THE STAR FORMATION NEWSLETTER

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

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The Star Formation Newsletter

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

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Cover Picture

HD 97300 is an intermediate mass young star in the Chamaeleon I star forming complex. It is a B9V star which is transitioning from Herbig Ae/Be type to a zero-age main sequence star. The star is illuminating the IC 2631 = Cederblad 112 reflection nebula. HD 97300 is an 0.8 arcsecond binary, where the lower-mass companion is about 3 magnitudes fainter at K, and thus likely a T Tauri star.

Image courtesy ESO.

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

The Star Formation Newsletter seeks a WEBMASTER

Are you one of those people with too much time on your hands and too much money in your pocket? Then go on reading.

The Star Formation Newsletter is a volunteer effort that I have invested time and energy in for the past 26 years, in recent years with the capable help from my Associate Editors Hsi-Wei Yen and Anna McLeod. Within our little team we have been able to solve almost all problems that arise within the production of the Newsletter, including a major change to the layout in 2012.

The Newsletter website, however, has not changed in all these years, and is now in clear need of a major revision and upgrade carried out by a competent webmaster. If you are an expert in webpages and want to volunteer for this task, please email me your interest at reipurth@ifa.hawaii.edu before February 1 with a description of your experience in this area. A good knowledge of LaTeX is also desirable.

The bulk of the work will be a one-time update of the webpage, after which there will be a minimal workload of monthly maintenance.

Bo Reipurth

Perspective

Herbig Ae/Be stars

René Oudmaijer

1 Summary

Here I describe the pre-Main Sequence Herbig Ae/Be stars and highlight their role in studies of star formation. They were discovered by George Herbig in 1960, at a time when the solar mass T Tauri stars had only just been identified to be in the pre-Main Sequence phase of evolution. Looking for more massive analogues, and by focussing his search on objects with A and B spectral types, Herbig found a few dozen such stars, which later came to be known as Herbig Ae/Be stars. They have masses between those of T Tauri stars and Massive Young Stellar Objects. The latter group of stars are optically invisible as they are still embedded in their native clouds (e.g. Lumsden et al. 2013). The intermediate-mass Herbig Ae/Be stars play a particularly important part in understanding the differences in the formation of, and accretion of matter onto, low- and high-mass stars, respectively.

As Herbig Ae/Be stars are bright and have relatively large disks, they are ideal targets for high spatial resolution observations (e.g. Garufi et al. 2018), and they have become prime targets to study planet formation in their circumstellar disks as well. Indeed, as of now, several systems have been observed to not only be actively accreting material but are also orbited by planets (see e.g. the review by Quanz 2015), although sometimes the evidence is ambiguous (e.g. Mendigutia et al. 2018).

As the proto-planetary disk aspect has been discussed in earlier *Perspectives* in the SF Newsletter (e.g. Nienke van der Marel in SF 308), I will focus on the stars' importance for understanding star formation with emphasis on identifying differences and similarities between low- and high-mass stars.

The study of Herbig Ae/Be stars is active and for recent reviews on the class, I refer the reader to the Topical Collection on Herbig Ae/Be stars published in 2015 by Astrophysics and Space Science[1]. It includes reviews by Kraus (2015) on interferometric results, Grady et al. (2015), Quanz (2015), and Wyatt et al. (2015) who review (proto-planetary) disks, Brittain et al. (2015) on spectroscopy, Vink (2015, spectropolarimetry), Duchêne (2015, binarity) and Beltran (2015) for the earlier phases in their formation. A dedicated workshop on the topic will take place in June 2019[2].

2 Introduction

Stars come in many sizes and masses, and traditionally astronomers study either high- or low-mass objects. Star formation has been no exception. In a way, this is quite understandable as there are large disparities in our understanding of the formation of low- and high-mass stars. For example, we can readily identify two issues that indicate that the formation of a massive star differs from that of a lower mass star.

Firstly, it has long been a recognized problem that the intense brightness of massive stars (the luminosity on the Main Sequence goes roughly as $M^{3.3}$) can halt the accretion of matter onto the stellar surface because of the increased radiation pressure on the infalling material. The upper limit to the maximum possible mass has been estimated to be of order 10-30 $M_\odot$ (e.g. Wolfire & Cassinelli 1987; Zinnecker & Yorke 2007), implying stars more massive than that cannot be formed. However, such stars are commonplace, so another mechanism for the formation of massive stars needs to be explored.

After intense debate over the last couple of decades, one of the more popular theories put forward to explain high mass star formation, the merging of two lower mass stars (Bonnell et al. 1998), lost support for being the sole such mechanism due to the exceptionally high densities of stars needed to make this happen (Baumgardt & Klessen 2011). The theories that are nowadays put forward can be roughly divided into two groups. On the one hand, a mechanism similar to the low-mass star formation paradigm is invoked. In this case a star forms through the monolithic collapse of a molecular cloud and is fed through an accretion disk (McKee & Tan 2003; Krumholz et al. 2009). Its main competing scenario requires the presence of clusters. In this scenario, a large number of stars form simultaneously through the gravitational collapse of a cloud.

[1] http://link.springer.com/journal/volumesAndIssues10509?tabName=topicalCollections

[2] https://starry-project.eu/final-conference/

The most massive of the fragments steal material from the other objects and grow more rapidly and to larger final masses. This process has been coined "competitive accretion" (Bonnell et al. 2001; 2004). A nice overview of massive star formation is provided by Jonathan Tan in the *Perspectives* of a recent issue of the SF Newsletter (306).

What is relevant here is that both theories require the presence of an accretion disk through which material is concentrated in the equatorial plane so that it may overcome the strong ionising radiation of the central object and be efficiently accreted (e.g. Kuiper et al., 2010; 2011). Much effort has been devoted to finding and characterizing the accretion disks.

This brings us to the second major difference in the formation of low- and high-mass stars. Magnetic fields are known to play an important role in the accretion of material onto lower mass stars. Material flows from an accretion disk onto the stars along magnetic field lines and crashes onto the young, growing and unsuspecting, object, giving rise to huge shocks that are visible in X-rays and Ultraviolet excess emission. This process is called magnetically controlled accretion (MA) and has stood the test of time thus far. A useful reference is for example Bouvier et al. (2007), where evidence for the MA paradigm is outlined.

The more massive objects are non-magnetic. Because their envelopes are radiative, no magnetic field is generated as this usually happens in stars by convection. Indeed, magnetic fields have hardly, if at all, been detected towards those (e.g. Alecian et al. 2013). As a result MA is not expected to apply in the case of the most massive objects, requiring another accretion mechanism. However, how the material arrives at the stellar surface in the absence of magnetic fields is still unclear.

In the following I highlight several studies of large samples of objects from an observational point of view to see to what extent the MA scenario may or may not apply to objects more massive than T Tauri stars.

3 From Herbig Ae to Herbig Be

It is in the mass range spanned by the Herbig Ae/Be objects that the acting star forming mechanism switches from magnetically controlled accretion from disks with inner holes to an as yet unknown mechanism. They play therefore an important role in understanding star formaiton at higher masses.

Traditionally, this transition was thought to occur at comparatively low stellar temperatures, at the G/F to A spectral type boundary, where the envelopes become radiative. However, since the start of this century, this view has been subject to scrutiny. It now appears that Herbig Ae stars are more akin to T Tauri stars than to Herbig Be stars. Among the earliest such reports are that the linear spectropolarimetric signatures across the Hα emission line observed in both T Tauri and Herbig Ae stars are very similar to each other, while those observed for higher mass Herbig Be stars are not (Vink et al. 2002; 2003). As the features towards the T Tauri stars can be explained with accretion hot spots due to magnetically channeled accreting material (Vink et al. 2005; Mottram et al. 2007), it would then follow that Herbig Ae stars may form in the same manner as T Tauri stars.

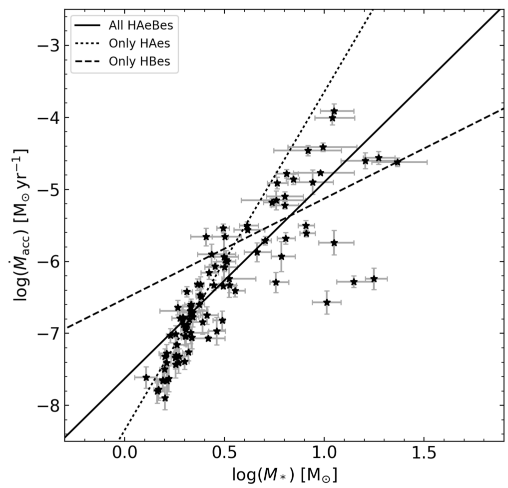

Figure 1: The derived mass accretion rate as function of mass for the Herbig Ae/Be stars with good Gaia DR2 parallaxes by Fairlamb et al. (2015) and Wichittanakom et al. (2019, in prep.). The mass dependency of the accretion rate is different for stars with mass lower and higher than 3 $M_\odot$, respectively.

Similar findings have been published since. Magnetic fields were reported to be present in some Herbig Ae/Be stars by some (Wade et al 2005; Hubrig et al. 2004; Alecian et al. 2013). Others reported differences in properties between Herbig Ae and Be stars but similarities between the Herbig Ae and T Tauri stars (Mendigutia et al. 2012). Grady et al. (2010) deduce that the accretion shock regions in a Herbig Ae star are comparable in size and location to those in the lower mass magnetic objects. Scholler et al. (2016) interpret the spectroscopic variability observed in the spectrum of a Herbig Ae star as evidence that it is currently undergoing magnetically-controlled accretion in the same manner as the T Tauri stars. On the other hand, dedicated modeling indicated that, if present at all, the magnetosphere in a particular Herbig Be star with spectral type B9IV must be small (Kurosawa et al. 2016) while for other Herbig Be stars MA may not be necessary at all to explain the observations (Patel et al. 2017). It would appear that there is a break at around late B spectral type where the MA star formation mechanism ceases to operate and another mechanism takes over.

In addition to these specific studies mentioning the modes of accretion, various studies have shown differences between low- and high-mass Herbig Ae/Be stars (e.g. Fuente et al. 1998 on mm emission; Testi et al. 1999 on clustering; Baines et al. 2006 on binarity; Millan-Gabet et al. 2007 on near-infrared sizes; Mendigutia et al. 2011a on spectroscopic variability). Using spectroscopy, Cauley & Johns-Krull (2014; 2015) infer that Herbig Ae stars are more likely to have red-shifted absorption than Herbig Be stars, indicating a different infall geometry. However, the precise mass where the lower mass objects deviate from higher mass objects is not well defined in the above studies.

To address this question, one needs large samples of objects, and below I discuss three recent studies that have the potential of settling this issue.

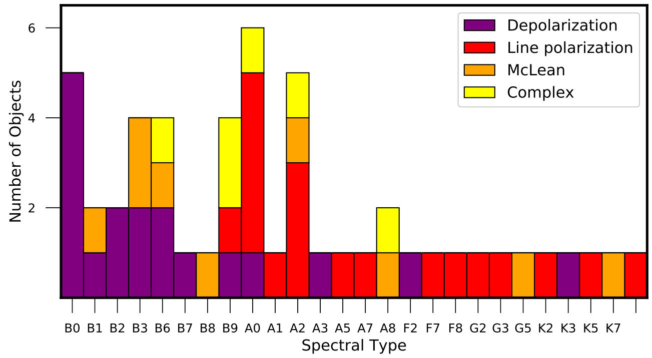

Figure 2: The occurrence of the various line effects observed in the linear spectropolarimetry as a function of spectral type. The "line *de*-polarization" across Hα probes disks reaching close to the star and is mostly found for the more massive Herbig Be stars. In contrast, the "line polarization" traces line emission scattering off a circumstellar disk. This is predominately present towards the lower mass, Herbig Ae and T Tauri stars. It appears that the change occurs roughly around spectral type B7-B8. Figure adapted from Ababakr et al. (2017).

3.1 Spectroscopic accretion diagnostics

Fairlamb et al. (2015) presented X-Shooter spectra for 91 Herbig Ae/Be objects, the largest such sample to have been investigated spectroscopically. From these data, they determined the stellar parameters such as temperature and gravity of these stars in a homogeneous fashion by fitting the spectra with stellar atmospheric models, and derived the accretion rates from the UV excess following the methodology of Muzerolle et al. (2004), Donehew & Brittain (2011) and extending the work of Mendigutia et al. (2011b) for all these objects. An interesting byproduct of the study was already discussed by Mendigutia et al. (2011b); all emission lines ranging from hydrogen recombination lines at various wavelengths to atomic permitted and forbidden lines have luminosities that correlate well with the accretion luminosity as measured by the UV excess. They therefore also correlate with accretion rate (Fairlamb et al. 2017). Although it is not clear whether this correlation is intrinsically due to accretion or some other effect (Mendigutia et al. 2015), they do provide an observationally cheap manner to derive the accretion rate of an object without having to resort to the rather delicate and time-consuming process of measuring the UV excess in Herbig Ae/Be stars, stars which have, contrary to the cooler T Tauri stars, a significant amount of intrinsic UV radiation already.

To extend the sample to the northern hemisphere, Wichittanakom (2019, in prep.) obtained spectra for 30 objects using the Isaac Newton Telescope and determined their stellar parameters in the same manner as Fairlamb et al. (2015). This led to a large, combined, sample of Herbig Ae/Be stars that were analyzed in a homogeneous manner.

Using the new Gaia DR2 data (Vioque et al. 2018) that are available for most of the stars in the Fairlamb and Wichittanakom samples, the distances to the objects can be determined to the highest accuracy hitherto possible. Armed with this information, the luminosities and masses, and hence the accretion rates, could be re-determined and determined, respectively. Restricting the sample to objects that were flagged as having good Gaia DR2 parallaxes (see discussion in Vioque et al.) results in a sample of 97 objects containing many of the Thé et al. Table 1 objects which are the best Herbig Ae/Be candidate stars known. Figure 1 shows the mass accretion rates as function of mass, and represents the best such data available. It can be seen that the slope is steeper at the low mass end than at the high mass end, while the spread in values is also increased. The break at which the slope changes is determined to be ~ 3 M$_{\odot}$. In addition, Fairlamb et al. (2015) found that Herbig Ae stars can be explained by MA, but that the earliest Herbig Be stars have too large UV-excesses to be explained by the usual accretion shock scenario.

