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

CG 4 belongs to the system of cometary globules that are found in the Gum Nebula and pointing towards the massive stars γ Vel and ζ Pup. These globules represent former cloud cores, which have been escavated from their more tenous parental clouds. The globules are associated with 2. generation low-mass star formation triggered by the expanding HII region and radiation pressure. Image obtained with ESO's Very Large Telescope.

Image courtesy ESO

Submitting your abstracts

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Derek Ward-Thompson

in conversation with Bo Reipurth

Q; *What was your PhD about and who was your adviser?*

A: My PhD was actually on the topic of magnetic fields in spiral galaxies. I worked with Mike Scarrott in the Durham Polarimetry Group, so I've always been interested in polarimetry and magnetic fields. However, after my PhD I decided that I wanted to look at objects that are a bit closer to home, so I decided to concentrate on regions of star formation. At the time the IRAS data were still relatively new, and I was determined to make images from the IRAS time-stream data. In fact, I was part of the vanguard of folk making images from IRAS data (something the satellite was never originally intended to do), and ultimately this was taken up by IPAC on an industrial scale. Now the IRAS all-sky data are amongst the prettiest pictures in infra-red astronomy.

Q; *You were among the first to use submillimetre observations of star forming regions. In 1989 you and your co-workers discovered the famous submillimetre source SM1 in ρ Oph A. What is known about this source today?*

A: For my first post-doc I worked with Ian Robson (who subsequently became JCMT Director), when the newest telescope opening up new windows was the JCMT, so I jumped at the chance to use it. Continuum bolometer detectors were becoming sensitive enough to see something, so we tested out a single-pixel bolometer at UKIRT – pointing it at ρ Oph A. We made the first continuum image (built up point by point) of ρ Oph A and detected a bright source which we named SM1 (sub-millimetre 1) for the first detected sub-millimetre continuum source in Oph A. Many people have referred to SM1 without ever understanding why we called it that! Now we know far more about this source. We know that it contains multiple sub-clumps, it is part of a shell around the S1 HII region, and we even know what its magnetic field looks like from SCUBA2 polarimeter and SOFIA HAWC+ data.

Q; *In 1993 came the famouns paper by Philippe André, yourself, and Mary Barsony on Class 0 sources. What was the genesis of that paper?*

A: The genesis of the Class 0 paper was actually very interesting. Philippe had been working with radio data of Ophiuchus and found a point source apparently just to one side of Oph A, which had the VLA catalogue name of VLA1623. He read my Oph A paper and wanted to know whether I had detected VLA1623 in any of my data. It could still have been a background radio galaxy at that point. So he wrote me an old-fashioned letter! International email was still in its infancy at that time and was very flaky. We eventually managed to make contact electronically and we realised that the UKIRT data were too low resolution to definitively say whether VLA1623 had been detected. So we agreed to write a telescope proposal for the still relatively new James Clerk Maxwell Telescope in Hawaii, where the single pixel bolometer had been moved to. Philippe had met Mary at a conference, and she had also expressed an interest in Ophiuchus, so the three of us wrote the proposal together and went observing together. When we took the data we realised what we had found – a very bright point source in the submillimetre that was by then known to have an energetic CO outflow that had to be a young stellar object – but it was invisible in the infra-red! At the time the YSO classification system of Class I, II & III had just been proposed. But it was clear that this object had to be more embedded (i.e. younger) than a Class I. We realised we had discovered a whole new class of objects that were not previously known! Philippe said, almost as a joke, that we should call the new class of objects Class 0. I remembered my classical education and knew that there was no Roman numeral zero, and so I agreed to this name straight away, because I thought that it would make my old school Latin teacher turn in his grave! And so it was decided – before we had even left the telescope control room. When we returned to sea level we drank champagne in the then Joint Astronomy Centre kitchen. We knew the paper that we planned to write would make a splash.

Q; *Another highly cited paper from around the same time dealt with submm observations of 'star-less' cores. What were your key conclusions?*

A: After VLA1623, I began to wonder if there was anything younger that we could see with our new-found submillimetre continuum sensitivity. At the time Phil Myers and co-workers had mapped a number of Lynds Dark Clouds in CO and ammonia, and had cross-referenced this with the IRAS point source catalogue, which detected all Class I, II & III sources. So I proposed to point the JCMT at a large number of clouds that had ammonia detections but no IRAS point sources to see what we could see. Because of the mismatch in resolution I didn't know exactly where to point the JCMT within the ammonia cores (there was still only one pixel in our camera), so I hit on the idea of mapping the cores in ^{13}CO (which was quicker than mapping in the continuum), and then pointing the bolometer at the ^{13}CO peak, and mapping around it. Sometimes I detected nothing at all. Sometimes I missed the continuum peak altogether, due to optical depth effects. But fortunately the time allocation committee kept faith in me, and I managed to map about half a dozen of them in the continuum. It was clear straight away that these were very different from Class 0 sources. They were clearly extended, they had no jets or outflows, yet they had masses consistent with being at least virialised when compared to their ammonia line-widths. So I started by calling them pre-proto-stellar cores to indicate that they were at the still earlier evolutionary stage. Eventually I realised that life was too short to be saying 'pre-proto-stellar cores' several times a day, so I shortened it to 'pre-stellar cores', and the name stuck.

Q; *You have been involved with the JCMT Gould Belt Legacy Survey using the, at the time, new SCUBA-2 submm imager. How did that arise?*

A: Once SCUBA came along, it absolutely revolutionised the field. We were able to take real pictures in real time. And then there was SCUBA-2, and suddenly it was as if the CCD era had reached the submm. The mapping speed and sensitivity increased by orders of magnitude, and we were able to contemplate key programmes over very large area surveys. The whole Gould Belt Programme with every telescope imaginable came about as a result of a lunch-time drink at a conference in Cambridge (the English one) with Philippe. He was already heavily involved with Herschel at that time, and I was only just becoming involved. He told me he had this plan to map every nearby star-forming region with Herschel, and was quizzing me about the potential ability of the almost finished camera for JCMT at that time, SCUBA-2. I confirmed that it could do the same. So we agreed that after we had parted, he would go back and persuade the Herschel community that his was a good plan, and I would do likewise in the JCMT community, which at that time included the UK, Canada and the Netherlands. Shortly after that I was at a conference in Aspen, Colorado, having a drink, this time with Doug Johnstone, and I got him on board with the plan. He went home and persuaded his pal James Di Francesco, and not long afterwards, at a meeting in the Netherlands, James and I got Michiel Hogerheijde and Jenny Hatchell on board, after which the rest of the JCMT community was delighted to join in. Thereafter, every self-respecting telescope had to have a Gould Belt Survey. So the message to younger readers is not to underestimate the value of the social time around conferences – that's where all the best plans are born!

Q; *With the launch of the Herschel Space Telescope, a new tool became available for the study of star formation. How do Herschel and SCUBA-2 compare?*

A: So, as a result of the afore-mentioned plotting, we had two massive data-sets to play with. The SPIRE camera on Herschel (of which I was by then a member of the consortium) was mapping huge swathes of the sky, with incredible dynamic range. It got everything from the bright, dense, nearby regions, to the inter-stellar cirrus, foreground asteroids, and back-ground high-Z galaxies – all in one frame! In a sense, it became a victim of its own success – how did you work out what was associated with your star-forming region that you were studying? In many regions, such as our 'control' region around Polaris, the limitation on signal to noise was nothing to do with the instrument – it was actually the density of faint background high-Z galaxies! This, of course, was why SPIRE was so successful, and the team that built it won an award from the RAS. But it left us with the problem of (in our case) how to determine what was a gravitationally bound pre-stellar core, and what was 'chaff'. That was when SCUBA-2 came riding to our rescue. In our paper on the comparison between SCUBA-2 and SPIRE data in Taurus (W-T et al, 2016, MN, 463, 1008), we showed that, in a 3-colour composite SCUBA-2 and SPIRE image, the pre-stellar cores were pickled out perfectly by SCUBA-2 – see the beautiful red objects in Figure 1 of that paper. We went on to quantify the effect, in that anything above 10^4 cm^{-3} was detected by SCUBA-2 at the distance of Taurus (Fig. 8), and we showed how this detection limit should scale with distance and temperature for the whole Herschel Gould Belt Survey.

Q; *Most recently you and your collaborators have presented first results from the polarimeter POL-2 on SCUBA-2, casting light on magnetic fields in starforming regions. What is the potential of this instrument?*

A: POL-2 on SCUBA-2 is a simply fantastic instrument. Our BISTRO survey (448 hours of JCMT time) is absolutely gobbling up the Gould Belt, and we are churning out the results. But the best is still to come. The first part of the survey – BISTRO1 – has now completed all observations, and the second part – BISTRO2 – is half-complete. But the data reduction is still ongoing, and only the first half-dozen regions have been published so far. However, we've already seen some spectacular results in Orion, Oph A, Oph B, Oph C, IC5146, and, above all, the 'Pillars of Creation'. The rest of the data are being analysed as we speak, and the rest of the papers will be published thick and fast. So this is one case where I can quite literally say – watch this space!

My Favorite Object

Gaia 17bpi: The latest FUor outburst

Carlos Contreras Peña

1 Introduction

I have always been fascinated by the study of variable stars, and ever since my PhD I have dedicated my time to research rare, but incredible, eruptive young stellar objects (YSOs).

The large and sudden brightness changes in these objects are thought to occur due to changes in the accretion rate of up to 3 orders of magnitude, going from the typical T Tauri rates of 10^{-7} $M_\odot$ yr^{-1} up to 10^{-4} $M_\odot$ yr^{-1}, with outburst lasting from weeks up to about 100 years, which can increase the central luminosity to 100 $L_\odot$, dumping as much as 0.01 $M_\odot$ onto the central star in one outburst (see e.g. Hartmann & Kenyon, 1996). Disk instabilities such as gravitational instabilities (Vorobyov & Basu, 2005), planet-induced thermal instabilities (e.g. Lodato & Clarke 2004) or instabilities due to interactions in a binary system (Bonnell & Bastien, 1992), are suggested as explanations of the large variability.

It is thought that highly variable accretion may be common amongst protostars, though rarely observed owing to a duty cycle consisting of long periods of slow accretion and much shorter periods of unstable accretion at a much higher rate. If this is true, it might explain both the observed under-luminosity of low-mass, class I YSOs (the "Luminosity problem"; see e.g. Kenyon et al. 1990; Evans et al. 2009) and the wide scatter seen in the Hertzsprung-Russell diagrams of pre-main-sequence (PMS) clusters (e.g. Baraffe et al. 2012). The episodes of enhanced accretion can also impact the formation of low mass stars and brown dwarfs (Stamatellos & Whitworth 2009) as well as the final architecture of planetary systems (Hubbard, 2017).

Most eruptive variable YSOs have historically been classified based on the photometric and spectroscopic characteristics of the observed outburst. They are classified as either EXors, which typically show less dramatic changes in the accretion rate and have outburst durations of weeks to months, with a maximum of 1.5 yr (Herbig, 2008), or FUors, which have long-duration outbursts (typically decades but at least 10 yr) and with accretion rates that can reach 10^{-4} $M_\odot$ yr^{-1} (Audard et al. 2014). With the advent of dedicated optical and near-infrared multi-epoch surveys, there has been an increase of discoveries with time (Hillenbrand et al. 2018). The more recent additions to the eruptive variable class have shown characteristics that make a classification as FUors or EXors difficult (see e.g. Contreras Peña et al. 2017b, Hillenbrand et al. 2019)

YSOs displaying FUor-like outbursts share clear spectroscopic signatures, such as P Cygni profiles in specific lines, the gradually cooler spectra at longer wavelengths, and the low-gravity spectral appearance (Connelley & Reipurth 2018). In these objects the spectral energy distribution (SED) is dominated by a disk accreting at rates of $\sim 10^{-4}$ $M_\odot$ yr^{-1}. In steady-accretion disk models the effective temperature of the disk varies with radius. Then, observations at longer wavelengths will be sensitive to the outer, cooler disk regions, which explains the variation of the spectral type with wavelength (Hartmann & Kenyon, 1996).

Many aspects of the young eruptive YSOs are still uncertain. The frequency and amplitude of the outbursts are not well constrained (see e.g. Scholz et al. 2013., Hillenbrand & Findeisen, 2015). In addition, there is controversy as to whether the very largest FUor outbursts occur across all stages of young stellar evolution or are just limited to the class 0/I phase (c.f. Sandell & Weintraub, 2001, Miller et al. 2011).

With the aim of determining the frequency of long-lasting, large outbursts and whether they are associated with the planet-building phase (class II stage) at all, we have been monitoring a large sample of known YSOs using the *Gaia* all-sky photometric survey. The *Gaia* consortium is publishing prompt alerts and light curves for stars seen to vary in the Gaia data stream[1]. The automated transient discovery is conducted down to $V \sim 19$ and is based on either detection of a new source, or a significant deviation in brightness of a known source compared with previous *Gaia* measurements (Hodgkin et al. 2013; S. T. Hodgkin et al. 2019, in preparation).

[1] http://gsaweb.ast.cam.ac.uk/alerts/alertsindex

2 Finding FUors

Finding FUors in multi-epoch photometric surveys such as *Gaia* is difficult. FUors are rare, as there are fewer than 17 recorded outbursts (see e.g. Connelley & Reipurth, 2018), and although episodic accretion is thought to be universal amongst YSOs, the recurrence timescale of these events is yet unclear (see Section 1).

In addition, high-amplitude variability in YSOs is not exclusively due to large changes in the accretion rate. In my previous work with the Vista Variables of the Via Lactea survey (VVV, Minniti et al. 2010), I found a large sample of high-amplitude ($\Delta K_s > 1$ mag) variable YSOs (Contreras Peña et al. 2017a). A high-amplitude cut avoids selecting YSOs where variability is driven by "typical" mechanisms such as for example cold or hot spots on the stellar photosphere (e.g. Scholz, 2012) or changes in disk parameters (Meyer et al. 1997). However, selecting high-amplitude variable stars as showing accretion-related outbursts, based only on photometric information has the risk of selecting objects with light curves that can mimic such outbursts, especially if the light curve sampling is sparse. At this high-amplitude level (extreme) cases of hot-spot variability and variable extinction can also explain the observed variability in YSOs (Contreras Peña et al. 2017a). Since changes in the extinction along the line of sight can produce variability with amplitudes that are effectively limitless, as it depends on the amount of dust that obscures the star, it is not hard to imagine that objects brightening from high-amplitude, long-lasting eclipses by inhomogeneities at long distances in the accretion disk (e.g. AA Tau) or a precessing disk in a binary system (e.g. KH 15D, Aronow et al. 2018) could mimic an FUor outburst.

The number of FUor outburst we expect to observe, $N_{\rm fuor}$, depends on the number of YSOs surveyed, $N_{\rm YSO}$, the baseline of observations, Δt, and the recurrence timescale of outbursts, r, with $N_{\rm fuor} = rN_{\rm YSO}\Delta t$ (see Hillenbrand & Findeisen, 2015). Since the recurrence timescale of outbursts is not well constrained, the only way to increase our chances of detecting FUor outbursts, given the baseline of *Gaia* observations ($\Delta t \sim 3$ yr), is to monitor the the largest possible sample of YSOs (See Figure 3 in Hillenbrand & Findeisen, 2015). With this objective in mind we have assembled a catalogue of approximately 20,000 YSOs. These have SuperCOSMOS (SSS, Hambly et al. 2001) magnitudes which we can fold through the Gaia bandpass to show that they are bright enough (G < 20) to trigger Gaia alerts if they change significantly in magnitude. In addition we also acknowledge the fact that the current membership lists for many nearby star-forming regions remains incomplete. If we take into account that YSOs are located in spatially coherent regions of star formation, hence clustered on the sky, we can also identify YSOs using what we term a "vicinity match". When an alert is not successfully cross-matched with any specific object in the search catalogs, but it is located within 2 arcminutes of a confirmed or candidate YSO, the object is still added as a possible YSO-related alert.

To determine whether the observed variability of a YSO relates to the FUor phenomenon, we must be able to obtain two or more epochs of photometric and/or spectroscopic monitoring after an alert has been flagged as being related to a likely YSO. Multi-colour photometry at different brightness levels allows us to identify whether the observed variability is related to variable accretion or to other known mechanisms that drive large amplitude variability in YSOs. For example changes in the extinction along the line of sight show a very distinctive behaviour in both colour-magnitude and colour-colour diagrams (see e.g. Froebrich et al. 2018). In addition, the use of spectroscopy is desirable to confirm that the alert shows the characteristics of YSOs in high states of accretion, as these objects show distinct characteristics in their optical and near-infrared spectra (see Section 1).

