The Star Formation Newsletter

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

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Cover Picture

An optical wide field image towards the center of the Galaxy. The HII regions Messier 8 and Messier 20 are seen to the upper left of the field, the Pipe Nebula (with B59 as the mouthpiece) is towards the right, and NGC 6357 and NGC 6334 are at the bottom.

Image courtesy Stephane Guisard

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
Nuria Calvet

in conversation with Bo Reipurth

Q: You were born in Venezuela. In those days astronomy in Latin America was far less developed than it is today. How did you persevere under those circumstances?

A: Since I was a child, I knew I wanted to be a scientist of some kind. I was not very social and read a lot and kept to myself. I was very lucky to have parents that supported my choices and never questioned me even if they did not understand them, and an uncle who was happy to teach me math and physics. These were the classes I liked the most in high school, and when my Math teacher suggested I go to the Faculty of Sciences I found it to be the natural path for me. I initially went into math, but switched to physics after the first semester at the University. There were very few women in physics and math, but that did not seem to be a problem. I got along well with my male classmates, and we formed study groups and friendships that have lasted until today. More of an issue was how precarious our studies were. While I was in Venezuela, the Government closed down the University three times. The last closure lasted for over a year, and a group of us decided to go to México to finish the physics career. Just by accident I took an Astronomy class, and the teacher - Manuel Peimbert - let us Venezuelans know that an observatory was being developed in Venezuela and possibly might need astronomers. He opened up the doors of the Instituto de Astronomia of UNAM for us, offering a warm and nurturing environment in a foreign city. At the time, I was particularly struck not only by the large number of women in the Instituto but by their important positions. Several of them became the role models I had never had. From México I went to Berkeley and my professional life started.

Q: Your very first paper from 1978 dealt with bipolar nebulae. Was that the start of your interest in winds from T Tauri stars?

A: My very first paper was with Martin Cohen on bipolar nebulae. Martin had thought that they were young objects, but by carefully analyzing their emission spectra we showed that the bipolar phenomenon could be present both at the beginning and at the end of stellar life. My interest in T Tauri stars in general, not only winds, grew out of my work with Len Kuhi, my formal advisor, and Martin. I participated in the gestation of the legendary survey of Cohen and Kuhi (1979). I went many times to Lick Observatory to observe with Len and Martin to obtain the beautiful spectra shown in that paper. I still remember with amusement how flabbergasted we were to see both blueshifted and redshifted absorption in the emission lines of a T Tauri star, wondering how could we possibly have both outflow and infall at the same time. At those times we only thought of spherical symmetry, but, of course, we now know that disks form from slowly rotating molecular cloud cores because of angular momentum conservation, and accretion from the star in magnetospheric flows co-exists with winds from the disk. Martin took me observing at Kitt Peak, and introduced me to the peculiarities of spectral classification. In those times women were already allowed at telescopes, but there were no ladies room at observatories. Still, I had a great time and became enchanted with T Tauri stars. I accompanied Len and Martin to visit George Herbig in Santa Cruz, a fantastic experience for me. Once at dinnertime in Lick, George Herbig asked me “What are you working on these days?” I timidly responded “T Tauri stars”, “Of course!” he said, “what about them?”, and I think that “of course” set my life interest.

Q: One of your most cited papers appeared in ApJ in 2002 and dealt with a developing gap in a 10 Myr old protoplanetary disk. Such gaps have become a major area of study. What do you see as the main open questions in this area?

A: The existence of cleared regions and gaps in protoplanetary disks was already discussed in pioneering work by the Stroms and Skrutskie in the late 1980’s. In the 2002 paper the cleared region showed more clearly with near and mid-IR spectroscopy from Mike Sitko’s group, but with the glorious spectra provided by the IRS instrument on board Spitzer covering from 5 to 30 microns, the structure of the inner cleared regions of what the IRS Disk team called the “transitional disks” could be really reconstructed. It was wonderful to see how the sizes of the “holes” predicted from analysis of the IRS spectra were confirmed by submillimeter interferometry. Later on, my former student Catherine Espaillat identified what she called the “pre-transitional disks”, disks in which optically thick material, a remnant of the original disk, was found close to the stars. These relatively frequent disks with gaps rather than cleared-up inner regions strongly support the hypothesis that the gaps and clearing are due to planet formation,
rather than photoevaporation. Many questions remain to be answered. For instance, Zhaohuan Zhu, Catherine Espaillat and collaborators have shown that it is difficult to explain both the large size of the cleared regions and the strength of the mass accretion rate onto the star in transitional disks. Multiple planets are required to explain the large gaps, but mass is used to form the planets leaving little to fall into the star. In contrast, a single planet could explain the observed accretion rates, but the gap would be too small. However, more recently Zhaohuan has shown that millimeter size grains would be held at the truncation radius, explaining the size of the cavities at mm wavelengths, while small grains would go in with the gas. Dust growth in the inner disks could explain their low opacity, but this still needs to be demonstrated. Another challenge is to discover the systems in which planets are beginning to open gaps. Small gaps would leave no trace on the SEDs, but hopefully will show up with ALMA, if the right candidates are observed.

Q: You and your colleagues have successfully built up a strong star formation group in Michigan. How did that come about?

A: I think there are two main reasons to explain the strength of the star formation group we have developed in Michigan. First, we have been lucky to have wonderful students, full of energy, curiosity, ability and will to succeed. We have now produced two Hubble fellows, John Tobin and Zhaohuan Zhu, and one Sagan fellow, Catherine Espaillat. A second and very important reason is that we are really a group, with strong inter-group collaborations. We meet weekly and present our research to the group. We all have joint projects and support each other with our resources. For instance, my collaborator Paola D’Alessio, from UNAM, and I are presently expanding her codes that calculate the structure and emission of irradiated accretion disks, and for this we are actively collaborating with Ted Bergin, Ilse Cleeves and other members of Ted’s group. John Tobin, a former student of Lee Hartmann, had Ted Bergin advise him for his radio studies. I helped Zhaohuan with some radiative transfer at the beginning, before he started teaching me. I am presently working with Fred Adams and his student Kassandra Anderson in disk photoevaporation problems. John Monnier teaches me the intricacies of interferometry. Ted is sharing his large knowledge of Herschel to help my student Melissa McClure interpret her data. Moreover, the students also collaborate with each other. For example, my former and present students, Laura Ingleby, Catherine Espaillat and Melissa McClure have developed strong professional ties, helping with observations and contributing with their individual strengths to each other’s papers. All in all, we form a very lively and interactive group, caring and actively helping each other and I think this has been key to our success.

Q: Which challenges do you currently see for astronomy in your native Venezuela?

A: The prospects for astronomy, and science, in general in Venezuela are uncertain, to say the least. The leadership of science in the country is in the hands of people whose first priority is politics instead of science, with unpredictable consequences. This is apparent in the Centro de Investigaciones de Astronomia, CIDA, in Mérida, Venezuela, where I used to work. The present Director is not an astronomer and his interests are elsewhere. On the other hand, astronomers working there are trying really hard to continue doing their work. People like César Briceno and Jesús Hernández, well known to the Star Formation community, are still at CIDA. They have managed to get funds to upgrade the CCD mosaic on the Schmidt camera to continue the Orion Variability Survey, which so far has resulted in the discovery of thousands of low mass young stars in the Orion OB1 association, with follow-up studies with Spitzer and Herschel. Moreover, they are training a new generation of students which hopefully will have a place to work in the future.

Q: Do you see any differences in the opportunities for women scientists in Latin America and in USA?

A: When I first came to this country in the early 1970’s, the situation for women in Astronomy was difficult. I remember being told by a classmate, with the best of intentions, a week before my Prelim not to worry, that no foreigner nor any women had ever passed the first time around (I did). In México, in contrast, there was some discrimination but not to that level. However, I think the situation has changed drastically, as the old, mostly male, generation retired, the middle generation that was first exposed to the new ideas on women’s equality in the 70’s and 80’s took over, and a new generation of professionals that grew up embedded in affirmative action and other sensitizing initiatives is slowly rising in rank. Moreover, the percentage of women in the student body of Astronomy Departments is getting closer to the ideal 50/50, so for the new generation there is no reason for males and females to be considered differently. That is not to say that the situation is ideal. The relation between family and profession is still an issue. Although many institutions, like the University of Michigan, provide some support for women faculty who want to start a family and for their partners who want to actively collaborate in raising children, I find that more support is needed. For instance, a longer, paid leave after child birth, commensurate with what is standard in other countries in particular in Latin America, should be implemented. Affordable yet good child care should be more common. Affordable yet good child care should be more common. Affordable yet good child care should be more common.
You can count on two fingers the known examples of roughly solar-mass classical (i.e., actively accreting) T Tauri star systems that lie well within 100 pc of Earth (see Torres et al. 2008): TW Hydrae \((D = 54 \text{ pc})\) and V4046 Sagittarii \((D = 73 \text{ pc})\). Both systems feature disks that are surprisingly massive and gas-rich, given their advanced ages \((\sim 8 \text{ Myr} \text{ and } \sim 12 \text{ Myr}, \text{ respectively})\), where the age and distance of V4046 Sgr are based on its likely membership in the \(\beta\) Pic Moving Group; Torres et al. 2006, 2008). Great effort has been devoted to the study of the TW Hya star/disk system, as it affords the opportunity to investigate pre-main sequence (pre-MS) accretion and planet formation processes at close range. The V4046 Sgr system, on the other hand, has thus far garnered less than \(\sim 25\%\) of the attention lavished on TW Hya, in terms of numbers of simbad references\(^1\). However, in certain key respects, V4046 Sgr is more intriguing: it is a close binary, consisting of a pair of \(\sim 0.9 \, M_\odot\) stars in a nearly circular, 2.4-day orbit (Stempels & Gaum 2004; Donati et al. 2011; and references therein). Furthermore, V4046 Sgr has a distant \((\sim 12 \text{ kAU})\) comoving companion that is itself evidently a close binary (Kastner et al. 2011). Hence, V4046 Sgr has much to teach us concerning the origin and dissolution of (hierarchical) binary systems and the formation of circumbinary planets, in addition to improving our general understanding of pre-MS stellar evolution and protoplanetary disks.

In this brief review, I offer a few highlights of recent work on V4046 Sgr, as well as some prognostications on promising directions for future studies of this important system.

**X-rays and accretion**

Although strong X-ray emission is a defining characteristic of T Tauri stars, precious few objects display clear evidence for an origin of the X-rays in star-disk interactions, as opposed to in coronae. Thanks mainly to its proximity, which makes X-ray gratings spectroscopy observations feasible, V4046 Sgr represents one such rare example (Günter et al. 2006): like TW Hya and a couple handfuls of other classical T Tauri stars, V4046 Sgr displays X-ray line ratios that betray the presence of the high-density, shock-heated plasma predicted by simulations of T Tauri accretion flows (e.g., Sacco et al. 2010).

Realizing the well-determined binary parameters of V4046 Sgr could be exploited to investigate the **geometries of X-ray-emitting accretion flows**, a team led by Thierry Montmerle obtained a series of three \(\sim 120 \text{ ks}\) exposures with XMM-Newton’s gratings spectrometer (RGS). The XMM exposure sequence spanned slightly more than two binary rotation periods, and was complemented by contemporaneous ground-based optical observations of V4046 Sgr (e.g., spectropolarimetry intended to yield insight into the surface magnetic field structures of its twin T Tauri stars; Donati et al. 2011).

Painstaking temporal/spectral analysis of the XMM/RGS dataset — which is punctuated by numerous small flares — revealed a \(\sim 1.2\text{-day}\) periodic variation in the fluxes of emission lines arising in the “cool,” dense (accretion shock) plasma (Argiroffi et al. 2012; Fig. 1). Argiroffi et al. interpreted these results as evidence for rotational modulation of X-ray-emitting accretion hotspots. The half-binary-period modulation can be explained via various system geometries, including one in which compact, azimuthally asymmetric accretion hotspots are present, at roughly equal intensity, on both stars. However, as Argiroffi et al. note, such a model must be reconciled with the lack of rotational modulation of accretion signatures apparent in the optical spectropolarimetry monitoring data (Donati et al. 2011). Further contemporaneous X-ray and optical spectroscopic monitoring of V4046 Sgr may help resolve this conundrum.