3.2 Probing the disks - linear spectropolarimetry

Linear spectropolarimetry across Hα has been long known to reveal the presence of very small-scale circumstellar disks (Oudmaijer & Drew 1999). Subsequent studies of Herbig Ae/Be stars showed that spectropolarimetric effects across the Hα emission fall into a small number of categories (e.g. Ababakr, Oudmaijer & Vink, 2016). In particular, Vink et al. (2002, 2003) found that intrinsic line polarization of Hα predominately occurs for T Tauri and Herbig Ae stars and can be explained by compact Hα emission scattered off a circumstellar disk, while the Herbig Be stars typically display a line *de*-polarization that can be explained with a disk reaching onto the stellar surface (Vink, Harries & Drew 2005).

With 56 objects, Ababakr, Oudmaijer & Vink (2017) presented the largest linear spectropolarimetric study of Herbig Ae/Be stars. They found a break in the spectropolarimetric, and possibly accretion, properties of high- and low-mass objects to occur around the B7-B8 spectral type. This is found in both the detection statistics and, especially, the nature of the line-effect (see Fig. 2). Intriguingly, the B7-B8 spectral type boundary corresponds to $\sim$3 $M_{\odot}$, just like the break in accretion properties above.

The similarities in the spectropolarimetric properties between T Tauri stars - which are known to undergo magnetospheric accretion - and the late-type Herbig Be and Herbig Ae stars suggest this mechanism also acts on these intermediate-mass stars (cf. Vink et al. 2002).

An accretion scenario for the more massive stars is not well established. A promising contestant is the so-called "Boundary Layer" accretion. In this model, the circumstellar disk reaches onto the stellar surface, and the thin layer in which the Keplerian rotating material loses its angular momentum and kinetic energy gives rise to excess UV emission (e.g. Blondel & Tjin a Djie 2006; Cauley & Johns-Krull 2015). As of yet, details have to be worked out for the case of higher mass pre-Main Sequence stars.

3.3 The new frontier : Gaia

Finally, a Gaia study of Herbig Ae/Be stars was recently completed by Vioque et al. (2018). After selecting on high-quality parallaxes, they were able to put more than 200 objects in the HR diagram (see Figure 3). In addition, they derived the photometric variability of the objects using the data provided in the Gaia catalogue and identified 43 strongly variable objects. It turns out that most of these variable objects have strong infrared excesses due to circumstellar dust, while the least variable objects appear to be surrounded by less dust. It suggests that the dust may be responsible for the extinction, and, indeed, most known UXOR variables are included in the highly variable sample. The UXORs are hypothesized to be surrounded by inhomogeneous, dusty, edge-on disks, whose orbital motions induce variable, but not necessarily periodic, extinction. The best observational evidence thus far for this scenario is the fact that during periods of high extinction, the linear polarization - tracing scattered light - peaks (e.g. Grinin 2000).

New support for this scenario now comes from the fact that Vioque et al. find that the occurrence of doubly-peaked

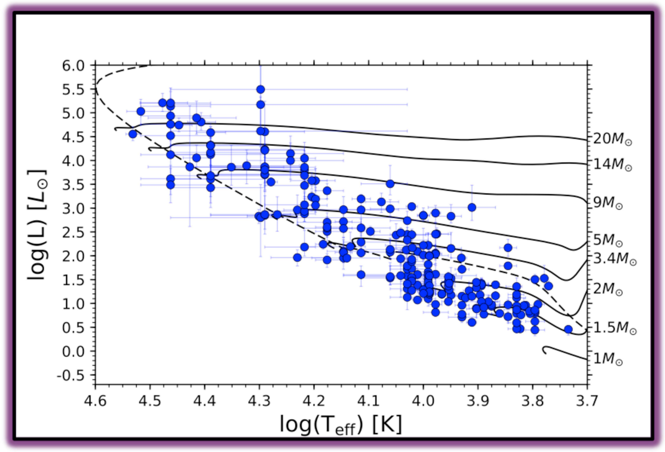

Figure 3: Herbig Ae/Be stars placed in the HR-diagam using Gaia DR2 parallaxes. Figure adapted from Vioque et al. (2018).

Hα emission line profiles (collated from the literature) is significantly higher in the variable sample than in the non-variable sample. As doubly-peaked emission is expected to originate from edge-on disk configurations. The edge-on (Hα lines), dusty (infrared excess) disk scenario for the UXOR phenomenon has now gained, strong, additional observational support.

Let us now return to the differences between high- and low-mass Herbig Ae/Be stars. The photometric variability and infrared excess are found to be present for low-mass stars, but not for higher mass stars. With masses obtained using the Gaia derived HR diagram, Vioque et al. (2018) find that the break occurs at 7 $M_{\odot}$. This is a higher mass than the 3 $M_{\odot}$ where both the accretion rates determined from spectroscopy as well as the nature of the accretion as probed by spectropolarimetry change. This apparent contradiction can be understood when we consider the spatial scales involved; whereas the spectroscopy and spectropolarimetry trace the ionized material very close to the star, the infrared emission traces the dusty material much further out. The former is therefore more likely to be associated with the accretion process, while the latter is more likely associated with dust dispersal mechanisms: the higher radiation pressure from the hotter and brighter objects will result in faster clearing of the dusty disks (e.g. Gorti et al. 2009).

4 Final remarks and Outlook

The main take away messages from this short overview are that:

i) Herbig Ae/Be stars bridge the gap between low- and high-mass young stars and cover the mass where a change in accretion mechanism occurs.

ii) From both mass accretion rates and Hα line spectropolarimetry, there appears to be a change in properties, and therefore perhaps accretion mode, at around 3 $M_\odot$ (corresponding to mid- to late B spectral type).
iii) Using Gaia DR2 data and auxiliary information, a large sample of Herbig Ae/Be stars has been placed in the HR diagram. A change in infrared and photometric properties is found to occur at higher masses, 7 $M_\odot$, which is identified with dust dispersal being faster and more efficient in the vicinity of hotter, luminous Herbig Be stars.

The latter study had been carried out in the context of the EU-funded STARRY project. It served as the first step in characterizing the known Herbig Ae/Be stars. We are currently using Gaia to expand the set of known Herbig Ae/Be stars from the Gaia database using machine learning techniques to improve on the statistical findings presented here. In addition, following the initial work by Testi, Palla & Natta (1999), we aim to establish the presence or absence of clusters around these objects to study their clustering properties as function of mass.

Acknowledgements:

It is a pleasure to thank Ignacio Mendigutía, Miguel Vioque and John Fairlamb for fruitful discussions and their feedback on an earlier version of this manuscript. I thank Chumpon Wichittanakom for kindly providing Figure 1 prior to publication. The STARRY project receives funding from the European Union's Horizon 2020 Marie Sklodowska Curie Actions (MSCA) programme under Grant Agreement No 676036.

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Abstracts of recently accepted papers

1 **Water and OH Emission from the inner disk of a Herbig Ae/Be star**

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We report the detection of hot H_2O and OH emission from the Herbig Ae/Be star HD 101412 using the Cryogenic Infrared Echelle Spectrograph on the *Very Large Telescope*. Previous studies of Herbig Ae/Be stars have shown the presence of OH around some of these sources, but H_2O has proven more elusive. While marginal water emission has been reported in the mid-infrared, and a few Herbig Ae/Be stars show water emission in the far-infrared, water emission near 2.9 μm has not been previously detected. We apply slab models to the ro-vibrational OH, H_2O, and CO spectra of this source and show that the molecules are consistent with being cospatial. We discuss the possibility that the detection of the CO overtone bandhead emission, detection of water emission, and the large line to continuum contrast of the OH lines may be connected to its high inclination and the λ Boö nature of this star. If the low abundance of refractories results from the selective accretion of gas relative to dust, the inner disk of HD 101412 should be strongly dust-depleted allowing us to probe deeper columns of molecular gas in the disk, enhancing its molecular emission. Our detection of C- and O-bearing molecules from the inner disk of HD 101412 is consistent with the expected presence in this scenario of abundant volatiles in the accreting gas.

Accepted by ApJ

https://arxiv.org/pdf/1812.07094.pdf

2 **On The Secular Evolution of GG Tau A Circumbinary Disc: A Msialigned Disc Scenario**

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The binary system GG Tau A is observed to have a circumbinary disc with a dust ring located further out than expected, assuming a co-planar disc and a corresponding semi-major axis of 34 AU. Given the binary separation, this large cavity can be explained by relaxing the assumption of a co-planar disc and instead fit the observations with a mis-aligned circumbinary disc around an eccentric binary with a wider semi-major axis of 60 AU, consistent with fitting the proper motion data for the system. We run SPH simulations to check this possibility and indeed we find that a misalignment angle of 30 degrees and a binary eccentricity of 0.45 fit both the astrometric data and the disc cavity. However, such configuration could in principle be unstable to polar, rather that planar alignment. We investigate the secular evolution of this configuration and show that it is indeed stable throughout the disc lifetime.

Accepted by MNRAS

http://arxiv.org/pdf/1809.06383

3 **Methyl cyanide (CH_3CN) and propyne (CH_3CCH) in the low mass protostar IRAS 16293−2422**

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Methyl cyanide (CH_3CN) and propyne (CH_3CCH) are two molecules commonly used as gas thermometers for interstellar gas. They are detected in several astrophysical environments and in particular towards protostars. Using data of the low-mass protostar IRAS 16293−2422 obtained with the IRAM 30m single-dish telescope, we constrained the origin of these two molecules in the envelope of the source. The line shape comparison and the results of a radiative transfer analysis both indicate that the emission of CH_3CN arises from a warmer and inner region of the envelope than the CH_3CCH emission. We compare the observational results with the predictions of a gas-grain chemical model. Our model predicts a peak abundance of CH_3CCH in the gas-phase in the outer part of the envelope, at around 2000 au from the central star, which is relatively close to the emission size derived from the observations. The predicted CH_3CN abundance only rises at the radius where the grain mantle ices evaporate, with an abundance similar to the one derived from the observations.

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4

A method to analyse velocity structure

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We present a new method of analysing and quantifying velocity structure in star forming regions suitable for the rapidly increasing quantity and quality of stellar position-velocity data. The method can be applied to data in any number of dimensions, does not require the centre or characteristic size (e.g. radius) of the region to be determined, and can be applied to regions with any underlying density and velocity structure. We test the method on a variety of example datasets and show it is robust with realistic observational uncertainties and selection effects. This method identifies velocity structures/scales in a region, and allows a direct comparison to be made between regions.

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5

Investigation of the stellar content in the IRAS 05168+3634 star-forming region

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We present the investigation results of structure and stellar content of a molecular cloud surrounding the five IRAS sources: 05168+3634, 05184+3635, 05177+3636, 05162+3639, and IRAS 05156+3643. Using multi-color criteria, we identified a rich population of embedded YSO candidates with infrared excess (Class 0/I and Class II) and their characteristics in a quite large molecular cloud which is located in the region of 24 arcmin radius. The molecular cloud includes 240 candidates of YSOs within the radii of sub-regions around 5 IRAS sources. The color-magnitude diagrams of the sub-regions suggest a very young stellar population. We construct the K luminosity function (KLF) of the sub-regions and according to the values of the slopes of KLFs, the age of the sub-regions can be estimated between 0.1-3 Myr. The SEDs are constructed for 45 Class I and 75 Class II evolutionary stages YSOs and the received parameters of those YSOs are well correlated with the results obtained by other methods.

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6 Creating retrogradely orbiting planets by prograde stellar fly-bys

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Several planets have been found that orbit their host star on retrograde orbits (spin-orbit angle $\varphi > 90°$). Currently, the largest measured projected angle between the orbital angular momentum axis of a planet and the rotation axis of its host star has been found for HAT-P-14b to be $\approx 171°$. One possible mechanism for the formation of such misalignments is through long-term interactions between the planet and other planetary or stellar companions. However, with this process, it has been found to be difficult to achieve retrogradely orbiting planets, especially planets that almost exactly counter-orbit their host star ($\varphi \approx 180°$) such as HAT-P-14b. By contrast, orbital misalignment can be produced efficiently by perturbations of planetary systems that are passed by stars. Here we demonstrate that not only retrograde fly-bys, but surprisingly, even **prograde** fly-bys can induce retrograde orbits. Our simulations show that depending on the mass ratio of the involved stars, there are significant ranges of planetary pre-encounter parameters for which counter-orbiting planets are the natural consequence. We find that the highest probability to produce counter-orbiting planets ($\approx 20\%$) is achieved with close prograde, coplanar fly-bys of an equal-mass perturber with a pericentre distance of one-third of the initial orbital radius of the planet. For fly-bys where the pericentre distance equals the initial orbital radius of the planet, we still find a probability to produce retrograde planets of ≈ 10 % for high-mass perturbers on inclined ($60° < i < 120°$) orbits. As usually more distant fly-bys are more common in star clusters, this means that inclined fly-bys probably lead to more retrograde planets than those with inclinations $< 60°$. Such close fly-bys are in general relatively rare in most types of stellar clusters, and only in very dense clusters will this mechanism play a significant role. The total production rate of retrograde planets depends then on the cluster environment. Finally, we briefly discuss the application of our results to the retrograde minor bodies in the solar system and to the formation of retrograde moons during the planet-planet scattering phase.

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7 The CIDA Variability Survey of Orion OB1. II: demographics of the young, low-mass stellar populations

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We present results of our large scale, optical, multi-epoch photometric survey across ~ 180 square degrees in the Orion OB1 association, complemented with extensive follow up spectroscopy. Our focus is mapping and characterizing the off-cloud, low-mass, pre-main sequence populations. We report 2062 K and M-type confirmed T Tauri members; 59% are located in the OB1a subassociation, 27% in the OB1b subassociation, and the remaining 14% in the A and B molecular clouds. We characterize two new clusterings of T Tauri stars, the HD 35762 and HR 1833 groups, both located in OB1a not far from the 25 Ori cluster. We also identify two stellar overdensities in OB1b, containing 231 PMS stars, and find that the OB1b region is composed of two populations at different distances, possibly due to the

OB1a subassociation overlapping on front of OB1b. A ~ 2 deg wide halo of young stars surrounds the Orion Nebula Cluster, corresponding in part to the low-mass populations of NGC 1977 and NGC 1980.
We use the strength of Hα in emission, combined with IR excess and optical variability, to define a new type of T Tauri star, the C/W class, stars we propose may be nearing the end of their accretion phase, in an evolutionary state between Classical and Weak-lined T Tauri stars. The evolution of the ensemble-wide equivalent width of Li I λ6707 indicates a Li depletion timescale of ~ 8.5 Myr. Disk accretion declines with an e-folding timescale of ~ 2 Myr, consistent with previous studies.

