THE STAR FORMATION NEWSLETTER

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

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The Star Formation Newsletter

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

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Cover Picture

The Lynds Bright Nebula 762/753 forms a complex of illuminated high-latitude dark clouds in Aries, just south of MBM 12, a low-mass star forming region at a distance of about 300 pc. The height of the figure is about 35 arcmin. North is up and east is left.

Image courtesy Mark Hanson (https://www.hansonastronomy.com)

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

José María Torrelles

in conversation with Bo Reipurth

Q: *What was your PhD about and who was your advisor?*

A: I did my PhD thesis at the Universidad Nacional Autónoma de México (UNAM) from 1979 to 1983, and I had the great fortune of having Jorge Cantó and Luis Felipe Rodríguez (UNAM) as advisors. During my doctoral studies, I also had the privilege of having Jim Moran (CfA) and Paul Ho (ASIAA) as mentors in the use of instruments such as the Haystack 37-m radio telescope and the Very Large Array (NRAO), which I used frequently for my research.

Shortly after arriving at the UNAM, research into star formation experienced a surge of interest in the community thanks to the discovery in 1980 of the bipolar molecular outflow phenomenon associated with YSOs. My thesis aimed at understanding the nature of the focusing agent of this new phenomenon by mapping in NH_3 a set of ten sources exhibiting bipolar molecular outflows. What I found was that the detected high-density cores engulfed the YSOs suspected to power the outflows, and in addition that they were generally elongated and oriented perpendicular to the direction of the outflows. These elongated structures we interpreted as interstellar toroids, with dimensions of tenths of a parsec, that could provide the focusing mechanism of the bipolar molecular outflows. After almost 40 years of that work, we now know that the collimation of an outflow occurs at much smaller scales, through accretion disks of ∼100 au and magnetohydrodynamically driven gas ejections. However, the interstellar toroids could still play an important role in reorienting the outflows at scales of tenths of parsecs.

I studied the ammonia emission of different star-forming regions, such as HH 1-2, L1551, Mon R2, S106, NGC 2071, S106, HH 26 IR, GGD 12-15, NGC 7129, and Cepheus A, among others. These early studies also served to motivate further detailed observations with higher angular resolution and sensitivity to characterize the high-density molecular gas in these regions, as well as to study the embedded YSOs through their radio continuum emission, in many cases tracing thermal radio jets.

Q: *The Cepheus A region has interested you for many years, and in 1996 you published a paper on high-resolution VLA-A observations of the jet from the massive young star HW2. What did you learn?*

A: Yes, and I'm still very interested in this region. At a distance of about 700 pc, Cepheus A is the second nearest high-mass star forming region after Orion, and therefore it has been possible to study, with very high-angular resolution and sensitivity, many of the physical ingredients associated with star formation, like outflows, jets, disks, maser emission, magnetic fields, etc. In particular, the luminous source HW2 is one of the best examples of a massive object containing a jet-protostar-disk-magnetic field system at scales of a few hundred au, supporting the scenario that massive stars form as low-mass stars do.

In our work from 1996, the main goal was to study with the VLA and with the highest angular resolution at that time (0.08 arcsec) the HW2 thermal radio jet, testing at 1.3 cm wavelengths the biconical ionized jet scenario previously proposed by our research team. Two of the main uncertainties when observed with the VLA at 1.3 cm wavelengths in its more extended configuration are sensitivity and calibration. At this wavelength and long baselines the flux of the source could be spread out because of atmospheric turbulence, so accurate imaging of the emission is only possible if calibration is nearly perfect. We got that nearly perfect calibration at 1.3 cm by observing simultaneously the continuum emission of HW2 and the associated strong H_2O emission, self-calibrating this strong signal to use it as the amplitude and phase reference for the radio continuum emission. This powerful technique of cross-calibration, first applied in a star-forming region, is now widely used. Our observations resolved the thermal radio jet, detecting two maxima separated by ∼0.14 arcsec (∼ 100 au at the source distance) along the major axis of the jet. These results are consistent with the radio continuum emission of HW2 coming from a biconical ionized jet.

In addition, one of the most important things we realized from our work on Cepheus A was how powerful masers are as a tool to study massive star formation. And this led us to deeper investigations of this region as well as many other regions.

Q: *In 2001 you and your collaborators published a Letter in Nature discussing proper motions of an arc of H_2O masers associated with HW2. What were the main conclusions?*

A: As part of a multi-epoch campaign of H_2O maser observations carried out with the Very Long Baseline Array (VLBA, NRAO) toward HW2, we discovered an arc of masers that can be fit to a nearly-perfect circle of radius 62 au to within one part in a thousand. This arc is ∼0.7 arcsec (∼500 au) south of HW2. The proper motions of individual sections of the arc are fully consistent with a uniform expansion perpendicular to the arc at ∼9 km s^{-1}. We interpreted these observations in terms of an almost perfect spherical ejection from - at that time - an unknown source that should be located at the center of the fitted circle. Through subsequent VLA continuum observations, we detected a weak continuum source at the center of the circle, as predicted. For that spherical ejection we estimated a kinematic age of only ∼33 years, which led to the conclusion that this phenomenon must be episodic in the early stages of massive star formation. Through new VLBA H_2O maser observations carried out by our group five years after the detection of the spherical ejection, we observed that the maser structure was undergoing a distortion in its expansion through the circumstellar medium, losing its previous high degree of symmetry. The dissipation of the maser structure in the ambient medium corroborates the short-lived nature of this phenomenon.

These results were surprising since, according to the core-accretion model, collimated outflows are already expected at the very early phases of the formation of stars rather than outflows expanding without any preferential direction. We know now more cases like the one we reported in 2001, strongly indicating that at the early life of massive stars there may exist episodic, short-lived (tens of years) events associated with very poorly collimated or nearly isotropic outflows with velocities of 10-30 km s^{-1}, as for example W75N(B). The origin of these poorly collimated outflows with relatively low velocity from massive protostars deserves further theoretical research.

Q: *You have studied W75N(B) for more than 20 years, would you like to comment on that?*

A: W75N(B) also contains a system of different massive protostars and strong maser emission as first reported by Todd Hunter (NRAO) and collaborators in 1994. We started to study this region in 1997 by observing simultaneously with the VLA the radio continuum emission of the massive protostars and the associated strong H_2O masers, calibrating the data with the same technique as we did in our work on Cepheus A HW2 in 1996. In addition to the two radio continuum sources previously reported by Hunter et al. (VLA1, VLA3), we detected a new compact continuum source at 1.3 cm (VLA2) located in between these two other sources. VLA1 and VLA2, which are separated by ∼0.7 arcsec (∼910 au), exhibited a different outflow geometry traced by the H_2O masers through multi-epoch VLBA observations. In the case of VLA1 the continuum emission revealed a thermal radio jet, with the masers tracing a collimated outflow along the major axis of the jet. However, in VLA2 the H_2O masers traced a wind-driven, shock-excited shell of ∼0.14 arcsec (∼180 au) diameter radially expanding with respect to the central, unresolved radio continuum source. During the last two decades our group, constituted of researchers from different countries (Chile, Italy, México, Netherlands, Republic of Korea, Spain, Sweden, and USA), has been studying this system of massive protostars through radio continuum emission observations carried out with the VLA, as well as through multi-epoch VLBI H_2O maser observations carried out with the VLBA, European VLBI Network (EVN), and VLBI Exploration of Radio Astronomy (VERA). Surprisingly, we have seen that over a period of about 18 years, the expanding H_2O maser shell found around VLA2, as well as the radio continuum source itself, have evolved together from a nearly circular morphology, tracing an almost isotropic outflow, to an elliptical one outlining collimated motions in the same direction as the thermal radio jet of the nearby VLA1 source. We have modeled this very peculiar behaviour in VLA2 (not seen before in massive protostars) in terms of an episodic, short-lived (tens of years), originally isotropic ionized wind whose morphology evolves as it moves within a toroidal density stratification. These results open a new, exciting window of opportunity to study how the basic ingredients of star formation, like molecular outflows, ionized winds, magnetic fields..., evolve in "real time" over the next few years. Such observations may have important implications for our understanding of the early stages of high-mass star formation.

Q: *What are you currently working on?*

A: Led by Gabriele Surcis from INAF, we are monitoring with the EVN the magnetic field and the expansion of the W75N(B)-VLA2 H_2O maser shell over a period of six years to understand its formation and evolution. I am also collaborating with researchers from México, Spain, and USA to characterize protoplanetary disks in terms of disk mass, grain evolution, early planet formation, disk photoevaporation, magnetic field, etc, combining VLA and ALMA data. I am also involved in an international project led by José Francisco Gómez (IAA, CSIC) and Hiroshi Imai (Kagoshima University) related to Water Fountains (WFs), which are evolved objects in transition between the late AGBs and early PNe phases. Some of these WF objects exhibit H_2O maser jets with bow-shock structures moving at hundreds of km s^{-1}, similar to what we also observe in protostars. Through multi-epoch VLBI H_2O maser observations we are studying the origin and launching mechanisms of the jets associated with those WFs. Finally, I continue to be very interested in massive objects containing jet-protostar-disk-magnetic field systems, as in HW2 and HH 80-81.

Abstracts of recently accepted papers

The chemistry of disks around T Tauri and Herbig Ae/Be stars

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Infrared and (sub-)mm observations of disks around T Tauri and Herbig Ae/Be stars point to a chemical differentiation between both types of disks, with a lower detection rate of molecules in disks around hotter stars. To investigate the potential underlying causes we perform a comparative study of the chemistry of T Tauri and Herbig Ae/Be disks, using a model that pays special attention to photochemistry. The warmer disk temperatures and higher ultraviolet flux of Herbig stars compared to T Tauri stars induce some differences in the disk chemistry. In the hot inner regions, H_2O, and simple organic molecules like C_2H_2, HCN, and CH_4 are predicted to be very abundant in T Tauri disks and even more in Herbig Ae/Be disks, in contrast with infrared observations that find a much lower detection rate of water and simple organics toward disks around hotter stars. In the outer regions, the model indicates that the molecules typically observed in disks, like HCN, CN, C_2H, H2CO, CS, SO, and HCO^+, do not have drastic abundance differences between T Tauri and Herbig Ae disks. Some species produced under the action of photochemistry, like C_2H and CN, are predicted to have slightly lower abundances around Herbig Ae stars due to a narrowing of the photochemically active layer. Observations indeed suggest that these radicals are somewhat less abundant in Herbig Ae disks, although in any case the inferred abundance differences are small, of a factor of a few at most. A clear chemical differentiation between both types of disks concerns ices, which are expected to be more abundant in Herbig Ae disks. The global chemical behavior of T Tauri and Herbig Ae/Be disks is quite similar. The main differences are driven by the warmer temperatures of the latter, which result in a larger reservoir or water and simple organics in the inner regions and a lower mass of ices in the outer disk.

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http://arxiv.org/pdf/1803.09450

Multiple Paths of Deuterium Fractionation in Protoplanetary Disks

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We investigate deuterium chemistry coupled with the nuclear spin-state chemistry of H_2 and H_3^+ in protoplanetary disks. Multiple paths of deuterium fractionation are found; exchange reactions with D atoms, such as HCO^+ + D, are effective in addition to those with HD. In a disk model with grain sizes appropriate for dark clouds, the freeze-out of molecules is severe in the outer midplane, while the disk surface is shielded from UV radiation. Gaseous molecules, including DCO^+, thus become abundant at the disk surface, which tends to make their column density distribution relatively flat. If the dust grains have grown to millimeter size, the freeze-out rate of neutral species is reduced and the abundances of gaseous molecules, including DCO^+ and N_2D^+, are enhanced in the cold midplane. Turbulent diffusion transports D atoms and radicals at the disk surface to the midplane, and stable ice species in the midplane to the disk surface. The effects of turbulence on chemistry are thus multifold; while DCO^+ and N_2D^+ abundances increase or decrease depending on the regions, HCN and DCN in the gas and ice are greatly reduced at the innermost radii, compared to the model without turbulence. When cosmic rays penetrate the disk, the ortho-topara ratio (OPR) of H_2 is found to be thermal in the disk, except in the cold ($\leq$10 K) midplane. We also analyze the OPR of H_3^+ and

H_2D^+, as well as the main reactions of H_2D^+, DCO^+, and N_2D^+, in order to analytically derive their abundances in the cold midplane.

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https://arxiv.org/pdf/1803.02498

ALMA Survey of Lupus Protoplanetary Disks II: Gas Disk Radii

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We present ALMA Band 6 observations of a complete sample of protoplanetary disks in the young (1–3 Myr) Lupus star-forming region, covering the 1.33 mm continuum and the ^{12}CO, ^{13}CO, and C^{18}O J=2–1 lines. The spatial resolution is 0$''$.25 with a medium 3-σ continuum sensitivity of 0.30 mJy, corresponding to $M_{\rm dust} \sim 0.2\ M_\oplus$. We apply "Keplerian masking" to enhance the signal-to-noise ratios of our ^{12}CO zero-moment maps, enabling measurements of gas disk radii for 22 Lupus disks; we find that gas disks are universally larger than mm dust disks by a factor of two on average, likely due to a combination of the optically thick gas emission as well as the growth and inward drift of the dust. Using the gas disk radii, we calculate the dimensionless viscosity parameter, $\alpha_{\rm visc}$, finding a broad distribution and no correlations with other disk or stellar parameters, suggesting that viscous processes have not yet established quasi-steady states in Lupus disks. By combining our 1.33 mm continuum fluxes with our previous 890 μm continuum observations, we also calculate the mm spectral index, $\alpha_{\rm mm}$, for 70 Lupus disks; we find an anti-correlation between $\alpha_{\rm mm}$ and mm flux for low-mass disks ($M_{\rm dust} < 5$), followed by a flattening as disks approach $\alpha_{\rm mm} = 2$, which could indicate faster grain growth in higher-mass disks, but may also reflect their larger optically thick components. In sum, this work demonstrates the continuous stream of new insights into disk evolution and planet formation that can be gleaned from unbiased ALMA disk surveys.