**The origin of (hierarchical) binary systems**

The deep XMM-Newton exposure provided by our temporal/spectral X-ray study and the earlier archival Chandra observation of V4046 Sgr (Günter et al. 2006) each yielded a serendipitous high-quality X-ray spectrum and light curve of a neighboring (2.8’ separation) M star, fellow \(\beta\) Pic Moving Group candidate GSC 07396–00759.
The likelihood that V4046 Sgr AB and C[D] (as we dubbed GSC0739) constitute a weakly bound, or perhaps recently dissolved, physical pair suggests this young, hierarchical binary has already led an action-packed life. This is because the close, nearly circular orbit of V4046 Sgr AB essentially guarantees the presence of an additional, perturbing body in the system (e.g., Fabrycky & Tremaine 2007). If this tertiary component is in fact V4046 Sgr C[D], then the large present-day separation of AB and C[D] implies that, ∼1 Myr ago, the two pairs had some sort of nasty encounter (or series of encounters) that shrank and circularized the orbit of AB, and pushed C[D] to its present, wide orbit (Fabrycky & Tremaine 2007; Reipurth & Mikkola 2012). The same event(s) may have stunted the growth of planets in the still-massive circumbinary disk orbiting AB (Kastner et al. 2011). Furthermore, if formed via the capture of C[D] by AB, then the V4046 Sgr hierarchical binary — like others of similar age in local moving groups (see Kastner et al. 2012) — may be informing us about the characteristics and dissolution of its birth cluster (e.g., Kouwenhoven et al. 2010; Moeckel & Clarke 2011).

A circumbinary disk spawning circumbinary (proto)planets?

The discovery of Kepler 16b laid to rest any lingering doubt that binary stars might host planetary systems and, furthermore, strongly indicated that such circumbinary planets could form in circumbinary disks (Doyle et al. 2011). Among the large number of pre-MS binaries now known to host disks, V4046 Sgr has a particularly small central binary separation, implying that its disk may be a particularly fruitful subject for the study of circumbinary planet formation. Just a few years ago, we established that the V4046 Sgr disk retains a significant reservoir of residual gas, with a mass and chemistry similar to the disk orbiting its single-star “cousin,” TW Hya (Kastner et al. 2008). Followup Submillimeter Array (SMA) imaging by Rodriguez et al. (2010) revealed that the gaseous disk orbiting V4046 Sgr is spectacularly large in radius — a whopping ∼10⁴ AU in diameter, or Rdisk ≈ 370 AU — much larger than the (only marginally resolved) dust disk, as seen in submm continuum emission.

Similarly glaring discrepancies between disk gas and dust radii had been noted previously for a few other, similarly evolved disks, including TW Hya (Andrews et al. 2012). Additional extended-configuration SMA observations of V4046 Sgr have revealed that its submm (dust) continuum emission is largely confined to an annulus of radius ∼40 AU (Fig. 2; Rosenfeld et al. 2013). Rosenfeld et al. (2013) demonstrate that a three-component model of V4046 Sgr’s disk structure — consisting of a narrow ring populated by large grains, an interior region filled

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2Torres et al. (2006) — who had also considered the physical association of V4046 Sgr and GSC0739 — flagged the latter as “SB2,” although this led them to doubt its β Pic Moving Group membership. Meanwhile, as Rosenfeld et al. (2013) recently noted, Nataf et al. (2010) also find GSC0739 to be a close binary, with a photometric period of ∼12 d.
Figure 2: Observations and modeling of the spectral energy distribution (SED) and submillimeter continuum and CO line surface brightnesses of the V4046 Sgr circumbinary disk, from Rosenfeld et al. (2013). (a) Model surface density profiles for the disk gas (dashed) and the large (“midplane”; green) and small (“atmosphere”; blue) grain populations. (b) The observed SED (black points and solid gray curve) compared with the model (red). The stellar photosphere model is shown as a dashed gray curve. (c) The deprojected, azimuthally-averaged (real) 1.3 mm continuum visibility profile, with model overlaid (in red); gray points indicate the residuals of the fit. (d) The observed, simulated, and residual 1.3 mm continuum emission synthesized maps. Contours are drawn at 5σ intervals. (e) A comparison of the observed and simulated 12CO moment maps; the color scale spans an LSR velocity width of ±3 km s\(^{-1}\) from the systemic value. (f) The same as panel (e), but for the 13CO line.

with small grains, and an extended halo dominated by gas — is required to simultaneously account for the disk’s submm continuum and CO surface brightness morphologies and its mid-to-far-infrared spectral energy distribution (Fig. 2). Such a configuration appears consistent with disk planet-building scenarios that involve the accumulation of large grains at radii just exterior to the positions of nascent massive planets (e.g., Pinilla et al. 2012). Furthermore, the Rosenfeld et al. (2013) model involves a surprisingly large disk mass of nearly 0.1 \(M_\odot\) — implying that, even after ~12 Myr of disk evolution, there remains plenty of material to accrete onto any massive planets that may still be taking shape around the V4046 Sgr binary.

Meanwhile, the strong molecular line emission from the V4046 Sgr circumbinary disk has yielded dividends beyond pinning down disk structure and mass. Rodriguez et al. (2010) used a model of disk CO kinematics to demonstrate that the orbital planes of the central binary and the circumbinary disk are nearly coincident. This result was subsequently confirmed and refined to an exquisite degree (pun intended) by Rosenfeld et al. (2012), who went on to determine the masses of the central stars to very high precision (i.e., 0.90 ± 0.05 and 0.85 ± 0.04 \(M_\odot\)). In light of its reasonably well-determined age and distance, the latter results for V4046 Sgr AB should offer stringent tests of theoretical pre-MS evolutionary tracks for roughly solar-mass stars, especially given the additional constraints imposed by the (presumably coeval) wide-separation companion(s), C[D]. Finally, we have recently conducted an unbiased 800 \(\mu\)m region line survey with the APEX 12 m...
(Fig. 3); these data, along with Spitzer and Herschel spectroscopy (Rapson et al. 2013, in prep.), have extended the census of bright molecular and atomic emission lines emanating from the disk, potentially yielding insight into, e.g., the impact of high-energy stellar radiation on disk heating and chemistry (see below).

V4046 Sgr: key questions and the tools to answer them

Although our understanding of V4046 Sgr has improved rapidly over the past few years, there remains a long and growing list of questions concerning this fascinating system. Here, I list a few of these questions — in no particular order — along with what I hope are the correct tools to (eventually) answer them.

- **How can a ∼12 Myr-old disk retain so much mass, especially after surviving whatever event(s) shrank and circularized the orbit of the central binary?** Simulations of the dynamical interactions between disk-bearing and non-disk-bearing components of hierarchical binaries, combined with efforts to better determine the structure and composition of the disk (see below), may help tease out the answer.

- **Have planets already formed in the disk?** The large central cavity seen in SMA submm imaging has been interpreted as evidence of ongoing planet-building (Rosenfeld et al. 2013). But a more definitive answer to this question must await the coming generation of extreme adaptive optics instruments — and ALMA. The latter will elucidate the structure of the V4046 Sgr disk at the sub-AU scales necessary to reveal, e.g., spiral density waves and/or resonances induced by giant planets.

- **Regarding the circularization and shrinking of AB’s orbit: is V4046 Sgr C[D] the culprit, or is there another (fifth) system component awaiting discovery?** Potential variations in the systemic velocity of V4046 Sgr AB hint at the presence of such an additional perturber in the system (Donati et al. 2011). The mass ($M_L$) and separation ($a$) of any such object are rather tightly constrained (i.e., $M_L \sim 0.03$−0.2 $M_\odot$ and $a \sim 3$ AU, Rosenfeld et al. 2013). Again, imaging with extreme adaptive optics (as well as continued radial velocity monitoring) will be required to make further progress in confirming or ruling out the presence of an additional (potentially) substellar component.

- **What are the effects of the intense EUV and X-ray radiation from the vicinity of V4046 Sgr AB on the structure, physical conditions, and chemistry of its circumbinary disk?** Observations suggest a direct link between high-energy stellar irradiation and disk chemical evolution (e.g., Kastner et al. 2008; Henning et al. 2010), and models continue to point to the importance of X-rays in disk heating (e.g., Glassgold et al. 2012) and dissipation (e.g., Rosotti et al. 2013). Thanks to its rich structure and composition — and, of course, its proximity — the V4046 Sgr circumbinary disk represents one of the best targets for future ALMA molecular line and continuum imaging studies aimed at understanding these radiation-disk connections. Such future ALMA observations of V4046 Sgr will be guided by detailed models of irradiated disks (e.g., Gorti et al. 2011) that are tailored to the specifications of the V4046 Sgr system.

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The inner few hundred pc of the Galactic center differs from the rest of the Galaxy in its ISM properties. This region is occupied by a large concentration of warm molecular gas with high column density, high velocity dispersion, high cosmic ray flux surrounded by a strong radiation field. A key question is whether these environmental factors are significant enough to trigger a different mode of star formation than that observed in the Galactic disk. A number of studies have recently discussed the application of the Schmidt-Kennicutt relation to determine if star formation processes differ in this region (Yusef-Zadeh et al. 2009; Longmore et al. 2013; Kruijssen et al. 2013). It turns out that the nuclear star cluster surrounding the $4\times10^6$ $M_\odot$ black hole Sgr A* is an excellent site to study the role of extreme environment in star formation processes. This region provides us with a fantastic opportunity to examine the nature of massive star formation and accretion onto a massive black hole with far reaching implications on the nature of star formation and AGN activity in the nuclei of more active galaxies hosting massive black holes.

The nuclear cluster consists of a mixture of an evolved stellar population and a young population of stars near Sgr A*. Within a pc of Sgr A*, the gravitational potential of the black hole is steep and the stellar radiation field is intense. Given the strong tidal field of the black hole, the presence of the young population of stars within sub-pc distance from Sgr A* is surprising. Even more surprising is the discovery of about 100 OB stars distributed in disk(s) orbiting clockwise and counterclockwise within $10''$ (0.4 pc) of Sgr A* (Levin and Beloborodov 2003; Paumard et al. 2006; Lu et al. 2009; see the review by Genzel et al. 2010). Two scenarios for the origin of these young stellar disks have been proposed, as described below.

One scenario considers a cluster of massive stars spiraling toward Sgr A* due to dynamical friction with the sea of evolved stars (e.g., Gerhard 2001; McMillan & Portegies Zwart 2003; Kim et al. 2004; Gürkan & Rasio 2005). The migration scenario requires an unrealistic massive cluster in order to reduce the dynamical friction time scale. In addition, the expected trail and the stellar orbits of young, massive stars in the inspiraling cluster picture are not consistent with observations.

An alternative scenario considers an in-situ star formation mechanism within the inner 1pc of Sgr A* (Nayakshin et al. 2007; Levin 2007). Two related questions are how a star forming cloud loses enough angular momentum to come so close to Sgr A* and how it fragments before forming a stellar disk. The gas density ($n$) required to overcome the critical Roche density is about $2\times10^8$ cm$^{-3}$ at 1pc from Sgr A* and is substantially higher at sub-pc distances ($n \propto r^{-3}$).

One possibility to account for the sub-parsec-scale disk of massive stars orbiting Sgr A* is by partial accretion of an extended, inhomogeneous cloud engulfing Sgr A* on a passage through the inner Galactic center. A schematic diagram in Figure 1 shows the passage of a cloud before and after it interacts with Sgr A* and forms a gas disk which is carved out from the molecular cloud. The cancellation of angular momentum of the captured cloud by self-interaction naturally creates a compact, gaseous disk of material with high surface density.

This will then lead to star formation when the Toomre’s Q parameter is less than one (Wardle and Yusef-Zadeh 2008).

Figure 1: A schematic diagram showing how a gas disk is captured before (top) and after (bottom) the passage of an interacting giant molecular cloud with a massive black hole (Wardle and Yusef-Zadeh 2008).
2008; Bonnel and Rice 2008; Alig et al. 2011; Mapelli et al. 2012). A generalized version of this idea has been applied to megamaser disks surrounding massive black holes in type II Seyferts (e.g., Kuo et al. 2010; Wardle and Yusef-Zadeh 2012). The study of megamaser disks and Sgr A* led to a scaling relation between the mass of the black hole and the disk mass formed by partial capture of clouds (see Fig. 2). In spite of a small sample of AGN megamasers, the scaling relation, as shown in Figure 2, is consistent with the capture scenario in AGNs. The megamaser disks make up only a small fraction of type II Seyferts that have not formed stars. The gas density in these disks is considered to be sufficiently high to form water masers but not enough for self-gravity to trigger star formation.

Now that in-situ star formation appears to be the most likely mechanism responsible for formation of stellar disks near Sgr A*, the paradox of youth (Ghez 2007) is shifted to the paradox of hostility. That is, on the one hand, a gas cloud gets ripped tidally by Sgr A* in the radial direction, thus is not able to survive. On the other hand, tidal squeezing of a gaseous disk in the vertical direction increases the gas density in order to overcome the Roche critical density. Similarly, the ram pressure of the strong UV radiation field plus wind and jet-driven outflows can not only destroy and evaporate the gas cloud but also compress the gas to a higher gas density. In other words, the environment of the Galactic center with its constructive and destructive characteristics acts as positive and negative feedback in triggering star formation.

Assuming that the Galactic center is fed continually by interstellar gas clouds, a captured gaseous disk such as the circumnuclear molecular ring that is Toomre unstable should show signatures of early phase of star formation.

