THE STAR FORMATION NEWSLETTER

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

No. 319 — 17 July 2019 Editor: Bo Reipurth (reipurth@ifa.hawaii.edu)

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

IC 2944 and IC 2948 form a large HII region in Centaurus, energized by a group of OB stars dominated by the O7 III star HD 101205. Projected towards the OB stars is a group of compact dark globules, discovered by A.D. Thackeray in 1955. The globules are splintered and have convulsed shapes, as well illustrated in this image taken with the ESO VLT. The globule complex is likely in the process of being destroyed by the powerful UV radiation.

Image courtesy ESO.

Submitting your abstracts

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

Carl Heiles

in conversation with Bo Reipurth

Q: *Your PhD thesis from 1966 dealt with observations of the spatial structure of interstellar hydrogen. What motivated you to choose that topic?*

A: As a kid I was interested in technical things and became a 'ham' radio operator. This began my interest in electronics and sparked my desire to be an electrical engineer, which was my original major at Cornell University in 1958. Cornell had a program of public lectures on various science topics. In my third year it focused on astronomy and had four amazing lecturers: Tommy Gold, Fred Hoyle, Hermann Bondi, and Geoffrey Burbidge. They talked about the great astronomical questions, ranging from Solar magnetohydrodynamics (MHD) to cosmology. I was hooked: I changed my major to Engineering Physics and took every course related to those areas that I could. Marshall Cohen taught Plasma physics; he went on to CalTech and specialized in VLBI. I took two courses on stellar structure: the conventional version with the differential equations, beautifully taught by John Cox; in contrast, Ed Salpeter eschewed the equations and emphasized phenomenology and order-of-magnitude estimates. Those two courses opened my eyes: you achieve deeper understanding by looking at problems from multiple viewpoints.

All this, plus being a grad student at Princeton under George Field and Lyman Spitzer, made the interstellar medium a hugely attractive research area. When the time came for my thesis work, the 300-foot telescope had just been finished and was superbly equipped for 21-cm line work with a 100-channel 1-bit digital correlator. There I was, a lowly graduate student, empowered with the best telescope/electronics in the world for this project. Who wouldn't jump in that direction?

Q: *Shortly after your PhD you became interested in the physical conditions inside dust clouds, which was the subject of your 1971 Annual Reviews article. What were the issues back then?*

A: My thesis work covered an area about 160 square degrees, which happened to contain some dust clouds with sizes of a degree or so. We had the idea that the dust/gas ratio was roughly constant, which meant that these clouds should have contained enormous amounts of interstellar gas. But the 21-cm line showed no excess intensity towards these clouds; if anything, it tended to be weaker! This planted the idea that the gas in the clouds might be molecular. When I got to Berkeley immediately after receiving my PhD, I was in the amazingly fortunate position that Berkeley's Hat Creek telescope was tuned to the OH line. So it was easy pickings to see if OH resided in those clouds. And it did! Using the dust content as a surrogate for the gas provided an estimate for the strength of self-gravity. And self-gravity turned out to be important! So these were likely areas of star formation. Connecting all those dots was an exciting prospect for an Annual Reviews article. History repeats itself: these days, the presence of 'dark gas'—large-density regions with no CO emission—is inferred in the same way.

Q: *Your discovery of H I shells and supershells at high Galactic latitudes appeared in 1979, with a follow-up in 1984, and these papers have been very widely cited. Please tell how this discovery came about.*

A: It was totally obvious that supershells would be detectable in the Galactic plane! Harm Habing and I had recently finished the Hat Creek 85-foot telescope survey of high-latitude 21-cm line emission—half a million H I line profiles! We pioneered using grayscale and color imaging to look at them. What jumped out of those first images were the Orion-Eridanus superbubble and the Sco-Oph supershell. They were tens of degrees in diameter and were nearby. Given the Copernican Principle, the Galaxy had to be peppered with such objects. At 1 Kpc distance, the angular diameter would be about 6 degrees. So I looked at Harold Weaver's Hat Creek H I survey of the Galactic plane—and there they were.

Q: *A few years later you calculated the rate at which clustered Type II supernovae produce bubbles that break through the dense, thin layer of disk gas. How is the correspondence with current observations?*

A: That's an excellent question because such events are responsible for transferring mass from the disk to the halo. This was explicitly shown by Colin Norman and Satoru Ikeuchi, who in 1989 wrote my favorite paper on this subject and invented the compelling moniker 'interstellar chimneys'. Also, infalling pristine intergalactic gas clouds have to transit through the ambient halo gas. These days there's a lot of activity pursuing these issues at high redshift, because they directly affect galactic evolution, but it's my impression that more work on synthesizing multiple data sets for local galaxies would reveal lots of important details.

Q: *You were early on interested in magnetic fields in clouds, and summarized what was known in an Annual Reviews article in 1976. You have maintained this interest all your life, so you must have a unique perspective on how the subject has developed over the years.*

A: My interest in magnetic fields stems from those public lectures at Cornell, where they were reinforced by a spectacular display of aurorae—rare at Cornell's magnetic latitude. In many astronomical systems, magnetic pressure is comparable to other pressures, so the field has to be important. But specifying the influence of the magnetic field as a single number misses the fundamental point that the magnetic forces are *anisotropic*, meaning that not only pressure but also magnetic tension plays a role, particularly because of the coupling of cosmic rays to the field and its frozen-in gas. It's these aspects that produce unique and important dynamics, such as sunspots and angular momentum transport.

Regarding my 'unique perspective', there's the scientific one and the human one. I think the more important, right now, is the human one, because technology has advanced to enable people to study magnetic phenomenae, both observationally (think optical CCDs and radio wideband Faraday rotation maps) and theoretically (think large-scale computers). So we need smart and clever people to exploit these opportunities. There's a big future here!

Q: *The tiny-scale atomic structure of the ISM was the subject of a study you published in 1997. What techniques did you use, and what were your conclusions?*

A: It is straightforward to show that tiny-scale atomic structure (TSAS) cannot exist: where the H I column density changes over small angles, the volume density must be large (scales of tens of AU), and this means high pressure, so the region will explode—and annihilate itself. The only problem: TSAS is commonly observed! Two ways out: (1) the structures are anisotropic, so lengths along the line-of-sight are longer than those across and volume densities don't need to be so high; (2) the rapid changes with angle are simply a manifestation of the spatial spectrum of interstellar turbulence (proposed by Avinash Deshpande). Almost certainly both occur, but we don't know which predominates. Similar statements apply to the ionized structures, which produce interstellar scintillation and scattering of pulsars and radio-loud quasars. These fascinating tiny structures are not receiving the attention they deserve, making this a field ripe for future studies!

Q: *In 2000 you published the results of the herculean task to agglomerate all existing stellar polarization catalogs, totaling 9286 stars. What did you learn?*

A: The agglomeration was an update of the original one by Mathewson and Ford; their spectacular result was the amazingly coherent pattern of linear polarization aligned with Radio Loop I (the North Polar Spur). The new agglomeration, together with the then-new all-sky H I maps, showed that the morphological similarity was essentially universal and applied to structure on all scales. These days, Susan Clark has used polarized dust emission from Planck together with the GALFA H I survey data to find highly elongated H I 'fibers' that are aligned with the neighboring magnetic field. This is proving to be a rich subject!

Q: *In the early 2000s you embarked, together with Thomas Troland, on the Millennium Arecibo 21 cm Absorption-Line Survey. What were the goals and achievements?*

A: Tom was the only grad student crazy enough to work with me on interstellar magnetic fields, specifically measuring Zeeman splitting of the 21-cm line seen in emission. Why 'crazy'? The detected signatures were weak, requiring huge integration times, and the instrumental effects (especially polarized beam response) comparable to the actual splitting. Fortunately, Tom is very methodical and careful, compensating for my deficiencies in those areas. He got results for his successful thesis and moved on to study fields in molecular clouds, often with Dick Crutcher. Meanwhile, we improved the Hat Creek instrumentation and measured H I Zeeman splitting for hundreds of positions. Those measurements were controversial because of the instrumental effects, with criticisms especially by Gerrit Verschuur (who made the first real measurements of Zeeman splitting in the ISM).

The obvious way around polarized beam response problems was to forgo emission lines and instead use absorption lines. The best telescope for that was Arecibo. Tom and I had kept in collaborative and social contact, and this idea popped up. It was a good project with useful results, not only for magnetic fields, but also statistics on nonthermal line broadening (turbulence), cloud temperature, ISM filling factors... Some highly-motivated crazy person needs to expand this work and attain a decent statistical sample!

Q: *What are your current interests?*

A: With retirement, I resolved to become more conscientious with my collaborative partners. But I'm a sucker for new and interesting projects, and I'm busier than ever on a number of seemingly disparate projects. These include time variations in OH/IR star masers (an outgrowth of radio results on Solar-orbiting spacecraft(!)), linear polarization of the 21-cm line, 'dark gas', magnetic fields, H I morphology and dynamics. I'm also working with Chinese radio astronomers on FAST—both instrumentally, with calibration, and scientifically, working with grad students. All of this activity continues to make my scientific life stimulating, productive, and fulfilling.

Perspective

Planet formation in clusters

Susanne Pfalzner

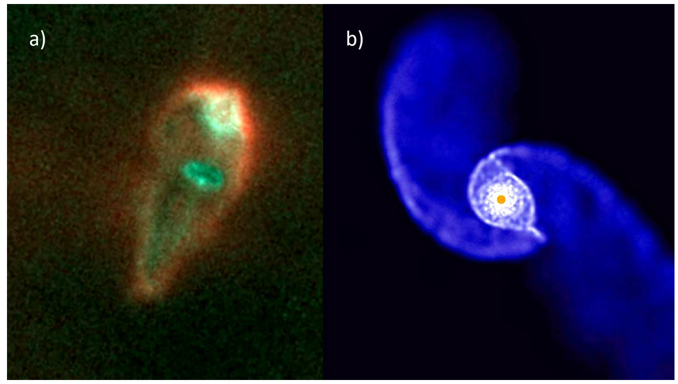

Figure 1: Environmental effects on protoplanetary discs. a) HST image of an externally photo-evaporated disc (credit: NASA/ESA) and b) simulation result of the effect of a stellar flyby.

One well-tested method in science is to separate the object of interest from its surroundings and look at it in isolation. The advantage is that unimportant information is removed and the true properties of the object are seen more clearly. However, sometimes the influences of the surroundings actually determine the properties of an object. In this case, not taking the environment into account can lead to incomplete or even false conclusions.

In the context of planet formation this question arises to: is it sufficient to study the nascent planetary system in isolation? Stars usually do *not* form in isolation but as part of a stellar group (Lada & Lada 2003, Porras 2003). The first important question in this field is then: *How important is the influence of the surrounding stars on circumstellar discs and forming planetary systems?* Distance to other stars in the same system is the key factor here, so the main parameter is obviously the local stellar density.

There are basically two main channels of influence exerted by the surrounding stars on discs: their radiation and gravitational interactions. Both effects might truncate or possibly even completely destroy a planet-forming disc. Famous examples of the influence of radiation on discs are the so-called proplyds in Orion, which show the destructive power of external photo-evaporation on young discs (Fig. 1a). The signs of gravitational truncation of discs are more difficult to track because close flybys mainly occur in the strongly embedded, and therefore difficult to observe, phase of young clusters. Tell-tale signs are spiral arms (Fig. 1b). However, they can also be caused by other processes and tend to evolve into ring-like structures within just a few thousand years (Cuello et al. 2019). Thus, we can pose a second important question: *Does radiation or gravitational interaction dominate?*

For both questions still no definite answer exists, but there has been considerable progress during past years.

The central parameter is the "stellar density" since it determines both the frequency and the strength of the external influence. This applies equally to radiation as to gravitational interactions. Sparse stellar groups like Cha I consist of just a few dozens of stars, whereas dense groups like NGC 3603 and Trumpler 14 can contain tens of thousands of stars packed within less than 1 pc^3. Even in high-mass stellar groups ($M_c > 10^3 \mathrm{M}_\odot$) the average stellar densities vary over many orders of magnitude from $<$ 0.1 $\mathrm{M}_\odot$ pc^{-3} to $> 10^5 \mathrm{M}_\odot$ pc^{-3} (Wolff et al. 2007).

Even without large simulations it is intuitively obvious that environmental effects will play a much larger role in Trumpler 14 than in Cha I. This is why investigations to date have tended to concentrate on fairly dense systems like the Orion Nebula Cluster (ONC) due to its relatively proximity to us (383 ± 3 pc; Kounkel et al. 2017). For this reason the ONC is often taken as model cluster for theoretical investigations, too (for example, Adams 2010, Wijnen et al. 2017, Winter et al. 2018, Cuello et al. 2019, Portegies Zwart 2019). The general outcome of these investigations is that the environment is only responsible for the destruction of 5-10% of all discs. Some small disc sizes can be attributed to the environment, but typically the disc size in the ONC is only reduced to about 100 AU. This is only slightly smaller than the typical disc sizes of 100-200 AU observed in sparse associations.