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Accelerating infall and rotational spin-up in the hot molecular core G31.41+0.31

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As part of our effort to search for circumstellar disks around high-mass stellar objects, we observed the well-known core G31.41+0.31 with ALMA at 1.4 mm with an angular resolution of ∼0.22" (∼1700 au). The dust continuum emission has been resolved into two cores namely Main and NE. The Main core, which has the strongest emission, is the most chemically rich, has a diameter of ∼5300 au, and is associated with two free-free continuum sources. The Main core looks featureless and homogeneous in dust continuum emission and does not present any hint of fragmentation. Each energy transition of CH_3CN and CH_3OCH, both ground and vibrationally excited, as well as those of CH_3CN isotopologues, shows a clear velocity gradient along the NE–SW direction, with the velocity linearly increasing with distance from the center, consistent with solid-body rotation. However, when comparing the velocity field of transitions with different energy levels, the rotation velocity increases with increasing energy of the transition, which suggests that the rotation speeds up towards the center. Spectral lines towards the dust continuum peak show an inverse P-Cygni profile that supports the existence of infall in the core. The infall velocity increases with the excitation energy of the transition suggesting that the infall is accelerating towards the center of the core, consistent with gravitational collapse. Despite the monolithic appearance of the Main core, the presence of red-shifted absorption, the existence of two embedded free-free sources at the center, and the rotational spin-up are consistent with an unstable core undergoing fragmentation with infall and differential rotation due to conservation of angular momentum. Therefore, the most likely explanation for the monolithic morphology is the large opacity of the dust emission that prevents the detection of any inhomogeneity in the core.

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The Inception of Star Cluster Formation Revealed by [CII] Emission Around an Infrared Dark Cloud

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We present *SOFIA-upGREAT* observations of [CII] emission of Infrared Dark Cloud (IRDC) G035.39-00.33, designed to trace its atomic gas envelope and thus test models of the origins of such clouds. Several velocity components of [CII] emission are detected, tracing structures that are at a wide range of distances in the Galactic plane. We find a main component that is likely associated with the IRDC and its immediate surroundings. This strongest emission component has a velocity similar to that of the ^{13}CO(2-1) emission of the IRDC, but offset by $\sim 3\,\mathrm{km\,s^{-1}}$ and with a larger velocity width of $\sim 9\,\mathrm{km\,s^{-1}}$. The spatial distribution of the [CII] emission of this component is also offset predominantly to one side of the dense filamentary structure of the IRDC. The CII column density is estimated to be of the order of $\sim 10^{17} - 10^{18}\,\mathrm{cm^{-2}}$. We compare these results to the [CII] emission from numerical simulations of magnetized, dense gas filaments formed from giant molecular cloud (GMC) collisions, finding similar spatial and kinematic offsets. These observations and modeling of [CII] add further to the evidence that IRDC G035.39-00.33 has been formed by a process of GMC-GMC collision, which may thus be an important mechanism for initiating star cluster formation.

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The Gaia-ESO Survey: kinematical and dynamical study of four young open clusters

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Context. The origin and dynamical evolution of star clusters is an important topic in stellar astrophysics. Several models have been proposed to understand the formation of bound and unbound clusters and their evolution, and these can be tested by examining the kinematical and dynamical properties of clusters over a wide range of ages and masses.
Aims. We use the Gaia-ESO Survey products to study four open clusters (IC 2602, IC 2391, IC 4665, and NGC 2547) that lie in the age range between 20 and 50 Myr.
Methods. We employ the gravity index γ and the equivalent width of the lithium line at 6708 Å, together with effective temperature T_{eff}, and the metallicity of the stars in order to discard observed contaminant stars. Then, we derive the cluster radial velocity dispersions σ_{c}, the total cluster mass M_{tot}, and the half mass radius r_{hm}. Using the Gaia-DR1 TGAS catalogue, we independently derive the intrinsic velocity dispersion of the clusters from the astrometric parameters of cluster members.
Results. The intrinsic radial velocity dispersions derived by the spectroscopic data are larger than those derived from the TGAS data, possibly due to the different masses of the considered stars. Using M_{tot} and r_{hm} we derive the virial velocity dispersion σ_{vir} and we find that three out of four clusters are supervirial. This result is in agreement with the hypothesis that these clusters are dispersing, as predicted by the "residual gas expulsion" scenario. However, recent simulations show that the virial ratio of young star clusters may be overestimated if it is determined using the global velocity dispersion, since the clusters are not fully relaxed.

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The JCMT Gould Belt Survey: A First Look at the Auriga–California Molecular Cloud with SCUBA-2

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We present 850 and 450 μm observations of the dense regions within the Auriga–California molecular cloud using SCUBA-2 as part of the JCMT Gould Belt Legacy Survey to identify candidate protostellar objects, measure the masses of their circumstellar material (disk and envelope), and compare the star formation to that in the Orion A molecular cloud. We identify 59 candidate protostars based on the presence of compact submillimeter emission, complementing these observations with existing *Herschel*/SPIRE maps. Of our candidate protostars, 24 are associated with young stellar objects (YSOs) in the *Spitzer* and *Herschel*/PACS catalogs of 166 and 60 YSOs, respectively (177 unique), confirming their protostellar nature. The remaining 35 candidate protostars are in regions, particularly around LkHα 101, where the background cloud emission is too bright to verify or rule out the presence of the compact 70 μm emission that is expected for a protostellar source. We keep these candidate protostars in our sample but note that they may indeed be prestellar in nature. Our observations are sensitive to the high end of the mass distribution in Auriga–Cal. We find that the disparity between the richness of infrared star forming objects in Orion A and the sparsity in Auriga–Cal extends to the submillimeter, suggesting that the relative star formation rates have not varied over the Class II lifetime and that Auriga–Cal will maintain a lower star formation efficiency.

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SPH simulations of structures in protoplanetary disks

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The hydrodynamic models of the protoplanetary disk, which perturbed by the embeded low-mass companion, were calculated by our modification of GADGET-2 code. The cases of circular and eccentric orbits which can be coplanar or slightly inclined to the disk midplane were considered. The column density of test particles on the line of sight between the central star and observer was computed during the simulations. Then the column density of the circumstellar dust was calculated under the assumption that the dust and gas are well mixed with a mass ratio 1 : 100. To research the influence of the disk orientation relative to the observer on the circumstellar extinction the calculations were made for four angles of inclination of the line of sight to the disk midplane and eight directions along the azimuth. The column density in the circumstellar and circumbinary disk were computed separately. The calculations have shown the periodic variations of column density can arise both in the circumstellar and circumbinary disks. The amplitude and shape of the variation strongly depend on the parameters of the simulated system (eccentricity and inclination of the orbit, the mass ratio of the companion and star) and its orientation in space. The results of our simulations can be used to explain the cyclic variation of the brightness of young UX Ori type stars.

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Planetesimal formation during protoplanetary disk buildup

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Models of dust coagulation and subsequent planetesimal formation are usually computed on the backdrop of an already fully formed protoplanetary disk model. At the same time, observational studies suggest that planetesimal formation should start early, possibly even before the protoplanetary disk is fully formed. In this paper, we investigate under which conditions planetesimals already form during the disk buildup stage, in which gas and dust fall onto the disk from its parent molecular cloud. We couple our earlier planetesimal formation model at the water snow line to a simple model of disk formation and evolution. We find that under most conditions planetesimals only form after the buildup stage when the disk becomes less massive and less hot. However, there are parameters for which planetesimals already form during the disk buildup. This occurs when the viscosity driving the disk evolution is intermediate ($\alpha_{\rm v} \sim 10^{-3}$–$10^{-2}$) while the turbulent mixing of the dust is reduced compared to that ($\alpha_{\rm t} \lesssim 10^{-4}$), and with the assumption that water vapor is vertically well-mixed with the gas. Such $\alpha_{\rm t} \ll \alpha_{\rm v}$ scenario could be expected for layered accretion, where the gas flow is mostly driven by the active surface layers, while the midplane layers, where most of the dust resides, are quiescent.

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Extreme star formation in the Milky Way: Luminosity distributions of young stellar objects in W49A and W51

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We have compared the star-formation properties of the W49A and W51 regions by using far-infrared data from the Herschel infrared Galactic Plane Survey (Hi-GAL) and 850-μm observations from the James Clerk Maxwell Telescope (JCMT) to obtain luminosities and masses, respectively, of associated compact sources. The former are infrared luminosities from the catalogue of Elia et al. (2017), while the latter are from the JCMT Plane survey source catalogue as well as measurements from new data. The clump-mass distributions of the two regions are found to be consistent with each other, as are the clump-formation efficiency and star-formation efficiency analogues. However, the frequency distributions of the luminosities of the young stellar objects are significantly different. While the luminosity distribution in W51 is consistent with Galaxy-wide samples, that of W49A is top-heavy. The differences are not dramatic, and are concentrated in the central regions of W49A. However, they suggest that physical conditions there, which are comparable in part to those in extragalactic starbursts, are significantly affecting the star-formation properties or evolution of the dense clumps in the region.

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Gas expulsion in highly substructured embedded star clusters

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We investigate the response of initially substructured, young, embedded star clusters to instantaneous gas expulsion of their natal gas. We introduce primordial substructure to the stars and the gas by simplistically modelling the star formation process so as to obtain a variety of substructure distributed within our modelled star forming regions. We show that, by measuring the virial ratio of the stars alone (disregarding the gas completely), we can estimate how much mass a star cluster will retain after gas expulsion to within 10% accuracy, no matter how complex the background structure of the gas is, and we present a simple analytical recipe describing this behaviour. We show that the evolution of the star cluster while still embedded in the natal gas, and the behavior of the gas before being expelled, are crucial processes that affect the timescale on which the cluster can evolve into a virialized spherical system. Embedded star clusters that have high levels of substructure are subvirial for longer times, enabling them to survive gas expulsion better than a virialized and spherical system. By using a more realistic treatment for the background gas than our previous studies, we find it very difficult to destroy the young clusters with instantaneous gas expulsion. We conclude that gas removal may not be the main culprit for the dissolution of young star clusters.

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On the Formation of Runaway Stars BN and x in the Orion Nebula Cluster

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We explore scenarios for the dynamical ejection of stars BN and x from source I in the Kleinmann-Low nebula of the Orion Nebula Cluster (ONC), which is important for being the closest region of massive star formation. This ejection would cause source I to become a close binary or a merger product of two stars. We thus consider binary-binary encounters as the mechanism to produce this event. By running a large suite of N-body simulations, we find that it is nearly impossible to match the observations when using the commonly adopted masses for the participants, especially a source I mass of 7 $M_{\odot}$. The only way to recreate the event is if source I is more massive, i.e., $\sim 20\ M_{\odot}$. However, even in this case, the likelihood of reproducing the observed system is low. We discuss the implications of these results for understanding this important star-forming region.

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Bipolar Jets Launched by a Mean-field Accretion Disk Dynamo

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By applying magnetohydrodynamic simulations, we investigate the launching of jets driven by a disk magnetic field generated by a mean-field disk dynamo. Extending our earlier studies, we explore the bipolar evolution of the disk $\alpha^2\Omega$-dynamo and the outflow. We confirm that a negative dynamo-α leads to a dipolar magnetic field geometry, whereas positive values generate quadrupolar fields. The latter remain mainly confined to the disk and cannot launch outflows. We investigate a parameter range for the dynamo-α ranging from a critical value below which field generation is negligible, $\alpha_{0,\rm crit} = -0.0005$, to $\alpha_0 = 1.0$. For weak $|\alpha_0| \leq 0.07$, two magnetic loop structures with opposite polarity may arise, which leads to reconnection in the disk and disturbs the field evolution and the accretion-ejection process. For a strong dynamo-α, a higher poloidal magnetic energy is reached, roughly scaling with $E_{\rm mag} \sim |\alpha_0|$, which also leads also to higher accretion and ejection rates. The terminal jet speed is governed by the available magnetic energy and increases with the dynamo-α. We find jet velocities on the order of the inner disk Keplerian velocity. For a strong dynamo-α, oscillating dynamo modes may occur that lead to a pulsed ejection. This is triggered by an oscillating mode in the toroidal field component. The oscillation period is comparable to the Keplerian time scale in the jet launching region, thus too short to be associated with the knots in observed jets. We find a hemispherically asymmetric evolution for the jet and counter jet in the mass flux and the field structure.

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Turbulence in the TW Hya disk

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Turbulence is a fundamental parameter in models of grain growth during the early stages of planet formation. As such, observational constraints on its magnitude are crucial. Here we self-consistently analyze ALMA CO(2-1), SMA CO(3-2), and SMA CO(6-5) observations of the disk around TW Hya and find an upper limit on the turbulent broadening of $<0.08c_s$ ($\alpha < 0.007$ for α defined only within 2-3 pressure scale heights above the midplane), lower than the tentative detection previously found from an analysis of the CO(2-1) data. We examine in detail the challenges of image plane fitting vs directly fitting the visibilities, while also considering the role of the vertical temperature gradient, systematic uncertainty in the amplitude calibration, and assumptions about the CO abundance, as potential sources of the discrepancy in the turbulence measurements. These tests result in variations of the turbulence limit

between <0.04c$_s$ and <0.13c$_s$, consistently lower than the 0.2-0.4c$_s$ found previously. Having ruled out numerous factors, we restrict the source of the discrepancy to our assumed coupling between temperature and density through hydrostatic equilibrium in the presence of a vertical temperature gradient and/or the confinement of CO to a thin molecular layer above the midplane, although further work is needed to quantify the influence of these prescriptions. Assumptions about hydrostatic equilibrium and the CO distribution are physically motivated, and may have a small influence on measuring the kinematics of the gas, but they become important when constraining small effects such as the strength of the turbulence within a protoplanetary disk.