Recent studies of the inner few pc of Sgr A* indeed suggest that early signs of star formation and massive YSOs formed in the last $\sim 10^5$ years. On a large scale, one study indicates a number of methanol and water masers associated with the circumnuclear molecular ring (Yusef-Zadeh et al. 2008). The circumnuclear molecular ring is a kinematically disturbed gas cloud with inner and outer radii of 2 and 7pc encircling Sgr A* with a velocity of $\sim 100$ kms$^{-1}$ (Montero-Castano et al. 2009; Martin et al. 2012). Figure 3 shows the distribution of H$_2$O and methanol masers associated with the molecular ring (Yusef-Zadeh et al. 2008). HCN line profiles of molecular clumps in the vicinity of the masers suggest the presence of protostellar outflows in the molecular ring. These masers are collisionally pumped at high densities and are generally considered to be excellent tracers of on-going star formation (Yusef-Zadeh et al. 2008; see alternative view by Sjouwerman et al. 2010).

On a smaller scale, another study shows a number of infrared excess dusty sources within 0.5 pc of Sgr A*. Perhaps the most remarkable collection of dusty sources is in the IRS 13N cluster at a projected distance of 0.12 pc from Sgr A* (Viehmann et al. 2006; Eckart et al. 2012). ALMA observations of the interior of the molecular ring show highly excited SiO (5-4) line emission from the inner
0.5pc of Sgr A*. It is generally thought that the gas in the vicinity of Sgr A* is fully ionized but the detection of SiO line emission strongly suggests that molecular gas survives in this tidally stressed environment (Montero-Castano et al. 2009; Yusef-Zadeh et al. 2013). Figure 4 shows the distribution of SiO (5-4) line emission superimposed on the distribution of ionized gas emitting at 3.6cm. The insets show the spectra of two clumps with the highest central velocities (∼150 km s⁻¹) and broaden line widths (FWZI∼ 200 km s⁻¹). The SiO molecule is generally a tracer of protostellar shocked outflows where silicon is removed from dust grains, significantly increasing gas-phase abundance (e.g., Gibb et al. 2007). The excitation of the SiO (5-4) line emission requires high density ∼10⁶ cm⁻³ and excitation temperature 100-200K. Figure 5 shows that the linewidths and SiO (5-4) luminosity of the emission are similar to those of low and high mass protostellar systems. We have also identified massive YSO candidates in the vicinity of SiO (5-4) clumps supporting the hypothesis that massive star formation takes place in this region. Because of limited spatial resolution, we can not identify bipolar outflows from YSO candidates but this should be doable in future ALMA observations.

Lastly, dark extended features in radio continuum images demonstrate that these features are imprints of embedded molecular clouds in a hot ionized medium (Yusef-Zadeh 2012). Dark radio clouds trace regions where there is a deficiency of radio continuum emission from the region of the embedded cloud. One of the best regions to study these radio dark clouds is toward star forming regions where the ionized and neutral gas interact with each other. Figure 6 (top) shows the distribution of ionized gas associated with the mini-spiral within the inner ∼0.5pc of Sgr A*. Two dark radio clouds are shown, one near the northern arm of the mini-spiral and the other adjacent to the IRS 13 complex. This complex consists of a cluster of young massive stars, IRS 13E, as well as a cluster of dusty sources, IRS 13N, with infrared excess (Maillard et al. 2004; Schödel et al. 2005; Eckart et al. 2013; Fritz et al. 2013). These dust shrouded sources are considered to be YSOs, thus suggesting that on-going star formation is taking place within a projected distance of 0.1 pc from Sgr A* (Eckart et al. 2013). To examine the relationship between the radio dark cloud and IRS 13, Figure 6 (bottom) shows an HCN (1-0) absorption spectrum centered on the radio dark cloud (Christopher et al. 2005). The HCN absorption spectrum shows several velocity components. The zero and negative velocity components are associated with clouds in the spiral arms of the Galactic toward the Galactic center. The positive velocity component, however, has broad linewidths ranging between 20 and 90 km s⁻¹ which is thought to be from the gas at the Galactic center. This range of positive radial velocities is similar to that of young stars associated with the IRS 13 cluster (Paumard et al. 2006). This similarity as well as the presence of a localized radio dark cloud near IRS 13 suggests that the molecular cloud near Sgr A* may be the site of star formation. Future studies will determine if the radio dark cloud near IRS 13 is the parent cloud from which YSOs are formed within 0.2pc of Sgr A*.

Figure 4: The distribution of SiO (5-4) clumps of emission (red+blue) taken with ALMA is superimposed on a 3.6 cm continuum radio image taken with the VLA (green). The inset shows the SiO (5-4) line emission with the highest velocity and linewidths corresponding to positions 1 and 11. Five arcseconds correspond to distance of 0.2pc at the Galactic center (Yusef-Zadeh et al. 2013).

Figure 5: Filled circles show the luminosity in the SiO(5-4) line versus full line width (FWZI) for the 11 sources detected within the circumnuclear ring. Open diamonds and open squares show the corresponding quantities for outflows from low and high-mass YSOs (Gibb et al. 2004; Gibb et al. 2007), respectively (Yusef-Zadeh et al. 2013).
In summary, the evidence for the presence of a cluster of OB stars within 0.5 pc of Sgr A* is well established. Several recent measurements of the inner 0.2-2 pc of the Galactic center point to massive star formation occurring in the last $\sim 10^4 - 10^5$ years. These measurements support in-situ star formation but it is not clear what mechanism is responsible for increasing the gas density above the threshold to overcome the critical Roche density. Given that there are young stellar disks and a 2pc molecular ring orbiting Sgr A*, it is possible that massive YSOs reside in a disk of gas clouds from which stars are being formed. Other possibilities that can increase the gas density are clump-clump collisions, external radiation pressure, wind-driven outflows from massive stars or a relativistic jet from Sgr A*. Once gravitational instability sets in at sufficiently high densities, signatures of star formation appears to be similar to those observed in low and high massive star forming regions in the disk of the Galaxy. Future observational and theoretical studies should be exciting in examining these ideas to further our understanding of the nature of star formation near supermassive black holes and determine if it differs from other star forming sites in the Galaxy.

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Figure 6: A VLA radio continuum image of the mini-spiral at 7mm (Yusef-Zadeh et al. 2012) shows the imprints of two dark radio clouds near the northern arm and the IRS 13 cluster, as marked by straight lines (top panel). An HCN (1-0) absorption spectrum with a spatial resolution of $5'' \times 1''$ with a PA=-29°.787 near IRS 13 (bottom panel). A more detailed account of this result will be given elsewhere.
ALMA Observations of the HH 46/47 Molecular Outflow
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The morphology, kinematics and entrainment mechanism of the HH 46/47 molecular outflow were studied using new ALMA Cycle 0 observations. Results show that the blue and red lobes are strikingly different. We argue that these differences are partly due to contrasting ambient densities that result in different wind components having a distinct effect on the entrained gas in each lobe. A 29-point mosaic, covering the two lobes at an angular resolution of about 3″, detected outflow emission at much higher velocities than previous observations, resulting in significantly higher estimates of the outflow momentum and kinetic energy than previous studies of this source, using the CO(1-0) line. The morphology and the kinematics of the gas in the blue lobe are consistent with models of outflow entrainment by a wide-angle wind, and a simple model may describe the observed structures in the position-velocity diagram and the integrated intensity map. The red lobe exhibits a more complex structure, and there is evidence that this lobe is entrained by a wide-angle wind and a collimated episodic wind. Three major clumps along the outflow axis show velocity distribution consistent with prompt entrainment by different bow shocks formed by periodic mass ejection episodes which take place every few hundred years. Position-velocity cuts perpendicular to the outflow cavity show gradients where the velocity increases towards the outflow axis, inconsistent with outflow rotation. Additionally, we find evidence for the existence of a small outflow driven by a binary companion.

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Hot Gas Lines in T Tauri Stars
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For Classical T Tauri Stars (CTTSs), the resonance lines of N\textsubscript{v}, Si\textsubscript{iv}, and C\textsubscript{iv}, as well as the He\textsubscript{ii} 1640 Å line, act as diagnostics of the accretion process. Here we assemble a large high-resolution dataset of these lines in CTTSs and Weak T Tauri Stars (WTTSs). We present data for 35 stars: one Herbig Ae star, 28 CTTSs, and 6 WTTSs. We decompose the C\textsubscript{iv} and He\textsubscript{ii} lines into broad and narrow Gaussian components (BC & NC). The most common (50%) C\textsubscript{iv} line morphology in CTTSs is that of a low-velocity NC together with a red shifted BC. The velocity centroids of the BCs and NCs are such that $V_{BC} > 4V_{NC}$, consistent with the predictions of the accretion shock model, in at most 12 out of 22 CTTSs. We do not find evidence of the post-shock becoming buried in the stellar photosphere due to the pressure of the accretion flow. The He\textsubscript{ii} CTTSs lines are generally symmetric and narrow, less redshifted than the CTTSs C\textsubscript{iv} lines, by $\sim 10$ km sec$^{-1}$. The flux in the BC of the He\textsubscript{ii} line is small compared to that of the C\textsubscript{iv} line, consistent with models of the pre-shock column emission. The observations are consistent with the presence of multiple accretion columns with different densities or with accretion models that predict a slow-moving, low-density region in the periphery of the accretion column. For HN Tau A and RW Aur A, most of the C\textsubscript{ii} line is blueshifted suggesting that the C\textsubscript{iv} emission is produced by shocks within outflow jets. In our sample, the Herbig Ae star DX Cha is the only object for which we find a P-Cygni profile in the C\textsubscript{iv} line, which argues for the presence of a hot ($10^5$ K) wind. For the overall sample, the Si\textsubscript{iv} and N\textsubscript{v} line luminosities are correlated with the C\textsubscript{iv} line luminosities, although the relationship between Si\textsubscript{iv} and C\textsubscript{iv} shows large scatter about a linear relationship and suggests that TW Hya, V4046 Sgr, AA Tau, DF Tau, GM Aur, and V1190 Sco are silicon-poor.

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Characterisation of global flow and local fluctuations in 3D SPH simulations of protoplanetary discs

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A complete and detailed knowledge of the structure of the gaseous component in protoplanetary discs is essential to the study of dust evolution during the early phases of pre-planetaryesimal formation. The aim of this paper is to determine if three-dimensional accretion discs simulated by the Smoothed Particle Hydrodynamics (SPH) method can reproduce the observational data now available and the expected turbulent nature of protoplanetary discs. The investigation is carried out by setting up a suite of diagnostic tools specifically designed to characterise both the global flow and the fluctuations of the gaseous disc. The main result concerns the role of the artificial viscosity implementation in the SPH method: in addition to the already known ability of SPH artificial viscosity to mimic a physical-like viscosity under specific conditions, we show how the same artificial viscosity prescription behaves like an implicit turbulence model. In fact, we identify a threshold for the parameters in the standard artificial viscosity above which SPH disc models present a cascade in the power spectrum of velocity fluctuations, turbulent diffusion and a mass accretion rate of the same order of magnitude as measured in observations. Furthermore, the turbulence properties observed locally in SPH disc models are accompanied by meridional circulation in the global flow of the gas, proving that the two mechanisms can coexist.
A family of cometary globules at the periphery of Cyg OB1: the star HBHA 3703-01 and the reflection nebula GM 2-39

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The interstellar medium in the region of a family of cometary globules including the reflection nebula GM 2-39 has been analyzed basing on our observations with the slit spectrograph, the results of our previous observations with a Fabry-Perot interferometer in the Hα line, Spitzer archival data together with CO microwave data. The structure of globules’ IR emission, velocity field of ionized gas in the Hα line and of molecular gas in the CO line have been considered. We have detected a CO cavern around the eastern globules and faint high-velocity Hα features of surrounding gas.

The most probable sources of ionizing radiation and wind of the Cyg OB 1 association responsible for the globules’ formation are proposed. Based on our multicolour photometry, it has been found that the brightest compact source in the southern 'head' of the cometary globule - the star HBHA 3703-01 (IRAS 20153+3850) - is a B(5-6)V star with $E(B-V) = 1.18$ mag. The strong and broad Hα emission line was revealed in its spectrum. The spectral energy distribution of HBHA 3703-01 in the 0.44-24 μm range has been modeled. It is shown that the star has a hot dust envelope with $T_{\text{dust}}=1400$ K and $\tau_V = 1.1$. Besides, the star HBHA 3703-01 illuminates the encompassing diffuse nebula GM 2-39 with a diameter of about 30 arcsec. With regard to all obtained observational data for HBHA 3703-01, this object may be classified as the Herbig Ae/Be star.

