THE STAR FORMATION NEWSLETTER

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

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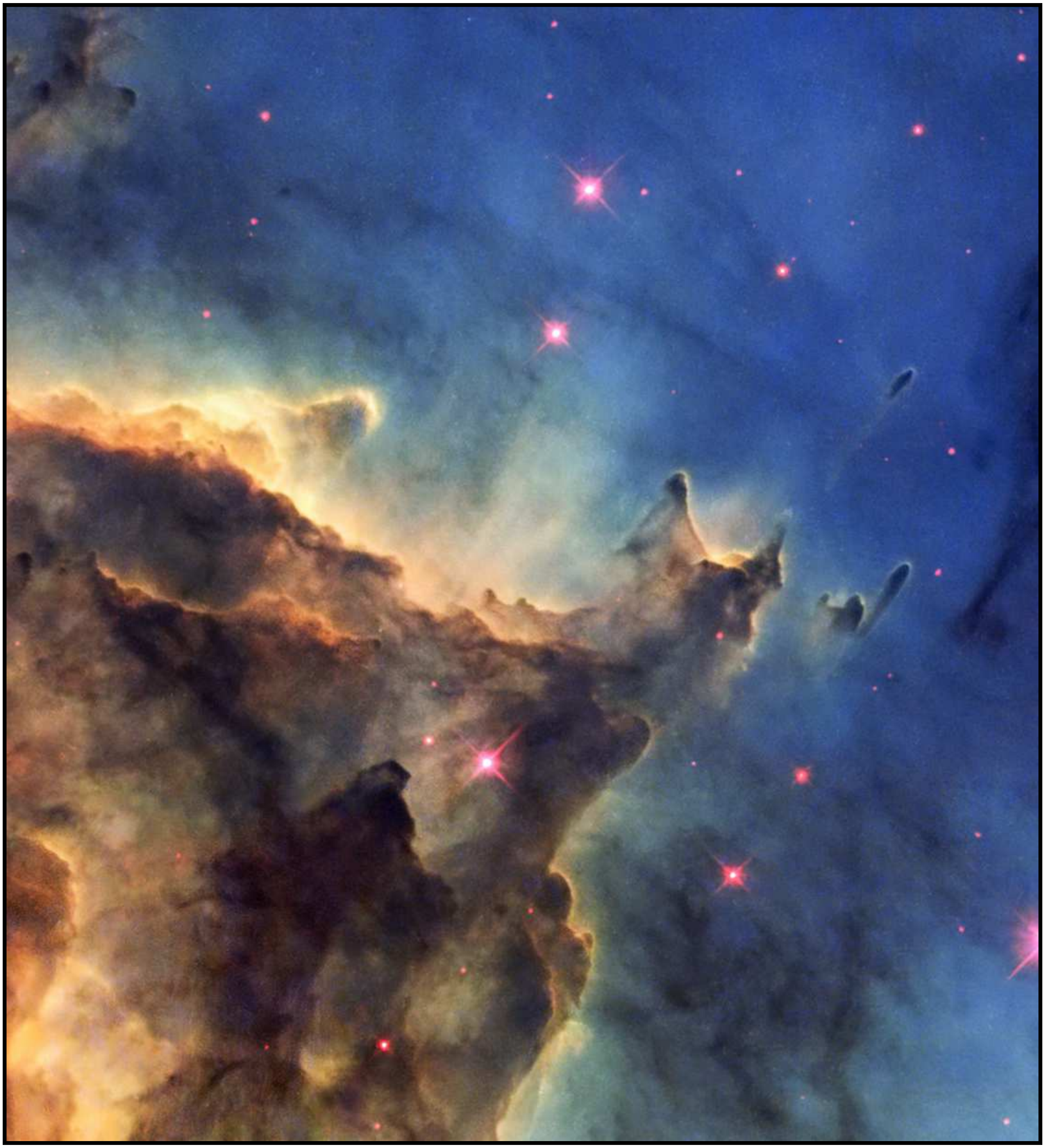

The Star Formation Newsletter

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

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Cover Picture

NGC 2175 is a 1-2 Myr old cluster in Gemini at a distance of roughly 2 kpc. It is dominated by the O6.5V star HD 42088, which ionizes the surrounding HII region, also known as NGC 2175, but more commonly as Sh2-252. The western side of the HII region is bounded by molecular clouds, which are sculpted by the UV radiation and the expansion of the HII region, as seen in this HST image.

Courtesy ESA/Hubble & NASA

Submitting your abstracts

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

Abstracts of recently accepted papers

Inner disk structure of the classical T Tauri star LkCa 15

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Magnetospheric accretion has been thoroughly studied in young stellar systems with full non-evolved accretion disks, but it is poorly documented for transition disk objects with large inner cavities. We aim at characterizing the star-disk interaction and the accretion process onto the central star of LkCa 15, a prototypical transition disk system with an inner dust cavity that is 50 au wide. We obtained quasi-simultaneous photometric and spectropolarimetric observations of the system over several rotational periods. We analyzed the system light curve and associated color variations, as well as changes in spectral continuum and line profile to derive the properties of the accretion flow from the edge of the inner disk to the central star. We also derived magnetic field measurements at the stellar surface. We find that the system exhibits magnetic, photometric, and spectroscopic variability with a period of about 5.70 days. The light curve reveals a periodic dip, which suggests the presence of an inner disk warp that is located at the corotation radius at about 0.06 au from the star. Line profile variations and veiling variability are consistent with a magnetospheric accretion model where the funnel flows reach the star at high latitudes. This leads to the development of an accretion shock close to the magnetic poles. All diagnostics point to a highly inclined inner disk that interacts with the stellar magnetosphere. The spectroscopic and photometric variability on a timescale of days to weeks of LkCa 15 is remarkably similar to that of AA Tau, the prototype of periodic dippers. We therefore suggest that the origin of the variability is a rotating disk warp that is located at the inner edge of a highly inclined disk close to the star. This contrasts with the moderate inclination of the outer transition disk seen on the large scale and thus provides evidence for a significant misalignment between the inner and outer disks of this planet-forming transition disk system.

Accepted by Astronomy & Astrophysics

http://arxiv.org/pdf/1811.04806

The Formation of Supermassive Black Holes from Population III.1 Seeds. I. Cosmic Formation Histories and Clustering Properties

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We calculate cosmic distributions in space and time of the formation sites of the first, "Pop III.1" stars, exploring a model in which these are the progenitors of all supermassive black holes (SMBHs), seen in the centers of most large galaxies. Pop III.1 stars are defined to form from primordial composition gas in dark matter minihalos with $\sim 10^6\, M_\odot$ that are isolated from neighboring astrophysical sources by a given isolation distance, $d_{\rm iso}$. We assume Pop

III.1 sources are seeds of SMBHs, based on protostellar support by dark matter annihilation heating that allows them to accrete a large fraction of their minihalo gas, i.e., $\sim 10^5\ M_\odot$. Exploring $d_{\rm iso}$ from 10–100 kpc (proper distances), we predict the redshift evolution of Pop III.1 source and SMBH remnant number densities. The local, $z = 0$ density of SMBHs constrains $d_{\rm iso} \sim< 100$ kpc (i.e., 3 Mpc comoving distance at $z \simeq 30$). In our simulated (~ 60 Mpc)^3 comoving volume, Pop III.1 stars start forming just after $z = 40$. Their formation is largely complete by $z \simeq 25$ to 20 for $d_{\rm iso} = 100$ to 50 kpc. We follow source evolution to $z = 10$, by which point most SMBHs reside in halos with $\gtrsim 10^8\ M_\odot$. Over this period, there is relatively limited merging of SMBHs for these values of $d_{\rm iso}$. We also predict SMBH clustering properties at $z = 10$: feedback suppression of neighboring sources leads to relatively flat angular correlation functions.

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https://arxiv.org/pdf/1608.04421

Kinematic links and the co-evolution of MHD winds, jets, and inner disks from a high-resolution optical [OI] survey

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We present a survey of optical [OI] emission at 6300 Å toward 65 TTauri stars at the spectral resolution of ~ 7 km/s. Past work identified a highly blueshifted velocity component (HVC) tracing microjets, and a less blueshifted low-velocity-component (LVC) attributed to winds. We focus here on the LVC kinematics to investigate links between winds, jets, accretion, and disk dispersal. We track the behavior of four types of LVC components: a broad and narrow component ("BC" and "NC") in LVCs that are decomposed into two Gaussians, which typically have an HVC, and the single-Gaussian LVC profiles separated into those that have an HVC ("SCJ") and those that do not ("SC"). LVC centroid velocities and line widths correlate with HVC equivalent width and accretion luminosity, suggesting that LVC/winds and HVC/jets are kinematically linked and connected to accretion. The deprojected HVC velocity correlates with accretion luminosity, showing that faster jets come with higher accretion. BC and NC kinematics correlate and their blueshifts are maximum at $\sim 35°$, suggesting a conical wind geometry with this semi-opening angle. Only SCs include n_{13-31} up to ~ 3 and their properties correlate with this infrared index, showing that [OI] emission recedes to larger radii as the inner dust is depleted, tracing less dense/hot gas and a decrease in wind velocity. All together, these findings support a scenario where optically thick, accreting inner disks launch radially-extended MHD disk winds that feed jets, and where inner disk winds recede to larger radii and jets disappear in concert with dust depletion.

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High-mass star formation at sub-50 AU scales

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Context: The hierarchical process of star formation has so far mostly been studied on scales from thousands of au to parsecs, but the smaller sub-1000 au scales of high-mass star formation are still largely unexplored in the submm regime.// *Aims*: We aim to resolve the dust and gas emission at the highest spatial resolution to study the physical properties of the densest structures during high-mass star formation. Methods: We observed the high-mass hot core region G351.77-0.54 with the Atacama Large Millimeter Array with baselines extending out to more than 16 km. This allowed us to dissect the region at sub-50 au spatial scales.// *Results*: At a spatial resolution of 18/40 au (depending on the distance), we identify twelve sub-structures within the inner few thousand au of the region. The brightness temperatures are high, reaching values greater 1000 K, signposting high optical depth toward the peak positions. Core separations vary between sub-100 au to several 100 and 1000 au. The core separations and approximate masses are largely consistent with thermal Jeans fragmentation of a dense gas core. Due to the high continuum optical depth, most spectral lines are seen in absorption. However, a few exceptional emission lines are found that most likely stem from transitions with excitation conditions above1000 K. Toward the main continuum source, these emission lines exhibit a velocity gradient across scales of 100-200 au aligned with the molecular outflow and perpendicular to the previously inferred disk orientation. While we cannot exclude that these observational features stem from an inner hot accretion disk, the alignment with the outflow rather suggests that it stems from the inner jet and outflow region. The highest-velocity features are found toward the peak position, and no Hubble-like velocity structure can be identified. Therefore, these data are consistent with steady-state turbulent entrainment of the hot molecular gas via Kelvin-Helmholtz instabilities at the interface between the jet and the outflow.// *Conclusions*: Resolving this high-mass star-forming region at sub-50 au scales indicates that the hierarchical fragmentation process in the framework of thermal Jeans fragmentation can continue down to the smallest accessible spatial scales. Velocity gradients on these small scales have to be treated cautiously and do not necessarily stem from disks, but may be better explained with outflow emission. Studying these small scales is very powerful, but covering all spatial scales and deriving a global picture from large to small scales are the next steps to investigate.

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

Direct imaging of molten protoplanets in nearby young stellar associations

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During their formation and early evolution, rocky planets undergo multiple global melting events due to accretionary collisions with other protoplanets. The detection and characterization of their post-collision afterglows (magma oceans) can yield important clues about the origin and evolution of the solar and extrasolar planet population. Here, we quantitatively assess the observational prospects to detect the radiative signature of forming planets covered by such collision-induced magma oceans in nearby young stellar associations with future direct imaging facilities. We have compared performance estimates for near- and mid-infrared instruments to be installed at ESO's Extremely Large Telescope (ELT), and a potential space-based mission called Large Interferometer for Exoplanets (LIFE). We modelled the frequency and timing of energetic collisions using N-body models of planet formation for different stellar types, and determine the cooling of the resulting magma oceans with an insulating atmosphere. We find that the probability of detecting at least one magma ocean planet depends on the observing duration and the distribution of atmospheric properties among rocky protoplanets. However, the prospects for detection significantly increase for young and close stellar targets, which show the highest frequencies of giant impacts. For intensive reconnaissance with a K band (2.2 μm) ELT filter or a 5.6 μm LIFE filter, the β Pictoris, Columba, TW Hydrae, and Tucana-Horologium associations represent promising candidates for detecting a molten protoplanet. Our results motivate the exploration of magma ocean planets using the ELT and underline the importance of space-based direct imaging facilities to investigate and

characterize planet formation and evolution in the solar vicinity.

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http://arxiv.org/pdf/1811.07411

Deep ALMA Search for CO Gas in the HD 95086 Debris Disc

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One of the defining properties of debris discs compared to protoplanetary discs used to be their lack of gas, yet small amounts of gas have been found around an increasing number of debris discs in recent years. These debris discs found to have gas tend to be both young and bright. In this paper we conduct a deep search for CO gas in the system HD 95086 – a 17 Myr old, known planet host that also has a debris disc with a high fractional luminosity of 1.5×10^{-3}. Using the Atacama Large Millimeter/submillimeter Array (ALMA) we search for CO emission lines in bands 3, 6 and 7. By implementing a spectro-spatial filtering technique, we find tentative evidence for CO J=2-1 emission in the disc located at a velocity, 8.5±0.2 km s^{-1}, consistent with the radial velocity of the star. The tentative detection suggests that the gas on the East side of the disc is moving towards us. In the same region where continuum emission is detected, we find an integrated line flux of 9.5±3.6 mJy km s^{-1}, corresponding to a CO mass of (1.4-13)$\times10^{-6}$ M$_\oplus$. Our analysis confirms that the level of gas present in the disc is inconsistent with the presence of primordial gas in the system and is consistent with second generation production through the collisional cascade.

