and pre-main sequence stellar evolution in a molecular cloud environment
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Hertzsprung-Russell diagrams of star forming regions show a large luminosity spread. This is incompatible with well-defined isochrones based on classic non-accreting protostellar evolution models. Protostars do not evolve in isolation of their environment, but grow through accretion of gas. In addition, while an age can be defined for a star forming region, the ages of individual stars in the region will vary. We show how the combined effect of a protostellar age spread, a consequence of sustained star formation in the molecular cloud, and time-varying protostellar accretion for individual protostars can explain the observed luminosity spread. We use a global MHD simulation including a sub-scale sink
particle model of a star forming region to follow the accretion process of each star. The accretion profiles are used to compute stellar evolution models for each star, incorporating a model of how the accretion energy is distributed to the disk, radiated away at the accretion shock, or incorporated into the outer layers of the protostar. Using a modelled cluster age of 5 Myr we naturally reproduce the luminosity spread and find good agreement with observations of the Collinder 69 cluster, and the Orion Nebular Cluster. It is shown how stars in binary and multiple systems can be externally forced creating recurrent episodic accretion events. We find that in a realistic global molecular cloud model massive stars build up mass over rel-atively long time-scales. This leads to an important conceptual change compared to the classic picture of non-accreting stellar evolution segmented in to low-mass Hayashi tracks and high-mass Henyey tracks.

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The JCMT Transient Survey: Stochastic and Secular Variability of Protostars and Disks In the Sub-Millimeter Observed Over Eighteen Months

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We analyze results from the first eighteen months of monthly sub-mm monitoring of eight star-forming regions in the JCMT Transient Survey. In our search for stochastic variability in 1643 bright peaks, only the previously identified source, EC 53, shows behavior well above the expected measurement uncertainty. Another four sources, two disks and two protostars, show moderately-enhanced standard deviations in brightness, as expected for stochastic variables. For the two protostars, this apparent variability is the result of single epochs that are much brighter than the mean. In our search for secular brightness variations that are linear in time, we measure the fractional brightness change per year for 150 bright peaks, fifty of which are protostellar. The ensemble distribution of slopes is well fit by a normal distribution with $\sigma \sim 0.023$. Most sources are not rapidly brightening or fading in the sub-mm. Comparison against time-randomized realizations shows that the width of the distribution is dominated by the uncertainty in the individual brightness measurements of the sources. A toy model for secular variability reveals that an underlying Gaussian distribution of linear fractional brightness change $\sigma = 0.005$ would be unobservable in the present sample, whereas an underlying distribution with $\sigma = 0.02$ is ruled out. Five protostellar sources, 10% of the protostellar sample, are found to have robust secular measures deviating from a constant flux. The sensitivity to secular brightness variations will improve significantly with a larger time sample, with a factor of two improvement expected by the conclusion of our 36-month survey.

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The Magellanic Bridge cluster NGC 796: Deep optical AO imaging reveals the stellar content and initial mass function of a massive open cluster

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NGC 796 is a massive young cluster located 59 kpc from us in the diffuse intergalactic medium of the 1/5–1/10 Z⊙ Magellanic Bridge, allowing to probe variations in star formation and stellar evolution processes as a function of metallicity in a resolved fashion, providing a link between resolved studies of nearby solar-metallicity and unresolved distant metal-poor clusters located in high-redshift galaxies. In this paper, we present adaptive optics griHα imaging of NGC 796 (at 0.5′′, which is ~0.14 pc at the cluster distance) along with optical spectroscopy of two bright members to quantify the cluster properties. Our aim is to explore if star formation and stellar evolution varies as a function of metallicity by comparing the properties of NGC 796 to higher metallicity clusters. We find from isochronal fitting of the cluster main sequence in the colour-magnitude diagram an age of 20±5 Myr. Based on the cluster luminosity function, we derive a top-heavy stellar initial mass function (IMF) with a slope α = 1.99±0.2, hinting at a metallicity and/or environmental dependence of the IMF which may lead to a top-heavy IMF in the early Universe. Study of the Hα emission line stars reveals that Classical Be stars constitute a higher fraction of the total B-type stars when compared with similar clusters at greater metallicity, providing some support to the chemically homogeneous theory of stellar evolution. Overall, NGC 796 has a total estimated mass of 990±200 M⊙, and a core radius of 1.4±0.3 pc which classifies it as a massive young open cluster, unique in the diffuse interstellar medium of the Magellanic Bridge.

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ALMA observations of the narrow HR 4796A debris ring

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The young A0V star HR 4796A is host to a bright and narrow ring of dust, thought to originate in collisions between planetesimals within a belt analogous to the Solar System’s Edgeworth-Kuiper belt. Here we present high spatial resolution 880 µm continuum images from the Atacama Large Millimeter Array. The 80 au radius dust ring is resolved radially with a characteristic width of 10 au, consistent with the narrow profile seen in scattered light. Our modelling consistently finds that the disk is also vertically resolved with a similar extent. However, this extent is less than the beam size, and a disk that is dynamically very cold (i.e. vertically thin) provides a better theoretical explanation for the narrow scattered light profile, so we remain cautious about this conclusion. We do not detect 12CO J=3–2 emission, concluding that unless the disk is dynamically cold the CO+CO2 ice content of the planetesimals is of order a few percent or less. We consider the range of semi-major axes and masses of an interior planet supposed to cause the ring’s eccentricity, finding that such a planet should be more massive than Neptune and orbit beyond 40 au. Independent of our ALMA observations, we note a conflict between mid-IR pericenter-glow and scattered light imaging interpretations, concluding that models where the spatial dust density and grain size vary around the ring should be explored.

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Structure of Protoplanetary Discs with Magnetically-driven Winds

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We present a new set of analytical solutions to model the steady state structure of a protoplanetary disc with a magnetically-driven wind. Our model implements a parametrization of the stresses involved and the wind launching mechanism in terms of the plasma parameter at the disc midplane, as suggested by the results of recent, local MHD simulations. When wind mass-loss is accounted for, we find that its rate significantly reduces the disc surface density, particularly in the inner disc region. We also find that models that include wind mass-loss lead to thinner dust layers.

As an astrophysical application of our models, we address the case of HL Tau, whose disc exhibits a high accretion rate and efficient dust settling at its midplane. These two observational features are not easy to reconcile with conventional accretion disc theory, where the level of turbulence needed to explain the high accretion rate would prevent a thin dust layer. Our disc model that incorporates both mass-loss and angular momentum removal by a wind is able to account for HL Tau observational constraints concerning its high accretion rate and dust layer thinness.

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The evolution of young HII regions

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High-mass stars form in much richer environments than those associated with isolated low-mass stars, and once they reach a certain mass, produce ionised (HII) regions. The formation of these pockets of ionised gas are unique to the formation of high-mass stars (M > 8 M$_\odot$), and present an excellent opportunity to study the final stages of accretion, which could include accretion through the HII region itself. This study of the dynamics of the gas on both sides of these ionisation boundaries in very young HII regions aims to quantify the relationship between the HII regions and their immediate environments. We present high-resolution (~ 0.5") ALMA observations of nine HII regions selected from the Red MSX Source (RMS) survey with compact radio emission and bolometric luminosities greater than 10$^4$ L$_\odot$. We focus on the initial presentation of the data, including initial results from the radio recombination line H29a, some complementary molecules, and the 256 GHz continuum emission. Of the six (out of nine) regions with H29a detections, two appear to have cometary morphologies with velocity gradients across them, and two appear more spherical with velocity gradients suggestive of infalling ionised gas. The remaining two were either observed at low resolution or had signals that were too weak to draw robust conclusions. We also present a description of the interactions between the ionised and molecular gas (as traced by CS (J=5-4)), often (but not always) finding the HII region had cleared its immediate vicinity of molecules. Of our sample of nine, the observations of the two clusters expected to have the youngest HII regions (from previous radio observations) are suggestive of having infalling motions in the H29a emission, which could be indicative of late stage accretion onto the stars despite the presence of an HII region.

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Evidence for feedback and stellar-dynamically regulated bursty star cluster formation: the case of the Orion Nebula Cluster

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A scenario for the formation of multiple co-eval populations separated in age by about 1 Myr in very young clusters (VYCs, ages less than 10 Myr) and with masses in the range 600 - 20000 $M_\odot$ is outlined. It rests upon a converging inflow of molecular gas building up a first population of pre-main sequence stars. The associated just-formed O stars ionise the inflow and suppress star formation in the embedded cluster. However, they typically eject each other out of the embedded cluster within $10^6$ yr, that is before the molecular cloud filament can be ionised entirely. The inflow of molecular gas can then resume forming a second population. This sequence of events can be repeated maximally over the life-time of the molecular cloud (about 10 Myr), but is not likely to be possible in VYCs with mass $< 300 M_\odot$, because such populations are not likely to contain an O star. Stellar populations heavier than about 2000 $M_\odot$ are likely to have too many O stars for all of these to eject each other from the embedded cluster before they disperse their natal cloud. VYCs with masses in the range 600 - 2000 $M_\odot$ are likely to have such multi-age populations, while VYCs with masses in the range 2000 - 20000 $M_\odot$ can also be composed solely of co-eval, mono-age populations. More massive VYCs are not likely to host sub-populations with age differences of about 1 Myr. This model is applied to the Orion Nebula Cluster (ONC), in which three well-separated pre-main sequences in the color-magnitude diagram of the cluster have recently been discovered. The mass-inflow history is constrained using this model and the number of OB stars ejected from each population are estimated for verification using Gaia data. As a further consequence of the proposed model, the three runaway O star systems, AE Aur, µ Col and ι Ori, are considered as significant observational evidence for stellar-dynamical ejections of massive stars from the oldest population in the ONC. Evidence for stellar-dynamical ejections of massive stars in the currently forming population is also discussed.
Polarized emission is detected in two young nearly edge-on protostellar disks in 343 GHz continuum at \(\sim 50\) au (\(\sim 0''12\)) resolution with Atacama Large Millimeter/submillimeter Array. One disk is in HH 212 (Class 0) and the other in HH 111 (early Class I) protostellar system. Polarization fraction is \(\sim 1\%\). The disk in HH 212 has a radius of \(\sim 60\) au. The emission is mainly detected from the nearside of the disk. The polarization orientations are almost perpendicular to the disk major axis, consistent with either self-scattering or emission by grains aligned with a \textit{poloidal} field around the outer edge of the disk because of optical depth effect and temperature gradient; the presence of a poloidal field would facilitate the launching of a disk wind, for which there is already tentative evidence in the same source. The disk of HH 111 VLA 1 has a larger radius of \(\sim 220\) au and is thus more resolved. The polarization orientations are almost perpendicular to the disk major axis in the nearside, but more along the major axis in the farside, forming roughly half of an elliptical pattern there. It appears that toroidal and poloidal magnetic field may explain the polarization on the near and far side of the disk, respectively. However, it is also possible that the polarization is due to self-scattering. In addition, alignment of dust grains by radiation flux may play a role in the farside. Our observations reveal a diversity of disk polarization patterns that should be taken into account in future modeling efforts.

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Bayesian assessment of moving group membership: importance of models and prior knowledge
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Young nearby moving groups are important and useful in many fields of astronomy such as studying exoplanets, low-mass stars, and the stellar evolution of the early planetary systems over tens of millions of years, which has led to intensive searches for their members. Identification of members depends on the used models sensitively, therefore, careful examination of the models is required. In this study, we investigate the effects of the models used in moving group membership calculations based on a Bayesian framework (e.g., BANYAN II) focusing on the \(\beta\) Pictoris moving group (BPMG). Three improvements for building models are suggested: (1) updating a list of accepted members by re-assessing memberships in terms of position, motion, and age, (2) investigating member distribution functions in XYZ, and (3) exploring field star distribution functions in XYZ and UVW. The effect of each change is investigated, and we suggest using all of these improvements simultaneously in future membership probability calculations. Using this improved MG membership calculation and the careful examination of the age, 57 bona fide members of BPMG are confirmed including 12 new members. We additionally suggest 17 highly probable members.