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Millimetre-Wave and Near-Infrared Signposts of Massive Molecular Clump Evolution and Star Cluster Formation

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We report new near-infrared and mm-wave observational data on a selection of massive Galactic molecular clumps (part of the CHaMP sample) and their associated young star clusters. The clumps show, for the first time in a “dense gas tracer”, a significant correlation between HCO+ line emission from cold molecular gas and Br-γ line emission of associated nebulae. This correlation arises in the HCO+ line's brightness, not its linewidth. In contrast, the correlation between the N2H+ line emission and Br-γ is weak or absent. The HCO+/N2H+ line ratio also varies widely from clump to clump: bright HCO+ emission tends to be more closely associated with Br-γ nebulosity, while bright N2H+ emission tends to avoid areas that are bright in Br-γ. Both molecular species show correlations of weak significance with infrared H2 $v=1\rightarrow0$ and $v=2\rightarrow1$ line emission, in or near the clumps. The H2 emission line ratio is consistent with fluorescent excitation in most of the clumps, although thermal excitation is seen in a few clumps. We interpret these trends as evidence for evolution in the gas conditions due to the effects of ongoing star formation in the clumps, in particular, the importance of UV radiation from massive YSOs as the driving agent that heats the molecular gas and alters its chemistry. This suggests that some traditional dense gas tracers of molecular clouds do not sample a homogeneous population of clumps, i.e., that the HCO+ brightness in particular is directly related to the heating and disruption of cold gas by massive young stars, whereas the N2H+ better samples gas not yet affected by this process. We therefore suggest that the HCO+–N2H+-Br-γ relationship is a useful diagnostic of a molecular clump’s progress in forming massive stars.

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Fragmentation and dynamical collapse of the starless high-mass star-forming region IRDC 18310-4

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Context: Because of their short evolutionary time-scales, the earliest stages of high-mass star formation prior to the existence of any embedded heating source have barely been characterized until today.

Aims: We study the fragmentation and dynamical properties of a massive starless gas clump at the onset of high-mass star formation.

Methods: Based on Herschel continuum data we identify a massive gas clump that remains far-infrared dark up to 100 μm wavelengths. The fragmentation and dynamical properties are investigated by means of Plateau de Bure Interferometer and Nobeyama 45 m single-dish spectral line and continuum observations.

Results: The massive gas reservoir (between ~800 and ~1600 M⊙, depending on the assumed dust properties) fragments at spatial scales of ~18000 AU in four cores. Comparing the spatial extent of this high-mass region with intermediate- to low-mass starless cores from the literature, we find that linear sizes do not vary significantly over the whole mass regime. However, the high-mass regions squeeze much more gas into these similar volumes and hence have orders of magnitude larger densities. The fragmentation properties of the presented low-to high-mass regions are consistent with gravitational unstable Jeans fragmentation. Furthermore, we find multiple velocity components associated with the resolved cores. Recent radiative transfer hydrodynamic simulations of the dynamic collapse of massive gas clumps also result in multiple velocity components along the line of sight because of the clumpy structure of the regions. This result is supported by a ratio between viral and total gas mass for the whole region <1.

Conclusions: This apparently still starless high-mass gas clump exhibits clear signatures of early fragmentation and dynamic collapse prior to the formation of an embedded heating source. A comparison with regions of lower mass reveals that the linear size of star-forming regions does not necessarily have to vary much for different masses, however, the mass reservoirs and gas densities are orders of magnitude enhanced for high-mass regions compared to their lower-mass siblings.

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Triggering Collapse of the Presolar Dense Cloud Core and Injecting Short-Lived Radioisotopes with a Shock Wave. II. Varied Shock Wave and Cloud Core Parameters

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A variety of stellar sources have been proposed for the origin of the short-lived radioisotopes that existed at the time of the formation of the earliest Solar System solids, including Type II supernovae, AGB and super-AGB stars, and Wolf-Rayet star winds. Our previous adaptive mesh hydrodynamics models with the FLASH2.5 code have shown which combinations of shock wave parameters are able to simultaneously trigger the gravitational collapse of a target dense cloud core and inject significant amounts of shock wave gas and dust, showing that thin supernova shocks may be uniquely suited for the task. However, recent meteoritical studies have weakened the case for a direct supernova...
injection to the presolar cloud, motivating us to re-examine a wider range of shock wave and cloud core parameters, including rotation, in order to better estimate the injection efficiencies for a variety of stellar sources. We find that supernova shocks remain as the most promising stellar source, though planetary nebulae resulting from AGB star evolution cannot be conclusively ruled out. Wolf-Rayet star winds, however, are likely to lead to cloud core shredding, rather than to collapse. Injection efficiencies can be increased when the cloud is rotating about an axis aligned with the direction of the shock wave, by as much as a factor of $\sim 10$. The amount of gas and dust accreted from the post-shock wind can exceed that injected from the shock wave, with implications for the isotopic abundances expected for a supernova source.

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AA Tau’s sudden and long-lasting deepening: enhanced extinction by its circumstellar disk

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AA Tau has been monitored for more than 20 years since 1987 and exhibited a nearly constant brightness level of $V=12.5$ mag. We report here that in 2011 it suddenly faded away, becoming 2 magnitudes fainter in the V-band, and has remained in this deep state since then. We investigate the origin of the sudden dimming of the AA Tau system. We report on new optical and near-IR photometry and spectroscopy obtained during the fading event. The system appears to be much redder and fainter than it was in the bright state. Moreover, the 8.2d photometric period continuously observed for more than 20 years is not detected during most of the deep state. The analysis of the system’s brightness and colors suggests that the visual extinction on the line of sight has increased by about 3-4 magnitudes in the deep state. At optical wavelengths, the system appears to be dominated by scattered light, probably originating from the upper surface layers of a highly inclined circumstellar disk. The profiles of the Balmer lines have significantly changed as well, with the disappearance of a central absorption component regularly observed in the bright state. We ascribe this change to the scattering of the system’s spectrum by circumstellar dust. Remarkably, the mass accretion rate in the inner disk and onto the central star has not changed as the system faded. We conclude that the deepening of the AA Tau system is due to a sudden increase of circumstellar dust extinction on the line of sight without concomitant change in the accretion rate. We suggest that the enhanced obscuration may be produced by a non-axisymmetric overdense region in the disk, located at a distance of 7.7 AU or more, that was recently brought into the line of sight by its Keplerian motion around the central star.

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VLT-CRIRES Survey of Rovibrational CO Emission from Protoplanetary Disks

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We present a large, comprehensive survey of rovibrational CO line emission at 4.7 µm from 69 protoplanetary disks, obtained with CRIRES on the ESO Very Large Telescope at the highest available spectral resolving power ($R=95,000$, $\Delta v=3.2$ km s$^{-1}$). The CO fundamental band ($\Delta v=1$) is a well-known tracer of warm gas in the inner, planet-forming regions of gas-rich disks around young stars, with the lines formed in the super-heated surfaces of the disks at radii of 0.1-10 AU. Our high spectral resolution data provide new insight into the kinematics of the inner disk gas. Pure double-peaked Keplerian profiles are surprisingly uncommon, beyond the frequency expected based on disk inclination. The majority of the profiles are consistent with emission from a disk plus a slow (few km s$^{-1}$) molecular disk wind. This is evidenced by analysis of different categories as well as an overall tendency for line profiles to have excess blue emission. Weak emission lines from isotopologues and vibrationally excited levels are readily detected. In general, $^{13}$CO lines trace cooler gas than the bulk $^{12}$CO emission and may arise from further out in the disk, as indicated by narrower line profiles. A high fraction of the sources show vibrationally excited emission ($\sim$50%) which is correlated with accretion luminosity, consistent with ultra-violet (UV) fluorescent excitation. Disks around early-type Herbig AeBe stars have narrower lines, on average, than their lower-mass late-type counterparts, due to their increased luminosity. Evolutionary changes in CO are also seen. Removal of the protostellar envelope between class I and II results in the disappearance of the strong absorption lines and CO ice feature characteristic of class I spectra. However, CO emission from class I and II objects is similar in detection frequency, excitation and line shape, indicating that inner disk characteristics are established early.

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The Effects of Radiative Transfer on the PDFs of Molecular MHD Turbulence
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We study the effects of radiative transfer on the Probability Distribution Functions (PDFs) of simulations of magnetohydrodynamic turbulence in the widely studied $^{13}$CO 2-1 transition. We find that the integrated intensity maps generally follow a log-normal distribution, with the cases that have $\tau \approx 1$ best matching the PDF of the column density. We fit a 2D variance-sonic Mach number relationship to our logarithmic PDFs of the form $\sigma_{ln(S/S_0)}^2 = A \times ln(1+b^2M_s^2)$ and find that, for parameter $b = 1/3$, parameter $A$ depends on the radiative transfer environment. We also explore the variance, skewness, and kurtosis of the linear PDFs finding that higher moments reflect both higher sonic Mach number and lower optical depth. Finally, we apply the Tsallis incremental PDF function and find that the fit parameters depend on both Mach numbers, but also are sensitive to the radiative transfer parameter space, with the $\tau \approx 1$ case best fitting the incremental PDF of the true column density. We conclude that, for PDFs of low optical depth cases, part of the gas is always sub-thermally excited so that the spread of the line intensities exceeds the spread of the underlying column densities and hence the PDFs do not reflect the true column density. Similarly, PDFs of optically thick cases are dominated by the velocity dispersion and therefore do not represent the true column density PDF. Thus, in the case of molecules like carbon monoxide, the dynamic range of intensities, structures observed and consequently, the observable PDFs, are less determined by turbulence and more-often determined by radiative transfer effects.

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LBT/LUCIFER NIR spectroscopy of PV Cephei. An outbursting YSO with an asymmetric jet
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Close Stellar Encounters in Young, Substructured, Dissolving Star Clusters: Statistics and Effects on Planetary Systems

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Both simulations and observations indicate that stars form in filamentary, hierarchically clustered associations, most of which disperse into their galactic field once feedback destroys their parent clouds. However, during their early evolution in these substructured environments, stars can undergo close encounters with one another that might have significant impacts on their protoplanetary disks or young planetary systems. We perform N-body simulations of the early evolution of dissolving, substructured clusters with a wide range of properties, with the aim of quantifying the expected number and orbital element distributions of encounters as a function of cluster properties. We show that the presence of substructure both boosts the encounter rate and modifies the distribution of encounter velocities compared to what would be expected for a dynamically relaxed cluster. However, the boost only lasts for a dynamical time, and as a result the overall number of encounters expected remains low enough that gravitational stripping is unlikely to be a significant effect for the vast majority of star-forming environments in the Galaxy. We briefly discuss the
implications of this result for models of the origin of the Solar System, and of free-floating planets. We also provide tabulated encounter rates and orbital element distributions suitable for inclusion in population synthesis models of planet formation in a clustered environment.

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Heavy water stratification in a low-mass protostar
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Context. Despite the low elemental deuterium abundance in the Galaxy, enhanced molecular D/H ratios have been found in the environments of low-mass star-forming regions and, in particular, the Class 0 protostar IRAS 16293-2422.

Aims. The key program Chemical HErschel Surveys of Star forming regions (CHESS) aims at studying the molecular complexity of the interstellar medium. The high sensitivity and spectral resolution of the Herschel/HIFI (Heterodyne Instrument for Far-Infrared) instrument provide a unique opportunity to observe the fundamental $^{1}\text{D}_2\text{O}$ at 607 GHz and the higher energy $^{2}\text{D}_2\text{O}$ at 898 GHz, both of which are inaccessible from the ground.

Methods. The ortho-$^{2}\text{D}_2\text{O}$ transition at 607 GHz was previously detected. We present in this paper the first tentative detection for the para-$^{2}\text{D}_2\text{O}$ transition at 898 GHz. The spherical Monte Carlo radiative transfer code RATRAN was used to reproduce the observed line profiles of $^{2}\text{D}_2\text{O}$ with the same method that was used to reproduce the HDO and $^{2}\text{H}_2^{18}\text{O}$ line profiles in IRAS 16293-2422.

Results. As for HDO, the absorption component seen on the $^{2}\text{D}_2\text{O}$ lines can only be reproduced by adding an external absorbing layer, possibly created by the photodesorption of the ices at the edges of the molecular cloud. The $^{2}\text{D}_2\text{O}$ column density is found to be about $2.5 \times 10^{12}$ cm$^{-2}$ in this added layer, leading to a $^{2}\text{D}_2\text{O}/\text{H}_2\text{O}$ ratio of about 0.5%. At a 3σ uncertainty, upper limits of 0.03% and 0.2% are obtained for this ratio in the hot corino and the colder envelope of IRAS 16293-2422, respectively.

Conclusions. The deuterium fractionation derived in our study suggests that the ices present in IRAS 16293-2422 formed on warm dust grains ($\sim 15 – 20$ K) in dense ($\sim 10^{4} – 5 \times 10^{4}$ cm$^{-3}$) translucent clouds. These results allow us to address the earliest phases of star formation and the conditions in which ices form.

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Protoplanetary disk evolution and stellar parameters of T Tauri binaries in Chamaeleon I
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are used to derive cloud kinematics and distances, so that we can estimate distance-dependent physical parameters.