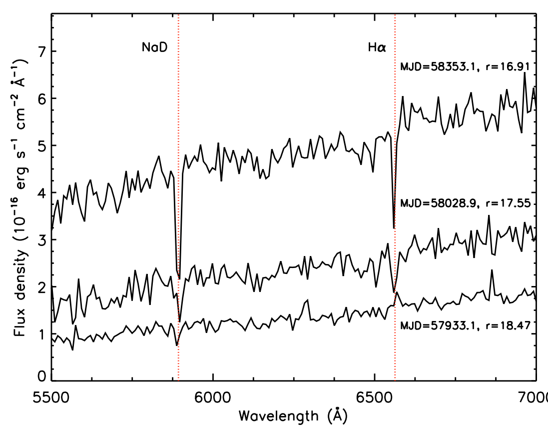

Figure 1: Portion of the Liverpool Telescope spectra of Gaia 17bpi at $R = 350$. From bottom to top, representing three different nights during the light curve rise. NaD and Hα absorption appears and strengthens.

3 Discovery of Gaia 17bpi

Gaia 17bpi was announced on the *Gaia* alerts public feed on June 23, 2017. The alert was triggered as a "delta-magnitude detection", i.e. a source brightening relative to earlier Gaia photometry by >1 mag in two consecutive transits of the satellite over the source position (in March and then June, in this case). Gaia 17bpi was not successfully cross-matched with any specific object in the search catalogs, but it was identified as a "vicinity match" as it has five YSOs falling in the vicinity of the alert coordinates, located at separations between 75 to 177 arcsec from the variable star.

4 Follow-up

We obtained *griz* photometry as well as low-resolution ($R = 350$) spectroscopy using the IO:O and SPRAT instruments, respectively, at the Liverpool telescope (Steele et al. 2004) 6 days after the alert was published, and then 3 months later when the object had become one magnitude brighter.

The early doubts

The low-resolution spectra at these two epochs appeared featureless (see middle and bottom spectra in Fig. 1). There was some evidence of absorption features from NaD and Hα, however these were hard to tell apart from the noisy spectrum. The colour change between these two epochs appeared consistent with variable extinction.

We collected ancillary data from the 2MASS (Cutri et al. 2003) and *Spitzer*/GLIMPSE (Churchwell et al. 2009) catalogs. In the latter, Gaia 17bpi only had detections at 3.6 and 4.5 μm. From these data alone we could not measure the infrared excess expected in YSOs. In fact the SED of Gaia 17bpi up to 4.5 μm is not dissimilar from a reddened stellar photosphere (see Section 5). In addition, while the light curve of Gaia 17bpi exhibits an FU Ori-like rise, several classes of large-amplitude pulsating variables have similarly slow rise times, as do active galactic nuclei. Some doubt also arose from the fact that the closest known YSO to Gaia 17bpi was located more than 1 arcmin from the alert.

Therefore analysis of these two epochs, along the additional information discussed above, lead to Gaia 17bpi being flagged as potentially a non-YSO alert.

Confirmation

The Gaia light curves of alerts that are classified this way are still updated frequently. This allows the possibility of determining whether there are any changes in the photometric properties that would change the classification of the alert. In the case of Gaia 17bpi we noticed that the object had continued to increase its brightness by over a magnitude and had reached an apparently stable bright state. Considering this we obtained a third epoch of photometry and spectroscopy on August 23 2018, more than a year after the alert was published. The third epoch of low-resolution spectra showed distinct absorption features of NaD and Hα (see top spectrum in Fig. 1).

These features alone, although promising, were not enough to confirm Gaia 17bpi as a member of the FUor class. We then alerted other members of the collaboration of the existence of this object. They obtained additional photometric and spectroscopic observations I describe below which covered optical to near-infrared wavelengths and that were fundamental to study the nature of Gaia 17bpi.

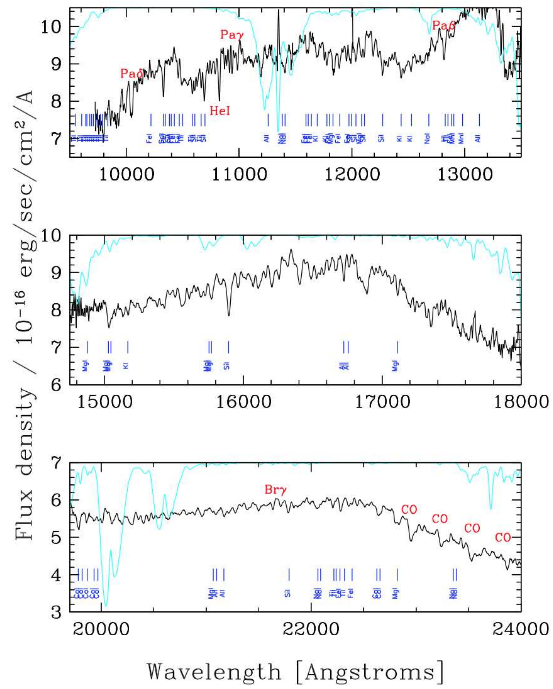

Figure 2: Portion of the Palomar/TripleSpec spectrum of Gaia 17bpi. The spectrum is similar to that of an M-type photosphere, mainly due to the prominent H_2O broad depressions in the H band and K band and the ^{12}CO (2−0) bandhead absorption in the K band. The spectrum agrees well with the set of FU Ori objects displayed in Figure 3 of Connelley & Reipurth (2018).

We obtained an optical Keck/DEIMOS (Faber et al. 2003) spectrum (4630-9865 Å, $R \simeq 2200$) and a near-infrared (10000-25000 Å, $R = 2700$) Palomar TripleSpec (Herter et al. 2008) spectrum of Gaia 17bpi on 2018 September 10, and 25, respectively. The DEIMOS spectrum confirmed the features observed in the third SPRAT spectrum, with numerous strong P-Cygni-type blueshifted absorption lines in NaD, Hα, and the Ca II triplet, consistent with an F-type spectrum. The TripleSpec spectrum showed ^{12}CO absorption in the 2.3μm region and prominent H_2O absorption in the K band and H band, similar to an M-type spectrum (see Fig. 2).

These two observations also confirm a key feature of classic FUor outbursts, which is the change in the spectral type with wavelength. Therefore making Gaia 17bpi the latest addition to the FUor class.

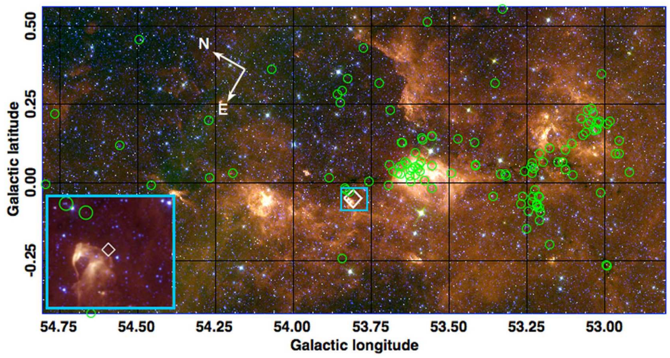

Figure 3: False colour image constructed from 3.6 μm (blue), 4.5 μm (green) and 8.0 μm (red) data from GLIMPSE-I. The location of Gaia 17bpi is marked by the white diamond. Green circles mark the location of infrared excess sources selected from 2MASS/*Sptizer* colours. Finally, the inset shows an expanded view 4.5×4 arcmin in size illustrating the adjacent small HII region HRDS G053.822-00.057.

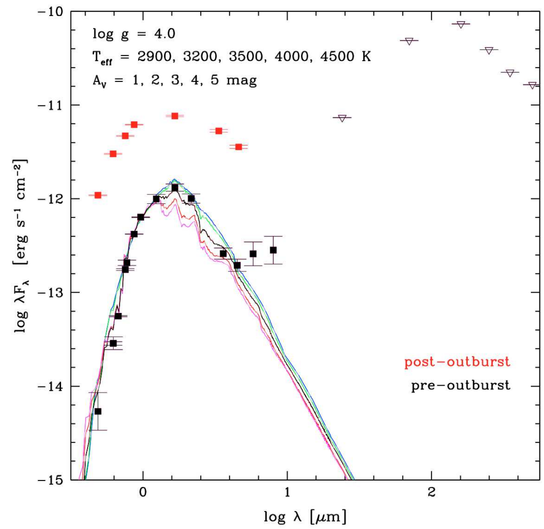

Figure 4: Spectral energy distribution of Gaia 17bpi. Red points are the post-outburst data, while black points are the assembled pre-outburst photometry with black downward triangles indicating upper limits. Also shown are reddened model photospheres normalized at z band to the pre-outburst photometry.

5 Characteristics

In the following I summarise some of the characteristics of Gaia 17bpi. For a more detailed information I refer the reader to Hillenbrand et al. (2018).

The Star-Forming region. Gaia 17bpi is associated with a previously faint optical ($r < 22$ mag), near-infrared, and mid-infrared point source. The position (see Fig. 3) is located toward the northern end of the elongated G53.2 infrared dark cloud (IRDC) just outside of a particularly opaque region on optical and infrared images, and adjacent to a small H II region cataloged as HRDS G053.822- 00.057 (Anderson et al. 2014). The modest star-forming region is hardly studied. To estimate the distance to Gaia 17bpi we used Spitzer/GLIMPSE, 2MASS, and Gaia DR2 (Gaia Collaboration et al. 2018) catalogs, and identified infrared excess sources that are likely YSOs by using the colour criteria of Gutermuth et al. (2009). The cloud distance was then estimated by examination of the Gaia parallax distribution of the infrared excess sources. A weighted median approach yields a distance of 1270^{+80}_{-70} pc.

The spectral energy distribution. The SED of the pre-outburst object was assembled from catalog data originating from the Gaia DR2, PanSTARRS DR1 (Flewelling et al. 2016), IPHaS (Barentsen et al. 2014), 2MASS, and *Spitzer*/GLIMPSE-I surveys, with additional use of images from IRAC (3.6, 4.5, 5.8, 8μm), MIPS (24, 70μm), and all Herschel data (70, 160 , 250, 350, 500 μm). The GLIMPSE-I catalog only contains measurements at the two shortest wavelengths (3.6 and 4.5 μm) for Gaia 17bpi. Inspection of 5.8 and 8.0 μm images showed that the object is also apparent, although faint. Gaia 17bpi is not observed in MIPS and Herschel images. We performed aperture photometry at the location of the object, where MIPS and Herschel measurements correspond to upper limits (see Fig. 4).

Photospheric models ranging in temperature from 2900 to 4500 K result in acceptable fits to the Wien part of the SED for corresponding visual extinction values of 1 to 5 mag. Integrating the pre-outburst photometry between 0.45 and 4.5 μm, and assuming the 1.27 kpc distance, a source luminosity of 0.3 $L_\odot$ is derived for the pre-outburst object. This luminosity is appropriate for a pre-main-sequence star in the 2900-4500 K temperature range. The corresponding spectral type would be mid-K to M.

Mid-infrared outburst. The position of Gaia 17bpi was observed at mid-infrared wavelengths as part GLIMPSE in late 2004, and there is a second set of IRAC 3.6 and 4.5 μm imaging data, taken in 2014 December, where the nearby infrared dark cloud was targeted twice (program 10012, PI: J. Hora). The position was also observed by WISE (Wright et al. 2010) in 2010 April and October, and again twice per year between 2014 October and 2018 October during the NEOWISE survey (Mainzer et al. 2014). Gaia 17bpi was not detected in the WISE observations. The source is, however, well detected at 3.4 and 4.6 μm in the NEOWISE observations beginning in 2015 April.

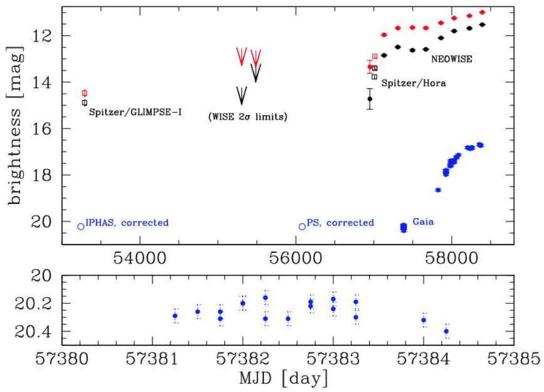

Figure 5: (top) Optical and mid-infrared light curve of Gaia 17bpi. (bottom) Zoom-in of the first epochs of Gaia photometry taken in late 2015. The variability of Gaia 17bpi has an amplitude of a few tenths of a mag with a timescale of a few days, consistent with the typical variability of T Tauri stars (see e.g. Cody & Hillenbrand 2018).

The light curve (Figure 5) suggests that the outburst may have started in the infrared and appeared later in the optical. As we do not sample the beginning of the burst in the optical, given the large time gap between the initial and subsequent Gaia photometry, we cannot calculate the time delay, but $\sim$1.5-2 yr is implied. The NEOWISE light curve further indicates a possible two-stage rise, with $\sim$ 18 months of mid-infrared brightening, followed by a plateau of about a year, then another at least 24 months of mid-infrared brightening corresponding to the optical rise that is well sampled by the Gaia measurements.

6 Final thoughts

The fact that Gaia 17bpi was originally selected as a "vicinity match" indicates that there is a large population of YSOs that are too faint for current and past photometric surveys. This is supported by the fact that the number of high-amplitude variable YSOs increases as we go towards fainter magnitudes (Contreras Peña et al. 2017a). Given this, the future multi-epoch Large Synoptic Survey Telescope (LSST) survey, which will go 5 magnitudes deeper than *Gaia*, will provide a large number of FU Ori outbursts.

Gaia 17bpi is also unique among FU Ori outbursts in having its photometric brightening detected at both optical and mid-infrared wavelengths. The burst appears to have started in the infrared, consistent with disk models that predict instabilities in the inner 0.5-1 au of protostellar and T Tauri accretion disks as the origin of FU Ori events. This demonstrates the importance of having contemporaneous multi-epoch surveys covering a wide range in wavelength (*Gaia*, VVV+VVVX, *WISE*+NEO*WISE*) in our understanding of the disk instabilities that drive the dramatic changes in the accretion rates of YSOs. In this sense, we will continue to monitor the outburst of Gaia 17bpi over a wide wavelength range by using *Gaia* (the light curves of past alerts are regularly updated by the *Gaia* consortium) and *Spitzer*, where we have recently been awarded time to follow-up the FUor with IRAC.

Acknowledgements

The discovery of Gaia 17bpi as a new member of the FUor class would have not been possible without the large collaboration between institutes in the UK and at Caltech. In this sense I would like to thank my co-authors Lynne Hillenbrand, Sam Morrell, Tim Naylor, Dirk Froebrich. Michael Kuhn, Roc Cutri, Luisa Rebull, Simon Hodgkin and Amy Mainzer. We are also grateful to Evan Kirby and to the Palomar Observatory staff.

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Abstracts of recently accepted papers

1
On the mass accretion rate and infrared excess in Herbig Ae/Be Stars

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The present study makes use of the unprecedented capability of the *Gaia* mission to obtain the stellar parameters such as distance, age, and mass of HAeBe stars. The accuracy of *Gaia* DR2 astrometry is demonstrated from the comparison of the *Gaia* DR2 distances of 131 HAeBe stars with the previously estimated values from the literature. This is one of the initial studies to estimate the age and mass of a confirmed sample of HAeBe stars using both the photometry and distance from the *Gaia* mission. Mass accretion rates are calculated from Hα line flux measurements of 106 HAeBe stars. Since we used distances and the stellar masses derived from the *Gaia* DR2 data in the calculation of mass accretion rate, our estimates are more accurate than previous studies. The mass accretion rate is found to decay exponentially with age, from which we estimated a disk dissipation timescale of 1.9 $\pm$ 0.1 Myr. Mass accretion rate and stellar mass exhibits a power law relation of the form, $\dot{M}_{\rm acc} \propto {M_\star}^{2.8\pm0.2}$. From the distinct distribution in the values of the infrared spectral index, $n_{2-4.6}$, we suggest the possibility of difference in the disk structure between Herbig Be and Herbig Ae stars.