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Tracing the atomic nitrogen abundance in star-forming regions with ammonia deuteration

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Partitioning of elemental nitrogen in star-forming regions is not well constrained. Most nitrogen is expected to be partitioned among atomic nitrogen, molecular nitrogen (N_2), and icy N-bearing molecules, such as NH_3 and N_2. Atomic nitrogen is not directly observable in the cold gas. In this paper, we propose an indirect way to constrain the amount of atomic nitrogen in the cold gas of star-forming clouds, via deuteration in ammonia ice, the $[ND_2H/NH_2D]/[NH_2D/NH_3]$ ratio. Using gas-ice astrochemical simulations, we show that if atomic nitrogen remains as the primary reservoir of nitrogen during cold ice formation stages, the $[ND_2H/NH_2D]/[NH_2D/NH_3]$ ratio is close to the statistical value of 1/3 and lower than unity, whereas if atomic nitrogen is largely converted into N-bearing molecules, the ratio should be larger than unity. Observability of ammonia isotopologues in the inner hot regions around low-mass protostars, where ammonia ice has sublimated, is also discussed. We conclude that the $[ND_2H/NH_2D]/[NH_2D/NH_3]$ ratio can be quantified using a combination of VLA and ALMA observations with reasonable integration times, at least toward IRAS 16293-2422 where high molecular column densities are expected.

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Depletion of heavy nitrogen in the cold gas of star-forming regions

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We investigate nitrogen isotope fractionation in forming and evolving molecular clouds using gas-ice astrochemical simulations. We find that the bulk gas can become depleted in heavy nitrogen (^{15}N) due to the formation of ^{15}N-enriched ices. Around the chemical transition from atomic nitrogen to N_2, $N^{15}N$ is selectively photodissociated, which results in the enrichment of ^{15}N in atomic nitrogen. As ^{15}N-enriched atomic nitrogen is converted to ammonia ice via grain surface reactions, the bulk gas is depleted in ^{15}N. The level of ^{15}N depletion in the bulk gas can be up to a factor of two compared to the elemental nitrogen isotope ratio, depending on the photodesorption yield of ammonia ice. Once the nitrogen isotopes are differentially partitioned between gas and solids in a molecular cloud, it should remain in the later stages of star formation (e.g., prestellar core) as long as the sublimation of ammonia ice is inefficient. Our model suggests that all the N-bearing molecules in the cold gas of star-forming regions can be depleted in ^{15}N, which is at least qualitatively consistent with the observations toward prestellar core L1544. In our models, icy species show both ^{15}N and deuterium fractionation. The fractionation pattern within ice mantles is different between ^{15}N and deuterium, reflecting their fractionation mechanisms; while the concentration of deuterium almost monotonically increases from the lower layers of the ice mantles to the upper layers, the concentration of ^{15}N reaches the maximum

at a certain depth and declines towards the surface.

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S Coronae Australis – a T Tauri Twin

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The star S CrA is a tight visual binary consisting of two classical T Tauri stars, both with outstanding spectral characteristics and brightness variations. High-resolution spectra were collected at ESO and photometric observations with the SMARTS telescope. Both stars undergo large variation in brightness caused mainly by variable foreground extinction.
From the stellar parameters we conclude that the two stars are remarkably similar, and that S CrA can be regarded as a T Tauri twin. Rotational periods and inclinations are also similar. The stars differ, however, in terms of degree of veiling and emission line profiles.
We compared observed Balmer emission line profiles with models including magnetospheric accretion and a disk wind. We found a good match between observed signatures of accreting gas, wind features, and rotational velocities with those resulting from our modelling for inclinations of $\sim$ 65 degrees. At this orientation the trajectories of infalling gas just above the stellar surfaces are parallel to the line-of-sight, and accordingly we observe extended red-shifted absorption components extending to + 380 km/s, the estimated free-fall velocity at the surface. However, our so derived inclinations differ from those derived from interferometric near-infrared spectroscopy, and we discuss possible causes for this puzzling discrepancy.

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Velocity-Resolved [CII] Emission from Cold Diffuse Clouds in the Interstellar Medium

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We have combined emission from the 158 μm fine structure transition of C^+ observed with the GREAT and upGREAT instruments on SOFIA with 21–cm absorption spectra and visual extinction to characterize the diffuse interstellar clouds found along the lines of sight. The weak [CII] emission is consistent in velocity and line width with the strongest HI component produced by the Cold Neutral Medium (CNM). The HI column density and kinetic temperature are known from the 21cm data, and assuming a fractional abundance of ionized carbon, we calculate the volume density and thermal pressure of each source, which vary considerably, with 27 cm^{-3} $\leq n(\mathrm{H}^0) \leq$ 210 cm^{-3} considering only the atomic hydrogen along the lines of sight to be responsible for the C^+, while 13 cm^{-3} $\leq n(\mathrm{H}^0 + \mathrm{H}_2) \leq$ 190 cm^{-3} including the hydrogen in both forms. The thermal pressure varies widely with 1970 cm^{-3}K $\leq P_{th}/k \leq$ 10440 cm^{-3}K for H^0 alone and 750 cm^{-3}K $\leq P_{th}/k \leq$ 9360 cm^{-3}K including both H^0 and H_2. The molecular hydrogen fraction varies between 0.10 and 0.67. Photoelectric heating is the dominant heating source, supplemented by a moderately–

enhanced cosmic ray ionization rate, constrained by the relatively low 45 K to 73 K gas temperatures of the clouds. The resulting thermal balance for the two lower–density clouds is satisfactory, but for the two higher–density clouds, the combined heating rate is insufficient to balance the observed C^+ cooling.

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A New 3D Maser Code Applied to Flaring Events

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We set out the theory and discretization scheme for a new finite-element computer code, written specifically for the simulation of maser sources. The code was used to compute fractional inversions at each node of a 3-D domain for a range of optical thicknesses. Saturation behaviour of the nodes with regard to location and optical depth were broadly as expected. We have demonstrated via formal solutions of the radiative transfer equation that the apparent size of the model maser cloud decreases as expected with optical depth as viewed by a distant observer. Simulations of rotation of the cloud allowed the construction of light-curves for a number of observable quantities. Rotation of the model cloud may be a reasonable model for quasi-periodic variability, but cannot explain periodic flaring.

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Unveiling the physical conditions of the youngest disks: a warm embedded disk in L1527

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Context. Protoplanetary disks have been studied extensively, both physically and chemically, to understand the environment in which planets form. However, the first steps of planet formation are likely to occur already when the protostar and disk are still embedded in their natal envelope. The initial conditions for planet formation may thus be provided by these young embedded disks, of which the physical and chemical structure is poorly characterized.
Aims. We aim to constrain the midplane temperature structure, one of the critical unknowns, of the embedded disk around L1527. In particular, we set out to determine whether there is an extended cold outer region where CO is frozen out, as is the case for Class II disks. This will show whether young disks are indeed warmer than their more evolved counterparts, as is predicted by physical models.
Methods. We use archival ALMA data of ^{13}CO $J = 2-1$, $C^{18}O$ $J = 2-1$ and N_2D^+ $J = 3-2$ to directly observe the midplane of the near edge-on L1527 disk. The optically thick CO isotopologues allow us to derive a radial temperature profile for the disk midplane, while N_2D^+, which can only be abundant when CO is frozen out, provides an additional constraint on the temperature. Moreover, the effect of CO freeze-out on the ^{13}CO, $C^{18}O$ and N_2D^+ emission is investigated using 3D radiative transfer modeling.
Results. Optically thick ^{13}CO and $C^{18}O$ emission is observed throughout the disk and inner envelope, while N_2D^+ is not detected. Both CO isotopologues have brightness temperatures $\gtrsim$ 25 K along the midplane. Disk and envelope emission can be disentangled kinematically, because the largest velocities are reached in the disk. A power law radial temperature profile constructed using the highest midplane temperature at these velocities suggest that the temperature is above 20 K out to at least 75 AU, and possibly throughout the entire 125 AU disk. The radiative transfer models show that a model without CO freeze-out in the disk matches the $C^{18}O$ observations better than a model with the CO snowline at $\sim$70 AU. In addition, there is no evidence for a large (order of magnitude) depletion of CO.
Conclusions. The disk around L1527 is likely to be warm enough to have CO present in the gas phase throughout the disk, suggesting that young embedded disks can indeed be warmer than the more evolved Class II disks.

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Dust concentration and chondrule formation

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Meteoritical and astrophysical models of planet formation make contradictory predictions for dust concentration factors in chondrule forming regions of the solar nebula. Meteoritical and cosmochemical models strongly suggest that chondrules, a key component of the meteoritical record, formed in regions with solids-to-gas mass ratios orders of magnitude above background. However, models of dust grain dynamics in protoplanetary disks struggle to surpass factors of a few outside of very brief windows in the lifetime of the dust grains. Worse, those models do not predict significant concentration factors for dust grains the size of chondrule precursors. We briefly develop the difficulty in concentrating dust particles in the context of nebular chondrule formation and show that the disagreement is sufficiently stark that cosmochemists should explore ideas that might revise the concentration factor requirements downwards.

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Searching for Hα emitting sources around MWC758: SPHERE/ZIMPOL high-contrast imaging

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MWC758 is a young star surrounded by a transitional disk. Recently, a protoplanet candidate has been detected around MWC758 through high-resolution L′-band observations. The candidate is located inside the disk cavity at a separation of ∼111 mas from the central star, and at an average position angle of ∼165.°5. We have performed simultaneous adaptive optics observations of MWC758 in the Hα line and the adjacent continuum using SPHERE/ZIMPOL at the Very Large Telescope (VLT). We aim at detecting accreting protoplanet candidates through spectral angular differential imaging observations. The data analysis does not reveal any Hα signal around the target. The derived contrast curve in the B_Ha filter allows us to derive a 5σ upper limit of ∼7.6 mag at 111 mas, the separation of the previously detected planet candidate. This contrast translates into a Hα line luminosity of $L_{\mathrm{H}\alpha} \lesssim 5 \times 10^{-5}\ L_\odot$ at 111 mas, and an accretion luminosity of $L_{\mathrm{acc}} < 3.7 \times 10^{-4}\ L_\odot$. For the predicted mass range of MWC758b, 0.5–5 M_{Jup}, this implies accretion rates of $\dot{M} \lesssim 3.4 \times (10^{-8}$–$10^{-9})\ M_\odot\ \mathrm{yr}^{-1}$, for an average planet radius of 1.1 R_{Jup}. Therefore, our estimates are consistent with the predictions of accreting circumplanetary accretion models for $R_{\mathrm{in}} = 1\ R_{\mathrm{Jup}}$. In

any case, the non-detection of any Hα emitting source in the ZIMPOL images does not allow us to unveil the true nature of the L$'$ detected source.

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ALMA observations of polarization from dust scattering in the IM Lup protoplanetary disk

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We present 870 μm ALMA observations of polarized dust emission toward the Class II protoplanetary disk IM Lup. We find that the orientation of the polarized emission is along the minor axis of the disk, and that the value of the polarization fraction increases steadily toward the center of the disk, reaching a peak value of $\sim$1.1%. All of these characteristics are consistent with models of self-scattering of submillimeter-wave emission from an optically thin inclined disk. The distribution of the polarization position angles across the disk reveals that while the average orientation is along the minor axis, the polarization orientations show a significant spread in angles; this can also be explained by models of pure scattering. We compare the polarization with that of the Class I/II source HL Tau. A comparison of cuts of the polarization fraction across the major and minor axes of both sources reveals that IM Lup has a substantially higher polarization fraction than HL Tau toward the center of the disk. This enhanced polarization fraction could be due a number of factors, including higher optical depth in HL Tau, or scattering by larger dust grains in the more evolved IM Lup disk. However, models yield similar maximum grain sizes for both HL Tau (72 μm) and IM Lup (61 μm, this work). This reveals continued tension between grain-size estimates from scattering models and from models of the dust emission spectrum, which find that the bulk of the (unpolarized) emission in disks is most likely due to millimeter (or even centimeter) sized grains.

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The *Herschel*-PACS Legacy of Low-mass Protostars: The Properties of Warm and Hot Gas Components and Their Origin in Far-UV Illuminated Shocks

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Recent observations from *Herschel* allow the identification of important mechanisms responsible for the heating of gas surrounding low-mass protostars and its subsequent cooling in the far-infrared (FIR). Shocks are routinely invoked to reproduce some properties of the far-IR spectra, but standard models fail to reproduce the emission from key molecules, e.g. H_2O. Here, we present the *Herschel*-PACS far-IR spectroscopy of 90 embedded low-mass protostars (Class 0/I). The *Herschel*-PACS spectral maps covering $\sim 55 - 210$ μm with a field-of-view of ∼50" are used to quantify the gas excitation conditions and spatial extent using rotational transitions of H_2O, high-J CO, and OH, as well as [O I] and [C II]. We confirm that a warm (∼300 K) CO reservoir is ubiquitous and that a hotter component (760 ± 170 K) is frequently detected around protostars. The line emission is extended beyond ∼1000 AU spatial scales in 40/90 objects, typically in molecular tracers in Class 0 and atomic tracers in Class I objects. High-velocity emission (> 90 km s^{-1}) is detected in only 10 sources in the [O I] line, suggesting that the bulk of [O I] arises from gas that is moving slower than typical jets. Line flux ratios show an excellent agreement with models of C-shocks illuminated by UV photons for pre-shock densities of $\sim 10^5$ cm^{-3} and UV fields 0.1-10 times the interstellar value. The far-IR molecular and atomic lines are a unique diagnostic of feedback from UV emission and shocks in envelopes of deeply embedded protostars.