Methods. We used high-angular resolution adaptive optics $JHK_sL'$-band photometry and 1.5–2.5 µm spectroscopy of 19 visual binary and 7 triple stars in ChaI – including one newly discovered tertiary component – with separations between ~25 au and ~1000 au. The data allowed us to infer stellar component masses and ages and, from the detection of near-infrared excess emission and the strength of Brackett-γ emission, the presence of ongoing accretion and hot circumstellar dust of the individual stellar component of each binary.

Results. Of all the stellar components in close binaries with separations of 25–100 au, $10^{+15}_ {-5}\%$ shows signs of accretion. This is less than half of the accretor fraction found in wider binaries, which itself appears significantly reduced ($\sim 44\%$) compared with previous measurements of single stars in ChaI. Hot dust was found around $50^{+30}_ {-15}\%$ of the target components, a value that is indistinguishable from that of ChaI single stars. Only the closest binaries ($< 25$ au) were inferred to have a significantly reduced fraction ($\lesssim 25\%$) of components that harbor hot dust. Accretors were exclusively found in binary systems with unequal component masses $M_{\text{secondary}}/M_{\text{primary}} < 0.8$, implying that the detected accelerated disk dispersal is a function of mass-ratio. This agrees with the finding that only one accreting secondary star was found, which is also the weakest accretor in the sample.

Conclusions. The results imply that disk dispersal is more accelerated the stronger the dynamical disk truncation, i.e., the smaller the inferred radius of the disk. Nonetheless, the overall measured mass accretion rates appear to be independent of the cluster environment or the existence of stellar companions at any separation $\gtrsim 25$ au, because they agree well with observations from our previous binary study in the Orion Nebula cluster and with studies of single stars in these and other star-forming regions.

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The first Hi-GAL observations of the outer Galaxy: a look to star formation in the third Galactic quadrant in the longitude range $216.5^\circ \leq \ell \leq 225.5^\circ$

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We present the first Herschel PACS and SPIRE photometric observations in a portion of the outer Galaxy ($216.5^\circ \leq \ell \leq 225.5^\circ$ and $-2^\circ \leq b \leq 0^\circ$) as a part of the Hi-GAL survey. The maps between 70 and 500 µm, the derived column density and temperature maps, and the compact source catalog are presented. NANTEN CO(1-0) line observations are used to derive cloud kinematics and distances, so that we can estimate distance-dependent physical parameters.
of the compact sources (cores and clumps) having a reliable spectral energy distribution, that we separate in 255 proto-stellar and 688 starless. Both typologies are found in association with all the distance components observed in the field, up to ~ 5.8 kpc, testifying the presence of star formation beyond the Perseus arm at these longitudes. Selecting the starless gravitationally bound sources we identify 590 pre-stellar candidates. Several sources of both proto- and pre-stellar nature are found to exceed the minimum requirement for being compatible with massive star formation, based on the mass-radius relation. For the pre-stellar sources belonging to the Local arm (d ≤ 1.5 kpc) we study the mass function, whose high-mass end shows a power-law $N(\log M) \propto M^{-1.0^{\pm0.2}}$. Finally, we use a luminosity vs mass diagram to infer the evolutionary status of the sources, finding that most of the proto-stellar are in the early accretion phase (with some cases compatible with a Class I stage), while for pre-stellar sources, in general, accretion has not started yet.

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**Young Stellar Objects in Lynds 1641: Disks, Accretion, and Star Formation History**

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We investigate the young stellar objects (YSOs) in the Lynds 1641 (L1641) cloud using multi-wavelength data including Spitzer, WISE, 2MASS, and XMM covering ~1390 YSOs across a range of evolutionary stages. In addition, we targeted a sub-sample of YSOs for optical spectroscopy. We use this data, along with archival photometric data, to derive spectral types, extinction values, masses, ages, as well as accretion rates. We obtain a disk fraction of ~ 50% in L1641. The disk frequency is almost constant as a function of stellar mass with a slight peak at $\log(M_*/M_\odot)\approx-0.25$. The analysis of multi-epoch spectroscopic data indicates that the accretion variability of YSOs cannot explain the two orders of magnitude of scatter for YSOs with similar masses. Forty-six new transition disk (TD) objects are confirmed in this work, and we find that the fraction of accreting TDs is lower than for optically thick disks (~ 40–45% vs. 77–79% respectively). We confirm our previous result that the accreting TDs have a similar median accretion rate to normal optically thick disks. We confirm that two star formation modes (isolated vs. clustered) exist in L1641. We find that the diskless YSOs are statistically older than the YSOs with optically-thick disks and the transition disk objects have a median age which is intermediate between the two populations. We tentatively study the star formation history in L1641 based on the age distribution and find that star formation started to be active 2–3 Myr ago.

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**Towards a Population Synthesis Model of Objects formed by Self-Gravitating Disc Fragmentation and Tidal Downsizing**

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Recently, the gravitational instability (GI) model of giant planet and brown dwarf formation has been revisited and recast into what is often referred to as the "tidal downsizing" hypothesis. The fragmentation of self-gravitating protostellar discs into gravitationally bound embryos - with masses of a few to tens of Jupiter masses, at semi major
axes above 30 - 40 AU - is followed by grain sedimentation inside the embryo, radial migration towards the central star and tidal disruption of the embryo’s upper layers. The properties of the resultant object depends sensitively on the timescales upon which each process occurs. Therefore, GI followed by tidal downsizing can theoretically produce objects spanning a large mass range, from terrestrial planets to giant planets and brown dwarfs. Whether such objects can be formed in practice, and what proportions of the observed population they would represent, requires a more involved statistical analysis. We present a simple population synthesis model of star and planet formation via GI and tidal downsizing. We couple a semi-analytic model of protostellar disc evolution to analytic calculations of fragmentation, initial embryo mass, grain growth and sedimentation, embryo migration and tidal disruption. While there are key pieces of physics yet to be incorporated, it represents a first step towards a mature statistical model of GI and tidal downsizing as a mode of star and planet formation. We show results from four runs of the population synthesis model, varying the opacity law and the strength of migration, as well as investigating the effect of disc truncation during the fragmentation process. Our early results suggest that GI plus tidal downsizing is not the principal mode of planet formation, but remains an excellent means of forming gas giant planets, brown dwarfs and low mass stars at large semimajor axes. (Abridged)

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Star Formation & Dust Heating in the FIR Bright Sources of M83
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We investigate star formation and dust heating in the compact FIR bright sources detected in the Herschel maps of M83. We use the source extraction code GETSOURCES to detect and extract sources in the FIR, as well as their photometry in the MIR and Hα. By performing infrared SED fitting and applying an Hα based star formation rate (SFR) calibration, we derive the dust masses and temperatures, SFRs, gas masses and star formation efficiencies (SFEs). The detected sources lie exclusively on the spiral arms and represent giant molecular associations (GMAs), with gas masses and sizes of $10^5 - 10^8 M_\odot$ and 200-300 pc, respectively. The inferred parameters show little to no radial dependence and there is only a weak correlation between the SFRs and gas masses, which suggests that more massive clouds are less efficient at forming stars. Dust heating is mainly due to local star formation. However, although the sources are not optically thick, the total intrinsic young stellar population luminosity can almost completely account for the dust luminosity. This suggests that other radiation sources contribute to the dust heating as well and approximately compensate for the unabsorbed fraction of UV light.

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Magnetically Active Stars in Taurus-Auriga: Evolutionary Status

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We have analyzed a sample of 74 magnetically active stars toward the Taurus-Auriga star-forming region. Based on accurate data on their basic physical parameters obtained from original photometric observations and published data on their proper motions, X-ray luminosities, and equivalent widths of the Hα and Li lines, we have refined the evolutionary status of these objects. We show that 50 objects are young stars with ages of 1-40 Myr and belong to the Taurus-Auriga star-forming region. Other 20 objects have a controversial evolutionary status and can belong to both Taurus-Auriga star-forming region and the Gould Belt. The remaining four objects with ages of 70-100 Myr belong to the zero-age main sequence. We have analyzed the relationship between the rotation period, mass, and age for 50 magnetically active stars. The change in the angular momentum of the sample stars within the first 40 Myr of their evolution has been investigated. An active star-protoplanetary disk interaction is shown to occur on a time scale from 0.7 to 10 Myr.

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Embedded Protostars in the Dust, Ice, and Gas In Time (DIGIT) Herschel Key Program: Continuum SEDs, and an Inventory of Characteristic Far-Infrared Lines from PACS Spectroscopy

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We present 50-210 μm spectral scans of 30 Class 0/I protostellar sources, obtained with Herschel-PACS, and 0.5-1000 μm SEDs, as part of the Dust, Ice, and Gas in Time (DIGIT) Key Program. Some sources exhibit up to 75 H2O lines ranging in excitation energy from 100-2000 K, 12 transitions of OH, and CO rotational lines ranging from J = 14 → 13 up to J = 40 → 39. [OI] is detected in all but one source in the entire sample; among the sources with detectable [OI] are two Very Low Luminosity Objects (VeLLOs). The mean 63/145 μm [OI] flux ratio is 17.2 ± 9.2. The [OI] 63 μm line correlates with Lbol, but not with the time-averaged outflow rate derived from low-J CO maps. [CII] emission is in general not local to the source. The sample Lbol increased by 1.25 (1.06) and Tbol decreased to 0.96 (0.96) of mean (median) values with the inclusion of the Herschel data. Most CO rotational diagrams are characterized by two optically thin components (meanN = (0.70 ± 1.12) × 1049 total particles). NCO correlates strongly with Lbol.
but neither $T_{\text{rot}}$ nor $N_{\text{CO}}(\text{warm})/N_{\text{CO}}(\text{hot})$ correlates with $L_{\text{bol}}$, suggesting that the total excited gas is related to the current source luminosity, but that the excitation is primarily determined by the physics of the interaction (e.g., UV-heating/shocks). Rotational temperatures for H$_2$O ($\text{mean } T_{\text{rot}} = 194 \pm 85$ K) and OH ($\text{mean } T_{\text{rot}} = 183 \pm 117$ K) are generally lower than for CO, and much of the scatter in the observations about the best fit is attributed to differences in excitation conditions and optical depths amongst the detected lines.

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Evolution of CO lines in time-dependent models of protostellar disk formation
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(Abridged) Star and planet formation theories predict an evolution in the density, temperature, and velocity structure as the envelope collapses and forms an accretion disk. The aim of this work is to model the evolution of the molecular excitation, line profiles, and related observables during low-mass star formation. Specifically, the signatures of disks during the deeply embedded stage are investigated. Semi-analytic 2D axisymmetric models have been used to describe the evolution of the density, stellar mass, and luminosity from the pre-stellar to the T-Tauri phase. A full radiative transfer calculation is carried out to accurately determine the time-dependent dust temperatures and CO abundance structure. We present non-LTE near-IR, FIR, and submm lines of CO have been simulated at a number of time steps. In contrast to the dust temperature, the CO excitation temperature derived from submm/FIR lines does not vary during the protostellar evolution, consistent with C$^{18}$O observations obtained with Herschel and from ground-based telescopes. The near-IR spectra provide complementary information to the submm lines by probing not only the cold outer envelope but also the warm inner region. The near-IR high-J ($> 8$) absorption lines are particularly sensitive to the physical structure of the inner few AU, which does show evolution. High signal-to-noise ratio subarcsec resolution data with ALMA are needed to detect the presence of small rotationally supported disks during the Stage 0 phase and various diagnostics are discussed.

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Gravitational Infall onto Molecular Filaments
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Two aspects of filamentary molecular cloud evolution are addressed: (1) Exploring analytically the role of the environment for the evolution of filaments demonstrates that considering them in isolation (i.e. just addressing the fragmentation stability) will result in unphysical conclusions about the filament’s properties. Accretion can also explain the observed decorrelation between FWHM and peak column density. (2) Free-fall accretion onto finite filaments can lead to the characteristic “fans” of infrared-dark clouds around star-forming regions. The fans may form due to tidal forces mostly arising at the ends of the filaments, consistent with numerical models and earlier analytical studies.

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Debris discs around M stars: non-existence versus non-detection

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Motivated by the reported dearth of debris discs around M stars, we use survival models to study the occurrence of planetesimal discs around them. These survival models describe a planetesimal disc with a small number of parameters, determine if it may survive a series of dynamical processes and compute the associated infrared excess. For the WISE satellite, we demonstrate that the dearth of debris discs around M stars may be attributed to the small semi-major axes generally probed if either: 1. the dust grains behave like blackbodies emitting at a peak wavelength coincident with the observed one; 2. or the grains are hotter than predicted by their blackbody temperatures and emit at peak wavelengths that are shorter than the observed one. At these small distances from the M star, planetesimals are unlikely to survive or persist for time scales of 300 Myr or longer if the disc is too massive. Conversely, our survival models allow for the existence of a large population of low-mass debris discs that are too faint to be detected with current instruments. However, our interpretation becomes less clear and large infrared excesses are allowed if only one of these scenarios holds: 3. the dust grains are hotter than blackbody and predominantly emit at the observed wavelength; 4. or are blackbody in nature and emit at peak wavelengths longer than the observed one. Both scenarios imply that the parent planetesimals reside at larger distances from the star than inferred if the dust grains behaved like blackbodies. In all scenarios, we show that the infrared excesses detected at 22 and 70 microns from AU Mic are easily reconciled with its young age. We elucidate the conditions under which stellar wind drag may be neglected when considering dust populations around M stars. The WISE satellite should be capable of detecting debris discs around young M stars with ages on the order of 10 Myr.