However, the density in a stellar group is far from constant, and changes by several orders of magnitude within just a few Myr. In my opinion, the key here lies in understanding early cluster dynamics. This means that the result obtained for the ONC is far from universal: it is only valid for this particular stellar group at this specific phase of its temporal development. If one is interested in

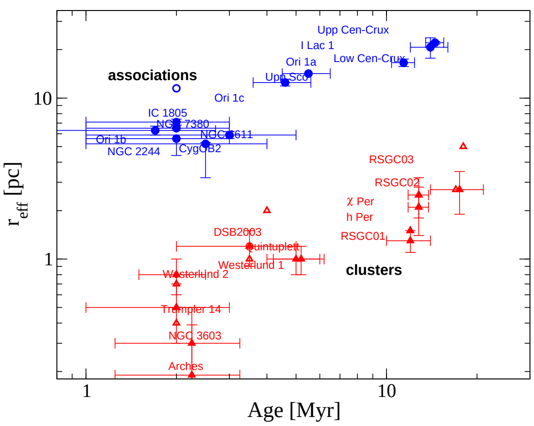

Figure 2: Two types of stellar groups — compact clusters (red) and loose associations (blue, figure adapted from Pfalzner 2009).

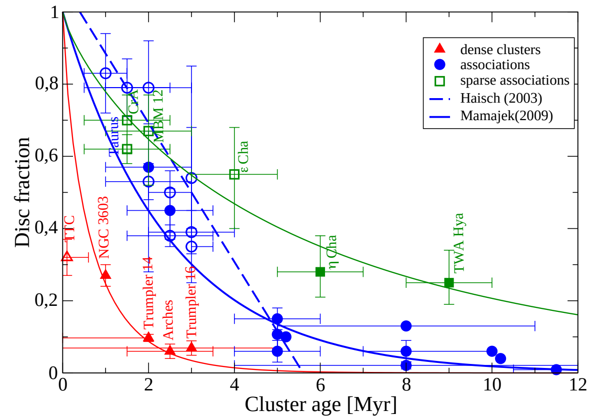

Figure 3: Disc fraction in compact clusters (red), associations (blue) and co-moving groups (green), Pfalzner et al. 2014.

the environmental influence on discs in general, one has to look at different stellar groups and also consider the time dependence of the stellar density.

Fortunately, we are spared the mammoth task of considering every observed stellar group individually, because it turns out there seem to be only two types of stellar groups: those that develop into long-lived clusters and those that largely dissolve within about 5-10 Myr. These two types are often referred to as clusters and associations, respectively[1]. Clusters are much more efficient in converting gas and dust into stars which allows them to form much more compact entities: at any given age their stellar density is at least 100× higher than that of an association of the same age and mass. However, it should be stressed that about 80-90% of the field population was formed in short-lived associations and only 10-20% in long-lived clusters (Adamo et al. 2011, Bastian 2013).

Associations and clusters develop along different, but well-defined evolutionary trajectories in terms of cluster size as a function of time (see Fig. 2). This means that simulations conforming to either of these temporal paths are not only valid for one specific stellar group at a given point of time, but for an entire class of stellar groups over the full time period considered — a huge reduction in the possible parameter space.

[1] Historically it was thought that clusters formed as bound and associations as unbound systems. Nowadays we know that most stellar groups are bound as long as they are still embedded in gas. The historical misinterpretation leads to the confusing nomenclature that many embedded stellar groups are labelled clusters, even though they will largely dissolve as soon as they lose their gas like most of the stellar groups in the solar neighbourhood.

Again, observations are snapshots in time, yet young stellar groups are highly dynamical objects whose density is constantly changing (Concha-Ramírez et al. 2019). Hence, understanding the dynamics of young clusters is the key to answering the question of how strong the influence of the surroundings actually is.

For a long time it was unclear whether stellar groups formed by merging of subgroups, or just appeared the way we observe them, and whether they expand as soon as they have formed. Recently the advent of Gaia results clarified this situation. At ages 1–3 Myr, stellar groups typically expand with a velocity of 0.5–1 pc/Myr (Kuhn et al. 2019) and remain in the very dense phase 3 Myr at most, and probably more likely only 1-2 Myr. This means that the stellar groups with little-to-no gas have in fact been much denser in the past, when the influence of the environment has also been stronger. Our simulations (Vincke & Pfalzner 2018) have shown that as soon as the gas is expelled and the stellar groups start to expand the influence of the environment drops considerably.

Given the difference in density, environmental effects are generally much stronger in clusters than in associations. Two properties can be tested in this respect by simulations and observations alike: disc frequency and disc size. Roughly speaking it can be said that simulations show that complete disc destruction rarely happens in associations that contain only a few hundred stars; only in clusters that contain a few thousand or ten thousand stars does disc destruction become an issue, at least near the cluster centre. However, even in massive associations probably less than 20% of discs can be completely destroyed by the environment (Olzcak et al. 2006, Vincke & Pfalzner 2016).

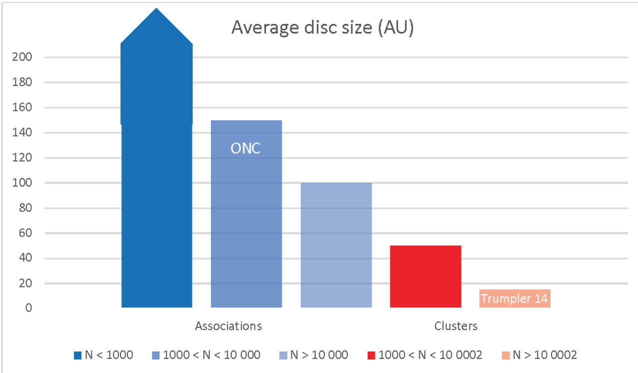

Figure 4: Average disc sizes expected from simulations of different environments at ages 3 Myr and older. Summary of the results by Vincke & Pfalzner 2016, 2018

Conversely, in clusters complete disc destruction by the environment is a real factor. A strong observational indicator is the much lower disc frequency in clusters compared to associations (see Fig. 3) at a given age. This seems to indicate that for very dense massive clusters environmental effects might be the dominant disc destruction process. However, one has to be careful with such a judgement as we have no observations covering the formation phase of such dense clusters. Therefore we do not know whether these clusters start out with basically all stars being surrounded by discs or not.

Total disc destruction is of course an extreme and rather negative outcome as far as forming planetary systems are concerned! What is much more common is that the environment leads to disc truncation or redistribution of disc material. Just considering gravitational interactions, the high flyby frequency in stellar groups like the ONC could be the reason that discs are rarely larger than 100-200 AU in such environments (Vincke 2016).

Unfortunately most clusters are further away from us than associations, so that there is little information about the disc sizes in such environments. Fig. 4 gives a schematic illustration of the average disc sizes that are expected in different environments from simulations. In the typical stellar groups found in the solar neighbourhood containing just a few hundred stars, the disc size is probably hardly affected by the environment. By contrast, in dense long-lived clusters, the mean disc size should be of the order of just 10-20 AU in environments like Westerlund 2 and Trumpler 14. This means that planetary systems in clusters should be much more compact than those that formed around field stars (Fujii & Hori 2019). In addition, it can be expected that the outermost planets of these planetary systems are often on eccentric and inclined orbits. As illustrated in Fig. 1b, any close stellar flybys excites matter onto eccentric orbits, which is not only the case for disc matter, but also for already formed planets. As most flybys will have some angle to the plane of the planets, this leads to inclined orbits. Pr 0211 in M44 is possibly a first example for such a system (Pfalzner et al. 2018).

The values given above are averages over entire stellar groups. However, it is the most central areas where the density is highest, and thus where disc destruction happens most frequently and disc fractions are lower than elsewhere. As these stellar groups expand so do these inner areas. As observations mainly focus on the similar-sized regions independent of cluster age, the cluster expansion might lead to a faster drop in disc fraction than really happens (Pfalzner et al. 2014)

There has been a long debate about whether external photo-evaporation or gravitational interactions dominate in star forming regions (recently, Champion et al. 2017, Haworth et al. 2018, Winter et al. 2018). To me, the answer is just that "it depends". Fig. 5 illustrates this in a qualitative way. Both effects require high stellar densities to be efficient. However, for external photo-evaporation to work it is also necessary for the radiation to penetrate efficiently through the cluster/association. This means that the gas/dust density in the stellar group has to be low enough not to absorb the radiation. The deeply embedded phase lasts less than 1 Myr and so far very few observational constraints exist. However, during this early phase it is gravitational interactions that set the scene. Afterwards the efficiency of close stellar flybys steadily decreases, because as soon as most discs are truncated to the disc size that is typical for this stellar group, events that truncate the disc even further become seldom. The frequency of events that change the disc size is reduced further when the stellar density eventually drops due to cluster expansion. The situation might be different in massive long-lived clusters, but very few observational constraints exist so far.

In associations external photo-evaporation (Fig. 5, black line) basically inherits the disc frequency and disc size distribution that close flybys have created and potentially leads to additional disc truncation or even destruction. The proplyds in the ONC are a prime example of such a situation. They are so clearly visible because the stellar group is just at the stage when it has become gas-free in the centre, while at the same time the stellar group has not yet started to expand. This is the moment when external photo-evaporation is at its strongest. However, this phase is relatively short-lived, because stellar groups are extremely dynamical. How short depends somewhat on the mass of the association: heavier ones develop faster than lighter ones. Most of the environmental influence happens approximately during the first 2-3 Myr. This means the time-window for efficient external photo-evaporation

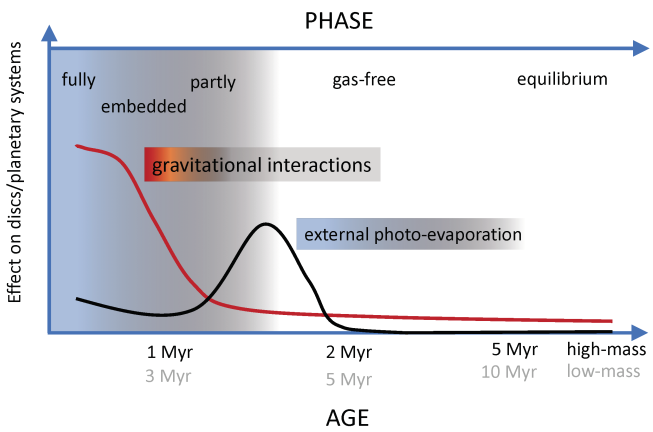

Figure 5: Schematics of the relative importance of gravitational interactions versus external photo-evaporation during the different phases of cluster development.

is only 1-2 Myr in associations. Afterwards, the massive stars dominating the radiation are just too distant to make external photo-evaporation work efficiently.

By contrast, although the frequency of close flybys that actually have an effect on the discs decreases dramatically, they never completely vanish. This means even in the planetary system phase such interactions can also influence the newly formed planetary systems (Malmberg et al. 2007, Hao et al. 2013, Wang et al. 2015, Cai et al. 2017). This is especially true in the most massive clusters like for example Westerlund 1. For a long time it was thought that such dense environments would hinder the formation of planets or at least reduce it considerably. However, in recent years over twenty planets have been found in long-lived clusters (Pfalzner et al. 2018), so that at least for short-period planets the environment does not prevent their formation. However, these systems will have likely more planets on highly eccentric orbits and fewer distant planets; something that future exoplanet surveys will test.

The influence of the environment is not restricted to distant stellar groups: our own solar system was once shaped by its environment. Several properties like the sharp outer edge at 30 AU or the composition of meteorites (Adams et al. 2006, Adams 2010, Parker 2017, Portegies Zwart 2019) seem to bear the hallmarks of the past external influences. Even the orbits of the hundreds of thousands of small objects moving outside Neptune's orbit might be due to a close stellar flyby in the Sun's past (Pfalzner et al. 2018).

The discovery of Oumuamua in 2017 (Meech et al. 2017) has brought a dramatic new aspect to the interplay between discs and their environment. Namely, what happens to all the material that becomes unbound due to the interactions with the stellar cluster (Hands et al. 2019)? If there are really 10^{15} of such objects floating around in interstellar space, as anticipated, some of them could become part of a newly formed circumstellar disc. Due to their size they could help to jump the meter-sized barrier. This way it is possible that these small objects are vital agents in seeding or accelerating planetary growth (Pfalzner & Bannister 2019).

Figure 6: Range of clustered star formation, stretching from (a) low-mass associations like σ Ori, where the environment plays a minor role, to (b) high-mass clusters like Westerlund 2 where disc sizes are dominated by the environment. Image credits: ESO and Digitized Sky Survey 2; NASA, ESA, the Hubble Heritage Team (STScI/AURA), A. Nota (ESA/STScI), and the Westerlund 2 Science Team.

In summary, I think it is important to see planetary systems not necessarily as isolated objects, but also to take the interactions with their environment into account. Star formation in the Milky Way mainly takes place in the short-lived associations, like the ones surrounding us. Here the influence on discs and forming planetary systems is non-negligible but moderate (Fig. 6a). By contrast, in long-lived clusters the environment plays a dominant role (Fig. 6b). Another important point is that even if specific clusters do not show signs of environmental influence going on at the moment, the situation might have been very different in their past. The relative importance of gravitational- vs. radiation-driven impact is a question of developmental phase. Gravitational interactions are most important during the strongly embedded phase, they set the initial conditions in terms of disc sizes and frequencies which can be modified by external photo-evaporation. However, there is only a relatively short time available for radiation to act.

What next? As pointed out above, cluster dynamics is a key factor here. The wealth of the Gaia data will hopefully enable us to put even tighter constraints on the dynamics of young clusters and associations alike. Equally, it would be important to obtain better information on discs in the embedded phase and in dense clusters, which is admittedly an observational challenge. On the theoretical front, it is important to take the newly found observational constraints into account and eventually bridge the still existing gap between cluster formation models and the following phase of cluster expansion (Farias et al. 2019). Moreover, so far it is rarely taken into account that such clusters contain a large fraction of binaries and multiple systems, and future studies should include that. Given the considerable progress during the last few years, I think all these aims are reachable in the near future.