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2
Building protoplanetary disks from the molecular cloud: redefining the disk timeline

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We study the formation of the protoplanetary disk by the collapse of a primordial molecular cloud, and how its evolution leads to the selection of specific types of planets. We use a hydrodynamical code that accounts for the dynamics, thermodynamics, geometry, and composition of the disk to numerically model its evolution as it is fed by the infalling cloud material. As the mass accretion rate of the disk onto the star determines its growth, we can calculate the stellar characteristics by interpolating its radius, luminosity, and temperature over the stellar mass from pre-calculated stellar evolution models. The density and midplane temperature of the disk then allow us to model the interactions between the disk and potential planets and determine their migration.
At the end of the collapse phase, when the disk reaches its maximum mass, it pursues its viscous spreading, similarly to the evolution from a minimum mass solar nebula (MMSN). In addition, we establish a timeline equivalence between the MMSN and a "collapse-formed disk" that would be older by about 2 Myr.
We can save various types of planets from a fatal type-I inward migration: in particular, planetary embryos can avoid falling on the star by becoming trapped at the heat transition barriers and at most sublimation lines (except the silicates one). One of the novelties concerns the possible trapping of putative giant planets around a few astronomical units from the star around the end of the infall. Moreover, trapped planets may still follow the traps outward during the collapse phase and inward after it. Finally, this protoplanetary disk formation model shows the early possibilities of trapping planetary embryos at disk stages that are anterior by a few million years to the initial state of the MMSN

approximation.

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3 Protoplanetary Disk Masses from Radiative Transfer Modeling: A Case Study in Taurus

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Measuring the masses of protoplanetary disks is crucial for understanding their planet-forming potential. Typically, dust masses are derived from (sub-)millimeter flux density measurements plus assumptions for the opacity, temperature, and optical depth of the dust. Here we use radiative transfer models to quantify the validity of these assumptions with the aim of improving the accuracy of disk dust mass measurements. We first carry out a controlled exploration of disk parameter space. We find that the disk temperature is a strong function of disk size, while the optical depth depends on both disk size and dust mass. The millimeter-wavelength spectral index can be significantly shallower than the naive expectation due to a combination of optical depth and deviations from the Rayleigh-Jeans regime. We fit radiative transfer models to the spectral energy distributions (SEDs) of 132 disks in the Taurus-Auriga region using a Markov chain Monte Carlo approach. We used all available data to produce the most complete SEDs used in any extant modeling study. We perform the fitting twice: first with unconstrained disk sizes and again imposing the disk size–brightness relation inferred for sources in Taurus. This constraint generally forces the disks to be smaller, warmer, and more optically thick. From both sets of fits, we find disks to be $\sim$1–5 times more massive than when derived using (sub-)millimeter measurements and common assumptions. With the uncertainties derived from our model fitting, the previously measured dust mass–stellar mass correlation is present in our study but only significant at the 2σ level.

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4 Young massive star cluster formation in the Galactic Centre is driven by global gravitational collapse of high-mass molecular clouds

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Young massive clusters (YMCs) are the most compact, high-mass stellar systems still forming at the present day. The precursor clouds to such systems are, however, rare due to their large initial gas mass reservoirs and rapid dispersal timescales due to stellar feedback. Nonetheless, unlike their high-z counterparts, these precursors are resolvable down to the sites of individually forming stars, and hence represent the ideal environments in which to test the current theories of star and cluster formation. Using high angular resolution ($1'' / 0.05$pc) and sensitivity ALMA observations of two YMC progenitor clouds in the Galactic Centre, we have identified a suite of molecular line transitions – e.g. c-C_3H_2 $(7-6)$ – that are believed to be optically thin, and reliably trace the gas structure in the highest density gas on star-forming core scales. We conduct a virial analysis of the identified core and proto-cluster regions, and show that half of the cores (5/10) and both proto-clusters are unstable to gravitational collapse. This is the first kinematic evidence of global gravitational collapse in YMC precursor clouds at such an early evolutionary stage. The implications are that if these clouds are to form YMCs, then they likely do so via the "conveyor-belt" mode, whereby stars continually form within dispersed dense gas cores as the cloud undergoes global gravitational collapse. The concurrent contraction of both the cluster-scale gas and embedded (proto)stars ultimately leads to the high (proto)stellar density in YMCs.

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5 Dust traps in the protoplanetary disc MWC 758: two vortices produced by two giant planets?

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Resolved ALMA and VLA observations indicate the existence of two dust traps in the protoplanetary disc MWC 758. By means of 2D gas+dust hydrodynamical simulations post-processed with 3D dust radiative transfer calculations, we show that the spirals in scattered light, the eccentric, asymmetric ring and the crescent-shaped structure in the (sub)millimetre can all be caused by two giant planets: a 1.5-Jupiter mass planet at 35 au (inside the spirals) and a 5-Jupiter mass planet at 140 au (outside the spirals). The outer planet forms a dust-trapping vortex at the inner edge of its gap (at ∼85 au), and the continuum emission of this dust trap reproduces the ALMA and VLA observations well. The outer planet triggers several spiral arms which are similar to those observed in polarised scattered light. The inner planet also forms a vortex at the outer edge of its gap (at ∼50 au), but it decays faster than the vortex induced by the outer planet, as a result of the disc's turbulent viscosity. The vortex decay can explain the eccentric inner ring seen with ALMA as well as the low signal and larger azimuthal spread of this dust trap in VLA observations. Finding the thermal and kinematic signatures of both giant planets could verify the proposed scenario.

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6 Discrepancies in the ages of young star clusters; evidence for mergers?

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There is growing evidence that star clusters can no longer be considered simple stellar populations (SSPs). Intermediate and old age clusters are often found to have extended main sequence turn-offs (eMSTOs) which are difficult to explain with single age isochrones, an effect attributed to rotation. In this paper, we provide the first characterisation of this effect in young (<20 Myr) clusters. We determine ages for 4 young massive clusters (2 LMC, 2 Galactic) by three different methods: using the brightest single turn-off (TO) star; using the luminosity function (LF) of the TO; and by using the lowest L_{bol} red supergiant (RSG). The age found using the cluster TO is consistently younger than the age found using the lowest RSG L_{bol}. Under the assumption that the lowest luminosity RSG age is the 'true' age, we argue that the eMSTOs of these clusters cannot be explained solely by rotation or unresolved binaries. We speculate that the most luminous stars above the TO are massive blue straggler stars formed via binary interaction, either as mass gainers or merger products. Therefore, using the cluster TO method to infer ages and initial masses of post-main sequence stars such as Wolf-Rayet stars, luminous blue variables and RSGs, will result in ages inferred being too young and masses too high.

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7 Photometric determination of the mass accretion rates of pre-main sequence stars. VI. The case of LH 95 in the Large Magellanic Cloud

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We report on the accretion properties of low-mass stars in the LH 95 association within the Large Magellanic Cloud (LMC). Using non-contemporaneous wide-band optical and narrow-band Hα photometry obtained with the *Hubble Space Telescope*, we identify 245 low-mass pre-main sequence (PMS) candidates showing Hα excess emission above the 4σ level. We derive their physical parameters, including effective temperatures, luminosities, masses ($M_\star$), ages, accretion luminosities, and mass accretion rates ($\dot{M}_{\rm acc}$). We identify two different stellar populations: younger than ~8 Myr with median $\dot{M}_{\rm acc} \sim 5.4 \times 10^{-8} M_\odot {\rm yr}^{-1}$ (and $M_\star \sim 0.15 - 1.8\, M_\odot$) and older than ~8 Myr with median $\dot{M}_{\rm acc} \sim 4.8 \times 10^{-9} M_\odot {\rm yr}^{-1}$ (and $M_\star \sim 0.6 - 1.2\, M_\odot$). We find that the younger PMS candidates are assembled in groups around Be stars, while older PMS candidates are uniformly distributed within the region without evidence of clustering. We find that $\dot{M}_{\rm acc}$ in LH 95 decreases with time more slowly than what is observed in Galactic star-forming regions (SFRs). This agrees with the recent interpretation according to which higher metallicity limits the accretion process both in rate and duration due to higher radiation pressure. The $\dot{M}_{\rm acc}$-$M_\star$ relationship shows different behaviour at different ages, becoming progressively steeper at older ages, indicating that the effects of mass and age on $\dot{M}_{\rm acc}$ cannot be treated independently. With the aim to identify reliable correlations between mass, age, and $\dot{M}_{\rm acc}$, we used for our PMS candidates a multivariate linear regression fit between these parameters. The comparison between our results with those obtained in other SFRs of our Galaxy and the Magellanic Clouds confirms the importance of the metallicity for the study of the $\dot{M}_{\rm acc}$ evolution in clusters with different environmental conditions.

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8 Rocky super-Earths or waterworlds: the interplay of planet migration, pebble accretion and disc evolution

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Recent observations have found a valley in the size distribution of close-in super-Earths that is interpreted as a signpost that close-in super-Earths are mostly rocky in composition. However, new models predict that planetesimals should first form at the water ice line such that close-in planets are expected to have a significant water ice component. Here we investigate the water contents of super-Earths by studying the interplay between pebble accretion, planet migration and disc evolution. Planets' compositions are determined by their position relative to different condensation fronts (ice lines) throughout their growth. Migration plays a key role. Assuming that planetesimals start at or exterior to the water ice line ($r > r_{H_2O}$), inward migration causes planets to leave the source region of icy pebbles and therefore to have lower final water contents than in discs with either outward migration or no migration. The water ice line itself moves inward as the disc evolves, and delivers water as it sweeps across planets that formed dry. The relative speed and direction of planet migration and inward drift of the water ice line is thus central in determining planets' water contents. If planet formation starts at the water ice line, this implies that hot close-in super-Earths ($r < 0.3$ au) with water contents of a few percent are a signpost of inward planet migration during the early gas phase. Hot super-Earths with larger water ice contents on the other hand, experienced outward migration at the water ice line and only migrated inwards after their formation was complete either because they become too massive to be contained in the region of outward migration or in chains of resonant planets. Measuring the water ice content of hot super-Earths may thus constrain their migration history.

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9 The Elusive Majority of Young Moving Groups. I. Young Binaries and Lithium-Rich Stars in the Solar Neighborhood

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Young stars in the solar neighborhood serve as nearby probes of stellar evolution and represent promising targets to directly image self-luminous giant planets. We have carried out an all-sky search for late-type ($\approx$ K7–M5) stars within 100 pc selected primarily on the basis of activity indicators from *GALEX* and *ROSAT*. Approximately two thousand active and potentially young stars are identified, over 600 of which we have followed up with low-resolution optical spectroscopy and over 1000 with diffraction-limited imaging using Robo-AO at the Palomar 1.5-m telescope. Strong lithium is present in 58 stars, implying ages spanning $\approx$10–200 Myr. Most of these lithium-rich stars are new or previously known members of young moving groups including TWA, β Pic, Tuc-Hor, Carina, Columba, Argus, AB Dor, Upper Centaurus Lupus, and Lower Centaurus Crux; the rest appear to be young low-mass stars without connections to established kinematic groups. Over 200 close binaries are identified down to $0\farcs2$ — the vast majority of which are new — and will be valuable for dynamical mass measurements of young stars with continued orbit monitoring in the future.

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10 Realistic On-The-Fly Outcomes of Planetary Collisions: Machine Learning Applied to Simulations of Giant Impacts

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Planet formation simulations are capable of directly integrating the evolution of hundreds to thousands of planetary embryos and planetesimals, as they accrete pairwise to become planets. In principle such investigations allow us to better understand the final configuration and geochemistry of the terrestrial planets, as well as to place our solar system in the context of other exosolar systems. These simulations, however, classically prescribe collisions to result in perfect mergers, but computational advances have begun to allow for more complex outcomes to be implemented. Here we apply machine learning to a large but sparse database of giant impact studies, streamlining simulations into a classifier of collision outcomes and a regressor of accretion efficiency. The classifier maps a 4-Dimensional parameter space (target mass, projectile-to-target mass ratio, impact velocity, impact angle) into the four major collision types: merger, "graze-and-merge", "hit-and-run", and disruption. The definition of the four regimes and their boundary is fully data-driven; the results do not suffer from any model assumption in the fitting. The classifier maps the structure of the parameter space and provides insights about the outcome regimes. The regressor is a neural network which is trained to closely mimic the functional relationship between the 4-D space of collision parameters, and a real-variable outcome, the mass of the largest remnant. This work is a prototype of a more complete surrogate model, based on extended sets of simulations ("big data"), that will quickly and reliably predict specific collision outcomes for use in realistic N-body dynamical studies of planetary formation.

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11 Filamentary Accretion Flows in the Infrared Dark Cloud G14.225-0.506 Revealed by ALMA

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Filaments are ubiquitous structures in molecular clouds and play an important role in the mass assembly of stars. We present results of dynamical stability analyses for filaments in the infrared dark cloud G14.225−0.506, where a delayed onset of massive star formation was reported in the two hubs at the convergence of multiple filaments of parsec length. Full-synthesis imaging is performed with the Atacama Large Millimeter/submillimeter Array (ALMA) to map the N_2H^+ $(1-0)$ emission in two hub-filament systems with a spatial resolution of ~ 0.034 pc. Kinematics are derived from sophisticated spectral fitting algorithm that accounts for line blending, large optical depth, and multiple velocity components. We identify five velocity coherent filaments and derive their velocity gradients with principal component analysis. The mass accretion rates along the filaments are up to 10^{-4} $M_\odot\,yr^{-1}$ and are significant enough to affect the hub dynamics within one free-fall time ($\sim 10^5$ yr). The N_2H^+ filaments are in equilibrium with virial parameter $\alpha_{vir} \sim 1.2$. We compare α_{vir} measured in the N_2H^+ filaments, NH_3 filaments, 870 μm dense clumps, and 3 mm dense

cores. The decreasing trend in $\alpha_{\rm vir}$ with decreasing spatial scales persists, suggesting an increasingly important role of gravity at small scales. Meanwhile, $\alpha_{\rm vir}$ also decreases with decreasing non-thermal motions. In combination with the absence of high-mass protostars and massive cores, our results are consistent with the global hierarchical collapse scenario.

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12 First interferometric study of enhanced N-fractionation in N_2H^+: the high-mass star-forming region IRAS 05358+3543

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Nitrogen (N) fractionation is used as a tool to search for a link between the chemical history of the Solar System and star-forming regions. A large variation of $^{14}N/^{15}N$ is observed towards different astrophysical sources, and current chemical models cannot reproduce it. With the advent of high angular resolution radiotelescopes it is now possible to search for N-fractionation at core scales. We present IRAM NOEMA observations of the J=1–0 transition of N_2H^+, $^{15}NNH^+$ and $N^{15}NH^+$ towards the high-mass protocluster IRAS 05358+3543. We find $^{14}N/^{15}N$ ratios that span from $\sim$100 up to $\sim$220 and these values are lower or equal than those observed with single-dish observations towards the same source. Since N-fractionation changes across the studied region, this means that it is regulated by local environmental effects. We find also the possibility, for one of the four cores defined in the protocluster, to have a more abundant $^{15}NNH^+$ with respect to $N^{15}NH^+$. This is another indication that current chemical models may be missing chemical reactions or may not take into account other mechanisms, like photodissociation or grain surface chemistry, that could be important.

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13 The ALMA-PILS survey: First detection of nitrous acid (HONO) in the interstellar medium

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Nitrogen oxides are thought to play a significant role as a nitrogen reservoir and to potentially participate in the formation of more complex species. Until now, only NO, N_2O and HNO have been detected in the interstellar medium. We report the first interstellar detection of nitrous acid (HONO). Twelve lines were identified towards component B of the low-mass protostellar binary IRAS 16293–2422 with the Atacama Large Millimeter/submillimeter Array, at the position where NO and N_2O have previously been seen. A local thermodynamic equilibrium model was used to derive the column density ($\sim 9\times10^{14}$ cm^{-2} in a 0.5" beam) and excitation temperature (~ 100 K) of this molecule. HNO,

NO_2, NO^+, and HNO_3 were also searched for in the data, but not detected. We simulated the HONO formation using an updated version of the chemical code Nautilus and compared the results with the observations. The chemical model is able to reproduce satisfactorily the HONO, N_2O, and NO_2 abundances, but not the NO, HNO, and NH_2OH abundances. This could be due to some thermal desorption mechanisms being destructive and therefore limiting the amount of HNO and NH_2OH present in the gas phase. Other options are UV photodestruction of these species in ices or missing reactions potentially relevant at protostellar temperatures.