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Molecular Gas Toward the Gemini OB1 Molecular Cloud Complex II: CO Outflow Candidates with Possible WISE Associations
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We present a large scale survey of CO outflows in the Gem OB1 molecular cloud complex and its surroundings using the Purple Mountain Observatory Delingha 13.7 m telescope. A total of 198 outflow candidates were identified over a large area (\(\sim 58.5\) square degrees), of which 193 are newly detected. Approximately 68\% (134/198) are associated with the Gem OB1 molecular cloud complex, including clouds GGMC 1, GGMC 2, BFS 52, GGMC 3 and GGMC 4. Other regions studied are: Local Arm (Local Lynds, West Front), Swallow, Horn, and Remote cloud. Outflow
candidates in GGMC 1, BFS 52, and Swallow are mainly located at ring-like or filamentary structures. To avoid excessive uncertainty in distant regions ($\gtrsim 3.8$ kpc), we only estimated the physical parameters for clouds in the Gem OB1 molecular cloud complex and in the Local arm. In those clouds, the total kinetic energy and the energy injection rate of the identified outflow candidates are $\lesssim 1\%$ and $\lesssim 3\%$ of the turbulent energy and the turbulent dissipation rate of each cloud, indicating that the identified outflow candidates cannot provide enough energy to balance turbulence of their host cloud at the scale of the entire cloud (several pc to dozens of pc). The gravitational binding energy of each cloud is $\gtrsim 135$ times the total kinetic energy of the identified outflow candidates within the corresponding cloud, indicating that the identified outflow candidates cannot cause major disruptions to the integrity of their host cloud at the scale of the entire cloud.

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Filamentary Fragmentation and Accretion in High-Mass Star-Forming Molecular Clouds

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Filamentary structures are ubiquitous in high-mass star-forming molecular clouds. Their relation with high-mass star formation is still to be understood. Here we report interferometric observations toward 8 filamentary high-mass star-forming clouds. A total of 50 dense cores are identified in these clouds, most of which present signatures of high-mass star formation. Five of them are not associated with any star formation indicators, hence are prestellar core candidates. Evolutionary phases of these cores and their linewidths, temperatures, NH$_3$ abundances, and virial parameters are found to be correlated. In a sub-sample of 4 morphologically well-defined filaments, we find that their fragmentation can not be solely explained by thermal or turbulence pressure support. We also investigate distributions of gas temperatures and non-thermal motions along the filaments, and find a spatial correlation between non-thermal linewidths and star formation activities. We find evidence of gas flows along these filaments, and derive an accretion rate along filaments of $\sim 10^{-4} M_{\odot} \text{yr}^{-1}$. These results suggest a strong relationship between massive filaments and high-mass star formation, through i) filamentary fragmentation in very early evolutionary phases to form dense cores, ii) accretion flows along filaments that are important for the growth of dense cores and protostars, and iii) enhancement of non-thermal motion in the filaments by the feedback or accretion during star formation.

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Molecular reconnaissance of the $\beta$ Pictoris gas disk with the SMA: a low HCN/(CO+CO$_2$) outgassing ratio and predictions for future surveys

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The exocometary origin of CO gas has been confirmed in several extrasolar Kuiper belts, with CO ice abundances consistent with Solar System comets. We here present a molecular survey of the $\beta$ Pictoris belt with the Submillimeter Array (SMA), reporting upper limits for CN, HCN, HCO$^+$, N$_2$H$^+$ and H$_2$CO, as well as for H$_2$S, CH$_3$OH, SiO and DCN from archival ALMA data. Non-detections can be attributed to rapid molecular photodissociation due to the A-star’s strong UV flux. CN is the longest-lasting and most easily detectable molecule after CO in this environment.
We update our NLTE excitation model to include UV fluorescence, finding it plays a key role in CO and CN excitation, and use it to turn the SMA CN/CO flux ratio constraint into an upper limit of \(<2.5\%\) on the HCN/(CO+CO\(_2\)) ratio of outgassing rates. This value is consistent with, but at the low end of, the broad range observed in Solar System comets. If sublimation dominates outgassing, then this low value may be caused by decreased outgassing for the less volatile molecule HCN compared to CO. If instead UV photodesorption or collisional vaporization of unbound grains dominates outgassing, then this low ratio of rates would imply a low ice abundance ratio, which would in turn indicate a variation in cometary cyanide abundances across planetary systems. To conclude, we make predictions for future molecular surveys and show that CN and HCN should be readily detectable with ALMA around \(\beta\) Pictoris for Solar-System-like exocometary compositions.

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An optical parsec-scale jet from a massive young star in the Large Magellanic Cloud

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Highly collimated parsec-scale jets, generally linked to the presence of an accretion disk, are a commonly observed phenomenon from revealed low-mass young stellar objects. In the past two decades, only a very few of these objects have been directly (or indirectly) observed towards high-mass (\(M > 8\ M_\odot\)) young stellar objects, adding to the growing evidence that disk-mediated accretion is a phenomenon also occurring in high-mass stars, the formation mechanism of which is still poorly understood. Of the observed jets from massive young stars, none is in the optical regime (due to these being typically highly obscured by their native material), and none are found outside of the Milky Way. Here, we report the detection of HH 1177, the first extragalactic optical ionized jet originating from a massive young stellar object located in the Large Magellanic Cloud. The jet is highly collimated over the entire measured extent of at least 10 pc, and has a bipolar geometry. The presence of a jet indicates ongoing, disk-mediated accretion, and together with the high degree of collimation, this system is therefore likely to be an up-scaled version of low-mass star formation. We conclude that the physics governing jet launching and collimation is independent of stellar mass.

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Molecular Gas in Debris Disks around Young A-type Stars

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According to the current paradigm of circumstellar disk evolution, gas-rich primordial disks evolve into gas-poor debris disks that are composed of second-generation dust. To explore the transition between these phases, we searched for \(^{12}\text{CO}, \, ^{13}\text{CO}\), and \(^{18}\text{O}\) emission in seven dust-rich debris disks around young A-type stars, using the Atacama Large Millimeter/submillimeter Array (ALMA) in Band 6. We discovered molecular gas in three debris disks. In all of these disks, the 12CO line was optically thick, highlighting the importance of less abundant molecules in reliable mass estimates. By supplementing our target list with literature data, we compiled a volume-limited sample of dust-rich
debris disks around young A-type stars within 150 pc. We obtained a CO detection rate of 11/16 above a $^{12}$CO J = 2-1 line luminosity threshold of $\sim 1.4 \times 10^4$ Jy km s$^{-1}$pc$^2$ in the sample. This high incidence implies that the presence of CO gas in the bright debris disks around young A-type stars is more likely the rule than the exception. Interestingly, dust-rich debris disks around young FG-type stars exhibit, with the same detectability threshold as A-type stars, a significantly lower gas incidence. While the transition from the protoplanetary phase to the debris phase is associated with a drop in the dust content, our results exhibit a large spread in the CO mass in our debris sample, with peak values that are comparable to those in the protoplanetary Herbig Ae disks. In the particularly CO-rich debris systems, the gas may have a primordial origin, which is a characteristic of a hybrid disk.

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Candidate Water Vapor Lines to Locate the H$_2$O Snowline Through High-dispersion Spectroscopic Observations. III. Sub-millimeter H$_2^{16}$O and H$_2^{18}$O Lines

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In this paper, we extend the results presented in our former papers (Notsu et al. 2016, 2017) on using ortho-H$_2^{16}$O line profiles to constrain the location of the H$_2$O snowline in T Tauri and Herbig Ae disks, to include sub-millimeter para-H$_2^{16}$O and ortho- and para-H$_2^{18}$O lines. Since the number densities of the ortho- and para-H$_2^{18}$O molecules are about 560 times smaller than their $^{16}$O analogues, they trace deeper into the disk than the ortho-H$_2^{16}$O lines (down to $z = 0$, i.e., the midplane). Thus these H$_2^{18}$O lines are potentially better probes of the position of the H$_2$O snowline at the disk midplane, depending on the dust optical depth. The values of the Einstein A coefficients of sub-millimeter candidate water lines tend to be lower (typically $< 10^{-4}$ s$^{-1}$) than infrared candidate water lines (Notsu et al. 2017). Thus in the sub-millimeter candidate water line cases, the local intensity from the outer optically thin region in the disk is around 104 times smaller than that in the infrared candidate water line cases. Therefore, in the sub-millimeter lines, especially H$_2^{18}$O and para-H$_2^{16}$O lines with relatively lower upper state energies ($\sim$ a few 100K) can also locate the position of the H$_2$O snowline. We also investigate the possibility of future observations with ALMA to identify the position of the water snowline. There are several candidate water lines that trace the hot water vapor inside the H$_2$O snowline in ALMA Bands 5–10.

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The Delivery of Water During Terrestrial Planet Formation

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The planetary building blocks that formed in the terrestrial planet region were likely very dry, yet water is compar-
atively abundant on Earth. We review the various mechanisms proposed for the origin of water on the terrestrial planets. Various in-situ mechanisms have been suggested, which allow for the incorporation of water into the local planetesimals in the terrestrial planet region or into the planets themselves from local sources, although all of those mechanisms have difficulties. Comets have also been proposed as a source, although there may be problems fitting isotopic constraints, and the delivery efficiency is very low, such that it may be difficult to deliver even a single Earth ocean of water this way. The most promising route for water delivery is the accretion of material from beyond the snow line, similar to carbonaceous chondrites, that is scattered into the terrestrial planet region as the planets are growing. Two main scenarios are discussed in detail. First is the classical scenario in which the giant planets begin roughly in their final locations and the disk of planetesimals and embryos in the terrestrial planet region extends all the way into the outer asteroid belt region. Second is the Grand Tack scenario, where early inward and outward migration of the giant planets implants material from beyond the snow line into the asteroid belt and terrestrial planet region, where it can be accreted by the growing planets. Sufficient water is delivered to the terrestrial planets in both scenarios. While the Grand Tack scenario provides a better fit to most constraints, namely the small mass of Mars, planets may form too fast in the nominal case discussed here. This discrepancy may be reduced as a wider range of initial conditions is explored. Finally, we discuss several more recent models that may have important implications for water delivery to the terrestrial planets.

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Chemical and Physical Picture of IRAS 16293-2422 Source B at a Sub-arcsecond Scale Studied with ALMA

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We have analyzed the OCS, H\textsubscript{2}CS, CH\textsubscript{3}OH, and HCOOCH\textsubscript{3} data observed toward the low-mass protostar IRAS 16293-2422 Source B at a sub-arcsecond resolution with ALMA. A clear chemical differentiation is seen in their distributions; OCS and H\textsubscript{2}CS are extended with a slight rotation signature, while CH\textsubscript{3}OH and HCOOCH\textsubscript{3} are concentrated near the protostar. Such a chemical change in the vicinity of the protostar is similar to the companion (Source A) case. The extended component is interpreted by the infalling-rotating envelope model with a nearly face-on configuration. The radius of the centrifugal barrier of the infalling-rotating envelope is roughly evaluated to be (30–50) au. The observed lines show the inverse P-Cygni profile, indicating the infall motion with in a few 10 au from the protostar. The nearly pole-on geometry of the outflow lobes is inferred from the SiO distribution, and thus, the infalling and outflowing motions should coexist along the line-of-sight to the protostar. This implies that the infalling gas is localized near the protostar and the current launching points of the outflow have an offset from the protostar. A possible mechanism for this configuration is discussed.