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Abstracts of recently accepted papers

1 The structure of the Orion Nebula in the direction of Theta 1 Ori C

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We have used existing optical emission and absorption lines, [C II] emission lines, and H I absorption lines to create a new model for a Central Column of material near the Trapezium region of the Orion Nebula. This was necessary because recent high spectral resolution spectra of optical emission lines and imaging spectra in the [C II] 158 micron line have shown that there are new velocity systems associated with the foreground Veil and the material lying between Theta 1 Ori C and the Main Ionization Front of the nebula. When a family of models generated with the spectral synthesis code Cloudy were compared with the surface brightness of the emission lines and strengths of the Veil absorption lines seen in the Trapezium stars, distances from Theta 1 Ori C, were derived, with the closest, highest ionization layer being 1.3 pc. The line of sight distance of this layer is comparable with the size of the inner Huygens Region in the plane of the sky. These layers are all blueshifted with respect to the Orion Nebula Cluster of stars, probably because of the pressure of a hot central bubble created by Theta 1 Ori C's stellar wind. We find velocity components that are ascribed to both sides of this bubble. Our analysis shows that the foreground [C II] 158 micron emission is part of a previously identified layer that forms a portion of a recently discovered expanding shell of material covering most of the larger Extended Orion Nebula.

Accepted by ApJ

http://arxiv.org/pdf/1906.07779

2 Revealing the chemical structure of the Class I disc Oph-IRS 67

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Recent results suggest that the first steps towards planet formation may be already taking place in protoplanetary discs during the first 100,000 years after stars form. It is therefore crucial to unravel the physical and chemical structures of such discs in their earliest stages while they are still embedded in their natal envelopes and compare them with more evolved systems. The purpose of this paper is to explore the structure of a line-rich Class I protobinary source, Oph-IRS 67, and analyse the differences and similarities with Class 0 and Class II sources. We present a systematic molecular line study of IRS 67 with the Submillimeter Array (SMA) on 1–2 arcsec (150–300 AU) scales. The wide instantaneous band-width of the SMA observations ($\sim$30 GHz) provide detections of a range of molecular transitions that trace different physics, such as CO isotopologues, sulphur-bearing species, deuterated species, and carbon-chain molecules. We see significant differences between different groups of species. For example, the CO isotopologues and sulphur-bearing species show a rotational profile and are tracing the larger-scale circumbinary disc structure, while CN, DCN, and carbon-chain molecules peak at the southern edge of the disc at blue-shifted velocities. In addition, the cold gas tracer DCO^+ is seen beyond the extent of the circumbinary disc. The detected molecular transitions can be grouped into three main components: cold regions far from the system, the circumbinary disc, and a UV-irradiated region likely associated with the surface layers of the disc that are reached by the UV radiation from the sources. The different components are consistent with the temperature structure derived from the ratio of two H_2CO transitions, that is, warm temperatures are seen towards the outflow direction, lukewarm temperatures are associated with the UV-radiated region, and cold temperatures are related with the circumbinary disc structure. The chemistry towards

IRS 67 shares similarities with both Class 0 and Class II sources, possibly due to the high gas column density and the strong UV radiation arising from the binary system. IRS 67 is, therefore, highlighting the intermediate chemistry between deeply embedded sources and T-Tauri discs.

Accepted by Astronomy & Astrophysics

http://arxiv.org/pdf/1906.00685

3 The Effect of Binarity on Circumstellar Disk Evolution

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We present new results on how the presence of stellar companions affects disk evolution based on a study of the 5-11 Myr old Upper Scorpius OB Association. Of the 50 G0-M3 Upper Sco members with disks in our sample, only seven host a stellar companion within 2" and brighter than K = 15, compared to 35 of 75 members without disks. This matches a trend seen in the 1-2 Myr old Taurus region, where systems with a stellar companion within 40 au have a lower fraction of infrared-identified disks than those without such companions, indicating shorter disk lifetimes in close multiple systems. However, the fractions of disk systems with a stellar companion within 40 au match in Upper Sco and Taurus. Additionally, we see no difference in the millimeter brightnesses of disks in Upper Sco systems with and without companions, in contrast to Taurus where systems with a companion within 300 au are significantly fainter than wider and single systems. These results suggest that the effects of stellar companions on disk lifetimes occur within the first 1-2 Myr of disk evolution, after which companions play little further role. By contrast, disks around single stars lose the millimeter-sized dust grains in their outer regions between ages of 1-2 Myr and 5-11 Myr. The end result of small dust disk sizes and faint millimeter luminosities is the same whether the disk has been truncated by a companion or has evolved through internal processes.

Accepted by Astrophysical Journal

http://arxiv.org/pdf/1906.04878

4 Variability of young stellar objects in the star-forming region Pelican Nebula

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We observed a field of $16' \times 16'$ in the star-forming region Pelican Nebula (IC 5070) at *BVRI* wavelengths for 90 nights spread over one year in 2012–2013. More than 250 epochs in *VRI*-bands are used to identify and classify variables up to $V \sim 21$ mag. We present a catalogue of optical time-series photometry with periods, mean-magnitudes and classifications for 95 variable stars including 67 pre-main-sequence variables towards star-forming region IC 5070. The pre-main-sequence variables are further classified as candidate classical T Tauri and weak-line T Tauri stars based on their light curve variations and the locations on the color-color and color-magnitude diagrams using optical and infrared data together with Gaia DR2 astrometry. Classical T Tauri stars display variability amplitudes up to three times the maximum fluctuation in disk-free weak-line T Tauri stars, which show strong periodic variations. Short-term variability is missed in our photometry within single nights. Several classical T Tauri stars display long-lasting ($\geq$10 days) single or multiple fading and brightening events up to a couple of magnitudes at optical wavelengths. The typical mass and age of the pre-main-sequence variables from the isochrone-fitting and spectral energy distributions are estimated to be $\leq 1\ M_\odot$ and $\sim$2 Myr, respectively. We do not find any correlation between the optical amplitudes or periods with the physical parameters (mass and age) of pre-main-sequence stars.

Accepted by A&A

http://arxiv.org/pdf/1906.00256

5 The complex chemistry of hot cores in Sagittarius B2(N): Influence of cosmic-ray ionization and thermal history

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As the number of complex organic molecules (COMs) detected in the interstellar medium increases, it becomes important to place meaningful constraints on the formation pathways of these species. The molecular cloud Sagittarius B2(N)-orth is host to several hot molecular cores in the early stage of star formation, where a great variety of COMs are detected in the gas phase. Because of its exposure to the extreme conditions of the Galactic center region, Sgr B2(N) is one of the best targets to study the impact of environmental conditions on the production of COMs. Our main goal is to characterize the physico-chemical evolution of Sgr B2(N)'s sources in order to explain their chemical differences and constrain their environmental conditions. The chemical composition of Sgr B2(N)'s hot cores, N2, N3, N4, and N5 is derived by modeling their 3 mm emission spectra extracted from the EMoCA imaging spectral line survey performed with ALMA. We derive the density distribution in the envelope of the sources based on the masses computed from the ALMA dust continuum emission maps. We use the radiative transfer code RADMC-3D to compute temperature profiles based on the COM rotational temperatures derived from population diagrams. We use published results of 3D RMHD simulations of high-mass star formation to estimate the time evolution of the sources properties. We employ the chemical code MAGICKAL to compute time-dependent chemical abundances in the sources and investigate how physical properties and environmental conditions influence the production of COMs. We find that chemical models with a cosmic-ray ionization rate of 7×10^{-16} s^{-1} best reproduce the abundances with respect to methanol of ten COMs observed toward Sgr B2(N2-N5). We also show that COMs still form efficiently on dust grains with minimum dust temperatures in the prestellar phase as high as 15 K, but that minimum temperatures higher than 25 K are excluded.

Accepted by A&A

https://arxiv.org/pdf/1906.04695

6 GG Tau A: Dark shadows on the ringworld

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Context. With its high complexity, large size, and close distance, the ringworld around GG Tau A is an appealing case to study the formation and evolution of protoplanetary disks around multiple star systems. However, investigations with radiative transfer models are usually neglecting the influence of the circumstellar dust around the individual stars.
Aims. We investigate how circumstellar disks around the stars of GG Tau A are influencing the emission that is scattered at the circumbinary disk and if constraints on these circumstellar disks can be derived.

Methods. We perform radiative transfer simulations with the code POLARIS to obtain spectral energy distributions and emission maps in the H-Band (near-infrared). Subsequently, we compare them with observations to achieve our aims.
Results. We studied the ratio of polarized intensity at different locations in the circumbinary disk and conclude that the observed scattered-light near-infrared emission is best reproduced, if the circumbinary disk lies in the shadow of at least two co-planar circumstellar disks surrounding the central stars. This implies that the inner wall of the circumbinary disk is strongly obscured around the midplane, while the observed emission is actually dominated by the most upper disk layers. In addition, the inclined dark lane ("gap") on the western side of the circumbinary disk, which is a stable (non rotating) feature since ∼20 yr, can only be explained by the self-shadowing of a misaligned circumstellar disk surrounding one of the two components of the secondary close-binary star GG Tau Ab.

Accepted by Astronomy & Astrophysics

https://arxiv.org/pdf/1906.11582

7 Sub-arcsecond (sub)millimeter imaging of the massive protocluster G358.93-0.03: Discovery of 14 new methanol maser lines associated with a hot core

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We present (sub)millimeter imaging at $0\farcs5$ resolution of the massive star-forming region G358.93−0.03 acquired in multiple epochs at 2 and 3 months following the recent flaring of its 6.7 GHz CH_3OH maser emission. Using SMA and ALMA, we have discovered 14 new Class II CH_3OH maser lines ranging in frequency from 199 to 361 GHz, which originate mostly from v_t=1 torsionally-excited transitions and include one v_t=2 transition. The latter detection provides the first observational evidence that Class II maser pumping involves levels in the v_t=2 state. The masers are associated with the brightest continuum source (MM1), which hosts a line-rich hot core. The masers present a consistent curvilinear spatial velocity pattern that wraps around MM1, suggestive of a coherent physical structure

1200 au in extent. In contrast, the thermal lines exhibit a linear pattern that crosses MM1 but at progressive position angles that appear to be a function of either increasing temperature or decreasing optical depth. The maser spectral profiles evolved significantly over one month, and the intensities dropped by factors of 3.0 to 7.2, with the v_t=2 line showing the largest change. A small area of maser emission from only the highest excitation lines closest to MM1 has disappeared. There are seven additional dust continuum sources in the protocluster, including another hot core (MM3). We do not find evidence for a significant change in (sub)millimeter continuum emission from any of the sources during the one month interval, and the total protocluster emission remains comparable to prior single dish measurements.

Accepted by The Astrophysical Journal Letters

http://arxiv.org/pdf/1907.02470

8 Modeling C-Shock Chemistry in Isolated Molecular Outflows

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Shocks are a crucial probe for understanding the ongoing chemistry within ices on interstellar dust grains where many complex organic molecules (COMs) are believed to be formed. However, previous work has been limited to the initial liberation into the gas phase through non-thermal desorption processes such as sputtering. Here, we present results from the adapted three-phase gas-grain chemical network code NAUTILUS, with the inclusion of additional high-temperature reactions, non-thermal desorption, collisional dust heating, and shock-physics parameters. This enhanced model is capable of reproducing many of the molecular distributions and abundance ratios seen in our prior observations of the prototypical shocked-outflow L1157. In addition, we find that, among others, NH_2CHO, $HCOOCH_3$, and CH_3CHO have significant post-shock chemistry formation routes that differ from those of many other COMs observed in shocks. Finally, a number of selected species and phenomena are studied here with respect to their usefulness as shock tracers in various astrophysical sources.

Accepted by ApJ

http://arxiv.org/pdf/1906.08774

9 Molecular complexity on disk-scales uncovered by ALMA: The chemical composition of the high-mass protostar AFGL 4176

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The chemical composition of high-mass protostars reflects the physical evolution associated with different stages of star formation. In this study, the molecular inventory of the forming high-mass star AFGL 4176 is studied in detail at high angular resolution ($\sim 0\farcs35$) using ALMA. This high resolution makes it possible to separate the emission associated with the inner hot envelope and disk around the forming star from that of its cool outer envelope. In addition, the high sensitivity of ALMA makes it possible to identify weak and optically thin lines and allows for many isotopologues

to be detected, providing a more complete and accurate inventory of the source. A total of 23 different molecular species and their isotopologues are detected in the spectrum towards AFGL 4176. The most abundant species is methanol (CH_3OH), remaining species are present at levels between 0.003% and 15% with respect to CH_3OH. Hints that N-bearing species peak slightly closer to the location of the peak continuum emission than the O-bearing species are seen. AFGL 4176 comprises a rich chemical inventory including many complex species present on disk-scales. On average, the derived column density ratios with respect to methanol of O-bearing species are higher than those derived for N-bearing species by a factor of three. This may indicate that AFGL 4176 is a relatively young source since nitrogen chemistry generally takes longer to evolve in the gas-phase. Taking methanol as a reference, the composition of AFGL 4176 more closely resembles that of the low-mass protostar IRAS 16293−2422B than that of high-mass star-forming regions located near the Galactic centre. This similarity hints that the chemical composition of complex species is already set in the cold cloud stage and implies that AFGL 4176 is a young source whose chemical composition has not yet been strongly processed by the central protostar.