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14 The dynamical evolution of molecular clouds near the Galactic Centre – III. Tidally–induced star formation in protocluster clouds

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As part of a series of papers aimed at understanding the evolution of the Milky Way's Central Molecular Zone (CMZ), we present hydrodynamical simulations of turbulent molecular clouds orbiting in an accurate model of the gravitational potential extant there. We consider two sets of model clouds differing in the energy content of their velocity fields. In the first, self–virialised set, the turbulent kinetic energies are chosen to be close in magnitude to the clouds' self–gravitational potential energies. Comparison with isolated clouds evolving without an external potential shows that the self–virialised clouds are unable to withstand the compressive tidal field of the CMZ and rapidly collapse, forming stars much faster and reaching gas exhaustion after a small fraction of a Galactocentric orbit. In the second, tidally–virialised, set of simulations, the clouds' turbulent kinetic energies are in equilibrium with the external tidal field. These models are better supported against the field and the stronger turbulence suppresses star formation. Our results strongly support the inference that anomalously low star formation rates in the CMZ are due primarily to high velocity dispersions in the molecular gas. The clouds follow open, eccentric orbits oscillating in all three spatial coordinates. We examine the consequences of the orbital dynamics, particularly pericentre passage, by performing companion simulations of clouds on circular orbits. The increased tidal forces at pericentre produce transient accelerations in star formation rates of at most a factor of 2.7. Our results demonstrate that modelling star formation in galactic centres requires the inclusion of tidal forces.

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15 The Mass of Stirring Bodies in the AU Mic Debris Disk Inferred from Resolved Vertical Structure

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The vertical distribution of dust in debris disks is sensitive to the number and size of large planetesimals dynamically stirring the disk, and is therefore well-suited for constraining the prevalence of otherwise unobservable Uranus and Neptune analogs. Information regarding stirring bodies has previously been inferred from infrared and optical observations of debris disk vertical structure, but theoretical works predict that the small particles traced by short-wavelength observations will be 'puffed up' by radiation pressure, yielding only upper limits. The large grains that dominate the disk emission at millimeter wavelengths are much less sensitive to the effects of stellar radiation or stellar winds, and therefore trace the underlying mass distribution more directly. Here we present ALMA 1.3 mm dust continuum observations of the debris disk around the nearby M star AU Mic. The 3 au spatial resolution of the observations, combined with the favorable edge-on geometry of the system, allows us to measure the vertical thickness of the disk. We report a scale height-to-radius aspect ratio of $h = 0.031^{+0.005}_{-0.004}$ between radii of ~ 23 au and ~ 41 au. Comparing this aspect ratio to a theoretical model of size-dependent velocity distributions in the collisional cascade, we find that the perturbing bodies embedded in the local disk must be larger than about 400 km, and the largest perturbing body must be smaller than roughly 1.8 $M_\odot$. These measurements rule out the presence of a gas giant or Neptune analog near the ~ 40 au outer edge of the debris ring, but are suggestive of large planetesimals or an Earth-sized planet stirring the dust distribution.

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16 Evidence of interacting elongated filaments in the star-forming site AFGL 5142

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To probe the ongoing physical mechanism, we studied a wide-scale environment around AFGL 5142 (area ∼25 pc × 20 pc) using a multi-wavelength approach. The *Herschel* column density ($N(H_2)$) map reveals a massive inverted Y-like structure (mass ∼6280 $M_\odot$), which hosts a pair of elongated filaments (lengths > 10 pc). The *Herschel* temperature map depicts the filaments in a temperature range of ∼12.5–13.5 K. These elongated filaments overlap each other at several places, where $N(H_2) > 4.5 \times 10^{21}$ cm^{-2}. The ^{12}CO and ^{13}CO line data also show two elongated cloud components (around −1.5 and −4.5 km s^{-1}) toward the inverted Y-like structure, which are connected in the velocity space. First moment maps of CO confirm the presence of two intertwined filamentary clouds along the line of sight. These results explain the morphology of the inverted Y-like structure through a combination of two different filamentary clouds, which are also supported by the distribution of the cold H I gas. Based on the distribution of young stellar objects (YSOs), star formation (SF) activities are investigated toward the inverted Y-like structure. The northern end of the structure hosts AFGL 5142 and tracers of massive SF, where high surface density of YSOs (i.e., 5–240 YSOs pc^{-2}) reveals strong SF activity. Furthermore, noticeable YSOs are found toward the overlapping zones of the clouds. All these observational evidences support a scenario of collision/interaction of two elongated filamentary clouds/flows, which appears to explain SF history in the site AFGL 5142.

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17 The protoplanetary disc of HD 163296 as observed by ALMA

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HD 163296 is one of the few protoplanetary discs displaying rings in the dust component. The present work uses ALMA observations of the 0.9 mm continuum emission having significantly better spatial resolution (∼8 au) than previously available, providing new insight on the morphology of the dust disc and its double ring structure. The disc is shown to be thin and its position angle and inclination with respect to the sky plane are accurately measured as are the locations and shapes that characterize the observed ring/gap structure. Significant modulation of the intensity of the outer ring emission have been revealed and discussed. In addition, earlier ALMA observations of the emission of three molecular lines, CO (2–1), $C^{18}O$ (2–1), and DCO^+ (3–2), having a resolution of ∼70 au, are used to demonstrate the Keplerian motion of the gas, found consistent with a central mass of 2.3 solar masses. An upper limit of ∼9% of the rotation velocity is placed on the in-fall velocity. The beam size is shown to give the dominant contribution to the line widths, accounting for both their absolute values and their dependence on the distance to the central star.

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18 Comparing the Properties of GMCs in M33 from Simulations and Observations

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We compare the properties of clouds in simulated M33 galaxies to those observed in the real M33. We apply a friends of friends algorithm and CPROPS to identify clouds, as well as a pixel by pixel analysis. We obtain very good agreement between the number of clouds, and maximum mass of clouds. Both are lower than occurs for a Milky Way-type galaxy and thus are a function of the surface density, size and galactic potential of M33. We reproduce the observed dependence of molecular cloud properties on radius in the simulations, and find this is due to the variation in gas surface density with radius. The cloud spectra also show good agreement between the simulations and observations, but the exact slope and shape of the spectra depends on the algorithm used to find clouds, and the range of cloud masses included when fitting the slope. Properties such as cloud angular momentum, velocity dispersions and virial relation are also in good agreement between the simulations and observations, but do not necessarily distinguish between simulations of M33 and other galaxy simulations. Our results are not strongly dependent on the level of feedback used here (10 and 20%) although they suggest that 15% feedback efficiency may be optimal. Overall our results suggest that the molecular cloud properties are primarily dependent on the gas and mass surface density, and less dependent on the localised physics such as the details of stellar feedback, or the numerical code used.

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19 Fate of the runner in hit-and-run collisions

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In similar-sized planetary collisions, a significant part of the impactor often misses the target and continues downrange. We follow the dynamical evolution of "runners" from giant impacts to determine their ultimate fate. Surprisingly, runners re-impact their target planets only about half of the time, for realistic collisional and dynamical scenarios. Otherwise they remain in orbit for tens of millions of years (the limit of our N-body calculations) and longer, or sometimes collide with a different planet than the first one. When the runner does return to collide again with the

same target planet, its impact velocity is mainly constrained by the outcome of the prior collision. Impact angle and orientation, however, are unconstrained by the prior collision.

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20 The CARMA-NRO Orion Survey: Statistical Signatures of Feedback in the Orion A Molecular Cloud

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We investigate the relationship between turbulence and feedback in the Orion A molecular cloud using maps of ^{12}CO (1–0), ^{13}CO (1–0) and C^{18}O (1–0) from the CARMA-NRO Orion survey. We compare gas statistics with the impact of feedback in different parts of the cloud to test whether feedback changes the structure and kinematics of molecular gas. We use principal component analysis, the spectral correlation function, and the spatial power spectrum to characterize the cloud. We quantify the impact of feedback with momentum injection rates of protostellar outflows and wind-blown shells as well as the surface density of young stars. We find no correlation between shells or outflows and any of the gas statistics. However, we find a significant anti-correlation between young star surface density and the slope of the ^{12}CO spectral correlation function, suggesting that feedback may influence this statistic. While calculating the principal components, we find peaks in the covariance matrix of our molecular line maps offset by 1–3 km s^{-1} toward several regions of the cloud which may be produced by feedback. We compare these results to predictions from molecular cloud simulations.

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21 A multi-scale exploration of a massive young stellar object - a transition disk around G305.20+0.21?

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The rarity of young massive stars combined with the fact that they are often deeply embedded has limited the understanding of their formation. Ground based mid-infrared (IR) interferometry is one way of securing the spatial resolution required to study massive young stellar objects (MYSOs) and as the spatial-frequency coverage of such observations is often incomplete, direct-imaging can be supplementary to such a dataset. By consolidating these observations with modelling, the features of a massive protostellar environment can be constrained. This work simultaneously fits the aforementioned observations and a spectral energy distribution (SED) with a 2.5D radiative transfer model, providing an extensive view of the physical characteristics of the accreting regions of the MYSO G305.20+0.21. The high-resolution observations were obtained using the Very Large Telescope's MIDI and VISIR instruments, producing visibilities in the N-band and near-diffraction-limited imaging in the Q-band respectively. A model including a central protostar with a luminosity of ?5×10^4L$_\odot$ surrounded by a low-density bipolar cavity, a flared 1M$_\odot$ disk and an envelope provides a sufficient fit all three types of observation. The need to include a disk in the model implies that this MYSO follows a scaled-up version of the low-mass star formation process. The weak silicate absorption feature within the SED requires low-density envelope cavities to be successfully fit and is an atypical characteristic in comparison to previously studied MYSOs. Additionally, the inner radius of the disk must be three times the dust sublimation radius to satisfy the MIDI visibilities. The low density, low extinction environment implies the object is a more evolved MYSO and this combined with large inner radius of the disk suggests that it could be an example of a transitional disk around an MYSO.

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22 The role of initial magnetic field structure in the launching of protostellar jets

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Magnetic fields are known to play a crucial role in the star formation process, particularly in the formation of jets and outflows from protostellar discs. The magnetic field structure in star forming regions is not always uniform and ordered, often containing regions of magnetic turbulence. We present grid-based, magneto-hydrodynamical simulations of the collapse of a $1\,\mathrm{M}_\odot$ cloud core, to investigate the influence of complex magnetic field structures on outflow formation, morphology and efficiency. We compare three cases: a uniform field, a partially turbulent field and a fully turbulent field, with the same magnetic energy in all three cases. We find that collimated jets are produced in the uniform-field case, driven by a magneto-centrifugal mechanism. Outflows also form in the partially turbulent case, although weaker and less collimated, with an asymmetric morphology. The outflows launched from the partially turbulent case carry the same amount of mass as the uniform-field case but at lower speeds, having only have 71% of the momentum of the uniform-field case. In the case of a fully turbulent field, we find no significant outflows at all. Moreover, the turbulent magnetic field initially reduces the accretion rate and later induces fragmentation of the disc, forming multiple protostars. We conclude that a uniform poloidal component of the magnetic field is necessary for the driving of jets.

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23 Is it possible to reconcile extragalactic IMF variations with a universal Milky Way IMF?

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One of the most robust observations of the stellar initial mass function (IMF) is its near-universality in the Milky Way and neighboring galaxies. But recent observations of early-type galaxies can be interpreted to imply a bottom-heavy IMF, while others of ultra-faint dwarfs could imply a top-heavy IMF. This would impose powerful constraints on star formation models. We explore what sort of cloud-scale IMF models could possibly satisfy these constraints. We utilize simulated galaxies which reproduce (broadly) the observed galaxy properties, while they also provide the detailed star formation history and properties of each progenitor star-forming cloud. We then consider generic models where the characteristic mass of the IMF is some arbitrary power-law function of progenitor cloud properties, along with well-known literature IMF models, which scale with Jeans mass, turbulent Bonnor-Ebert mass, temperature, the opacity limit, metallicity, or the protostellar heating mass. We show that no IMF models currently in the literature - nor any model where the turnover mass is an arbitrary power-law function of a combination of cloud temperature/density/size/metallicity/velocity dispersion/magnetic field - can reproduce the claimed IMF variation in ellipticals or dwarfs without severely violating observational constraints in the Milky Way. Specifically, they predict too much variation in the extreme environments of the Galaxy, compared to that observed. Either the IMF varies in a more complicated manner, or alternative interpretations of the extragalactic observations must be explored.

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24 Stellar models and isochrones from low-mass to massive stars including pre-main sequence phase with accretion

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Grids of stellar models are useful tools to derive the properties of stellar clusters, in particular young clusters hosting massive stars, and to provide information on the star formation process in various mass ranges. Because of their short evolutionary timescale, massive stars end their life while their low-mass siblings are still on the pre-main sequence (pre-MS) phase. Thus the study of young clusters requires consistent consideration of all the phases of stellar evolution. But despite the large number of grids that are available in the literature, a grid accounting for the evolution from the pre-MS accretion phase to the post-MS phase in the whole stellar mass range is still lacking. We build a grid of stellar models at solar metallicity with masses from 0.8 $M_\odot$ to 120 $M_\odot$, including pre-MS phase with accretion. We use the GENEC code to run stellar models on this mass range. The accretion law is chosen to match the observations of pre-MS objects on the Hertzsprung-Russell diagram. We describe the evolutionary tracks and isochrones of our models. The grid is connected to previous MS and post-MS grids computed with the same numerical method and physical assumptions, which provides the widest grid in mass and age to date. Numerical tables of our models and corresponding isochrones are available online.

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25 Probing the protosolar disk using dust filtering at gaps in the early Solar System

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Jupiter and Saturn formed early, before the gas disk dispersed. The presence of gap-opening planets affects the dynamics of the gas and embedded solids, and halts the inward drift of grains above a certain size. A drift barrier can explain the absence of calcium-aluminium-rich inclusions (CAIs) in chondrites originating from parent bodies that accreted in the inner Solar System. Employing an interdisciplinary approach, we use a μ-X-Ray-fluorescence scanner to search for large CAIs and a scanning electron microscope to search for small CAIs in the ordinary chondrite NWA 5697. We carry out long-term, two-dimensional simulations including gas, dust, and planets to characterize the transport of grains within the viscous α-disk framework exploring the scenarios of a stand-alone Jupiter, Jupiter and Saturn *in situ*, or in a 3:2 resonance. In each case, we find a critical grain size above which drift is halted as a function of the physical conditions in the disk. From the laboratory search we find four CAIs with a largest size of $\approx$200 μm. Combining models and data, we provide an estimate for the upper limit of the α-viscosity and the surface density at the location of Jupiter, using reasonable assumptions about the stellar accretion rate during inward transport of CAIs, and assuming angular momentum transport to happen exclusively through viscous effects. Moreover, we find that the compound gap structure in the presence of Saturn in a 3:2 resonance favors inward transport of grains larger than CAIs currently detected in ordinary chondrites.

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26 A Radiative Heating Model for Chondrule and Chondrite Formation

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We propose that chondrules and chondrites formed together during a brief radiative heating event caused by the close encounter of a small (m to km-scale), primitive planetesimal (SPP) with incandescent lava on the surface of a large (100 km-scale) differentiated planetesimal (LDP). In our scenario, chondrite lithification occurs by hot isostatic pressing (HIP) simultaneously with chondrule formation, in accordance with the constraints of complementarity and cluster chondrites. Thermal models of LDPs formed near t=0 predict that there will be a very narrow window of time, coincident with the chondrule formation epoch, during which crusts are thin enough to frequently rupture by impact, volcanism and/or crustal foundering, releasing hot magma to their surfaces. The heating curves we calculate are more gradual and symmetric than the "flash heating" characteristic of nebular models, but in agreement with the constraints of experimental petrology. The SPP itself is a plausible source of the excess O, Na and Si vapor pressure (compared to a solar nebula environment) that is required by chondrule observations. Laboratory experiments demonstrate that FeO-poor porphyritic olivine chondrules, the most voluminous type of chondrule, can be made using heating and cooling curves predicted by the "flyby" model. If chondrules are a by-product of chondrite lithification, then their high volume abundance within well-lithified chondritic material is not evidence that they were once widespread within the Solar System. Relatively rare events, such as the flybys modeled here, could account for their abundance in the meteorite record.