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Triggering Collapse of the Presolar Dense Cloud Core and Injecting Short-Lived Radioisotopes with a Shock Wave. VI. Protostar and Protoplanetary Disk Formation

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Cosmochemical evaluations of the initial meteoritical abundance of the short-lived radioisotope (SLRI) ^{26}Al have remained fairly constant since 1976, while estimates for the initial abundance of the SLRI ^{60}Fe have varied widely recently. At the high end of this range, ^{60}Fe initial abundances have seemed to require ^{60}Fe nucleosynthesis in a core collapse supernova, followed by incorporation into primitive meteoritical components within $\sim$ 1 Myr. This paper continues the detailed exploration of this classical scenario, using models of the self-gravitational collapse of molecular cloud cores that have been struck by suitable shock fronts, leading to the injection of shock front gas into the collapsing cloud through Rayleigh-Taylor fingers formed at the shock-cloud interface. As before, these models are calculated using the FLASH three dimensional, adaptive mesh refinement (AMR), gravitational hydrodynamical code. While the previous models used FLASH 2.5, the new models employ FLASH 4.3, which allows sink particles to be introduced to represent the newly formed protostellar object. Sink particles permit the models to be pushed forward farther in time to the phase where a $\sim 1 M_\odot$ protostar has formed, orbited by a rotating protoplanetary disk.

These models are thus able to define what type of target cloud core is necessary for the supernova triggering scenario to produce a plausible scheme for the injection of SLRIs into the presolar cloud core: a $\sim 3M_{\odot}$ cloud core rotating at a rate of $\sim 3 \times 10^{-14}$ rad s^{-1} or higher.

Accepted by Astrophysical Journal

https://home.dtm.ciw.edu/users/boss/triggerVI.pdf

Rotational spectroscopy of the HCCO and DCCO radicals in the millimeter and submillimeter range

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The ketenyl radical, HCCO, has recently been detected in the ISM for the first time. Further astronomical detections of HCCO will help us understand its gas-grain chemistry, and subsequently revise the oxygen-bearing chemistry towards dark clouds. Moreover, its deuterated counterpart, DCCO, has never been observed in the ISM. HCCO and DCCO still lack a broad spectroscopic investigation, although they exhibit a significant astrophysical relevance. In this work we aim to measure the pure rotational spectra of the ground state of HCCO and DCCO in the millimeter and submillimeter region, considerably extending the frequency range covered by previous studies. The spectral acquisition was performed using a frequency-modulation absorption spectrometer between 170 and 650 GHz. The radicals were produced in a low-density plasma generated from a select mixture of gaseous precursors. For each isotopologue we were able to detect and assign more than 100 rotational lines. The new lines have significantly enhanced the previous data set allowing the determination of highly precise rotational and centrifugal distortion parameters. In our analysis we have taken into account the interaction between the ground electronic state and a low-lying excited state (Renner-Teller pair) which enables the prediction and assignment of rotational transitions with K_a up to 4. The present set of spectroscopic parameters provides highly accurate, millimeter and submillimeter rest-frequencies of HCCO and DCCO for future astronomical observations. We also show that towards the pre-stellar core L1544, ketenyl peaks in the region where c-C_3H_2 peaks, suggesting that HCCO follows a predominant hydrocarbon chemistry, as already proposed by recent gas-grain chemical models.

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A VLT/FLAMES survey for massive binaries in Westerlund 1 V. the X-ray selected blue stragglers Wd1-27 and -30a

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Observational studies suggest that many OB stars are found within binary systems which may be expected to interact during their lifetimes. Significant mass transfer or merger of both components will modify evolutionary pathways, facilitating the production of exceptionally massive stars which will present as blue stragglers. Identification and characterisation of such objects is crucial if the outcomes of binary evolutionary channels are to be quantified. The massive cluster Westerlund 1 hosts a rich population of X-ray bright stars where the emission is thought to derive from the wind collision zones of massive binaries. Selected on this basis, we present the results of a multiwavelength analysis of the X-ray luminous O stars Wd1-27 and -30a. We find both to be early/mid-O hypergiants with luminosities, temperatures and masses significantly in excess of other early stars within Wd1, hence qualifying as massive blue stragglers. The nature of Wd1-27 remains uncertain but the detection of radial velocity changes and the X-ray properties of Wd1-30a suggest that it is a binary. Analysis of Gaia proper motion and parallactic data indicates that both are cluster members; we also provide a membership list for Wd1 based on this analysis. The presence of hypergiants of spectral types O to M within Wd1 cannot be understood via single-star evolution. We suppose that the early-B and mid-O hypergiants formed via binary-induced mass-stripping of the primary and mass-transfer to the secondary, respectively. This implies that for a subset of objects massive star-formation may be regarded as a two-stage process, with binary-driven mass-transfer or merger yielding stars with masses significantly in excess of their initial birth mass.

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Environmental conditions shaping star formation: The Carina Nebula

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Using the Mopra telescope, we have targeted 61 regions in the Carina Nebula, covering an area of 1.5 square degrees, of bright and compact 870 μm dust continuum emission for molecular line emission from a host of 16 spectral lines at 3mm, including several dense gas tracers. We found that the clumps detected in Carina in general have in average higher temperatures (27 K compared to 21 K), and lower masses (214 $M_\odot$ compared to 508 $M_\odot$) than clumps located at a similar distance to us in the Galactic Plane. We compare the properties of the molecular line emission of these clumps with the MALT90 survey, finding that the detection rates of the molecular lines are similar to MALT90 clumps that are classified as PDRs. However, most of the clumps located within 10' of η Carina have little molecular line emission detected in our observations. Given the lack of maser detection in the Carina region, we also compared the properties the clumps in Carina to those of Galactic clumps associated with 6.7-GHz methanol masers. We found that the clumps in Carina are warmer, less massive, and show less emission from the four most commonly detected molecules, HCO^+, N_2H^+, HCN, and HNC, compared to clumps associated with masers in the Galactic Plane. Overall our results are consistent with the scenario in which the high radiation field of η Carina is dramatically affecting its local environment, and therefore the chemical composition of the dense clumps.

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Dusty spirals triggered by shadows in transition discs

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Context. Despite the recent discovery of spiral-shaped features in protoplanetary discs in the near-infrared and millimetric wavelengths, there is still an active discussion to understand how they formed. In fact, the spiral waves observed in discs around young stars can be due to different physical mechanisms: planet/companion torques, gravitational perturbations or illumination effects.

Aims. We study the spirals formed in the gaseous phase due to two diametrically opposed shadows cast at fixed disc locations. The shadows are created by an inclined non-precessing disc inside the cavity, which is assumed to be optically thick. In particular, we analyse the effect of these spirals on the dynamics of the dust particles and discuss their detectability in transition discs.
Methods. We perform gaseous hydrodynamical simulations with shadows, then we compute the dust evolution on top of the gaseous distribution, and finally we produce synthetic ALMA observations of the dust emission based on radiative transfer calculations.
Results. Our main finding is that mm- to cm-sized dust particles are efficiently trapped inside the shadow-triggered spirals. We also observe that particles of various sizes starting at different stellocentric distances are well mixed inside these pressure maxima. This dynamical effect would favour grain growth and affect the resulting composition of planetesimals in the disc. In addition, our radiative transfer calculations show spiral patterns in the disc at 1.6 μm and 1.3 mm. Due to their faint thermal emission (compared to the bright inner regions of the disc) the spirals cannot be detected with ALMA. Our synthetic observations prove however that shadows are observable as dips in the thermal emission.

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Submillimetre dust polarisation and opacity in the HD163296 protoplanetary ring system

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We present ALMA images of the sub-mm continuum polarisation and spectral index of the protoplanetary ringed disk HD163296. The polarisation fraction at 870 μm is measured to be ∼0.9% in the central core and generally increases with radius along the disk major axis. It peaks in the gaps between the dust rings, and the largest value (∼4%) is found between rings 1 and 2. The polarisation vectors are aligned with the disk minor axis in the central core, but become more azimuthal in the gaps, twisting by up to $\pm 9^{\circ}$ in the gap between rings 1 and 2. These general characteristics are consistent with a model of self-scattered radiation in the ringed structure, without requiring an additional dust alignment mechanism. The 870/1300 μm dust spectral index exhibits minima in the centre and the inner rings, suggesting these regions have high optical depths. However, further refinement of the dust or the disk model at higher resolution is needed to reproduce simultaneously the observed degree of polarisation and the low spectral index.

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The magnetic propeller accretion regime of LkCa 15

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We present a spectropolarimetric study of the classical T Tauri star (cTTS) LkCa 15 investigating the large-scale magnetic topology of the central star and the way the field connects to the inner regions of the accretion disc. We find that the star hosts a strong poloidal field with a mainly axisymmetric dipole component of 1.35 kG, whereas the mass accretion rate at the surface of the star is $10^{-9.2}$ $M_{\odot}yr^{-1}$. It implies that the magnetic field of LkCa 15 is able to evacuate the central regions of the disc up to a distance of 0.07 au at which the Keplerian orbital period equals the stellar rotation period. Our results suggest that LkCa 15, like the lower-mass cTTS AA Tau, interacts with its disc in a propeller mode, a regime supposedly very efficient at slowing down the rotation of cTTSs hosting strong dipolar fields.

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Observational Signatures of Planets in Protoplanetary Disks: Planet-Induced Line Broadening in Gaps

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Protoplanets can produce structures in protoplanetary disks via gravitational disk-planet interactions. Once detected, such structures serve as signposts of planet formation. Here we investigate the kinematic signatures in disks produced by multi-Jupiter mass planets using 3D hydrodynamics and radiative transfer simulations. Such a planet opens a deep gap, and drives transonic vertical motions inside. Such motions include both a bulk motion of the entire half-disk column, and turbulence on scales comparable to and smaller than the scale height. They significantly broaden molecular lines from the gap, producing double-peaked line profiles at certain locations, and a kinematic velocity dispersion comparable to thermal after azimuthal averaging. The same planet does not drive fast vertical motions outside the gap, except at the inner spiral arms and the disk surface. Searching for line broadening induced by multi-Jupiter mass planets inside gaps requires an angular resolution comparable to the gap width, an assessment of the gap gas temperature to within a factor of 2, and a high sensitivity needed to detect line emission from the gap.

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High-Resolution SOFIA/EXES Spectroscopy of SO_2 Gas in the Massive Young Stellar Object MonR2 IRS3: Implications for the Sulfur Budget

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Sulfur has been observed to be severely depleted in dense clouds leading to uncertainty in the molecules that contain it and the chemistry behind their evolution. Here, we aim to shed light on the sulfur chemistry in young stellar objects (YSOs) by using high-resolution infrared spectroscopy of absorption by the $\nu 3$ rovibrational band of SO_2 obtained with the Echelon-Cross-Echelle Spectrograph on the Stratospheric Observatory for Infrared Astronomy. Using local thermodynamic equilibrium models we derive physical parameters for the SO_2 gas in the massive YSO MonR2 IRS3. This yields a SO_2/H abundance lower limit of $5.6 \pm 0.5 \times 10^{-7}$, or >4% of the cosmic sulfur budget, and an intrinsic line width (Doppler parameter) of $b < 3.20$ km s^{-1}. The small line widths and high temperature ($T_{\rm ex} = 234 \pm 15$ K) locate the gas in a relatively quiescent region near the YSO, presumably in the hot core where ices have evaporated. This sublimation unlocks a volatile sulfur reservoir (e.g., sulfur allotropes as detected abundantly in comet 67P/Churyumov–Gerasimenko), which is followed by SO_2 formation by warm, dense gas-phase chemistry. The narrowness of the lines makes formation of SO_2 from sulfur sputtered off grains in shocks less likely toward MonR2 IRS3.

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X-ray spectral characterization of the young Cygnus OB2 population

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We analyze the X-ray spectra of the ∼8000 sources detected in the Cygnus OB2 Chandra Legacy Survey (Drake et al., this issue), with the goals of characterizing the coronal plasma of the young low-mass stars in the region and estimating their intrinsic X-ray luminosities. We adopt two different strategies for X-ray sources for which more or less than 20 photons were detected. For the brighter sample we fit the spectra with absorbed isothermal models. In order to limit uncertainties, for most of the fainter Cygnus OB2 members in this sample, we constrain the spectral parameters to characteristic ranges defined from the brightest stars. For X-ray sources with <20 net photons we adopt a conversion factor from detected photon flux to intrinsic flux. This was defined, building on the results for the previous sample, as a function of the 20% quantile of the detected photon energy distributions, which we prove to also correlate well with extinction. We then use the X-ray extinction from the spectral fits to constrain the ratio between optical and X-ray extinction toward Cygnus OB2, finding it consistent with standard "Galactic" values, when properly accounting for systematics. Finally we exploit the large number of sources to constrain the average coronal abundances of several elements, through two different ensemble analyses of the X-ray spectra of low-mass Cygnus OB2 members. We find the pattern of abundances to be largely consistent with that derived for the young stellar coronae in the Orion Nebula Cluster.

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Contemporaneous broad-band photometry and Hα observations of T Tauri stars

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The study of contemporaneous variations of the continuum flux and emission lines is of great importance to understand the different astrophysical processes at work in T Tauri stars.

In this paper we present the results of a simultaneous $BVRI$ and Hα photometric monitoring, contemporaneous to medium-resolution spectroscopy of six T Tauri stars in the Taurus-Auriga star forming region. We have characterized the Hα photometric system using synthetic templates and the contemporaneous spectra of the targets. We show that we can achieve a precision corresponding to 2–3 Å in the Hα equivalent width, in typical observing conditions.

The spectral analysis has allowed us to determine the basic stellar parameters and the values of quantities related to the accretion. In particular, we have measured a significant veiling only for the three targets with the strongest Hα emission (T Tau, FM Tau, and DG Tau).

The broad-band photometric variations are found to be in the range 0.05–0.70 mag and are often paired to variations in the Hα intensity, which becomes stronger when the stellar continuum is weaker. In addition, we have mostly observed a redder $V-I$ and a bluer $B-V$ color as the stars become fainter. For most of the targets, the timescales of these variations seem to be longer than the rotation period. One exception is T Tau, for which the broad-band photometry varies with the rotation period. The most plausible interpretation of these photometric and Hα variations is that they are due to non-stationary mass accretion onto the stars, but rotational modulation can play a major role in some cases.