Accepted by A&A

http://arxiv.org/pdf/1906.06156

10 Upper limits on the water vapour content of the β Pictoris debris disk

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The debris disk surrounding β Pictoris has been observed with ALMA to contain a belt of CO gas with a distinct peak at ∼85 au. This CO clump is thought to be the result of a region of enhanced density of solids that collide and release CO through vaporisation. The parent bodies are thought to be comparable to solar system comets, in which CO is trapped inside a water ice matrix. Since H_2O should be released along with CO, we aim to put an upper limit on the H_2O gas mass in the disk of β Pictoris. We use archival data from the Heterodyne Instrument for the Far-Infrared (HIFI) aboard the Herschel Space Observatory to study the ortho-H_2O 1_{10}–1_{01} emission line. The line is undetected. Using a python implementation of the radiative transfer code RADEX, we convert upper limits on the line flux to H_2O gas masses. The resulting lower limits on the CO/H_2O mass ratio are compared to the composition of solar system comets. Depending on the assumed gas spatial distribution, we find a 95% upper limit on the ortho-H_2O line flux of 7.5×10^{-20} W m^{-2} or 1.2×10^{-19} W m^{-2}. These translate into an upper limit on the H_2O mass of 7.4×10^{16}–1.1×10^{18} kg depending on both the electron density and gas kinetic temperature. The range of derived gas-phase CO/H_2O ratios is marginally consistent with low-ratio solar system comets.

Accepted by A&A

http://arxiv.org/pdf/1906.11106

11 Silicate features in the circumstellar envelopes of the Class I binary driving source of HH 250

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The silicate feature near 10μm one of the main tools available to study the mineralogy of circumstellar disks and envelopes, providing information on the thermal processing, growth, location, and circulation of dust grains. We investigate the silicate feature of the two Class I components of HH 250-IRS, a resolved binary system with a separation

of 0"53 driving a Herbig-Haro flow. Each component has its own circumstellar envelope, and the system is surrounded by a circumbinary disk. We have carried out low resolution spectroscopy in the 8-13μm range using VISIR, the thermal infrared imager and spectrograph at ESOs Very Large Telescope. The silicate features of both sources are clearly different. The NW component has a broad, smooth absorption profile lacking structure. We attribute most of it to foreground interstellar dust absorption, but estimate that additional absorption by amorphous silicates takes place in the circumstellar envelope of the young stellar object. The SE component shows the silicate feature in emission, with structure longwards of 9.5μm indicating the presence of crystalline dust in the dominant form of forsterite. The apparent lack of an absorption feature caused by foreground dust is probably due to the filling of the band with emission by amorphous silicates in the envelope of the object. Despite their virtually certain coevality, the differences in the components of the HH 250-IRS binary are most likely due to markedly different circumstellar environments. The NW component displays an unevolved envelope, whereas dust growth and crystallization has taken place in the SE component. The weak or absent signatures of enstatite in the latter are fairly unusual among envelopes with crystalline dust, and we tentatively relate it to a possible wide gap or an inner truncation of the disk already hinted in previous observations by a drop in the L'-band flux, which might indicate that the SE component could actually be a very close binary. We speculate that the clear differences between the silicate feature spectra of both components of HH 250-IRS may be due either to disk evolution sped up by multiplicity, or by accretion variability leading to episodes of crystal formation. Different inclinations with respect to the line of sight may play a role as well, although it is very unlikely that they are the sole responsible for the differences between both objects.

Accepted by Astronomy and Astrophysics

http://www.eso.org/~fcomeron/hh250_spec_final.pdf

12 Planet formation and stability in polar circumbinary discs

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Context. Dynamical studies suggest that most of the circumbinary discs (CBDs) should be coplanar, i.e. the rotation vectors of the binary and the disc are aligned. However, some theoretical works show that under certain conditions a CBD can become polar, which means that its rotation vector is orthogonal with respect to the binary orbital plane. Interestingly, very recent observations showed that polar CBDs exist in Nature (e.g. HD 98800).

Aims. We test the predictions of CBD alignment around eccentric binaries based on linear theory. In particular, we compare prograde and retrograde CBD configurations. Then, assuming planets form in these systems, we thoroughly characterise the orbital behaviour and stability of misaligned (P-type) particles. This is done for massless and massive particles.

Methods. The evolution of the CBD alignment for various configurations is modelled through three-dimensional hydrodynamical simulations. For the orbital characterisation and the analysis stability, we relied on long-term N-body integrations and structure and chaos indicators, such as Δe and MEGNO.

Results. We confirm previous analytical predictions on CBD alignment, but find an unexpected symmetry breaking between prograde and retrograde configurations. More specifically, we observe polar alignment for a retrograde misaligned CBD that was expected to become coplanar with respect to the binary disc plane. Therefore, the likelihood of becoming polar for a highly misaligned CBD is higher than previously thought. Regarding the stability of circumbinary P-type planets (aka Tatooines), polar orbits are stable over a wide range of binary parameters. In particular, for binary eccentricities below 0.4, the orbits are stable for any value of the binary mass ratio. In the absence of gas, planets with masses below 10^{-5} $M_\odot$ have negligible effects on the binary orbit. Finally, we predict that Polar Tatooines should be searched around mildly eccentric equal-mass binaries.

Accepted by Astronomy & Astrophysics

https://arxiv.org/pdf/1906.10579

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The Degree of Alignment Between Circumbinary Disks and Their Binary Hosts

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All four circumbinary (CB) protoplanetary disks orbiting short-period ($P < 20$ day) double-lined spectroscopic binaries (SB2s)—a group that includes UZ Tau E, for which we present new ALMA data—exhibit sky-plane inclinations $i_{\rm disk}$ which match, to within a few degrees, the sky-plane inclinations $i_\star$ of their stellar hosts. Although for these systems the true mutual inclinations θ between disk and binary cannot be directly measured because relative nodal angles are unknown, the near-coincidence of $i_{\rm disk}$ and $i_\star$ suggests that θ is small for these most compact of systems. We confirm this hypothesis using a hierarchical Bayesian analysis, showing that 68% of CB disks around short-period SB2s have $\theta < 3.0^\circ$. Near co-planarity of CB disks implies near co-planarity of CB planets discovered by Kepler, which in turn implies that the occurrence rate of close-in CB planets is similar to that around single stars. By contrast, at longer periods ranging from 30–10^5 days (where the nodal degeneracy can be broken via, e.g., binary astrometry), CB disks exhibit a wide range of mutual inclinations, from co-planar to polar. Many of these long-period binaries are eccentric, as their component stars are too far separated to be tidally circularized. We discuss how theories of binary formation and disk-binary gravitational interactions can accommodate all these observations.

Accepted by ApJ

http://arxiv.org/pdf/1906.03269

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Dynamics of magnetic flux tubes in accretion discs of T Tauri stars

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Dynamics of slender magnetic flux tubes (MFT) in the accretion discs of T Tauri stars is investigated. We perform simulations taking into account buoyant, aerodynamic and turbulent drag forces, radiative heat exchange between MFT and ambient gas, magnetic field of the disc. The equations of MFT dynamics are solved using Runge-Kutta method of the fourth order. The simulations show that there are two regimes of MFT motion in absence of external magnetic field. In the region $r < 0.2$ au, the MFT of radii $0.05 \leq a_0 \leq 0.16H$ (H is the scale height of the disc) with initial plasma β of 1 experience thermal oscillations above the disc. The oscillations decay over some time, and MFT continue upward motion afterwards. Thinner or thicker MFT do not oscillate. MFT velocity increases with initial radius and magnetic field strength. MFT rise periodically with velocities up to 5–15 km s^{-1} and periods of 0.5–10 yr determined by the toroidal magnetic field generation time. Approximately 20% of disc mass and magnetic flux can escape to disc atmosphere via the magnetic buoyancy over characteristic time of disc evolution. MFT dispersal forms expanding magnetized corona of the disc. External magnetic field causes MFT oscillations near the disc surface. These magnetic oscillations have periods from several days to 1–3 months at $r < 0.6$ au. The magnetic oscillations decay over few periods. We simulate MFT dynamics in accretion discs in the Chameleon I cluster. The simulations demonstrate that MFT oscillations can produce observed IR-variability of T Tauri stars.

Accepted by MNRAS

http://arxiv.org/pdf/1906.05133

15 Double-peaked OI profile: a likely signature of the gaseous ring around KH 15D

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KH 15D is a well-known spectroscopic binary because of its unique and dramatic photometric variability. The variability is explained by a circumbinary dust ring but the ring itself was never directly detected. We present a new interpretation of the double-peaked [O I] λ6300 profiles as originating from the hot disk surface of KH 15D. By modeling these profiles, we measure emitting radii between $\sim$0.5–5 au, basically a gaseous ring very similar in radial extent to the dust ring inferred from modeling the system's photometric variability. We also discuss the possibility that external photoevaporation driven by UV photons from the nearby massive star HD 47887 has truncated the outer edge of the disk to the observed value.

Accepted by ApJL

http://arxiv.org/pdf/1906.04723

16 CO Detected in CI Tau b: Hot Start Implied by Planet Mass and M_K

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We acquired high resolution IR spectra of CI Tau, the host star of one of the few young planet candidates amenable to direct spectroscopic detection. We confirm the planet's existence with a direct detection of CO in the planet's atmosphere. We also calculate a mass of 11.6 M_J based on the amplitude of its radial velocity variations. We estimate its flux contrast with its host star to get an absolute magnitude estimate for the planet of 8.17 in the K band. This magnitude implies the planet formed via a "hot start" formation mechanism. This makes CI Tau b the youngest confirmed exoplanet as well as the first exoplanet around a T Tauri star with a directly determined, model-independent, dynamical mass.

Accepted by ApJ letters

https://arxiv.org/pdf/1906.02860

17 The SPHERE view of the jet and the envelope of RY Tau

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Jets are rarely associated with pre-main-sequence intermediate-mass stars. Optical and near-IR observations of jet-driving sources are often hindered by the presence of a natal envelope. Jets around partly embedded sources are a useful diagnostic to constrain the geometry of the concealed protoplanetary disk. In fact, the jet-driving mechanisms are affected by both spatial anisotropies and episodic variations at the (sub-)au scale from the star. We obtained a rich set of high-contrast VLT/SPHERE observations from 0.6 micron to 2.2 micron of the young intermediate-mass star RY Tau. Given the proximity to the Sun of this source, our images have the highest spatial resolution ever obtained for an atomic jet. Optical observations in polarized light show no sign of the protoplanetary disk detected by ALMA. Instead, we observed a diffuse signal resembling a remnant envelope with an outflow cavity. The jet is detected in four spectral lines. The jet appears to be wiggling and its radial width increasing with the distance is complementary to the shape of the outflow cavity suggesting a strong jet/envelope interaction. Through the estimated tangential velocity, we revealed a possible connection between the launching time of the jet sub-structures and the stellar activity of RY Tau. RY Tau is at an intermediate stage toward the dispersal of the natal envelope. This source shows episodic increases of mass accretion/ejection similarly to other known intermediate-mass stars. The amount of observed jet wiggle is consistent with the presence of a precessing disk warp or misaligned inner disk that would be induced by an unseen planetary/sub-stellar companion at sub-/few-au scales. The high disk mass of RY Tau and of two other jet-driving intermediate-mass stars, HD163296 and MWC480, suggests that massive, full disks are more efficient at launching prominent jets.

Accepted by A&A

https://arxiv.org/pdf/1906.06910

18

Warm gas in protostellar outflows. II. EHV jet and outflows from OMC-2/3

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OMC-2/3 is one of the nearest embedded cluster-forming region that includes intermediate-mass protostars at early stages of evolution. A previous CO (3–2) mapping survey towards this region revealed outflow activity related to sources at different evolutionary phases. The present work aims to study the warm gas in the high-velocity emission from several outflows found in CO (3–2) emission by previous observations, determine their physical conditions, and make comparison with previous results in low-mass star-forming regions. We use the CHAMP+ heterodyne array on the APEX telescope to map the CO (6–5) and CO (7–6) emission in the OMC-2 FIR 6 and OMC-3 MMS 1-6 regions, and to observe ^{13}CO (6–5) at selected positions. We analyze these data together with previous CO (3–2) observations.

In addition, we mapped the SiO (5–4) emission in OMC-2 FIR 6. The CO (6–5) emission was detected in most of the outflow lobes in the mapped regions, while the CO (7–6) was found mostly from the OMC-3 outflows. In the OMC-3 MMS 5 outflow, a previously undetected extremely high velocity gas was found in CO (6–5). This extremely high velocity emission arises from the regions close to the central object MMS 5. Radiative transfer models revealed that the high-velocity gas from MMS 5 outflow consists of gas with $n_{H_2} = 10^4$–10^5 cm^{-3} and $T > 200$ K, similar to what is observed in young Class 0 low-mass protostars. For the other outflows, values of $n_{H_2} > 10^4$ cm^{-3} were found. The physical conditions and kinematic properties of the young intermediate-mass outflows presented here are similar to those found in outflows from Class 0 low-mass objects. Due to their excitation requirements, mid-J CO lines are good tracers of extremely high velocity gas in young outflows likely related to jets.