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8 Spectroscopic study of the extremely young O-type triple system Herschel 36 A in the Hourglass Nebula. I. Orbital properties

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We present a detailed spectroscopic study of Herschel 36 A (H36A), the main stellar component of the massive multiple system Herschel 36 in the Hourglass Nebula, based on high-resolution optical spectra obtained along an 11 years span. The three stellar components present in the spectrum of H36A are separated by means of a spectral disentangling technique. Individual spectral classifications are improved, and high precision orbital solutions for the inner and the outer orbits are calculated. H36A is confirmed to be a hierarchical triple system composed of a close massive binary (Ab1+Ab2, O9.5 V+B0.7 V) in wide orbit around a third O-type star (Aa, O7.5 Vz). The inner-pair orbit is characterized by a period of 1.54157$\pm$0.00006 days, and semi-amplitudes of 181.2$\pm$0.7 and 295.4$\pm$1.7 km/s. The outer orbit has a period of 492.81$\pm$0.69 days, and semi-amplitudes of 62.0$\pm$0.6 and 42.4$\pm$0.8 km/s. Inner and outer orbits are not coplanar, having a relative inclination of at least 20 degrees. Dynamical minimum masses of 20.6$\pm$0.8 $M_\odot$, 18.7$\pm$1.1 $M_\odot$, and 11.5$\pm$1.1 $M_\odot$ are derived for the Aa, Ab1, and Ab2 components, respectively, in reasonable agreement with the theoretical calibrations.

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9 The early instability scenario: terrestrial planet formation during the giant planet instability, and the effect of collisional fragmentation

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The solar system's dynamical state can be explained by an orbital instability among the giant planets. A recent model has proposed that the giant planet instability happened during terrestrial planet formation. This scenario has been shown to match the inner solar system by stunting Mars' growth and preventing planet formation in the asteroid belt. Here we present a large sample of new simulations of the "Early Instability" scenario. We use an N-body integration scheme that accounts for collisional fragmentation, and also perform a large set of control simulations that do not include an early giant planet instability. Since the total particle number decreases slower when collisional fragmentation is accounted for, the growing planets' orbits are damped more strongly via dynamical friction and encounters with small

bodies that dissipate angular momentum (eg: hit-and-run impacts). Compared with simulations without collisional fragmentation, our fully evolved systems provide better matches to the solar system's terrestrial planets in terms of their compact mass distribution and dynamically cold orbits. Collisional processes also tend to lengthen the dynamical accretion timescales of Earth analogs, and shorten those of Mars analogs. This yields systems with relative growth timescales more consistent with those inferred from isotopic dating. Accounting for fragmentation is thus supremely important for any successful evolutionary model of the inner solar system.

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Flybys in protoplanetary discs: I. Gas and dust dynamics

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We present 3D smoothed particle hydrodynamics simulations of protoplanetary discs undergoing a flyby by a stellar perturber on a parabolic orbit lying in a plane inclined relative to the disc mid-plane. We model the disc as a mixture of gas and dust, with grains ranging from 1 μm to 10 cm in size. Exploring different orbital inclinations, periastron distances and mass ratios, we investigate the disc dynamical response during and after the flyby. We find that flybys induce evolving spiral structure in both gas and dust which can persist for thousands of years after periastron. Gas and dust structures induced by the flyby differ because of drag-induced effects on the dust grains. Variations in the accretion rate by up to an order of magnitude occur over a time-scale of order 10 years or less, inducing FU Orionis-like outbursts. The remnant discs are truncated and warped. The dust disc is left more compact than the gas disc, both because of disc truncation and accelerated radial drift of grains induced by the flyby.

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A search for accreting young companions embedded in circumstellar disks: High-contrast Hα imaging with VLT/SPHERE

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In recent years, our understanding of giant planet formation progressed substantially. Even the detections of a few young protoplanet candidates still embedded in the circumstellar disks of their host stars have been made. The exact physics that describes the accretion of material from the circumstellar disk onto the suspected circumplanetary disk and eventually onto the young, forming planet is still an open question.We want to detect and quantify observables related to accretion processes occurring locally in circumstellar disks, which could be attributed to young forming planets. We focus on objects known to host protoplanet candidates and/or disk structures thought to be the result of interactions with planets. We analyzed observations of 6 young stars (age $3.5 - 10$ Myr) and their surrounding environments with the SPHERE/ZIMPOL instrument on the VLT in the Hα filter (656 nm) and a nearby continuum filter (644.9 nm). We applied several PSF subtraction techniques to reach the highest possible contrast near the primary star, specifically investigating regions where forming companions were claimed or have been suggested based on observed disk morphology. We re-detect the known accreting M-star companion HD142527 B with the highest published signal to noise to date in both Hα and the continuum. We derive new astrometry ($r = 62.8^{+2.1}_{-2.7}$ mas and $PA = (98.7 \pm 1.8)^{\circ}$) and photometry ($\Delta$N_Ha=$6.3^{+0.2}_{-0.3}$ mag, ΔB_Ha=6.7 ± 0.2 mag and ΔCnt_Ha=$7.3^{+0.3}_{-0.2}$ mag) for the companion in agreement with previous studies, and estimate its mass accretion rate ($\dot{M} \approx 1-2 \times 10^{-10}\, M_{\odot} yr^{-1}$). A faint point-like source around HD135344 B (SAO206462) is also investigated, but a second deeper observation is required to reveal its nature. No other companions are detected. In the framework of our assumptions we estimate detection limits at the locations of companion candidates around HD100546, HD169142 and MWC 758 and calculate that processes involving Hα fluxes larger than $\sim 8 \times 10^{-14} - 10^{-15}\, erg/s/cm^2$ ($\dot{M} > 10^{-10} - 10^{-12}\, M_{\odot} yr^{-1}$) can be excluded. Furthermore, flux upper limits of $\sim 10^{-14} - 10^{-15}\, erg/s/cm^2$ ($\dot{M} < 10^{-11} - 10^{-12}\, M_{\odot} yr^{-1}$) are estimated within the gaps identified in the disks surrounding HD135344 B and TW Hya. The derived luminosity limits exclude Hα signatures at levels similar to those previously detected for the accreting planet candidate LkCa15 b.

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12 A 3D Hydrodynamics Study of Gravitational Instabilities in a Young Circumbinary Disc

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We present a 3D hydrodynamics study of gravitational instabilities (GIs) in a 0.14 $M_{\odot}$ circumbinary protoplanetary disc orbiting a 1 $M_{\odot}$ star and a 0.02 $M_{\odot}$ brown dwarf companion. We examine the thermodynamical state of the disc and determine the strengths of GI-induced density waves, nonaxisymmetric density structures, mass inflow and outflow, and gravitational torques. Results are compared with a parallel simulation of a protoplanetary disc without the brown dwarf binary companion. Simulations are performed using CHYMERA, a radiative 3D hydrodynamics code. The onset of GIs in the circumbinary disc is much more violent due to the stimulation of a strong one-armed density

wave by the brown dwarf. Despite this early difference, detailed analyses show that both discs relax to a very similar quasi-steady phase by 2,500 years after the beginning of the simulations. Similarities include the thermodynamics of the quasi-steady phase, the final surface density distribution, radial mass influx, and nonaxisymmetric power and torques for spiral arm multiplicities of two or more. Effects of binarity in the disc are evident in gravitational torque profiles, temperature profiles in the inner discs, and radial mass transport. After 3,800 years, the semimajor axis of the binary decreases by about one percentage and the eccentricity roughly doubles. The mass transport in the outer circumbinary disc associated with the one-armed wave may influence planet formation.

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13 A Model-Independent Mass and Moderate Eccentricity for β Pic b

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We use a cross-calibration of *Hipparcos* and *Gaia* DR2 astrometry for β Pic to measure the mass of the giant planet β Pic b ($13 \pm 3\,M_{\rm Jup}$) in a comprehensive joint orbit analysis that includes published relative astrometry and radial velocities. Our mass uncertainty is somewhat higher than previous work because our astrometry from the *Hipparcos–Gaia* Catalog of Accelerations accounts for the error inflation and systematic terms that are required to bring the two data sets onto a common astrometric reference frame, and because we fit freely for the host-star mass ($1.84 \pm 0.05\,M_{\odot}$). This first model-independent mass for a directly imaged planet is inconsistent with cold-start models given the age of the β Pic moving group (22 ± 6 Myr) but consistent with hot- and warm-start models, concordant with past work. We find a higher eccentricity (0.24 ± 0.06) for β Pic b compared to previous orbital fits. If confirmed by future observations, this eccentricity may help explain inner edge, scale height, and brightness asymmetry of β Pic's disk. It could also potentially signal that β Pic b has migrated inward to its current location, acquiring its eccentricity from interaction with the 3:1 outer Lindblad resonance in the disk.

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14 Episodic excursions of low-mass protostars on the Hertzsprung-Russell diagram

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Following our recent work devoted to the effect of accretion on the pre-main-sequence evolution of low-mass stars, we perform a detailed analysis of episodic excursions of low-mass protostars in the Hertzsprung-Russell (H-R) diagram triggered by strong mass accretion bursts typical of FU Orionis-type objects (FUors). These excursions reveal themselves as sharp increases in the stellar total luminosity and/or effective temperature of the protostar and can last from hundreds to a few thousands of years, depending on the burst strength and characteristics of the protostar. During the excursions, low-mass protostars occupy the same part of the H-R diagram as young intermediate-mass protostars in the quiescent phase of accretion. Moreover, the time spent by low-mass protostars in these regions is on average a factor of several longer than that spent by the intermediate-mass stars in quiescence. During the excursions, low-mass protostars pass close to the position of most known FUors in the H-R diagram, but owing to intrinsic ambiguity the

model stellar evolutionary tracks are unreliable in determining the FUor properties. We find that the photospheric luminosity in the outburst state may dominate the accretion luminosity already after a few years after the onset of the outburst, meaning that the mass accretion rates of known FUors inferred from the bolometric luminosity may be systematically overestimated, especially in the fading phase.

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Star Cluster Formation from Turbulent Clumps. II. Gradual Star Cluster Formation

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We investigate the dynamical evolution of star clusters during their formation, assuming that they are born from a turbulent starless clump of a given mass that is embedded within a parent self-gravitating molecular cloud characterized by a particular mass surface density. In contrast to the standard practice of most N-body studies, we do not assume that all stars are formed at once. Rather, we explore the effects of different star formation rates on the global structure and evolution of young embedded star clusters, also considering various primordial binary fractions and mass segregation levels. Our fiducial clumps studied in this paper have initial masses of $M_{\rm cl} = 3000\,M_{\odot}$, are embedded in ambient cloud environments of $\Sigma_{\rm cloud} = 0.1$ and 1 g cm^{-2}, and gradually form stars with an overall efficiency of 50% until the gas is exhausted. We investigate star formation efficiencies per free-fall time in the range $\epsilon_{\rm ff} = 0.01$ to 1, and also compare to the instantaneous case ($\epsilon_{\rm ff} = \infty$) of Paper I. We show that most of the interesting dynamical processes that determine the future of the cluster, happen during the early formation phase. In particular, the ejected stellar population is sensitive to the duration of star cluster formation: for example, clusters with longer formation times produce more runaway stars, since these clusters remain in a dense state for longer, thus favouring occurrence of dynamical ejections. We also show that the presence of radial age gradients in star clusters depends sensitively on the star formation efficiency per free fall time, with observed values being matched best by our slowest forming clusters with $\epsilon_{\rm ff} \lesssim 0.03$.

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Gas density perturbations induced by forming planet(s) in the AS 209 protoplanetary disk as seen with ALMA

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The formation of planets occurs within protoplanetary disks surrounding young stars, resulting in perturbation of the gas and dust surface densities. Here, we report the first evidence of spatially resolved gas surface density (Σ_g) perturbation towards the AS 209 protoplanetary disk from the optically thin $C^{18}O$ ($J = 2-1$) emission. The observations were carried out at 1.3 mm with ALMA at a spatial resolution of about 0.3″ × 0.2″ (corresponding to $\sim 38 \times 25$ au). The $C^{18}O$ emission shows a compact ($\leq$60 au), centrally peaked emission and an outer ring peaking

at 140 au, consistent with that observed in the continuum emission and, its azimuthally averaged radial intensity profile presents a deficit that is spatially coincident with the previously reported dust map. This deficit can only be reproduced with our physico-thermochemical disk model by lowering Σ_{gas} by nearly an order of magnitude in the dust gaps. Another salient result is that contrary to $C^{18}O$, the DCO^+ ($J = 3 - 2$) emission peaks between the two dust gaps. We infer that the best scenario to explain our observations ($C^{18}O$ deficit and DCO^+ enhancement) is a gas perturbation due to forming-planet(s), that is commensurate with previous continuum observations of the source along with hydrodynamical simulations. Our findings confirm that the previously observed dust gaps are very likely due to perturbation of the gas surface density that is induced by a planet of at least 0.2 $M_{\rm Jupiter}$ in formation. Finally, our observations also show the potential of using CO isotopologues to probe the presence of saturn mass planet(s).

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17 The Planet Formation Potential Around a 45 Myr old Accreting M Dwarf

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Debris disk detections around M dwarfs are rare, and so far no gas emission has been detected from an M dwarf debris disk. This makes the 45 Myr old M dwarf WISEJ080822.18-644357.3 a bit of a curiosity; it has a strong infrared excess at an age beyond the lifetime of a typical planet-forming disk, and also exhibits broad Hα emission consistent with active accretion from a gaseous disk. To better understand the cold gas and dust properties of this system, we obtained ALMA observations of the 1.3mm continuum and the $CO/^{13}CO/C^{18}O$ J=2-1 emission lines. No cold CO gas is detected from this system, ruling out a gas-rich protoplanetary disk. Unresolved dust continuum emission is detected at a flux of 198±15 μJy, consistent with 0.057±0.006 $M_\oplus$ worth of optically thin dust, and consistent with being generated through a collisional cascade induced by large bodies at radii <16 au. With a sufficiently strong stellar wind, dust grains released in the outer disk can migrate inwards via PR drag, potentially serving as a source of grains for the strong infrared excess.