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Analytical theory for the initial mass function: III time dependence and star formation rate

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The present paper extends our previous theory of the stellar initial mass function (IMF) by including the time-dependence, and by including the impact of magnetic field. The predicted mass spectra are similar to the time-independent ones with slightly shallower slopes at large masses and peak locations shifted toward smaller masses by a factor of a few. Assuming that star-forming clumps follow Larson type relations, we obtain core mass functions in good agreement with the observationally derived IMF, in particular when taking into account the thermodynamics of the gas. The time-dependent theory directly yields an analytical expression for the star formation rate (SFR) at cloud scales. The SFR values agree well with the observational determinations of various Galactic molecular clouds. Furthermore, we show that the SFR does not simply depend linearly on density, as sometimes claimed in the literature, but depends also strongly on the clump mass/size, which yields the observed scatter. We stress, however, that any SFR theory depends, explicitly or implicitly, on very uncertain assumptions like clump boundaries or the mass of the most massive stars that can form in a given clump, making the final determinations uncertain by a factor of a few. Finally, we derive a fully time-dependent model for the IMF by considering a clump, or a distribution of clumps accreting at a constant rate and thus whose physical properties evolve with time. In spite of its simplicity, this model reproduces reasonably well various features observed in numerical simulations of converging flows. Based on this general theory, we present a paradigm for star formation and the IMF.

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Millimeter dust emission compared with other mass estimates in N11 molecular clouds in the LMC

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CO and dust emission at millimeter wavelengths are independent tracers of cold interstellar matter, which have seldom been compared on the scale of GMCs in other galaxies. In this study, and for the first time in the Large Magellanic Cloud, we compute the molecular cloud masses from the mm emission of the dust and compare them with the masses derived from their CO luminosity and virial theorem. We present CO (J=1-0,2-1) and 1.2 mm continuum observations of the N11 star forming region in the LMC obtained with the SEST telescope and the SIMBA bolometer, respectively. We use the CO data to identify individual molecular clouds and measure their physical properties. The correlations between the properties of the N11 clouds are in agreement with those found in earlier studies in the LMC that sample a larger set of clouds and a larger range of cloud masses. For the N11 molecular clouds, we compare the masses estimated from the CO luminosity (X_CO L_CO), the virial theorem (M_vir) and the millimeter dust luminosity (L_d). The measured ratios L_CO/M_vir and L_d/M_vir constrain the X_CO and K_d (dust emissivity at 1.2 mm per unit gas mass) parameters as a function of the virial parameter α_vir. The comparison between the different mass estimates yields a X_CO-factor of 8.8 × 10^20 cm^{-2} (K km s^{-1})^{-1} × α_vir and a K_d parameter of 1.5 × 10^{-3} cm^2 g^{-1} × α_vir. We compare our N11 results with a similar analysis for molecular clouds in the Gould’s Belt. We do not find in N11 a large discrepancy between the dust mm and virial masses as reported in earlier studies of molecular clouds in the SMC. The ratio between L_d and M_vir in N11 is half of that measured for Gould’s Belt clouds, which can be accounted for by a factor of two lower gas-to-dust mass ratio, as the difference in gas metallicities. If the two samples have similar α_vir values, this result implies that their dust far-IR properties are also similar.

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Mapping the core mass function onto the stellar IMF: multiplicity matters

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Observations indicate that the central portions of the Present-Day Prestellar Core Mass Function (hereafter CMF) and the Stellar Initial Mass Function (hereafter IMF) both have approximately log-normal shapes, but that the CMF is displaced to higher mass than the IMF by a factor F ~ 4±1. This has lead to suggestions that the shape of the IMF is directly inherited from the shape of the CMF – and therefore, by implication, that there is a self-similar mapping from the CMF onto the IMF. If we assume a self-similar mapping, it follows (i) that F = N_0/η, where η is the mean fraction of a core’s mass that ends up in stars, and N_0 is the mean number of stars spawned by a single core; and (ii) that the stars spawned by a single core must have an approximately log-normal distribution of relative masses, with universal standard deviation σ_0. Observations can be expected to deliver ever more accurate estimates of F, but this still leaves a degeneracy between η and N_0; and σ_0 is also unconstrained by observation. Here we show that these parameters can be estimated by invoking binary statistics. Specifically, if (a) each core spawns one long-lived binary system, and (b) the probability that a star of mass M is part of this long-lived binary is proportional to M^α, current
observations of the binary frequency as a function of primary mass, $b(M_1)$, and the distribution of mass ratios, $p_\eta$, strongly favour $\eta \sim 1.0 \pm 0.3$, $N_\eta \sim 4.3 \pm 0.4$, $\sigma_\eta \sim 0.3 \pm 0.03$ and $a \sim 0.9 \pm 0.6$: $\eta > 1$ just means that, when its mass is measured and when it finishes spawning stars, a core accretes additional mass, for example from the filament in which it is embedded. If not all cores spawn a long-lived binary system, $db/dM_1 < 0$, in strong disagreement with observation; conversely, if a core typically spawns more than one long-lived binary system, then $N_\eta$ and $\eta$ have to be increased further. The mapping from CMF to IMF is not necessarily self-similar – there are many possible motivations for a non self-similar mapping – but if it is not, then the shape of the IMF cannot be inherited from the CMF. Given the limited observational constraints currently available and the ability of a self-similar mapping to satisfy them, the possibility that the shape of the IMF is inherited from the CMF cannot be ruled out at this juncture.

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On the Coagulation and Size Distribution of Pressure Confined Cores

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Observations of the Pipe Nebula have led to the discovery of dense starless cores. The mass of most cores is too small for their self gravity to hold them together. Instead, they are thought to be pressure confined. The observed dense cores’ mass function (CMF) matches well with the initial mass function (IMF) of stars in young clusters. Similar CMF’s are observed in other star forming regions such as the Aquila Nebula, albeit with some dispersion. The shape of these CMF provides important clues to the competing physical processes which lead to star formation and its feedback on the interstellar media. In this paper, we investigate the dynamical origin of the the mass function of starless cores which are confined by a warm, less dense medium. We consider the coagulation between the cold cores and their ablation due to Kelvin-Helmholtz instability induced by their relative motion through the warm medium. We are able to reproduce the observed CMF among the starless cores in the Pipe nebula. Our results indicate that in environment similar to the Pipe nebula: 1) before the onset of their gravitational collapse, the mass distribution of the progenitor cores is similar to that of the young stars, 2) the observed CMF is a robust consequence of dynamical equilibrium between the coagulation and ablation of cores, and 3) a break in the slope of the CMF is due to the enhancement of collisional cross section and suppression of ablation for cores with masses larger than the cores’ Bonnor-Ebert mass.

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Misalignment of Magnetic Fields and Outflows in Protostellar Cores

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We present results of $\lambda 1.3$ mm dust polarization observations toward 16 nearby, low-mass protostars, mapped with $\sim 2.5$ arcsec resolution at CARMA. The results show that magnetic fields in protostellar cores on scales of $\sim 1000$ AU are not tightly aligned with outflows from the protostars. Rather, the data are consistent with scenarios where outflows and magnetic fields are preferentially misaligned (perpendicular), or where they are randomly aligned. If one assumes that outflows emerge along the rotation axes of circumstellar disks, and that the outflows have not disrupted the fields in the surrounding material, then our results imply that the disks are not aligned with the fields in the cores from which they formed.

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Direct diagnostics of forming massive stars: stellar pulsation and periodic variability of maser sources

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The 6.7 GHz methanol maser emission, a tracer of forming massive stars, sometimes shows enigmatic periodic flux variations over several 10-100 days. In this Letter, we propose that this periodic variations could be explained by the pulsation of massive protostars growing under rapid mass accretion with rates of $> 10^{-3} \, M_{\odot} \, yr^{-1}$. Our stellar evolution calculations predict that the massive protostars have very large radius exceeding $100 \, R_{\odot}$ at maximum, and we here study the pulsational stability of such the bloated protostars by way of the linear stability analysis. We show that the protostar becomes pulsationally unstable with various periods of several 10-100 days, depending on different accretion rates. With the fact that the stellar luminosity when the star is pulsationally unstable also depends on the accretion rate, we derive the period-luminosity relation $\log (L/L_{\odot}) = 4.62 + 0.98 \log (P/100 \, \text{day})$, which is testable with future observations. Our models further show that the radius and mass of the pulsating massive protostar should also depend on the period. It would be possible to infer such protostellar properties and the accretion rate with the observed period. Measuring the maser periods enables a direct diagnosis of the structure of accreting massive protostars, which are deeply embedded in dense gas and inaccessible with other observations.

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Chemistry of massive young stellar objects with a disk-like structure

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Our goal is to take an inventory of complex molecules in three well-known high-mass protostars for which disks or toroids have been claimed and to study the similarities and differences with a sample of massive YSOs without evidence of such flattened disk-like structures. With a disk-like geometry, UV radiation can escape more readily and potentially affect the ice and gas chemistry on hot-core scales. A partial submillimeter line survey, targeting CH$_3$OH, H$_2$CO, C$_2$H$_5$OH, HCOOCH$_3$, CH$_3$OCH$_3$, CH$_3$CN, HNCO, NH$_2$CHO, C$_2$H$_5$CN, CH$_2$CO, HCOOH, CH$_3$CN, and CH$_3$CCH, was made toward three massive YSOs with disk-like structures, IRAS20126+4104, IRAS18089-1732, and G31.41+0.31. Rotation temperatures and column densities were determined by the rotation diagram method, as well as by independent spectral modeling. The molecular abundances were compared with previous observations of massive YSOs without evidence of any disk structure, targeting the same molecules with the same settings and using the same analysis method. Consistent with previous studies, different complex organic species have different characteristic rotation temperatures and can be classified either as warm ($>$100 K) or cold ($<$100 K). The excitation temperatures and abundance ratios are similar from source to source and no significant difference can be established between the two source types. Acetone, CH$_3$COCH$_3$, is detected for the first time in G31.41+0.31 and IRAS18089-1732. Temperatures and abundances derived from the two analysis methods generally agree within factors of a few. The lack of chemical differentiation between massive YSOs with and without observed disks suggest either that the chemical complexity
is already fully established in the ices in the cold prestellar phase or that the material experiences similar physical conditions and UV exposure through outflow cavities during the short embedded lifetime.

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Young stellar population and ongoing star formation in the HII complex Sh2-252

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In this paper, an extensive survey of the star forming complex Sh2-252 has been undertaken with an aim to explore its hidden young stellar population as well as to understand the structure and star formation history for the first time. This complex is composed of five prominent embedded clusters associated with the sub-regions A, C, E, NGC 2175s and Teu 136. We used 2MASS-NIR and Spitzer-IRAC, MIPS photometry to identify and classify the young stellar objects (YSOs) by their infra-red excess emission. Using the IR colour-colour criteria, we identified 577 YSOs, of which, 163 are Class I, 400 are Class II and 14 are transition disk YSOs, suggesting a moderately rich number of YSOs in this complex. Spatial distribution of the candidate YSOs shows that they are mostly clustered around the sub-regions in the western half of the complex, suggesting enhanced star formation activity towards its west. Using the spectral energy distribution and optical colour-magnitude diagram based age analyses, we derived probable evolutionary status of the sub-regions of Sh2-252. Our analysis shows that the region A is the youngest (∼ 0.5 Myr), the regions B, C and E are of similar evolutionary stage (∼ 1-2 Myr) and the clusters NGC 2175s and Teu 136 are slightly evolved (∼ 2-3 Myr). Morphology of the region in the 1.1 mm map shows a semi-circular shaped molecular shell composed of several clumps and YSOs bordering the western ionization front of Sh2-252. Our analyses suggest that next generation star formation is currently under way along this border and that possibly fragmentation of the matter collected during the expansion of the HII region as one of the major processes responsible for such stars. We observed the densest concentration of YSOs (mostly Class I, ∼ 0.5 Myr) at the western outskirts of the complex, within a molecular clump associated with water and methanol masers and we suggest that it is indeed a site of cluster formation at a very early evolutionary stage, sandwiched between the two relatively evolved CHII regions A and B.