Accepted by A&A

http://arxiv.org/pdf/1906.03522

19 Two accreting protoplanets around the young star PDS 70

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Newly forming proto-planets are expected to create cavities and substructures in young, gas-rich proto-planetary disks, but they are difficult to detect as they could be confused with disk features affected by advanced image-analysis techniques. Recently, a planet was discovered inside the gap of the transitional disk of the T-Tauri star PDS 70. Here we report on the detection of strong Hα emission from two distinct locations in the PDS 70 system, one corresponding to the previously discovered planet PDS 70 b, which confirms the earlier Hα detection, and another located close to the outer-edge of the gap, coinciding with a previously identified bright dust spot in the disk and with a small opening in a ring of molecular emission. We identify this second Hα peak as a second proto-planet in the PDS 70 system. The Hα emission spectra of both proto-planets indicate ongoing accretion onto the proto-planets, which appear to be near a 2:1 mean motion resonance. Our observations show that adaptive-optics-assisted, medium-resolution, integral-field spectroscopy with MUSE targeting accretion signatures will be a powerful way to trace ongoing planet formation in transitional disks at different stages of their evolution. Finding more young planetary systems in mean motion resonance would give credibility to the Grand Tack hypothesis in which Jupiter and Saturn migrated in a resonance orbit during the early formation period of our Solar System.

Accepted by Nature Astronomy

http://arxiv.org/pdf/1906.01486

20 Submillimeter emission associated with candidate protoplanets

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We present the discovery of a spatially unresolved source of sub-millimeter continuum emission ($\lambda = 855\mu$m) associated with a young planet, PDS 70 c, recently detected in Hα emission around the 5 Myr old T Tauri star PDS 70. We interpret the emission as originating from a dusty circumplanetary disk with a dust mass between 2×10^{-3} and 4.2×10^{-3} Earth masses. Assuming a standard gas-to-dust ratio of 100, the ratio between the total mass of the circumplanetary disk and the mass of the central planet would be between 10^{-4}–10^{-5}. Furthermore, we report the discovery of another compact continuum source located $0''.074 \pm 0''.013$ South-West of a second known planet in this system, PDS 70 b, that was previously detected in near-infrared images. We speculate that the latter source might trace dust orbiting in proximity of the planet, but more sensitive observations are required to unveil its nature.

Accepted by ApJL

http://arxiv.org/pdf/1906.06156

21 Intrinsic polarisation of elongated porous dust grains

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ALMA observations revealed recently polarised radiation of several protoplanetary disks in the (sub-)millimetre wavelength range. Besides self-scattering of large particles, thermal emission by elongated grains is a potential source for the detected polarisation signal. We calculate the wavelength dependent absorption and intrinsic polarisation of spheroidally shaped, micrometre and sub-millimetre sized dust grains using the discrete dipole approximation. In particular, we analyse the impact of dust grain porosity which appears to be present in disks when small grains coagulate to form larger aggregates. For the first time our results show that (a) the intrinsic polarisation decreases for increasing grain porosity and (b) the polarisation orientation flips by 90 degree for certain ratios of wavelength to grain size. We present a new method to constrain grain porosity and the grain size in protoplanetary disks using multi-wavelength polarisation observations in the far-infrared to millimetre wavelengths. Finally, we find that moderate grain porosities ($\mathcal{P} \leq 0.7$) potentially explain the observed polarisation fraction in the system HD 142527 while highly porous grains ($\mathcal{P} > 0.7$) fail unless the grain's axis ratio is extraordinarily large.

Accepted by MNRAS

https://arxiv.org/pdf/1906.10699

22 The Bridge: a transient phenomenon of forming stellar multiples

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Observations with modern instruments such as *Herschel* reveal that stars form clustered inside filamentary arms of ∼1 pc length embedded in Giant Molecular Clouds. On smaller scales (∼1000 au), observations of, e.g., IRAS 16293–2422 show signs of filamentary 'bridge' structures connecting young protostars in their birth environment. We aim to find the origin of bridges associated with deeply embedded protostars, by characterizing their connection to the filamentary structure present on GMC scales and to the formation of protostellar multiples. Using the magnetohydrodynamical code ramses, we carry out zoom-in simulations of low-mass star formation starting from Giant-Molecular-Cloud-scales. We analyze the morphology and dynamics involved in the formation process of a triple system. Colliding flows of gas in the filamentary arms induce the formation of two protostellar companions at distances of ∼1000 au from the primary. After their birth, the stellar companions quickly ($\Delta t \sim 10$ kyr) approach and orbit the primary on eccentric orbits with separations of ∼100 au. The colliding flows induce transient structures lasting for up to a few 10 kyr connecting two forming protostellar objects that are kinematically quiescent along the line-of-sight. Colliding flows compress the gas and trigger the formation of stellar companions via turbulent fragmentation. Our results suggest that protostellar companions initially form with a wide separation of ∼1000 au. Smaller separations ($a \sim 100$

au or less) are a consequence of subsequent migration and capturing. Associated with the formation phase of the companion, the turbulent environment induces the formation of arc- and bridge-like structures. These bridges can become kinematically quiescent, when the velocity components of the colliding flows eliminate each other. However, the gas in bridges still contributes to stellar accretion later. Our results demonstrate: bridge-like structures are a transient phenomenon of stellar multiple formation.

Accepted by A&A

http://arxiv.org/pdf/1907.02083

23 Compact Disks in a High Resolution ALMA Survey of Dust Structures in the Taurus Molecular Cloud

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We present a high-resolution ($\sim 0\farcs12$, $\sim$16 au, mean sensitivity of 50 μJy beam^{-1} at 225 GHz) snapshot survey of 32 protoplanetary disks around young stars with spectral type earlier than M3 in the Taurus star-forming region using Atacama Large Millimeter Array (ALMA). This sample includes most mid-infrared excess members that were not previously imaged at high spatial resolution, excluding close binaries and highly extincted objects, thereby providing a more representative look at disk properties at 1–2 Myr. Our 1.3 mm continuum maps reveal 12 disks with prominent dust gaps and rings, 2 of which are around primary stars in wide binaries, and 20 disks with no resolved features at the observed resolution (hereafter smooth disks), 8 of which are around the primary star in wide binaries. The smooth disks were classified based on their lack of resolved substructures, but their most prominent property is that they are all compact with small effective emission radii ($R_{\rm eff,95\%} \lesssim 50$ au). In contrast, all disks with $R_{\rm eff,95\%}$ of at least 55 au in our sample show detectable substructures. Nevertheless, their inner emission cores (inside the resolved gaps) have similar peak brightness, power law profiles, and transition radii to the compact smooth disks, so the primary difference between these two categories is the lack of outer substructures in the latter. These compact disks may lose their outer disk through fast radial drift without dust trapping, or they might be born with small sizes. The compact dust disks, as well as the inner disk cores of extended ring disks, that look smooth at the current resolution will likely show small-scale or low-contrast substructures at higher resolution. The correlation between disk size and disk luminosity correlation demonstrates that some of the compact disks are optically thick at millimeter wavelengths.

Accepted by ApJ

http://arxiv.org/pdf/1906.10809

24 Angular momentum in bipolar outflows: dynamical evolutionary model

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We model molecular outflows produced by the time dependent interaction between a stellar wind and a rotating cloud envelope in gravitational collapse, studied by Ulrich. We consider spherical and anisotropic stellar winds. We assume that the bipolar outflow is a thin shocked shell, with axial symmetry around the cloud rotation axis and obtain the mass and momentum fluxes into the shell. We solve numerically a set of partial differential equations in space and time, and obtain the shape of the shell, the mass surface density, the velocity field, and the angular momentum of the material in the shell. We find that there is a critical value of the ratio between the wind and the accretion flow momentum rates β that allows the shell to expand. As expected, the elongation of the shells increase with the stellar wind anisotropy. In our models, the rotation velocity of the shell is the order to 0.1–0.2 km s^{-1}, a factor of 5–10 lower than the values measured in several sources. We compare our models with those of Wilkin and Stahler for early evolutionary times and find that our shells have the same sizes at the pole, although we use different boundary conditions at the equator.

Accepted by ApJ

http://arxiv.org/pdf/1906.02166

25 Observational signatures of outbursting protostars - I: From hydrodynamic simulations to observations

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Accretion onto protostars may occur in sharp bursts. Accretion bursts during the embedded phase of young protostars are probably most intense, but can only be inferred indirectly through long-wavelength observations. We perform radiative transfer calculations for young stellar objects (YSOs) formed in hydrodynamic simulations to predict the long wavelength, sub-mm and mm, flux responses to episodic accretion events, taking into account heating from the young protostar and from the interstellar radiation field. We find that the flux increase due to episodic accretion events is more prominent at sub-mm wavelengths than at mm wavelengths; e.g. a factor of ~ 570 increase in the luminosity of the young protostar leads to a flux increase of a factor of 47 at 250 μm but only a factor of 10 at 1.3 mm. Heating from the interstellar radiation field may reduce further the flux increase observed at longer wavelengths. We find that

during FU Ori-type outbursts the bolometric temperature and luminosity may incorrectly classify a source as a more evolved YSO, due to a larger fraction of the radiation of the object being emitted at shorter wavelengths.

Accepted by MNRAS

https://arxiv.org/pdf/1906.01960

26 Observational signatures of outbursting protostars - II: Exploring a wide range of eruptive protostars

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Young stars exhibit variability due to changes in the gas accretion rate onto them, an effect that should be quite significant in the early stages of their formation. As protostars are embedded within their natal cloud, this variability may only be inferred through long wavelength observations. We perform radiative transfer simulations of young stellar objects (YSOs) formed in hydrodynamical simulations, varying the structure and luminosity properties in order to estimate the long-wavelength, sub-mm and mm, variations of their flux. We find that the flux increase due to an outburst event depends on the protostellar structure and is more prominent at sub-mm wavelengths than at mm wavelengths; e.g. a factor of 40 increase in the luminosity of the young protostar leads to a flux increase of a factor of 10 at 250 μm but only a factor of 2.5 at 1.3 mm. We find that the interstellar radiation field dilutes the flux increase but that this effect may be avoided if resolution permits the monitoring of the inner regions of a YSO, where the heating is primarily due to protostellar radiation. We also confirm that the bolometric temperature and luminosity of outbursting protostars may result in an incorrect classification of their evolutionary stage.

Accepted by MNRAS

https://arxiv.org/pdf/1906.01966

27 Looking deep into the Rosette Nebula's heart: the (sub)stellar content of the massive young cluster NGC 2244

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As part of the ongoing effort to characterize the low-mass (sub-)stellar population in a sample of massive young clusters, we have targeted the ∼2 Myr old cluster NGC 2244. The distance to NGC 2244 from *Gaia DR2* parallaxes is 1.59 kpc, with errors of 1% (statistical) and 11% (systematic). We used the FLAMINGOS-2 near-infrared camera at the Gemini-South telescope for deep multi-band imaging of the central portion of the cluster ($\sim 2.4\,\mathrm{pc}^2$). We determined membership in a statistical manner, through a comparison of the cluster's color-magnitude diagram to that of a control field. Masses and extinctions of the candidate members are then calculated with the help of evolutionary

models, leading to the first Initial Mass Function (IMF) of the cluster extending into the substellar regime, with the 90-percent completeness limit around $0.02\,M_\odot$. The IMF is well represented by a broken power-law ($dN/dM \propto M^{-\alpha}$), with a break at $\sim 0.4\,M_\odot$. The slope at the high mass side ($0.4 - 7\,M_\odot$) is $\alpha = 2.12 \pm 0.08$, close to the standard Salpeter's slope. In the low-mass range ($0.02 - 0.4\,M_\odot$), we find a slope $\alpha = 1.03 \pm 0.02$, which is on the high end of the typical values obtained in nearby star-forming regions ($\alpha = 0.5 - 1.0$), but still in agreement within the uncertainties. Our results reveal no clear evidence for variations in the formation efficiency of brown dwarfs and very-low mass stars due to the presence of OB stars, or a change in stellar densities. Our finding rules out photoevaporation and fragmentation of infalling filaments as substantial pathways for brown dwarf formation.

Accepted by ApJ

https://arxiv.org/pdf/1907.00617

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Modeling of CoRoT and Spitzer lightcurves in NGC 2264 caused by an optically thick warp

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Aims: We present an analysis of simultaneously observed CoRoT and Spitzer lightcurves for 4 systems in the stellar forming region NGC 2264: Mon-660, Mon-811, Mon-1140 and Mon-1308. These objects share in common a high resemblance between the optical and infrared lightcurves, such that the mechanism responsible to produce them is the same. The aim of this paper is to explain both lightcurves simultaneously with only one mechanism.
Methods: We modeled the infrared emission as coming from a warp composed of an optically thick wall and an optically thick asymmetric disk beyond this location. We modeled the optical emission mainly by partial stellar occultation by the warp.
Results: The magnitude amplitude of the CoRoT and Spitzer observations for all the objects can be described with the emission coming from the system components. The difference between them is the value of the disk flux compared with the wall flux and the azimuthal variations of the former. This result points out the importance of the hydrodynamical interaction between the stellar magnetic field and the disk.
Conclusions: CoRoT and Spitzer lightcurves for the stellar systems Mon-660, Mon-811, Mon-1140 and Mon-1308 can be simultaneously explained using the emission coming from an asymmetric disk and emission with stellar occultation by an optically thick wall.

Accepted by Astronomy & Astrophysics

http://arxiv.org/pdf/1906.10110

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Are the observed gaps in protoplanetary discs caused by growing planets?