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27 Origin of Misalignments: Protostellar Jet, Outflow, Circumstellar Disc, and Magnetic Field

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Recent observations uncover various phenomena around the protostar such as misalignment between the outflow and magnetic field, precession of the jet, and time variability of the ejected clumps, whose origins are under debate. We perform a three-dimensional resistive magnetohydrodynamics simulation of the protostar formation in a star-forming core whose rotation axis is tilted at an angle 45° with respect to the initial magnetic field, in which the protostar is resolved with a spatial resolution of 0.01 au. In low-dense outer region, the prestellar core contracts along the magnetic field lines due to the flux freezing. In high-dense inner region, on the other hand, the magnetic dissipation becomes efficient and weakens the magnetic effects when the gas number density exceeds about $10^{11}\,\mathrm{cm}^{-3}$. Then, the normal direction of the flattened disc is aligned with the angular momentum vector. The outflow, jet, and protostellar ejection are driven from different scales of the circumstellar disc and spout in different directions normal to the warped disc. These axes do not coincide with the global magnetic field direction and vary with time. This study demonstrates that a couple of misalignment natures reported by observations can be simultaneously reproduced only by assuming the star-forming core rotating around a different direction from the magnetic field.

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28 On the origin of very massive stars around NGC 3603

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The formation of the most massive stars in the Universe remains an unsolved problem. Are they able to form in relative isolation in a manner similar to the formation of solar-type stars, or do they necessarily require a clustered environment? In order to shed light on this important question, we study the origin of two very massive stars (VMS): the O2.5If*/WN6 star RFS7 ($\sim 100\,M_{\odot}$), and the O3.5If* star RFS8 ($\sim 70\,M_{\odot}$), found within ≈ 53 and 58 pc respectively from the Galactic massive young cluster NGC 3603, using *Gaia* data. RFS7 is found to exhibit motions resembling a runaway star from NGC 3603. This is now the most massive runaway star candidate known in the Milky Way. Although RFS8 also appears to move away from the cluster core, it has proper-motion values that appear inconsistent with being a runaway from NGC 3603 at the 3σ level (but with substantial uncertainties due to distance and age). Furthermore, no evidence for a bow-shock or a cluster was found surrounding RFS8 from available near-infrared photometry. In summary, whilst RFS7 is likely a runaway star from NGC 3603, making it the first VMS runaway in the Milky Way, RFS8 is an extremely young (~ 2 Myr) VMS, which might also be a runaway, but this would need to be established from future spectroscopic and astrometric observations, as well as precise distances. If RFS8 were still not meeting the criteria for being a runaway from NGC 3603 from such future data, this would have important ramifications for current theories of massive star formation, as well as the way the stellar initial mass function (IMF) is sampled.

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29 Effect of Different Angular Momentum Transport Mechanisms on the Distribution of Water in Protoplanetary Disks

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The snow line in a protoplanetary disk demarcates regions with H_2O ice from regions with H_2O vapor. Where a planet forms relative to this location determines how much water and other volatiles it forms with. Giant planet formation may be triggered at the water snow line if vapor diffuses outward and is cold-trapped beyond the snow line faster than icy particles can drift inward. In this study we investigate the distribution of water across the snow line, considering three different radial profiles of the turbulence parameter $\alpha(r)$, corresponding to three different angular momentum transport mechanisms. We consider the radial transport of water vapor and icy particles by diffusion, advection, and drift. We show that even for similar values of α, the gradient of α(r) across the snow line significantly changes the snow line location, the sharpness of the volatile gradient across the snow line, and the final water/rock ratio in planetary bodies. A profile of radially decreasing α, consistent with transport by hydrodynamic instabilities plus magnetic disk winds, appears consistent with the distribution of water in the solar nebula, with monotonically-increasing radial water content and a diverse population of asteroids with different water content. We argue that $\Sigma(r)$ and water abundance $N_{\mathrm{H_2O}}(r)/N_{\mathrm{H_2}}(r)$ are likely a diagnostic of $\alpha(r)$ and thus the mechanism for angular momentum transport in inner disks.

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30 Millimeter-wave polarization due to grain alignment by the gas flow in protoplanetary disks

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Dust grains emit intrinsic polarized emission if they are elongated and aligned in the same direction. The direction of the grain alignment is determined by external forces, such as magnetic fields, radiation, and gas flow against the dust grains. In this letter, we apply the concept of the grain alignment by gas flow, which is called mechanical alignment, to the situation of a protoplanetary disk. We assume that grains have a certain helicity, which results in the alignment with the minor axis parallel to the grain velocity against the ambient disk gas and discuss the morphology of polarization vectors in a protoplanetary disk. We find that the direction of the polarization vectors depends on the Stokes number, which denotes how well grains are coupled to the gas. If the Stokes number is less than unity, orientation of polarization is in the azimuthal direction since the dust velocity against the gas is in the radial direction. If the Stokes number is as large as unity, the polarization vectors show a leading spiral pattern since the radial and azimuthal components of the gas velocity against the dust grains are comparable. This suggests that if the observed polarization vectors show a leading spiral pattern, it would indicate that Stokes number of dust grains is around unity, which is presumably radially drifting.

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31 Stellar encounters with giant molecular clouds

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Giant molecular clouds (GMCs) are believed to affect the biospheres of planets as their host star passes through them. We simulate the trajectories of stars and GMCs in the Galaxy and determine how often stars pass through GMCs. We find a strong decreasing dependence with Galactocentric radius, and with the velocity perpendicular to the Galactic plane, V_z. The XY-component of the kinematic heating of stars was shown to not affect the GMC hit rate, unlike the Z-dependence (V_z) implies that stars hit fewer GMCs as they age. GMCs are locations of star formation, therefore we also determine how often stars pass near supernovae. For the supernovae the decrease with V_z is steeper as how fast the star passes through the GMC determines the probability of a supernova encounter. We then integrate a set of Sun-like trajectories to see the implications for the Sun. We find that the Sun hits 1.6±1.3 GMCs per Gyr which results in 1.5±1.1 or (with correction for clustering) 0.8±0.6 supernova closer than 10 pc per Gyr. The different supernova frequencies are from whether one considers multiple supernova per GMC crossing (few Myr) as separate events. We then discuss the effect of the GMC hits on the Oort cloud, and the Earth's climate due to accretion, we also discuss the records of distant supernova. Finally, we determine Galactic Habitable Zone using our model. For the thin disk we find it to lie between 5.8–8.7 kpc and for the thick disk to lie between 4.5–7.7 kpc.

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32 The Core Mass Function in the Infrared Dark Cloud G28.37+0.07

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In this paper, we analyze the 1.3 mm continuum ALMA data that cover the majority of the infrared dark cloud (IRDC) G28.37+0.07. With a spatial resolution of 0.5" (2500 au at 5 kpc), the continuum image reveals five groups of dense cores. Each core group has a projected physical scale of about 1 pc, with core masses spanning a dynamic range of about 100. We use the dendrogram method (astrodendro) and a newly developed graph method (astrograph) to identify individual cores. The core masses are estimated through the millimeter continuum flux, assuming constant temperature and using an NH3-based gas temperature. We construct core mass functions (CMFs) based on the two methods and fit a power-law relation $dN/d \log M \propto M^{-\alpha}$ to the CMFs for $M > 0.79\ M_\odot$. In the constant-temperature scenario, astrograph gives $\alpha = 0.80 \pm 0.10$, while astrodendro gives $\alpha = 0.71 \pm 0.11$, both significantly shallower than the Salpeter-type initial mass function with $\alpha = 1.35$. In the scenario where the NH3 gas temperature is applied to cores, astrograph gives $\alpha = 1.37 \pm 0.06$, while astrodendro gives $\alpha = 0.87 \pm 0.07$. Regional CMF slope variation is seen between the core groups. We also compare CMFs in three different environments, including IRDC G28.37+0.07, IRDC clumps, and G286.21+0.17, using the identical dendrogram method. Results show that IRDCs have smaller α than the cluster-forming cloud G286.21+0.17.

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https://ui.adsabs.harvard.edu/#abs/2019ApJ...873...31K/abstract

33 Widespread Molecular Outflows in the Infrared Dark Cloud G28.37+0.07: Indications of Orthogonal Outflow-Filament Alignment

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We present ALMA CO(2-1) observations toward a massive infrared dark cloud G28.37+0.07. The ALMA data reveal numerous molecular (CO) outflows with a wide range of sizes throughout the cloud. Sixty-two 1.3 mm continuum cores were identified to be driving molecular outflows. We have determined the position angle in the plane-of-sky of 120 CO outflow lobes and studied their distribution. We find that the distribution of the plane-of-sky outflow position angles peaks at about 100 deg, corresponding to a concentration of outflows with an approximately east-west direction. For most outflows, we have been able to estimate the plane-of-sky angle between the outflow axis and the filament that harbors the protostar that powers the outflow. Statistical tests strongly indicate that the distribution of outflow-filament orientations is consistent with most outflow axes being mostly orthogonal to their parent filament in 3D. Such alignment may result from filament fragmentation or continuous mass transportation from filament to the embedded protostellar core. The latter is suggested by recent numerical studies with moderately strong magnetic fields.

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34 Close companions around young stars

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Multiplicity is a fundamental property that is set early during stellar lifetimes, and it is a stringent probe of the physics of star formation. The distribution of close companions around young stars is still poorly constrained by observations. We present an analysis of stellar multiplicity derived from APOGEE-2 spectra obtained in targeted observations of nearby star-forming regions. This is the largest homogeneously observed sample of high-resolution spectra of young stars. We developed an autonomous method to identify double lined spectroscopic binaries (SB2s). Out of 5007 sources spanning the mass range of ∼0.05–1.5 $M_\odot$, we find 399 binaries, including both RV variables and SB2s. The mass ratio distribution of SB2s is consistent with a uniform for $q < 0.95$ with an excess of twins with $q > 0.95$. The period distribution is consistent with what has been observed in close binaries (< 10 AU) in the evolved populations. Three systems are found to have $q \sim 0.1$, with a companion located within the brown dwarf desert. There are not any strong trends in the multiplicity fraction (MF) as a function of cluster age from 1 to 100 Myr. There is a weak dependence on stellar density, with companions being most numerous at $\Sigma_* \sim 30$ stars/pc^{-2}, and decreasing in more diffuse regions. Finally, disk-bearing sources are deficient in SB2s (but not RV variables) by a factor of ∼2; this deficit is recovered by the systems without disks. This may indicate a quick dispersal of disk material in short-period equal mass systems that is less effective in binaries with lower q.

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35 Exploring the dimming event of RW Aur A through multi-epoch VLT/X-Shooter spectroscopy

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RW Aur A is a classical T Tauri star that has suddenly undergone three major dimming events since 2010. The reason for these dimming events is still not clear. We aim to understand the dimming properties, examine accretion variability, and derive the physical properties of the inner disc traced by the CO ro-vibrational emission at near-infrared wavelengths (2.3 μm). We compared two epochs of X-Shooter observations, during and after the dimming. We modelled the rarely detected CO bandhead emission in both epochs to examine whether the inner disc properties had changed. The spectral energy distribution was used to derive the extinction properties of the dimmed spectrum and compare the infrared excess between the two epochs. Lines tracing accretion were used to derive the mass accretion rate in both states. The CO originates from a region with physical properties of T=3000 K, $N_{CO}=1\times10^{21}$ cm^{-2} and $v_k \sin i=113$ km/s. The extinction properties of the dimming layer were derived with the effective optical depth ranging from τ_{eff} ∼2.5-1.5 from the UV to the near-IR. The inferred mass accretion rate $\dot{M}_{acc}$ is $\sim 1.5 \times 10^{-8}$ $M_\odot$/yr and $\sim 2 \times 10^{-8}$ $M_\odot$/yr after and during the dimming respectively. By fitting the spectral energy distribution, additional emission is observed in the infrared during the dimming event from dust grains with temperatures of 500-700 K. The physical conditions traced by the CO are similar for both epochs, indicating that the inner gaseous disc properties do not change during the dimming events. The extinction curve is flatter than that of the interstellar medium, and large grains of a few hundred microns are thus required. When we correct for the observed extinction, the mass accretion rate is constant in the two epochs, suggesting that the accretion is stable and therefore does not cause the dimming. The additional hot emission in the near-IR is located at about 0.5 au from the star and is not consistent with an occulting body located in the outer regions of the disc. The dimming events could be due to a dust-laden wind, a severe puffing-up of the inner rim, or a perturbation caused by the recent star-disc encounter.

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36 The Origins of Protostellar Core Angular Momenta

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We present the results of a suite of numerical simulations designed to explore the origin of the angular momenta of protostellar cores. Using the hydrodynamic grid code *Athena* with a sink implementation, we follow the formation of protostellar cores and protostars (sinks) from the subvirial collapse of molecular clouds on larger scales to investigate the range and relative distribution of core properties. We find that the core angular momenta are relatively unaffected by large-scale rotation of the parent cloud; instead, we infer that angular momenta are mainly imparted by torques between neighboring mass concentrations and exhibit a log-normal distribution. Our current simulation results are limited to size scales ~ 0.05 pc ($\sim 10^4$ AU), but serve as first steps toward the ultimate goal of providing initial conditions for higher-resolution studies of core collapse to form protoplanetary disks.

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37 Modeling Sulfur Depletion in Interstellar Clouds

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The elemental depletion of interstellar sulfur from the gas phase has been a recurring challenge for astrochemical models. Observations show that sulfur remains relatively non-depleted with respect to its cosmic value throughout the diffuse and translucent stages of an interstellar molecular cloud, but its gas-phase constituents cannot account for this cosmic value towards higher-density environments. We have attempted to address this issue by modeling the evolution of an interstellar cloud from its pristine state as a diffuse atomic cloud to a molecular environment of much higher density, using a gas/grain astrochem. code and an enhanced sulfur reaction network. A common gas/grain reaction network has been systematically updated and greatly extended based on previous lit. and models, with a focus on the grain chemistry and processes. A simple model was used to benchmark the resulting network updates, and the results of the model were compared to typical astronomical observations sourced from the literature. Our new gas/grain model is able to reproduce the elemental depletion of sulfur, whereby sulfur can be depleted from the gas-phase by two orders of magnitude, and this process may occur under dark cloud conditions if the cloud has a chemical age of at least 1 Myrs. The resulting mix of sulfur-bearing species on the grain ranges across all the most common chemical elements (H/C/N/O), not dissimilar to the molecules observed in cometary environments. Notably, this mixture is not dominated simply by H_2S, unlike all other current astrochem. models. Despite our relatively simple physical model, most of the known gas-phase S-bearing molecular abundances are accurately reproduced under dense conditions, however they are not expected to be the primary molecular sinks of sulfur. Our model predicts that most of the missing sulfur is in the form of organo-sulfur species trapped on grains.

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38 The ice composition in the disk around V883 Ori revealed by its stellar outburst

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Complex organic molecules (COMs), which are the seeds of prebiotic material and precursors of amino acids and sugars, form in the icy mantles of circumstellar dust grains but cannot be detected remotely unless they are heated and released to the gas phase. Around solar-mass stars, water and COMs only sublimate in the inner few AU of the circumstellar disk, making them extremely difficult to spatially resolve and study. Sudden increases in the luminosity of the central star will quickly expand the sublimation front (the so-called snow line) to larger radii, as seen previously in the FU Ori outburst of the young star V883 Ori. Here, we take advantage of the rapid increase in disk temperature of V883 Ori to detect and analyse five different COMs — methanol, acetone, acetonitrile, acetaldehyde and methyl formate — in spatially resolved submillimetre observations. The abundances of COMs in the disk around V883 Ori are in reasonable agreement with cometary values, suggesting that outbursting young stars can provide a special opportunity to study the ice composition of material directly related to planet formation.

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39 Sulfur chemistry in protoplanetary disks: CS and H_2CS

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The nature and abundance of sulfur chemistry in protoplanetary disks (PPDs) may impact the sulfur inventory on young planets and therefore their habitability. PPDs also present an interesting test bed for sulfur chemistry models, since each disk present a diverse set of environments. In this context, we present new sulfur molecule observations in PPDs, and new S-disk chemistry models. With ALMA we observed the CS 5–4 rotational transition toward five PPDs (DM Tau, DO Tau, CI Tau, LkCa 15, MWC 480), and the CS 6–5 transition toward three PPDs (LkCa 15, MWC 480 and V4046 Sgr). Across this sample, CS displays a range of radial distributions, from centrally peaked, to gaps and rings. We also present the first detection in PPDs of ^{13}CS 6–5 (LkCa 15 and MWC 480), C^{34}S 6–5 (LkCa 15), and H_2CS 8_{17}–7_{16}, 9_{19}–8_{18} and 9_{18}–8_{17} (MWC 480) transitions. Using LTE models to constrain column densities and excitation temperatures, we find that either ^{13}C and ^{34}S are enhanced in CS, or CS is optically thick despite its relatively low brightness temperature. Additional lines and higher spatial resolution observations are needed to distinguish between these scenarios. Assuming CS is optically thin, CS column density model predictions reproduce the observations within a factor of a few for both MWC 480 and LkCa 15. However, the model underpredicts H_2CS by 1–2 orders of magnitude. Finally, comparing the H_2CS/CS ratio observed toward the MWC 480 disk and toward different ISM sources, we find the closest match with prestellar cores.