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On the spatial distributions of dense cores in Orion B

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We quantify the spatial distributions of dense cores in three spatially distinct areas of the Orion B star-forming region. For L1622, NGC 2068/NGC 2071 and NGC 2023/NGC 2024 we measure the amount of spatial substructure using the Q-parameter and find all three regions to be spatially substructured ($Q < 0.8$). We quantify the amount of mass segregation using $\Lambda_{\text{MSR}}$ and find that the most massive cores are mildly mass segregated in NGC 2068/NGC 2071 ($\Lambda_{\text{MSR}} \sim 2$), and very mass segregated in NGC 2023/NGC 2024 ($\Lambda_{\text{MSR}} = 28^{+13}_{-10}$ for the four most massive cores). Whereas the most massive cores in L1622 are not in areas of relatively high surface density, or deeper gravitational potentials, the massive cores in NGC 2068/NGC 2071 and NGC 2023/NGC 2024 are significantly so. Given the low density (10 cores pc$^{-2}$) and spatial substructure of cores in Orion B, the mass segregation cannot be dynamical. Our results are also inconsistent with simulations in which the most massive stars form via competitive accretion, and instead hint that magnetic fields may be important in influencing the primordial spatial distributions of gas and stars in star-forming regions.

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Modeling CO, CO$_2$, and H$_2$O Ice Abundances in the Envelopes of Young Stellar Objects in the Magellanic Clouds

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Massive young stellar objects (MYSOs) in the Magellanic Clouds show infrared absorption features corresponding to significant abundances of CO, CO$_2$, and H$_2$O ice along the line of sight, with the relative abundances of these ices differing between the Magellanic Clouds and the Milky Way. CO ice is not detected toward sources in the Small Magellanic Cloud, and upper limits put its relative abundance well below sources in the Large Magellanic Cloud and the Milky Way. We use our gas-grain chemical code MAGICKAL, with multiple grain sizes and grain temperatures, and further expand it with a treatment for increased interstellar radiation field intensity to model the elevated dust temperatures observed in the MCs. We also adjust the elemental abundances used in the chemical models, guided by observations of H II regions in these metal-poor satellite galaxies. With a grid of models, we are able to reproduce the relative ice fractions observed in MC MYSOs, indicating that metal depletion and elevated grain temperature are important drivers of the MYSO envelope ice composition. Magellanic Cloud elemental abundances have a subgalactic C/O ratio, increasing H$_2$O ice abundances relative to the other ices; elevated grain temperatures favor CO$_2$ production over H$_2$O and CO. The observed shortfall in CO in the Small Magellanic Cloud can be explained by a combination of reduced carbon abundance and increased grain temperatures. The models indicate that a large variation in radiation field strength is required to match the range of observed LMC abundances. CH$_3$OH abundance is found to be enhanced in low-metallicity models, providing seed material for complex organic molecule formation in the Magellanic Clouds.

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Formation of interstellar methanol ice prior to the heavy CO freeze-out stage

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The formation of methanol (CH$_3$OH) on icy grain mantles during the star formation cycle is mainly associated with the CO freeze-out stage. Yet there are reasons to believe that CH$_3$OH also can form at an earlier period of interstellar
ice evolution in CO-poor and H$_2$O-rich ices. This work focuses on CH$_3$OH formation in a H$_2$O-rich interstellar ice environment following the OH-mediated H-abstraction in the reaction, CH$_4$ + OH. Experimental conditions are systematically varied to constrain the CH$_3$OH formation yield at astronomically relevant temperatures. CH$_4$, O$_2$, and hydrogen atoms are co-deposited in an ultrahigh vacuum chamber at 10–20 K. OH radicals are generated by the H + O$_2$ surface reaction. Temperature programmed desorption – quadrupole mass spectrometry (TPD–QMS) is used to characterize CH$_3$OH formation, and is complemented with reflection absorption infrared spectroscopy (RAIRS) for CH$_3$OH characterization and quantitation. CH$_3$OH formation is shown to be possible by the sequential surface reaction chain, CH$_4$ + OH $\rightarrow$ CH$_3$ + H$_2$O and CH$_3$ + OH $\rightarrow$ CH$_3$OH at 10–20 K. This reaction is enhanced by tunneling, as noted in a recent theoretical investigation (Lamberts et al. 2017). The CH$_3$OH formation yield via the CH$_4$ + OH route versus the CO + H route is approximately 20 times smaller for the laboratory settings studied. The astronomical relevance of the new formation channel investigated here is discussed.

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Is HH 47 slowing down?

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We have used three epochs of red [S II] and H$\alpha$ Hubble Space Telescope (HST) archival images of HH 47 to determine the proper motion velocities of the knots along the jet. With the three available epochs we compute two sets of proper motions (one using the first two epochs, and the second one using the last two epochs). Somewhat surprisingly, we find that the [S II] proper motion velocities show a significant decrease as a function of increasing time. The knots present decelerations of up to $\sim$ 50% over the 14 years covered by the three epochs of HST images. This rather dramatic effect might be a result of a variable ejection direction (which would be consistent with the sinuous morphology of the HH 47 jet), leading to the direct interaction of the knots with the surrounding environment.

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The time-dependent wavelet spectrum of HH 1 and 2

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We have calculated the wavelet spectra of four epochs (spanning $\sim$ 20 yr) of H$\alpha$ and [S II] HST images of HH 1 and 2. From these spectra we calculate the distribution functions of the (angular) radii of the emission structures. We find that the size distributions have maxima (corresponding to the characteristic sizes of the observed structures) with radii that are logarithmically spaced with factors of $\sim$ 2 $\rightarrow$ 3 between the successive peaks. The positions of these peaks generally show small shifts towards larger sizes as a function of time. This result indicates that the structures of HH 1 and 2 have a general expansion (seen at all scales), and/or are the result of a sequence of merging events resulting in the formation of knots with larger characteristic sizes.

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Shaping HR8799’s outer dust belt with an unseen planet
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HR8799 is a benchmark system for direct imaging studies. It hosts two debris belts, which lie internally and externally to four giant planets. This paper considers how the four known planets and a possible fifth planet, interact with the external population of debris through N-body simulations. We find that when only the known planets are included, the inner edge of the outer belt predicted by our simulations is much closer to the outermost planet than recent ALMA observations suggest. We subsequently include a fifth planet in our simulations with a range of masses and semi-major axes, which is external to the outermost known planet. We find that a fifth planet with a mass and semi-major axis of 0.1 MJ and 138 au predicts an outer belt that agrees well with ALMA observations, whilst remaining stable for the lifetime of HR8799 and lying below current direct imaging detection thresholds. We also consider whether inward scattering of material from the outer belt can input a significant amount of mass into the inner belt. We find that for the current age of HR8799, only ~1% of the mass loss rate of the inner disk can be replenished by inward scattering. However we find that the higher rate of inward scattering during the first ~10Myr of HR8799 would be expected to cause warm dust emission at a level similar to that currently observed, which may provide an explanation for such bright emission in other systems at ~10Myr ages.

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A NIKA view of two star-forming infrared dark clouds: dust opacity variations and mass concentration
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The thermal emission of dust grains is a powerful tool for probing cold, dense regions of molecular gas in the interstellar medium, and so constraining dust properties is key to obtaining accurate measurements of dust mass and temperature. By placing constraints on the dust emissivity spectral index, β, towards two star-forming infrared dark clouds – SDC18.888-0.476 and SDC24.489-0.689 – we evaluate the role of mass concentration in the associated star-formation activity. We exploit the simultaneous 1.2 mm and 2.0 mm imaging capability of the NIKA camera on the IRAM 30 m telescope to construct maps of β for both clouds, and by incorporating Herschel observations, we create H₂ column density maps with 13 arcsec angular resolution. While we find no significant systematic radial variations around the most massive clumps in either cloud on >0.1 pc scales, their mean β values are significantly different, with
\[ \bar{\beta} = 2.07 \pm 0.09 \text{ (random)} \pm 0.25 \text{ (systematic)} \] for SDC18.888-0.476 and \[ \bar{\beta} = 1.71 \pm 0.09 \text{ (random)} \pm 0.25 \text{ (systematic)} \] for SDC24.489-0.689. These differences could be a consequence of the very different environments in which both clouds lie, and we suggest that the proximity of SDC18.888-0.476 to the W39 HII region may raise \[ \beta \text{ on scales of } \sim 1 \text{ pc.} \]

We also find that the mass in SDC24.489-0.689 is more centrally concentrated and circularly symmetric than in SDC18.888-0.476, and is consistent with a scenario in which spherical globally-collapsing clouds concentrate a higher fraction of their mass into a single core than elongated clouds that will more easily fragment, distributing their mass into many cores. We demonstrate that \[ \beta \text{ variations towards interstellar clouds can be robustly constrained with high signal-to-noise ratio NIKA observations, providing more accurate estimates of their masses.} \]

The methods presented here will be applied to the Galactic Star Formation with NIKA2 (GASTON) guaranteed time large programme, extending our analysis to a statistically significant sample of star-forming clouds.

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Intensity-Corrected Herschel Observations of Nearby Isolated Low-Mass Clouds
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We present intensity-corrected Herschel maps at 100 \( \mu \text{m}, 160 \mu \text{m}, 250 \mu \text{m}, 350 \mu \text{m}, \) and 500 \( \mu \text{m} \) for 56 isolated low-mass clouds. We determine the zero-point corrections for Herschel PACS and SPIRE maps from the Herschel Science Archive (HSA) using Planck data. Since these HSA maps are small, we cannot correct them using typical methods. Here, we introduce a technique to measure the zero-point corrections for small Herschel maps. We use radial profiles to identify offsets between the observed HSA intensities and the expected intensities from Planck. Most clouds have reliable offset measurements with this technique. In addition, we find that roughly half of the clouds have underestimated HSA-SPIRE intensities in their outer envelopes relative to Planck, even though the HSA-SPIRE maps were previously zero-point corrected. Using our technique, we produce corrected Herschel intensity maps for all 56 clouds and determine their line-of-sight average dust temperatures and optical depths from modified blackbody fits. The clouds have typical temperatures of \( \sim 14 - 20 \text{ K} \) and optical depths of \( \sim 10^{-5} - 10^{-3} \). Across the whole sample, we find an anti-correlation between temperature and optical depth. We also find lower temperatures than what was measured in previous Herschel studies, which subtracted out a background level from their intensity maps to circumvent the zero-point correction. Accurate Herschel observations of clouds are key to obtaining accurate density and temperature profiles. To make such future analyses possible, intensity-corrected maps for all 56 clouds are publicly available in the electronic version.

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Deuterated Formaldehyde in the low mass protostar HH212
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HH212, a nearby (400 pc) object in Orion, is a Class 0 protostellar system with a Keplerian disk and collimated bipolar SiO jets. Deuterated water, HDO and a deuterated complex molecule, methanol (CH$_2$DOH) have been reported in the source. Here, we report the HDCO (deuterated formaldehyde) line observation from ALMA data to probe the inner region of HH212. We compare HDCO line with other molecular lines to understand the possible chemistry and physics of the source. The distribution of HDCO emission suggests it may be associated with the base of the outflow. The emission also shows a rotation but it is not associated with the Keplerian rotation of disk or the rotating infalling envelope, rather it is associated with the outflow as previously seen in C$^{34}$S. From the possible deuterium fractionation, we speculate that the gas phase formation of deuterated formaldehyde is active in the central hot region of the low-mass protostar system, HH212.

Evidence of an Upper Bound on the Masses of Planets and its Implications for Giant Planet Formation

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Celestial bodies with a mass of $M \sim 10$ $M_{\text{Jup}}$ have been found orbiting nearby stars. It is unknown whether these objects formed like gas-giant planets through core accretion or like stars through gravitational instability. I show that objects with $M \lesssim 4$ $M_{\text{Jup}}$ orbit metal-rich solar-type dwarf stars, a property associated with core accretion. Objects with $M \gtrsim 10$ $M_{\text{Jup}}$ do not share this property. This transition is coincident with a minimum in the occurrence rate of such objects, suggesting that the maximum mass of a celestial body formed through core accretion like a planet is less than 10 $M_{\text{Jup}}$. Consequently, objects with $M \gtrsim 10$ $M_{\text{Jup}}$ orbiting solar-type dwarf stars likely formed through gravitational instability and should not be thought of as planets. Theoretical models of giant planet formation in scaled minimum-mass solar nebula Shakura–Sunyaev disks with standard parameters tuned to produce giant planets predict a maximum mass nearly an order of magnitude larger. To prevent newly formed giant planets from growing larger than 10 $M_{\text{Jup}}$, protoplanetary disks must therefore be significantly less viscous or of lower mass than typically assumed during the runaway gas accretion stage of giant planet formation. Either effect would act to slow the Type I/II migration of planetary embryos/giant planets and promote their survival. These inferences are insensitive to the host star mass, planet formation location, or characteristic disk dissipation time.