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ALMA detections of the youngest protostars in Ophiuchus

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We present Atacama Large Millimeter/submillimeter Array (ALMA) observations of 1.1 mm dust continuum and CO 2-1 emission toward six dense cores within the Ophiuchus molecular cloud. We detect compact, sub-arcsecond continuum structures toward three targets, two of which (Oph A N6 and SM1) are located in the Ophiuchus A ridge. Two targets, SM1 and GSS 30, contain two compact sources within the ALMA primary beam. We argue that several of the compact structures are small ($R < 80$ au) accretion disks around young protostars, due to their resolved, elongated structures, coincident radio and x-ray detections, or bipolar outflow detections. While CO line wings extend to $\pm 10 - 20$ km s^{-1} for the more evolved sources GSS 30 IRS3 and IRS1, CO emission toward other sources, where detected, only extends a few km s^{-1} from the cloud $v_{\rm LSR}$. The dust spectral index toward the compact objects suggests that the disks are either optically thick at 1.1 mm, or that significant grain growth has already occurred. We identify, for the first time, a single compact continuum source ($R \sim 100$ au) toward N6 embedded within a larger continuum structure. SM1N is extended in the continuum but is highly centrally concentrated, with a density profile that follows a $r^{-1.3}$ power law within 200 au, and additional structure suggested by the uv-data. Both N6 and SM1N show no clear bipolar outflows with velocities greater than a few km s^{-1} from the cloud velocity. These sources are candidates to be the youngest protostars or first hydrostatic cores in the Ophiuchus molecular cloud.

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Modelling the abundance structure of isocyanic acid (HNCO) toward the low-mass solar type protostar IRAS 16293−2422

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Isocyanic acid (HNCO), the most stable of the simplest molecules containing the four main elements essential for organic chemistry, has been observed in several astrophysical environments such as molecular clouds, star-forming regions, external galaxies and comets. In this work, we model HNCO spectral line profiles toward the low-mass solar type protostar IRAS 16293−2422 observed with the ALMA interferometer, the IRAM, JCMT and APEX single-dish radio telescopes, and the HIFI instrument on board the Herschel Space Observatory. In star-forming environments, the HNCO emission is not always in Local Thermodynamical Equilibrium (LTE). A non-LTE radiative transfer approach is necessary to properly interpret the line profiles, and accurate collisional rate coefficients are needed. Here, we used the RADEX package with a completely new set of collisional quenching rates between HNCO and both ortho-H_2 and para-H_2 obtained from quantum chemical calculations yielding a novel potential energy surface in the rigid rotor approximation. We find that the lines profiles toward IRAS 16293−2422 are very well reproduced if we assume that the HNCO emission arises from a compact, dense and hot physical component associated with the hot corino, a warm component associated with the internal part of the protostellar envelope, and a cold and more extended component associated with the outer envelope. The derived HNCO abundances from our model agree well with those computed with the Nautilus chemical code.

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ALMA observations of the protostellar disk around the VeLLO IRAS 16253–2429

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We present ALMA long-baseline observations toward the Class 0 protostar IRAS 16253-2429 (hereafter IRAS 16253) with a resolution down to $0.12''$ ($\sim$15 au). The 1.3 mm dust continuum emission has a deconvolved Gaussian size of $0.16'' \times 0.07''$ (20 au $\times$ 8.8 au), likely tracing an inclined dusty disk. Interestingly, the position of the 1.38 mm emission is offset from that of the 0.87 mm emission along the disk minor axis. Such an offset may come from a torus-like disk with very different optical depths between these two wavelengths. Furthermore, through CO $(2-1)$ and $C^{18}O$ $(2-1)$ observations, we study rotation and infall motions in this disk-envelope system and infer the presence of a Keplerian disk with a radius of $8-32$ au. This result suggests that the disk could have formed by directly evolving from a first core, because IRAS 16253 is too young to gradually grow a disk to such a size considering the low rotation rate of its envelope. In addition, we find a quadruple pattern in the CO emission at low velocity, which may originate from CO freeze out at the disk/envelope midplane. This suggests that the "cold disk" may appear in the early stage, implying a chemical evolution for the disk around this proto-brown dwarf (or very low-mass protostar) different from that of low-mass stars.

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G11.92−0.61 MM 1: A fragmented Keplerian disk surrounding a proto-O star

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We present high resolution (∼300 au) Atacama Large Millimeter/submillimeter Array (ALMA) observations of the massive young stellar object G11.92−0.61 MM 1. We resolve the immediate circumstellar environment of MM 1 in 1.3 mm continuum emission and CH_3CN emission for the first time. The object divides into two main sources — MM 1a, which is the source of a bipolar molecular outflow, and MM 1b, located 0.″57 (1920 au) to the South-East. The main component of MM 1a is an elongated continuum structure, perpendicular to the bipolar outflow, with a size of 0.″141 × 0.″050 (480×170 au). The gas kinematics toward MM 1a probed via CH_3CN trace a variety of scales. The lower energy J=12–11 K=3 line traces extended, rotating gas within the outflow cavity, while the $v8$=1 line shows a clearly-resolved Keplerian rotation signature. Analysis of the gas kinematics and dust emission shows that the total enclosed mass in MM 1a is 40±5 $M_\odot$ (where between 2.2–5.8 $M_\odot$ is attributed to the disk), while MM 1b is <0.6 $M_\odot$. The extreme mass ratio and orbital properties of MM 1a and MM 1b suggest that MM 1b is one of the first observed examples of the formation of a binary star via disk fragmentation around a massive young (proto)star.

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Observing substructure in circumstellar discs around massive young stellar objects

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Simulations of massive star formation predict the formation of discs with significant substructure, such as spiral arms and clumps due to fragmentation. Here we present a semi-analytic framework for producing synthetic observations of discs with substructure, in order to determine their observability in interferometric observations. Unlike post-processing of hydrodynamical models, the speed inherent to our approach permits us to explore a large parameter space of star and disc parameters, and thus constrain properties for real observations. We compute synthetic dust continuum and molecular line observations probing different disc masses, distances, inclinations, thermal structures, dust distributions, and number and orientation of spirals and fragments. With appropriate spatial and kinematic filtering applied, our models predict that ALMA observations of massive YSOs at ¡5 kpc distances should detect spirals in both gas and dust in strongly self-gravitating discs (i.e. discs with fewer spiral arms and strong kinematic perturbations). Detecting spirals will be possible in discs of arbitrary inclination, either by directly spatially resolving them for more face-on discs, or through a kinematic signature otherwise. Clumps resulting from disc fragmentation should be detectable in the continuum, if the clump is sufficiently hotter than the surrounding disc material.

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Dynamical masses of M-dwarf binaries in young moving groups: II - Toward empirical mass-luminosity isochrones

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Low-mass stars exhibit substantial pre-main sequence evolution during the first ∼100 Myrs of their lives. Thus, young M-type stars are prime targets for isochronal dating, especially in young moving groups (YMGs), which contain large amounts of stars in this mass and age range. If the mass and luminosity of a star can both be directly determined, this allows for a particularly robust isochronal analysis. This motivates in-depth studies of low-mass binaries with spatially resolvable orbits, where dynamical masses can be derived. Here we present the results of an observing campaign dedicated to orbital monitoring of AB Dor Ba/Bb, which is a close M-dwarf pair within the quadruple AB Dor system. We have acquired eight astrometric epochs with the SPHERE/ZIMPOL and NACO instruments, which we combine with literature data to improve the robustness and precision for the orbital characterization of the pair. We find a system mass $0.66\pm0.12\ M_\odot$ and bolometric luminosities in $\log(L/L_\odot)$ of -2.02 ± 0.02 and -2.11 ± 0.02 for AB Dor Ba and Bb, respectively. These measurements are combined with other YMG pairs in the literature to start building a framework of empirical isochrones in mass-luminosity space. This can be used to calibrate theoretical isochrones and to provide a model-free basis for assessing relative stellar ages. We note a tentative emerging trend where the youngest moving group members are largely consistent with theoretical expectations, while stars in older associations such as the AB Dor moving group appear to be systematically underluminous relative to isochronal expectations.

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The Dynamics, Structure, and Fate of a Young Cluster During Gas Dispersal: Hectoschelle, Chandra, Spitzer, and Gaia Observations of Cep OB3b

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We present a study of the kinematics and structure of the Cep OB3b cluster based on new spectra obtained with the Hectoschelle spectrograph on the MMT and data from *Spitzer*, *Chandra*, and *Gaia*. At a distance of 819±16 pc, Cep OB3b is one of the closest examples of a young (∼3 - 5 Myr), large (∼3000 total members) cluster at the late stages of gas dispersal. The cluster is broken into two sub-clusters surrounded by a lower density halo. We fit the empirical density law of King (1962) to each sub-cluster to constrain their sizes and structure. The richer eastern sub-cluster has circular symmetry, a modest central density, and lacks molecular gas toward its core suggesting it has undergone expansion due to gas dispersal. In contrast, the western sub-cluster deviates from circular symmetry, has a smaller core size, and contains significant molecular gas near its core, suggesting that it is in an earlier phase of gas dispersal. We present posterior probability distributions for the velocity dispersions from the Hectoschelle spectra. The east will continue to expand and likely form a bound cluster with ∼35% of stars remaining. The west is undergoing slower gas dispersal and will potentially form a bound cluster with ∼75% of stars remaining. If the halo dissipates, this will leave two independent clusters with ∼300 members; proper motions suggest that the two sub-clusters are not bound to each other.

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Jets and outflows of massive protostars - From cloud collapse to jet launching and cloud dispersal

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In a comprehensive convergence study, we investigate the computational conditions necessary to resolve disk formation and jet-launching processes, and analyze possible caveats. We explore the magneto-hydrodynamic (MHD) processes of the collapse of massive prestellar cores in detail, including an analysis of the forces involved and their temporal evolution for up to two free-fall times. We conduct MHD simulations, combining nonideal MHD, self-gravity, and very high resolutions as they have never been achieved before. Our setup includes a 100 $M_\odot$ cloud core that collapses under its own self-gravity to self-consistently form a dense disk structure and launch tightly collimated magneto-centrifugal jets and wide-angle winds. Our high-resolution simulations can resolve a magneto-centrifugal jet and a magnetic pressure-driven outflow, separately. The nature of the outflows depends critically on spatial resolution. Only high-resolution simulations are able to differentiate a magneto-centrifugally launched, highly collimated jet from a slow wide-angle magnetic-pressure-driven tower flow. Of these two outflow components, the tower flow dominates angular-momentum transport. The mass outflow rate is dominated by the entrained material from the interaction of the jet with the stellar environment and only part of the ejected medium is directly launched from the accretion disk. A tower flow can only develop to its full extent when much of the original envelope has already dispersed. Taking into account both the mass launched from the surface of the disk and the entrained material from the envelope, we find an ejection-to-accretion efficiency of 10%. Nonideal MHD is required to form centrifugally supported accretion disks and the disk size is strongly dependent on spatial resolution.

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Imaging [CI] around HD 131835: reinterpreting young debris discs with protoplanetary disc levels of CO gas as shielded secondary discs

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Despite being >10 Myr, there are ∼10 debris discs with as much CO gas as in protoplanetary discs. Such discs have been assumed to be “hybrid”, i.e., with secondary dust but primordial gas. Here we show that both the dust and gas in such systems could instead be secondary, with the high CO content caused by accumulation of neutral carbon (C^0) that shields CO from photodissociating; i.e., these could be “shielded secondary discs”. New ALMA observations are presented of HD131835 that detect $\sim 3\times10^{-3}\ M_\oplus$ of C^0, the majority 40–200 au from the star, in sufficient quantity to shield the previously detected CO. A simple semi-analytic model for the evolution of CO, C and O originating in a volatile-rich planetesimal belt shows how CO shielding becomes important when the viscous evolution is slow (low α parameter) and/or the CO production rate is high. Shielding by C0 may also cause the CO content to reach levels at which CO self-shields, and the gas disc may become massive enough to affect the dust evolution. Application to the HD 131835 observations shows these can be explained if $\alpha \sim 10^{-3}$; an inner cavity in C^0 and CO may also mean the system has yet to reach steady state. Application to other debris discs with high CO content finds general agreement for $\alpha = 10^{-3}$ to 0.1. The shielded secondary nature of these gas discs can be tested by searching for C^0, as well as CN, N_2 and CH^+, which are also expected to be shielded by C^0.

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Kinematics in Young Star Clusters and Associations with Gaia DR2

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The *Gaia* mission has opened a new window into the internal kinematics of young star clusters at the sub-km s^{-1} level, with implications for our understanding of how star clusters form and evolve. We use a sample of 28 clusters and associations with ages from ∼1–5 Myr, where lists of members are available from previous X-ray, optical, and infrared studies. Proper motions from *Gaia* DR2 reveals that at least 75% of these systems are expanding; however, rotation is only detected in one system. Typical expansion velocities are on the order of ∼0.5 km s^{-1}, and, in several systems, there is a positive radial gradient in expansion velocity. Systems that are still embedded in molecular clouds are less likely to be expanding than those that are partially or fully revealed. One-dimensional velocity dispersions, which range from $\sigma_{1D} = 1$ to 3 km s^{-1}, imply that most of the stellar systems in our sample are supervirial and that some are unbound. In star-forming regions that contain multiple clusters or subclusters, we find no evidence that these groups are coalescing, implying that hierarchical cluster assembly, if it occurs, must happen rapidly during the embedded stage.