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18 A 1000 AU Scale Molecular Outflow Driven by a Protostar with an age of $lesssim$4000 Years

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To shed light on the early phase of a low-mass protostar formation process, we conducted interferometric observations towards a protostar GF 9-2 using the CARMA and SMA. The observations have been carried out in the ^{12}CO $J = 3-2$ line and in the continuum emission at the wavelengths of 3.3 mm, 1.1 mm and 850 μm with a spatial resolution of $\approx$ 400 AU. All the continuum images detected a single point-like source with a beam-deconvolved effective radius of 250±80 AU at the center of the previously known 1.1 − 4.5 $M_\odot$ molecular cloud core. A compact emission is detected towards the object at the *Spitzer* MIPS and IRAC bands as well as the four bands at the *WISE*. Our spectroscopic imaging of the CO line revealed that the continuum source is driving a 1000 AU scale molecular outflow, including a pair of lobes where a collimated "higher" velocity (~ 10 km s^{-1} with respect to the velocity of the cloud) red lobe exists inside a poorly collimated "lower" velocity (~ 5 km s^{-1}) red lobe. These lobes are rather young (dynamical time scales of $\sim 500 - 2000$ yrs) and the least powerful (momentum rates of $\sim 10^{-8} - 10^{-6}$ $M_\odot$ km s^{-1} yr^{-1}) ones so far detected. A protostellar mass of $M_* \lesssim 0.06$ $M_\odot$ was estimated using an upper limit of the protostellar age of $\tau_* \lesssim (4 \pm 1) \times 10^3$ yrs and an inferred non-spherical steady mass accretion rate of $\sim 1 \times 10^{-5}$ $M_\odot$ yr^{-1}. Together with results from an SED analysis, we discuss that the outflow system is driven by a protostar whose surface temperature of $\sim 3,000$ K, and that the natal cloud core is being dispersed by the outflow.

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19 ALMA Observations of the massive molecular outflow G331.512−0.103 II: physical properties, kinematics, and geometry modeling

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We present observations and analysis of the massive molecular outflow G331.512−0.103, obtained with ALMA band 7, continuing the work from Merello et al. (2013). Several lines were identified in the observed bandwidth, consisting of two groups: lines with narrow profiles, tracing the emission from the core ambient medium; and lines with broad velocity wings, tracing the outflow and shocked gas emission. The physical and chemical conditions, such as density, temperature, and fractional abundances are calculated. The ambient medium, or core, has a mean density of $\sim 5 \times 10^6$ cm^{-3} and a temperature of $\sim$70 K. The SiO and SO_2 emission trace the very dense and hot part of the shocked outflow, with values of $n_{H_2} \sim 10^9$ cm^{-3} and $T \sim$ 160–200 K. The interpretation of the molecular emission suggests an expanding cavity geometry powered by stellar winds from a new-born UCHII region, alongside a massive and high-velocity molecular outflow. This scenario, along with the estimated physical conditions, is modeled using the 3D geometry radiative transfer code MOLLIE for the SiO(J=8–7) molecular line. The main features of the outflow and the expanding shell are reproduced by the model.

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20 Gaia 17bpi: An FU Ori Type Outburst

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We report on the source Gaia 17bpi and identify it as a new, ongoing FU Ori type outburst, associated with a young stellar object. The optical lightcurve from *Gaia* exhibited a 3.5 mag rise with the source appearing to plateau in mid/late 2018. Mid-infrared observations from *NEOWISE* also show a >3 mag rise that occurred in two stages, with the second one coincident with the optical brightening, and the first one preceeding the optical brightening by $\sim$1.5

years. We model the outburst as having started between October and December of 2014. This wavelength-dependent aspect of young star accretion-driven outbursts has never been documented before. Both the mid-infrared and the optical colors of the object become bluer as the outburst proceeds. Optical spectroscopic characteristics in the outburst phase include: a GK-type absorption spectrum, strong wind/outflow in e.g. Mgb, NaD, Hα, KI, OI, and CaII profiles, and detection of LiI 6707 Å. The infrared spectrum in the outburst phase is similar to that of an M-type spectrum, notably exhibiting prominent H_2O and ^{12}CO (2-0) bandhead absorption in the K-band, and likely HeI wind in the Y-band. The new FU Ori source Gaia 17bpi is associated with a little-studied dark cloud in the galactic plane, located at a distance of 1.27 kpc.

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21 On the resolution requirements for modelling molecular gas formation in solar neighbourhood conditions

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The formation of molecular hydrogen (H_2) and carbon monoxide (CO) is sensitive to the volume and column density distribution of the turbulent interstellar medium. In this paper, we study H_2 and CO formation in a large set of hydrodynamical simulations of periodic boxes with driven supersonic turbulence, as well as in colliding flows with the Flash code. The simulations include a non-equilibrium chemistry network, gas self-gravity, and diffuse radiative transfer. We investigate the spatial resolution required to obtain a converged H_2 and CO mass fraction and formation history. From the numerical tests we find that H_2 converges at a spatial resolution of $\lesssim 0.2$ pc, while the required resolution for CO convergence is $\lesssim 0.04$ pc in gas with solar metallicity which is subject to a solar neighbourhood interstellar radiation field. We derive two critical conditions from our numerical results: the simulation has to at least resolve the densities at which (1) the molecule formation time in each cell in the computational domain is equal to the dissociation time, and (2) the formation time is equal to the the typical cell crossing time. For both H_2 and CO, the second criterion is more restrictive. The formulae we derive can be used to check whether molecule formation is converged in any given simulation.

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22 CO Outflow Survey of 68 Very Low Luminosity Objects: a Search for Proto-Brown Dwarf Candidates

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We present the results of a systematic search for molecular outflows in 68 Very Low Luminosity Objects (VeLLOs) from single-dish observations in CO isotopologues which find 16 VeLLOs showing clear outflow signatures in the

CO maps. With additional three VeLLOs from the literature, we analyzed the outflow properties for 19 VeLLOs, identifying 15 VeLLOs as proto-Brown Dwarf (BD) candidates and four VeLLOs as likely faint protostar candidates. The proto-BD candidates are found to have a mass accretion rate ($\sim 10^{-8} - 10^{-7}$ M$_\odot$ yr^{-1}) lower than that of the protostar candidates ($\gtrsim 10^{-6}$ M$_\odot$ yr^{-1}). Their accretion luminosities are similar to or smaller than their internal luminosities, implying that many proto-BD candidates might have had either small accretion activity in a quiescent manner throughout their lifetime, or be currently exhibiting a relatively higher (or episodic) mass accretion than the past. There are strong trends that outflows of many proto-BDs are less active if they are fainter or have less massive envelopes. The outflow forces and internal luminosities for more than half of the proto-BD candidates seem to follow an evolutionary track of a protostar with its initial envelope mass of $\sim$0.08 M$_\odot$, indicating that some BDs may form in less massive dense cores in a way similar to normal stars. But, because there also exists a significant fraction (about 40%) of proto-BDs with much weaker outflow force than expected by the relations for protostars, we should not rule out the possibility of other formation mechanism for the BDs.

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23 Dependence of Hall Coefficient on Grain Size and Cosmic Ray Rate and Implication for Circumstellar Disk Formation

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The Hall effect plays a significant role in star formation because it induces rotation in the infalling envelope, which in turn affects the formation and evolution of the circumstellar disk. The importance of the Hall effect varies with the Hall coefficient, and this coefficient is determined by the fractional abundances of charged species. These abundance values are primarily based on the size and quantity of dust grains as well as the cosmic ray intensity, which respectively absorb and create charged species. Thus, the Hall coefficient varies with both the properties of dust grains and the cosmic ray rate (or ionization source). In this study, we explore the dependence of the Hall coefficient on the grain size and cosmic ray ionization rate using a simplified chemical network model. Following this, using an analytic model, we estimate the typical size of a circumstellar disk induced solely by the Hall effect. The results show that the disk grows during the main accretion phase to a size of $\sim$ 3 - 100 au, with the actual size depending on the parameters. These findings suggest that the Hall effect greatly affects circumstellar disk formation, especially in the case that the dust grains have a typical size of $\sim$ 0.025 μm - 0.075 μm.

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24 The outbursting protostar 2MASS 22352345+7517076 and its environment

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We studied the Class I protostar 2MASS 22352345+7517076 whose dramatic brightening between the *IRAS*, *Akari*, and *WISE* surveys was reported by Onozato et al. (2015). 2MASS 22352345+7517076 is a member of a small group of low-mass young stellar objects, associated with IRAS 22343+7501 in the molecular cloud Lynds 1251. The *IRAS*, *ISO*, *Spitzer*, *Akari*, *Herschel*, and *WISE* missions observed different stages of its outburst. Supplemented these data with archival and our own near-infrared observations, and considering the contributions of neighbouring sources to the mid-infrared fluxes we studied the nature and environment of the outbursting object, and its photometric variations from 1983 to 2017. The low-state bolometric luminosity $L_{\rm bol} \approx 32\,{\rm L}_\odot$ is indicative of a 1.6–1.8M$_\odot$, 1–2$\times10^5$ years

old protostar. Its 2-μm brightness started rising between 1993 and 1998, reached a peak in 2009–2011, and started declining in 2015. Changes in the spectral energy distribution suggest that the outburst was preceded by a decade-long, slow brightening in the near-infrared. The actual accretion burst occurred between 2004 and 2007. We fitted the spectral energy distribution in the bright phases with simple accretion disc models. The modelling suggested an increase of the disc accretion rate from $\sim 3.5 \times 10^{-7}\, M_{\odot}\, yr^{-1} to \sim 1.1 \times 10^{-4}\, M_{\odot}\, yr^{-1}$. The central star accreted nearly 10^{-3}M$_{\odot}$, about a Jupiter mass during the ten years of the outburst. We observed H_2 emission lines in the K-band spectrum during the fading phase in 2017. The associated optical nebulosity RNO 144 and the Herbig–Haro object HH 149 have not exhibited significant variation in shape and brightness during the outburst.

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25 Characterising the high-mass star forming filament G351.776–0.527 with Herschel and APEX dust continuum and gas observations

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G351.776-0.527 is among the most massive, closest, and youngest filaments in the inner Galactic plane and therefore it is an ideal laboratory to study the kinematics of dense gas and mass replenishment on a large scale. In this paper, we present far-infrared (FIR) and submillimetre wavelength continuum observations combined with spectroscopic $C^{18}O$ (2–1) data of the entire region to study its temperature, mass distribution, and kinematics. The structure is composed of a main elongated region with an aspect ratio of ~ 23, which is associated with a network of filamentary structures. The main filament has a remarkably constant width of 0.2 pc. The total mass of the network (including the main filament) is $\geq 2600\,M_{\odot}$, while we estimate a mass of $\sim 2000\,M_{\odot}$ for the main structure. Therefore, the network harbours a large reservoir of gas and dust that could still be accreted onto the main structure. From the analysis of the gas kinematics, we detect two velocity components in the northern part of the main filament. The data also reveal velocity oscillations in $C^{18}O$ along the spine in the main filament and in at least one of the branches. Considering the region as a single structure, we find that it is globally close to virial equilibrium indicating that the entire structure is approximately in a stable state.

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26 Catalogue of High Protostellar Surface Density Regions in Nearby Embedded Clusters

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We analyze high-quality stellar catalogs for 24 young and nearby (within 1 kpc) embedded clusters and present a catalogue of 32 groups which have a high concentration of protostars. The median effective radius of these groups is 0.17 pc. The median protostellar and pre-main sequence star surface densities are 46 $M_\odot$ pc^{-2} and 11 $M_\odot$ pc^{-2}, respectively. We estimate the age of these groups using a model of constant birthrate and random accretion stopping and find a median value of 0.25 Myr. Some groups in Aquila and Serpens, Corona Australia and Ophichus L1688 show high protostellar surface density and high molecular gas surface density, which seem to be undergoing vigorous star formation. These groups provide an excellent opportunity to study initial conditions of clustered star formation. Comparison of protostellar and pre-main-sequence stellar surface densities reveal continuous low-mass star formation of these groups over several Myr in some clouds. For groups with typical protostellar separations of less than 0.4 pc, we find that these separations agree well with the thermal Jeans fragmentation scale. On the other hand, for groups with typical protostellar separations larger than 0.4 pc, these separations are always larger than the associated Jeans length.

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Evolutionary models of cold and low-mass planets: Cooling curves, magnitudes, and detectability

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Future instruments like NIRCam and MIRI on JWST or METIS at the ELT will be able to image exoplanets that are too faint (because of a low mass, and hence a small size or low effective temperature) for current direct imaging instruments. On the theoretical side, core accretion formation models predict a significant population of low-mass and/or cool planets at orbital distances of $\sim$ 10–100 au. Evolutionary models predicting the planetary intrinsic luminosity as a function of time have traditionally concentrated on gas-dominated giant planets. We extend these cooling curves to Saturnian and Neptunian planets.We simulate the cooling of isolated core-dominated and gas giant planets with masses of 5 Earth masses to 2 Jupiter masses. The planets consist of a core made of iron, silicates, and ices, surrounded by a H/He envelope, similar to the ice giants in the solar system. The luminosity includes the contribution from the cooling and contraction of the core and of the H/He envelope, as well as radiogenic decay. For the atmosphere we use grey, `AMES-Cond`, `petitCODE`, and `HELIOS` models. We consider solar and non-solar metallicities as well as cloud-free and cloudy atmospheres. The most important initial conditions, namely the core-to-envelope ratio and the initial (i.e., post formation) luminosity are taken from planet formation simulations based on the core accretion paradigm.We first compare our cooling curves for Uranus, Neptune, Jupiter, Saturn, GJ 436b, and a 5 Earth masses planet with a 1% H/He envelope with other evolutionary models. We then present the temporal evolution of planets with masses between 5 Earth masses and 2 Jupiter masses in terms of their luminosity, effective temperature, radius, and entropy. We discuss the impact of different post formation entropies. For the different atmosphere types and initial conditions magnitudes in various filter bands between 0.9 and 30 micrometer wavelength are provided. Using black body fluxes and non-grey spectra, we estimate the detectability of such planets with JWST. It is found that a 20 (100) Earth masses planet can be detected with JWST in the background limit up to an age of about 10 (100) Myr with NIRCam and MIRI, respectively.