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The Coordinated Radio and Infrared Survey for High-Mass Star Formation III. A catalogue of northern ultra-compact H II regions

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A catalogue of 239 ultra-compact H II regions (UCHIIs) found in the CORNISH survey at 5 GHz and 1.5″ resolution in the region $10^\circ < l < 65^\circ$, $|b| < 1^\circ$ is presented. This is the largest complete and well-selected sample of UCHIIs to date and provides the opportunity to explore the global and individual properties of this key state in massive star formation at multiple wavelengths. The nature of the candidates was validated, based on observational properties and calculated spectral indices, and the analysis is presented in this work. The physical sizes, luminosities and other physical properties were computed by utilising literature distances or calculating the distances whenever a value was not available. The near- and mid-infrared extended source fluxes were measured and the extinctions towards the UCHIIs were computed. The new results were combined with available data at longer wavelengths and the spectral energy distributions (SEDs) were reconstructed for 177 UCHIIs. The bolometric luminosities obtained from SED fitting are presented. By comparing the radio flux densities to previous observational epochs, we find about 5% of the sources appear to be time variable. This first high-resolution area survey of the Galactic plane shows that the total number of UCHIIs in the Galaxy is ~ 750 – a factor of 3-4 fewer than found in previous large area radio surveys. It will form the basis for future tests of models of massive star formation.

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Distortion of Magnetic Fields in a Starless Core III: Polarization–Extinction Relationship in FeSt 1-457

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The relationship between dust polarization and extinction was determined for the cold dense starless molecular cloud core FeSt 1-457 based on the background star polarimetry of dichroic extinction at near-infrared wavelengths. Owing to the known (three-dimensional) magnetic field structure, the observed polarizations from the core were corrected by considering (a) the subtraction of the ambient polarization component, (b) the depolarization effect of inclined distorted magnetic fields, and (c) the magnetic inclination angle of the core. After these corrections, a linear relationship between polarization and extinction was obtained for the core in the range up to $A_V \approx 20$ mag. The initial polarization vs. extinction diagram changed dramatically after the corrections of (a) to (c), with the correlation coefficient being refined from 0.71 to 0.79. These corrections should affect the theoretical interpretation of the observational data. The slope of the finally obtained polarization–extinction relationship is $P_H/E_{H-K_s} = 11.00 \pm 0.72$ % mag^{-1}, which is close to the statistically estimated upper limit of the interstellar polarization efficiency (Jones 1989). This consistency suggests that the upper limit of interstellar polarization efficiency might be determined by the observational viewing angle toward polarized astronomical objects.

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A radial velocity survey of the Carina Nebula's O-type stars

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We have obtained multi-epoch observations of 31 O-type stars in the Carina Nebula using the CHIRON spectrograph on the CTIO/SMARTS 1.5-m telescope. We measure their radial velocities to 1–2 km s^{-1} precision and present new or updated orbital solutions for the binary systems HD 92607, HD 93576, HDE 303312, and HDE 305536. We also compile radial velocities from the literature for 32 additional O-type and evolved massive stars in the region. The combined data set shows a mean heliocentric radial velocity of 0.6 km s^{-1}. We calculate a velocity dispersion of $\leq$9.1 km s^{-1}, consistent with an unbound, substructured OB association. The Tr 14 cluster shows a marginally significant 5 km s^{-1} radial velocity offset from its neighbor Tr 16, but there are otherwise no correlations between stellar position and velocity. The O-type stars in Cr 228 and the South Pillars region have a lower velocity dispersion than the region as a whole, supporting a model of distributed massive-star formation rather than migration from the central clusters. We compare our stellar velocities to the Carina Nebula's molecular gas and find that Tr 14 shows a close kinematic association with the Northern Cloud. In contrast, Tr 16 has accelerated the Southern Cloud by 10–15 km s^{-1}, possibly triggering further massive-star formation. The expansion of the surrounding H II region is not symmetric about the O-type stars in radial velocity space, indicating that the ionized gas is constrained by denser material on the far side.

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The CARMA-NRO Orion Survey

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We present the first results from a new, high resolution, ^{12}CO(1-0), ^{13}CO(1-0), and C^{18}O(1-0) molecular line survey of the Orion A cloud, hereafter referred to as the CARMA-NRO Orion Survey. CARMA observations have been combined with single-dish data from the Nobeyama 45m telescope to provide extended images at about 0.01 pc resolution, with a dynamic range of approximately 1200 in spatial scale. Here we describe the practical details of the data combination in uv space, including flux scale matching, the conversion of single dish data to visibilities, and joint deconvolution of single dish and interferometric data. A Δ-variance analysis indicates that no artifacts are caused by combining data from the two instruments. Initial analysis of the data cubes, including moment maps, average spectra, channel maps, position-velocity diagrams, excitation temperature, column density, and line ratio maps provides evidence of complex and interesting structures such as filaments, bipolar outflows, shells, bubbles, and photo-eroded pillars. The implications for star formation processes are profound and follow-up scientific studies by the CARMA-NRO Orion team are now underway. We plan to make all the data products described here generally accessible; some are already available at https://dataverse.harvard.edu/dataverse/CARMA-NRO-Orion.

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Scale-free gravitational collapse as the origin of $\rho \sim r^{-2}$ density profile – a possible role of turbulence in regulating gravitational collapse

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Astrophysical systems, such as clumps that form star clusters share a density profile that is close to $\rho \sim r^{-2}$. We prove analytically this density profile is the result of the scale-free nature of the gravitational collapse. Therefore, it should

emerge in many different situations as long as gravity is dominating the evolution for a period that is comparable or longer than the free-fall time, and this does not necessarily imply an isothermal model, as many have previously believed. To describe the collapse process, we construct a model called the turbulence-regulated gravitational collapse model, where turbulence is sustained by accretion and dissipates in roughly a crossing time. We demonstrate that a $\rho \sim r^{-2}$ profile emerges due to the scale-free nature the system. In this particular case, the rate of gravitational collapse is regulated by the rate at which turbulence dissipates the kinetic energy such that the infall speed can be $20-50\%$ of the free-fall speed(which also depends on the interpretation of the crossing time based on simulations of driven turbulence). These predictions are consistent with existing observations, which suggests that these clumps are in the stage of turbulence-regulated gravitational collapse. Our analysis provides a unified description of gravitational collapse in different environments.

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New constraints on turbulence and embedded planet mass in the HD 163296 disk from planet-disk hydrodynamic simulations

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Recent Atacama Large Millimeter and Submillimeter Array (ALMA) observations of the protoplanetary disk around the Herbig Ae star HD 163296 revealed three depleted dust gaps at 60, 100 and 160 au in the 1.3 mm continuum as well as CO depletion in the middle and outer dust gaps. However, no CO depletion was found in the inner dust gap. To examine the planet–disk interaction model, we present results of two-dimensional two fluid (gas + dust) hydrodynamic simulations coupled with three-dimensional radiative transfer simulations. In order to fit the high gas-to-dust ratio of the first gap, we find the Shakura–Sunyaev viscosity parameter must be very small ($\lesssim 10^{-4}$) in the inner disk. On the other hand, a relatively large α ($\sim 7.5 \times 10^{-3}$) is required to reproduce the dust surface density in the outer disk. We interpret the variation of α as an indicator of the transition from an inner dead zone to the outer magnetorotational instability (MRI) active zone. Within $\sim$100 au, the HD 163296 disk's ionization level is low, and non-ideal magnetohydrodynamic (MHD) effects could suppress the MRI, so the disk can be largely laminar. The disk's ionization level gradually increases toward larger radii, and the outermost disk ($r > 300$ au) becomes turbulent due to MRI. Under this condition, we find that the observed dust continuum and CO gas line emissions can be reasonably fit by three half-Jovian-mass planets (0.46, 0.46 and 0.58 $M_{\rm J}$) at 59, 105 and 160 au, respectively.

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Detection of $HOCO^+$ in the protostar IRAS 16293−2422

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The protonated form of CO_2, $HOCO^+$, is assumed to be an indirect tracer of CO_2 in the millimeter/submillimeter regime since CO_2 lacks a permanent dipole moment. Here, we report the detection of two rotational emission lines ($4_{0,4}$–$3_{0,3}$) and ($5_{0,5}$–$4_{0,4}$) of $HOCO^+$ in IRAS 16293−2422. For our observations, we have used EMIR heterodyne 3 mm receiver of the IRAM 30m telescope. The observed abundance of $HOCO^+$ is compared with the simulations using the 3-phase NAUTILUS chemical model. Implications of the measured abundances of $HOCO^+$ to study the chemistry of CO_2 ices using JWST-MIRI and NIRSpec are discussed as well.

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Excitation mechanism of OI lines in Herbig Ae/Be stars

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We have investigated the role of a few prominent excitation mechanisms viz. collisional excitation, recombination, continuum fluorescence and Lyman beta fluorescence on the OI line spectra in Herbig Ae/Be stars. The aim is to understand which of them is the central mechanism that explains the observed OI line strengths. The study is based on an analysis of the observed optical spectra of 62 Herbig Ae/Be stars and near-infrared spectra of 17 Herbig Ae/Be stars. The strong correlation observed between the line fluxes of OI $\lambda 8446$ and OI $\lambda 11287$, as well as a high positive correlation between the line strengths of OI $\lambda 8446$ and Hα suggest that Lyman beta fluorescence is the dominant excitation mechanism for the formation of OI emission lines in Herbig Ae/Be stars. Further, from an analysis of the emission line fluxes of OI $\lambda 7774$, $\lambda 8446$, and comparing the line ratios with those predicted by theoretical models, we assessed the contribution of collisional excitation in the formation of OI emission lines.

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Magnetically regulated collapse in the B335 protostar? I. ALMA observations of the polarized dust emission

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The role of the magnetic field during protostellar collapse is poorly constrained from an observational point of view, although it could be significant if we believe state-of-the-art models of protostellar formation. We present polarimetric observations of the 233 GHz thermal dust continuum emission obtained with ALMA in the B335 Class 0 protostar. Linearly polarized dust emission arising from the circumstellar material in the envelope of B335 is detected at all scales probed by our observations, from radii of 501000 au. The magnetic field structure producing the dust polarization has a very ordered topology in the inner envelope, with a transition from a large-scale poloidal magnetic field, in the outflow direction, to strongly pinched in the equatorial direction. This is probably due to magnetic field lines being dragged along the dominating infall direction since B335 does not exhibit prominent rotation. Our data and their qualitative comparison to a family of magnetized protostellar collapse models show that, during the magnetized collapse in B335, the magnetic field is maintaining a high level of organization from scales of 100050 au: this suggests the field is dynamically relevant and capable of influencing the typical outcome of protostellar collapse, such as regulating the disk size in B335.

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Ejection processes in the young open cluster NGC 2264. A study of the [OI]λ6300Å emission line.

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Context. Statistical studies of the spectral signatures of jets and winds in young stars are crucial to characterizing outflows and understand their impact on disk and stellar evolution. The young, open cluster NGC 2264 contains hundreds of well-characterized classical T Tauri stars (CTTS), being thus an ideal site for these statistical studies. Its slightly older age than star forming regions studied in previous works, such as Taurus, allows us to investigate outflows in a different phase of CTTS evolution.
Aims. We search for correlations between the [OI]λ6300 line, a well-known tracer of jets and winds in young stars, and stellar, disk and accretion properties in NGC 2264, aiming to characterize the outflow phenomena that occur within the circumstellar environment of young stars.
Methods. We analyzed FLAMES spectra of 184 stars, detecting the [OI]λ6300 line in 108 CTTSs and two Herbig AeBe stars. We identified the main features of this line: a high-velocity component (HVC), and a broad and narrow low-velocity components (BLVC and NLVC). We calculated luminosities and kinematic properties of these components, then compared them with known stellar and accretion parameters.
Results. The luminosity of the [OI]λ6300 line and its components correlate positively with the stellar and accretion luminosity. The HVC is only detected among systems with optically thick inner disks; the BLVC is found in thick disk systems and few systems with anemic disks; and the NLVC is common among systems with all types of disks, including transition disks. Our BLVCs present blueshifts of up to 50 km/s and widths compatible with an origin between 0.05 au and $\sim$3 au from the central object. Most of the NLVCs in our sample have centroid velocities and widths consistent with what could be expected for photoevaporative disk winds originating between 1 and 15 au, but we cannot exclude other possible driving mechanisms for this component. A comparison of [OI]λ6300 profiles with CoRoT light curves shows that the HVC is found most often among sources with irregular, aperiodic photometric variability, usually associated with CTTSs accreting in an unstable regime. The mechanical luminosity transported by protostellar jets correlates positively with the accretion luminosity. However no stellar properties (T_{eff}, mass, rotation) appear to significantly influence any property of these jets. We find jet velocities on average similar to those found in Taurus.
Conclusion. We confirm earlier findings in Taurus which favor an inner MHD disk wind as the origin of the BLVC, while the NLVC might trace photoevaporative disk winds. The [OI]λ6300 line profile shows signs of evolving as the disk disperses, with the HVC and BLVC disappearing as the inner disk becomes optically thin, in support of the scenario of inside-out gas dissipation in the inner disk.

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VISION - Vienna Survey in Orion II. Infrared extinction in Orion A

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We have investigated the shape of the extinction curve in the infrared up to $\sim$25 μm for the Orion A star-forming complex. The basis of this work is near-infrared data acquired with the Visual and Infrared Survey Telescope for Astronomy, in combination with Pan-STARRS and mid-infrared *Spitzer* photometry. We obtain colour excess ratios for eight passbands by fitting a series of colour-colour diagrams. The fits are performed using Markov chain Monte Carlo methods, together with a linear model under a Bayesian formalism. The resulting colour excess ratios are directly interpreted as a measure of the extinction law. We show that the Orion A molecular cloud is characterized by flat mid-infrared extinction, similar to many other recently studied sightlines. Moreover, we find statistically significant evidence that the extinction law from $\sim$1 μm to at least $\sim$6 μm varies across the cloud. In particular, we

find a gradient along galactic longitude, where regions near the Orion Nebula Cluster show a different extinction law compared to L1641 and L1647, the low-mass star-forming sites in the cloud complex. These variations are of the order of only 3% and are most likely caused by the influence of the massive stars on their surrounding medium. While the observed general trends in our measurements are in agreement with model predictions, both well-established and new dust grain models are not able to fully reproduce our infrared extinction curve. We also present a new extinction map featuring a resolution of 1 arcmin and revisit the correlation between extinction and dust optical depth. This analysis shows that cloud substructure, which is not sampled by background sources, affects the conversion factor between these two measures. In conclusion, we argue that specific characteristics of the infrared extinction law are still not well understood, but Orion A can serve as an unbiased template for future studies.