The Detection of Hot Cores and Complex Organic Molecules in the Large Magellanic Cloud

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We report the first extragalactic detection of the complex organic molecules (COMs) dimethyl ether (CH$_3$OCH$_3$) and methyl formate (CH$_3$OCHO) with the Atacama Large Millimeter/submillimeter Array (ALMA). These COMs together with their parent species methanol (CH$_3$OH), were detected toward two 1.3 mm continuum sources in the N 11 3 star-forming region in the low-metallicity Large Magellanic Cloud (LMC). Rotational temperatures ($T_{\text{rot}} \sim 130$ K) and total column densities ($N_{\text{rot}} \sim 10^{16}$ cm$^{-2}$) have been calculated for each source based on multiple transitions of CH$_3$OH. We present the ALMA molecular emission maps for COMs and measured abundances for all detected species. The physical and chemical properties of two sources with COMs detection, and the association with H$_2$O and OH maser emission indicate that they are hot cores. The fractional abundances of COMs scaled by a factor of 2.5 to account for the lower metallicity in the LMC are comparable to those found at the lower end of the range in Galactic hot cores. Our results have important implications for studies of organic chemistry at higher redshift.

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Hydrodynamics with gas-grain chemistry and radiative transfer: comparing dynamical and static models

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Context. We study the evolution of chemical abundance gradients using dynamical and static models of starless cores.

Aims. We aim to quantify if the chemical abundance gradients given by a dynamical model of core collapse including time-dependent changes in density and temperature differ greatly from abundances derived from static models where the density and temperature structures of the core are kept fixed as the chemistry evolves.

Methods. We developed a new one-dimensional spherically symmetric hydrodynamics code that couples the hydrodynamics equations with a comprehensive time-dependent gas-grain chemical model, including deuterium and spin-state chemistry, and radiative transfer calculations to derive self-consistent time-dependent chemical abundance gradients. We apply the code to model the collapse of a starless core up to the point when the infall flow becomes supersonic.

Results. The abundances predicted by the dynamical and static models are almost identical at early times during the quiescent phase of core evolution. After the onset of core collapse the results from the two models begin to diverge: at late times the static model generally underestimates abundances in the high-density regions near the core center, and overestimates them in the outer parts of the core. Deuterated species are clearly overproduced by the static model near the center of the model core. On the other hand, simulated lines of NH$_3$ and N$_2$H$^+$ are brighter in the dynamical model because they originate in the central part of the core where the dynamical model predicts higher abundances than the static model. The reason for these differences is that the static model ignores the history of the density and temperature profiles which has a large impact on the abundances, and therefore on the molecular lines. Our results also indicate that the use of a very limited chemical network in hydrodynamical simulations may lead to an overestimate of the collapse timescale, and in some cases may prevent the collapse altogether. Limiting the set of molecular coolants has a similar effect. In our model, most of the line cooling near the center of the core is due to HCN, CO, and NO.

Conclusions. Our results show that the use of a static physical model is not a reliable method of simulating chemical abundances in starless cores after the onset of gravitational collapse. The abundance differences between the dynamical and static models translate to large differences in line emission profiles, showing that the difference between the models is at the observable level. The adoption of complex chemistry and a comprehensive set of cooling molecules is necessary to model the collapse adequately.

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Resolving the Inner Arcsecond of the RY Tau Jet with HST

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Faint X-ray emission from hot plasma (T \(x \geq 10^6\) K) has been detected extending outward a few arcseconds along the optically-delineated jets of some classical T Tauri stars including RY Tau. The mechanism and location where the jet is heated to X-ray temperatures is unknown. We present high spatial resolution Hubble Space Telescope (HST) far-ultraviolet long-slit observations of RY Tau with the slit aligned along the jet. The primary objective was to search for C IV emission from warm plasma at \(T_{CIV} \sim 10^5\) K within the inner jet (<1′′) that cannot be fully-resolved by X-ray telescopes. Spatially-resolved C IV emission is detected in the blueshifted jet extending outward from the star to 1′′ and in the redshifted jet out to 0′′.5. C IV line centroid shifts give a radial velocity in the blueshifted jet of \(-136 \pm 10\) km s\(^{-1}\) at an offset of 0′′.29 (39 au) and deceleration outward is detected. The deprojected jet speed is subject to uncertainties in the jet inclination but values >200 km s\(^{-1}\) are likely. The mass-loss rate in the blueshifted jet is at least \(\dot{M}_{jet,blue} = 2.3 \times 10^{-9}\) M\(_\odot\) yr\(^{-1}\), consistent with optical determinations. We use the HST data along with optically-determined jet morphology to place meaningful constraints on candidate jet-heating models including a hot-launch model in which the jet is heated near the base to X-ray temperatures by an unspecified (but probably magnetic) process, and downstream heating from shocks or a putative jet magnetic field.

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Interaction between a pulsating jet and a surrounding disk wind. A hydrodynamical perspective

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The molecular richness of fast protostellar jets within 20-100 au of their source, despite strong ultraviolet irradiation, remains a challenge for the models investigated so far. We aim to investigate the effect of interaction between a time-variable jet and a surrounding steady disk wind, to assess the possibility of jet chemical enrichment by the wind, and the characteristic signatures of such a configuration. We have constructed an analytic model of a jet bow shock driven into a surrounding slower disk wind in the thin shell approximation. The refilling of the post bow shock cavity from below by the disk wind is also studied. An extension of the model to the case of two or more successive internal working surfaces (IWS) is made. We then compared this analytic model with numerical simulations with and without a surrounding disk wind. We find that at early times (of order the variability period), jet bow shocks travel in refilled pristine disk-wind material, before interacting with the cocoon of older bow shocks. This opens the possibility of bow shock chemical enrichment (if the disk wind is molecular and dusty) and of probing the unperturbed disk wind structure near the jet base. Several distinctive signatures of the presence of a surrounding disk wind are identified, in the bow shock morphology and kinematics. Numerical simulations validate our analytical approach and further show that at large scale, the passage of many jet IWS inside a disk wind produces a stationary V-shaped cavity, closing down onto the axis at a finite distance from the source.

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The Spectroscopic Variations of the FU Orionis Object V960 Mon

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We present the results of the spectroscopic monitoring of the FU Orionis type star V960 Mon. Spectroscopic variations of a FU Orionis type star will provide valuable information of its physical nature and the mechanism of the outburst. We conducted medium-resolution (R ∼ 10000) spectroscopic observations of V960 Mon with 2m Nayuta telescope at the Nishi-Harima Astronomical Observatory, from 2015 January to 2017 January for 53 nights in total. We focused on Hα line and nearby atomic lines, and detected the strength variations in both absorption and emission lines. The observed variation in the equivalent width of the absorption lines correspond to a decrease in effective temperature and increase in surface gravity. These variations were likely to originate from the luminosity fading of the accretion disk due to the decrease in mass accretion rate.

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Survey Observations to Study Chemical Evolution from High-Mass Starless Cores to High-Mass Protostellar Objects I: HC₃N and HC₅N

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We carried out survey observations of HC₃N and HC₅N in the 42–45 GHz band toward 17 high-mass starless cores (HMSCs) and 35 high-mass protostellar objects (HMPOs) with the Nobeyama 45 m radio telescope. We have detected HC₃N from 15 HMSCs and 28 HMPOs, and HC₅N from 5 HMSCs and 14 HMPOs, respectively. The average values of the column density of HC₃N are found to be (5.7 ± 0.7) × 10¹² and (1.03 ± 0.12) × 10¹³ cm⁻² in HMSCs and HMPOs, respectively. The average values of the fractional abundance of HC₃N are derived to be (6.6 ± 0.8) × 10⁻¹¹ and (3.6 ± 0.5) × 10⁻¹¹ in HMSCs and HMPOs, respectively.

We find that the fractional abundance of HC₃N decreases from HMSCs to HMPOs using the Kolmogorov-Smirnov test. On the other hand, its average value of the column density slightly increases from HMSCs to HMPOs. This may imply that HC₃N is newly formed in dense gas in HMPO regions. We also investigate the relationship between the column density of HC₃N in HMPOs and the luminosity-to-mass ratio (L/M), a physical evolutional indicator. The column density of HC₃N tends to decrease with increasing the L/M ratio, which suggests that HC₃N is destroyed by the stellar activities.

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Sub-structure formation in starless cores

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Motivated by recent observational searches of sub-structure in starless molecular cloud cores, we investigate the evolution of density perturbations on scales smaller than the Jeans length embedded in contracting isothermal clouds, adopting the same formalism developed for the expanding Universe and the solar wind. We find that initially small amplitude, Jeans-stable perturbations (propagating as sound waves in the absence of a magnetic field) are amplified adiabatically during the contraction, approximately conserving the wave action density, until they either become non-linear and steepen into shocks at a time $t_{nl}$, or become gravitationally unstable when the Jeans length decreases below the scale of the perturbations at a time $t_{gr}$. We evaluate analytically the time $t_{nl}$ at which the perturbations enter the non-linear stage using a Burgers’ equation approach, and we verify numerically that this time marks the beginning of the phase of rapid dissipation of the kinetic energy of the perturbations. We then show that for typical values of the rms Mach number in molecular cloud cores, $t_{nl}$ is smaller than $t_{gr}$, and therefore density perturbations likely dissipate before becoming gravitational unstable. Solenoidal modes grow at a faster rate than compressible modes, and may eventually promote fragmentation through the formation of vortical structures.

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Global photometric analysis of galactic HII regions

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Total infrared fluxes are estimated for 99 HII regions around massive stars. The following wavebands have been used for the analysis: 8 and 24 $\mu$m, based on data from Spitzer space telescope (IRAC and MIPS, respectively); 70, 160, 250, 350, and 500 $\mu$m, based on data from Herschel Space Observatory (PACS and SPIRE). The estimated fluxes are used to evaluate the mass fraction of polycyclic aromatic hydrocarbons ($q_{PAH}$) and the intensity of the ultraviolet emission in the studied objects. It is shown that the PAH mass fraction, $q_{PAH}$, is much lower in these objects than the average Galactic value, implying effective destruction of aromatic particles in HII regions. Estimated radiation field intensities ($U$) are close to those derived for extragalactic HII complexes. Color indices $[F_{24}/F_{8}]$, $[F_{70}/F_{24}]$, $[F_{160}/F_{24}]$, $[F_{160}/F_{70}]$ are compared to criteria proposed to distinguish between regions of ionized hydrogen and planetary nebulae. Also, we relate our results to analogous color indices for extragalactic complexes of ionized hydrogen.

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Imaging the water snowline in a protostellar envelope with H$^{13}$CO$^+$

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Snowlines are key ingredients for planet formation. Providing observational constraints on the locations of the major snowlines is therefore crucial for fully connecting planet compositions to their formation mechanism. Unfortunately, the most important snowline, that of water, is very difficult to observe directly in protoplanetary disks due to its close
proximity to the central star. Based on chemical considerations, HCO$^+$ is predicted to be a good chemical tracer of the water snowline, because it is particularly abundant in dense clouds when water is frozen out. This work maps the optically thin isotopologue $^{13}$HCO$^+$ ($J = 3 – 2$) toward the envelope of the low-mass protostar NGC1333-IRAS2A (observed with NOEMA at $\sim 0.9$” resolution), where the snowline is at larger distance from the star than in disks. The $^{13}$HCO$^+$ emission peaks $\sim 2$” northeast of the continuum peak, whereas the previously observed $^{18}$H$_2$O shows compact emission on source. Quantitative modeling shows that a decrease in $^{13}$HCO$^+$ abundance by at least a factor of six is needed in the inner $\sim 360$ AU to reproduce the observed emission profile. Chemical modeling predicts indeed a steep increase in HCO$^+$ just outside the water snowline; the 50% decrease in gaseous H$_2$O at the snowline is not enough to allow HCO$^+$ to be abundant. This places the water snowline at 225 AU, further away from the star than expected based on the 1D envelope temperature structure for NGC1333-IRAS2A. In contrast, DCO$^+$ observations show that the CO snowline is at the expected location, making an outburst scenario unlikely. The spatial anticorrelation of the $^{13}$HCO$^+$ and $^{18}$H$_2$O emission provide a proof of concept that $^{13}$HCO$^+$ can be used as a tracer of the water snowline.