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The Stellar Membership of the Taurus Star-forming Region

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The high-precision astrometry from the second data release of the Gaia mission has made it possible to greatly improve the census of members of nearby clusters and associations. I have applied the Gaia data to the Taurus star-forming region, refining the sample of known members and identifying candidates for undiscovered members. The resulting samples of members and candidates provide the best constraints to date on the distribution of ages and the initial mass function (IMF) in Taurus. Several studies over the last 30 years have proposed the existence of a population of older stars (≥10 Myr) that is associated with the Taurus clouds. The data from Gaia demonstrate that such a population does not exist. Meanwhile, previous IMF estimates for small fields surrounding the Taurus aggregates have exhibited a surplus of K7–M0 stars (0.7–0.8 $M_\odot$) relative to star-forming clusters like IC 348 and the Orion Nebula Cluster. However, that difference disappears when the new census of the entire region is considered, which should be complete for spectral types earlier than M6–M7 at $A_J < 1$. Thus, there is little variation in the stellar IMF across the 3–4 orders of magnitude in stellar density that are present in nearby star-forming regions. Finally, I note that the proper motions of two previously known members, KPNO 15 and 2MASS J04355209+2255039, indicate that they may have been ejected from the same location within the L1536 cloud ∼7200 years ago.

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The ALMA-PILS survey: The first detection of doubly-deuterated methyl formate (CHD_2OCHO) in the ISM

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Studies of deuterated isotopologues of complex organic molecules can provide important constraints on their origin in regions of star formation. In particular, the abundances of deuterated species are very sensitive to the physical conditions in the environment where they form. Due to the low temperatures in regions of star formation, these isotopologues are enhanced to significant levels, making detections of multiply-deuterated species possible. However, for complex organic species, only the multiply-deuterated variants of methanol and methyl cyanide have been reported so far. The aim of this paper is to initiate the characterisation of multiply-deuterated variants of complex organic species with the first detection of doubly-deuterated methyl formate, CHD_2OCHO. We use ALMA observations from the Protostellar Interferometric Line Survey (PILS) of the protostellar binary IRAS 16293–2422, in the spectral range of 329.1 GHz to 362.9 GHz. Spectra towards each of the two protostars are extracted and analysed using an LTE model in order to derive the abundances of methyl formate and its deuterated variants. We report the first detection of doubly-deuterated methyl formate CHD_2OCHO in the ISM. The D/H ratio of CHD_2OCHO is found to be 2–3 times higher than the D/H ratio of CH_2DOCHO for both sources, similar to the results for formaldehyde from the same dataset. The observations are compared to a gas-grain chemical network coupled to a dynamical physical model, tracing the evolution of a molecular cloud until the end of the Class 0 protostellar stage. The overall D/H ratio enhancements found in the observations are of the same order of magnitude as the predictions from the model for the early stages of Class 0 protostars. However, the higher D/H ratio of CHD_2OCHO compared to the D/H ratio of CH_2DOCHO is still not predicted by the model. This suggests that a mechanism is enhancing the D/H ratio of singly- and doubly-deuterated methyl formate that is not in the model, e.g. mechanisms for H–D substitutions. This new detection provides an important constraint on the formation routes of methyl formate and outlines a path forward in terms of using these ratios to determine the formation of organic molecules through observations of differently deuterated isotopologues towards embedded protostars.

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RCW 120: A possible case of hit and run, elucidated by multitemperature dust mapping

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We present resolution-enhanced images of warm dust at multiple temperatures and opacity index values in the star-forming bubble/HII region, RCW 120. The image set, representing a 4D hypercube of differential column density, was obtained using our Bayesian procedure, PPMAP. The cool peripheral material ($\sim$ 16–22 K) exhibits ragged clumpy structure as noted previously by others. However, at higher temperatures ($\gtrsim$ 26 K) the geometry changes dramatically, showing a bubble boundary which is accurately circular in projection, except for the previously-reported opening in the north. Comparison with *Spitzer* 8 μm data suggests that the $\sim$ 26–30 K dust seen by *Herschel* resides in the photodissociation region (PDR) surrounding the HII region. Its projected radial profile is consistent with that of a spherical shell, thus arguing against previous suggestions of cylindrical or planar geometry. The inferred geometry is, in fact, consistent with previous interpretations of the HII region as a classical Strömgren sphere, except for the fact that the ionising star (CD -38°.11636; O8V) is displaced by more than half a radius from its geometric centre. None of the previously published models has satisfactorily accounted for that displacement. It could, however, be explained by proper motion of the O star at $\sim$ 2–4 km s^{-1} since its formation, possibly due to a cloud-cloud collision. We suggest that the current spherical bubble constitutes the fossilised remnant of the initial expansion of the HII region following the formation of the star, which now continues to flee its formation site.

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GMRT observations of the protostellar jet associated with IRAS 16547-4247

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We report continuum GMRT observations aimed to explore the behavior of the jet associated with IRAS 16547-4247 at very low frequencies (325 MHz and 610 MHz). The obtained maps reveal an elongated morphology in the SE-NW direction. In addition, the 610 MHz map shows three knots associated to the elongated morphology that seems to correspond to the triple radio source identified as the jet seen at higher frequencies. However, at 325 MHz, although an elongated morphology is also observed, only two knots appear in the map. By comparing our knot positions at both frequencies with a precessing jet model used in a previous work, we find that the knots fall closely to the wiggling path and, hence, they likely represent shocks of the material of the precessing jet with the medium. Only the nature of the southernmost knot detected at 325 MHz remains unclear. Besides, we found that the whole emission of the lobes is non-thermal down to very low frequencies and that the possible associated emission mechanisms work differently in in both lobes, causing the discrepancies between observed frequencies. To explain these discrepancies we investigate mechanisms such as synchrotron radiative losses in a magnetic field of ∼0.5 mG in the shocks and find this possibility unlikely to occur. Alternatively, we invoke interaction with an inhomogeneous medium as the most probable scenario.

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A Very Compact Extremely High Velocity Flow toward MMS 5 / OMC-3 Revealed with ALMA

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Both high- and low-velocity outflows are occasionally observed around a protostar by molecular line emission. The high-velocity component is called 'Extremely High-Velocity (EHV) flow,' while the low-velocity component is simply referred as '(molecular) outflow.' This study reports a newly found EHV flow and outflow around MMS 5 in the Orion Molecular Cloud 3 observed with ALMA. In the observation, CO J=2–1 emission traces both the EHV flow ($|v_{\rm LSR} - v_{\rm sys}| \approx 50$–$100$ km s^{-1}) and outflow ($|v_{\rm LSR} - v_{\rm sys}| \approx 10$–$50$ km s^{-1}). On the other hand, SiO J=5–4 emission only traces the EHV flow. The EHV flow is collimated and located at the root of the V-shaped outflow. The CO outflow extends up to ∼14,000 AU with a position angle (P.A.) of ∼79° and the CO redshifted EHV flow extends to ∼11,000 AU with P.A. ∼96°. The EHV flow is smaller than the outflow, and the dynamical timescale of the EHV flow is shorter than that of the outflow by a factor of ∼3. The flow driving mechanism is discussed based on the size, time scale, axis difference between the EHV flow and outflow, and the periodicity of the knots. Our results are consistent with the nested wind scenario, although the jet entrainment scenario could not completely be ruled out.

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Super-Earths in the TW Hya disc

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We test the hypothesis that the sub-millimetre thermal emission and scattered light gaps seen in recent observations of TW Hya are caused by planet-disc interactions. We perform global three-dimensional dusty smoothed particle hydrodynamics simulations, comparing synthetic observations of our models with dust thermal emission, CO emission and scattered light observations. We find that the dust gaps observed at 24 au and 41 au can be explained by two super-Earths ($\sim 4\ M_\oplus$). A planet of approximately Saturn-mass can explain the CO emission and the depth and width of the gap seen in scattered light at 94 au. Our model produces a prominent spiral arm while there are only hints of this in the data. To avoid runaway growth and migration of the planets we require a disc mass of $\lesssim 10^{-2}\ M_\odot$ in agreement with CO observations but 10–100 times lower than the estimate from HD line emission.

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Burst occurrence in young massive stellar objects

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Episodic accretion-driven outbursts are an extreme manifestation of accretion variability. It has been proposed that the development of gravitational instabilities in the proto-circumstellar medium of massive young stellar objects (MYSOs) can lead to such luminous bursts, when clumps of fragmented accretion discs migrate onto the star. We simulate the early evolution of MYSOs formed by the gravitational collapse of rotating $100\,\mathrm{M}_\odot$ pre-stellar cores and analyze the characteristics of the bursts that episodically accompany their strongly time-variable protostellar lightcurve. We predict that MYSOs spend $\approx 10^3\,\mathrm{yr}$ ($\approx 1.7\%$) of their modelled early 60 kyr experiencing eruptive phases, during which the peak luminosity exceeds the quiescent pre-burst values by factors from 2.5 to more than 40. Throughout these short time periods, they can acquire a substential fraction (up to $\approx 50\,\%$) of their zero-age-main sequence mass. Our findings show that fainter bursts are more common than brighter ones. We discuss our results in the context of the known bursting MYSOs, e.g. NGC6334I-MM1 and S255IR-NIRS3, and propose that these monitored bursts are part of a long-time ongoing series of eruptions, which might, in the future, be followed by other luminous flares.

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Disc wind models for FU Ori objects

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We present disc wind models aimed at reproducing the main features of the strong Na I resonance line P-Cygni profiles in the rapidly-accreting pre-main sequence FU Ori objects. We conducted Monte Carlo radiative transfer simulations for a standard magnetocentrifugally driven wind (MHD) model and our own "Genwind" models, which allows for a more flexible wind parameterisation. We find that the fiducial MHD wind and similar Genwind models, which have flows emerging outward from the inner disc edge, and thus have polar cavities with no absorbing gas, cannot reproduce the deep, wide Na I absorption lines in FU Ori objects viewed at low inclination. We find that it is necessary to include an "inner wind" to fill this polar cavity to reproduce observations. In addition, our models assuming pure scattering source functions in the Sobolev approximation at intermediate viewing angles ($30^\circ \leq i \leq 60^\circ$) do not yield sufficiently deep line profiles. Assuming complete absorption yields better agreement with observations, but simple estimates strongly suggest that pure scattering should be a much better approximation. The discrepancy may indicate

that the Sobolev approximation is not applicable, possibly due to turbulence or non-monotonic velocity fields; there is some observational evidence for the latter. Our results provide guidance for future attempts to constrain FU Ori wind properties using full MHD wind simulations, by pointing to the importance of the boundary conditions necessary to give rise to an inner wind, and by suggesting that the winds must be turbulent to produce sufficiently deep line profiles.

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Synchrotron emission in molecular cloud cores: the SKA view

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Understanding the role of magnetic fields in star-forming regions is of fundamental importance. In the near future, the exceptional sensitivity of SKA will offer a unique opportunity to evaluate the magnetic field strength in molecular clouds and cloud cores through synchrotron emission observations. The most recent Voyager 1 data, together with Galactic synchrotron emission and Alpha Magnetic Spectrometer data, constrain the flux of interstellar cosmic-ray electrons between ≈ 3 MeV and ≈ 832 GeV, in particular in the energy range relevant for synchrotron emission in molecular cloud cores at SKA frequencies. Synchrotron radiation is entirely due to primary cosmic-ray electrons, the relativistic flux of secondary leptons being completely negligible. We explore the capability of SKA in detecting synchrotron emission in two starless molecular cloud cores in the southern hemisphere, B68 and FeSt 1-457, and we find that it will be possible to reach signal-to-noise ratios of the order of $2 - 23$ at the lowest frequencies observable by SKA ($60 - 218$ MHz) with one hour of integration.

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Dynamics of wind and the dusty environments in the accreting T Tauri stars RY Tau and SU Aur

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Classical T Tauri stars with ages of less than 10 Myr possess accretion discs. Magnetohydrodynamic processes at the boundary between the disc and the stellar magnetosphere control the accretion and ejections gas flows. We carried out a long series of simultaneous spectroscopic and photometric observations of the classical T Tauri stars RY Tau and SU Aur with the aim to quantify the accretion and outflow dynamics at time scales from days to years. It is shown that dust in the disc wind is the main source of photometric variability of these stars. In RY Tau we observed a new effect: during events of enhanced outflow the circumstellar extinction gets lower. The characteristic time of changes in outflow velocity and stellar brightness indicates that the obscuring dust is near the star. The outflow activity in both stars is changing on a time scale of years. Periods of quiescence in Hα profile variability were observed during

2015-2016 season in RY Tau and during 2016-2017 season in SU Aur. We interpret these findings in the framework of the magnetospheric accretion model, and discuss how the global stellar magnetic field may influence the long-term variations of the outflow activity.

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High-Resolution ALMA Observations of HD100546: Asymmetric Circumstellar Ring, and Circumplanetary Disk Upper Limits

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We present long baseline Atacama Large Millimeter/submillimeter Array (ALMA) observations of the 870 μm dust continuum emission and CO (3–2) from the protoplanetary disk around the Herbig Ae/Be star HD 100546, which is one of the few systems claimed to have two young embedded planets. These observations achieve a resolution of 4 au (3.8 mas), an rms noise of 66 μJy/beam, and reveal an asymmetric ring between ∼20–40 au with largely optically thin dust continuum emission. This ring is well fit by two concentric and overlapping Gaussian rings of different widths and a Vortex. In addition, an unresolved component is detected at a position consistent with the central star, which may trace the central inner disk (<2 au in radius). We report a lack of compact continuum emission at the positions of both claimed protoplanets. We use this result to constrain the circumplanetary disk (CPD) mass and size of 1.44 $M_\oplus$ and 0.44 au in the optically thin and thick regime, respectively, for the case of the previously directly imaged protoplanet candidate at ∼55 au (HD100546 b). We compare these empirical CPD constraints to previous numerical simulations. This suggests that HD100546 b is inconsistent with several planet accretion models, while gas-starved models are also still compatible. We estimate the planetary mass as 1.65 M_J by using the relation between planet, circumstellar, and circumplanetary masses derived from numerical simulations. Finally, the CO integrated intensity map shows a possible spiral arm feature that would match the spiral features identified in Near-Infrared scattered light polarized emission, which suggests a real spiral feature in the disk surface that needs to be confirmed with further observations.