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Dynamical Ages of the Young Local Associations with Gaia

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The Young Local Associations constitute an excellent sample for the study of a variety of astrophysical topics, especially the star formation process in low-density environments. Data from the Gaia mission allows us to undertake studies of the YLAs with unprecedented accuracy. We determine the dynamical age and place of birth of a set of associations in a uniform and dynamically consistent manner. There are nine YLAs in our sample ϵ Chamaeleontis, TW Hydrae, β Pictoris, Octans, Tucana-Horologium, Columba, Carina, Argus and AB Doradus. We designed a method for deriving the dynamical age of the YLAs based on the orbital integration. It involves a strategy to account for the effect of observational errors and we tested it using mock YLAs. Finally, we applied it to our set of nine YLAs with astrometry from the first Gaia data release and complementary on-ground radial velocities from the literature. Our orbital analysis yields a first estimate of the dynamical age of 3^{+9}_{-0} Myr, 13^{+7}_{-0} Myr and 5^{+23}_{-0} Myr for ϵ Cha, β Pict and Tuc-Hor, respectively. For four other associations (Oct, Col, Car and Arg), we provide a lower limit for the dynamical age. Our rigorous error treatment indicates that TW Hya and AB Dor deserve further study. Our dynamical ages are compatible spectroscopic and isochrone fitting ages obtained elsewhere. From the orbital analysis, we suggest a scenario with two episodes of star formation: one $\sim$40 Myr ago in the first quadrant that gave birth to ϵ Cha, TW Hya and β Pic, and another 5–15 Myr ago close to the Sun that formed Tuc-Hor, Col, and Car. Future Gaia data will provide the necessary accuracy to improve the present results, especially for the controversial age determinations, and additional evidence for the proposed scenario, once a complete census of YLAs and better membership can be obtained.

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Radiation Hydrodynamics Simulations of Photoevaporation of Protoplanetary Disks by Ultra Violet Radiation: Metallicity Dependence

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Protoplanetary disks are thought to have lifetimes of several million years in the solar neighborhood, but recent observations suggest that the disk lifetimes are shorter in a low metallicity environment. We perform a suite of radiation hydrodynamics simulations of photoevaporating protoplanetary disks to study their long-term evolution of ~ 10000 years, and the metallicity dependence of mass-loss rates. Our simulations follow hydrodynamics, extreme and far ultra-violet radiative transfer, and non-equilibrium chemistry in a self-consistent manner. Dust grain temperatures are also calculated consistently by solving the radiative transfer of the stellar irradiation and grain (re-)emission. We vary the disk metallicity over a wide range of $10^{-4}\ Z_\odot \le Z \le 10\ Z_\odot$. The photoevaporation rate is lower with higher metallicity in the range of $10^{-1}\,Z_\odot \le Z \le 10\,Z_\odot$, because dust shielding effectively prevents far-ultra violet (FUV) photons from penetrating into and heating the dense regions of the disk. The photoevaporation rate sharply declines at even lower metallicities in $10^{-2}\,Z_\odot \le Z \le 10^{-1}\,Z_\odot$, because FUV photoelectric heating becomes less effective than dust-gas collisional cooling. The temperature in the neutral region decreases, and photoevaporative flows are excited only in an outer region of the disk. At $10^{-4}\,Z_\odot \le Z \le 10^{-2}\,Z_\odot$, HI photoionization heating acts as a dominant gas heating process and drives photoevaporative flows with roughly a constant rate. The typical disk lifetime is shorter at $Z = 0.3\ Z_\odot$ than at $Z = Z_\odot$, being consistent with recent observations of the extreme outer galaxy.

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Extremely ^{54}Cr- and ^{50}Ti-rich presolar oxide grains in a primitive meteorite: Formation in rare types of supernovae and implications for the astrophysical context of solar system birth

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We report the identification of 19 presolar oxide grains from the Orgueil CI meteorite with substantial enrichments in ^{54}Cr, with ^{54}Cr/^{52}Cr ratios ranging from 1.2 to 56 times the solar value. The most enriched grains also exhibit enrichments at mass 50, most likely due in part to ^{50}Ti, but close-to-normal or depleted ^{53}Cr/^{52}Cr ratios. There is a strong inverse relationship between ^{54}Cr enrichment and grain size; the most extreme grains are all <80 nm in diameter. Comparison of the isotopic data with predictions of nucleosynthesis calculations indicate that these grains most likely originated in either rare, high-density Type Ia supernovae (SNIa), or in electron-capture supernovae (ECSN) which may occur as the end stage of evolution for stars of mass 8–10 $M_\odot$. This is the first evidence for preserved presolar grains from either type of supernova. An ECSN origin is attractive since these likely occur much more frequently than high-density SNIa, and their evolutionary timescales ($\sim$20 Myr) are comparable to those of molecular clouds. Self-pollution of the Sun's parent cloud from an ECSN may explain the heterogeneous distribution of n-rich isotopic anomalies in planetary materials, including a recently reported dichotomy in Mo isotopes in the solar system. The stellar origins of three grains with solar ^{54}Cr/^{52}Cr, but anomalies in ^{50}Cr or ^{53}Cr, as well as of a grain enriched in ^{57}Fe, are unclear.

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The Maximum Mass Solar Nebula and the early formation of planets

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Current planet formation theories provide successful frameworks with which to interpret the array of new observational data in this field. However, each of the two main theories (core accretion, gravitational instability) is unable to explain some key aspects. In many planet formation calculations, it is usual to treat the initial properties of the planet forming

disc (mass, radius, etc.) as free parameters. In this paper, we stress the importance of setting the formation of planet forming discs within the context of the formation of the central stars. By exploring the early stages of disc formation, we introduce the concept of the Maximum Mass Solar Nebula (MMSN), as opposed to the oft-used Minimum Mass Solar Nebula (here mmsn). It is evident that almost all protoplanetary discs start their evolution in a strongly self-gravitating state. In agreement with almost all previous work in this area, we conclude that on the scales relevant to planet formation these discs are not gravitationally unstable to gas fragmentation, but instead form strong, transient spiral arms. These spiral arms can act as efficient dust traps allowing the accumulation and subsequent fragmentation of the dust (but not the gas). This phase is likely to populate the disc with relatively large planetesimals on short timescales while the disc is still veiled by a dusty-gas envelope. Crucially, the early formation of large planetesimals overcomes the main barriers remaining within the core accretion model. A prediction of this picture is that essentially all observable protoplanetary discs are already planet hosting.

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Gravitationally unstable condensations revealed by ALMA in the TUKH122 prestellar core in the Orion A cloud

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We have investigated the TUKH122 prestellar core in the Orion A cloud using ALMA 3 mm dust continuum, N_2H^+ ($J = 1 - 0$), and CH_3OH ($J_K = 2_K - 1_K$) molecular line observations. Previous studies showed that TUKH122 is likely on the verge of star formation because the turbulence is almost dissipated and chemically evolved among other starless cores in the Orion A cloud. By combining ALMA 12-m and ACA data, we recover extended emission with a resolution of ~ 5" corresponding to 0.01 pc and identify 6 condensations with a mass range of $0.1 - 0.4\ M_\odot$ and a radius of < 0.01 pc. These condensations are gravitationally bound following a virial analysis and are embedded in the filament including the elongated core with a mass of $\sim 29\ M_\odot$ and a radial density profile of $r^{-1.6}$ derived by *Herschel*. The separation of these condensations is ~ 0.035 pc, consistent with the thermal jeans length at a density of 4.4×10^5 cm^{-3}. This density is similar to the central part of the core. We also find a tendency that the N_2H^+ molecule seems to deplete at the dust peak condensation. This condensation may be beginning to collapse because the linewidth becomes broader. Therefore, the fragmentation still occurs in the prestellar core by thermal Jeans instability and multiple stars are formed within the TUKH122 prestellar core. The CH_3OH emission shows a large shell-like distribution and surrounds these condensations, suggesting that the CH_3OH molecule formed on dust grains is released into gas phase by non-thermal desorption such as photoevaporation caused by cosmic-ray induced UV radiation.

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Cosmic-ray ionisation in circumstellar discs

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Galactic cosmic rays are a ubiquitous source of ionisation of the interstellar gas, competing with UV and X-ray photons as well as natural radioactivity in determining the fractional abundance of electrons, ions and charged dust grains in molecular clouds and circumstellar discs. We model the propagation of different components of Galactic cosmic rays versus the column density of the gas. Our study is focussed on the propagation at high densities, above a few g cm^{-2}, especially relevant for the inner regions of collapsing clouds and circumstellar discs. The propagation of primary and secondary CR particles (protons and heavier nuclei, electrons, positrons, and photons) is computed in the continuous slowing down approximation, diffusion approximation, or catastrophic approximation, by adopting a matching procedure for the different transport regimes. A choice of the proper regime depends on the nature of the dominant loss process, modelled as continuous or catastrophic. The CR ionisation rate is determined by CR protons and their secondary electrons below $\approx$ 130 g cm^{-2} and by electron/positron pairs created by photon decay above $\approx$ 600 g cm^{-2}. We show that a proper description of the particle transport is essential to compute the ionisation rate in the latter case, since the electron/positron differential fluxes depend sensitively on the fluxes of both protons and photons. Our results show that the CR ionisation rate in high-density environments, like, e.g., the inner parts of collapsing molecular clouds or the mid-plane of circumstellar discs, is larger than previously assumed. It does not decline exponentially with increasing column density, but follows a more complex behaviour due to the interplay of different processes governing the generation and propagation of secondary particles.

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A Universal Break in the Planet-to-Star Mass-Ratio Function of Kepler MKG stars

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We follow the microlensing approach and quantify the occurrence of *Kepler* exoplanets as a function of planet-to-star mass ratio, q, rather than planet radius or mass. For planets with radii $\sim 1-6\,\mathrm{R}_\oplus$ and periods < 100 days, we find that, except for a normalization factor, the occurrence rate vs q can be described by the same broken power law with a break at $\sim 3\times10^{-5}$ independent of host type for hosts below $1\,\mathrm{M}_\odot$. These findings indicate that the planet-to-star mass ratio is a more fundamental quantity in planet formation than planet mass. We then compare our results to those from microlensing for which the overwhelming majority satisfies the $M_{\rm host} < 1\,\mathrm{M}_\odot$ criterion. The break in q for the microlensing planet population, which mostly probes the region outside the snowline, is ~3-10 times higher than that inferred from *Kepler*. Thus, the most common planet inside the snowline is ~3-10 times less massive than the one outside. With rocky planets interior to gaseous planets, the Solar System broadly follows the combined mass-ratio function inferred from *Kepler* and microlensing. However, the exoplanet population has a less extreme radial distribution of planetary masses than the Solar System. Establishing whether the mass-ratio function beyond the snowline is also host type independent will be crucial to build a comprehensive theory of planet formation.

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Orbital alignment of circumbinary planets that form in misaligned circumbinary discs: the case of Kepler-413b

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Although most of the circumbinary planets detected by the Kepler spacecraft are on orbits that are closely aligned with the binary orbital plane, the systems Kepler-413 and Kepler-453 exhibit small misalignments of $\sim 2.^{\circ}5$. One possibility is that these planets formed in a circumbinary disc whose midplane was inclined relative to the binary orbital plane. Such a configuration is expected to lead to a warped and twisted disc, and our aim is to examine the inclination evolution of planets embedded in these discs. We employed 3D hydrodynamical simulations that examine the disc response to the presence of a modestly inclined binary with parameters that match the Kepler-413 system, as a function of disc parameters and binary inclinations. The discs all develop slowly varying warps, and generally display very small amounts of twist. Very slow solid body precession occurs because a large outer disc radius is adopted. Simulations of planets embedded in these discs resulted in the planet aligning with the binary orbit plane for disc masses close to the minimum mass solar nebular, such that nodal precession of the planet was controlled by the binary. For higher disc masses, the planet maintains near coplanarity with the local disc midplane. Our results suggest that circumbinary planets born in tilted circumbinary discs should align with the binary orbit plane as the disc ages and loses mass, even if the circumbinary disc remains misaligned from the binary orbit. This result has important implications for understanding the origins of the known circumbinary planets.

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Detection of Dust Condensations in the Orion Bar Photon-dominated Region

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We report Submillimeter Array dust continuum and molecular spectral line observations toward the Orion Bar photon-dominated region (PDR). The 1.2 mm continuum map reveals, for the first time, a total of 9 compact ($r < 0.01$ pc) dust condensations located within a distance of ∼0.03 pc from the dissociation front of the PDR. Part of the dust condensations are seen in spectral line emissions of CS (5–4) and H_2CS ($7_{1,7}$–$6_{1,6}$), though the CS map also reveals dense gas further away from the dissociation front. We detect compact emissions in H_2CS ($6_{0,6}$–$5_{0,5}$), ($6_{2,4}$–$5_{2,3}$) and $C^{34}S$, $C^{33}S$ (4–3) toward bright dust condensations. The line ratio of H_2CS ($6_{0,6}$–$5_{0,5}$)/($6_{2,4}$–$5_{2,3}$) suggests a temperature of 73±58 K. A non-thermal velocity dispersion of ∼0.25–0.50 km s^{-1} is derived from the high spectral resolution $C^{34}S$ data, and indicates a subsonic to transonic turbulence in the condensations. The masses of the condensations are estimated from the dust emission, and range from 0.03 to 0.3 $M_{\odot}$, all significantly lower than any critical mass that is required for self-gravity to play a crucial role. Thus the condensations are not gravitationally bound, and could not collapse to form stars. In cooperating with recent high resolution observations of the surface layers of the molecular cloud in the Bar, we speculate that the condensations are produced as a high-pressure wave induced by the expansion of the HII region compresses and enters the cloud. A velocity gradient along a direction perpendicular to the major axis of the Bar is seen in H_2CS ($7_{1,7}$–$6_{1,6}$), and is consistent with the scenario that the molecular gas behind the dissociation front is being compressed.