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New insights into the nature of transition disks from a complete disk survey of the Lupus star forming region

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Transition disks with large dust cavities around young stars are promising targets for studying planet formation. Previous studies have revealed the presence of gas cavities inside the dust cavities hinting at recently formed, giant planets. However, many of these studies are biased towards the brightest disks in the nearby star forming regions, and it is not possible to derive reliable statistics that can be compared with exoplanet populations. We present the analysis of 11 transition disks with large cavities ($\geq 20$ AU radius) from a complete disk survey of the Lupus star forming region, using ALMA Band 7 observations at $0.3”$ ($22$–$30$ AU radius) resolution of the $345$ GHz continuum, $^{13}$CO and C$^{18}$O $3–2$ observations and the Spectral Energy Distribution of each source. Gas and dust surface density profiles are derived using the physical-chemical modeling code DALI. This is the first study of transition disks of large cavities within a complete disk survey within a star forming region. The dust cavity sizes range from 20–90 AU radius and in three cases, a gas cavity is resolved as well. The deep drops in gas density and large dust cavity sizes are consistent with clearing by giant planets. The fraction of transition disks with large cavities in Lupus is $\geq 11\%$, which is inconsistent with exoplanet population studies of giant planets at wide orbits. Furthermore, we present a hypothesis of an evolutionary path for large massive disks evolving into transition disks with large cavities.

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Protostellar birth with ambipolar and ohmic diffusion

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The transport of angular momentum is capital during the formation of low-mass stars; too little removal and rotation ensures stellar densities are never reached, too much and the absence of rotation means no protoplanetary disks can form. Magnetic diffusion is seen as a pathway to resolving this long-standing problem. We investigate the impact of including resistive MHD in simulations of the gravitational collapse of a 1 $M_\odot$ gas sphere, from molecular cloud densities to the formation of the protostellar seed; the second Larson core. We used the AMR code RAMSES to perform two 3D simulations of collapsing magnetised gas spheres, including self-gravity, radiative transfer, and a non-ideal gas equation of state to describe $\text{H}_2$ dissociation which leads to the second collapse. The first run was carried out under the ideal MHD approximation, while ambipolar and ohmic diffusion was incorporated in the second calculation. In the ideal MHD simulation, the magnetic field dominates the energy budget everywhere inside and around the first core, fueling interchange instabilities and driving a low-velocity outflow. High magnetic braking removes essentially all angular momentum from the second core. On the other hand, ambipolar and ohmic diffusion create a barrier which prevents amplification of the magnetic field beyond 0.1 G in the first Larson core which is now fully thermally supported. A significant amount of rotation is preserved and a small Keplerian-like disk forms around the second core. When studying the radiative efficiency of the first and second core accretion shocks, we found that it can vary by several orders of magnitude over the 3D surface of the cores. Magnetic diffusion is a pre-requisite to star-formation; it enables the formation of protoplanetary disks in which planets will eventually form, and also plays a determinant role in the formation of the protostar itself.

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Knotty protostellar jets as a signature of episodic protostellar accretion?

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We aim at studying the causal link between the knotty jet structure in CARMA 7, a young Class 0 protostar in the Serpens South cluster, and episodic accretion in young protostellar disks. We used numerical hydrodynamics simulations to derive the protostellar accretion history in gravitationally unstable disks around solar-mass protostars. We compared the time spacing between luminosity bursts $\Delta \tau_{\text{mod}}$, caused by dense clumps spiralling on the protostar, with the differences of dynamical timescales between the knots $\Delta \tau_{\text{obs}}$ in CARMA 7. We found that the time spacing between the bursts have a bi-modal distribution caused by isolated and clustered luminosity bursts. The former are characterized by long quiescent periods between the bursts with $\Delta \tau_{\text{mod}} = \text{a few } \times (10^3 - 10^4) \text{ yr}$, whereas the latter occur in small groups with time spacing between the bursts $\Delta \tau_{\text{mod}} = \text{a few } \times (10 - 10^2) \text{ yr}$. For the clustered bursts, the distribution of $\Delta \tau_{\text{mod}}$ in our models can be fit reasonably well to the distribution of $\Delta \tau_{\text{obs}}$ in the protostellar jet of CARMA 7, if a certain correction for the (yet unknown) inclination angle with respect to the line of sight is applied. The K-S test on the model and observational data sets suggests the best-fit values for the inclination angles of $55^\circ - 80^\circ$, which become narrower ($75^\circ - 80^\circ$) if only strong luminosity bursts are considered. The dynamical timescales of the knots in the jet of CARMA 7 are too short for a meaningful comparison with the long time spacings between isolated bursts in our models. Moreover, the exact sequences of time spacings between the luminosity bursts in our models and knots in the jet of CARMA 7 were found difficult to match. Given the short time passed since the presumed luminosity bursts (from tens to hundreds years), a possible overabundance of the gas-phase CO in the envelope of CARMA 7 as compared to what could be expected from the current luminosity may be used to confirm the burst nature of this object. More sophisticated numerical models and observational data on jets with longer dynamical timescales are needed to further explore the possible causal link between luminosity bursts and knotty jets.
The early evolution of viscous and self-gravitating circumstellar disks with a dust component

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The long-term evolution of a circumstellar disk starting from its formation and ending in the T Tauri phase was simulated numerically with the purpose of studying the evolution of dust in the disk with distinct values of viscous $\alpha$-parameter and dust fragmentation velocity $v_{\text{frag}}$. We solved numerical hydrodynamics equations in the thin-disk limit, which are modified to include a dust component consisting of two parts: sub-micron-sized dust and grown dust with a maximum radius $a_r$. The former is strictly coupled to the gas, while the latter interacts with the gas via friction. The conversion of small to grown dust, dust growth, and dust self-gravity are also considered. We found that the process of dust growth known for the older protoplanetary phase also holds for the embedded phase of disk evolution. The dust growth efficiency depends on the radial distance from the star — $a_r$ is largest in the inner disk and gradually declines with radial distance. In the inner disk, $a_r$ is limited by the dust fragmentation barrier. The process of small-to-grown dust conversion is very fast once the disk is formed. The total mass of grown dust in the disk (beyond 1 AU) reaches tens or even hundreds of Earth masses already in the embedded phase of star formation and even a greater amount of grown dust drifts in the inner, unresolved 1 AU of the disk. Dust does not usually grow to radii greater than a few cm. A notable exception are models with $\alpha \leq 10^{-3}$, in which case a zone with reduced mass transport develops in the inner disk and dust can grow to meter-sized boulders in the inner 10 AU. Grown dust drifts inward and accumulates in the inner disk regions. This effect is most pronounced in the $\alpha \leq 10^{-3}$ models where several hundreds of Earth masses can be accumulated in a narrow region of several AU from the star by the end of embedded phase.

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Not all stars form in clusters – measuring the kinematics of OB associations with \textit{Gaia}

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It is often stated that star clusters are the fundamental units of star formation and that most (if not all) stars form in dense stellar clusters. In this monolithic formation scenario, low density OB associations are formed from the expansion of gravitationally bound clusters following gas expulsion due to stellar feedback. \textit{N}-body simulations of this process show that OB associations formed this way retain signs of expansion and elevated radial anisotropy over tens of Myr. However, recent theoretical and observational studies suggest that star formation is a hierarchical process, following the fractal nature of natal molecular clouds and allowing the formation of large-scale associations in-situ. We distinguish between these two scenarios by characterising the kinematics of OB associations using the \textit{Tycho-Gaia} Astrometric Solution catalogue. To this end, we quantify four key kinematic diagnostics: the number ratio of stars with positive radial velocities to those with negative radial velocities, the median radial velocity, the median radial velocity normalised by the tangential velocity, and the radial anisotropy parameter. Each quantity presents a useful diagnostic of whether the association was more compact in the past. We compare these diagnostics to models...
representing random motion and the expanding products of monolithic cluster formation. None of these diagnostics show evidence of expansion, either from a single cluster or multiple clusters, and the observed kinematics are better represented by a random velocity distribution. This result favours the hierarchical star formation model in which a minority of stars forms in bound clusters and large-scale, hierarchically-structured associations are formed in-situ.

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Characterizing the variable dust permeability of planet-induced gaps

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Aerodynamic theory predicts that dust grains in protoplanetary disks will drift radially inward on comparatively short timescales. In this context, it has long been known that the presence of a gap opened by a planet can alter the dust dynamics significantly. In this paper, we carry out a systematic study employing long-term numerical simulations aimed at characterizing the critical particle-size for retention outside a gap as a function of particle size and for various key parameters defining the protoplanetary disk model. To this end, we perform multifluid hydrodynamical simulations in two dimensions, including different dust species, which we treat as pressureless fluids. We initialize the dust outside of the planet’s orbit and study under which conditions dust grains are able to cross the gap carved by the planet. In agreement with previous work, we find that the permeability of the gap depends both on dust dynamical properties and the gas disk structure: while small dust follows the viscously accreting gas through the gap, dust grains approaching a critical size are progressively filtered out. Moreover, we introduce and compute a depletion factor that enables us to quantify the way in which higher viscosity, smaller planet mass, or a more massive disk can shift this critical size to larger values. Our results indicate that gap-opening planets may act to deplete the inner reaches of protoplanetary disks of large dust grains – potentially limiting the accretion of solids onto forming terrestrial planets.

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The Near-Infrared Outflow and Cavity of the proto-Brown Dwarf Candidate ISO-Oph 200

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In this letter a near-infrared integral field study of a proto-brown dwarf candidate is presented. A $\sim 0''5$ blue-shifted outflow is detected in both H$_2$ and [FeII] lines at $V_{\mathrm{sys}} = (−35 \pm 2)$ \kms and $V_{\mathrm{sys}} = (−51 \pm 5)$ \kms respectively. In addition, slower ($\sim\pm10$ \kms) H$_2$ emission is detected out to $<5''4$, in the direction of both the blue and red-shifted outflow lobes but along a different position angle to the more compact faster emission. It is argued that the more compact emission is a jet and the extended H$_2$ emission is tracing a cavity. The source extinction is estimated at $A_V = 18 \pm 1$ mag and the outflow extinction at $A_V = 9 \pm 0.4$ mag. The H$_2$ outflow temperature is calculated to be $1422 \pm 255$ K and the electron density of the [FeII] outflow is measured at $\sim 10000 \, \mathrm{cm}^{-3}$. Furthermore, the mass outflow rate is estimated at $\dot{M}_{\mathrm{out}}[\mathrm{H}_2] = 3.8 \times 10^{-10} \, M_\odot \, \mathrm{yr}^{-1}$ and $\dot{M}_{\mathrm{out}}[\mathrm{FeII}] = 1 \times 10^{-8} \, M_\odot \, \mathrm{yr}^{-1}$. $\dot{M}_{\mathrm{out}}[\mathrm{FeII}]$ takes a Fe depletion of $\sim 88\%$ into account. The depletion is investigated using the ratio of the [FeII] 1.257 $\mu$m and [PII] 1.188 $\mu$m lines. Using the Pa$\beta$ and Br$\gamma$ lines and a range in stellar mass and radius $\dot{M}_{\mathrm{acc}}$ is calculated to be $(3-10) \times 10^{-8} \, M_\odot \, \mathrm{yr}^{-1}$. Comparing these rates puts the jet efficiency in line with predictions of magneto-centrifugal models of jet launching in low mass protostars. This is a further case of a brown dwarf outflow exhibiting analogous properties to protostellar jets.