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28 ALMA Detection of Extended Millimeter Halos in the HD 32297 and HD 61005 Debris Disks

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We present ALMA 1.3 mm (230 GHz) observations of the HD 32297 and HD 61005 debris disks, two of the most iconic debris disks due to their dramatic swept-back wings seen in scattered light images. These observations achieve sensitivities of 14 and 13 μJy beam^{-1} for HD 32297 and HD 61005, respectively, and provide the highest resolution images of these two systems at millimeter wavelengths to date. By adopting a MCMC modeling approach, we determine that both disks are best described by a two-component model consisting of a broad ($\Delta R/R > 0.4$) planetesimal belt with a rising surface density gradient, and a steeply falling outer halo aligned with the scattered light disk. The inner and outer edges of the planetesimal belt are located at 78.5±8.1 AU and 122±3 AU for HD 32297, and 41.9±0.9 AU and 67.0±0.5 AU for HD 61005. The halos extend to 440±32 AU and 188±8 AU, respectively. We also detect ^{12}CO J=2–1 gas emission from HD 32297 co-located with the dust continuum. These new ALMA images provide observational evidence that larger, millimeter-sized grains may also populate the extended halos of these two disks previously thought to only be composed of small, micron-sized grains. We discuss the implications of these results for potential shaping and sculpting mechanisms of asymmetric debris disks.

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29 The JCMT Transient Survey: An Extraordinary Submillimetre Flare in the T Tauri Binary System JW 566

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The binary T Tauri system JW 566 in the Orion Molecular Cloud underwent an energetic, short-lived flare observed at submillimetre wavelengths by the SCUBA-2 instrument on 26 November 2016 (UT). The emission faded by nearly 50% during the 31 minute integration. The simultaneous source fluxes averaged over the observation are 500 +/- 107 mJy/beam at 450 microns and 466 +/- 47 mJy/beam at 850 microns. The 850 micron flux corresponds to a radio luminosity of $L_\nu = 8 \times 10^{19}$ erg/s/Hz, approximately one order of magnitude brighter (in terms of νL_ν) than that of a flare of the young star GMR-A, detected in Orion in 2003 at 3mm. The event may be the most luminous known flare associated with a young stellar object and is also the first coronal flare discovered at sub-mm wavelengths. The spectral index between 450 microns and 850 microns of $\alpha = 0.11$ is broadly consistent with non-thermal emission. The brightness temperature was in excess of 6×10^4 K. We interpret this event to be a magnetic reconnection that

energised charged particles to emit gyrosynchrotron/synchrotron radiation.

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30 Structure of a protobinary system: an asymmetric circumbinary disk and spiral arms

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We investigate the gas structures around young binary stars by using three-dimensional numerical simulations. Each model exhibits circumstellar disks, spiral arms, and a circumbinary disk with an inner gap or cavity. The circumbinary disk has an asymmetric pattern rotating at an angular velocity of approximately one-fourth of the binary orbit of the moderate-temperature models. Because of this asymmetry, the circumbinary disk has a density bump and a vortex, both of which continue to exist until the end of our calculation. The density bump and vortex are attributed to enhanced angular momentum, which is promoted by the gravitational torque of the stars. In a hot model ($c \geq 2.0$), the asymmetry rotates considerably more slowly than in the moderate-temperature models. The cold models ($c \leq 0.02$) exhibit eccentric circumbinary disks, the precession of which is approximated by a secular motion of the ballistic particles. The asymmetry in the circumbinary disk does not depend on the mass ratio, but it becomes less clear as the specific angular momentum of the infalling envelope increases. The relative accretion rate onto the stars is sensitive to the angular momentum of the infalling envelope. For envelopes with constant angular momentum, the secondary tends to have a higher accretion rate than the primary, except in very low angular momentum cases. For envelopes with a constant angular velocity, the primary has a higher accretion rate than the secondary because gas with low specific angular momentum falls along the polar directions.

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31 On the episodic excursions of massive protostars in the Hertzsprung-Russell diagram

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Massive protostars grow and evolve under the effect of rapid accretion of circumstellar gas and dust, falling at high rates ($\geq 10^{-4}$-$10^{-3}\,\mathrm{M}_\odot\,\mathrm{yr}^{-1}$). This mass infall has been shown, both numerically and observationally, to be episodically interspersed by accretion of dense gaseous clumps migrating through the circumstellar disc to the protostellar surface, causing sudden accretion and luminous bursts. Using numerical gravito-radiation-hydrodynamics and stellar evolution calculations, we demonstrate that, in addition to the known bloating of massive protostars, variable episodic accretion further influences their evolutionary tracks of massive young stellar objects (MYSOs). For each accretion-driven flare, they experience rapid excursions toward more luminous, but colder regions of the Hertzsprung-Russell diagram. During these excursions, which can occur up to the end of the pre-main-sequence evolution, the photosphere of massive protostars can episodically release much less energetic photons and MYSOs surreptitiously adopt the same spectral type as evolved massive (supergiants) stars. Each of these evolutionary loop brings the young high-mass stars close to the forbidden Hayashi region and might make their surrounding H IIregions occasionally fainter, before they

recover their quiescent, pre-burst surface properties. We interpret such cold, intermittent pre-main-sequence stellar evolutionary excursions and the dipping variability of HII regions as the signature of the presence of a fragmenting circumstellar accretion disc surrounding the MYSOs. We conjecture that this mechanism might equivalently affect young stars in the intermediate-mass regime.

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32 The Zeeman Effect in the 44 GHz Class I Methanol (CH_3OH) Maser Line Toward DR21W

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We report the detection of the Zeeman effect in the 44 GHz Class I methanol maser line toward the high mass star forming region DR21W. There are two prominent maser spots in DR21W at the ends of a northwest-southeast linear arrangement. For the maser at the northwestern end (maser A), we fit three Gaussian components. In the strongest component, we obtain a significant Zeeman detection, with $zB_{\rm los} = -23.4 \pm 3.2$ Hz. If we use $z = -0.920$ Hz mG^{-1} for the $F = 5 \rightarrow 4$ hyperfine transition, this corresponds to a magnetic field $|B_{\rm los}| = 25.4$ mG; $B_{\rm los}$ would be higher if a different hyperfine was responsible for the 44 GHz maser, but our results also rule out some hyperfines, since fields in these regions cannot be hundreds of mG. Class I methanol masers form in outflows where shocks compress magnetic fields in proportion to gas density. Designating our detected $B_{\rm los} = 25$ mG as the magnetic field in the post-shock gas, we find that $B_{\rm los}$ in the pre-shock gas should be 0.1–0.8 mG. Although there are no thermal-line Zeeman detections toward DR21W, such values are in good agreement with Zeeman measurements in the CN thermal line of 0.36 and 0.71 mG about $3'.5$ away in DR21(OH) in gas of comparable density to the pre-shock gas density in DR21W. Comparison of our derived magnetic energy density to the kinetic energy density in DR21W indicates that magnetic fields likely play a significant role in shaping the dynamics of the post-shocked gas in DR21W.

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33 Shock-Generating Planetesimals Perturbed by a Giant Planet in a Gas Disk

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We examined the excitations of planetesimals caused by the resonances of a giant planet in a protoplanetary gas disk. The highly excited planetesimals generate bow shocks, the mechanism of which results in chondrule formation, crystallization of silicate dust, and evaporation of icy planetesimals. The planetesimals beyond 2:1 resonance migrate owing to the gas drag and obtain the maximum eccentricity around 3:1 resonance, which is located at approximately half the planetary distance. The eccentricity depends on the parameters of the planetesimals and the Jovian planet, such as size and location, and gas density of the disk. The maximum relative velocity of a 100-km-sized planetesimal with respect to the gas disk reaches up to $\sim$12 km s^{-1} in the case of Jupiter owing to secular resonance, which occurs because of the disk's gravity. We find that if a Jovian mass planet is located within 10 au, the planetesimals larger than 100 km gain sufficient velocity to cause the melting of chondrule precursors and crystallization of the silicate. The maximum velocity is higher for large planetesimals and eccentric planets. Planetesimals are trapped temporarily in the resonances and continue to have high speed over >1 Myr after the formation of a Jovian planet. This duration fits into the timescale of chondrule formation suggested by the isotopic data. The evaporation of icy planetesimals

occurs when a Jovian planet is located within 15 au. This mechanism can be a new indicator of planet formation in exosystems if some molecules ejected from icy planetesimals are detected.

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Gaia-DR2 confirms VLBA parallaxes in Ophiuchus, Serpens and Aquila

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We present Gaia-DR2 astrometry of a sample of YSO candidates in Ophiuchus, Serpens Main and Serpens South/W40 in the Aquila Rift, which had been mainly identified by their infrared excess with Spitzer. We compare the Gaia-DR2 parallaxes against published and new parallaxes obtained from our Very Long Baseline Array (VLBA) program GOBELINS. We obtain consistent results between Gaia and the VLBA for the mean parallaxes in each of the regions analyzed here. We see small offsets, when comparing mean values, of a few tens of micro-arcseconds in the parallaxes, which are either introduced by the Gaia zero-point error or due to a selection effect by Gaia toward the brightest, less obscured stars. Gaia-DR2 data alone conclusively places Serpens Main and Serpens South at the same distance, as we first inferred from VLBA data alone in a previous publication. Thus, Serpens Main, Serpens South and W40 are all part of the same complex of molecular clouds, located at a mean distance of 436±9 pc. In Ophiuchus, both Gaia and VLBA suggest a small parallax gradient across the cloud, and the distance changes from 144.2±1.3 pc to 138.4±2.6 pc when going from L1689 to L1688.

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ALMA Observations of Ethyl Formate toward Orion KL

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Orion KL is one of the prime templates of astrochemical and prebiotic chemical studies. We wish to explore more organic molecules with increasing complexity in this region. In particular, we have searched for one of the most complex organic molecules detected in space so far, ethyl formate (C_2H_5OCHO). This species is the next step in chemical complexity after the simplest member of esters (methyl formate, CH_3OCHO). The mechanisms leading to its formation are still poorly known. We have used high angular resolution ($\sim 1.''5$) ALMA observations covering a large bandwidth from 214 to 247 GHz. We have detected 82 unblended lines of C_2H_5OCHO (49 and 33 of the trans and gauche conformers, respectively). The line images showed that C_2H_5OCHO arises mainly from the compact ridge and the hot core-southwest regions. The derived rotational temperatures and column densities are 122 ± 34 K, (0.9 ± 0.3) × 10^{16} cm^{-2} for the hot core-SW, and 103 ± 13 K, (0.6 ± 0.3) × 10^{16} cm^{-2} for the compact ridge. The comparison of spatial distribution and abundance ratios with chemically related molecules (methyl formate, ethanol and formic acid) indicates that C_2H_5OCHO is likely formed on the surface of dust grains by addition of CH_3 to functional-group radicals (CH_2OCHO) derived from methyl formate (CH_3OCHO)

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36 Unveiling the nature of candidate high-mass young stellar objects in the Magellanic Clouds with near-IR spectroscopy

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As nearby neighbors to the Milky Way, the Large and Small Magellanic Clouds (LMC and SMC) provide a unique opportunity to study star formation in the context of their galactic ecosystems. Thousands of young stellar objects (YSOs) have been characterized with large-scale Spitzer and Herschel surveys. In this paper, we present new near-IR spectroscopy of five high-mass YSOs in the LMC and one in the SMC. We detect multiple hydrogen recombination lines, as well as He I 2.058 μm, H_2, [Fe II], and [S III] in these highly excited sources. We estimate the internal extinction of each source and find that it is highest for sources with the youngest evolutionary classifications. Using line ratios, we assess the dominant excitation mechanism in the three sources where we detect both H_2 2.12 μm and [Fe II] 1.64 μm. In each case, photoexcitation dominates over shock excitation. Finally, we detect CO bandhead absorption in one of our LMC sources. While this feature is often associated with evolved stars, this object is likely young with strong PAH and fine-structure emission lines tracing an H II region detected at longer wavelengths. Compared to high-mass YSOs in the Galaxy, our sources have higher bolometric and line luminosities, consistent with their selection as some of the brightest sources in the LMC and SMC.

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37 A 6.7 GHz methanol maser survey of the central molecular zone

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The Central Molecular Zone (CMZ) spans the inner ∼450 pc (∼3deg) of our Galaxy. This region is defined by its enhanced molecular emission and contains 5% of the entire Galaxy's molecular gas mass. However, the number of detected star forming sites towards the CMZ may be low for the amount of molecular gas that is present, and improved surveys of star formation indicators can help clarify this. With the Karl G Jansky Very Large Array (VLA), we conducted a blind survey of 6.7 GHz methanol masers spanning the inner 3deg × 40arcmin (450 pc × 100 pc) of the Galaxy. We detected 43 methanol masers towards 28 locations, 16 of which are new detections. The velocities of most of these masers are consistent with being located within the CMZ. A majority of the detected methanol masers are distributed towards positive Galactic longitudes, similar to 2/3 of the molecular gas mass distributed at positive Galactic longitudes. The 6.7 GHz methanol maser is an excellent indicator of high mass (> 8 solar mass) star formation, with new detections indicating sites of massive star formation in the CMZ.

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38 **Flat Spectrum Radio Continuum Emission Associated with ϵ Eridani**

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We present Very Large Array observations at 33.0 GHz that detect emission coincident with ϵ Eridani to within $0\farcs07$ (0.2 AU at the distance of this star), with a positional accuracy of $0\farcs05$. This result strongly supports the suggestion of previous authors that the quiescent centimeter emission comes from the star and not from a proposed giant exoplanet with a semi-major axis of $\sim 1\farcs0$ (3.4 AU). The centimeter emission is remarkably flat and is consistent with optically thin free-free emission. In particular, it can be modeled as a stellar wind with a mass loss rate of the order of $6.6 \times 10^{-11}\ M_\odot\ \mathrm{yr}^{-1}$, which is 3,300 times the solar value, exceeding other estimates of this star's wind. However, interpretation of the emission in terms of other thermal mechanisms like coronal free-free and gyroresonance emission cannot be discarded.