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Rotation of Low-Mass Stars in Upper Scorpius and Rho Ophiuchus with K2

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We present an analysis of K2 light curves (LCs) for candidate members of the young Upper Sco (USco) association ∼8 Myr) and the neighboring ρ Oph embedded cluster (∼1 Myr). We establish ∼1300 stars as probable members, ∼80% of which are periodic. The phased LCs have a variety of shapes which can be attributed to physical causes ranging from stellar pulsation and stellar rotation to disk-related phenomena. We identify and discuss a number of observed behaviors. The periods are ∼0.2-30 days with a peak near 2 days and the rapid period end nearing break-up velocity. M stars in the young USco region rotate systematically faster than GK stars, a pattern also present in K2 data for the older Pleiades and Praesepe systems. At higher masses (types FGK), the well-defined period-color relationship for slowly rotating stars seen in the Pleiades and Praesepe is not yet present in USco. Circumstellar disks are present predominantly among the more slowly rotating Ms in USco, with few disks in the sub-day rotators. However, M dwarfs with disks rotate faster on average than FGK systems with disks. For four of these disked Ms, we provide direct evidence for disk-locking based on the K2 LC morphologies. Our preliminary analysis shows a relatively mass-independent spin-up by a factor of ∼3.5 between USco and the Pleiades, then mass-dependent spin-down between Pleiades and Praesepe.

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A Decade of MWC 758 Disk Images: Where Are the Spiral-Arm-Driving Planets?

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Large-scale spiral arms have been revealed in scattered light images of a few protoplanetary disks. Theoretical models suggest that such arms may be driven by and co-rotate with giant planets, which has called for remarkable observational efforts to look for them. By examining the rotation of the spiral arms for the MWC 758 system over a 10-yr timescale, we are able to provide dynamical constraints on the locations of their perturbers. We present reprocessed Hubble Space Telescope (HST)/NICMOS F110W observations of the target in 2005, and the new Keck/NIRC2 L′-band observations in 2017. MWC 758's two well-known spiral arms are revealed in the NICMOS archive at the earliest observational epoch. With additional Very Large Telescope (VLT)/SPHERE data, our joint analysis leads to a pattern speed of $0.^{\circ}6^{+3.^{\circ}3}_{-0.^{\circ}6}$ yr^{-1} at 3σ for the two major spiral arms. If the two arms are induced by a perturber on a near-circular orbit, its best fit orbit is at 89 au ($0.''59$), with a 3σ lower limit of 30 au ($0.''20$). This finding is consistent with the simulation prediction of the location of an arm-driving planet for the two major arms in the system.

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OH absorption in the first quadrant of the Milky Way as seen by THOR

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The hydroxyl radical (OH) is present in the diffuse molecular and partially atomic phases of the interstellar medium (ISM), but its abundance relative to hydrogen is not clear. We aim to evaluate the abundance of OH with respect to molecular hydrogen using OH absorption against cm-continuum sources over the first Galactic quadrant. This OH study is part of the HI/OH/Recombination line survey (THOR). THOR is a Karl G. Jansky Very Large Array large program to observe atomic, molecular and ionized gas in the range $15^\circ \leq l \leq 67^\circ$ and $|b| \leq 1^\circ$. It is the highest-resolution unbiased OH absorption survey to date towards this region. We combine the derived optical depths with literature ^{13}CO(1-0) and HI observations to determine the OH abundance. We detect absorption in the 1665 and 1667 MHz transitions for continuum sources stronger than $F_{\rm cont} \geq$0.1 Jy/beam. OH absorption is found against ∼15% of these continuum sources with increasing fractions for stronger sources. Most of the absorption is associated with Galactic HII regions. We find OH and ^{13}CO gas to have similar kinematic properties. The OH abundance decreases with increasing hydrogen column density. The OH abundance with respect to the total hydrogen nuclei column density (atomic and molecular phase) is in agreement with a constant abundance for A_V <10-20. Towards the lowest column densities, we find sources that exhibit OH absorption but no ^{13}CO emission, indicating that OH is a well suited tracer of the low column density molecular gas. We present spatially resolved OH absorption towards W43. The unbiased nature of the THOR survey opens a new window onto the gas properties of the ISM. The characterization of the OH abundance over a large range of hydrogen gas column densities contributes to the understanding of OH as a molecular gas tracer and provides a starting point for future investigations.

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YSO jets in the Galactic Plane from UWISH2: V – Jets and Outflows in M17

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Jets and outflows are the first signposts of stellar birth. Emission in the H_2 1–0 S(1) line at 2.122 μm is a powerful tracer of shock excitation in these objects. Here we present the analysis of 2.0 × 0.8 square degrees data from the UK Widefield Infrared Survey for H_2 (UWISH2) in the 1–0 S(1) line to identify and characterize the outflows of the M17 complex. We uncover 48 probable outflows, of which, 93 per cent are new discoveries. We identified driving source candidates for 60 per cent of the outflows. Among the driving source candidate YSOs: 90 per cent are protostars and the reminder 10 per cent are Class II YSOs. Comparing with results from other surveys, we suggest that H_2 emission fades very quickly as the objects evolve from protostars to pre-main-sequence stars. We fit SED models to 14 candidate outflow driving sources and conclude that the outflows of our sample are mostly driven by moderate-mass YSOs that are still actively accreting from their protoplanetary disc. We examined the spatial distribution of the outflows with the gas and dust distribution of the complex, and observed that the filamentary dark-cloud "M17SWex" located at the south-western side of the complex, is associated with a greater number of outflows. We find our results corroborate previous suggestions, that in the M17 complex, M17SWex is the most active site of star formation. Several of our newly identified outflow candidates are excellent targets for follow up studies to better understand very early phase of protostellar evolution.

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Multi-epoch monitoring of the AA Tau like star V354 Mon - Indications for a low gas-to-dust ratio in the inner disk warp

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Disk warps around classical T Tauri stars (CTTS) can periodically obscure the central star for some viewing geometries. For these so-called AA Tau-like variables, the obscuring material is located in the inner disk and absorption spectroscopy allows one to characterize its dust and gas content. Since the observed emission from CTTS consists of several components (photospheric, accretion, jet, and disk emission), which can all vary with time, it is generally challenging to disentangling disk features from emission variability. Multi-epoch, flux-calibrated, broadband spectra provide us with the necessary information to cleanly separate absorption from emission variability. We applied this method to three epochs of VLT/X-Shooter spectra of the CTTS V354 Mon (CSI Mon-660) located in NGC 2264 and find that: (a) the accretion emission remains virtually unchanged between the three epochs; (b) the broadband flux evolution is best described by disk material obscuring part of the star, and (c) the Na and K gas absorption lines show only a minor increase in equivalent width during phases of high dust extinction. The limits on the absorbing gas column densities indicate a low gas-to-dust ratio in the inner disk, less than a tenth of the ISM value. We speculate that the evolutionary state of V354 Mon, rather old with a low accretion rate, is responsible for the dust excess through an evolution toward a dust dominated disk or through the fragmentation of larger bodies that drifted inward from larger radii in a still gas dominated disk.

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Multiple Gaps in the Disk of the Class I Protostar GY 91

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We present the highest spatial resolution ALMA observations to date of the Class I protostar GY 91 in the ρ Ophiuchus L1688 molecular cloud complex. Our 870 μm and 3 mm dust continuum maps show that the GY 91 disk has a radius of ∼80 AU, and an inclination of ∼40, but most interestingly that the disk has three dark lanes located at 10 AU, 40 AU, and 70 AU. We model these features assuming they are gaps in the disk surface density profile and find that their widths are 7 AU, 30 AU, and 10 AU. These gaps bear a striking resemblance to the gaps seen in the HL Tau disk, suggesting that there may be Saturn-mass planets hiding in the disk. To constrain the relative ages of GY 91 and HL Tau, we also model the disk and envelope of HL Tau and find that they are of similar ages, although GY 91 may be younger. Although snow lines and magnetic dead zones can also produce dark lanes, if planets are indeed carving these gaps then Saturn-mass planets must form within the first ∼0.5 Myr of the lifetime of protoplanetary disks.

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From large-scale to protostellar disk fragmentation into close binary stars

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Recent observations of young stellar systems with the Atacama Large Millimeter/submillimeter Array (ALMA) and the Karl G. Jansky Very Large Array (VLA) are helping to cement the idea that close companion stars form via fragmentation of a gravitationally unstable disk around a protostar early in the star formation process. As the disk grows in mass, it eventually becomes gravitationally unstable and fragments, forming one or more new protostars in orbit with the first at mean separations of 100 astronomical units (AU) or even less. Here we report direct numerical calculations down to scales as small as ∼0.1 AU, using a consistent Smoothed Particle Hydrodynamics (SPH) code, that show the large-scale fragmentation of a cloud core into two protostars accompanied by small-scale fragmentation of their circumstellar disks. Our results demonstrate the two dominant mechanisms of star formation, where the disk forming around a protostar, which in turn results from the large-scale fragmentation of the cloud core, undergoes eccentric ($m = 1$) fragmentation to produce a close binary. We generate two-dimensional emission maps and simulated ALMA 1.3 mm continuum images of the structure and fragmentation of the disks that can help explain the dynamical processes occurring within collapsing cloud cores.

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Dynamical evolution of stars and gas of young embedded stellar sub-clusters

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We present simulations of the dynamical evolution of young embedded star clusters. Our initial conditions are directly derived from X-ray, infrared, and radio observations of local systems, and our models evolve both gas and stars simultaneously. Our regions begin with both clustered and extended distributions of stars, and a gas distribution which can include a filamentary structure in addition to gas surrounding the stellar subclusters. We find that the regions become spherical, monolithic, and smooth quite quickly, and that the dynamical evolution is dominated by the gravitational interactions between the stars. In the absence of stellar feedback, the gas moves gently out of the centre of our regions but does not have a significant impact on the motions of the stars at the earliest stages of cluster formation. Our models at later times are consistent with observations of similar regions in the local neighbourhood. We conclude that the evolution of young proto-star clusters is relatively insensitive to reasonable choices of initial conditions. Models with more realism, such as an initial population of binary and multiple stars and ongoing star formation, are the next step needed to confirm these findings.

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The diverse lives of massive protoplanets in self-gravitating discs

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Gas giant planets may form early-on during the evolution of protostellar discs, while these are relatively massive. We study how Jupiter-mass planet-seeds (termed *protoplanets*) evolve in massive, but gravitationally stable ($Q \gtrsim 1.5$), discs using radiative hydrodynamic simulations. We find that the protoplanet initially migrates inwards rapidly, until it opens up a gap in the disc. Thereafter, it either continues to migrate inwards on a much longer timescale or starts migrating outwards. Outward migration occurs when the protoplanet resides within a gap with gravitationally unstable edges, as a high fraction of the accreted gas is high angular momentum gas from outside the protoplanet's orbit. The effect of radiative heating from the protoplanet is critical in determining the direction of the migration and the eccentricity of the protoplanet. Gap opening is facilitated by efficient cooling that may not be captured by the commonly used β-cooling approximation. The protoplanet initially accretes at a high rate ($\sim 10^{-3}\mathrm{M_J\ yr^{-1}}$), and its accretion luminosity could be a few tenths of the host star's luminosity, making the protoplanet easily observable (albeit only for a short time). Due to the high gas accretion rate, the protoplanet generally grows above the deuterium-burning mass-limit. Protoplanet radiative feedback reduces its mass growth so that its final mass is near the brown dwarf-planet boundary. The fate of a young planet-seed is diverse and could vary from a gas giant planet on a circular orbit at a few AU from the central star to a brown dwarf on an eccentric, wide orbit.

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The formation of rings and gaps in magnetically coupled disk-wind systems: ambipolar diffusion and reconnection

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Radial substructures in circumstellar disks are now routinely observed by ALMA. There is also growing evidence that disk winds drive accretion in such disks. We show through 2D (axisymmetric) simulations that rings and gaps develop naturally in magnetically coupled disk-wind systems on the scale of tens of au, where ambipolar diffusion (AD) is the dominant non-ideal MHD effect. In simulations where the magnetic field and matter are moderately coupled, the disk remains relatively laminar with the radial electric current steepened by AD into a thin layer near the midplane. The toroidal magnetic field sharply reverses polarity in this layer, generating a large magnetic torque that drives fast accretion, which drags the poloidal field into a highly pinched radial configuration. The reconnection of this pinched field creates magnetic loops where the net poloidal magnetic flux (and thus the accretion rate) is reduced, yielding dense rings. Neighbouring regions with stronger poloidal magnetic fields accrete faster, forming gaps. In better magnetically coupled simulations, the so-called 'avalanche accretion streams' develop continuously near the disk surface, rendering the disk-wind system more chaotic. Nevertheless, prominent rings and gaps are still produced,

at least in part, by reconnection, which again enables the segregation of the poloidal field and the disk material similar to the more diffusive disks. However, the reconnection is now driven by the non-linear growth of MRI channel flows. The formation of rings and gaps in rapidly accreting yet laminar disks has interesting implications for dust settling and trapping, grain growth, and planet formation.

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Unveiling the remarkable photodissociation region of M8

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Messier 8 is one of the brightest HII regions in the sky. Using SOFIA, APEX 12 m and IRAM 30 m telescopes, we have performed a comprehensive imaging survey of the emission from the [CII], [CI] and CO isotopologues within 1.3 × 1.3 pc around the dominant Herschel 36 (Her 36) stellar system. To further explore the morphology of the region we compare archival infrared, optical and radio images of the nebula with our newly obtained [CII] and CO data. We perform a quantitative analysis, using both LTE and non-LTE methods to determine the abundances of some of the observed species as well as kinetic temperatures and volume densities. Bright CO, [CII] and [CI] emission has been found towards the HII region and the photodissociation region (PDR) in M8. Our analysis places the bulk of the molecular material in the background of the nebulosity illuminated by the bright stellar systems Her 36 and 9 Sagitarii. Since the emission from all observed atomic and molecular tracers peaks at or close to the position of Her 36, we conclude that the star is still physically close to its natal dense cloud core and heats it. A veil of warm gas moves away from Her 36 toward the Sun and its associated dust contributes to the foreground extinction in the region. One of the most prominent star forming regions in M8, the Hourglass Nebula, is particularly bright due to cracks in this veil close to Her 36. By using radiative transfer modeling of different transitions of CO isotopologues, we obtain H_2 densities ranging from $\sim 10^4$–10^6 cm^{-3} and kinetic temperatures of 100–150 K in the bright PDR caused by Her 36.