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Gravity drives the evolution of infrared dark hubs: JVLA observations of SDC13

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Converging networks of interstellar filaments, that is hubs, have been recently linked to the formation of stellar clusters and massive stars. Understanding the relationship between the evolution of these systems and the formation of cores and stars inside them is at the heart of current star formation research. The goal is to study the kinematic and density structure of the SDC13 prototypical hub at high angular resolution to determine what drives its evolution and fragmentation. We have mapped SDC13, a ∼1000 M_☉ infrared dark hub, in NH₃(1,1) and NH₃(2,2) emission lines, with both the Jansky Very Large Array and Green Bank Telescope. The high angular resolution achieved in the combined dataset allowed us to probe scales down to 0.07pc. After fitting the ammonia lines, we computed the integrated intensities, centroid velocities and line widths, along with gas temperatures and H₂ column densities. The mass-per-unit-lengths of all four hub filaments are thermally super-critical, consistent with the presence of tens of gravitationally bound cores identified along them. These cores exhibit a regular separation of ∼ 0.37 ± 0.16 pc suggesting gravitational instabilities running along these super-critical filaments are responsible for their fragmentation. The observed local increase of the dense gas velocity dispersion towards starless cores is believed to be a consequence of such fragmentation process. Using energy conversion arguments, we estimate that the gravitational to kinetic energy conversion efficiency in the SDC13 cores is ∼ 35%. We see velocity gradient peaks towards ∼ 63% of cores as expected during the early stages of filament fragmentation. Another clear observational signature is the presence of the most massive cores at the filaments’ junction, where the velocity dispersion is largest. We interpret this as the result of the hub morphology generating the largest acceleration gradients near the hub centre. We propose a scenario for the evolution of the SDC13 hub in which filaments first form as post-shock structures in a supersonic turbulent flow. As a result of the turbulent energy dissipation in the shock, the dense gas within the filaments is initially mostly sub-sonic. Then gravity takes over and starts shaping the evolution of the hub, both fragmenting filaments and pulling the gas towards the centre of the gravitational well. By doing so, gravitational energy is converted into kinetic energy in both local (cores) and global (hub centre) potential well minima. Furthermore, the generation of larger gravitational acceleration gradients at the filament junctions promotes the formation of more massive cores.

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Protoplanetary Disc Response to Distant Tidal Encounters in Stellar Clusters

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The majority of stars form in a clustered environment. This has an impact on the evolution of surrounding protoplanetary discs (PPDs) due to either photoevaporation or tidal truncation. Consequently, the development of planets depends on formation environment. Here we present the first thorough investigation of tidally induced angular momentum loss in PPDs in the distant regime, partly motivated by claims in the literature for the importance of distant encounters in disc evolution. We employ both theoretical predictions and dynamical/hydrodynamical simulations in 2D and 3D. Our theoretical analysis is based on that of Ostriker (1994) and leads us to conclude that in the limit that the closest approach distance x_{min} ≫ r, the radius of a particle ring, the fractional change in angular momentum scales as ∼ (x_{min}/r)^{-5}. This asymptotic limit ensures that the cumulative effect of distant encounters is minor in terms of its influence on disc evolution. The angular momentum transfer is dominated by the m = 2 Lindblad resonance for closer encounters and by the m = 1, ω = 0 Lindblad resonance at large x_{min}/r. We contextualise these results by comparing expected angular momentum loss for the outer edge of a PPD due to distant and close encounters. Contrary to the suggestions of previous works we do not find that distant encounters contribute significantly to angular momentum loss in PPDs. We define an upper limit for closest approach distance where interactions are significant as a function of arbitrary host to perturber mass ratio M2/M1.

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The Kinematics of the Scorpius-Centaurus OB Association from Gaia DR1
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We present a kinematic study of the Scorpius-Centaurus (Sco-Cen) OB association (Sco OB2) using \textit{Gaia} DR1 parallaxes and proper motions. Our goal is to test the classical theory that OB associations are the expanded remnants of dense and compact star clusters disrupted by processes such as residual gas expulsion. \textit{Gaia} astrometry is available for 258 out of 433 members of the association, with revised \textit{Hipparcos} astrometry used for the remainder. We use this data to confirm that the three subgroups of Sco-Cen are gravitationally unbound and have non-isotropic velocity dispersions, suggesting they have not had time to dynamically relax. We also explore the internal kinematics of the subgroups to search for evidence of expansion. We test Blaauw’s classical linear model of expansion, search for velocity trends along the Galactic axes, compare the expanding and non-expanding convergence points, perform traceback analysis assuming both linear trajectories and using an epicycle approximation, and assess the evidence for expansion in proper motions corrected for virtual expansion / contraction. None of these methods provide coherent evidence for expansion of the subgroups, with no evidence to suggest that the subgroups had a more compact configuration in the past. We find evidence for kinematic substructure within the subgroups that supports the view that they were not formed by the disruption of individual star clusters. We conclude that Sco-Cen was likely born highly substructured, with multiple small-scale star formation events contributing to the overall OB association, and not as single, monolithic bursts of clustered star formation.

The collapse of a molecular cloud core to stellar densities using radiation non-ideal magnetohydrodynamics
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We present results from radiation non-ideal magnetohydrodynamics (MHD) calculations that follow the collapse of rotating, magnetised, molecular cloud cores to stellar densities. These are the first such calculations to include all three non-ideal effects: ambipolar diffusion, Ohmic resistivity and the Hall effect. We employ an ionisation model in which cosmic ray ionisation dominates at low temperatures and thermal ionisation takes over at high temperatures. We explore the effects of varying the cosmic ray ionisation rate from $\zeta_{\text{cr}} = 10^{-10}$ to $10^{-16}$ s$^{-1}$. Models with ionisation rates $\gtrsim 10^{-12}$ s$^{-1}$ produce results that are indistinguishable from ideal MHD. Decreasing the cosmic ray ionisation rate extends the lifetime of the first hydrostatic core up to a factor of two, but the lifetimes are still substantially shorter than those obtained without magnetic fields. Outflows from the first hydrostatic core phase are launched in all models, but the outflows become broader and slower as the ionisation rate is reduced. The outflow morphology following stellar core formation is complex and strongly dependent on the cosmic ray ionisation rate. Calculations with high ionisation rates quickly produce a fast ($\approx 14$ km s$^{-1}$) bipolar outflow that is distinct from the first core outflow, but with the lowest ionisation rate a slower ($\approx 3 - 4$ km s$^{-1}$) conical outflow develops gradually and seamlessly merges into the first core outflow.

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Embedded Clusters

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The past decade has seen an increase of star formation studies made at the molecular cloud scale, motivated mostly by the deployment of a wealth of sensitive infrared telescopes and instruments. Embedded clusters, long recognised as the basic units of coherent star formation in molecular clouds, are now seen to inhabit preferentially cluster complexes tens of parsecs across. This chapter gives an overview of some important properties of the embedded clusters in these complexes and of the complexes themselves, along with the implications of viewing star formation as a molecular-cloud scale process rather than an isolated process at the scale of clusters.

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Moving ... ??

If you move or your e-mail address changes, please send the editor your new address. If the Newsletter bounces back from an address for three consecutive months, the address is deleted from the mailing list.
The aim of this thesis is the study of the star formation rate distribution with respect to the gas density named star formation law in the literature, in a sample of Galactic molecular clouds (GMCs) and infrared dark clouds (IRDCs) embedded in these, as well other star formation activity parameters. The clouds are defined using the $^{13}$CO molecular emission line and the young stellar objects (YSOs) are selecting from Spitzer GLIMPSE y MIPSGAL 24 $\mu$m databases. For each cloud the mass function (MF) of the YSOs is obtained in the mass range from 0.1 $M_\odot$ to 30 $M_\odot$. The resulting MF have a log normal form for low masses and an extended tail toward higher masses, resembling well to the Salpeters form. This MF is consistent with the resulting mass distribution in protostellar cores and young star clusters in recent studies. With the YSOs mass and cloud masses, the star formation rate (SFR) and star formation efficiency (SFE) are determined for all the clouds. These have a SFR range from 12.0 to 756.0 $M_\odot$ Myr$^{-1}$, whilst the SFEs varying from 0.5 % to 3.8 %. These SFR/SFE values are comparable to Orion A/B values and other Galactic star-forming regions.

The star formation rate (SFR) surface densities ($\Sigma$SFR) is obtained from count of the YSOs at successive bins of gas column densities traced by the $^{13}$CO line emission. The density gas ($\Sigma_{\text{gas}}$) is obtained in the same column density contours. For almost the clouds (8/10), a broken power law (BPL) with two indexes have better agreement with the observed data. The first index has values from 0.1 to 0.6 in the $\Sigma_{\text{gas}}$ range from $\sim$20 to $\sim$100 $M_\odot$ pc$^{-2}$, while the second index ranging from 1.3 to 3.6 from $\sim$100 to $\sim$1000 $M_\odot$ pc$^{-2}$. The BPL relation suggest the presence of two gas density regimes in the star formation law: a low density gas regime with weak (sublinear) star formation activity, whilst the high density gas regime has strong star formation activity. A break is found in the gas density range for the change of regime on the star formation relation within the clouds. The break ($\Sigma_{\text{gas}}$) values are from 150 to 360 $M_\odot$ pc$^{-2}$, which compares well with threshold values in $\Sigma_{\text{gas}}$ for Galactic star-forming regions in the recent literature. When the star formation law is analyzed with global values, the clouds lie above the Kennicutt relation by a factor.
between 1.5 up to 30.0 and below the linear relation of massive dense clumps. Compared to the Galactic studies, the clouds have more dense $\Sigma_{\text{gas}}$ values than the low-mass star-forming regions although with similar $\Sigma_{\text{SFR}}$ values, and they are overlapped to the lowest $\Sigma_{\text{gas}}$ values for dense clumps.

Also I present the star formation law and the ability of IRDCs to form high mass stars and star clusters. For this, IRDCs were selected from the molecular cloud sample using Spitzer $8\mu m$ data and their physical properties obtained. In addition, the associated YSOs have been selected in each IRDC. The gas surface density is obtained from the mass and area of each IRDC and the surface density of the SFR is obtained from counting YSOs within the IRDCs. The resultant distribution shows that the IRDCs do not follow a correlation in the $\Sigma_{\text{SFR}}$ - $\Sigma_{\text{gas}}$ diagram and these are clustered around $\Sigma_{\text{gas}} \sim 300 \, \text{M}_\odot \, \text{pc}^{-2}$, which is explained by the dependence of $\Sigma_{\text{gas}}$ on the mass-radio correlation present in the IRDCs. Roughly 40% of the total of IRDCs obey the mass size criterion for the star formation regions that can form high mass stars and star clusters. 25 IRDCs have masses greater than $1000 \, \text{M}_\odot$, which positioned them as good candidates to study the initial conditions of the formation of star clusters.

**Abstract submission deadline**

The deadline for submitting abstracts and other submissions is the first day of the month.
The existence of interstellar molecules raises the question, are these molecules the same molecules we see on the Solar system today? This is still an open question with far reaching consequences. Some light may be shed on this issue if we are able to trace the heritage of a group of chemically linked molecules, a so-called reservoir. The best tool to trace the heritage of reservoirs are isotopic ratios. The element that shows the largest isotopic ratio variations in the Solar system is nitrogen. For this is an indication that the isotopic ratio of nitrogen is sensitive to the physical conditions during star formation.

The main objective of this thesis is to identify the reservoirs of nitrogen at different stages of star and planet formation. The first step in this endeavour was to identify the isotopic ratio of the bulk of nitrogen in the local ISM today. This was determined to be $323 \pm 30$ from the CN/$^{15}$N ratio in the protoplanetary disk around TW Hya. Along with it we also measured the HCN/$^{15}$N = $128 \pm 36$ in the protoplanetary disk around MWC 480. This very distinct nitrogen isotopic ratios on protoplanetary disks are a clear indication that there are at least two reservoirs of nitrogen in protoplanetary disks. How these reservoirs get separated is however unknown. This could possibly happen due to chemical fractionation reactions taking place in prestellar cores. We therefore aimed to obtain an accurate direct measurement of the nitrogen isotopic ratio of HCN in the prestellar core L1498.