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39 **Evolution of Hubble wedges in episodic protostellar outflows**

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

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40 **Evidence of Hubble flow-like motion of young stellar populations away from the Perseus arm**

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In this letter we present evidence of coherent outward motion of a sample of young stars (t <30 Myr) in the Perseus Arm, whose apparent origin is located in the vicinity of the W3/W4/W5 complex. Using astrometric and photometric data from the Gaia DR2 catalog of an 8° radius field centered near W4, we selected a sample of young, intermediate to high-mass star candidates. The sample is limited to sources with parallax uncertainties below 20% and Bayesian distance estimates within 1800 and 3100 pc. The selection includes embedded stellar populations as well as young open clusters. Projected velocities derived from perspective-corrected proper motions clearly suggest that the young star population emerge from the Perseus arm, with a possible convergence zone near W3/W4/W5 region, tracing a front that expands away at a rate of about 15 km s^{-1} kpc^{-1}.

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41 Identifying Young Stellar Objects in the Outer Galaxy: $l = 224°$ Region in Canis Major

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We study a very young star-forming region in the outer Galaxy that is the most concentrated source of outflows in the *Spitzer Space Telescope* GLIMPSE360 survey. This region, dubbed CMa–l224, is located in the Canis Major OB1 association. CMa–l224 is relatively faint in the mid-infrared, but it shines brightly at the far-infrared wavelengths as revealed by the *Herschel Space Observatory* data from the Hi-GAL survey. Using the 3.6 and 4.5 μm data from the *Spitzer*/GLIMPSE360 survey, combined with the JHK_s 2MASS and the 70–500 μm *Herschel*/Hi-GAL data, we develop a young stellar object (YSO) selection criteria based on color-color cuts and fitting of the YSO candidates' spectral energy distributions with YSO 2D radiative transfer models. We identify 293 YSO candidates and estimate physical parameters for 210 sources well-fit with YSO models. We select an additional 47 sources with GLIMPSE360-only photometry as 'possible YSO candidates'. The vast majority of these sources are associated with high H_2 column density regions and are good targets for follow-up studies. The distribution of YSO candidates at different evolutionary stages with respect to *Herschel* filaments supports the idea that stars are formed in the filaments and become more dispersed with time. Both the supernova-induced and spontaneous star formation scenarios are plausible in the environmental context of CMa–l224. However, our results indicate that a spontaneous gravitational collapse of filaments is a more likely scenario. The methods developed for CMa–l224 can be used for larger regions in the Galactic plane where the same set of photometry is available.

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IRAM and Gaia views of multi-episodic star formation in IC1396A: The origin and dynamics of the Class 0 protostar at the edge of an HII region

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IC 1396A is a cometary globule that contains the Class 0 source IC1396A-PACS-1, discovered with *Herschel*.
We use IRAM 30m telescope and Gaia DR2 data to explore the star-formation history of IC 1396A and investigate the possibilities of triggered star formation.
IRAM and *Herschel* continuum data are used to obtain dust temperature and column density maps. Heterodyne data reveal the velocity structure of the gas. Gaia DR2 proper motions for the stars complete the kinematics of the region.
IC1396A-PACS-1 presents molecular emission similar to a hot corino with warm carbon chain chemistry due to the UV irradiation. The source is embedded in a dense clump surrounded by gas at velocities significantly different from the velocities of the Tr 37 cluster. CN emission reveals photoevaporation, while continuum data and high density tracers ($C^{18}O$, HCO^+, DCO^+, N_2D^+) reveal distinct gaseous structures with a range of densities and masses.
Combining the velocity, column density, and temperature information and Gaia DR2 kinematics, we confirm that the globule has suffered various episodes of star formation. IC1396A-PACS-1 is probably the last intermediate-mass protostar that will form within IC 1396A, showing evidence of triggering by radiative driven implosion. Chemical signatures such as CCS place IC1396A-PACS-1 among the youngest protostars known. Gaia DR2 data reveal velocities in the plane of the sky $\sim$4 km/s for IC 1396A with respect to Tr 37. The total velocity difference (8 km/s) between the Tr 37 cluster and IC 1396A is too small for IC 1396A to have undergone substantial rocket acceleration, which imposes constraints on the distance to the ionizing source in time and the possibilities of triggered star formation. The three stellar populations in the globule reveal that objects located within relatively close distances ($<$0.5 pc) can be formed in various star-forming episodes within $\sim$1-2 Myr period. Once the remaining cloud disperses, we expect substantial differences in evolutionary stage and initial conditions for the resulting objects and their protoplanetary disks, which may affect their evolution. Finally, evidence for short-range feedback from the embedded protostars and, in particular, the A-type star V390 Cep is also observed.

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Chandra Observations of the Massive Star-Forming Region Onsala 2

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Previous radio and infrared observations have revealed an obscured region of high-mass star formation in Cygnus known as Onsala 2 (ON 2). Within this region lies the optically-revealed young stellar cluster Berkeley 87 which contains several OB stars and the rare oxygen-type Wolf-Rayet star WR 142. Previous radio studies of ON 2 have also discovered masers and several H II regions excited by embedded OB stars. Radio and GAIA parallaxes have now shown that the H II regions are more distant than Berkeley 87. We summarize two *Chandra* X-ray observations of ON 2 which detected more than 300 X-ray sources. Several optically-identified stars in Berkeley 87 were detected including massive OB stars and WR 142, the latter being a faint hard source whose X-ray emission likely arises in hot thermal plasma. Intense X-ray emission was detected near the compact H II regions G75.77+0.34 and G75.84+0.40 consisting of numerous point sources and diffuse emission. Heavily-absorbed X-ray sources and their near-IR counterparts that may be associated with the exciting OB stars of the H II regions are identified. Shocked winds from embedded massive stars offer a plausible explanation of the diffuse emission. Young stellar object candidates in the ON 2 region are identified using near-IR colors, but surprisingly few counterparts of X-ray sources have near-IR excesses typical of classical T Tauri stars.

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Multicomponent kinematics in a massive filamentary IRDC

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To probe the initial conditions for high-mass star and cluster formation, we investigate the properties of dense filaments within the infrared dark cloud G035.39−00.33 (IRDC G035.39) in a combined Very Large Array (VLA) and the Green Bank Telescope (GBT) mosaic tracing the NH_3 (1,1) and (2,2) emission down to 0.08 pc scales. Using agglomerative hierarchical clustering on multiple line-of-sight velocity component fitting results, we identify seven extended velocity-coherent components in our data, likely representing spatially coherent physical structures, some exhibiting complex gas motions. The velocity gradient magnitude distribution peaks at its mode of 0.35 km s^{-1} pc^{-1} and has a long tail extending into higher values of 1.5–2 km s^{-1} pc^{-1}, and is generally consistent with those found toward the same cloud in other molecular tracers and with the values found towards nearby low-mass dense cloud cores at the same scales. Contrary to observational and theoretical expectations, we find the non-thermal ammonia line widths to be systematically narrower (by about 20%) than those of N_2H^+ (1–0) line transition observed with similar resolution. If the observed ordered velocity gradients represent the core envelope solid-body rotation, we estimate the specific angular momentum to be about 2×10^{21} cm^2 s^{-1}, similar to the low-mass star-forming cores. Together with the previous finding of subsonic motions in G035.39, our results demonstrate high levels of similarity between kinematics of a high-mass star-forming IRDC and the low-mass star formation regime.

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On the Gravitational Instabilities of Protoplanetary Disks

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The gravitational instabilities are important to the evolution of the disks and the planet formation in the disks. We calculate the evolution of the disks which form from the collapse of the molecular cloud cores. By changing the properties of the cloud cores and the hydrodynamical viscosity parameters, we explore their effects on the properties of the gravitational instabilities. We find that the disk is unstable when the angular velocity of the molecular cloud core is larger than a critical value. The time duration of the instability increases as the angular velocity of the core increases. The increase of the hydrodynamical viscosity parameter hardly affects the stability of the disk, but decreases

the time duration of the critical state of the gravitational instability in the disk. The instability of the disks can happen at very early time of evolution of the disk, which is consistent with the observations.

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The CARMA-NRO Orion Survey: The filamentary structure as seen in $C^{18}O$ emission

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We present an initial overview of the filamentary structure in the Orion A molecular cloud utilizing a high angular and velocity resolution $C^{18}O$(1-0) emission map that was recently produced as part of the CARMA-NRO Orion Survey. The main goal of this study is to build a credible method to study varying widths of filaments which has previously been linked to star formation in molecular clouds. Due to the diverse star forming activities taking place throughout its ?20 pc length, together with its proximity of 388 pc, the Orion A molecular cloud provides an excellent laboratory for such an experiment to be carried out with high resolution and high sensitivity. Using the widely-known structure identification algorithm, DisPerSE, on a 3-dimensional (PPV) $C^{18}O$ cube, we identified 625 relatively short (the longest being 1.74 pc) filaments over the entire cloud. We study the distribution of filament widths using FilChaP, a python package that we have developed and made publicly available. We find that the filaments identified in a 2 square degree PPV cube do not overlap spatially, except for the complex OMC-4 region that shows distinct velocity components along the line of sight. The filament widths vary between 0.02 and 0.3 pc depending on the amount of substructure that a filament possesses. The more substructure a filament has, the larger is its width. We also find that despite this variation, the filament width shows no anticorrelation with the central column density which is in agreement with previous Herschel observations.

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The formation of rings and gaps in wind-launching non-ideal MHD disks: three-dimensional simulations

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Previous axisymmetric investigations in two dimensions (2D) have shown that rings and gaps develop naturally in non-ideal magnetohydrodynamic (MHD) disk-wind systems, especially in the presence of ambipolar diffusion (AD). Here we extend these 2D simulations to three dimensions (3D) and find that rings and gaps are still formed in the presence of a moderately strong ambipolar diffusion. The rings and gaps form from the same basic mechanism that was identified in the 2D simulations, namely, the redistribution of the poloidal magnetic flux relative to the disk material as a result of the reconnection of a sharply pinched poloidal magnetic field lines. Thus, the less dense gaps are more strongly magnetized with a large poloidal magnetic field compared to the less magnetized (dense) rings. The rings and gaps start out rather smoothly in 3D simulations that have axisymmetric initial conditions. Non-axisymmetric variations arise spontaneously at later times, but they do not grow to such an extent as to disrupt the rings and gaps. These disk substructures persist to the end of the simulations, lasting up to 3000 orbital periods at the inner edge of the simulated disk. The longevity of the perturbed yet still coherent rings make them attractive sites for trapping large grains that would otherwise be lost to rapid radial migration due to gas drag. As the ambipolar diffusivity decreases, both the disk and the wind become increasingly turbulent, driven by the magnetorotational instability, with tightly-wound spiral arms becoming more prominent in the disk.

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48 The young star population of L1188

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We present new results on the young star population of the Lynds 1188 molecular cloud, associated with the Cepheus Bubble, a giant interstellar shell around the association Cep OB 2. In order to reveal the star-forming scenario of the molecular cloud located on the supershell, and understand the history of star formation in the region, we identified and characterized young star candidates based on an Hα emission survey and various published photometric datasets. Using Gaia DR2 astrometry we studied the spatial distribution of the young star candidates and isolated three groups based on their distances. We constructed spectral energy distributions of our target stars, based on Pan-STARRS, 2MASS, *Spitzer* and *WISE* photometric data, estimating their spectral types, extinctions, and luminosities. We estimated masses by means of pre-main-sequence evolutionary models, and derived accretion rates from the equivalent width of the Hα line. We studied the structure of the cloud by constructing a new extinction map, based on Pan-STARRS data. Our results show that the distribution of low-mass young stars in L1188 is well correlated with that of the dust and molecular gas. We identified two small, compact clusters and a loose aggregate of young stars. We found that star formation in L1188 started about 5 million years ago. The apparent age gradient of young stars across the cloud and the ammonia cores located to the east of the optically visible young stellar groups support the scenario of star formation propagating away from the centre of the Cepheus Bubble.

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49 ALMA High Angular Resolution Polarization Study; An Extremely Young Class 0 Source, OMC-3/MMS 6

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Using the ≈15 km ALMA long baselines, we imaged the Stokes *I* emission and linearly polarized intensity (*PI*) in the 1.1-mm continuum band of a very young intermediate-mass protostellar source, MMS 6, in the Orion Molecular Cloud-3. The achieved angular resolution, $0\farcs02 \times 0\farcs03$ (≈10 AU), shows for the first time a wealth of data on the dust emission polarization in the central 200 AU of a protostar. The *PI* peak is offset to the south-west (SW) by ≈20 AU with respect to the Stokes *I* peak. Its polarization degree is 11% with its *E*-vector orientation of P.A.≈135°. A partial ring-like structure with a radius of ≈80 AU is detected in *PI* but not in the Stokes *I*. NW (north-west) and SE (south-east) parts of the ring are bright with a high polarization degree of ≳10%, and their *E*-vector orientations are roughly orthogonal to those observed near the center. We also detected arm-like polarized structures, extending to 1000 AU scale to the north, with the *E*-vectors aligned along the minor axis of the structures. We explored possible origins of the polarized emission comparing with magnetohydrodynamical (MHD) simulations of the toroidal wrapping of the magnetic field. The simulations are consistent with the *PI* emission in the ring-like and the extended arm-like structures observed with ALMA. However, the current simulations do not completely reproduce observed polarization characteristics in the central 50 AU. Although the self-scattering model can explain the polarization pattern and positional offset between the Stokes *I* and *PI*, this model is not able to reproduce the observed high degree of polarization.