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Connection between dense gas mass fraction, turbulence driving, and star formation efficiency of molecular clouds

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We examine the physical parameters that affect the accumulation of gas in molecular clouds to high column densities where the formation of stars takes place. In particular, we analyze the dense gas mass fraction (DGMF) in a set of self-gravitating, isothermal, magnetohydrodynamic turbulence simulations including sink particles to model star
formation. We find that the simulations predict close to exponential DGMFs over the column density range $N(\text{H}_2) = 3 - 25 \times 10^{21} \text{ cm}^{-2}$ that can be easily probed via, e.g., dust extinction measurements. The exponential slopes correlate with the type of turbulence driving and also with the star formation efficiency. They are almost uncorrelated with the sonic Mach number and magnetic-field strength. The slopes at early stages of cloud evolution are steeper than at the later stages. A comparison of these predictions with observations shows that only simulations with relatively non-compressive driving ($b \lesssim 0.4$) agree with the DGMFs of nearby molecular clouds. Massive infrared dark clouds can show DGMFs that are in agreement with more compressive driving. The DGMFs of molecular clouds can be significantly affected by how compressive the turbulence is on average. Variations in the level of compression can cause scatter to the DGMF slopes, and some variation is indeed necessary to explain the spread of the observed DGMF slopes. The observed DGMF slopes can also be affected by the clouds’ star formation activities and statistical cloud-to-cloud variations.

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First results from the Herschel Gould Belt Survey in Taurus

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The whole of the Taurus region (a total area of 52 sq. deg.) has been observed by the Herschel SPIRE and PACS instruments at wavelengths of 70, 160, 250, 350 and 500 $\mu$m as part of the Herschel Gould Belt Survey. In this paper we present the first results from the part of the Taurus region that includes the Barnard 18 and L1536 clouds. A new source-finding routine, the Cardiff Source-finding Algorithm (CSAR), is introduced, which is loosely based on CLUMPFIND, but that also generates a structure tree, or dendrogram, which can be used to interpret hierarchical clump structure in a complex region. Sources were extracted from the data using the hierarchical version of CSAR and plotted on a mass-size diagram. We found a hierarchy of objects with sizes in the range 0.024-2.7 pc. Previous
studies showed that gravitationally bound prestellar cores and unbound starless clumps appeared in different places on the mass-size diagram. However, it was unclear whether this was due to a lack of instrumental dynamic range or whether they were actually two distinct populations. The excellent sensitivity of Herschel shows that our sources fill the gap in the mass-size plane between starless and pre-stellar cores, and gives the first clear supporting observational evidence for the theory that unbound clumps and (gravitationally bound) prestellar cores are all part of the same population, and hence presumably part of the same evolutionary sequence (c.f. Simpson et al. 2011).

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Resolving the gap and AU-scale asymmetries in the pre-transitional disk of V1247 Orionis
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Pre-transitional disks are protoplanetary disks with a gapped disk structure, potentially indicating the presence of young planets in these systems. In order to explore the structure of these objects and their gap-opening mechanism, we observed the pre-transitional disk V1247 Orionis using the Very Large Telescope Interferometer, the Keck Interferometer, Keck-II, Gemini South, and IRTF. This allows us spatially resolve the AU-scale disk structure from near- to mid-infrared wavelengths (1.5 to 13 μm), tracing material at different temperatures and over a wide range of stellocentric radii. Our observations reveal a narrow, optically-thick inner-disk component (located at 0.18 AU from the star) that is separated from the optically thick outer disk (radii > 46 AU), providing unambiguous evidence for the existence of a gap in this pre-transitional disk. Surprisingly, we find that the gap region is filled with significant amounts of optically thin material with a carbon-dominated dust mineralogy. The presence of this optically thin gap material cannot be deduced solely from the spectral energy distribution, yet it is the dominant contributor at mid-infrared wavelengths. Furthermore, using Keck/NIRC2 aperture masking observations in the H, K′, and L′ band, we detect asymmetries in the brightness distribution on scales of ~ 15–40 AU, i.e. within the gap region. The detected asymmetries are highly significant, yet their amplitude and direction changes with wavelength, which is not consistent with a companion interpretation but indicates an inhomogeneous distribution of the gap material. We interpret this as strong evidence for the presence of complex density structures, possibly reflecting the dynamical interaction of the disk material with sub-stellar mass bodies that are responsible for the gap clearing.

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Clumping and the Interpretation of kpc-Scale Maps of the Interstellar Medium: Smooth H I and Clumpy, Variable H2 Surface Density
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Many recent models consider the structure of individual interstellar medium (ISM) clouds as a way to explain observations of large parts of galaxies. To compare such models to observations, one must understand how to translate between surface densities observed averaging over large (~kpc) scales and surface densities on the scale of individual clouds (~pc scale), which are treated by models. We define a "clumping factor" that captures this translation as the ratio of the mass-weighted surface density, which is often the quantity of physical interest, to the area-weighted surface density, which is observed. We use high spatial resolution (sub-kpc) maps of CO and H\text{\textsc{i}} emission from nearby galaxies to measure the clumping factor of both atomic and molecular gas. The molecular and atomic ISM exhibit dramatically different degrees of clumping. As a result, the ratio H\text{\textsc{2}}/H\text{\textsc{i}} measured at ~kpc resolution cannot be trivially interpreted as a cloud-scale ratio of surface densities. H\text{\textsc{i}} emission appears very smooth, with a clumping factor of only ~1.3. Based on the scarce and heterogeneous high resolution data available, CO emission is far more clumped with a widely variable clumping factor, median ~7 for our heterogeneous data. Our measurements do not provide evidence for a universal mass-weighted surface density of molecular gas, but also cannot conclusively rule out such a scenario. We suggest that a more sophisticated treatment of molecular ISM structure, one informed by high spatial resolution CO maps, is needed to link cloud-scale models to kpc-scale observations of galaxies.

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Evidence of a SiO collimated outflow from a massive YSO in IRAS 17233-3606

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Studies of molecular outflows in high-mass young stellar objects reveal important information about the formation process of massive stars. We therefore selected the close-by IRAS 17233-3606 massive star-forming region to perform SiO observations with the SMA interferometer in the (5-4) line and with the APEX single-dish telescope in the (5-4) and (8-7) transitions. In this paper, we present a study of one of the outflows in the region, OF1, which shows several properties similar to jets driven by low-mass protostars, such as HH211 and HH212. It is compact and collimated, and associated with extremely high velocity CO emission, and SiO emission at high velocities. We used a state-of-the-art shock model to constrain the pre-shock density and shock velocity of OF1. The model also allowed us to self-consistently estimate the mass of the OF1 outflow. The shock parameters inferred by the SiO modelling are comparable with those found for low-mass protostars, only with higher pre-shock density values, yielding an outflow mass in agreement with those obtained for molecular outflows driven by early B-type young stellar objects. Our study shows that it is possible to model the SiO emission in high-mass star-forming regions in the same way as for shocks from low-mass young stellar objects.

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Massive Quiescent Cores In Orion: Their Supercritical State Revealed by High Resolution Ammonia Maps

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We present combined VLA and GBT images of NH\textsubscript{3} inversion transitions (1,1) and (2,2) toward OMC2 and OMC3. We focus on the relatively quiescent Orion cores, which are away from the Trapezium cluster and have no sign of massive protostars nor evolved star formation. The 5'' angular resolution and 0.6 km s\textsuperscript{-1} velocity resolution of these data enable us to study the thermal and dynamic state of these cores at \(\sim 0.02\) pc scales, comparable to or smaller than those of the current dust continuum surveys. We measure temperatures for a total of 30 cores, with average masses and radii of 11 M\(_\odot\) and 0.039 pc, respectively. Compared to other Gould Belt dense cores, more Orion cores have a high gravitational–to–kinetic energy ratio (virial mass ratio \(R_{\text{vir}} > 3\)), resembling results for other clouds forming high–mass stars. This results from Orion cores having velocity dispersions similar to those in, e.g., Perseus and Ophiuchus, but higher masses for given sizes. 12 out of 30 cores are associated with embedded YSOs identified by Spitzer. The protostellar cores have a mean mass of 16.5 M\(_\odot\) versus 7.3 M\(_\odot\) for starless cores, while mean size and temperature are similar regardless of the cores’ stellar content. 11 starless massive Orion cores are supercritical (mass-to-critical-mass ratio \(R_c > 1\)). These massive Orion starless cores will likely collapse or fragment quickly and can thus be considered direct precursors to protostars.

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High angular resolution observations towards OMC-2 FIR 4: Dissecting an intermediate-mass protocluster

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OMC-2 FIR 4 is one of the closest known young intermediate-mass protoclusters, located at a distance of 420 pc in Orion. This region is one of the few where the complete 500-2000 GHz spectrum has been observed with the heterodyne spectrometer HIFI on board the Herschel satellite, and unbiased spectral surveys at 0.8, 1, 2 and 3 mm have been obtained with the JCMT and IRAM 30-m telescopes. In order to investigate the morphology of this region, we used the IRAM Plateau de Bure Interferometer to image OMC-2 FIR 4 in the 2-mm continuum emission, as well as in DCO\textsuperscript{+}(2-1), DCN(2-1), C\textsuperscript{34}S(3-2), and several CH\textsubscript{3}OH lines. In addition, we analysed observations of the NH\textsubscript{3}(1,1) and (2,2) inversion transitions made with the Very Large Array of the NRAO. The resulting maps have an angular resolution which allows us to resolve structures of 5", equivalent to 2000 AU. Our observations reveal three spatially
resolved sources within OMC-2 FIR 4, of one or several solar masses each, with hints of further unresolved substructure within them. Two of these sources have elongated shapes and are associated with dust continuum emission peaks, thus likely containing at least one molecular core each. One of them also displays radio continuum emission, which may be attributed to a young B3-B4 star that dominates the overall luminosity output of the region. The third source identified displays a DCO\(^+\)(2-1) emission peak, and weak dust continuum emission. Its higher abundance of DCO\(^+\) relative to the other two regions suggests a lower temperature and therefore its possible association with either a younger low-mass protostar or a starless core. It may alternatively be part of the colder envelope of OMC-2 FIR 4. Our interferometric observations evidence the complexity of this region, where multiple cores, chemical differentiation and an ionised region all coexist within an area of only 10000 AU.

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V2494 Cyg: A unique FU Ori type object in the Cygnus OB7 complex

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A photometric and spectral study of the variable star V2494 Cyg in the L 1003 dark cloud is presented. The brightness of the star, formerly known as HH 381 IRS, increased by 2.5 mag in R (probably in the 1980s) and since then has remained nearly constant. Since the brightness increase, V2494 Cyg has illuminated a bipolar cometary nebula. The stellar spectrum has several features typical of the FU Ori type, plus it exhibits very strong H\(\alpha\) and forbidden emission lines with high-velocity components. These emission lines originate in the HH jet near the star. The kinematic age of the jet is consistent with it forming at the time of the outburst leading to the luminosity increase. V2494 Cyg also produces a rather extended outflow; it is the first known FUor with both an observed outburst and a parsec-sized HH flow. The nebula, illuminated by V2494 Cyg, possesses similar morphological and spectral characteristics to Hubble’s Variable Nebula (R Monocerotis/NGC 2261).

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Density distributions of outflow driven turbulence

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Protostellar jets and outflows are signatures of star formation and promising mechanisms for driving supersonic turbulence in molecular clouds. We quantify outflow-driven turbulence through three-dimensional numerical simulations using an isothermal version of the robust total variation diminishing code. We drive turbulence in real-space using
a simplified spherical outflow model, analyse the data through density probability distribution functions (PDF), and investigate the Core Formation Rate per free-fall time (CFR$_{ff}$). The real-space turbulence driving method produces a negatively skewed density PDF possessing an enhanced tail on the low-density side. It deviates from the log-normal distributions typically obtained from Fourier-space turbulence driving at low densities, but can provide a good fit at high-densities, particularly in terms of mass weighted rather than volume weighted density PDF. Due to this fact, we suggest that the CFR$_{ff}$ determined from a Fourier-driven turbulence model could be comparable to that of our particular real-space driving model, which has a ratio of solenoidal to compressional components from the resulting turbulence velocity fields of $\sim 0.6$.

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The Mysterious Sickle Object in the Carina Nebula: A stellar wind induced bow shock grazing a clump?

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Optical and near-infrared images of the Carina Nebula show a peculiar arc-shaped feature, which we call the "Sickle", next to the B-type star Trumpler 14 MJ 218. We use multi-wavelength observations to explore and constrain the nature and origin of the nebulosity. Using sub-mm data from APEX/LABoCA as well as Herschel far-infrared maps, we discovered a dense, compact clump with a mass of $\sim 40\,M_\odot$ located close to the apex of the Sickle. We investigate how the B-star MJ 218, the Sickle, and the clump are related. Our numerical simulations show that, in principle, a B-type star located near the edge of a clump can produce a crescent-shaped wind shock front, similar to the observed morphology. However, the observed proper motion of MJ 218 suggest that the star moves with high velocity ($\sim 100\,\text{km}\,\text{s}^{-1}$) through the ambient interstellar gas. We argue that the star is just about to graze along the surface of the clump, and the Sickle is a bow shock induced by the stellar wind, as the object moves supersonically through the density gradient in the envelope of the clump.