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An efficient method for determining the chemical evolution of gravitationally collapsing prestellar cores

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We develop analytic approximations to the density evolution of prestellar cores, based on the results of hydrodynamical simulations. We use these approximations as input for a time-dependent gas-grain chemical code to investigate the

effects of differing modes of collapse on the molecular abundances in the core. We confirm that our method can provide reasonable agreement with an exact numerical solution of both the hydrodynamics and chemistry while being significantly less computationally expensive, allowing a large grid of models varying multiple input parameters to be run. We present results using this method to illustrate how the chemistry is affected not only by the collapse model adopted, but also by the large number of unknown physical and chemical parameters. Models which are initially gravitationally unstable predict similar abundances despite differing densities and collapse timescales, while ambipolar diffusion produces more extended inner depleted regions which are not seen in observations of prestellar cores. Molecular observations are capable of discriminating between modes of collapse despite the unknown values of various input parameters. We also investigate the evolution of the ambipolar diffusion timescale for a range of collapse modes, metallicities and cosmic ray ionization rates, finding that it remains comparable to or larger than the collapse timescale during the initial stages for all models we consider, but becomes smaller at later evolutionary stages. This confirms that ambipolar diffusion is an important process for diffuse gas, but becomes less significant as cores collapse to higher densities.

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Kinematic Identification of Young Nearby Moving Groups from a sample of chromospherically active stars in the RAVE catalog

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The purpose of this study is the identification of young ($1 < age < 100$ Myr), nearby ($d \leq 100$ pc) moving groups (YNMGs) through their kinematic signature. YNMGs could be the result of the recent dispersal of young embedded clusters, such that they still represent kinematically cold groups, carrying the residual motion of their parental cloud. Using the fact that a large number (~ 14000) of the RAVE sources with evidence of chromospheric activity, also present signatures of stellar youth, we selected a sample of solar type sources with the highest probability of chromospheric activity to look for common kinematics. We made use of radial velocity information from RAVE and astrometric parameters from GAIA DR2 to construct a 6-dimension position-velocity vector catalog for our full sample. We developed a method based on the grouping of stars with similar orientation of their velocity vectors, which we call the Cone Method Sampling. Using this method, we detected 646 sources with high significance in the velocity space, with respect to the average orientation of artificial distributions made from a purely Gaussian velocity ellipsoid with null vertex deviation. We compared this sample of highly significant sources with a catalog of YNMGs reported in previous studies, which yield 75 confirmed members. From the remaining sample, about 50% of the sources have ages younger than 100 Myr, which indicate they are highly probable candidates to be new members of identified or even other YNMGs in the solar neighborhood.

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The Multiple Pre-Main Sequence System PR Ori and the Associated HH 305 Flow

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A detailed imaging and spectroscopic analysis is presented of the little-studied T Tauri star PR Ori and its associated Herbig-Haro flow HH 305, located on the outskirts of the L1641-N cluster in Orion. PR Ori is shown to be a multiple system, where the A-component is a close 0.077 arcsecbinary, and the B-component at a distance of 3.50 arcsec is the driver of the large Herbig-Haro flow. A low-luminosity source, here called C, is located 9.3 arcsec to the southeast and is shown spectroscopically to be straddling the stellar/brown dwarf boundary. The corresponding separations in projection are 32, 1450, and 3900 AU, respectively. Although PR Ori A is a weakline T Tauri star, high-resolution optical spectra reveal high-velocity outflowing winds and at the same time material infalling with speeds up to 200 km s^{-1}. PR Ori B shows a similar combination of outflow and infall, but is a strong Hα emission star, with a major near-infrared excess that dominates the luminosity of the system at wavelengths longer than $\sim$5 μm. HH 305 displays three pairs of knots symmetrically on either side of PR Ori, with higher velocities near the source and gradually decreasing velocities with increasing distance from the source. The innermost knots show bubble-like morphologies, very different from a collimated jet, with the northern lobe redshifted and the southern lobe blueshifted. The origin and nature of this unusual Herbig-Haro flow is discussed.

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Chemical tracers in proto-brown dwarfs: CO, ortho-H_2CO, para-H_2CO, HCO^+, CS observations

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We present a study of the CO isotopologues and the high-density tracers H_2CO, HCO^+, and CS in Class 0/I proto-brown dwarfs (proto-BDs). We have used the IRAM 30m telescope to observe the ^{12}CO (2-1), ^{13}CO (2-1), $C^{18}O$ (2-1), $C^{17}O$ (2-1), H_2CO (3-2), HCO^+ (3-2), and CS (5-4) lines in 7 proto-BDs. The hydrogen column density for the proto-BDs derived from the CO gas emission is $\sim$2-15 times lower than that derived from the dust continuum emission, indicating CO depletion from the gas-phase. The mean H_2CO ortho-to-para ratio is $\sim$3 for the proto-BDs and indicates gas-phase formation for H_2CO. We have investigated the correlations in the molecular abundances between the proto-BDs and protostars. Proto-BDs on average show a factor of $\sim$2 higher ortho-to-para H_2CO ratio than the protostars. Possible explanations include a difference in the H_2CO formation mechanism, spin-selective photo-dissociation, self-shielding effects, or different emitting regions for the ortho and para species. There is a tentative trend of a decline in the HCO^+ and H_2CO abundances with decreasing bolometric luminosity, while the CS and CO abundances show no particular difference between the proto-BDs and protostars. These trends reflect the scaled-down physical structures for the proto-BDs compared to protostars and differences in the peak emitting regions for these species. The $C^{17}O$ isotopologue is detected in all of the proto-BDs as well as the more evolved Class Flat/Class II BDs in our sample, and can probe the quiescent gas at both early and late evolutionary stages.

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First ALMA maps of HCO, an important precursor of complex organic molecules, towards IRAS 16293-2422

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The formyl radical HCO has been proposed as the basic precursor of many complex organic molecules such as methanol (CH_3OH) or glycolaldehyde (CH_2OHCHO). Using ALMA, we have mapped, for the first time at high angular resolution ($\sim$1″, $\sim$140 au), HCO towards the Solar-type protostellar binary IRAS 16293−2422, where numerous complex organic molecules have been previously detected. We also detected several lines of the chemically related species H_2CO, CH_3OH and CH_2OHCHO. The observations revealed compact HCO emission arising from the two protostars. The line profiles also show redshifted absorption produced by foreground material of the circumbinary envelope that is infalling towards the protostars. Additionally, IRAM 30m single-dish data revealed a more extended HCO component arising from the common circumbinary envelope. The comparison between the observed molecular abundances and our chemical model suggests that whereas the extended HCO from the envelope can be formed via gas-phase reactions during the cold collapse of the natal core, the HCO in the hot corinos surrounding the protostars is predominantly formed by the hydrogenation of CO on the surface of dust grains and subsequent thermal desorption during the protostellar phase. The derived abundance of HCO in the dust grains is high enough to produce efficiently more complex species such as H_2CO, CH_3OH, and CH_2OHCHO by surface chemistry. We found that the main formation route of CH_2OHCHO is the reaction between HCO and CH_2OH.

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Abundant Z-cyanomethanimine in the interstellar medium: paving the way to the synthesis of adenine

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We report the first detection in the interstellar medium of the Z-isomer of cyanomethanimine (HNCHCN), an HCN dimer proposed as precursor of adenine. We identified six transitions of Z-cyanomethanimine, along with five transitions of E-cyanomethanimine, using IRAM 30m observations towards the Galactic Center quiescent molecular cloud G+0.693. The Z-isomer has a column density of $(2.0\pm0.6)\times10^{14}$ cm^{-2} and an abundance of 1.5×10^{-9}. The relative abundance ratio between the isomers is [Z/E]$\sim$6. This value cannot be explained by the two chemical formation routes previously proposed (gas-phase and grain surface), which predicts abundances ratios between 0.9 and 1.5. The observed [Z/E] ratio is in good agreement with thermodynamic equilibrium at the gas kinetic temperature (130−210 K). Since isomerization is not possible in the ISM, the two species may be formed at high temperature. New chemical models, including surface chemistry on dust grains and gas-phase reactions, should be explored to explain our findings. Whatever the formation mechanism, the high abundance of Z-HNCHCN shows that precursors of adenine are efficiently formed in the ISM.

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Particle acceleration in the Herbig-Haro objects HH 80 and HH 81

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We present an analysis of radio (Karl G. Jansky Very Large Array (VLA)), optical (HST), and X-ray (Chandra and XMM-Newton) observations and archival data of the Herbig-Haro objects HH 80 and HH 81 in the context of jet-cloud interactions. Our radio images are the highest angular resolution to date of these objects, allowing to spatially resolve the knots and compare the regions emitting in the different spectral ranges. We found that soft X-ray thermal emission is located ahead of the non-thermal radio peak. This result is consistent with a radiative forward shock that heats the shocked gas up to 10^6 K, and an adiabatic reverse shock able to accelerate particles and produce synchrotron radiation detectable at radio frequencies. These high angular resolution radio images also reveal a bow shock structure in the case of HH 80N, being the first time this morphology is detected in a Herbig-Haro object at these frequencies.

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Evolution of Hubble wedges in episodic protostellar outflows

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Young low-mass protostars undergo short phases of high accretion and outburst activity leading to lumpy outflows. Recent observations have shown that the position–velocity and mass–velocity diagrams of such outflows exhibit individual bullet-like features; some of these bullets subscribe to a 'Hubble Law' velocity relation, and others are manifest as 'Hubble wedges'. In order to explore the origin of these features, we have developed a new episodic outflow model for the SPH code GANDALF, which mimics the accretion and ejection behaviour of FU Ori type stars. We apply this model to simulations of star formation, invoking two types of initial conditions: spherically symmetric cores in solid-body rotation with $\rho \approx r^{-2}$, and spherically symmetric turbulent cores with density proportional to the density of a Bonnor-Ebert sphere. For a wide range of model parameters, we find that episodic outflows lead to self-regulation of the ejected mass and momentum, and we achieve acceptable results, even with relatively low resolution. Using this model, we find that recently ejected outflow bullets produce a 'Hubble wedge' in the position–velocity relation. However, once such a bullet hits the leading shock front, it decelerates and aligns with older bullets to form a 'Hubble-law'. Bullets can be identified as bumps in the mass-velocity relation, which can be fit with a power-law, $dM/dv_{\rm RAD} \approx {v_{\rm RAD}}^{-1.5}$.

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Dust Polarization Toward Embedded Protostars in Ophiuchus with ALMA. II. IRAS 16293-2422

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We present high resolution ($\sim$ 35 au) ALMA Band 6 1.3 mm dust polarization observations of IRAS 16293. These observations spatially resolve the dust polarization across the two protostellar sources and toward the filamentary structures between them. The dust polarization and inferred magnetic field have complicated structure throughout the region. In particular, we find that the magnetic field is aligned parallel to three filamentary structures. We characterize the physical properties of the filamentary structure that bridges IRAS 16293A and IRAS 16293B and estimate a magnetic field strength of 23-78 mG using the Davis-Chandrasekhar-Fermi method. We construct a toy model for the bridge material assuming that the young stars dominate the mass and gravitational potential of the system. We find that the expected gas flow to each star is of comparable order to the Alfvén speed, which suggests that the field may be regulating the gas flow. We also find that the bridging material should be depleted in $\sim 10^3$ yr. If the bridge is part of the natal filament that formed the stars, then it must have accreted new material. Alternatively, the bridge could be a transient structure. Finally, we show that the 1.3 mm polarization morphology of the optically-thick IRAS 16293B system is qualitatively similar to dust self-scattering. Based on similar polarization measurements at 6.9 mm, we propose that IRAS 16293B has produced a substantial population of large dust grains with sizes between $200 - 2000$ μm.

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Probing accretion of ambient cloud material into the Taurus B211/B213 filament

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Herschel observations have emphasized the role of molecular filaments in star formation. However, the origin and evolution of these filaments are not yet well understood, partly because of the lack of kinematic information. We aim to confirm that Taurus B211/B213 filament is accreting background cloud material from a kinematic viewpoint and to investigate the potential influence of large-scale external effects on the formation of the filament. To examine whether the B211/B213 filament is accreting background gas due to its gravitational potential, we produced a toy accretion model and compared its predictions to the velocity patterns observed in ^{12}CO (1–0) and ^{13}CO (1–0). We also examined the spatial distributions of Hα, *Planck* 857 GHz dust continuum, and HI emission to search for evidence of large-scale external effects. We estimated the depth of the Taurus cloud around the B211/B213 filament to be ∼0.3–0.7 pc under the assumption that the density of the gas is the same as the critical density of ^{13}CO (1–0). Compared to a linear extent of ¿ 10 pc in the plane of the sky, this suggests that the 3D morphology of the cloud surrounding the B211/B213 filament is sheet-like. Position-velocity (*PV*) diagrams observed in ^{12}CO (1–0) and ^{13}CO (1–0) perpendicular to the filament axis show that the emission from the gas surrounding B211/B213 is redshifted to the northeast of the filament and blueshifted to the southwest, respectively, and that the velocities of both components approach the velocity of the B211/B213 filament as the line of sight approaches the crest of the filament. The *PV* diagrams predicted by our accretion model are in good agreement with the observed ^{12}CO (1–0) and ^{13}CO (1–0) *PV* diagrams, supporting the scenario of mass accretion into the filament proposed by Palmeirim et al. Moreover, inspection of the spatial distribution of the Hα and *Planck* 857 GHz emission in the Taurus-California-Perseus region on scales up to ¿200 pc suggests that the B211/B213 filament may have formed as a result of an expanding supershell generated by the Per OB2 association. Based on these results, we propose a scenario in which the B211/B213 filament was initially formed by large-scale compression of HI gas and then is now growing in mass due to the gravitational accretion of ambient cloud molecular gas.