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40 Planetesimal Population Synthesis: Pebble Flux Regulated Planetesimal Formation

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We propose an expression for a local planetesimal formation rate proportional to the instantaneous radial pebble flux. The result — a radial planetesimal distribution — can be used as initial condition to study the formation of planetary embryos. We follow the idea that one needs particle traps to locally enhance the dust-to-gas ratio sufficiently such that particle gas interactions can no longer prevent planetesimal formation on small scales. The location of these traps can emerge everywhere in the disk. Their occurrence and lifetime is subject of ongoing research, thus they are implemented via free parameters. This enables us to study the influence of the disk properties on the formation of

planetesimals, predicting their time dependent formation rates and location of primary pebble accretion. We show that large α-values of 0.01 (strong turbulence) prevent the formation of planetesimals in the inner part of the disk, arguing for lower values of around 0.001 (moderate turbulence), at which planetesimals form quickly at all places where they are needed for proto-planets. Planetesimals form as soon as dust has grown to pebbles (∼mm to dm) and the pebble flux reaches a critical value, which is after a few thousand years at 2–3AU and after a few hundred thousand years at 20–30AU. Planetesimal formation lasts until the pebble supply has decreased below a critical value. The final spatial planetesimal distribution is steeper compared to the initial dust and gas distribution which helps to explain the discrepancy between the minimum mass solar nebula and viscous accretion disks.

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41 Dust settling against hydrodynamic turbulence in protoplanetary discs

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Enhancing the local dust-to-gas ratio in protoplanetary discs is a necessary first step to planetesimal formation. In laminar discs, dust settling is an efficient mechanism to raise the dust-to-gas ratio at the disc midplane. However, turbulence, if present, can stir and lift dust particles, which ultimately hinders planetesimal formation. In this work, we study dust settling in protoplanetary discs with hydrodynamic turbulence sustained by the vertical shear instability. We perform axisymmetric numerical simulations to investigate the effect of turbulence, particle size, and solid abundance or metallicity on dust settling. We highlight the positive role of drag forces exerted onto the gas by the dust for settling to overcome the vertical shear instability. In typical disc models we find particles with a Stokes number $\sim 10^{-3}$ can sediment to $\lesssim$10% of the gas scale-height, provided that $\Sigma_{\rm d}/\Sigma_{\rm g} \gtrsim$ 0.02–0.05, where $\Sigma_{\rm d,g}$ are the surface densities in dust and gas, respectively. This coincides with the metallicity condition for small particles to undergo clumping via the streaming instability. Super-solar metallicities, at least locally, are thus required for a self-consistent picture of planetesimal formation. Our results also imply that dust rings observed in protoplanetary discs should have smaller scale-heights than dust gaps, provided that the metallicity contrast between rings and gaps exceed the corresponding contrast in gas density.

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42 New powerful outburst of the unusual young star V1318 Cyg S (LkHα 225)

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Aims. Young double star V1318 Cyg, which is associated with a small isolated star-forming region around HAeBe star BD+40°4124, has very unusual photometric and spectral behavior. We present results of photometric and spectroscopic observations in the optical range.

Methods. We carried out BVRI CCD photometric observations of V1318 Cyg from 2015 Sept. to 2017 July. For the same period we acquired medium- and low-resolution spectra. Observations were performed with the 2.6 m telescope of the Byurakan observatory. We also analyzed the images of this field in IPHAS and other surveys.

Results. We analyze the historical light curve for V1318 Cyg and demonstrate that the southern component, V1318 Cyg S, after being rather bright in the 1970s (V∼14 mag) started to lower its brightness and in 1990 became practically invisible in the optical. After its reappearance in the second half of the 1990s the star started to become very slowly brighter. Between 2006 and 2010 V1318 Cyg S started brightening more quickly, and in 2015 had become brighter by more than five magnitudes in visible light. Since this time V1318 Cyg S has remained at this maximum. Its spectrum shows little variability and consists of a mixture of emission and absorption lines, which has allowed for estimates of its spectral type as early Ae, with obvious evidence of matter outow. We derive its current $A_V \approx 7.2$ and L = 750

L_{sun} thus confirming that V1318 Cyg S should belong to the Herbig Ae stars, making it, along with BD+40°4124 and V1686 Cyg, the third luminous young star in the group. It is very probable that we observe V1318 Cyg S near the pole and that the inclination of its dense and slow (≈ 100 km/s) outow is low.

Conclusions. The unusual variability and other features of V1318 Cyg S make it difficult to classify this star among known types of eruptive young stars. It could be an extreme, higher-mass example of an EXor, or an object of intermediate class between EXors and FUors, like V1647 Ori.

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43 Connecting substellar and stellar formation. The role of the host star's metallicity

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Most of our current understanding of the planet formation mechanism is based on the planet metallicity correlation derived mostly from solar-type stars harbouring gas-giant planets. To achieve a far more reaching grasp on the substellar formation process we aim to analyse in terms of their metallicity a diverse sample of stars (in terms of mass and spectral type) covering the whole range of possible outcomes of the planet formation process (from planetesimals to brown dwarfs and low-mass binaries). Our methodology is based on the use of high-precision stellar parameters derived by our own group in previous works from high-resolution spectra by using the iron ionisation and equilibrium conditions. All values are derived in an homogeneous way, except for the M dwarfs where a methodology based on the use of pseudo equivalent widths of spectral features was used. Our results show that as the mass of the substellar companion increases the metallicity of the host star tendency is to lower values. The same trend is maintained when analysing stars with low-mass stellar companions and a tendency towards a wide range of host star's metallicity is found for systems with low mass planets. We also confirm that more massive planets tend to orbit around more massive stars. The core-accretion formation mechanism for planet formation achieves its maximum efficiency for planets with masses in the range 0.2 and 2 $M_{\rm Jup}$. Substellar objects with higher masses have higher probabilities of being formed as stars. Low-mass planets and planetesimals might be formed by core-accretion even around low-metallicity stars.

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44 HH 276, A Collimated Outflow in the Region of FS Tau A/B

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Results from studies of the extended Herbig-Haro flow HH 276 in the region of FS Tau A/B are presented. Long-slit and Fabry-Perot spectroscopy were carried out on the 6-m telescope at the Special Astrophysical Observatory of the Russian Academy of Sciences and the 2.6-m telescope at the Byurakan Astrophysical Observatory. A new Herbig-Haro knot HH 276E, located on the axis of the already known outflow HH 276, was discovered. The radial velocities of this outflow indicate that the collimated stream is oriented perpendicular to the line of sight. A presumed source of the outflow, a bright infrared object, has been found. The slit spectrum in the optical range confirms the youth of this object and reveals signs of a Herbig-Haro outflow.

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45 Revealing signatures of planets migrating in protoplanetary discs with ALMA multi-wavelength observations

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Recent observations show that rings and gaps are ubiquitous in protoplanetary discs. These features are often interpreted as being due to the presence of planets; however, the effect of planetary migration on the observed morphology has not been investigated hitherto. In this work we investigate whether multiwavelength mm/submm observations can detect signatures of planet migration, using 2D dusty hydrodynamic simulations to model the structures generated by migrating planets and synthesising ALMA continuum observations at 0.85 and 3 mm. We identify three possible morphologies for a migrating planet: a slowly migrating planet is associated with a single ring outside the planet's orbit, a rapidly migrating planet is associated with a single ring inside the planet's orbit while a planet migrating at intermediate speed generates one ring on each side of the planet's orbit. We argue that multiwavelength data can distinguish multiple rings produced by a migrating planet from other scenarios for creating multiple rings, such as multiple planets or discs with low viscosity. The signature of migration is that the outer ring has a lower spectral index, due to larger dust grains being trapped there. Of the recent ALMA observations revealing protoplanetary discs with multiple rings and gaps, we suggest that Elias 24 is the best candidate for a planet migrating in the intermediate speed regime.

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46 The complexity of Orion: an ALMA view III. The explosion impact

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The chemistry of complex organic molecules in interstellar dark clouds is still highly uncertain due in part to the lack of constraining observations. Orion is the closest massive star-forming region, and observations making use of ALMA allow us to separate the emission regions of various Complex Organic Molecules (COMs) in both velocity and space. Orion also benefits from an exceptional situation, in that it is the site of a powerful explosive event that occured ∼550 years ago. We show that the closely surrounding Kleinmann-Low region has clearly been influenced by this explosion, with some molecular species having been pushed away from the densest parts while others have remained in close proximity. This dynamical segregation reveals the time dependence of the chemistry and, therefore allows us to better constrain the formation sequence of COMs and other species, including deuterated molecules.

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http://aramis.obspm.fr/~pagani/lettre_explosion.pdf

47 A hypothesis for the rapid formation of planets

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The discovery of 1I/Oumuamua confirmed that planetesimals must exist in great numbers in interstellar space. Originally generated during planet formation, they are scattered from their original systems and subsequently drift through interstellar space. As a consequence they should seed molecular clouds with at least hundred-metre-scale objects. We consider how the galactic background density of planetesimals, enriched from successive generations of star and system formation, can be incorporated into forming stellar systems. We find that at minimum of the order of 10^7

Oumuamua-sized and larger objects, plausibly including hundred-kilometre-scale objects, should be present in protoplanetary disks. At such initial sizes, the growth process of these seed planetesimals in the initial gas- and dust-rich protoplanetary disks is likely to be substantially accelerated. This could resolve the tension between accretionary timescales and the observed youth of fully-fledged planetary systems. Our results strongly advocate that the population of interstellar planetesimals should be taken into account in future studies of planet formation. As not only the Galaxy's stellar metallicity increased over time but also the density of interstellar objects, we hypothesize that this enriched seeding enhances planetary formation after the first generation of planetary systems.

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48 Multi-epoch Ultraviolet HST Observations of Accreting Low-mass Stars

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Variability is a defining characteristic of young low-mass stars that are still accreting material from their primordial protoplanetary disk. Here we present the largest *HST* variability study of Classical T Tauri stars (CTTS) to date. For 5 of these objects, we obtained a total of 25 spectra with the Space Telescope Imaging Spectrograph (STIS). Mass accretion rates and the fraction of the star covered by accretion columns (i.e., filling factors) were inferred using 1D NLTE physical models whose parameters were fit within a Bayesian framework. On week long timescales, typical changes in the mass accretion rates range up to a factor of ~ 2, while changes of up to a factor of ~ 5 are inferred for the filling factors. In addition to this, we observed a possible accretion burst in the transitional disk system GM Aur, and an incident we interpret as a chance alignment of an accretion column and the undisturbed photosphere along our line of sight in the full disk system VW Cha. We also measure correlations between mass accretion rate and line luminosities for use as secondary tracers of accretion. We place our objects in context with recent high-cadence photometric surveys of low-mass star formation regions and highlight the need for more broad-wavelength, contemporaneous data to better understand the physical mechanisms behind accretion variability in CTTS.

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49 How the power spectrum of dust continuum images may hide the presence of a characteristic filament width

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Context: *Herschel* observations of interstellar clouds support a paradigm for star formation in which molecular filaments play a central role. One of the foundations of this paradigm is the finding, based on detailed studies of the transverse column density profiles observed with *Herschel*, that nearby molecular filaments share a common inner width of ~ 0.1 pc. The existence of a characteristic filament width has been recently questioned, however, on the grounds that it seems inconsistent with the scale-free nature of the power spectrum of interstellar cloud images.
Aims: In an effort to clarify the origin of this apparent discrepancy, we examined the power spectra of the *Herschel*/SPIRE 250 μm images of the Polaris, Aquila, and Taurus–L1495 clouds in detail and performed a number of

simple numerical experiments by injecting synthetic filaments in both the *Herschel* images and synthetic background images.
Methods: We constructed several populations of synthetic filaments of 0.1 pc width with realistic area filling factors ($A_{\rm fil}$) and distributions of column density contrasts (δ_c). After adding synthetic filaments to the original *Herschel* images, we re-computed the image power spectra and compared the results with the original, essentially scale-free power spectra. We used the $\chi^2_{\rm variance}$ of the residuals between the best power-law fit and the output power spectrum in each simulation as a diagnostic of the presence (or absence) of a significant departure from a scale-free power spectrum.
Results: We found that $\chi^2_{\rm variance}$ depends primarily on the combined parameter $\delta_c^2\,A_{\rm fil}$. According to our numerical experiments, a significant departure from a scale-free behavior and thus the presence of a characteristic filament width become detectable in the power spectrum when $\delta_c^2\,A_{\rm fil} \geq 0.1$ for synthetic filaments with Gaussian profiles and $\delta_c^2\,A_{\rm fil} \geq 0.4$ for synthetic filaments with Plummer-like density profiles. Analysis of the real *Herschel* 250 μm data suggests that $\delta_c^2\,A_{\rm fil}$ is ~ 0.01 in the case of the Polaris cloud and ~ 0.016 in the Aquila cloud, significantly below the fiducial detection limit of $\delta_c^2\,A_{\rm fil} \sim 0.1$ in both cases. In both clouds, the observed filament contrasts and area filling factors are such that the filamentary structure contributes only $\sim 1/5$ of the power in the image power spectrum at angular frequencies where an effect of the characteristic filament width is expected.
Conclusions: We conclude that the essentially scale-free power spectra of *Herschel* images remain consistent with the existence of a characteristic filament width ~ 0.1 pc and do not invalidate the conclusions drawn from studies of the filament profiles.

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50 Planetesimal fragmentation and giant planet formation II: dependencies with planetesimal relative velocities and compositions

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Most of planet formation models that incorporate planetesimal fragmentation consider a catastrophic impact energy threshold for basalts at a constant velocity of 3 km s^{-1} during all the process of the formation of the planets. However, as planets grow the relative velocities of the surrounding planetesimals increase from velocities of the order of m s^{-1} to a few km s^{-1}. In addition, beyond the ice line where giant planets are formed, planetesimals are expected to be composed roughly by 50% of ices. We aim to study the role of planetesimal fragmentation on giant planet formation considering planetesimal catastrophic impact energy threshold as a function of the planetesimal relative velocities and compositions. We improve our model of planetesimal fragmentation incorporating a functional form of the catastrophic impact energy threshold with the planetesimal relative velocities and compositions. We also improve in our model the accretion of small fragments produced by the fragmentation of planetesimals during the collisional cascade considering specific pebble accretion rates. We find that a more accurate and realistic model for the calculation of the catastrophic impact energy threshold tends to slow down the formation of massive cores. Only for reduced grain opacity values at the envelope of the planet, the cross-over mass is achieved before the disk time-scale dissipation. While planetesimal fragmentation favors the quick formation of massive cores of 5–10 $M_\oplus$ the cross-over mass could be inhibited by planetesimal fragmentation. However, grain opacity reduction or pollution by the accreted planetesimals together with planetesimal fragmentation could explain the formation of giant planets with low-mass cores.

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51 High Precision Dynamical Masses of Pre-Main Sequence Stars with ALMA and Gaia

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The Keplerian rotation in protoplanetary disks can be used to robustly measure stellar masses at very high precision if the source distance is known. We present Atacama Large Millimeter/submillimeter Array (ALMA) observations of spatially and spectrally resolved ^{12}CO (2–1) emission towards the disks around 2MASS J16262774–2527247 (the tertiary companion to ROXs 12 at 5100 au), CT Cha, and DH Tau. We employ detailed modeling of the Keplerian rotation profile, coupled with accurate distances from *Gaia*, to directly measure the stellar masses with $\sim$2% precision. We also compare these direct mass measurements with the masses inferred from evolutionary models, determined in a statistically rigorous way. We find that 2MASS J16262774–2527247 has a mass of $0.535^{+0.006}_{-0.007}$ $M_\odot$ and CT Cha has a mass of $0.796^{+0.015}_{-0.014}$ $M_\odot$, broadly consistent with evolutionary models, although potentially significant differences remain. DH Tau has a mass of $0.101^{+0.004}_{-0.003}$ $M_\odot$, but it suffers from strong foreground absorption that may affect our mass estimate. The combination of ALMA, *Gaia*, and codes like **pdspy**, presented here, can be used to infer the dynamical masses for large samples of young stars and substellar objects, and place constraints on evolutionary models.