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Recent detailed observations of protoplanetary discs revealed a lot of sub-structures which are mostly ring-like. One interpretation is that these rings are caused by growing planets. These potential planets are not yet opening very deep gaps in their discs. These planets instead form small gaps in the discs to generate small pressure bumps exterior to their orbits that stop the inflow of the largest dust particles. In the pebble accretion paradigm, this planetary mass corresponds to the pebble isolation mass, where pebble accretion stops and efficient gas accretion starts. We perform planet population synthesis via pebble and gas accretion including type-I and type-II migration. In the first stage of our simulations, we investigate the conditions necessary for planets to reach the pebble isolation mass and compare their position to the observed gaps. We find that in order to match the gap structures 2000 $M_\oplus$ in pebbles is needed, which would be only available for the most metal rich stars. We then follow the evolution of these planets for a few My to compare the resulting population with the observed exoplanet populations. Planet formation in discs with

these large amounts of pebbles result in mostly forming gas giants and only very little super-Earths, contradicting observations. This leads to the conclusions that either (i) the observed discs are exceptions, (ii) not all gaps in observed discs are caused by planets or (iii) that we miss some important ingredients in planet formation related to gas accretion and/or planet migration.

Accepted by MNRAS

http://arxiv.org/pdf/1906.11491

30 Exploring the properties of warm and cold atomic hydrogen in the Taurus and Gemini regions

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We report Arecibo 21 cm absorption-emission observations to characterise the physical properties of neutral hydrogen (HI) in the proximity of five giant molecular clouds (GMCs): Taurus, California, Rosette, Mon OB1, and NGC 2264. Strong HI absorption was detected toward all 79 background continuum sources in the ∼60×20 square degree region. Gaussian decompositions were performed to estimate temperatures, optical depths and column densities of the cold and warm neutral medium (CNM, WNM). The properties of individual CNM components are similar to those previously observed along random Galactic sightlines and in the vicinity of GMCs, suggesting a universality of cold HI properties. The CNM spin temperature (T_s) histogram peaks at ∼50K. The turbulent Mach numbers of CNM vary widely, with a typical value of ∼4, indicating that their motions are supersonic. About 60% of the total HI gas is WNM, and nearly 40% of the WNM lies in thermally unstable regime 500–5000K. The observed CNM fraction is higher around GMCs than in diffuse regions, and increases with increasing column density (N_{HI}) to a maximum of ∼75%. On average, the optically thin approximation (N^*_{HI}) underestimates the total N_{HI} by ∼21%, but we find large regional differences in the relationship between N_{HI} and the required correction factor, $f = N_{HI}/N^*_{HI}$. We examine two different methods (linear fit of f vs $\log_{10} N^*_{HI}$ and uniform T_s) to correct for opacity effects using emission data from the GALFA-HI survey. We prefer the uniform T_s method, since the linear relationship does not produce convincing fits for all subregions.

Accepted by ApJ

http://arxiv.org/pdf/1906.06846

31 Sulfur-Bearing Species Tracing the Disk/Envelope System in the Class I Protostellar Source Elias 29

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We have observed the Class I protostellar source Elias 29 with Atacama Large Millimeter/submillimeter Array (ALMA). We have detected CS, SO, ^{34}SO, SO_2, and SiO line emissions in a compact component concentrated near the protostar and a ridge component separated from the protostar by 4 arcsec ($\sim$ 500 au). The former component is found to be abundant in SO and SO_2 but deficient in CS. The abundance ratio SO/CS is as high as $3^{+13}_{-2} \times 10^2$ at the protostar, which is even higher than that in the outflow-shocked region of L1157 B1. However, organic molecules ($HCOOCH_3$, CH_3OCH_3, CCH, and c-C_3H_2) are deficient in Elias 29. We attribute the deficiency in organic molecules and richness in SO and SO_2 to the evolved nature of the source or the relatively high dust temperature ($\gtrsim$ 20 K) in the parent cloud of Elias 29. The SO and SO_2 emissions trace rotation around the protostar. Assuming a highly inclined configuration ($i \geq 65°$; 0° for a face-on configuration) and Keplerian motion for simplicity, the protostellar mass is estimated to be (0.8 – 1.0) $M_\odot$. The ^{34}SO and SO_2 emissions are asymmetric in their spectra; the blue-shifted components are weaker than the red-shifted ones. Although this may be attributed to the asymmetric molecular distribution, other possibilities are also discussed.

Accepted by Astrophysical Journal

https://arxiv.org/pdf/1906.09724

32 JCMT BISTRO Survey observations of the Ophiuchus Molecular Cloud: Dust grain alignment properties inferred using a Ricean noise model

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The dependence of polarization fraction p on total intensity I in polarized submillimeter emission measurements is typically parameterized as $p \propto I^{-\alpha}$ ($\alpha \leq 1$), and used to infer dust grain alignment efficiency in star-forming regions, with an index $\alpha = 1$ indicating near-total lack of alignment of grains with the magnetic field. In this work we demonstrate that the non-Gaussian noise characteristics of polarization fraction may produce apparent measurements of $\alpha \sim 1$ even in data with significant signal-to-noise in Stokes Q, U and I emission, and so with robust measurements of polarization angle. We present a simple model demonstrating this behavior, and propose a criterion by which well-characterized measurements of polarization fraction may be identified. We demonstrate that where our model is applicable, α can be recovered by fitting the $p-I$ relationship with the mean of the Rice distribution, without statistical debiasing of polarization fraction. We apply our model to JCMT BISTRO Survey POL-2 850μm observations of three clumps in the Ophiuchus Molecular Cloud, finding that in the externally-illuminated Oph A region, $\alpha \approx 0.34$, while in the more isolated Oph B and C, despite their differing star formation histories, $\alpha \sim 0.6 - 0.7$. Our results thus suggest that dust grain alignment in dense gas is more strongly influenced by incident interstellar radiation field than by star formation history. We further find that grains may remain aligned with the magnetic field at significantly higher gas densities than has previously been believed, thus allowing investigation of magnetic field properties within star-forming clumps and cores.

Accepted by ApJ

https://arxiv.org/pdf/1906.03391

33 Vortex instabilities triggered by low-mass planets in pebble-rich, inviscid protoplanetary discs

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In the innermost regions of protoplanerary discs, the solid-to-gas ratio can be increased considerably by a number of processes, including photoevaporative and particle drift. MHD disc models also suggest the existence of a dead-zone at $R \lesssim 10$ AU, where the regions close to the midplane remain laminar. In this context, we use two-fluid hydrodynamical simulations to study the interaction between a low-mass planet ($\sim$1.7 $M_\oplus$) on a fixed orbit and an inviscid pebble-rich disc with solid-to-gas ratio $\epsilon \geq 0.5$. For pebbles with Stokes numbers $St = 0.1,\ 0.5$, multiple dusty vortices are formed through the Rossby Wave Instability at the planet separatrix. Effects due to gas drag then lead to a strong enhancement in the solid-to-gas ratio, which can increase by a factor of $\sim 10^3$ for marginally coupled particles with $St = 0.5$. As in streaming instabilities, pebble clumps reorganize into filaments that may plausibly collapse to form planetesimals. When the planet is allowed to migrate in a MMSN disc, the vortex instability is delayed due to migration but sets in once inward migration stops due a strong positive pebble torque. Again, particle filaments evolving in a gap are formed in the disc while the planet undergoes an episode of outward migration. Our results suggest that vortex instabilities triggered by low-mass planets could play an important role in forming planetesimals in pebble-rich, inviscid discs, and may significantly modify the migration of low-mass planets. They also imply that planetary dust gaps may not necessarily contain planets if these migrated away.

Accepted by MNRAS

http://arxiv.org/pdf/1906.07959

34 The Duration of Star Formation in Galactic Giant Molecular Clouds. I. The Great Nebula in Carina

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We present a novel infrared spectral energy distribution (SED) modeling methodology that uses likelihood-based weighting of the model fitting results to construct probabilistic H–R diagrams (pHRD) for X-ray identified, intermediate-mass (2–8 $M_\odot$), pre-main sequence young stellar populations. This methodology is designed specifi-

cally for application to young stellar populations suffering strong, differential extinction ($\Delta A_V > 10$ mag), typical of Galactic massive star-forming regions. We pilot this technique in the Carina Nebula Complex (CNC) by modeling the 1–8 μm SEDs of 2269 likely stellar members that exhibit no excess emission from circumstellar dust disks at 4.5 μm or shorter wavelengths. A subset of ∼100 intermediate-mass stars in the lightly-obscured Trumpler 14 and 16 clusters have available spectroscopic $T_{\rm eff}$, measured from the Gaia-ESO survey. We correctly identify the stellar temperature in 70% of cases, and the aggregate pHRD for all sources returns the same peak in the stellar age distribution as obtained using the spectroscopic $T_{\rm eff,S}$. The SED model parameter distributions of stellar mass and evolutionary age reveal significant variation in the duration of star formation among four large-scale stellar overdensities within the CNC and a large distributed stellar population. Star formation began ∼10 Myr ago and continues to the present day, with the star formation rate peaking < 3 Myr ago when the massive Trumpler 14 and 16 clusters formed. We make public the set of 100,000 SED models generated from standard pre-main sequence evolutionary tracks and our custom software package for generating pHRDs and mass-age distributions from the SED fitting results.

Accepted by ApJ

https://arxiv.org/pdf/1906.01730

35 Gas accretion within the dust cavity in AB Aur

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AB Aur is a Herbig Ae star hosting a well-known transitional disk. Because of its proximity and low inclination angle, it is an excellent object to study planet formation. Our goal is to investigate the chemistry and dynamics of the molecular gas component in the AB Aur disk, and its relation with the prominent horseshoe shape observed in continuum mm emission. We used the NOEMA interferometer to map with high angular resolution the $J = 3$–2 lines of HCO^+ and HCN. By combining both, we can gain insight into the AB Aur disk structure. Chemical segregation is observed in the AB Aur disk: HCO^+ shows intense emission toward the star position, at least one bright molecular bridge within the dust cavity, and ring-like emission at larger radii, while HCN is only detected in an annular ring that is coincident with the dust ring and presents an intense peak close to the dust trap. We use HCO^+ to investigate the gas dynamics inside the cavity. The observed bright HCO^+ bridge connects the compact central source with the outer dusty ring. This bridge can be interpreted as an accretion flow from the outer ring to the inner disk/jet system proving gas accretion through the cavity.

Accepted by MNRAS

http://arxiv.org/pdf/1906.11638

36 Pebble-driven planet formation for TRAPPIST-1 and other compact systems

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Recently, seven Earth-sized planets were discovered around the M-dwarf star TRAPPIST-1. Thanks to transit-timing variations, the masses and therefore the bulk densities of the planets have been constrained, suggesting that all TRAPPIST-1 planets are consistent with water mass fractions on the order of 10%. These water fractions, as well as the similar planet masses within the system, constitute strong constraints on the origins of the TRAPPIST-1 system.

In a previous work, we outlined a pebble-driven formation scenario. In this paper we investigate this formation scenario in more detail. We used a Lagrangian smooth-particle method to model the growth and drift of pebbles and the conversion of pebbles to planetesimals through the streaming instability. We used the N-body code *MERCURY* to follow the composition of planetesimals as they grow into protoplanets by merging and accreting pebbles. This code is adapted to account for pebble accretion, type-I migration, and gas drag. In this way, we modelled the entire planet formation process (pertaining to planet masses and compositions, not dynamical configuration). We find that planetesimals form in a single, early phase of streaming instability. The initially narrow annulus of planetesimals outside the snowline quickly broadens due to scattering. Our simulation results confirm that this formation pathway indeed leads to similarly-sized planets and is highly efficient in turning pebbles into planets (∼50% solids-to-planets conversion efficiency). The water content of planets resulting from our simulations is on the order of 10%, and our results predict a 'V-shaped' trend in the planet water fraction with orbital distance: from relatively high (innermost planets) to relatively low (intermediate planets) to relatively high (outermost planets).

Accepted by A&A

http://arxiv.org/pdf/1906.00669

37 The Physical and chemical structure of Sagittarius B2 – IV. Converging filaments in the high-mass cluster forming region Sgr B2(N)

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We have used an unbiased, spectral line-survey that covers the frequency range from 211 to 275 GHz and was obtained with ALMA (angular resolution of 0.4 arcsec) to study the small-scale structure of the dense gas in Sagittarius B2 (north). Eight filaments are found converging to the central hub and extending for about 0.1 pc. The spatial structure, together with the presence of the massive central region, suggest that these filaments may be associated with accretion processes. In order to derive the kinematic properties of the gas in a chemically line-rich source like SgrB2(N), we have developed a new tool that stacks all the detected transition lines of any molecular species. This permits to increase the signal-to-noise ratio of our observations and average out line blending effects, which are a common problem in line-rich regions. We derive velocity gradients along the filaments of about 20-100 km/s/pc, which are 10-100 times larger than those typically found on larger scales (1 pc) in other star-forming regions. The mass accretion rates of individual filaments are about 0.05 Msun/yr, which result in a total accretion rate of 0.16 Msun/yr. Some filaments harbor dense cores that are likely forming stars and stellar clusters. The stellar content of these dense cores is on the order of 50% of the total mass. We conclude that the cores may merge in the center when already forming stellar clusters but still containing a significant amount of gas, resulting in a "damp" merger. The high density and mass of the central region, combined with the presence of converging filaments with high mass, high accretion rates and embedded dense cores already forming stars, suggest that SgrB2(N) may have the potential to evolve into a super stellar cluster.