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50 Time Evolution of 3D Disk Formation with Misaligned Magnetic Field and Rotation Axes

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Distinguishing diagnostic observational signatures produced by MHD models is essential in understanding the physics for the formation of protostellar disks in the ALMA era. Developing suitable tools along with time evolution will facilitate better identification of diagnostic features. With a ray-tracing based radiative transfer code Perspective, we explore time evolution of MHD models carried out in Li, Krasnopolsky & Shang (2013) — most of which have 90° misalignment between the rotational axis and the magnetic field. Four visible object types can be characterized, origins of which are dependent on the initial conditions. Our results show complex spiraling density, velocity and polarization structures. The systems are under constant change, but many of those distinctive features are present already early on, and they grow more visible in time, but most could not be identified from the data without examining their change in time. The results suggest that spiraling pseudodisk structures could function as an effective observation signature of the formation process, and we witness accretion in the disk with eccentric orbits which appear as spiral-like perturbation from simple circular Keplerian orbits. Magnetically aligned polarization appears purely azimuthal in the disk and magnetic field can lead to precession of the disk.

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51 Modeling carbon-chain species formation in lukewarm corinos with new multiphase models

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Context. Abundant carbon-chain species have been observed towards lukewarm corinos L1527, B228, and L483. These carbon-chain species are believed to be synthesized in the gas phase after CH_4 desorbs from the dust grain surface at the temperature around 30 K.
Aims. We investigate carbon-chain species formation in lukewarm corinos using a more rigorous numerical method and advanced surface chemical models. We also pay attention to the significance of the finite size effect.
Methods. We use the macroscopic Monte Carlo method in simulations. In addition to the two-phase model, the basic multiphase model and the new multiphase models are used for modeling surface chemistry on dust grains. All volatile species can sublime at their sublimation temperatures in the two-phase model while most volatile species are frozen in the ice mantle before water ice sublimes in the basic and the new multiphase models. The new multiphase models allow more volatile species to sublime at their sublimation temperatures than the basic multiphase model does.
Results. The significance of the finite size effect is dependent on the duration of the cold phase. The discrepancies between the rate equation approach and the Monte Carlo method decrease as the duration of the cold phase increases. When $T \sim 30\,\mathrm{K}$, the abundances of gaseous CH_4 and CO in the two-phase model are the highest while the basic multiphase model predicts the lowest CO and CH_4 abundances among all models. The abundances of carbon-chain species in the basic and the new multiphase models are lower than that in the two-phase model when $T \sim 30\,\mathrm{K}$ because CH_4 is crucial for the synthesis of carbon-chain species. However, because the abundance of electrons increases as the abundance of H_3O^+ decreases, some carbon-chain species abundances predicted by the basic multiphase model may not be lower than that in the new multiphase models. The two-phase model performs the best to predict carbon-chain species abundances to fit observations while the basic multiphase model works the worst. The abundances of carbon-chain species predicted by the new multiphase models agree reasonably well with observations.
Conclusions. The amount of CH_4 that can diffuse inside the ice mantle, thus sublime upon warm-up plays a crucial role in the synthesis of carbon-chain species in the gas phase. The carbon-chain species observed in lukewarm corinos may be able to gauge surface chemical models.

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52 The role of magnetic fields in the formation of protostellar discs

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The formation of a protostellar disc is a natural outcome during the star formation process. As gas in a molecular cloud core collapses under self-gravity, the angular momentum of the gas will slow its collapse on small scales and promote the formation of a protostellar disc. Although the angular momenta of dense star-forming cores remain to be fully characterized observationally, existing data indicates that typical cores have enough angular momenta to form relatively large, rotationally supported discs. However, molecular clouds are observed to be permeated by magnetic fields, which can strongly affect the evolution of angular momentum through magnetic braking. Indeed, in the ideal MHD limit, magnetic braking has been shown to be so efficient as to remove essentially all of the angular momentum of the material close to the forming star such that disc formation is suppressed. This is known as the magnetic braking catastrophe. The catastrophe must be averted in order for the all-important rotationally supported discs to appear, but when and how this happens remains debated. We review the resolutions proposed to date, with emphasis on misalignment, turbulence and especially non-ideal effects. The dissipative non-ideal effects weaken the magnetic field, and the dispersive term redirects it to promote or hinder disc formation. When self-consistently applying non-ideal

processes, rotationally supported discs of at least tens of au form, thus preventing the magnetic braking catastrophe. The non-ideal processes are sensitive to the magnetic field strength, cosmic ray ionization rate, and gas and dust grain properties, thus a complete understanding of the host molecular cloud is required. Therefore, the properties of the host molecular cloud – and especially its magnetic field – cannot be ignored when numerically modelling the formation and evolution of protostellar discs.

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53 IN-SYNC. VIII. Primordial Disk Frequencies in NGC 1333, IC 348, and the Orion A Molecular Cloud

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In this paper, we address two issues related to primordial disk evolution in three clusters (NGC 1333, IC 348, and Orion A) observed by the INfrared Spectra of Young Nebulous Clusters (IN-SYNC) project. First, in each cluster, averaged over the spread of age, we investigate how disk lifetime is dependent on stellar mass. The general relation in IC 348 and Orion A is that primordial disks around intermediate-mass stars (2–5 Msun) evolve faster than those around loss-mass stars (0.1–1 Msun), which is consistent with previous results. However, considering only low-mass stars, we do not find a significant dependence of disk frequency on stellar mass. These results can help to better constrain theories on gas giant planet formation timescales. Second, in the Orion A molecular cloud, in the mass range of 0.35–0.7Msun, we provide the most robust evidence to date for disk evolution within a single cluster exhibiting modest age spread. By using surface gravity as an age indicator and employing 4.5 micron excess as a primordial disk diagnostic, we observe a trend of decreasing disk frequency for older stars. The detection of intra-cluster disk evolution in NGC 1333 and IC 348 is tentative, since the slight decrease of disk frequency for older stars is a less than 1-sigma effect.

Accepted by ApJ

http://arxiv.org/pdf/1810.06088

54 JCMT POL-2 and ALMA polarimetric observations of 6000–100 au scales in the protostar B335: linking magnetic field and gas kinematics in observations and MHD simulations

Hsi-Wei Yen[1,2], Bo Zhao[3], I-Ta Hsieh[1], Patrick Koch[1], Ruben Krasnopolsky[1], Chin-Fei Lee[1], Zhi-Yun Li[4], Sheng-Yuan Liu[1], Nagayoshi Ohashi[5], Shigehisa Takakuwa[6,1] and Ya-Wen Tang[1]

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We present our analysis of the magnetic field structures from 6000 au to 100 au scales in the Class 0 protostar B335 inferred from our JCMT POL-2 observations and the ALMA archival polarimetric data. To interpret the observational results, we perform a series of (non-)ideal MHD simulations of the collapse of a rotating non-turbulent dense core, whose initial conditions are adopted to be the same as observed in B335, and generate synthetic polarization maps. The comparison of our JCMT and simulation results suggests that the magnetic field on a 6000 au scale in B335 is pinched and well aligned with the bipolar outflow along the east–west direction. Among all our simulations, the

ALMA polarimetric results are best explained with weak magnetic field models having an initial mass-to-flux ratio of 9.6. However, we find that with the weak magnetic field, the rotational velocity on a 100 au scale and the disk size in our simulations are larger than the observational estimates by a factor of several. An independent comparison of our simulations and the gas kinematics in B335 observed with the SMA and ALMA favors strong magnetic field models with an initial mass-to-flux ratio smaller than 4.8. We discuss two possibilities resulting in the different magnetic field strengths inferred from the polarimetric and molecular-line observations, (1) overestimated rotational-to-gravitational energy in B335 and (2) additional contributions in the polarized intensity due to scattering on a 100 au scale.

Accepted by ApJ

https://arxiv.org/pdf/1901.00242

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An Asymmetric Keplerian Disk Surrounding an O-type Protostar

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During the last decades, a great interest has emerged to know if even the most massive stars in our galaxy (namely the spectral O-type stars) are formed in a similar manner as the low- and intermediate-mass stars, that is, through the presence of accreting disks and powerful outflows. Here, using sensitive observations of the Atacama Large Millimeter/Submillimeter Array (ALMA), we report a resolved Keplerian disk (with fifteen synthesized beams across its major axis) surrounding the deeply embedded O-type protostar IRAS16547−4247. The disk shows some asymmetries that could arise because of the disk is unstable and fragmenting or maybe because of different excitation conditions within the disk. The enclosed mass estimated from the disk Keplerian radial velocities is 25±3 $M_\odot$. The molecular disk is at the base of an ionized thermal radio jet and is approximately perpendicular to the jet axis orientation. We additionally find the existence of a binary system of compact dusty objects at the center of the accreting disk, which indicates the possible formation of an O-type star and a companion of lower mass. This is not surprising due to the high binary fraction reported in massive stars. Subtracting the contribution of the dusty disk plus the envelope and the companion, we estimated a mass of 20 $M_\odot$ for the central star.

Accepted by The Astrophysical Journal

http://adsabs.harvard.edu/pdf/2019arXiv190104896Z

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Inclined Massive Planets in a Protoplanetary Disc: Gap Opening, Disc Breaking, and Observational Signatures

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We carry out three-dimensional hydrodynamical simulations to study planet-disc interactions for inclined high mass planets, focusing on the disc's secular evolution induced by the planet. We find that, when the planet is massive enough and the induced gap is deep enough, the disc inside the planet's orbit breaks from the outer disc. The inner and outer discs precess around the system's total angular momentum vector independently at different precession rates, which causes significant disc misalignment. We derive the analytical formulae, which are also verified numerically, for: 1) the relationship between the planet mass and the depth/width of the induced gap, 2) the migration and inclination damping rates for massive inclined planets, and 3) the condition under which the inner and outer discs can break and undergo differential precession. Then, we carry out Monte-Carlo radiative transfer calculations for the simulated

broken discs. Both disc shadowing in near-IR images and gas kinematics probed by molecular lines (e.g. from ALMA) can reveal the misaligned inner disc. The relationship between the rotation rate of the disc shadow and the precession rate of the inner disc is also provided. Using our disc breaking condition, we conclude that the disc shadowing due to misaligned discs should be accompanied by deep gaseous gaps (e.g. in Pre/Transitional discs). This scenario naturally explains both the disc shadowing and deep gaps in several systems (e.g. HD 100453, DoAr 44, AA Tau, HD 143006) and these systems should be the prime targets for searching young massive planets ($>M_{\rm J}$) in discs.

Accepted by MNRAS

http://arxiv.org/pdf/1812.01262

Moving ... ??

If you move or your e-mail address changes, please send the editor your new address. If the Newsletter bounces back from an address for three consecutive months, the address is deleted from the mailing list.

Abstracts of recently accepted major reviews

Star Clusters Across Cosmic Time

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Star clusters stand at the intersection of much of modern astrophysics: the interstellar medium, gravitational dynamics, stellar evolution, and cosmology. Here we review observations and theoretical models for the formation, evolution, and eventual disruption of star clusters. Current literature suggests a picture of this life cycle with several phases: (1) Clusters form in hierarchically-structured, accreting molecular clouds that convert gas into stars at a low rate per dynamical time until feedback disperses the gas. (2) The densest parts of the hierarchy resist gas removal long enough to reach high star formation efficiency, becoming dynamically-relaxed and well-mixed. These remain bound after gas removal. (3) In the first ∼100 Myr after gas removal, clusters disperse moderately fast, through a combination of mass loss and tidal shocks by dense molecular structures in the star-forming environment. (4) After ∼100 Myr, clusters lose mass via two-body relaxation and shocks by giant molecular clouds, processes that preferentially affect low-mass clusters and cause a turnover in the cluster mass function to appear on ∼1–10 Gyr timescales. (5) Even after dispersal, some clusters remain coherent and thus detectable in chemical or action space for multiple galactic orbits. In the next decade a new generation of space- and AO-assisted ground-based telescopes will enable us to test and refine this picture.

Accepted by ARAA

http://arxiv.org/pdf/1812.01615

Solar System formation in the context of extra-solar planets

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Exoplanet surveys have confirmed one of humanity's (and all teenagers') worst fears: we are *weird*. If our Solar System were observed with present-day Earth technology – to put our system and exoplanets on the same footing – Jupiter is the only planet that would be detectable. The statistics of exo-Jupiters indicate that the Solar System is unusual at the ∼1% level among Sun-like stars (or ∼0.1% among all main sequence stars). But why are we different?

This review focuses on global models of planetary system formation. Successful formation models for both the Solar System and exoplanet systems rely on two key processes: orbital migration and dynamical instability. Systems of close-in 'super-Earths' or 'sub-Neptunes' cannot have formed in-situ, but instead require substantial radial inward motion of solids either as drifting mm- to cm-sized pebbles or migrating Earth-mass or larger planetary embryos. We argue that, regardless of their formation mode, the late evolution of super-Earth systems involves migration into chains of mean motion resonances anchored at the inner edge of the protoplanetary disk. The vast majority of resonant chains go unstable when the disk dissipates. The eccentricity distribution of giant exoplanets suggests that migration followed by instability is also ubiquitous in giant planet systems. We present three different models for inner Solar

System formation – the low-mass asteroid belt, Grand Tack, and Early Instability models – each of which invokes a combination of migration and instability. We discuss how each model may be falsified.

We argue that most Earth-sized habitable zone exoplanets are likely to form much faster than Earth, with most of their growth complete within the disk lifetime. Their water contents should span a wide range, from dry rock-iron planets to water-rich worlds with tens of percent water. Jupiter-like planets on exterior orbits may play a central role in the formation of planets with small but non-zero, Earth-like water contents. Water loss during giant impacts and heating from short-lived radioisotopes like ^{26}Al may also play an important role in setting the final water budgets of habitable zone planets.

Finally, we identify the key bifurcation points in planetary system formation. We present a series of events that can explain why our Solar System is so *weird*. Jupiter's core must have formed fast enough to quench the growth of Earth's building blocks by blocking the flux of pebbles drifting inward through the gaseous disk. The large Jupiter/Saturn mass ratio is rare among giant exoplanets but may be required to maintain Jupiter's wide orbit. The giant planets' instability must have been gentle, with no close encounters between Jupiter and Saturn, also unusual in the larger (exoplanet) context. Our Solar System system is thus the outcome of multiple unusual, but not unheard of, events.