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52 Extreme Debris Disk Variability — Exploring the Diverse Outcomes of Large Asteroid Impacts During the Era of Terrestrial Planet Formation

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The most dramatic phases of terrestrial planet formation are thought to be oligarchic and chaotic growth, on timescales of up to 100–200 Myr, when violent impacts occur between large planetesimals of sizes up to proto-planets. Such events are marked by the production of large amounts of debris as has been observed in some exceptionally bright and young debris disks (termed extreme debris disks). Here we report five years of Spitzer measurements of such systems around two young solar-type stars: ID8 and P1121. The short-term (weekly to monthly) and long-term (yearly) disk variability is consistent with the aftermaths of large impacts involving large asteroid-size bodies. We demonstrate that an impact-produced clump of optically thick dust, under the influence of the dynamical and viewing geometry effects, can produce short-term modulation in the disk light curves. The long-term disk flux variation is related to the collisional evolution within the impact-produced fragments once released into a circumstellar orbit. The time-variable behavior observed in the P1121 system is consistent with a hypervelocity impact prior to 2012 that produced vapor condensates as the dominant impact product. Two distinct short-term modulations in the ID8 system argue for two violent impacts at different times and locations. Its long-term variation is consistent with the collisional evolution of two different populations of impact-produced debris dominated by either vapor condensates or escaping boulders. The bright, variable emission from the dust produced in large impacts from extreme debris disks provides a unique opportunity to study violent events during the era of terrestrial planet formation.

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53 System IMF of the 25 Ori Group from Planetary-Mass Objects to Intermediate/High-Mass Stars

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The stellar initial mass function (IMF) is an essential input for many astrophysical studies but only in a few cases it has been determined over the whole cluster mass range, limiting the conclusions about its nature. The 25 Orionis group (25 Ori) is an excellent laboratory to investigate the IMF across the entire mass range of the population, from planetary-mass objects to intermediate/high-mass stars. We combine new deep optical photometry with optical and near-infrared data from the literature to select 1687 member candidates covering a 1.1° radius area in 25 Ori. With this sample we derived the 25 Ori system IMF from 0.012 to 13.1 $M_\odot$. This system IMF is well described by a two-segment power-law with $\Gamma = -0.74 \pm 0.04$ for $m < 0.4\ M_\odot$ and $\Gamma = 1.50 \pm 0.11$ for $m \geq 0.4\ M_\odot$. It is also well described over the whole mass range by a tapered power-law function with $\Gamma = 1.10 \pm 0.09$, $m_p = 0.31 \pm 0.03$ and $\beta = 2.11 \pm 0.09$. The best lognormal representation of the system IMF has $m_c = 0.31 \pm 0.04$ and $\sigma = 0.46 \pm 0.05$ for $m < 1\ M_\odot$. This system IMF does not present significant variations with the radii. We compared the resultant system IMF as well as the BD/star ratio of 0.16 ± 0.03 we estimated for 25 Ori with that of other stellar regions with diverse conditions and found no significant discrepancies. These results support the idea that general star formation mechanisms are probably not strongly dependent to environmental conditions. We found that the substellar and stellar objects in 25 Ori have similar spatial distributions and confirmed that 25 Ori is a gravitationally unbound stellar association.

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54 Gas vs dust sizes of protoplanetary disks: effects of dust evolution

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The extent of the gas in protoplanetary disks is observed to be universally larger than the extent of the dust. This is often attributed to radial drift and grain growth of the mm grains, but line optical depth produces a similar observational signature. We investigate in what parts of the disk structure parameter space dust evolution and line optical depth are the dominant drivers of the observed gas and dust size difference. Using the thermochemical model DALI with dust evolution included we ran a grid of models aimed at reproducing the observed gas and dust size dichotomy. The relation between $R_{\rm dust}$ and dust evolution is non-monotonic and depends on the disk structure. $R_{\rm gas}$ is directly related to the radius where the CO column density drops below 10^{15} cm^{-2} and CO becomes photodissociated. $R_{\rm gas}$ is not affected by dust evolution but scales with the total CO content of the disk. $R_{\rm gas}/R_{\rm dust} > 4$ is a clear sign for dust evolution and radial drift in disks, but these cases are rare in current observations. For disks with a smaller $R_{\rm gas}/R_{\rm dust}$, identifying dust evolution from $R_{\rm gas}/R_{\rm dust}$ requires modelling the disk structure including the total CO content. To minimize the uncertainties due to observational factors requires FWHM$_{\rm beam}$ $< 1\times$ the characteristic radius and a peak SNR > 10 on the ^{12}CO emission moment zero map. For the dust outer radius to enclose most of the disk mass, it should be defined using a high fraction (90–95%) of the total flux. For the gas, any radius enclosing $> 60\%$ of the ^{12}CO flux will contain most of the disk mass. To distinguish radial drift and grain growth from line optical depth effects based on size ratios requires disks to be observed at high enough angular resolution and the disk structure should to be modelled to account for the total CO content of the disk.

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http://arxiv.org/pdf/1903.06190

55 Molecular Cloud Cores in the Galactic Center 50 km s^{-1} Molecular Cloud

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The Galactic Center 50 km s^{-1} Molecular Cloud (50MC) is the most remarkable molecular cloud in the Sagittarius A region. This cloud is a candidate for the massive star formation induced by cloud-cloud collision (CCC) with a collision velocity of $\sim$30 km s^{-1} that is estimated from the velocity dispersion. We observed the whole of the 50MC with a high angular resolution ($\sim 2''.0 \times 1''.4$) in ALMA cycle 1 in the $H^{13}CO^+$ J=1–0 and $C^{34}S$ J=2–1 emission lines. We identified 241 and 129 bound cores with a virial parameter of less than 2, which are thought to be gravitationally bound, in the $H^{13}CO^+$ and $C^{34}S$ maps using the clumpfind algorithm, respectively. In the CCC region, the bound $H^{13}CO^+$ and $C^{34}S$ cores are 119 and 82, whose masses are 68 % and 76 % of those in the whole 50MC, respectively. The distribution of the core number and column densities in the CCC are biased to larger densities than those in the non-CCC region. The distributions indicate that the CCC compresses the molecular gas and increases the number of the dense bound cores. Additionally, the massive bound cores with masses of $> 3000\ M_\odot$ exist only in the CCC region, although the slope of the core mass function (CMF) in the CCC region is not different from that in the non-CCC region. We conclude that the compression by the CCC efficiently formed massive bound cores even if the slope of the CMF is not changed so much by the CCC.

Accepted by Astrophysics of Galaxies

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56 Multi-line Herschel/HIFI observations of water reveal infall motions and chemical segregation around high-mass protostars

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The physical conditions during high-mass star formation are poorly understood. Outflow and infall motions have been detected around massive protostellar objects, but their dependence on mass, luminosity, and age is unclear. In addition, physical conditions and molecular abundances are often estimated using simple assumptions such as spherical shape and chemical homogeneity, which may limit the accuracy of the results. We aim to characterize the dust and gas distribution and kinematics of the envelopes of high-mass protostars. In particular, we search for infall motions, abundance variations, and deviations from spherical symmetry, using Herschel data from the WISH program.

We used HIFI maps of the 987 GHz H_2O 2_{02}–1_{11} emission to measure the sizes and shapes of 19 high-mass protostellar envelopes. To identify infall, we used HIFI spectra of the optically thin $C^{18}O$ 9–8 and $H_2^{18}O$ 1_{11}–0_{00} lines. The high-J $C^{18}O$ line traces the warm central material and redshifted $H_2^{18}O$ 1_{11}–0_{00} absorption indicates material falling onto the warm core. We probe small-scale chemical differentiation by comparing H_2O 752 and 987 GHz spectra with those of $H_2^{18}O$.

Our measured radii of the central part of the H_2O 2_{02}–1_{11} emission are 30-40% larger than the predictions from spherical envelope models, and axis ratios are <2, which we consider good agreement. For 11 of the 19 sources, we find a significant redshift of the $H_2^{18}O$ 1_{11}–0_{00} line relative to $C^{18}O$ 9–8. The inferred infall velocities are 0.6–3.2 $\mathrm{km\,s^{-1}}$, and estimated mass inflow rates range from 7×10^{-5} to 2×10^{-2} $M_\odot$/yr. The highest mass inflow rates seem to occur toward the sources with the highest masses, and possibly the youngest ages. The other sources show either expanding motions or $H_2^{18}O$ lines in emission. The $H_2^{18}O$ 1_{11}–0_{00} line profiles are remarkably similar to the *differences* between the H_2O 2_{02}–1_{11} and 2_{11}–2_{02} profiles, suggesting that the $H_2^{18}O$ line and the H_2O 2_{02}–1_{11} absorption originate just inside the radius where water evaporates from grains, typically 1000–5000 au from the center. In some sources, the $H_2^{18}O$ line is detectable in the outflow, where no $C^{18}O$ emission is seen.

Together, the $H_2^{18}O$ absorption and $C^{18}O$ emission profiles show that the water abundance around high-mass protostars has at least three levels: low in the cool outer envelope, high within the 100 K radius, and very high in the outflowing gas. Thus, despite the small regions, the combination of lines presented in this work reveals systematic inflows and chemical information about the outflows.

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http://arxiv.org/pdf/1903.11305

57 The ALMA-PILS survey: Gas dynamics in IRAS 16293-2422 and the connection between its two protostars

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The majority of stars form in binary or higher order systems. The evolution of each protostar in a multiple system may start at different times and may progress differently. The Class 0 protostellar system IRAS 16293−2422 contains two protostars, "A" and "B", separated by ∼600 au and embedded in a single, 10^4 au scale envelope. Their relative evolutionary stages have been debated. We aim to study the relation and interplay between the two protostars A and B at spatial scales of 60 au up to $\sim10^3$ au. We selected molecular gas line transitions of the species CO, H_2CO, HCN, CS, SiO, and CCH from the ALMA-PILS spectral imaging survey (329–363 GHz) and used them as tracers of kinematics, density, and temperature in the IRAS 16293−2422 system. The angular resolution of the PILS data set allows us to study these quantities at a resolution of 0.5 arcsec (60 au at the distance of the source). Line-of-sight velocity maps of both optically thick and optically thin molecular lines reveal: (i) new manifestations of previously known outflows emanating from protostar A; (ii) a kinematically quiescent bridge of dust and gas spanning between the two protostars, with an inferred density between 4×10^4 and $\sim 3 \times 10^7\,cm^{-3}$; and (iii) a separate, straight filament seemingly connected to protostar B seen only in CCH, with a flat kinematic signature. Signs of various outflows, all emanating from source A, are evidence of high-density and warmer gas; none of them coincide spatially and kinematically with the bridge. We hypothesize that the bridge arc is a remnant of filamentary substructure in the protostellar envelope material from which protostellar sources A and B have formed. One particular morphological structure appears to be due to outflowing gas impacting the quiescent bridge material. The continuing lack of clear outflow signatures unambiguously associated to protostar B and the vertically extended shape derived for its disk-like structure lead us to conclude that source B may be in an earlier evolutionary stage than source A.

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58 Fates of hydrous materials during planetesimal collisions

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Hydrous minerals are found on the surfaces of asteroids, but their origin is not clear. If their origin is endogenic, the hydrous minerals that were formed in the inner part of a planetesimal (or parent body) should come out on to the surface without dehydration. If their origin is exogenic, the source of hydrous minerals accreting onto asteroids is needed. Collisions in the asteroid belt would be related to both origins because collisions excavate the surface and eject the materials. However, the fate of hydrous minerals in large planetesimals during the collisional process has not been well investigated. Here, we explore planetesimal collisions by using the iSALE-2D code, and investigate the effect of an impact for the target planetesimal containing hydrous minerals. Our numerical results for the fiducial case (5 km s^{-1} of the impact velocity) show that hydrous minerals are slightly heated during the collisions. This moderate heating indicates that they can avoid the dehydration reaction and keep their original composition. Some hydrous minerals have larger velocity than the escape velocity of the collision system. This means that hydrous minerals can escape from the planetesimal and support the theory of exogenic origin for the hydrous minerals on asteroids. Meanwhile, the velocity of other hydrous minerals is smaller than the escape velocity of the system. This also indicates the possibility of an endogenic origin for the hydrous minerals on asteroids. Our results suggest that hydrous minerals on asteroids can be provided by planetesimal collisions.

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59 New Near-Infrared Imaging and Spectroscopy of NGC 2071-IR

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We present high resolution images of NGC 2071-IR in the J, H, and K bands and in the emission at 2.12 ?m of the v=1?0 S(1) line of molecular hydrogen. We also present moderate resolution K-band spectra of two young stellar objects, IRS 1 and IRS 3, within NGC 2071-IR, that are candidates sources of one or more of the outflows observed in the region. Two of the eight originally identified infrared point sources in NGC 2071-IR are binaries, and we identifiy two new sources, one coincident with the radio source VLA-1 and highly reddened. The H2 Q(3)/S(1) line intensity ratios at IRS 1 and IRS 3 yield high and very high extinctions, respectively, to them, as is implied by their near-infrared colors and K-band continuum slopes. The spectra also reveal the presence of hot, dense circumstellar molecular gas in each, suggesting that both are strong candidates for having energetic molecular outflows. We agree with a previous suggestion that IRS 1 is the likely source of an E-W-oriented outflow and conclude that this outflow is probably largely out of the plane of the sky. We also conclude that if IRS 3 is the source of the large scale NE-SW outflow, as has been previously suggested, its jet/wind must precess in order to explain the angular width of that outflow. We discuss the natures of the point sources and their probable contributions, if any, to the complex morphology of the H2 line emission.

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https://arxiv.org/pdf/1903.03583

60 Sheets, filaments and clumps - high resolution simulations of how the thermal instability can form molecular clouds

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This paper describes 3D simulations of the formation of collapsing cold clumps via thermal instability inside a larger cloud complex. The initial condition was a diffuse atomic, stationary, thermally unstable, 200 pc diameter spherical cloud in pressure equilibrium with low density surroundings. This was seeded with 10% density perturbations at the finest initial grid level (0.29 pc) around n_H=1.1 cm^{-3} and evolved with self-gravity included. No magnetic field was imposed. Resimulations at a higher resolution of a region extracted from this simulation (down to 0.039 pc), show that the thermal instability forms sheets, then filaments and finally clumps. The width of the filaments increases over time, in one particular case from 0.26 to 0.56 pc. Thereafter clumps with sizes of around 5 pc grow at the intersections of filaments. 21 distinct clumps, with properties similar to those observed in molecular clouds, are found by using the FellWalker algorithm to find minima in the gravitational potential. Not all of these are gravitationally bound, but the convergent nature of the flow and increasing central density suggest they are likely to form stars. Further simulation of the most massive clump shows the gravitational collapse to a density $> 10^6$ cm^{-3}. These results provide realistic initial conditions that can be used to study feedback in individual clumps, interacting clumps and the entire molecular cloud complex.

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61 The Gaia-ESO Survey: Asymmetric expansion of the Lagoon Nebula cluster NGC 6530 from GES and Gaia DR2

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The combination of precise radial velocities from multi-object spectroscopy and highly accurate proper motions from Gaia DR2 opens up the possibility for detailed 3D kinematic studies of young star forming regions and clusters. Here, we perform such an analysis by combining Gaia-ESO Survey spectroscopy with Gaia astrometry for ~900 members of the Lagoon Nebula cluster, NGC 6530. We measure the 3D velocity dispersion of the region to be $5.35^{+0.39}_{-0.34}$ km s^{-1},

which is large enough to suggest the region is gravitationally unbound. The velocity ellipsoid is anisotropic, implying that the region is not sufficiently dynamically evolved to achieve isotropy, though the central part of NGC 6530 does exhibit velocity isotropy that suggests sufficient mixing has occurred in this denser part. We find strong evidence that the stellar population is expanding, though this is preferentially occurring in the declination direction and there is very little evidence for expansion in the right ascension direction. This argues against a simple radial expansion pattern, as predicted by models of residual gas expulsion. We discuss these findings in the context of cluster formation, evolution and disruption theories.

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Parallaxes for star forming regions in the inner Perseus spiral arm

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We report trigonometric parallax and proper motion measurements of 6.7-GHz CH_3OH and 22-GHz H_2O masers in eight high-mass star-forming regions (HMSFRs) based on VLBA observations as part of the BeSSeL Survey. The distances of these HMSFRs combined with their Galactic coordinates, radial velocities, and proper motions, allow us to assign them to a segment of the Perseus arm with $\lesssim 70°$. These HMSFRs are clustered in Galactic longitude from $\sim 30°$ to $\sim 50°$, neighboring a dirth of such sources between longitudes $\sim 50°$ to $\sim 90°$.