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Testing Larson's relationships in massive clumps

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We tested the validity of the three Larson relations in a sample of 213 massive clumps selected from the Herschel Hi-GAL survey and combined with data from the MALT90 survey of 3mm emission lines. The clumps have been divided in 5 evolutionary stages to discuss the Larson relations also as function of evolution. We show that this ensemble does not follow the three Larson relations, regardless of clump evolutionary phase. A consequence of this breakdown is that the virial parameter $\alpha_{\rm vir}$ dependence with mass (and radius) is only a function of the gravitational energy, independent of the kinetic energy of the system, and $\alpha_{\rm vir}$ is not a good descriptor of clump dynamics. Our results suggest that clumps with clear signatures of infall motions are statistically indistinguishable from clumps with no such signatures. The observed non-thermal motions are not necessarily ascribed to turbulence acting to sustain the gravity, but they may be due to the gravitational collapse at the clump scales. This seems particularly true for the most massive ($M \geq 1000\ M_{\odot}$) clumps in the sample, where also exceptionally high magnetic fields may not be

enough to stabilize the collapse.

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Structure of X-ray emitting jets close to the launching site: from embedded to disk-bearing sources

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Several observations of stellar jets show evidence of X-ray emitting shocks close to the launching site. In some cases, the shocked features appear to be stationary, also for YSOs at different stages of evolution. We study the case of HH 154, the jet originating from the embedded binary Class 0/I protostar IRS 5, and the case of the jet associated to DG Tau, a more evolved Class II disk-bearing source or Classical T Tauri star (CTTS), both located in the Taurus star-forming region. We aim at investigating the effect of perturbations in X-ray emitting stationary shocks in stellar jets; the stability and detectability in X-rays of these shocks; and explore the differences in jets from Class 0 to Class II sources. We performed a set of 2.5-dimensional magnetohydrodynamic numerical simulations that modelled supersonic jets ramming into a magnetized medium. The jet is formed by two components: a continuously driven component that forms a quasi-stationary shock at the base of the jet; and a pulsed component constituted by blobs perturbing the shock. We explored different parameters for both components. We studied two cases: a jet less dense than the ambient medium (light jet), representing the case of HH 154; and a jet denser than the ambient (heavy jet), associated with DG Tau. We synthesized the count rate from the simulations and compared with available Chandra observations. Our model explains the formation of X-ray emitting quasi-stationary shocks observed at the base of jets in a natural way, being able to reproduce the observed jet properties at different evolutionary phases (in particular, for HH 154 and DG Tau). The jet is collimated by the magnetic field forming a quasi-stationary shock at the base which emits in X-rays even when perturbations formed by a train of blobs are present. We found similar collimation mechanisms dominating in both heavy and light jets.

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Star formation toward the H II region IRAS 10427−6032

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The formation and properties of star clusters formed at the edges of H II regions are poorly known. We study stellar content, physical conditions, and star formation processes around a relatively unknown young H II region IRAS 10427−6032, located in the southern outskirts of the Carina Nebula. We make use of near-IR data from VISTA, mid-IR from Spitzer and WISE, far-IR from Herschel, sub-mm from ATLASGAL, and 843 MHz radio-continuum data. Using multi-band photometry, we find a total of 5 Class I and 29 Class II young stellar object (YSO) candidates, most of which newly identified, in the $5' \times 5'$ region centered on the IRAS source position. Modeling of the spectral energy distribution for selected YSO candidates using radiative transfer models shows that most of these candidates are intermediate mass YSOs in their early evolutionary stages. A majority of the YSO candidates are found to be coincident with the cold dense clump at the western rim of the H II region. Lyman continuum luminosity calculation

using radio emission indicates the spectral type of the ionizing source to be earlier than B0.5–B1. We identified a candidate massive star possibly responsible for the H II region with an estimated spectral type B0–B0.5. The temperature and column density maps of the region constructed by performing pixel-wise modified blackbody fits to the thermal dust emission using the far-IR data show a high column density shell-like morphology around the H II region, and low column density (0.6×10^{22} cm^{-2}) and high temperature ($\sim$21 K) matter within the H II region. Based on the morphology of the region in the ionized and the molecular gas, and the comparison between the estimated timescales of the H II region and the YSO candidates in the clump, we argue that the enhanced star-formation at the western rim of the H II region is likely due to compression by the ionized gas.

Accepted by New Astronomy

http://arxiv.org/pdf/1803.06384

Very Massive Stars: a metallicity-dependent upper-mass limit, slow winds, and the self-enrichment of Globular Clusters

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One of the key questions in Astrophysics concerns the issue of whether there exists an upper-mass limit to stars, and if so, what physical mechanism sets this limit, which might also determine if the upper-mass limit is metallicity (Z) dependent. We argue that mass loss by radiation-driven winds mediated by line opacity is one of the prime candidates setting the upper-mass limit. We present mass-loss predictions from Monte Carlo radiative transfer models for relatively cool (Teff = 15kK) inflated very massive stars (VMS) with large Eddington Gamma factors in the mass range 100-1000 Msun as a function of metallicity down to 1/100 Z/Zsun. We employ a hydrodynamic version of our Monte Carlo method, allowing us to predict the rate of mass loss and the terminal wind velocity (vinf) simultaneously. Interestingly, we find wind terminal velocities (vinf) that are low (100-500 km/s) over a wide Z-range, and we propose that the slow winds from VMS are an important source of self-enrichment in globular clusters. We also find mass-loss rates (dM/dt-wind), exceeding the typical mass-accretion rate (dM/dt-accr) of 0.001 Msun/yr during massive-star formation. We express our mass-loss predictions as a function of mass and Z, finding log dM/dt = -9.13 + 2.1 log(M/Msun) + 0.74 log(Z/Zsun) (Msun/yr). Even if stellar winds would not directly halt and reverse mass accretion during star formation, if the most massive stars form by stellar mergers stellar wind mass loss may dominate over the rate at which stellar growth takes place. We therefore argue that the upper-mass limit is effectively Z-dependent due to the nature of radiation-driven winds. This has dramatic consequences for the most luminous supernovae, gamma-ray bursts, and other black hole formation scenarios at different Cosmic epochs.

Accepted by Astronomy and Astrophysics

https://arxiv.org/pdf/1803.08042

Resolved Millimeter Observations of the HR 8799 Debris Disk

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We present 1.3 millimeter observations of the debris disk surrounding the HR 8799 multi-planet system from the Submillimeter Array to complement archival ALMA observations that spatially filtered away the bulk of the emission. The image morphology at 3.8 arcsec (150 AU) resolution indicates an optically thin circumstellar belt, which we associate with a population of dust-producing planetesimals within the debris disk. The interferometric visibilities are fit well by an axisymmetric radial power-law model characterized by a broad width, $\Delta R/R > 1$. The belt inclination and orientation parameters are consistent with the planet orbital parameters within the mutual uncertainties. The models constrain the radial location of the inner edge of the belt to $R_{in} = 104^{+8}_{-12}$ AU. In a simple scenario where the

chaotic zone of the outermost planet b truncates the planetesimal distribution, this inner edge location translates into a constraint on the planet b mass of $M_{pl} = 5.8^{+7.9}_{-3.1}$ $\mathrm{M_{Jup}}$. This mass estimate is consistent with infrared observations of the planet luminosity and standard hot-start evolutionary models, with the uncertainties allowing for a range of initial conditions. We also present new 9 millimeter observations of the debris disk from the Very Large Array and determine a millimeter spectral index of 2.41 ± 0.17. This value is typical of debris disks and indicates a power-law index of the grain size distribution $q = 3.27 \pm 0.10$, close to predictions for a classical collisional cascade.

Accepted by The Astrophysical Journal

https://arxiv.org/pdf/1803.00054

Constraint on ion–neutral drift velocity in the Class 0 protostar B335 from ALMA observations

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Aims. Ambipolar diffusion can cause a velocity drift between ions and neutrals. This is one of the non-ideal magnetohydrodynamcis (MHD) effects proposed to enable the formation of large-scale Keplerian disks with sizes of tens of au. To observationally study ambipolar diffusion in collapsing protostellar envelopes, we compare here gas kinematics traced by ionized and neutral molecular lines and discuss the implication on ambipolar diffusion.
Methods. We analyzed the data of the $H^{13}CO^+$ (3–2) and $C^{18}O$ (2–1) emission in the Class 0 protostar B335 obtained with our ALMA observations. We constructed kinematical models to fit the velocity structures observed in the $H^{13}CO^+$ and $C^{18}O$ emission and to measure the infalling velocities of the ionized and neutral gas on a 100 au scale in B335.
Results. A central compact ($\sim$1″–2″) component that is elongated perpendicular to the outflow direction and exhibits a clear velocity gradient along the outflow direction is observed in both lines and most likely traces the infalling flattened envelope. With our kinematical models, the infalling velocities in the $H^{13}CO^+$ and $C^{18}O$ emission are both measured to be 0.85 ± 0.2 km s^{-1} at a radius of 100 au, suggesting that the velocity drift between the ionized and neutral gas is at most 0.3 km s^{-1} at a radius of 100 au in B335.
Conclusions. The Hall parameter for $H^{13}CO^+$ is estimated to be $\gg$1 on a 100 au scale in B335, so that $H^{13}CO^+$ is expected to be attached to the magnetic field. Our non-detection or upper limit of the velocity drift between the ionized and neutral gas could suggest that the magnetic field remains rather well coupled to the bulk neutral material on a 100 au scale in this source, and that any significant field-matter decoupling, if present, likely occurs only on a smaller scale, leading to an accumulation of magnetic flux and thus efficient magnetic braking in the inner envelope. This result is consistent with the expectation from the MHD simulations with a typical ambipolar diffusivity and those without ambipolar diffusion. On the other hand, the high ambipolar drift velocity of 0.5–1.0 km s^{-1} on a 100 au scale predicted in the MHD simulations with an enhanced ambipolar diffusivity by removing small dust grains, where the minimum grain size is 0.1 μm, is not detected in our observations. However, because of our limited angular resolution, we cannot rule out a significant ambipolar drift only in the midplane of the infalling envelope. Future observations with higher angular resolutions ($\sim$0.″1) are needed to examine this possibility and ambipolar diffusion on a smaller scale.

Accepted by A&A

https://arxiv.org/pdf/1803.09893.pdf

The Orion fingers: H_2 temperatures and excitation in an explosive outflow

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We measure H_2 temperatures and column densities across the Orion BN/KL explosive outflow from a set of thirteen near-IR H_2 rovibrational emission lines observed with the TripleSpec spectrograph on Apache Point Observatory's 3.5-meter telescope. We find that most of the region is well-characterized by a single temperature (∼2000–2500 K), which may be influenced by the limited range of upper energy levels (6000–20,000 K) probed by our data set. The H_2 column density maps indicate that warm H_2 comprises 10^{-5}–10^{-3} of the total H_2 column density near the center of the outflow. Combining column density measurements for co-spatial H_2 and CO at $T = 2500$ K, we measure a CO/H_2 fractional abundance of 2×10^{-3}, and discuss possible reasons why this value is in excess of the canonical 10^{-4} value, including dust attenuation, incorrect assumptions on co-spatiality of the H_2 and CO emission, and chemical processing in an extreme environment. We model the radiative transfer of H_2 in this region with UV pumping models to look for signatures of H_2 fluorescence from H I Lyα pumping. Dissociative (J-type) shocks and nebular emission from the foreground Orion H II region are considered as possible Lyα sources. From our radiative transfer models, we predict that signatures of Lyα pumping should be detectable in near-IR line ratios given a sufficiently strong source, but such a source is not present in the BN/KL outflow. The data are consistent with shocks as the H_2 heating source.

Accepted by ApJ

http://arxiv.org/pdf/1803.01903

IRAS 22150+6109 — a young B-type star with a large disc

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We present the results of a spectroscopic analysis and spectral energy distribution (SED) modelling of the optical counterpart of the infrared source IRAS 22150+6109. The source was suggested to be as a Herbig Be star located in the star forming region L 1188. Absorption lines in the optical spectrum indicate a spectral type B3, while weak Balmer emission lines reflect the presence of a circumstellar gaseous disc. The star shows no excess radiation in the near-infrared spectral region and a strong excess in the far-infrared that we interpret as radiation from a large disc, whose inner edge is located very far from the star (550 au) and does not attenuate its radiation. We conclude that IRAS 22150+6109 is an intermediate-mass star that is currently undergoing a short pre-main-sequence evolutionary stage.