Accepted by Astronomy&Astrophysics

https://arxiv.org/pdf/1906.10979

38 A Radial Velocity Survey of Embedded Sources in the Rho Ophiuchi Cluster

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We present the results of a radial velocity survey of young stellar objects (YSOs) in early stages of evolution in the core of the L1688 molecular cloud. New and archival spectra obtained with four high-resolution infrared spectrographs were analyzed using Markov chain Monte Carlo techniques that simultaneously fit for the radial velocity, T_{eff}, $vsini$, and veiling by comparison with synthetic spectra. The radial velocity distribution for 32 objects, most with Class I or flat-spectrum spectral energy distributions, is marginally Gaussian, with a higher dispersion relative to optical surveys at the 2σ level. When comparing the results from both proper-motion and radial velocity surveys in L1688, there is a trend for the 1D dispersions to be higher for samples of Class I/flat-spectrum YSOs that reside in the cloud core compared to Class II/III dominated samples, which are located in the lower extinction periphery. In addition, there is a velocity gradient along the major axis of the cloud core that appears more pronounced than that derived from optically visible objects at the cloud edges. If these higher dispersions for Class I/flat-spectrum objects are confirmed by future surveys, this could imply a supervirial state for the less evolved objects in the cloud core and be a signature of the initial collapse and rebound of the cluster as suggested by recent simulations of cluster evolution.

Accepted by The Astronomical Journal

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Cyanopolyyne Chemistry around Massive Young Stellar Objects

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Recent radio astronomical observations have revealed that HC_5N, the second shortest cyanopolyyne ($HC_{2n+1}N$), is abundant around some massive young stellar objects (MYSOs), which is not predicted by classical carbon-chain chemistry. For example, the observed HC_5N abundance toward the G28.28−0.36 MYSO is higher than that in L1527, which is one of the warm carbon chain chemistry (WCCC) sources, by more than one order of magnitude (Taniguchi et al. 2017). In this paper, we present chemical simulations of hot-core models with a warm-up period using the astrochemical code Nautilus. We find that the cyanopolyynes are formed initially in the gas phase and accreted onto the bulk and surface of granular ice mantles during the lukewarm phase, which occurs at $25 < T < 100$ K. In slow warm-up period models, the peak abundances occur as the cyanopolyynes desorb from dust grains after the temperature rises above 100 K. The lower limits of the abundances of HC_5N, CH_3CCH, and CH_3OH observed in the G28.28−0.36 MYSO can be reproduced in our hot-core models, after their desorption from dust grains. Moreover, previous observations suggested chemical diversity in envelopes around different MYSOs. We discuss possible interpretations of relationships between stages of the star-formation process and such chemical diversity, such as the different warm-up timescales. This timescale depends not only on the mass of central stars but also on the relationship between the size of warm regions and their infall velocity.

Accepted by The Astrophysical Journal

https://arxiv.org/pdf/1906.11296

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Feedback from OB stars on their parent cloud: Gas exhaustion rather than gas ejection

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Feedback from high-mass stars shapes the ISM of galaxies and thereby impacts gas that will form future generations of stars. However, due to our inability to track the time evolution of individual molecular clouds, quantifying the exact role of feedback on their star formation history is an observationally challenging task. In the present study, we take advantage of the unique properties of the G316.75−00.00 high-mass star-forming ridge to determine how feedback from O-stars impacts the dynamical stability of filaments. G316.75 is a 13.6 pc long ridge containing 18,900 $M_\odot$ of H_2 gas which is half IR dark, half IR bright. The IR bright half has already formed 4 O-type stars over the past 2 Myr, while the IR dark half is still quiescent. Therefore, by assuming the gas properties of the dark part represents an earlier evolutionary stage of the bright part, we can quantify how feedback impacts these properties by contrasting them. We use archive Herschel and molecular line data, tracing both dense (NH_3 and N_2H^+) and more diffuse (^{13}CO) gas, to measure the ratio of kinetic to gravitational energy per-unit-length, virial-ratio-per-line, across the ridge for a range of gas volume densities. We show that despite the presence of 4 embedded O-stars, feedback cannot unbind the ridge's mass except for some small gas pockets near the O-stars. In fact, the virial-ratio-per-line is almost indistinguishable for both parts of the ridge. These results are at odds with most simulations where O-star-forming clouds are dispersed by feedback within a few cloud free-fall time. We conclude that the discrepancy between such simulations and our observations originates from different cloud morphologies and average densities when the first O-star forms. These results have important implications regarding, for instance, how feedback is implemented within cosmological and galactic-scale simulations.

Accepted by A&A

http://arxiv.org/pdf/1906.09275

41 A Census Star Formation in the Outer Galaxy: the SMOG field

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In this paper we undertake a study of the 21 square degree SMOG field, a Spitzer cryogenic mission Legacy program to map a region of the outer Milky Way towards the Perseus and Outer spiral arms with the IRAC and MIPS instruments. We identify 4648 YSOs across the field. Using the DBSCAN method we identify 68 clusters or aggregations of YSOs in the region, having 8 or more members. We identify 1197 class Is, 2632 class IIs, 819 class IIIs, of which 45 are candidate transition disk objects, utilizing the MIPS 24 photometry. The ratio of YSOs identified as members of clusters was 2872/4648, or 62%. The ratios of class I to class II YSOs in the clusters are broadly consistent with those found in the inner galactic and nearby Gould's Belt young star formation regions. The clustering properties indicate that the protostars may be more tightly bound to their natal sites than the class IIs, and the class IIIs are generally widely distributed. We further perform an analysis of the WISE data of the SMOG field to determine how the lower resolution and sensitivity of WISE affects the identification of YSOs as compared to Spitzer: we identify 931 YSOs using combined WISE and 2MASS photometry, 931/4648 or 20% of the total number identified with Spitzer. Performing the same clustering analysis finds 31 clusters which reliably trace the larger associations identified with the Spitzer data. Twelve of the clusters identified have previously measured distances from the WISE HII survey. SEDFitter modeling of these YSOs is reported, leading to an estimation of the IMF in the aggregate of these clusters which approximates that found in the inner galaxy, implying that the processes behind stellar mass distribution during star formation are not widely affected by the lower density and metallicity of the outer galaxy.

Accepted by ApJ

https://arxiv.org/pdf/1906.03267

42 HL Tau disk in HCO^+ (3–2) and (1–0) with ALMA: gas density, temperature, gap, and one-arm spiral

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We present our observational results of the 1.1 mm continuum and the HCO^+ (3–2) line in HL Tau at angular resolutions of 0.″1 obtained with ALMA and our data analysis of the 2.9 mm and 1.1 mm continuum and the HCO^+ (3–2) and (1–0) lines of the HL Tau disk. The Keplerian rotation of the HL Tau disk is well resolved in the HCO^+ (3–2) emission, and the stellar mass is estimated to be 2.1±0.2 $M_\odot$ with a disk inclination angle of 47°. The radial profiles of the HCO^+ column density and excitation temperature are measured with the LTE analysis of the two transitions of the HCO^+ emission. An HCO^+ gas gap at a radius of 30 au, where the column density drops by a factor of 4–8, is found in the HCO^+ column density profile, coincident with the dust gap traced by the continuum emission. No other clear HCO^+ gas gap is seen. This HCO^+ gas gap can be opened by a planet with mass of 0.5–0.8 M_J, which is comparable to the planet mass adopted in numerical simulations to form the dust gap at the same radius in the HL Tau disk. In addition to the disk component, a one-arm spiral with a length of ∼3″ (520 au) stretching out from the inner disk is observed in the HCO^+ (3–2) emission. The observed velocity structures along the spiral suggest an infalling and rotating gas stream toward the inner disk.

Accepted by ApJ

https://arxiv.org/pdf/1906.05535

43 Structure, kinematics, and ages of the young stellar populations in the Orion region

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We present a study of the three dimensional structure, kinematics, and age distribution of the Orion OB association, based on the second data release of the Gaia satellite (Gaia DR2). Our goal is to obtain a complete picture of the star formation history of the Orion complex and to relate our findings to theories of sequential and triggered star formation. We select the Orion population with simple photometric criteria, and we construct a three dimensional map in galactic Cartesian coordinates to study the physical arrangement of the stellar clusters in the Orion region. The map shows structures that extend for roughly 150 pc along the line of sight, divided in multiple sub-clusters. We separate different groups by using the density based clustering algorithm DBSCAN. We study the kinematic properties of all the groups found by DBSCAN first by inspecting their proper motion distribution, and then by applying a kinematic modelling code based on an iterative maximum likelihood approach, which we use to derive their mean velocity, velocity dispersion and isotropic expansion. By using an isochrone fitting procedure we provide ages and extinction values for all the groups. We confirm the presence of an old population (∼15 Myr) towards the 25 Ori region, and we find that groups with ages of 12–15Myr are present also towards the Belt region. We notice the presence of a population of ∼10 Myr also in front of the Orion A molecular cloud. Our findings suggest that star formation in Orion does not follow a simple sequential scenario, but instead consists of multiple events, which caused kinematic and physical sub-structure. To fully explain the detailed sequence of events, specific simulations and further radial velocity data are needed.

Accepted by A&A

http://arxiv.org/pdf/1906.07002

44 Probing the initial conditions of high-mass star formation. III. Fragmentation and triggered star formation

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Massive clumps tend to fragment into clusters of cores and condensations, some of which form high-mass stars. In this work, we study the structure of massive clumps at different scales, analyze the fragmentation process, and investigate the possibility that star formation is triggered by nearby HII regions. We present a high angular resolution study of a sample of 8 massive proto-cluster clumps. Combining infrared data, we use few-arcsecond resolution radio- and millimeter interferometric data to study their fragmentation and evolution. Our sample is unique in the sense that all the clumps have neighboring HII regions. Taking advantage of that, we test triggered star formation using a novel method where we study the alignment of the centres of mass traced by dust emission at multiple scales. The eight massive clumps have masses ranging from 228 to 2279 $M_{\odot}$. The brightest compact structures within infrared bright clumps are typically associated with embedded compact radio continuum sources. The smaller scale structures of $R_{\rm eff} \sim 0.02$ pc observed within each clump are mostly gravitationally bound and massive enough to form at least a B3-B0 type star. Many condensations have masses larger than 8 $M_{\odot}$ at small scale of $R_{\rm eff} \sim 0.02$ pc. Although the clumps are mostly infrared quiet, the dynamical movements are active at clump scale ($\sim$1 pc). We studied the spatial distribution of the gas conditions detected at different scales. For some sources we find hints of external triggering, whereas for others we find no significant pattern that indicates triggering is dynamically unimportant. This probably indicates that the different clumps go through different evolutionary paths. In this respect, studies with larger samples are highly desired.

Accepted by A&A

http://arxiv.org/pdf/1906.03216

Dissertation Abstracts

The formation, evolution, and survivability of discs around young binary stars

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Ph.D dissertation directed by: Christoph Federrath

Ph.D degree awarded: July 2019

In the age of the *Kepler* space telescope and other exoplanet finding missions, a variety of exotic planets have been discovered. Some of these planets have been found to be in binary star systems — systems which have historically been overlooked in planet formation models. This is due to the single star scenario being simpler to model than binaries, as well our anthropocentric bias towards single stars like our Sun. However, planet formation around binary stars is an important topic because a large fraction ($\sim$50%) of stars form in binary systems.

In this thesis I investigated the physics that influences the creation, stability, and survivability of discs around binary stars with the broad understanding that the longer the lifetime of a disc (around a single or binary star) the higher the likelihood of producing planets.

The theoretical work of this thesis was conducted using the ideal magnetohydrodynamical numerical simulation program `FLASH`. I simulated the collapse of molecular cores until the formation of protostars and followed the early evolution of these systems. For the first theoretical project I investigated the influence that binarity had on the global evolution of a young stellar system. This included studying mechanisms such as accretion, jets and outflows, and dynamical interactions. I found that binary stars produce weaker outflows when considering the transport of mass, linear momentum, and angular momentum. For the second theoretical project I investigated the formation of discs in binary stars with the inclusion of turbulence in the initial conditions. I found that the turbulence helped to build large circumbinary discs which restructured the magnetic fields for efficient outflow launching, but too much turbulence may also disrupt this organisation of magnetic fields. Given the environment where binary stars form (turbulent molecular cores), it appears that the formation of circumbinary discs should be common place, however circumstellar discs could also be destroyed quickly in these same environments.

My observational work aimed to determine the typical survivability of discs around binary star systems. This work was carried out by using the Wide Field Spectrograph (WiFeS) on the Australian National University 2.3 m Telescope

to search for radial velocity variation in disc-bearing members of the 11 Myr and 17 Myr old star-forming regions Upper Scorpius and Upper Centaurus-Lupus. I found that the binary fraction of disc-bearing stars in these regions do not differ significantly from the field star binary fraction. I hypothesised that this is due to two competing factors: circum*stellar* discs are disrupted by companions and are dispersed quickly, but circum*binary* discs are more common than equivalently sized discs around single stars. These results suggest that the typical lifetimes of discs in single and binary stars are comparable.

Overall, I found that in some scenarios binary stars may produce hostile environments for planet formation via the destruction of circum*stellar* discs, but the formation of large circum*binary* discs is likely to be a common occurrence. This suggests that planet formation is as likely around binary stars as single stars. Therefore, planet formation around binary stars needs to be considered to understand overall planet formation.