To obtain this measurement the most important hurdle to overcome were the hyperfine anomalies of HCN. These hyperfine anomalies arise due to the overlap of hyperfine components. They are especially sensitive to the column density of HCN, but also to the velocity field and line widths. Thus hyperfine anomalies are a tool to measure the abundance of HCN and to probe the kinematics of prestellar cores.

To accurately reproduce the hyperfine anomalies, and thus measure accurate column densities for HCN, we needed to explore a degenerate parameter space of 15 dimensions. To minimise the degeneracies we have derived a density profile based on continuum maps of L1498. This reduced the parameter space to 12 dimensions. The exploration of this parameter space was done through the use of a MCMC minimisation method. Through this exploration we obtained HCN/$^{15}$N = $338 \pm 28$ and HCN/H$^{13}$CN = $45 \pm 3$. The uncertainties on these values are calibration limited and determined non-arbitrarily by the MCMC method. Implications of these results are discussed in the concluding chapter, where we also present some future perspectives.
Research Fellow in Star and Planet Formation

Applications are invited for an ambitious researcher to work on the formation of brown dwarfs and free-floating planets. The fellow will work with Dr. Aleks Scholz and the SONYC collaboration on a multi-faceted observational study of young brown dwarfs, using data from JWST, Gaia, Kepler/K2 and JCMT. SONYC is short for 'Substellar Objects in Nearby Young Clusters', an international long-term project to investigate young brown dwarfs down to masses comparable to giant planets. The team has Guaranteed Time for Cycle 1 at the James Webb Space Telescope and access to the James Clerk Maxwell Telescope as well as the Las Cumbres Observatory global telescope network.

The School of Physics & Astronomy offers a vibrant and modern work environment. Astrophysics research in St Andrews combines theoretical, numerical and observational research in star formation, protoplanetary discs, extrasolar planets, stellar magnetic activity, star-planet interaction, gravitational lensing, active galactic nuclei, galaxy dynamics and cosmology. The School hosts members of the recently founded cross-disciplinary Center for Exoplanet Science.

The successful candidate should have a PhD in astronomy, astrophysics, or a closely related field by the appointment start date, with experience in multi-wavelength or time-domain observations of young stellar or substellar objects. The position is available for a starting date between 1 May 2018 and 1 September 2018, for a period of three years. The position is supported by an STFC consolidated grant and includes funds for computing and travel.

Candidates should submit a cover letter, CV, publication list, and a brief statement of research experience and interests through the online application system of the University of St Andrews (job id AR2024ML under https://www.vacancies.st-andrews They should also arrange for two letters of recommendation to be sent directly to Dr Aleks Scholz. The deadline for the applications is the 1st of March 2018.

2 Postdoc & 2 PhD Positions in Astrochemistry (with Dr H J Fraser) @ the OU, UK

The School of Physical Sciences at the Open University, UK, is seeking to fill 2 STFC-funded PDRA positions and 2 PhD positions in the Astrochemistry Group in collaboration with Dr. Helen Jane Fraser. The overarching aim of this group is to understand the role of ices in star- and planet-formation processes, through observational and laboratory activities.

For further information on any of these positions, please contact Dr. Helen Jane Fraser helen.fraser@open.ac.uk .

• PDRA - (Laboratory Astrophysics: Ice Aggregation Studies)
  2 year fixed term, until 31st March 2020
  [Ref: 14377]
  £29,799 - £38,833 (based on experience)
  Closing date 28th Feb 2018 (12 noon) [Interviews between March 8th and 13th 2018]

This project aims to understand how ensembles of icy interstellar grains aggregate to form pebbles in the regions around the snowline in proto-planetary disks, and to establish if this process can generate gas-phase water in the same regions. The successful candidate will continue the development of a novel instrument, designed to study the aggregation of ensembles of icy grains. They will be expected to lead the day-to-day experimental work, data analysis
and resulting scientific publications. The experiments will focus on the aggregation of solid mm-sized icy grains, and porous-mm to cm-sized icy grains, as well as quantifying the collision induced outgassing of water. Some of the experiments will be conducted in microgravity environments in addition to the OU Astrochemistry Laboratories. Applicants will have a PhD in Experimental Physics, Physical Chemistry or Laboratory Astrochemistry or a directly related experimental field, and will be experienced in working with at least two of the following techniques: ultra-high vacuum, mass spectroscopy, cryogenics, ultra-fast video imaging. Additionally, they will have experience of experiment development and experimental computer control and data analysis. The successful candidate will also have excellent communication skills and be able to evidence strong teamwork in scientific or engineering projects, as well as demonstrating an emerging track record of peer-reviewed publications in international scientific journals.

- **PDRA - (Laboratory Astrophysics: Ice Aggregation Studies)**
  1 year fixed term, starting between April 1st 2018 and Oct 1st 2018
  [Ref: 14379]
  29,799 - 38,833 (based on experience)
  Closing date 28th Feb 2018 (12 noon) [Interviews between March 8th and 13th 2018]

This project applies fundamental condensed matter physics and neutron scattering techniques to our understanding of the materials involved in planet aggregation processes. The PDRA will be expected to design and lead experiments to form, manipulate and store the small amorphous icy particles, which will then subsequently be exploited in aggregation studies. The bulk and surface structure of the particles will be characterized using neutron-scattering techniques at a variety of nano- and micrometre length scales, exploiting the ISIS neutron facility at Rutherford Appleton Laboratories, UK. Subsequently the thermal and temporal evolution of these particles will also be investigated. By the time of taking up the post, the successful applicant will have a PhD in Neutron Science, Condensed Matter, Experimental Physics, Physical Chemistry or Laboratory Astrochemistry or a directly related experimental field. They will be experienced in working at large-scale neutron facilities and have experience with at least two of the following techniques: condensed molecular material (ice), cryogens, particle handing, particle characterization methods (e.g. mass distribution, size distribution, spectroscopic analysis). Additionally, they will have experience of neutron scattering experiments and the associated data analysis and necessary coding experience. The successful candidate will also have excellent communication skills and be able to evidence strong teamwork in scientific or engineering projects, as well as demonstrating an emerging track record of peer-reviewed publications in international scientific journals.

For detailed information on how to apply follow the respective hyperlinks to each position above.

You will need to complete an online application and also provide a full academic CV (including names and contact details for three academic referees), a publication list and a cover letter explaining why this project is of interest, how a PDRA fits with your longer-term career aspirations and how you meet the person specifications for the role.

- **PhD: (Observational Astrochemistry: Ice-Mapping in the JWST Era)**
  3.5 year fixed term, commencing October 1st 2018
  [Ref: A5]
  up to £14,533 (tax free stipend per annum) plus fees (terms & conditions apply)
  Applications will be considered from Feb 16th 2018, with initial interviews March 14th & 15th 2018, followed by a further round of interviews in late March until all positions are filled. Early application is advised.

This PhD will build on our legacy of ice-mapping with the AKARI satellite to pave the way for the next generation of space- and ground-based facilities, which are set to revolutionize the icy astronomy world - JWST and E-ELT (Metis). The PhD will involve software and simulation preparations for JWST cycle 1 observations, particularly NIRCAM slitless spectroscopy of star-forming regions. The observations have been awarded time as part of the JWST ERS 'Ice Age' programme (on which HJF is a Co-I) and the PhD student will be involved in the ERS data reduction and analysis. Subsequently the student will be involved in NIRSPEC MSA ice-mapping of pre-stellar cores, in JWST Cycle 1 and 2, as well as having the opportunity for planning and simulating future ice observations possible with E-ELT Metis. In addition, this PhD will exploit archival data to generate combined ice-dust-gas maps of up to 12 pre-stellar cores, for which data from AKARI, Spitzer, Herschel, JCMT, Nobeyama and IRAM are already in hand. The analysis will not only produce beautiful imagery, but decipher for the first time, how water, CO and CO2 ices
(as well as methanol and ammonia) are interrelated, and how ice chemistry can be linked to deuteration processes (or other isotopic differentiation), as well as dust abundances and the gas-phase abundances of key chemical and physical tracers in star-forming regions, such as CO, HCO+, H2D+ and CH3OH. There will be scope to apply for telescope observing time on VLT (KMOS), Subaru, Keck and JCMT / IRAM / NOEMA / ALMA, to obtain new gas- dust-and ice- observations to extend our chemical picture.

Applicants require a Masters Degree in Physics or Astronomy, with evidence of extended observational or computing-based project work.

- **PhD: (Laboratory Astrochemistry: Experimenting with the Earliest Stages of Planet Formation)**

  3.5 year fixed term, commencing October 1st 2018

  [Ref: A4]

  up to £14,533 (tax free stipend per annum) plus fees (terms & conditions apply)

  Applications will be considered from Feb 16th 2018, with initial interviews March 14th & 15th 2018, followed by a further round of interviews in late March until all positions are filled. Early application is advised.

  This PhD will focus on laboratory work to produce and characterize the porous amorphous icy particles required for collision experiments, testing the earliest stages of planet formation. Our scientific goal is to describe, qualitatively and quantitatively, the collisions that dominate the earliest stages of icy planetesimal-formation, to answer, 'how do planets form?' We use laboratory experiments to test icy grain collisions, taking advantage of the microgravity duration and quality in parabolic and sub-orbital flight, to study cm to sub-cm s-1 collisions between ensembles of micrometre-sized icy grains, forming micron mm sized ‘fluffy’ ice aggregates, that stick to form cm-sized icy ‘pebbles’. These ‘ingredients’ form the basis of material that aggregates in protoplanetary disks (including our own pre-solar nebula) to form the cores of planets, comets and asteroids. The PhD work will move from coarse proof of concept experiments in the laboratory, to large-scale reproducible production of icy grains, which will be characterized through neutron scattering experiments, and IR spectroscopy, and whose behavior will be tested in drop tower and parabolic flight experiments. The PhD includes significant facilities use requiring week(s) on ‘in situ’ experimentation away from the OU. There is also an opportunity to apply the research to understanding of mission data (e.g. Rosetta, OSIRIS-Rex, Phobos sample return), and astronomical observations (e.g. JWST and ALMA).

  Applicants require a good quality pass in an undergraduate degree in Physics or Materials or Engineering, with evidence of extended laboratory based project work potentially involving image analysis, Labview programming, and handling of cryogens. An understanding of atomic and molecular physics is desirable.

  For detailed information on how to apply for either of these PhDs go to;


  You will need send a completed an application form (available at the link above), full CV (including names and contact details for two academic referees), full transcript of courses studied and grades awarded, and a cover letter explaining why this project is of interest, how a PhD fits with your longer-term career aspirations to STEM-SPS-PhD-admin@open.ac.uk as soon as possible. Please state the PhD project reference number on your application.

  Both PhD projects are also open to students worldwide with personal fellowship funding or those eligible for SEPNET scholarships. Please look at;

  http://www.sepnet.ac.uk/sepnet-phd-scholarships-2018/

  for further details of the SEPNET scholarship application process, which closes on Feb 14th 2018.
3 ERC-funded postdoctoral positions on PASIPHAE at FORTH / University of Crete, Greece

The Foundation for Research and Technology - Hellas, the foremost research organization in Greece, invites applications for 3 postdoctoral positions for the ERC-funded project PASIPHAE (see http://pasiphae.science). PASIPHAE is an international collaboration between FORTH and the University of Crete in Greece, Caltech in the US, the Inter-University Center for Astronomy and Astrophysics in India, the South African Astronomical Observatory, and the University of Oslo in Norway.