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LMT/AzTEC Mon R2 Dense Core SurveyEarly science with the Large Millimetre Telescope: An LMT/AzTEC 1.1 mm Survey of Dense Cores in the Monoceros R2 Giant Molecular Cloud

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We present a 1.1 mm census of dense cores in the Mon R2 Giant Molecular Cloud with the AzTEC instrument on the Large Millimeter Telescope (LMT). We detect 295 cores (209 starless, and 86 with protostars) in a two square degree shallow survey. We also carry out a deep follow-up survey of 9 regions with low to intermediate ($3 < A_V < 7$) gas column densities and detect 60 new cores in the deeper survey which allows us to derive a completeness limit. After performing corrections for low signal-to-noise cores, we find a median core mass of $\sim 2.1 M_\odot$ and a median size of 0.08 pc. 46% of the cores (141) have masses exceeding the local Bonor-Ebert mass for cores with T=12K, suggesting that in the absence of supporting non-thermal pressure, these regions are unstable to gravitational collapse. We present the core mass function (CMF) for various subdivisions of the core sample. We find that cores with masses $>10\ M_\odot$ are exclusively found in regions with high core number densities and that the CMF of the starless cores has an excess of low-mass cores ($<5\ M_\odot$) compared to the CMF of protostellar cores. We report a power law correlation of index 1.99 ± 0.03 between local core mass density and gas column density (as traced by Herschel) over a wide range of size scales (0.3-5 pc). This power law is consistent with that predicted for thermal fragmentation of a self-gravitating sheet.

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The Primordial Solar wind as a Sculptor of Terrestrial Planet Formation

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Our Solar system is almost entirely devoid of material interior to Mercury's orbit, in sharp contrast to the multiple Earth masses of material commonly residing within the analogous region of extrasolar planetary systems. Recent work has suggested that Jupiter's orbital migration early in the Solar system's history fragmented primordial planetary material within the inner Solar System. However, the reason for the absence of subsequent planet formation within 0.4 AU remains unsolved. Here, we show that the up debris interior to Mercury's current orbit is susceptible to outward migration driven by the early Solar wind, enhanced by the Sun's primordial rapid rotation and strong magnetic field. The ram pressure arising from azimuthal motion of the Solar wind plasma transported ~100 m-sized objects and smaller from 0.1 AU out to the terrestrial planet-forming zone within the suspected ~30–50 Myr timespan of the Earth's formation. The mass of material within this size class typically exceeds Mercury, and can rival that of Earth. Consequently, the present-day region of terrestrial planets and the asteroid belt has been supplied by a large mass of material from the innermost, hot Solar system, providing a potential explanation for the evidence of high-temperature alteration within some asteroids and the high iron content of Mercury.

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Radiation Hydrodynamics Simulations of Spherical Protostellar Collapse for Very Low Mass Objects

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We perform radiation hydrodynamical simulations of protostellar collapse in spherical symmetry, with a special focus on very low-mass objects, i.e. brown dwarfs and sub-brown dwarfs. The inclusion of a realistic equation of state that includes the effect of hydrogen dissociation allows for a modeling of the complete process from the beginning of the

collapse until the formation of the protostar. We solve the frequency-dependent radiative transfer equation without any diffusion approximation, using realistic dust and gas opacities.
Our results show that the properties of the protostar are essentially independent of the initial conditions, which had previously only been confirmed for higher mass ranges. For very low mass initial conditions, however, we find that the first core phase of the collapse shows some significant differences in the time evolution, with the first core lifetime increasing dramatically because of the reduced accretion rate from the surrounding envelope. We consider the observational implications of this. We also investigate the opposite case of a collapse without any first core phase, which may occur for very unstable initial conditions.
In the appendix, we describe a severe numerical problem that causes an unphysical expansion after the formation of the protostar, which may affect other attempts at similar calculations of self-gravitational collapse. We explain the origin of the unphysical behavior and present a solution that can be used in similar investigations.

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Chemical segregation of complex organic O-bearing species in Orion KL

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We investigate the chemical segregation of complex O-bearing species (including the largest and most complex ones detected to date in space) towards Orion KL, the closest high-mass star-forming region. The molecular line images obtained using the ALMA science verification data reveal a clear segregation of chemically related species depending on their different functional groups. We map the emission of $^{13}CH_3OH$, $HCOOCH_3$, CH_3OCH_3, CH_2OCH_2, CH_3COOCH_3, $HCOOCH_2CH_3$, $CH_3CH_2OCH_3$, HCOOH, $OHCH_2CH_2OH$, CH_3COOH, CH_3CH_2OH, CH_3OCH_2OH, $OHCH_2CHO$, and CH_3COCH_3 with $1\farcs5$ angular resolution and provide molecular abundances of these species toward different gas components of this region. We disentangle the emission of these species in the different Orion components by carefully selecting lines free of blending and opacity effects. Possible effects in the molecular spatial distribution due to residual blendings and different excitation conditions are also addressed. We find that while species containing the C-O-C group, i.e. an ether group, exhibit their peak emission and higher abundance towards the compact ridge, the hot core south is the component where species containing a hydroxyl group (-OH) bound to a carbon atom (C-O-H) present their emission peak and higher abundance. This finding allows us to propose methoxy (CH_3O-) and hydroxymethyl (-CH_2OH) radicals as the major drivers of the chemistry in the compact ridge and the hot core south, respectively, as well as different evolutionary stages and prevailing physical processes in the different Orion components.

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The Formation Conditions of the Wide Binary Class 0 Protostars within BHR 71

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We present a characterization of the binary protostar system that is forming within a dense core in the isolated dark cloud BHR71. The pair of protostars, IRS1 and IRS2, are both in the Class 0 phase, determined from observations that resolve the sources from 1 μm out to 250 μm and from 1.3 mm to 1.3 cm. The resolved observations enable the luminosities of IRS1 and IRS2 to be independently measured (14.7 and 1.7 $L_\odot$, respectively), in addition to the bolometric temperatures 68 K, and 38 K, respectively. The surrounding core was mapped in NH_3 (1,1) with the Parkes radio telescope, and followed with higher-resolution observations from ATCA in NH_3 (1,1) and 1.3 cm continuum. The protostars were then further characterized with ALMA observations in the 1.3 mm continuum along with N_2D^+ (J = 3–2), ^{12}CO, ^{13}CO, and $C^{18}O$ (J = 2–1) molecular lines. The Parkes observations find evidence for a velocity gradient across the core surrounding the two protostars, while ATCA reveals more complex velocity structure toward the protostars within the large-scale gradient. The ALMA observations then reveal that the two protostars are at the same velocity in $C^{18}O$, and N_2H^+ exhibits a similar velocity structure as NH_3. However, the $C^{18}O$ kinematics reveal that the rotation on scales <1000 AU around IRS1 and IRS2 are in opposite directions. Taken with the lack of a systematic velocity difference between the pair, it is unlikely that their formation resulted from rotational fragmentation. We instead conclude that the binary system most likely formed via turbulent fragmentation of the core.

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The Spectral Type of the Ionizing Stars and the Infrared Fluxes of HII Regions

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The 20 cm radio continuum fluxes of 91 HII regions in a previously compiled catalog have been determined. The spectral types of the ionizing stars in 42 regions with known distances are estimated. These spectral types range from B0.5 to O7, corresponding to effective temperatures of 29 000-37 000 K. The dependences of the infrared (IR) fluxes at 8, 24, and 160 μm on the 20 cm flux are considered. The IR fluxes are used as a diagnostic of heating of the matter, and the radio fluxes as measurements of the number of ionizing photons. It is established that the IR fluxes grow approximately linearly with the radio flux. This growth of the IR fluxes probably indicates a growth of the mass of heated material in the envelope surrounding the HII region with increasing effective temperature of the star.

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The Flared Gas Structure of the Transitional Disk around Sz 91

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We report 0.14" resolution observations of the dust continuum at band 7, and the CO(3–2) and HCO^+(4–3) line emissions toward the transitional disk around Sz 91 with Atacama Large Millimeter/submillimeter Array (ALMA). The dust disk appears to be an axisymmetric ring, peaking a radius of ∼95 au from a Gaussian fit. The Gaussian fit widths of the dust ring are 24.6 and 23.7 au for the major and the minor axes, respectively, indicating that the dust ring is not geometrically thin. The gas disk extends out to ∼320 au and is also detected in the inner hole of the dust ring. A twin-line pattern is found in the channel maps of CO, which can be interpreted as the emission from the front and rear of the flared gas disk. We perform the radiative transfer calculations using RADMC-3D, to check whether the twin-line pattern can be reproduced under the assumption that the flared gas disk has a power-law form for the column density and $T_{\rm gas} = T_{\rm dust}$. The thermal Monte Carlo calculation in RADMC-3D shows that the disk temperature has a gradient along the vertical direction beyond the dust ring, as it blocks the stellar radiation, and thus the twin-line pattern can be naturally explained by the flared gas disk in combination with the dust ring. In addition, no significant depletion of the CO molecules in the cold midplane achieves a reasonable agreement with the observed twin-line pattern. This result indicates that the CO emission from the rear surface must be heavily absorbed in the cold midplane.

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Does misalignment between magnetic field and angular momentum enhance or suppress circumstellar disk formation?

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The effect of misalignment between the magnetic field $\mathbf{B}$ and the angular momentum $\mathbf{J}_{\rm ang}$ of molecular cloud cores on the angular momentum evolution during the gravitational collapse is investigated by ideal and non-ideal MHD simulations. For the non-ideal effect, we consider the ohmic and ambipolar diffusion. Previous studies that considered the misalignment reported qualitatively contradicting results. Magnetic braking was reported as being either strengthened or weakened by misalignment in different studies. We conducted simulations of cloud-core collapse by varying the stability parameter α (the ratio of the thermal to gravitational energy of the core) with and without including magnetic diffusion The non-ideal MHD simulations show the central angular momentum of the core with $\theta = 0°$ ($\mathbf{J}_{\rm ang} \parallel \mathbf{B}$) being always greater than that with $\theta = 90°$ ($\mathbf{J}_{\rm ang} \perp \mathbf{B}$), independently of α, meaning that circumstellar disks form more easily form in a core with $\theta = 0°$. The ideal MHD simulations, in contrast, show the the central angular momentum of the core with $\theta = 90°$ being greater than with $\theta = 0°$ for small α, and is smaller for large α. Inspection of the angular momentum evolution of the fluid elements reveals three mechanisms contributing to the evolution of the angular momentum: (i) magnetic braking in the isothermal collapse phase, (ii) selective accretion of the rapidly (for $\theta = 90°$) or slowly (for $\theta = 0°$) rotating fluid elements to the central region, and (iii) magnetic braking in the first-core and the disk. The difference between the ideal and non-ideal simulations arises from the different efficiencies of (iii).

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The distribution of heavy-elements in giant protoplanetary atmospheres: the importance of planetesimal-envelope interactions

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In the standard model for giant planet formation, the planetary growth begins with accretion of solids followed by a buildup of a gaseous atmosphere as more solids are accreted, and finally, by rapid accretion of gas. The interaction of the solids with the gaseous envelope determines the subsequent planetary growth and the final internal structure. In this work we simulate the interaction of planetesimals with a growing giant planet (proto-Jupiter) and investigate how different treatments of the planetesimal-envelope interaction affect the heavy-element distribution, and the inferred core mass. We consider various planetesimal sizes and compositions as well as different ablation and radiation efficiencies, and fragmentation models. We find that in most cases the core reaches a maximum mass of 2 Earth's Mass. We show that the value of the core's mass mainly depends on the assumed size and composition of the solids, while the heavy-element distribution is also affected by the fate of the accreted planetesimals (ablation/fragmentation). Fragmentation, which is found to be important for planetesimals > 1 km, typically leads to enrichment of the inner part of the envelope while ablation results in enrichment of the outer atmosphere. Finally, we present a semi-analytical prescription for deriving the heavy-element distribution in giant protoplanets.

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The ALMA Lupus protoplanetary disk survey: evidence for compact gas disks and molecular rings from CN

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The cyanide radical CN is abundant in protoplanetary disks, with line fluxes often comparable to those of ^{13}CO. It is known to be sensitive to UV irradiation of the upper disk atmosphere, with models predicting ring-shaped emission. We seek to characterize the CN emission from 94 Class II disks in the Lupus star forming region, compare it to observations in other regions, and interpret our observations with a grid of models. The CN emission morphology is discussed for two primordial disks, Sz 71 and Sz 98, and modeled in more detail. ALMA observed CN N=3–2 in Lupus disks down to sensitivities better than previous surveys. Models constructed with the physico-chemical code DALI are used to study the integrated fluxes of the disks and resolved emission of CN in disks without (dust) substructures. We find that CN N=3–2 is bright, and detected in 38% of sources, but its disk-integrated flux is not strongly correlated to either ^{13}CO or continuum flux. Compared to pre-ALMA single-dish surveys, no significant difference in the CN flux distributions in Lupus and Taurus-Auriga is found, although ρ Ophiuchus disks may be fainter on average. We find ring-shaped CN emission with peak radii of ∼50 AU in two resolved disks. We conclude that a large fraction of sources is faint in CN; only exponential gas surface density cutoffs at $R_c \leq 15$ AU can reconcile observations with models. This is the first observational evidence of such a compact gas disk population in Lupus. Absolute intensities and the emission morphology of CN are reproduced by DALI models without the need for any continuum substructure; they are unrelated to the CO snowline location. These observations and the successful modeling of these rings provide a new probe of the structure and conditions in disks, and particularly their incident UV radiation field, if disk size is determined by the data.

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Non-thermal emission from massive star forming regions: A possible SNR candidate G351.7–1.2?

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We present low frequency wide band observations ($300 - 500$ MHz) of the star forming complex G351.7–1.2 using upgraded Giant Metrewave Radio Telescope (uGMRT), India. Combining this with the optical, infrared and submillimeter data, we analyse the large scale diffuse radio emission associated with the region that exhibits a broken shell morphology. The spectral index of the emission in the shell is -0.8, indicating non-thermal emission. Hα emission that mimics the morphology of the radio shell on a smaller scale is also detected here. Based on the non-thermal emission from the radio shell and the presence of its optical counterpart, we classify G351.7–1.2 as a candidate SNR. A γ-ray source detected by *Fermi* LAT (1FGLJ1729.1–3641c) is located towards the south-west of the radio shell and could have a possible origin in the interaction between high velocity particles from the SNR and the ambient molecular cloud.