New Jobs

Postdoctoral position in dusty turbulence

Applications are invited for a 2-year Postdoctoral Research Fellow to work with Dr. Benoît Commerçon and Dr. Guillaume Laibe at the Centre de Recherche Astrophysique de Lyon (http://cral.univ-lyon1.fr) in the AstroENS team based at Ecole Normale Supérieure de Lyon on characterising and modelling astrophysical dusty turbulence in the context of star and planet formation.

This includes any of the following aspects:

- Numerical simulations of dusty turbulence at different scales with the Adaptative Mesh-Refinement grid-based or Smoothed Particle Hydrodynamics methods.

- Modelling the statistics of interstellar dusty turbulence.

- Interpreting the experiments of dusty turbulence conducted at the Physics Department at ENS de Lyon (UMR5672).

The successful candidate should have a Ph.D. in Astrophysics, Physics or Applied mathematics in relation with hydrodynamics with experience in turbulence, high-performance computing or dust-gas flows.

By August 16th 2019, enthusiastic candidates should submit on the web platform on the web platform indicated just below i) a CV including a publication list, ii) a brief statement of research interests and iii) arrange for three letters of reference to be provided separately (sent to benoit.commercon@ens-lyon.fr and guillaume.laibe@ens-lyon.fr). Applications which will not be submitted on the web platform can not be considered.

Web platform for applications:

https://emploi.cnrs.fr/Offres/CDD/UMR5574-BENCOM-001/Default.aspx?lang=EN

Complementary information:

Informal enquiries: benoit.commercon@ens-lyon.fr guillaume.laibe@ens-lyon.fr

Starting date: Between Fall 2019 and Spring 2020

Salary: The initial monthly net salary is around 2000 and is comensurate with experience.

Included Benefits: National medical insurance, maternity/paternity leaves, family supplement for children, participation to public transport fees, pension contributions. School is free in France for children above 3. The Universit de Lyon provides support for settling in Lyon and France.

Miscellaneous:

- Since 2016, the École Normale Supérieure de Lyon appears in the world's Top 5 small universities of the Times Higher Education ranking.

- Lyon is a vibrant city with high quality of life (e.g. https://www.nytimes.com/2006/07/02/travel/02goingto.html)

- The project is funded by the IDEXLyon project (contract n?ANR-16-IDEX-0005) under University of Lyon auspices.

Meetings

European Conference on Laboratory Astrophysics
Linking Dust, Ice and Gas in Space
19 - 24 April 2020, Anacapri, 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 and astrophysical modelling in close connection with space exploration and astronomical observations. We are living a very exciting time at the interplay between current and future missions/facilities. Return of extra-terrestrial samples is one of the drivers of these missions (e.g. Hayabusa 2, OSIRIS-Rex) together with a more and more detailed exploration of the Solar System planets, moons and other bodies (e.g. Martian rovers ExoMars and Mars 2020, BepiColumbo for Mercury, the future JUICEand Europa Clipper missions for Jupiter and its moon Europa). From the astronomical side, new perspectives arise from progress in high angular resolution observations from the optical/infrared (VLT and the coming JWST and ELT) to the sub-mm/mm range (ALMA, NOEMA) to the mid-radio frequencies (SKA) together with a better coverage of the electromagnetic spectrum (e.g. ATHENA for X-rays) and the discovery of new exo-worlds (e.g. PLATO, ARIEL).

The ECLA 2020 conference will provide the opportunity for interdisciplinary exchanges between scientists active in different research fields, which range from astronomy to geology and from chemistry to instrumentation. These interactions will foster collaborations that will result in better scientific exploitation of missions/facilities in planetology and astronomy in relation with the major questions on our origins.

http://www.frcongressi.it/ecla2020/

”Cool Stars, Stellar Systems, and the Sun” (CS21) first announcement
22 - 26 June 2020, Toulouse, France

We are pleased to announce that the international conference ”Cool Stars, Stellar Systems, and the Sun (CS21)” will be held in Toulouse, France in June 2020, 22nd to 26th. The pre-registration is open. Please go to:

https://coolstars21.github.io (see website for details)

Please note the following important dates:

June 17th 2019 : opening of pre-registration

Early September 2019: Call for Splinter sessions

Late November 2019: Deadline for submission of Splinter Sessions

Mid December 2019: list of Splinter sessions selected

January 2020 : Early bird Registration fee and Abstract soumission to main conference and splinters

Early February 2020: Deadline for travel grant support request

Early March 2020 : Normal registration fee

Mid April 2020 : announcement of program and selected grantees

Early May 2020: Late registration fee

Please mark your calendar, looking forward to seeing you all in Toulouse, next Summer. You can contact us at: cs21@irap.omp.eu

A.S. Brun, J. Bouvier and P. Petit for the SOC/LOC

The Physics of Star Formation: From Stellar Cores to Galactic Scales

June 29 - July 3 2020 - Lyon, France

http://staratlyon.univ-lyon1.fr

We are happy to announce the conference "The Physics of Star Formation: From Stellar Cores to Galactic Scales" which will take place from June 29 to July 3 2020 in Lyon.

Pre-registration is open on the website of the conference.

Looking forward to seeing you in Lyon in early summer 2020!

Rationale

Stars are the visible building blocks of the cosmic structures, and as such are essential for our understanding of the Universe and the physical processes that govern its evolution. Star formation lies at the centre of the interstellar matter cycle that drives cosmic evolution. Although star formation is recognised to be central in a wide range of astrophysical processes (galaxy formation and evolution, molecular cloud evolution and destruction, planet formation, and potentially the development of life), it is one of the least understood processes in the Universe.

The aim of this conference is to bring together the communities related to star formation through the physical scales and cosmic times. This topic is particularly timely for defining major explorations of the star forming Universe to be carried out in the next decade with new instruments designed for observations and exascale HPC. The state-of-the-art of the three pillars of modern astrophysics, theory, observation, and numerical simulations, will be represented. The program will be divided into eight sessions. Each session will be covered by invited reviews, invited presentations as well a large fraction of contributed talks.

Invited Reviews

- Nate Bastian (Liverpool John Moores University, UK)
- Avishai Dekel (Hebrew University of Jerusalem, Israel)
- James Di Francesco (NRCC, Canada)
- Reinhard Genzel (MPE Garching, Germany)
- Patrick Hennebelle (CEA Saclay, France)
- Philip Hopkins (CalTech, USA)
- Shu-ichiro Inutsuka (University of Nagoya, Japan)
- Diederik Kruijssen (University of Heidelberg, Germany)
- Mark Krumholz (Australian National University, Australia)
- Adam Leroy (Ohio State University, USA)
- Anaëlle Maury (CEA Saclay, France)
- Raffaella Schneider (University of Rome, Italy)
- Kengo Tomida (University of Osaka, Japan)
- Yusuke Tsukamoto (University of Kagoshima, Japan)
- Stefanie Walch (University of Cologne, Germany)

Topics

1/ Physic and numerics for star formation
2/ Isolated star formation: from brown dwarfs to massive stars
3/ Cluster formation
4/ Protostellar disc formation and evolution
5/ Initial Mass Function and Star Formation Rate

6/ Stellar feedback on molecular clouds
7/ Galactic disc formation and evolution
8/ Star formation across redshift

Scientific Organization Committee

Philippe André, Avishai Dekel, Patrick Hennebelle, Shu-ichiro Inutsuka, Helen Kirk, Ralf Klessen, Steven Longmore, Frédérique Motte, Christopher McKee, Nami Sakai, Joe Silk, Simon White.

Local Organization Committee

Gilles Cabrier (co-chair), Benoît Commercon (co-chair), Congresss Team of the University of Lyon 1

E-mail contact: staratlyon@univ-lyon1.fr

Planet Formation: From Dust Coagulation to Final Orbit Assembly

1 - 26 June 2020, Munich, Germany

Organizers:
Man Hoi Lee (Department of Earth Sciences, The University of Hong Kong)
Nader Haghighipour (Institute for Astronomy, University of Hawaii-Manoa)
Soko Matsumura (Department of Physics, University of Dundee)
Hilke Schlichting, (Department of Earth, Space, and Planetary Sciences, UCLA)

Dear colleagues,

It gives us great pleasure to announce the 2020 Planet Formation program at the Munich Institute for Astro- and Particle Physics (MIAPP) in Garching, Germany. The program will be held on June 1-26, 2020. This four-week program aims to bring together experts with complementary expertise in observation and theory in solar system and extrasolar planetary astronomy to assess the current status of planet formation models, highlight problems in each formation stage, and explore the possibility of developing comprehensive models that can be applied to different planetary systems. Please see the program website for more details: http://www.munich-iapp.de/planetformation

The structure of the program will be informal. The main goal of the program is to create an environment that will facilitate collaborations and new initiatives. There will be daily gathering for discussing specific topics, new results, and brain storming.

Each attendee will be provided with an office and Internet access. Financial support at the rate of EUR 80 per day will be provided for accommodation and local expenses. Additional financial support for attendees with family and children and for graduate students is available. Details with regard to financial support can be found at http://www.munich-iapp.de/home/information-for-participants/financial-support/

In order to attend, it is necessary to apply to the program. Please go to the program website (http://www.munich-iapp.de/planetformation), scroll down to the bottom of the page, and click on "Register here" (that is actually the link to apply for the program). Please note that the application deadline is September 1, 2019. Please also note that MIAPP requires attendance for at least two weeks and that the program can accommodate only 45 attendees in each week. So please apply early.

We invite and encourage you to apply. We also request that you kindly pass this information to your colleagues, collaborators, students and postdocs who are involved and/or interested in planet formation.

Looking forward to receiving your applications.

Best regards,
Man Hoi, Nader, Soko, and Hilke

E-mail contact: nader@ifa.hawaii.edu

http://www.munich-iapp.de/planetformation

Summary of Upcoming Meetings

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 JWST
26 - 30 Aug 2019 Courmayeur, Italy
http://www.stsci.edu/institute/conference/unsfjwst2019

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

First Stars VI
1 - 6 March 2020 Concepcion, Chile
http://www.astro.udec.cl/FirstStarsVI/

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
22 -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

GaussPy+: A fully automated Gaussian decomposition package for emission line spectra

Our understanding of the dynamics of the interstellar medium is informed by the study of the detailed velocity structure of emission line observations. However, the accumulation of ever increasing datasets, such as large Galactic plane surveys, requires tools to simplify the enormous quantity of information present in these observations and facilitate the extraction of interesting physical quantities.

With this goal in mind, we have developed GaussPy+, a fully automated Gaussian decomposition package that can be applied to emission line datasets, especially large surveys of HI and isotopologues of CO. We built our package upon the existing GaussPy algorithm (Lindner et al., 2015, AJ, 149, 138), but added many new functionalities and convenience functions and significantly improved its performance for low signal-to-noise data.

The GaussPy+ package was designed to deal with different populations of emission peaks, such as a mixture of narrow and broad line shapes that are expected from contributions of the cold and warm neutral medium in HI observations, respectively. GaussPy+ also contains automated spatial refitting routines that can add spatial coherence to the decomposition results by refitting spectra based on neighbouring fit solutions, which allows, for instance, a better decision on how to decompose blended emission peaks.

GaussPy+ should be of assistance to anyone interested in extracting and analyzing the detailed velocity structure from emission line observations that can be well fitted with Gaussian components to, for example, study the turbulence properties of molecular clouds or gain information on the (integrated) intensity and velocity dispersion values present in the dataset, whenever simpler techniques such as moment analysis cannot be applied straightforwardly.

The GaussPy+ package is written in Python 3 and freely available on GitHub: https://github.com/mriener/gausspyplus

For a technical description of the GaussPy+ package and a discussion about decomposition results for synthetic spectra and a test field from the Galactic Ring Survey (Jackson et al., 2006, ApJS, 163, 145) please see:
Riener et al., 2019, accepted for publication in A&A https://arxiv.org/pdf/1906.10506

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SOFIA Cycle 8 Calls for Proposals / Funding opportunities

The SOFIA Observatory, the only aircraft-based facility offering an access to the 4-600μm wavelength range, has recently released calls for proposals (https://www.sofia.usra.edu/science/proposing-and-observing/proposal-calls/cycle-8) for the Cycle 8 period, with a deadline of September 6, 2019 (9 p.m. PDT). Anyone in the astronomy scientific community is welcome to apply for time, and US-based proposers are also eligible for funding opportunities listed below.

In this observing Cycle, we are offering:

- up to 300 hours of observations for Regular Proposals and up to 400 hours for Legacy Proposals (1-4 proposals up to 200 h of observations each, spread over 2 observing cycles)
- one Southern Hemisphere deployment to New Zealand with two instruments
- improved mapping modes on instruments FORCAST (spectral mapping) and HAWC+ (on-the-fly polarimetry mapping)
- new filters for FIFI-LS improving the sensitivity at the [OIII] 52μm line and for HAWC+ making band B (63μm) available

Also note the following funding opportunities for US-based proposers:

- Up to $3M for Regular Proposals
- Up to $2M per year for Legacy Proposals
- $300k available through our new archival research proposal program
- for proposals which are central to a PhD thesis, additional funding can be requested through the Thesis-enabling Program (up to two years of graduate student funding)

In addition, the SOFIA Science Center provides specialist support for proposal preparation and data analysis via email, phone, and otherwise. Please feel free to contact the Science Center through our HelpDesk: sofia_help@sofia.usra.edu. We will also hold a webinar on August 9th to provide support for proposers on how to design effective observing proposals and use SOFIA proposal tools (more information to come on the SOFIA website https://www.sofia.usra.edu/science).

The selection results will be announced in December of 2019. Good luck!