We are building a team with diverse expertise (both observational and theoretical), including the Galactic magnetic field, optopolarimetry, numerical and statistical analysis (including the numerical solutions of complex boundary-value problems and/or machine learning algorithms), interstellar medium astrophysics, high-energy astrophysics including gamma-ray and cosmic-ray astrophysics, and stellar astrophysics (with emphasis on intrinsic stellar polarizations). Applicants with a strong background in any of these fields are encouraged to apply.

The duration of the positions will be up to 3 years. A starting date in September 2018 is anticipated. The salary is competitive, depending on experience, and a generous travel allowance will be provided. The successful candidates will also have the opportunity to spend time at and interact with other PASIPHAE Collaboration Institutions.

Consideration of applications will begin February 15th and will continue until positions are filled. Candidates are requested to send a CV, a discussion of their past research, and three letters of recommendation to Prof. Kostas Tassis (tassis@physics.uoc.gr).

For more information see http://pasiphae.science/jobs
The Wonders of Star Formation, 
a tribute to Hans Zinnecker

September 3-7, 2018
John McIntyre Conference Centre, Edinburgh, UK

Rationale: This meeting will celebrate the many and varied contributions that Hans Zinnecker has made to the study of star formation during his long and active career, and the inspiration that working with Hans has given countless astronomers, both young and old, over the years. Understanding when, where and how stars form continues to be one of the most compelling problems in astrophysics, and a new generation of instruments is set to maintain the excitement of this field into the foreseeable future. We will explore the key observations and theories, their contradictions and limitations, and the steps being taken to overcome them. The meeting will be held in the beautiful city of Edinburgh, where Hans was a postdoc 35 years ago. The aim will be to chart the progress that has been made since then, to identify the problems that still need to be addressed, and how best to go about solving them. We hope you will be able to join us and help to make this a memorable meeting.

Principle Themes: Molecular Clouds and Filaments; Low-Mass Star Formation; Jets and Outflows; Massive Star Formation; Feedback from Massive Stars; Multiple Systems; Clusters; The Initial Mass Function; Starbursts and the Galactic Context.

Invited speakers:
Matthew Bate  Bernhard Brandl  Sylvie Cabrit  Bruce Elmegreen
Yasuo Fukui  Alvaro Hacar  Patrick Hennebelle  Shu-ichiro Inutsuka
Kaitlin Kratter  Diederic Kruijssen  Rolf Kuiper  Charlie Lada
Richard Parker  Bo Reipurth  Jürgen Stutzki  Jonathan Tan
John Tobin  Steffi Walch  Derek Ward-Thompson  Richard Wünsch
Hal Yorke  Annie Zavagno  Hans Zinnecker

Important deadlines:
Early registration, 2018 April 30;
Abstract submission, 2018 June 15;
Talk/poster allocation, 2018 July 6;
Late registration, 2018 July 31.

Registration:
https://events.ph.ed.ac.uk/star-formation

SOC: Ant Whitworth (chair), Ken Rice (deputy chair), John Bally, Ian Bonnell, Cathie Clarke, Mark McCaughrean, Bo Reipurth, Dimitri Stamatellos, Steffi Walch, Hal Yorke.
Magnetic fields along the star-formation sequence: bridging polarization-sensitive views
Focus Meeting 4 at the IAU General Assembly Vienna, Austria August 30-31, 2018

https://escience.aip.de/iau30-fm4/

Dear colleagues,

We invite you to join us at the 2018 IAU General Assembly for a Focus Meeting dedicated to the role of magnetic fields in the star-formation process.

In this Focus Meeting we wish to gather the different communities working with magnetized models and polarimetric observations of the various stages and objects along the star formation sequence, from molecular clouds to young stars reaching the main sequence.

The goal is to discuss how to compare constraints on magnetic fields at different evolutionary stages and physical scales in order to establish a coherent view of their role in the multi-scale process of star formation. Combining observational results and theoretical expectations from different communities is complex, so we especially welcome contributions that will emphasize how different measurements of magnetic fields can be compared and interpreted in a coherent way, despite the widely varying observing techniques, objects, and physical scales that are involved in studies across the star-formation sequence.

If you would like to receive updates about the organization of the Focus Meeting, please register your contact information on our webpage: https://escience.aip.de/iau30-fm4/registration/

Note that registration for IAU GA 2018 and payment of the corresponding fees will be handled by the IAU General Assembly organizers and are mandatory to participate in the event! See submission details below.

We look forward to seeing you in Vienna in August, 2018!

On behalf of the SOC, Anäelle Maury, Swetlana Hubrig, and Chat Hull (co-chairs), Silvia Alencar, Andrea Bracco, Edith Falgarone, Josep Miquel Girart, Martin Houde, Jungmi Kwon, Hiro Takami, Helmut Wiesemeyer, Qizhou Zhang.

Abstract submission is possible once registration is completed on the IAU XXX GA webpage (early-bird rate before Jan. 31, 2018):

https://astronomy2018.univie.ac.at/registration/online-registration/

Any inquiry about the scientific program of Focus Meeting 4 can be directed to: iau2018.fm4@gmail.com
Formation of substellar objects: theory and observations
ESAC May 21-23, 2018, Madrid, Spain

On behalf of Local and Scientific Organizing Committees, we are pleased to announce a three days workshop devoted to brown dwarfs and their formation mechanism/s. More than 20 years have passed since the discovery of the first confirmed substellar objects. However, there are still many problems concerning brown dwarf formation and evolution.

During the last years, a large number of works have been focused on explaining the origin of brown dwarfs. Thanks to Spitzer, Herschel and lately ALMA, there are now evidences of a star-like scenario to explain the formation of these substellar objects. However, there are still open questions, like the role of turbulence, and the efficiency of other mechanisms (e.g. photo-evaporation, disk fragmentation) to produce BDs. On the other hand, the study of young clusters is producing more and more spectroscopically confirmed substellar IMFs, which are fundamental to understand BD formation and evolution.

The scope of this workshop is to gather experts on BD formation, both theoreticians and observational astronomers, to discuss about the results of the last decade. We plan to compare the theoretical expectations with the results from observations to understand which questions have been answered, and which ones are still open. Moreover, experts from other fields, such as exoplanets and chemical modeling, are welcome since one of the goals is to study the phenomena from a comprehensive perspective and to produce new synergies and projects. In addition, we will discuss about the advances that can be done in this field with the advent of new facilities like e.g. JWST or Euclid.

CONFIRMED INVITED SPEAKERS:
Matthew R. Bate (University of Exeter, UK), Gilles Chabrier (Ecole Normale Superieure de Lyon, France), Masahiro N. Machida (Kyushu University, Japan), Estelle Moraux (Univ. Grenoble Alpes, CNRS, France), Aina Palau (Instituto de Radioastronomia y Astrofisica, UNAM, Mexico), Ken Rice (University of Edinburgh, UK), Luca Ricci (California State University, Northridge & JPL, USA)

SCIENTIFIC ORGANIZING COMMITTEE:
David Barrado (CAB, co-chair), Carlos Eiroa (UAM, co-chair), Amelia Bayo (U. De Valparaiso, Chile), Philippe André (CEA Saclay, France), Itziar de Gregorio-Monsalvo (ESO/ALMA, Chile), Michael Dunham (State University NY at Fredonia, US), Basmah Riaz (MPE Garching, Germany), Dimitris Stamatellos (University of Central Lancashire, UK), Aina Palau (UNAM, Mexico), Oscar Morata (ASIAA, Taiwan), Chang Won Lee (KASI, Republic of Korea), Erick Young (NASA Ames, USA)

IMPORTANT DATES:
- Registration is now OPEN
- Deadline for abstract submission and early registration fee: March 15th, 2018

All relevant information can be found at:

Regards,
David Barrado, María Morales, Nuria Huelamo and Carlos Eiroa, on behalf of the SOC and LOC
Summary of Upcoming Meetings

Star and Planet Formation in the Southwest 2 (SPF2)
12 - 16 March 2018, Oracle, Arizona, USA
http://tinyurl.com/spf2018

Circumplanetary Disks and Satellite Formation
26 - 30 March 2018
https://cpdsf2018.wixsite.com/home

Complex Organic Molecules in the Universe: Current Understanding and Perspective
4 April 2018, Liverpool, UK
http://eas.unige.ch/EWASS2018/session.jsp?id=SS5

Cosmic Rays: the salt of the star formation recipe
2 - 4 May 2018, Florence, Italy
http://www.arcetri.astro.it/cosmicrays

EPoS 2018 The Early Phase of Star Formation - Archetypes
13 - 18 May 2018, Ringberg Castle, Tegernsee, Germany

Interstellar: The Matter
14 - 18 May 2018, Cozumel, Mexico
http://bigbang.nucleares.unam.mx/astroplasmas/interstellar-the-matter

Cloudy workshop
14 - 25 May 2018, Chiang Mai, Thailand

From Prestellar Cores to Solar Nebulae
14 May - 22 June 2018, Paris-Saclay, France
https://www.ias.u-psud.fr/core2disk/

Formation of substellar objects: theory and observation
21-23 May 2018, ESAC, Madrid, Spain

The Olympian Symposium 2018: Gas and stars from milli- to mega- parsecs
28 May - 1 June 2018, Mt. Olympus, Greece
http://www.olympiansymposium.org

Tracing the Flow: Galactic Environments and the Formation of Massive Stars
2 - 6 July 2018, Lake Windermere, UK
http://almaost jb.man.ac.uk/meetings/TtF

The Laws of Star Formation: from the Cosmic Dawn to the Present Universe
2 - 6 July 2018, Cambridge, UK
http://www.ast.cam.ac.uk/meetings/2018/sf.law2018.cambridge

The Cosmic Cycle of Dust and Gas in the Galaxy: from Old to Young Stars
9 - 13 July 2018, Quy Nhon, Vietnam
https://cosmiccycle2018.sciencesconf.org

Astrochemistry: Past, Present, and Future
10 - 13 July, 2018, Pasadena, USA
http://www.cfa.harvard.edu/events/2018/astrochem18
COSPAR 2018 sessions on Planet Formation and Exoplanets
14 - 22 July 2018, Pasadena, USA
https://www.cospar-assembly.org/admin/sessioninfo.php?session=744

Cool Stars 20: Cambridge Workshop on Cool Stars, Stellar Systems and the Sun
29 July - 3 August 2018, Cambridge/Boston, USA
http://www.coolstars20.com

Origins: From the Protosun to the First Steps of Life
20 - 23 August 2018, Vienna, Austria
http://ninlil.elte.hu/IAUS345/

Magnetic fields along the star-formation sequence: bridging polarization-sensitive views
30-31 August 2018, Vienna, Austria
http://escience.aip.de/iau30-fm4/

The Wonders of Star Formation
3 - 7 September 2018, Edinburgh, Scotland
http://events.ph.ed.ac.uk/star-formation

Take a Closer Look - The Innermost Region of Protoplanetary Discs and its Connection to the Origin of Planets
15 - 19 October 2018, ESO Headquarters, Garching, Germany
http://www.eso.org/sci/publications/announcements/sciann17072.html
Dear colleagues!

The Fizeau exchange visitors program in optical interferometry funds (travel and accommodation) visits of researchers to an institute of his/her choice (within the European Community) to perform collaborative work and training on one of the active topics of the European Interferometry Initiative. The visits will typically last for one month, and strengthen the network of astronomers engaged in technical, scientific and training work on optical/infrared interferometry. The program is open for all levels of astronomers (Ph.D. students to tenured staff), with priority given to PhD students and young postdocs. non-EU based missions will only be funded if considered essential by the Fizeau Committee. Applicants are strongly encouraged to seek also partial support from their home or host institutions.

The deadline for applications is March 15 for visits to be carried out between May 2018 and October 2018!.

Note: requests for support for the Fizeau school in July 2018 are NOT part of this call. Such requests will be handled by the school organizers.

Further informations and application forms can be found at [http://www.european-interferometry.eu](http://www.european-interferometry.eu)

The program is funded by OPTICON/H2020.

Please distribute this message also to potentially interested colleagues outside of your community!

Looking forward to your applications,

Josef Hron & Péter Ábrahám
(for the European Interferometry Initiative)