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Deep, multi-band photometry of low-mass stars to reveal young clusters: a blind study of the NGC 2264 region

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We aim to test a purely photometric approach to statistically identify a young clustered population embedded in a large population of field stars, with no prior knowledge on the nature of stars in the field. We conducted our blind test study on the NGC 2264 region, which hosts a well-known young cluster. We selected a large (4 deg^2) area around the NGC 2264 cluster, and assembled an extensive r, i, J catalog of the field from pre-existing large-scale surveys. We then mapped the stellar color locus on the $(i - J,\ r - i)$ diagram to select M-type stars, which: i) comprise a significant fraction of the Galactic stellar population; ii) exhibit the strongest luminosity evolution from the PMS to the MS; iii) have r, i, J color properties that provide a direct and empirical estimate of A_V. A comparative analysis of the photometric and spatial properties of M-type stars as a function of A_V enabled us to probe the structure and stellar content of our field. We could identify two distinct populations: a diffuse field population and a clustered population. The presence of occulting material, spatially associated with the clustered population, allowed us to derive an estimate of its distance (800–900 pc) and age (∼0.5–5 Myr), consistent with the literature parameters for the NGC 2264 star-forming region. The extracted clustered population exhibits a hierarchical structure, in excellent agreement with the NGC 2264 subregions reported in the literature. Our selection of clustered members is coherent with the literature census of the NGC 2264 cluster for about 95% of the objects in the inner regions of the field, where the contamination rate by field stars in our sample is only 2%. The method tested here can be readily applied to surveys like Pan-STARRS and the future LSST to undertake a first complete census of low-mass, young star populations down to distances of several kpc across the Galactic plane.

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A simple approach to CO cooling in molecular clouds

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Carbon monoxide plays an important role in interstellar molecular clouds, both as a coolant, and as a diagnostic molecule. However, a proper evaluation of the cooling rate due to CO requires a determination of the populations of many levels, the spontaneous and stimulated radiative de-excitation rates between these levels, and the transfer of the emitted multi-line radiation; additionally, this must be done for three isotopologues. It would be useful to have a simple analytic formulation that avoided these complications and the associated computational overhead; this could then be used in situations where CO plays an important role as a coolant, but the details of this role are not the main concern. We derive such a formulation here, by first considering the two asymptotic forms that obtain in the limits of (a) low volume-density and optical depth, and (b) high volume-density and optical depth. These forms are then combined in such a way as to fit the detailed numerical results from Goldsmith & Langer (1978; hereafter GL78). The GL78 results cover low temperatures, and a range of physical conditions where the interplay of thermal and sub-thermal excitation, optical-depth effects, and the contributions from rare isotopologues, are all important. The fit is obtained using the Metropolis-Hastings method, and reproduces the results of GL78 well. It is a purely local and analytic function of state — specifically a function of the density, ρ, isothermal sound speed, a, CO abundance, $X_{\rm CO}$, and velocity divergence, $\nabla \cdot \upsilon$. As an illustration of its use, we consider the cooling layer following a slow steady non-magnetic planar J-shock. We show that, in this idealised configuration, if the post-shock cooling is dominated by CO and its isotopologues, the thickness of the post-shock cooling layer is very small and approximately independent of the pre-shock velocity, $\upsilon_{\rm o}$, or pre-shock isothermal sound speed, $a_{\rm o}$.

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Bipolar HII regions produced by cloud/cloud collisions

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We suggest that Bipolar HII Regions may be the aftermath of collisions between clouds. Such a collision will produce a shock-compressed layer, and a star cluster can then condense out of the dense gas near the centre of the layer. If the clouds are sufficiently massive, the star cluster is likely to contain at least one massive star, which emits ionising radiation, and excites an HII region, which then expands, sweeping up the surrounding neutral gas. Once most of the matter in the clouds has accreted onto the layer, expansion of the HII Region meets little resistance in directions perpendicular to the mid-plane of the layer, and so it expands rapidly to produce two lobes of ionised gas, one on each side of the layer. Conversely, in directions parallel to the mid-plane of the layer, expansion of the HII Region stalls due to the ram-pressure of the gas that continues to fall towards the star cluster from the outer parts of the layer; a ring of dense neutral gas builds up around the waist of the Bipolar HII Region, and may spawn a second generation of star formation. In this paper we present a dimensionless model for the flow of ionised gas in a Bipolar HII Region created according to the above scenario, and predict the characteristics of the resulting freefree continuum and recombination-line emission. This dimensionless model can be scaled to the physical parameters of any particular system. Our intention is that these predictions will be useful in testing the scenario outlined above, and thereby providing indirect support for the role of cloud/cloud collisions in triggering star formation.

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Detection of Nitrogen gas in the β Pictoris circumstellar disk

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The debris disk surrounding β Pictoris has a gas composition rich in carbon and oxygen, relative to solar abundances. Two possible scenarios have been proposed to explain this enrichment. The preferential production scenario suggests that the gas produced may be naturally rich in C and O, while the alternative preferential depletion scenario states that the enrichment has evolved to the current state from a gas with solar-like abundances. In the latter case, the radiation pressure from the star expels the gas outwards, leaving behind species less sensitive to stellar radiation such as C and O. Nitrogen is also not sensitive to radiation pressure due to its low oscillator strength, which would make it also overabundant under the preferential depletion scenario. As such, the abundance of N in the disk may provide clues to why C and O are overabundant. We aim to measure the N column density in the direction of β Pic, and use this information to disentangle these different scenarios explaining the C and O overabundance. Using far-UV spectroscopic data collected by the HST's Cosmic Origins Spectrograph (COS) instrument, we analyse the spectrum and characterise the NI triplet by modelling the absorption lines. We measure the N column density in the direction of β Pic for the first time, and find it to be $\log(N_{\rm NI}/1\ {\rm cm}^2) = 14.9 \pm 0.7$. The N gas is found to be consistent with solar abundances and Halley dust. The solar N abundance supports the preferential production hypothesis, in which the composition of gas in β Pic is the result of photodesorption from icy grains rich in C and O or collisional vaporisation of C and O rich dust in the disk. It does not support the hypothesis that C and O are overabundant due to the insensitivity of C and O to radiation pressure thereby leaving them to accumulate in the disk.

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Does HL Tau Disk Polarization in ALMA Band 3 Come from Radiatively Aligned Grains?

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Disk polarization in (sub)millimeter dust continuum is a rapidly growing field in the ALMA era. It opens up the exciting possibility of detecting and characterizing magnetic fields and grain growth in disks around young stellar objects. However, to use polarization for probing the disk properties, its production mechanism must be ascertained first. To date, the conventional mechanism involving magnetically aligned grains fails to explain the polarization patterns detected in most disks. This is especially true for the inclined disk of HL Tau in ALMA Band 3 (wavelength $\sim$ 3 mm), which has an elliptical polarization pattern. The elliptical pattern was taken as evidence for polarized emission by dust grains aligned with their long axes perpendicular the direction of the radiative flux. We show that the radiatively aligned grains produce a circular, rather than elliptical, polarization pattern even in inclined disks such as HL Tau. An elliptical polarization pattern can be produced if the grains are aligned aerodynamically by the difference in rotation speed between the dust and gas through the Gold mechanism. However, a strong azimuthal variation in polarized intensity is expected for both the radiative and aerodynamic alignment, but not observed in the HL Tau disk in ALMA Band 3. We conclude that neither of these two mechanisms alone can explain the data and the origin of the 3 mm polarization remains a mystery. We speculate that this mystery may be resolved by a combination of both direct emission and scattering by aerodynamically aligned grains.

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Physical properties and chemical composition of the cores in the California molecular cloud

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We aim to reveal the physical properties and chemical composition of the cores in the California molecular cloud (CMC), so as to better understand the initial conditions of star formation. We made a high-resolution column density map (18.2") with Herschel data, and extracted a complete sample of the cores in the CMC with the *fellwalker* algorithm. We performed new single-pointing observations of molecular lines near 90 GHz with the IRAM 30m telescope along the main filament of the CMC. In addition, we also performed a numerical modeling of chemical evolution for the cores under the physical conditions. We extracted 300 cores, of which 33 are protostellar and 267 are starless cores. About 51% (137 of 267) of the starless cores are prestellar cores. Three cores have the potential to evolve into high-mass stars. The prestellar core mass function (CMF) can be well fit by a log-normal form. The high-mass end of the prestellar CMF shows a power-law form with an index $\alpha = -0.9 \pm 0.1$ that is shallower than that of the Galactic field stellar mass function. Combining the mass transformation efficiency (ε) from the prestellar core to the star of $15 \pm 1\%$ and the core formation efficiency (CFE) of 5.5%, we suggest an overall star formation efficiency of about 1% in the CMC. In the single-pointing observations with the IRAM 30m telescope, we find that 6 cores show blue-skewed profile, while 4 cores show red-skewed profile. $[HCO^+]/[HNC]$ and $[HCO^+]/[N_2H^+]$ in protostellar cores are higher than those in prestellar cores; this can be used as chemical clocks. The best-fit chemical age of the cores with line observations is $\sim 5 \times 10^4$ years.

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Star-forming content of the giant molecular filaments in the Milky Way

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Observations have discovered numerous giant molecular filaments (GMFs) in the Milky Way. However, their role in the Galactic star formation and Galaxy-scale evolution of dense gas is still unknown. We investigate systematically the star-forming content of all currently known GMFs. This allows us to estimate the star formation rates (SFRs) of the GMFs and to establish relationships between the SFRs and the GMF properties. We identify and classify the young stellar object (YSO) population of each GMF using multi-wavelength photometry from near- to far-infrared. We estimate the total SFRs assuming a universal and fully sampled initial mass function and luminosity function. We uniformly estimate the physical properties of 57 GMFs. The GMFs show correlations between the ^{13}CO line width, mass, and size, similar to Larson's relations. We identify 36 394 infrared excess sources in 57 GMFs and obtain SFRs for 46 GMFs. The median SFR surface density ($\Sigma_{\rm SFR}$) and star formation efficiency (SFE) of GMFs are 0.62 $M_\odot$

Myr^{-1} pc^{-2} and 1%, similar to the nearby star-forming clouds. The star formation rate per free-fall time of GMFs is between 0.002–0.05 with the median value of 0.02. We also find a strong correlation between SFR and dense gas mass that is defined as gas mass above a visual extinction of 7 mag, which suggests that the SFRs of the GMFs scale similarly with dense gas as those of nearby molecular clouds. We also find a strong correlation between the mean SFR per unit length and dense gas mass per unit length. The origin of this scaling remains unknown, calling for further studies that can link the structure of GMFs to their SF activity and explore the differences between GMFs and other molecular clouds.

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http://arxiv.org/pdf/1811.02197

The Nearby, Young, Argus Association: Membership, Age, and Dusty Debris Disks

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The reality of a field Argus Association has been doubted in some papers in the literature. We apply Gaia DR2 data to stars previously suggested to be Argus members and conclude that a true association exists with age 40–50 Myr and containing many stars within 100 pc of Earth; β Leo and 49 Cet are two especially interesting members. Based on youth and proximity to Earth, Argus is one of the better nearby moving groups to target in direct imaging programs for dusty debris disks and young planets.

Accepted by ApJ

http://arxiv.org/pdf/1811.01508

Abstracts of recently accepted major reviews

Brown Dwarf Formation: Theory

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We rehearse the physical and theoretical considerations that define the nature of Brown Dwarfs, in particular the maximum mass for a Brown Dwarf (set by the Hydrogen-Burning Limit) and the minimum mass for a Brown Dwarf (set by the Opacity Limit). We then review the range of mechanisms that have been invoked to explain the formation of Brown Dwarfs and their statistical properties. These include turbulent fragmentation, fragmentation of filaments and discs, dynamical ejection of stellar embryos, and photoerosion. The primary contenders would seem to be turbulent fragmentation and disc fragmentation, and the observations needed to evaluate their relative importance may soon be available.

Accepted by The Handbook of Exoplanets

http://arxiv.org/pdf/1811.06833

Understanding the structure of molecular clouds: Multi-line wide-field imaging of Orion B

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Ph.D degree awarded: October 2018

The new generation of wide-bandwidth high-resolution receivers turns almost any radio observation into a spectral survey. In the case of wide-field imaging of the interstellar medium, large, highly multi-dimensional datasets are generated. Such a wealth of data simultaneously provides new diagnostic tools and creates new challenges in terms of data processing and analysis - new methods therefore need to be developed. This is the goal of the ORION-B project, which is observing 5 square degrees of the Orion B molecular cloud, or about half of the clouds surface, over the entire 3 mm band. The observations have provided velocity-resolved maps of the emission of tens of molecular tracers, which are analysed using statistical, machine learning approaches.

Having access to spatially resolved maps from many molecular species enables us to identify the tracers most typical of given regions, with different gas densities and illuminations. Conversely, the multi-dimensional data in chemical space allow us to segment the molecular cloud into typical regions based on their molecular emission, and to quantify the most meaningful correlations of different molecular tracers with each other and with physical quantities such as density or dust temperature.