Accepted by Planetary Astrobiology (Eds Meadows, Arney, Des Marais, Schmidt)

https://arxiv.org/pdf/1812.01033

The Role of Magnetic Fields in the Formation of Protostellar Discs

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The formation of a protostellar disc is a natural outcome during the star formation process. As gas in a molecular cloud core collapses under self-gravity, the angular momentum of the gas will slow its collapse on small scales and promote the formation of a protostellar disc. Although the angular momenta of dense star-forming cores remain to be fully characterized observationally, existing data indicates that typical cores have enough angular momenta to form relatively large, 100 au-scale, rotationally supported discs, as illustrated by hydrodynamic simulations. However, the molecular clouds are observed to be permeated by magnetic fields, which can in principle strongly affect the evolution of angular momentum during the core collapse through magnetic braking. Indeed, in the ideal magnetohydrodynamic (MHD) limit, magnetic braking has been shown to be so efficient as to remove essentially all of the angular momentum of the material close to the forming star such that disc formation is suppressed. This failure to produce discs in idealized cores is known as the magnetic braking catastrophe. The catastrophe must be averted in order for the all-important rotationally supported discs to appear, but when and how this happens remains debated. We review the resolutions proposed to date, with emphasis on misalignment, turbulence and especially non-ideal effects. Non-ideal MHD accounts for charged and neutral species, making it a natural extension to the ideal MHD approximation, since molecular clouds are only weakly ionized. The dissipative non-ideal effects diffuse the magnetic field to weaken it, and the dispersive term redirects the magnetic field to promote or hinder disc formation, dependent upon the magnetic geometry. When self-consistently applying non-ideal processes, rotationally supported discs of at least tens of au form, thus preventing the magnetic braking catastrophe. The non-ideal processes are sensitive to the magnetic field strength, cosmic ray ionization rate, and gas and dust grain properties, thus a complete understanding of the host molecular cloud is required. Therefore, the properties of the host molecular cloudand especially its magnetic fieldcannot be ignored when numerically modeling the formation and evolution of protostellar discs.

Accepted by Frontiers in Astronomy and Space Sciences

https://www.frontiersin.org/articles/10.3389/fspas.2018.00039/full
http://arxiv.org/pdf/1812.06728

New Jobs

Postdoctoral position in theoretical and numerical star formation

Applications are invited for a three-year Post-Doctoral Research Associate (PDRA) position in The School of Physics and Astronomy at Cardiff University, to work with Professor Anthony Whitworth, on theoretical and numerical star formation. This PDRA position is funded by a Consolidated Grant from the UK's Science and Engineering Research Council (Ref. ST/S00033X/1). The project is focused on exploring the formation and fragmentation of filaments and cores, the properties of the stars and star-systems they spawn, the roles of radiative and mechanical feedback, and the constraints that can be inferred from dust continuum and molecular line observations of filaments and cores.

The Astrophysics, Gravitational Waves, and Astronomical Instrumentation Groups in Cardiff comprise 32 faculty, 19 postdoctoral fellows and research associates, and 50 PhD students. We have a broad range of research programmes in star and planet formation, galaxies, cosmology gravitational wave sources, and in building the instruments needed to detect and observe these objects, particularly at far-infrared and sub-millimetre wavelengths. The School of Physics and Astronomy was ranked sixth in the most recent UK Research Excellence Framework evaluation, and provides a stimulating and well-resourced environment in which to pursue research, with very good computing facilities.

Applicants must have a PhD in astrophysics or a closely related discipline, or expect to be awarded their PhD before the start of the position. They must have expertise in numerical hydrodynamics and/or radiation transport, preferably in the context of star formation.

The closing date for applications is 18 February 2019.

Applications should be made electronically via http://www.cardiff.ac.uk/jobs, 'Academic Vacancies', Ref. 8156BR. With your completed application, please submit your full CV, a list of publications, and a brief statement of research experience, research interests and career goals.

Informal enquiries about the role can be made to Professor Whitworth by email [ant@astro.cf.ac.uk] or telephone [+4429-20874798]. Informal enquiries about working at Cardiff University can be made to Glesni Lloyd by email [LloydGW@cardiff.ac.uk].

The position is fixed term until 31st March 2022.

Salary: £33199 to £39609 (Grade 6), depending on experience.

Interviews will be held, and offers made, by 1st March 2019.

Cardiff University and the School of Physics and Astronomy are committed to supporting and promoting equality and diversity. Our inclusive environment welcomes applications from talented people from diverse backgrounds. We strongly encourage female applicants and those from any ethnic minority group. The School of Physics & Astronomy has a Juno Practitioner accreditation that recognises good employment practice and a commitment to develop the careers of women working in science. The University sustains a positive working environment for all staff to flourish and achieve. The University has developed a flexible and responsive framework of procedures to support staff in managing their work and personal commitments.

Two Tenure-Track Faculty Positions in the Department of Astronomy at the University of Florida

The Department of Astronomy at the University of Florida invites applications for two full-time, nine-month, tenure-track faculty positions at the level of Assistant Professor to begin on August 16, 2019. We invite applications from observers, theorists, and instrumentalists. We are conducting two parallel searches. The first search focuses on the area of star formation in the Milky Way and nearby galaxies, including (but not limited to) molecular cloud physics, interstellar medium, young stellar objects, and circumstellar disks. The second search focuses on the areas of stars and stellar systems, including (but not limited to) the solar system, stellar physics, multiple star systems, stellar populations, extrasolar planets (e.g., detection, characterization or demographics). The Department of Astronomy is especially interested in qualified candidates who can contribute, through their research, teaching, and service, to the diversity and excellence of the academic community at the University of Florida.

These searches are part of a continuing effort by the University of Florida to expand in the area of Astronomy and Astrophysics and follow three tenure-track faculty hires in the Department of Astronomy and two astrophysics-related tenure-track faculty hires in the Department of Physics last year. The University of Florida has access to several world-class research facilities and telescopes. In addition, the university is home to HiPerGator, the third most powerful computer at a US public university. We welcome applicants who can benefit from access to these resources while developing high impact research programs using other major observational national and international astronomical facilities, and publicly-available large datasets. The Department of Astronomy has built numerous state-of-the-art instruments for some of the best observatories on Earth, and is currently involved in several major international projects, including the Illustris collaboration and the Dark Energy Spectroscopic Instrument. Information about the Department of Astronomy can be found at www.astro.ufl.edu.

Candidates should already have a strong established research program that complements ongoing research in the Department of Astronomy, a compelling plan for future research, and the ability to supervise both graduate and undergraduate research projects. A Ph.D. degree in Astronomy, Astrophysics, Physics, or a closely related field is required. The salary is competitive and commensurate with qualifications and experience, and includes a full benefits package.

Applications must be submitted online. Candidates may be considered for both positions through the submission of two independent applications. The link to each position is http://apply.interfolio.com/55767 and http://apply.interfolio.com/55777 . All applications must include: (1) a cover letter, (2) a complete curriculum vitae, (3) a list of publications, (4) a research statement summarizing the applicants qualifications, past research, and future research plans, (5) a statement of teaching experience and interest, and (6) three confidential letters of recommendation. For full consideration, applications should be submitted by December 17, 2018, at which time the committee will begin reviewing applications. Applications received after this date may be considered at the discretion of the committee until the two positions are filled.

The successful candidates will be required to provide an official transcript to the hiring department upon hire. A transcript will not be considered official if a designation of Issued to Student is visible. Degrees earned from an educational institution outside of the United States require evaluation by a professional credentialing service provider approved by the National Association of Credential Evaluation Services (NACES), which can be found at http://www.naces.org/ .

The University of Florida is an equal opportunity institution dedicated to building a broadly diverse and inclusive faculty and staff and strongly encourages applications from female and minority candidates. Searches are conducted in accordance with Florida's Sunshine Law. If an accommodation due to disability is needed to apply for this position, please call (352) 392-2477 or the Florida Relay System at (800) 955-8771 (TDD). The Department of Astronomy is committed to creating an environment that affirms diversity across a variety of dimensions, including ability, class, ethnicity/race, gender identity and expression. We particularly welcome applicants who can contribute to such an environment through their scholarship, teaching, mentoring, and professional service. The university and greater Gainesville community enjoy a diversity of cultural events, restaurants, year-round outdoor recreational activities, and social opportunities.

Questions may be addressed to the Search Committee Chair, Professor Rafael Guzman at guzman@astro.ufl.edu .

Two positions in Astrophysics at the University of Exeter

The University of Exeter has two positions available in Astrophysics to expand current research performed in the Astrophysics group (theoretical, observational, computational, instrumentation). The group is particularly active in the fields of exoplanets, star formation and computational stellar astrophysics and engages in cutting-edge instrumentation projects. Candidates in areas related or complementary to existing Exeter strengths will be considered.

More information can be found at the links below

- Tenure Lecturer/Senior Lecturer/Associate Professor position: https://jobregister.aas.org/ad/1d3bcf7c

- Lecturer/Senior Lecturer position on a fixed term basis of up to 5 years: https://jobregister.aas.org/ad/922d3faa

The application deadline for both positions is January 31 2019.

Abstract submission deadline

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

Meetings

Second Announcement

From Stars to Planets II

Abstract Submission by 28th Feb. 2019

From Stars to Planets II - Connecting our understanding of star and planet formation

Mon. 17th - Thur. 20th June 2019

Chalmers University, Gothenburg, Sweden

http://cosmicorigins.space/fstpii/

Star formation, planet formation, astrochemistry and exoplanet studies are undergoing rapid, revolutionary advances and this conference aims to bring together researchers in these fields, especially to explore and develop new connections. The scientific scope of the meeting will include:

- Molecular Clouds and Star Formation in the Milky Way
- Star Cluster Formation and Evolution
- Pre-stellar and Protostellar Cores
- Protostellar and Protoplanetary Disks
- Planet Formation
- Astrochemistry of Star and Planet Forming Regions and Exoplanets
- Exoplanet Properties and Evolution
- Formation and Evolution of the Solar System

Meeting schedule and preliminary logistics:
Sunday 16th June 2019, 6pm Welcome reception
Monday 17th - Thur. 20th June 2019, 3.5 days of science sessions, 0.5 day excursion
Friday 21st June 2019, Midsummer celebration (optional post-conference activity)

Confirmed Invited Speakers:
- Viviana Guzman
- Anders Johansen
- Christoph Mordasini
- Gijs Mulders
- Richard Nelson
- David Nesvorny
- Stella Offner
- Nami Sakai
- Leonardo Testi
- Ewine van Dishoeck
- Catherine Walsh
- Zhaohuan Zhu

SOC: Jonathan Tan (Chair, Chalmers/UVa), Ilse Cleeves (UVa), Maria Drozdovskaya (Bern), Eric Herbst (UVa), Jouni Kainulainen (Chalmers), Zhi-Yun Li (UVa), Yamila Miguel (Leiden), Darin Ragozinne (BYU), John Tobin (NRAO), Jonathan Williams (UH), Andrew Youdin (UA)

LOC Contact: Jonathan Tan (jonathan.tan@chalmers.se)

ABSTRACT SUBMISSION:

If you are interested in attending the conference, please submit an abstract by 28th February 2019 via the link from this page: http://cosmicorigins.space/fstpii/

We expect decisions on abstracts to be made by mid March. Note, it is possible that we will receive more submissions than can be accepted given the size of the venue. Registration and logistics information, including hotel room blocks, for attendees will be sent out by the end of March.

The Pleiades and friends: stellar associations in the GAIA era

A Coruña, Spain, 9-13 September 2019

Stellar clusters play a crucial role in astrophysics, because they provide homogeneous samples of stars of the same age and metallicity. In fact, they can be considered as astrophysical laboratories, because they provide snap shots at different times. That is, any particular association allows study of dependencies with stellar mass, whereas the comparison of stars of the same mass but belonging to different associations allows one to derive how any property depends on age.

Gaia has forced us to revisit many of our assumptions: better proper motions yield new membership lists, improved distances translate into different age estimates. The results from DR2 are starting to be digested, but a huge effort to truly understand the implications from Gaia in many diverse areas is needed. In addition, new large photometric and spectroscopic surveys are providing an amazing amount of data concerning open clusters (Gaia-ESO, Vista, K2, TESS, and so on). This wealth of data has to be put in context within the new Gaia framework.

In this realm, the Pleiades cluster has a very significant role, due to its age and proximity. Thousands of papers have been devoted to this amazing cluster. It is truly a stepping stone to understand key stellar properties such as rotation, activity, internal mixing, etc. In a wider context, the Pleiades together with younger and older siblings may allow us to put planetary formation in better context.

This conference is devoted to the Gaia DR2 exploitation in the context of the stellar (and substellar) members of stellar clusters and associations. The goal is to provide a venue to present the most up-to-date results and to foster new collaborations, keeping in mind that future Gaia DR will provide new waves of amazing data and surprising results which will shape our astrophysical knowledge. We plan to have special session devoted to Big Data and new tools and techniques.

Webpage: http://www.laeff.cab.inta-csic.es/projects/pleiades2019/main/index.php

Summary of Upcoming Meetings

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

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

Chemical Abundances in Gaseous Nebulae
11 - 14 March 2019, São José Dos Campos, Brazil
https://www.univap.br/universidade/instituto-de-pesquisa/agenda-e-eventos/chemical-abundances-in-gaseous-neb

Star Clusters: from the Milky Way to the Early Universe
27 - 31 May 2019, Bologna, Italy
http://iausymp351.oas.inaf.it/

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

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

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

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

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

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

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

Gordon Conference on Origins of Solar Systems: Meteoritical, Spacecraft and Astrophysical Perspectives on the Assembly and Composition of Planets
23 - 28 June 2019
https://www.grc.org/origins-of-solar-systems-conference/2019/

Astrochemistry: From nanometers to megaparsecs - A Symposium in Honour of John H. Black
24 - 28 June 2019, Gothenburg, Sweden
https://www.chalmers.se/en/conference/JHBlacksymp2019/

Great Barriers in Planet Formation
21 - 26 July 2019 Palm Cove, Australia
https://dustbusters.bitbucket.io/great-barriers-2019/

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

The Pleiades and friends: stellar associations in the GAIA era
9 - 13 September 2019, Coruña, Spain
http://www.laeff.cab.inta-csic.es/projects/pleiades2019/main/index.php

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

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