Accepted by MNRAS

http://arxiv.org/pdf/1803.06830

The Pan-STARRS1 Proper-Motion Survey for Young Brown Dwarfs in Nearby Star-Forming Regions. I. Taurus Discoveries and a Reddening-Free Classification Method for Ultracool Dwarfs

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We are conducting a proper-motion survey for young brown dwarfs in the Taurus-Auriga molecular cloud based on the Pan-STARRS1 3π Survey. Our search uses multi-band photometry and astrometry to select candidates, and is wider (370 deg^2) and deeper (down to $\approx$3 M_{Jup}) than previous searches. We present here our search methods and spectroscopic follow-up of our high-priority candidates. Since extinction complicates spectral classification, we have developed a new approach using low-resolution ($R \approx 100$) near-infrared spectra to quantify reddening-free spectral types, extinctions, and gravity classifications for mid-M to late-L ultracool dwarfs ($\approx 100 - 3$ M_{Jup} in Taurus). We have discovered 25 low-gravity (VL-G) and the first 11 intermediate-gravity (INT-G) substellar (M6–L1) members of Taurus, constituting the largest single increase of Taurus brown dwarfs to date. We have also discovered 1 new Pleiades member and 13 new members of the Perseus OB2 association, including a candidate very wide separation (58 kAU) binary. We homogeneously reclassify the spectral types and extinctions of all previously known Taurus brown dwarfs. Altogether our discoveries have thus far increased the substellar census in Taurus by $\approx$ 40% and added three more L-type members ($\approx 5 - 10$ M_{Jup}). Most notably, our discoveries reveal an older (>10 Myr) low-mass population in Taurus, in accord with recent studies of the higher-mass stellar members. The mass function appears to differ between the younger and older Taurus populations, possibly due to incompleteness of the older stellar members or different star formation processes.

Accepted by The Astrophysical Journal

https://arxiv.org/pdf/1804.01533

Iron and silicate dust growth in the Galactic interstellar medium: clues from element depletions

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The interstellar abundances of refractory elements indicate a substantial depletion from the gas phase, that increases with gas density. Our recent model of dust evolution, based on hydrodynamic simulations of the lifecycle of giant molecular clouds (GMCs) proves that the observed trend for [Si_{gas}/H] is driven by a combination of dust growth by accretion in the cold diffuse interstellar medium (ISM) and efficient destruction by supernova (SN) shocks (Zhukovska et al. 2016). With an analytic model of dust evolution, we demonstrate that even with optimistic assumptions for the dust input from stars and without destruction of grains by SNe it is impossible to match the observed [Si_{gas}/H]–n_H relation without growth in the ISM. We extend the framework developed in our previous work for silicates to include the evolution of iron grains and address a long-standing conundrum: "Where is the interstellar iron?". Much higher depletion of Fe in the warm neutral medium compared to Si is reproduced by the models, in which a large fraction of interstellar iron (70%) is locked as inclusions in silicate grains, where it is protected from sputtering by SN shocks. The slope of the observed [Fe_{gas}/H]–n_H relation is reproduced if the remaining depleted iron resides in a population of metallic iron nanoparticles with sizes in the range of 1–10 nm. Enhanced collision rates due to the Coulomb focusing are important for both silicate and iron dust models to match the observed slopes of the relations between depletion and density and the magnitudes of depletion at high density.

Accepted by ApJ

http://arxiv.org/pdf/1803.01929

Abstracts of recently accepted major reviews

Formation of Terrestrial Planets

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The past decade has seen major progress in our understanding of terrestrial planet formation. Yet key questions remain. In this review we first address the growth of 100 km-scale planetesimals as a consequence of dust coagulation and concentration, with current models favoring the streaming instability. Planetesimals grow into Mars-sized (or larger) planetary embryos by a combination of pebble- and planetesimal accretion. Models for the final assembly of the inner Solar System must match constraints related to the terrestrial planets and asteroids including their orbital and compositional distributions and inferred growth timescales. Two current models – the Grand-Tack and low-mass (or empty) primordial asteroid belt scenarios – can each match the empirical constraints but both have key uncertainties that require further study. We present formation models for close-in super-Earths – the closest current analogs to our own terrestrial planets despite their very different formation histories – and for terrestrial exoplanets in gas giant systems. We explain why super-Earth systems cannot form in-situ but rather may be the result of inward gas-driven migration followed by the disruption of compact resonant chains. The Solar System is unlikely to have harbored an early system of super-Earths; rather, Jupiter's early formation may have blocked the ice giants' inward migration. Finally, we present a chain of events that may explain why our Solar System looks different than more than 99% of exoplanet systems.

Accepted by Handbook of Exoplanets

http://arxiv.org/pdf/1803.08830

Chondrules in enstatite chondrites

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We review silicate chondrules and metal-sulfide nodules in unequilibrated enstatite chondrites (EH3 and EL3). Their unique mineralogical assemblage, with a wide diversity of opaque phases, nitrides, nearly FeO-free enstatite etc. testify to exceptionally reduced conditions. While those have long been ascribed to a condensation sequence at supersolar C/O ratios, with the oldhamite-rich nodules among the earliest condensates, evidence for relatively oxidized local precursors suggests that their peculiarities may have been acquired during the chondrule-forming process itself. Silicate phases may have been then sulfidized in an O-poor and S-rich environment; metal-sulfide nodules in EH3 chondrites could have originated in the silicate chondrules whereas those in EL3 may be impact products. The astrophysical setting (nebular or planetary) where such conditions were achieved, whether by depletion in water or enrichment in dry organics-silicate mixtures, is uncertain, but was most likely sited inside the snow line, consistent with the Earth-like oxygen isotopic signature of most EC silicates, with little data constraining its epoch yet.

Accepted by "Chondrules and the protoplanetary disc" (editors S. Russell, H. C. Connolly Jr, A. N. Krot)

http;//arxiv.org/pdf/1710.01174

Dynamical Evolution of Planetary Systems

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Planetary systems can evolve dynamically even after the full growth of the planets themselves. There is actually circumstantial evidence that most planetary systems become unstable after the disappearance of gas from the protoplanetary disk. These instabilities can be due to the original system being too crowded and too closely packed or to external perturbations such as tides, planetesimal scattering, or torques from distant stellar companions. The Solar System was not exceptional in this sense. In its inner part, a crowded system of planetary embryos became unstable, leading to a series of mutual impacts that built the terrestrial planets on a timescale of ∼100 My. In its outer part, the giant planets became temporarily unstable and their orbital configuration expanded under the effect of mutual encounters. A planet might have been ejected in this phase. Thus, the orbital distributions of planetary systems that we observe today, both solar and extrasolar ones, can be different from the those emerging from the formation process and it is important to consider possible long-term evolutionary effects to connect the two.

Accepted by Handbook of Exoplanets

http://arxiv.org/pdf/1803.06704

Accretion Processes

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In planetary science, accretion is the process in which solids agglomerate to form larger and larger objects and eventually planets are produced. The initial conditions are a disc of gas and microscopic solid particles, with a total mass of about 1% of the gas mass. Accretion has to be effective and fast. Effective, because the original total mass in solids in the solar protoplanetary disk was probably of the order of ∼300 Earth masses, and the mass incorporated into the planets is ∼100 Earth masses. Fast, because the cores of the giant planets had to grow to tens of Earth masses in order to capture massive doses of hydrogen and helium from the disc before the dispersal of the latter, i.e. in a few millions of years. There is probably not one accretion process but several, depending on the scale at which accretion operates. A first process is the sticking of microscopic dust into larger grains and pebbles. A second process is the formation of an intermediate class of objects called planetesimals. A third accretion process has to lead from planetesimals to planets. Actually, several processes can be involved in this step, from collisional coagulation among planetesimals to the accretion of small particles under the effect of gas drag, to giant impacts between protoplanets. This chapter will detail all these processes, adopting a historical perspective: i.e. from the classic processes investigated in the past decades to those unveiled in the last years.

Accepted by Oxford Encyclopedia

http://arxiv.org/pdf/1803.06708

Moving ... ??

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Meetings

Summer School on Origins of the Solar System

July 16-20, 2018 – Taipei, Taiwan

This summer school is projected to be the first of joint activities between ASIAA and the Center of Star and Planet Formation and the Niels Bohr International Academy at the University of Copenhagen, based on the mutual interests of members of their respective institutions in Cosmochemistry, Theoretical Astrophysics and Star and Planet Formation. The theme on Origins of the Solar System is one that closely covers the broad interests and expertise present in both local institutions and forms the foundation of exchanges and efforts of collaborations and cooperations. The planned topics in this first summer school spread from nucleosynthesis, the influence of the interstellar medium, the formation and evolution of protoplanetary systems, and the planetary materials that contribute to the making of planets. The objectives are to bring researchers and students alike from within both countries and worldwide to participate in the exciting journey through the exploration of multidisciplinary studies.

The lectures are designed for graduate students in Physics, Astronomy and Astrophysics, Geophysics and Chemistry; but participants at all levels are welcomed to attend. Registration is required for all participants. The school is limited to a total of roughly 60 people. For Masters and PhD students, an email confirming their research status provided by an academic or research advisor is also mandatory. A limited number of merit-based lodging support may be available for Masters and PhD students from outside of Taipei.

Deadline for Registration: June 15, 2018

Deadline for applying for lodging support: May 31, 2018

Deadline for participants holding PRC passports: April 30, 2018

Details, registration and logistics of the school can be found here:

http://events.asiaa.sinica.edu.tw/school/20180716/

E-mail: school@tiara.sinica.edu.tw

Star Cluster Formation: Mapping the first few Myrs

29-31 August 2018, Universite Grenoble Alpes, Grenoble, France

On behalf of Local and Scientific Organizing Committees, we are pleased to announce a 2.5-days workshop on the formation and early evolution of star clusters that will be held in Grenoble, 29-31 August 2018. This will provide a forum for the star formation community to discuss the big issues of this field. Combining observation and theory, and with a particular emphasis on results obtained from Gaia DR2, topics will include: initial conditions of stars and gas in stellar cluster formation; spatial and kinematic properties of newly formed/active massive star cluster regions, open clusters and stellar associations; and early dynamical evolution and simulations of massive star cluster regions.

This is the second workshop hosted by the StarFormMapper (SFM) project, an EU Horizon2020 funded collaboration between the University of Leeds, University of Cardiff, University Grenoble Alps and Quasar Science Resources SL. The key aim of the project is to combine state-of-the-art numerical simulations with data from Gaia and Herschel and ground based surveys to constrain the mechanisms that underlie massive star and star cluster formation. Taken collectively, these facilities cover all stages from the formation of molecular cores, through the formation of stars, to the dispersal of the gas in young clusters. We are developing new automated statistical techniques to extract the full scientific value of these combined data, that will eventually be released as common user tools to the community. Our scientific results will underpin the study of how all galaxies evolve.

SCIENTIFIC ORGANIZING COMMITTE:

Emilio Alfaro (IAA, Spain, Chair), Pouria Khalaj (IPAG, France), Anne Buckner (Leeds Univ., UK)

IMPORTANT DATES:

Registration will be open from 1st May to 30th June 2018.

Register your interest now : https://sfm.leeds.ac.uk/registerinterest/

Zooming in on Star Formation
A tribute to Åke Nordlund
9 - 14 June 2019 – Nafplio, Greece

This conference will be a venue to celebrate the rich career of Prof. Åke Nordlund (Niels Bohr Institute & Starplan, Copenhagen Denmark) and his numerous contributions to the field of star formation. The program will also include sessions related to other fields in which Åke is very active, namely the modeling of stellar/solar atmospheres, numerical code development, and planet formation. We hope many of you can attend the conference and celebrate with us Aake's career.

Webpage: http://www.nbia.dk/nbia-zoomstarform-2019

Important dates

- 15 March 2018 : pre-registration opens. Please pre-register if you would like to receive future announcements about the conference
- 15 October 2018: registration and submission of abstracts.

Sessions:

- Galactic scale star formation
- Formation of Molecular clouds and the origin and characteristics of turbulent motions in molecular clouds and in the interstellar medium
- Fragmentation of clouds, filaments, core mass function and the origin of the stellar mass function
- High mass star formation, stellar feedback, and the formation of stellar clusters
- Low mass star formation, disk formation, and non-ideal MHD effects
- The formation of planets and the Solar system
- Solar/Stellar physics and connections to star formation
- Recent advances in code development for astrophysical fluid dynamics

Confirmed invited speakers: Philippe André, Davide Elia, Troels Haugbølle, Patrick Hennebelle, Mark Heyer, Anders Johansen, Rolf Kuiper, Paolo Padoan, Åke Nordlund, Kengo Tomida, Diego Turrini, Sarah Sadavoy, Jim Stone, Richard Wünsch, Annie Zavagno, and more to come

SOC: Sami Dib (chair), Doris Arzoumanian, Shantanu Basu, Thomas Henning, Uffe Jørgensen, Di Li, Susana Lizano, Fumitaka Nakamura, Martin Pessah, Danae Polychroni, Dimitrios Stamatellos, Romain Teyssier

LOC: Sami Dib (co-chair), Danae Polychroni (co-chair), Martin Pessah, Dimitrios Stamatellos, Anette Stutdsgård

Summary of Upcoming Meetings

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

EPoS 2018 The Early Phase of Star Formation - Archetypes
13 - 18 May 2018, Ringberg Castle, Tegernsee, Germany
http://www.mpia.de/homes/stein/EPoS/epos.php

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

Cloudy workshop
14 - 25 May 2018, Chiang Mai, Thailand
http://www.narit.or.th/en/index.php/cloudy

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

Formation of substellar objects: theory and observation
21-23 May 2018, ESAC, Madrid, Spain
http://www.laeff.cab.inta-csic.es/projects/ws18/main/index.php

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

Cosmic Rays and the Inter Stellar Medium
25 - 29 June 2018, Grenoble, France
https://crism2008.sciencesconf.org/

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

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

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

Astrochemistry: Past, Present, and Future
10 - 13 July, 2018, Pasadena, USA
http://www.cfa.harvard.edu/events/2018/astrochem18

Summer School on Origins of the Solar System
16 - 20 July, 2018, Taipei, Taiwan
http://events.asiaa.sinica.edu.tw/school/20180716/

COSPAR 2018 sessions on Planet Formation and Exoplanets
14 - 22 July 2018, Pasadena, USA
https://www.cospar-assembly.org/admin/sessioninfo.php?session=744

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

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

Star Cluster Formation: Mapping the first few Myrs
29 - 31 August 2018, Grenoble, France
https://sfm.leeds.ac.uk/registerinterest/

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

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

Triple Evolution and Dynamics
10 - 14 September 2018, Leiden, The Netherlands
http://www.lorentzcenter.nl/lc/web/2018/1016/info.php3?wsid=1016&venue=Oort

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

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

Abstract submission deadline

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