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Dynamics of a Massive Binary at Birth

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Almost all massive stars have bound stellar companions, existing in binaries or higher-order multiples. While binarity is theorized to be an essential feature of how massive stars form, essentially all information about such properties is derived from observations of already formed stars, whose orbital properties may have evolved since birth. Little is known about binarity during formation stages. Here we report high angular resolution observations of 1.3 mm continuum and H30α recombination line emission, which reveal a massive protobinary with apparent separation of 180 au at the center of the massive star-forming region IRAS07299-1651. From the line-of-sight velocity difference of 9.5 km s^{-1} of the two protostars, the binary is estimated to have a minimum total mass of 18 solar masses, consistent with several other metrics, and maximum period of 570 years, assuming a circular orbit. The H30α line from the

primary protostar shows kinematics consistent with rotation along a ring of radius of 12 au. The observations indicate that disk fragmentation at several hundred au may have formed the binary, and much smaller disks are feeding the individual protostars.

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Physical Properties of Large-Scale Galactic Filaments

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The characterization of our Galaxy's longest filamentary gas features has been the subject of several studies in recent years, producing not only a sizeable sample of large-scale filaments, but also confusion as to whether all these features (e.g. "Bones", "Giant Molecular Filaments") are the same. They are not. We undertake the first standardized analysis of the physical properties (H_2 column densities, dust temperatures, morphologies, radial column density profiles) and kinematics of large-scale filaments in the literature. We expand and improve upon prior analyses by using the same data sets, techniques, and spiral arm models to disentangle the filaments' inherent properties from selection criteria and methodology. Our results suggest that the myriad filament finding techniques are uncovering different physical structures, with length ($11-269$ pc), width ($1-40$ pc), mass (3×10^3 $M_\odot - 1.1\times10^6$ $M_\odot$), aspect ratio (3:1-117:1), and high column density fraction (0.2-100%) varying by over an order of magnitude across the sample of 45 filaments. We develop a radial profile fitting code, `RadFil`, which is publicly available. We also perform a *position-position-velocity* (*p-p-v*) analysis on a subsample and find that while 60-70% lie spatially in the plane of the Galaxy, only 30-45% concurrently exhibit spatial *and* kinematic proximity to spiral arms. In a parameter space defined by aspect ratio, dust temperature, and column density, we broadly distinguish three filament categories, which could indicate different formation mechanisms or histories. Highly elongated "Bone-like" filaments show the most potential for tracing gross spiral structure (e.g. arms, spurs), while other categories could be large concentrations of molecular gas (GMCs, core complexes).

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Mapping Distances Across the Perseus Molecular Cloud Using CO Observations, Stellar Photometry, and Gaia DR2 Parallax Measurements

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We present a new technique to determine distances to major star-forming regions across the Perseus Molecular Cloud, using a combination of stellar photometry, astrometric data, and ^{12}CO spectral-line maps. Incorporating the Gaia DR2 parallax measurements when available, we start by inferring the distance and reddening to stars from their Pan-STARRS1 and 2MASS photometry, based on a technique presented in Green et al. (2014, 2015) and implemented in their 3D "Bayestar" dust map of three-quarters of the sky. We then refine the Green et al. technique by using the velocity slices of a CO spectral cube as dust templates and modeling the cumulative distribution of dust along the line of sight towards these stars as a linear combination of the emission in the slices. Using a nested sampling algorithm, we fit these per-star distance-reddening measurements to find the distances to the CO velocity slices towards each star-forming region. This results in distance estimates explicitly tied to the velocity structure of the molecular gas. We determine distances to the B5, IC348, B1, NGC1333, L1448, and L1451 star-forming regions and find that individual clouds are located between $\approx 275-300$ pc, with typical combined uncertainties of $\approx 5\%$. We find that the velocity gradient across Perseus corresponds to a distance gradient of about 25 pc, with the eastern portion of the cloud

farther away than the western portion. We determine an average distance to the complex of 294 17 pc, about 60 pc higher than the distance derived to the western portion of the cloud using parallax measurements of water masers associated with young stellar objects. The method we present is not limited to the Perseus Complex, but may be applied anywhere on the sky with adequate CO data in the pursuit of more accurate 3D maps of molecular clouds in the solar neighborhood and beyond.

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RadFil: a Python Package for Building and Fitting Radial Profiles for Interstellar Filaments

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We present RadFil, a publicly available python package that gives users full control over how to build and fit radial density profiles for interstellar filaments. RadFil builds filament profiles by taking radial cuts across the spine of a filament, thereby preserving the radial structure of the filament across its entire length. Pre-existing spines can be inputted directly into RadFil, or can be computed for the user as part of the RadFil workflow. We provide Gaussian and Plummer built-in fitting functions, in addition to a background subtraction estimator, which can be fit to the entire ensemble of radial cuts or an average radial profile for the filament. Users can tweak parameters like the radial cut sampling interval, the background subtraction estimation radii, and the Gaussian/Plummer fitting radii. As a result, RadFil can provide treatment of how the resulting filament properties rely on systematics in the building and fitting process. We walk through the typical RadFil workflow and compare our results to those from an independent radial density profile code obtained using the same data; we find that our results are entirely consistent. RadFil can be obtained via GitHub or installed via pip. Also on GitHub, users will find a complete working tutorial of the code available as a jupyter notebook, which users can download and run themselves.

Accepted by ApJ

https://arxiv.org/pdf/1807.06567

Abstract submission deadline

The deadline for submitting abstracts and other submissions is the first day of the month. Abstracts submitted after the deadline will appear in the following month's issue.

Orion Uncovered

Leiden (The Netherlands), August 26-30, 2019

Rationale:

Since decades, Orion has been traditionally used as local benchmark for all our star-formation theories. During the last years, a new generation of observational and theory works are revolutionizing our description of this region at multiple scales. The whole community is invited to join this workshop to discuss the current state-of-the-art and future perspectives on the star-formation studies in Orion.

Concept:

The aim of this workshop is to maximize the collaboration and exchange of ideas among researchers from different fields. With that purpose, the meeting will be divided in two parts, in a similar setup as the one we pioneered for "Orion (un)plugged" in Vienna in 2015:

• **Part I: online presentations (August 26-27)**

To set the scene, we will review the latest results in Orion with a series of online talks. This not only includes observational results, but also relevant theory and simulations, as well as Orion in the context of the Milky Way as a whole and nearby galaxies. With an online conferencing system, we will have participant presentations for a few hours a day, with time slots that should be convenient for the majority of the participants. To maximize the impact and legacy of these contributions, all talks will be broadcasted and stored as part of our YouTube channel (link) and will be open to the entire community. Participants are invited to give their presentations either from their home institutions or directly from Leiden.

• **Part II: un-conference (August 28-30)**

The second half of the workshop will be held at the Leiden Observatory. This Part II will be dynamically scheduled following the format of an un-conference meeting. For that, participants are encouraged to propose, vote, and discuss topics of their interests on the spot. Different rooms and screens will be available to maximize the interactions and discussions among participants and groups. To facilitate these interactions, this second part will be restricted to 50 participants.

- While we encourage to join both online (Part I) and un-conferenced (Part II) sessions, applicants are invited to participate in any of the two parts independently.
- No experience in this type of workshop is required.
- This workshop has no registration fee.
- Limited funds are available in support of young researchers.

SOC: Alvaro Hacar, Jan Forbrich, Jõao Alves, Paula Teixeira

REGISTRATION DEADLINE: June 15, 2019

Conference website: https://sites.google.com/view/OrionLeiden2019

The second international workshop
The UX Ori type stars and related topics
September 30 - October 4, 2019,
St. Petersburg, Russia

Organizers; Crimean Astrophysical Observatory of RAS and the Star Formation Team of the Pulkovo Observatory of RAS

The UX Ori type stars (or UXORs) are the photometrically most active young objects, predominantly Herbig Ae stars. They demonstrate aperiodic algol-like minima with amplitudes up to $\Delta V = 2 - 3^m$ and duration from a few days to a few weeks. The brightness variations are accompanied by changes in color, linear polarization and spectra. The most natural explanation of the observed phenomena is a model of variable circumstellar (CS) extinction taking into account scattered radiation from the CS disks. The source of the variable CS extinction is the perturbations in the innermost regions of the CS disks. Therefore the photometric behavior of UXORs is an important, and in some respects unique source of information about the dynamical state of these regions. In recent years extinction events on different timescales have been observed in several T Tauri stars. An important step in the study of such objects was made with the help of photometric observations from space: the CoRoT and Kepler missions. They have shown that the small-amplitude extinction events (dips) of different types (periodic or aperiodic) have been frequently observed in T Tauri stars. In this case the main source of the variable extinction are the dusty disk wind and the region of interaction of CS disk with the stellar magnetosphere. The goal of our workshop is to discuss the observational properties of UXORs and related objects in the light of new theoretical models.

The main topics are:
Photometry, polarimetry and spectroscopy of UXORs,
Infrared activity of UXORs and related objects,
The circumstellar disks, disk winds and the nearest environment of young stars,
Shadows on the disks, the disks in polarized light,
Hydrodynamic processes in protoplanetary disks, periodic perturbations and planet formation,
The UXOR phenomena in T Tauri stars, connection with the AA Tau variables and dippers,
The evolutionary trends of the UXORs activity

SOC: Silvia Alencar, Jerome Bouvier, Konstantin Grankin, Vladimir Grinin (co-chair), Sergej Lamzin, Geoffroy Lesur, Agnes Kospal, Antonella Natta, Rene Oudmaijer, Alla Rostopchina-Shakovskaya (co-chair)

Confirmed invited speakers:
Megan Ansdell, Center for Integrative Planetary Science, University of California at Berkeley, Berkeley,
Tatjana Demidova, CrAO,
Goesta Gahm, Department of Astronomy, AlbaNova University Center, Stockholm University,
Antonio Garufi, OA Arcetri, INAF
Stefano Facchini, Max-Planck-Institut for Extraterrestrische Physik, Garching,
Catrina Hamilton-Drager, Department of Physics and Astronomy, Dickinson College,
Alexander Kreplin, University of Exeter,
Rebeca Garcia Lopez, DIAS, University of Dublin,
Ignacio Mendigutia, Centro de Astrobiologia (CSIC-INTA), Departamento de Astrofisica, ESA-ESAC,
Benjamin Montesinos, Unidad Asociada Astro UAM-CSIC, Spain,
Peter Petrov, CrAO,
Ilya Potravnov, ISTP,
Timo Prusti, Directorate of Science, ESTEC-ESA,
Eduard Vorobyev, Southern Federal University,
Claudio Zanni, INAF - Osservatorio Astrofisico di Torino

E-mail: uxors-2019@crao.ru
Registration: http://uxors-2019.craocrimea.ru

First Announcement

From Gas to Stars: The Links between Massive Star and Star Cluster Formation

16-20 September 2019, Yorkshire Museum, York UK

We are pleased to announce a conference on the formation and early evolution of massive star clusters. The aim of the conference is to bring together the communities who study the properties of the natal giant molecular clouds, with those who study the stellar populations. The release of Gaia DR2 in 2018 allows the structure of young stellar cluster and associations to be defined well for the first time. It also allows us to study more embedded structures, before the gas is fully dispersed. By contrasting the results obtained in this way with those that study the gas and dust component, in particular results from Herschel and ground based follow-ups with arrays such as ALMA and NOEMA, we can hope to understand how these massive star formation regions change as they evolve. Bringing these separate communities together in this way is especially timely. We also plan to bring together those with an overall view of the larger scale pictures of how such structures form in the first place down to those who are more interested in how the accretion disks from which the stars are formed feed and are disrupted in the cluster environment.

The conference will combine observational and theoretical aspects, with topics including:

- The global picture of young star clusters and giant molecular clouds in the Galaxy.
- Properties of star forming clouds.
- Evolution of molecular clouds: feedback and dissipation.
- Population and structures of young clusters and OB associations.
- Dynamics of young clusters and OB associations.
- Protostars in clusters.

Confirmed Invited Speakers Tristan Cantat-Gaudin, Timea Csengeri, Adam Ginsburg, Helen Kirk, Marina Kounkel, Michael Kuhn, Yueh-Ning Lee, Richard Parker

Scientific Organising Committee

Hervé Bouy, Ignacio de la Calle, Paul Clark, Roberto Galván-Madrid, Alvaro Hacar, Stuart Lumsden (chair), Estelle Moraux, Rene Oudmaijer, Stefanie Walch

Venue

The conference will be held at the Yorkshire Museum, in the heart of York, an ancient city in the north of England (https://www.visityork.org/) York has excellent rail connections to Leeds, London and Manchester.

Abstract submissions

Abstract submissions can be made now for both posters and talks. Our aim is to give preference where possible to early career researchers. The deadline for submission is 30^{th} June for both.

Registration Fee

The registration fee for the conference is £300. This will include coffee, lunches and the conference dinner. Registration will close on 31^{st} July. Conference details can be found on our website. If you have any questions about the conference then please contact us by email.

Conference Website

Both abstract submissions and registration are now open at:

https://starformmapper.org/final-conference/

Young European Radio Astronomers Conference 2019

26th - 29th August 2019, Dublin, Ireland
https://dias.ie/yerac2019/

Throughout its 50 year history, the Young European Radio Astronomers Conference (YERAC; http://www.yerac.org/) has brought together postgraduate and early-career radio astronomers working at European institutions in order to facilitate networking, raise awareness of new developments in radio astronomy and aide in professional development. This year, the Dublin Institute for Advanced Studies has been chosen to host YERAC with financial support from RadioNet (https://www.radionet-org.eu/radionet/). All radio astronomy-related PhD students, and early career researchers, working at European institutions are encouraged to apply for a total of 30 places, for which they are expected to give a presentation about their work within radio astronomy. Please see https://dias.ie/yerac2019/registration.html for details on how to apply.

European Conference on Laboratory Astrophysics ECLA 2020: Linking dust, ice and gas in space

19 - 24 April 2020, Capri, Italy

The interplay between ubiquitous dust, ice and gas in space knits an interesting tale from collapsing interstellar clouds to the formation of new stars, planets, moons and comets. Along this path the formation of complex organic molecules necessary to construct the building blocks of life brings us a step closer to the understanding of the evolution of life. The advancement in the understanding of these vast intricacies of space lies in the development of varied laboratory techniques together with astronomical observations and astrophysical modeling.

The conference allows us an opportunity to ensure collaborations between scientists active in different research fields, which range from astronomy to geology and from chemistry to instrumentation. Further, new results will be discussed and ideas will be exchanged from interdisciplinary perspectives to address questions that will guide observations with the upcoming astronomical large-scale facilities, such as the James Webb Space Telescope.

Summerschool on Protoplanetary Disks and Planet Formation

We are pleased to announce the NBIA Summer School on "Protoplanetary Disks and Planet Formation" hosted by the Niels Bohr International Academy at the Niels Bohr Institute that will take place August 5-9 in Copenhagen. Registration is open until May 15, 2019.

Further details about the school can be found at
http://nbia.nbi.ku.dk/nbia-school-2019

We will very much appreciate it if you could forward this email to MSc and PhD students.

Best regards,
Martin Pessah
on behalf of the organizers

Summary of Upcoming Meetings

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

Cloudy Workshop
20 - 24 May 2019, University of Kentucky, USA
http://cloud9.pa.uky.edu/~gary/cloudy/CloudySummerSchool/

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

Partially Ionised Plasmas in Astrophysics
3 - 7 June 2019, Palma de Mallorca, Spain
http://solar1.uib.es/pipa2019/

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/

Smoothed Particle Hydrodynamics International Workshop
25 - 27 June 2019, Exeter, UK
http://spheric2019.co.uk/

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

Summer School Protoplanetary Disks and Planet Formation
5 - 9 August 2019 Copenhagen, Denmark
http://nbia.nbi.ku.dk/nbia-school-2019

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

Understanding the Nearby Star-forming Universe with JCMT
26 - 30 Aug 2019 Courmayeur, Italy
http://www.stsci.edu/contents/events/jwst/2019/august/understanding-the-nearby-star-forming-universe-with-jw

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

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

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

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

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

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

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

Short Announcements

Fizeau exchange visitors program - call for applications

Electronic mail: fizeau@european-interferometry.eu

Dear colleagues!

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

The deadline for applications is May 15 for visits to be carried out between mid July 2019 and December 2019!.

Note: the next call will be issued in November 2019!

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

The program is funded by OPTICON/H2020.

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

Looking forward to your applications,
Josef Hron & Péter Ábrahám
(for the European Interferometry Initiative)

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.