The large spatial and spectral dynamical range of the dataset also provides a detailed view of the kinematics and dynamics of the molecular cloud, in particular in relation with its star formation activity. In this thesis, I statistically characterize the nature of the motions in the cloud, and quantify the amount of momentum in the compressive and solenoidal (rotational) modes of turbulence. The cloud is dominated by solenoidal motions, with the compressive modes being concentrated in two star-forming regions. I also approach star formation from a morphological point of view, by identifying and characterizing the numerous filaments present in the cloud. These prove to have rather low densities, and to be very stable against gravitational collapse - and yet they show signs of longitudinal and radial fragmentation. All these results highlight the role of compressive forcing and dense filamentary structures in the star formation process. They are also consistent with the overall very low star formation efficiency of the Orion B cloud, while suggesting that it might host more triggered star formation in the future.

http://iram.fr/~orkisz/files/JanOrkisz-THESIS.pdf

IRDCs to Star Clusters: In Depth Study of the Structure, Evolution and Kinematics of Few Southern Massive Star Forming Regions

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The formation and the evolution of massive stars (M$\geq$ 8 $M_\odot$) are found to dominate the fate of their parental clouds and the host galaxies. This is primarily due to the enhanced feedback mechanisms from these stars that alter the environments on local, global and cosmic scales. The radiative feedback from massive stars causes the ionisation of neutral gas whereas the mechanical feedback effects such as supernovae explosions impart mechanical energy into the ambient interstellar medium (ISM), and can even vent energy into the galactic halo. The nucleosynthesis processes in massive stars and their core collapse supernovae play a crucial role in the chemical enrichment of the ISM that drive the chemical evolution in galaxies. While theoretical formulations have been proposed to explain their formation, observational studies of the early phases remain limited. Most of these observational works are designed to examine the large scale properties of a sample of massive star forming regions. While there are studies that focuses on individual regions, majority of them probe the northern Galactic sky. In this context, we have carried out a multiwavelength study towards a selected number of massive star forming regions in the southern Galactic sky that are in different evolutionary stages. Our intention is to examine the properties and initial conditions related to the formation of massive stars across different evolutionary phases. We investigate the structure and kinematics of these star forming regions that gives a better insight into the complex interaction mechanisms between massive stars and their parental clouds. In this study, we have considered three star forming regions: a filamentary IRDC (G333.73+0.37) and two H II regions (IRAS 17256–361 and IRAS 17258–3637). In addition to these, we have also probed the star forming complex associated with IRAS 17256–3631 and IRAS 17258–3637, to investigate the large scale environment of massive stars.

We have conducted our observational study at infrared, submillimeter and radio wavelengths. Radio observations serve as a powerful tool to discern regions associated with newly formed massive stars as well as to identify the nature of the ionising sources. Far-infared and millimeter continuum data traces the emission from the cold and dense regions of molecular clouds that often appear as dark extinction features in the optical images. Near and mid-infrared data on the other hand, are useful in examining the warm dust emission and young stellar objects (YSOs) in these regions. Spectral line data such as radio recombination lines and molecular lines are excellent for probing the complex kinematics of the ionised gas and molecular cloud.

The star formation activity in G333.73+0.37 and IRAS 17256–3631 has been scrutinized using a diverse range of tracers such as the presence of H II regions, infrared YSOs, maser spots etc. We find these regions to be in a star formation flurry. The molecular clouds associated with the regions are massive (M $\sim 10^4$ $M_\odot$). The typical dust temperatures and column densities are $15-35$ K and $\sim 10^{22}$ cm^{-2}, respectively. Molecular line studies reveal signatures of infall and/or outflow activity in both the clouds, consistent with results obtained from continuum analysis. We also detect an embedded infrared cluster in IRAS 17256–3631. We have also used low frequency radio recombination lines (H172α and C172α) and molecular line data in an attempt to sample the velocity structure of the H II regions IRAS 17256–3631 and IRAS 17258–3637. We have successfully mapped the H172α RRL emission across these H II regions and we find velocity gradients in the ionised gas. Our findings suggest that the observed morphologies are governed by strong density gradients prevailing in the molecular clouds. We also observe signatures of pressure and dynamical broadening in the line widths of H172α RRLs. This is the first ever RRL mapping study of H II regions at low frequency bands. Using low radio frequency wide band observations, we have detected large scale diffuse emission towards the star forming complex associated with the H II region IRAS 17256–3631 and IRAS 17258–3637. The emission has a shell-like morphology. Using radio spectral index analysis and complementary archival data, we identify this feature to be a previously unknown supernova remnant candidate SNR G351.7–1.2. The findings emphasize on the importance of low frequency observations in segregating the emission from SNRs that are associated with H II regions and molecular clouds.

Abstract submission deadline

The deadline for submitting abstracts and other submissions is the first day of the month.

New Jobs

3 year Postdoctoral Position Funded by STFC at the University of Dundee

We are looking for a motivated postdoc to join the Astrophysics group at the University of Dundee, UK, working on emission line tomography of young stars to study accretion, activity, and planet migration in the innermost disk. The successful candidate will work with Aurora Sicilia-Aguilar and Soko Matsumura, analyzing time-resolved emission line spectra of young stars to map accretion structures and the innermost disk and their relation to planet formation and migration. Part of the project includes the development of Python-based tools to analyze the emission line spectra of significant numbers of stars.

A background in star formation, young stars, protoplanetary disks, planet searches, and/or high-resolution optical spectroscopy is required. Knowledge of Python programming language is highly desirable.

The starting date is April 1, 2019 (subject to negotiation), and the post is for 3 years.

Please arrange for a cv with publication list, research statement (max 2 pages), and 2 reference letters to be sent to Dr. A. Sicilia-Aguilar (asiciliaaguilar@dundee.ac.uk). Informal enquiries can be directed to the same address.

Applications received before January 10, 2019 will receive full consideration.

Post-doctoral Fellowships in Exoplanet Detection, Characterization, and Formation

Now is a great time to study exoplanets at the University of Michigan. We are looking to hire multiple postdoctoral scholars, to work with Professors Michael Meyer, John Monnier, and Emily Rauscher on various aspects of exoplanet research. Specifically, we are targeting the areas of:

formation and evolution of planetary systems (Meyer, https://jobregister.aas.org/ad/93fdfa5f, deadline: Jan 4)

imaging of planet-forming disks (Monnier, https://jobregister.aas.org/ad/27e4d7a9, deadline: Jan 15), and

theoretical studies of exoplanet atmospheres (Rauscher, https://jobregister.aas.org/ad/393515bb, deadline: Dec 21).

The University of Michigan hosts a vibrant astrophysics research community within the Astronomy and Physics Departments, as well as significant expertise in planetary sciences within the Earth & Environmental Sciences and Climate & Space Sciences Departments. We are particularly strong in the interrelated study of stars, planets, and their formation (https://lsa.umich.edu/astro/research/stars-exoplanets.html). A postdoctoral researcher in our department can apply as PI to any of our telescope facility partnerships, currently including the Magellan Telescopes in Chile, the MDM Observatory in Arizona, the CHARA Interferometer, the SWIFT space telescope, and the NOEMA mm array. Significant computing resources are available through the Department and through the University of Michigan. The Michigan Institute for Research in Astrophysics funds cross-disciplinary efforts, including a series of intellectually stimulating conferences.

The University of Michigan is recognized as a top academic employer and Ann Arbor, Michigan is routinely celebrated for its high quality of life. We are a department that values diversity, equity, and inclusion as essential to scientific excellence (https://sites.google.com/umich.edu/astro-dei/home) and encourage applications from those with identities underrepresented in astronomy.

Faculty Position at Leiden Observatory, Leiden University, the Netherlands

Leiden Observatory is conducting **two** separate faculty searches:

Faculty search in Molecular Astrophysics: Leiden Observatory aims to build on existing excellence in molecular astrophysics through strengthening its faculty in this area. We are looking for outstanding candidates who can connect observations, theory, and laboratory work to carry out breakthrough research in Galactic or extragalactic astrophysics. Candidates should have an excellent track record, a strong vision for future research, and demonstrated commitment to interdisciplinary research and education.

Application forms and instructions for the position in Molecular Astrophysics are available at
http://jobs.strw.leidenuniv.nl/2018/MolecularAstrophysics
Complete applications received by 10 January 2019 will receive full consideration.

General information:

Leiden astronomers carry out observational and theoretical research in the fields of cosmology, formation and evolution of galaxies, Galactic structure, compact objects, gravitational waves, molecular astrophysics, star- and planet formation, exo-planets, and astronomical instrumentation. Staff members have access to a wide variety of telescopes on the ground and in space, as well as excellent computing facilities.

Candidates should possess a PhD in a relevant field such as astronomy, chemistry or physics. Candidates are encouraged to identify collaborative opportunities with scientists at Leiden Observatory and other departments of Leiden University, and to outline how available local, national, and international facilities will be exploited.

The department offers a complete undergraduate (BSc) and graduate (MSc, PhD) teaching program that focuses on integrating students in research as soon as possible. Successful candidates are expected to actively participate in the education and supervision of students. Candidates are invited to describe their vision on teaching in an international and diverse learning environment, and how they plan to contribute to research-driven education at Leiden University.

Applicants are requested to use the web sites indicated above to upload a curriculum vitae, a statement of research interests and experience, and the contact information for at least three reference letters, by the indicated deadlines. The positions are open to candidates from all countries. Leiden University is strongly committed to diversity within its community and we strongly encourage applications from individuals who add to diversity and inclusiveness at Leiden Observatory.

Additional information on Leiden Observatory can be found at http://www.strw.leidenuniv.nl

Information about Leiden University, including information on working and living conditions and benefits, can be found at https://www.universiteitleiden.nl/en and
https://www.staff.universiteitleiden.nl/human-resources/new-staff?cf=science&cd=leiden-observatory

Included Benefits: The position comes with a competitive salary and comprehensive benefits including paid vacation, sick leave, disability insurance, maternity and parental leave, and social security and retirement benefits.

Postdoctoral Position in Protostars and Observational Star Formation at the University of Toledo

The department of Physics & Astronomy at the University of Toledo invites applications for a postdoctoral position in the area of protostars and star formation. The selected applicant will work with Dr. Tom Megeath on a NASA funded program using archival Herschel, Spitzer, WISE, NEOWISE and HST data to create a database of protostars and their variability; extending the Herschel Orion Protostar Survey (HOPS) to all surveyed star forming regions within 500 pc. They will draw on the expertise, tools, and collaborative network established for HOPS, work with graduate and undergraduate students, lead investigations based on these data, and obtain follow-up data using ALMA, SOFIA and other telescopes. The University of Toledo is a partner in the 4.3 meter Discovery Channel Telescope, and the postdoc will be encouraged to use this facility. They will also have the opportunity to participate in JWST proposal planning utilizing the database. The appointment will be for a minimum of two years starting in the summer/fall of 2019; additional years will depend on available funding. The astronomy program at UToledo currently has six faculty, three postdocs, and 16 graduate students who maintain a vigorous program of research and public outreach. The program was recently selected as one of three areas of research excellence within the university. Requirements are a Ph.D. in astronomy and research experience in IR and sub-mm astronomy. Expertise in star and planet formation will be very helpful. Please send a cover letter, CV, a statement of research interest up to two pages in length, and contact information for at least three references to s.megeath@utoledo.edu. Review of applications will begin on January 4th.

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.

Meetings

Crete III: Through dark lanes to new stars

Celebrating the career of Prof. Charles Lada

23-27 September 2019 - Hersonissos, Crete

The Crete Summer Schools in Star Formation in 1994 and 1998, organized by Charles Lada and Nick Kylafis, were a landmark in the development of the star and planet formation community. Many of the attendants of these schools are now well-established researchers across the world, pushing the boundaries of the field forward with a new generation of telescopes and simulations. The Crete III conference, to be organized in Crete in September 2019, will be a celebration of star formation research, its community, and in particular, the career of Prof. Charles Lada and its impact on the field. The program will cover research on molecular clouds, dense cores, disks and outflows, YSO classification, embedded clusters, star formation rates and efficiencies.

Webpage: http://www.crete3.org

Gaia's view of pre-Main Sequence evolution. Linking the T Tauri and Herbig Ae/Be stars

Leeds, UK - 18-21 June 2019

The Herbig Ae/Be stars bridge the gap in mass between the lower mass T Tauri stars and the higher mass Massive Young Stellar Objects. By linking the low and high mass stars, the Herbig Ae/Be stars are crucial in finding similarities and differences between the formation processes in both regimes.

Since the last conference dedicated to Herbig Ae/Be stars in 2014 in Chile, new facilities such as ALMA, SPHERE, GPI and Gravity allowed detailed studies into their formation and evolution as well as of the planets forming in their disk. Moreover, the Gaia astrometry mission will contribute greatly in their study.

Therefore the time is ripe for experts to come together and discuss their latest results on star formation. The time is also ripe to probe the links between the T Tauri stars and Herbig Ae/Be stars in more detail and a major aim of the workshop is to bring the respective communities together to compare and contrast the properties, appearance and formation mechanisms of both types of object.

The conference will take place in Leeds, one of UKs largest cities and named by Lonely Planet Top 10 Best in Europe destination for 2017. The conference will last 3.5 days from Tuesday morning 18th of June 2019 until Friday midday 21st of June 2019. The social programme includes a welcome reception on Monday night, a visit to the world renowned Royal Armories is scheduled for Tuesday night and the conference dinner takes place on Thursday. Lunches are included in the conference fee. The conference venue is at Weetwood Halls and has also reserved accommodation on site.

https://starry-project.eu/final-conference/

Summary of Upcoming Meetings

Planet Formation and Evolution
27 February - 1 March 2019, Rostock, Germany
http://pfe2019.stat.physik.uni-rostock.de

Dusting the Universe
4 - 8 March 2019, Tucson, USA
http://www.noao.edu/meetings/dust2019/

New Quests in Stellar Astrophysics IV. Astrochemistry, astrobiology and the Orign of Life
31 March - 5 April 2019, Puerto Vallarta, mexico
http://www.inaoep.mx/puerto19

New Horizons in Planetary Systems
13 - 17 May 2019 - Victoria, Canada
http://go.nrao.edu/NewHorizons

Exploring the Infrared Universe: The Promise of SPICA
20 - 23 May 2019, Crete, Greece
http://www.spica2019.org

Workshop on Polarization in Protoplanetary Disks and Jets
20 - 24 May 2019, Sant Cugat del Vallès, Catalonia, Spain
http://sites.google.com/view/sant-cugat-forum-astrophysics/next-session

Zooming in on Star Formation - A tribute to Åke Nordlund
9 - 14 June 2019, Nafplio, Greece
http://www.nbia.dk/nbia-zoomstarform-2019

From Stars to Planets II: Connecting our Understanding of Star and Planet Formation
17 - 20 June 2019, Gothenburg, Sweden
http://cosmicorigins.space/fstpii

Gaia's View of Pre-Main Sequence Evolution. Linking the T Tauri and Herbig Ae/Be Stars
18 - 21 June 2019, Leeds, UK
https://starry-project.eu/final-conference

Crete III: Through Dark Lanes to New Stars
23 - 27 September 2019, Crete, Greece
http://www.crete3.org