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The Plateau de Bure + 30 m Arcsecond Whirlpool Survey reveals a thick disk of diffuse molecular gas in the M51 galaxy

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We present the data of the Plateau de Bure Arcsecond Whirlpool Survey (PAWS), a high spatial and spectral resolution
$^{12}$CO (1–0) line survey of the inner $\sim 10 \times 6$ kpc of the M51 system, and the first wide-field imaging of molecular gas in a star-forming spiral galaxy with resolution matched to the typical size of Giant Molecular Clouds (40 pc). We describe the observation, reduction, and combination of the Plateau de Bure Interferometer (PdBI) and IRAM-30m “short spacing” data. The final data cube attains 1.1″-resolution over the $\sim 270'' \times 170''$ field of view, with sensitivity to all spatial scales from the combination of PdBI and IRAM-30m data, and brightness sensitivity of 0.4 K (1σ) in each 5 km s$^{-1}$-wide channel map. We find a CO-luminosity of $9 \times 10^{8}$ K km s$^{-1}$ pc$^2$, corresponding to a molecular gas mass of $4 \times 10^9 M_\odot$ for a standard CO-to-H$_2$ conversion factor. Unexpectedly, we find that a large fraction, $(50 \pm 10)\%$, of this emission arises mostly from spatial scales larger than $36'' \sim 1.3$ kpc. Through a series of tests, we demonstrate that this extended emission does not result from a processing artifact. We discuss its origin in light of the stellar component, the $^{12}$CO/$^{13}$CO ratio, and the difference between the kinematics and structure of the PdBI-only and hybrid synthesis (PdBI + IRAM-30m) images. The extended emission is consistent with a thick, diffuse disk of molecular gas with a typical scale height of $\sim 200$ pc, substructured in unresolved filaments which fills $\sim 0.1\%$ of the volume.

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Modeling the Atomic-to-Molecular Transition and Chemical Distributions of Turbulent Star-Forming Clouds
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We use 3D-PDR, a three-dimensional astrochemistry code for modeling photodissociation regions (PDRs), to post-process hydrodynamic simulations of turbulent, star-forming clouds. We focus on the transition from atomic to molecular gas, with specific attention to the formation and distribution of H, C$^+$, C, H$_2$ and CO. First, we demonstrate that the details of the cloud chemistry and our conclusions are insensitive to the simulation spatial resolution, to the resolution at the cloud edge, and to the ray angular resolution. We then investigate the effect of geometry and simulation parameters on chemical abundances and find weak dependence on cloud morphology as dictated by gravity and turbulent Mach number. For a uniform external radiation field, we find similar distributions to those derived using a one-dimensional PDR code. However, we demonstrate that a three-dimensional treatment is necessary for a spatially varying external field, and we caution against using one-dimensional treatments for non-symmetric problems. We compare our results with the work of Glover et al. (2010), who self-consistently followed the time evolution of molecule formation in hydrodynamic simulations using a reduced chemical network. In general, we find good agreement with this in situ approach for C and CO abundances. However, the temperature and H$_2$ abundances are discrepant in the boundary regions (Av $\leq$ 5), which is due to the different number of rays used by the two approaches.

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The binary companion mass ratio distribution: an imprint of the star formation process?
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We explore the effects of dynamical evolution in dense clusters on the companion mass ratio distribution (CMRD) of binary stars. Binary systems are destroyed by interactions with other stars in the cluster, lowering the total binary fraction and significantly altering the initial semi-major axis distribution. However, the shape of the CMRD is unaffected by dynamics; an equal number of systems with high mass ratios are destroyed compared to systems with low mass ratios. We might expect a weak dependence of the survivability of a binary on its mass ratio because its binding energy is proportional to both the primary and secondary mass components of the system. However, binaries are broken up by interactions in which the perturbing star has a significantly higher energy (by a factor of $> 10$, $\ldots\ldots$)
depending on the particular binary properties) than the binding energy of the binary, or through multiple interactions in the cluster. We therefore suggest that the shape of the observed binary CMRD is an outcome of the star formation process, and should be measured in preference to the distributions of orbital parameters, such as the semi-major axis distribution.

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Acetone in Orion BN/KL - High-resolution maps of a special oxygen-bearing molecule

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As one of the prime targets of interstellar chemistry study, Orion BN/KL clearly shows different molecular distributions between large nitrogen- (e.g., C2H5CN) and oxygen-bearing (e.g., HCOOCH3) molecules. However, acetone (CH3)2CO, a special complex O-bearing molecule, has been shown to have a very different distribution from other typical O-bearing molecules in the BN/KL region. We searched for acetone within our IRAM Plateau de Bure Interferometer 3 mm and 1.3 mm data sets. Twenty-two acetone lines were searched within these data sets. The angular resolution ranged from 1.8′′ × 0.8′′ to 6.0′′ × 2.3′′, and the spectral resolution ranged from 0.4 to 1.9 km s−1. Nine of the acetone lines appear free of contamination. Three main acetone peaks (Ace-1, 2, and 3) are identified in Orion BN/KL. The new acetone source Ace-3 and the extended emission in the north of the hot core region have been found for the first time. An excitation temperature of about 150 K is determined toward Ace-1 and Ace-2, and the acetone column density is estimated to be 2 − 4 × 1016 cm−2 with a relative abundance of 1 − 6 × 10−8 toward these two peaks. Acetone is a few times less abundant toward the hot core and Ace-3 compared with Ace-1 and Ace-2. We find that the overall distribution of acetone in BN/KL is similar to that of N-bearing molecules, e.g., NH3 and C2H5CN, and very different from those of large O-bearing molecules, e.g., HCOOCH3 and (CH3)2O. Our findings show the acetone distribution is more extended than in previous studies and does not originate only in those areas where both N-bearing and O-bearing species are present. Moreover, because the N-bearing molecules may be associated with shocked gas in Orion BN/KL, this suggests that the formation and/or destruction of acetone may involve ammonia or large N-bearing molecules in a shocked-gas environment.

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Explaining millimeter-sized particles in brown dwarf disks

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Planets have been detected around a variety of stars, including low-mass objects, such as brown dwarfs. However, such extreme cases are challenging for planet formation models. Recent sub-millimeter observations of disks around brown dwarf measured low spectral indices of the continuum emission that suggest that dust grains grow to mm-sizes even in these very low mass environments. To understand the first steps of planet formation in scaled-down versions of T-Tauri disks, we investigate the physical conditions that can theoretically explain the growth from interstellar dust to millimeter-sized grains in disks around brown dwarf. We modeled the evolution of dust particles under conditions of low-mass disks around brown dwarfs. We used coagulation, fragmentation and disk-structure models to simulate the evolution of dust, with zero and non-zero radial drift. For the non-zero radial drift, we considered strong inhomogeneities in the gas surface density profile that mimic long-lived pressure bumps in the disk. We studied different scenarios that could lead to an agreement between theoretical models and the spectral slope found by millimeter observations. We find that fragmentation is less likely and rapid inward drift is more significant for particles in brown dwarf disks than in T-Tauri disks. We present different scenarios that can nevertheless explain millimeter-sized grains. As an example, a model that combines the following parameters can fit the millimeter fluxes measured for brown dwarf disks: strong pressure inhomogeneities of $\sim 40\%$ of amplitude, a small radial extent $\sim 15$ AU, a moderate turbulence strength $a_{\text{turb}} = 10^{-3}$, and average fragmentation velocities for ices $v_f = 10 \text{ m s}^{-1}$.

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The Identification of 93 Day Periodic Photometric Variability for YSO YLW 16A
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Periodic variability in young stellar objects (YSOs) offers indirect evidence for an active dynamical mechanism. Starspots, accretion, stellar companions, and disk veiling can contribute to the photometric variability of YSOs. As part of an ongoing study of the Rho Oph star forming region, we report the discovery of 92.6 day periodic variations for the Class I YSO YLW 16A, observed over a period of three years. A SED model was fit to available photometric data for the object. We propose a triple-system with an inner binary with a period of 93 days eclipsed by a warped circum-binary disk. The nature of the secondary is unconstrained and could be stellar or sub-stellar. We report the discovery of a tertiary companion at a projected separation of $\sim 40$ AU that could account for the circum-binary disk warp. This light curve and model is similar to the model we proposed for WL 4 in previous work. Understanding these systems may lead to insights about the nature of stellar evolution and planetary formation, and provide valuable benchmarks for future theoretical modeling and near- and mid-infrared synoptic surveys of YSOs.

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Thermals in stratified regions of the ISM
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We present a model of a “thermal” (i.e., a hot bubble) rising within an exponentially stratified region of the ISM. This model includes terms representing the ram pressure braking and the entrainment of environmental gas into the thermal. We then calibrate the free parameters associated with these two terms through a comparison with 3D numerical simulations of a rising bubble. Finally, we apply our “thermal” model to the case of a hot bubble produced by a SN within the stratified ISM of the Galactic disk.

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Universality of the companion mass-ratio distribution
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We present new results regarding the companion mass-ratio distribution (CMRD) of stars, as a follow-up of our previous work. We used a maximum-likelihood-estimation method to re-derive the field CMRD power law avoiding dependence on the arbitrary binning. We also considered two new surveys of multiples in the field for solar-type stars and M dwarfs to test the universality of the CMRD. We found no significant differences in the CMRD for M dwarfs and solar-type stars compared with previous results over the common mass ratio and separation range. The new best-fit power law of the CMRD in the field, combining two previous sets of data, is $dN/dq \propto q^\beta$, with $\beta = 0.25 \pm 0.29$.

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The Hubble Space Telescope Treasury Program on the Orion Nebula Cluster
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The Hubble Space Telescope (HST) Treasury Program on the Orion Nebula Cluster has used 104 orbits of HST time to image the Great Orion Nebula region with the Advanced Camera for Surveys (ACS), the Wide-Field/Planetary Camera 2 (WFPC2) and the Near Infrared Camera and Multi Object Spectrograph (NICMOS) instruments in 11 filters ranging from the U-band to the H-band equivalent of HST. The program has been intended to perform the definitive study of the stellar component of the ONC at visible wavelengths, addressing key questions like the cluster IMF, age spread, mass accretion, binarity and circumstellar disk evolution. The scanning pattern allowed to cover a contiguous field of approximately 600 square arcminutes with both ACS and WFPC2, with a typical exposure time of approximately 11 minutes per ACS filter, corresponding to a point source depth AB(F435W) = 25.8 and AB(F775W) = 25.2 with 0.2 magnitudes of photometric error. We describe the observations, data reduction and data products, including images, source catalogs and tools for quick look preview. In particular, we provide ACS photometry for 3399 stars, most of them detected at multiple epochs, WFPC2 photometry for 1643 stars, 1021 of them detected in the U-band, and NICMOS JH photometry for 2116 stars. We summarize the early science results that have been presented in a number of papers. The final set of images and the photometric catalogs are publicly available through the archive as High Level Science Products at the STScI Multimission Archive hosted by the Space Telescope Science Institute.

Properties of dense cores in clustered massive star-forming regions at high angular resolution

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We aim at characterising dense cores in the clustered environments associated with massive star-forming regions. For this, we present an uniform analysis of VLA NH₃(1,1) and (2,2) observations towards a sample of 15 massive star-forming regions, where we identify a total of 73 cores, classify them as protostellar, quiescent starless, or perturbed starless, and derive some physical properties. The average sizes and ammonia column densities are 0.06 pc and $10^{15}$ cm⁻², respectively, with no significant differences between the starless and protostellar cores, while the linewidth and rotational temperature of quiescent starless cores are smaller, 1.0 km s⁻¹ and 16 K, than those of protostellar (1.8 km s⁻¹, 21 K), and perturbed starless (1.4 km s⁻¹, 19 K) cores. Such linewidths and temperatures for these quiescent starless cores in the surroundings of massive stars are still significantly larger than the typical values measured in starless cores of low-mass star-forming regions, implying an important non-thermal component. We confirm at high angular resolutions the correlations previously found with single-dish telescopes between the linewidth, the temperature of the cores, and the bolometric luminosity. In addition, we find a correlation between the temperature of each core and the incident flux from the most massive star in the cluster, suggesting that the large temperatures measured in the starless cores of our sample could be due to heating from the nearby massive star. A simple virial equilibrium analysis seems to suggest a scenario of a self-similar, self-gravitating, turbulent, virialised hierarchy of structures from clumps (0.1-10 pc) to cores (0.05 pc). A closer inspection of the dynamical state taking into account external pressure effects,
reveal that relatively strong magnetic field support may be needed to stabilise the cores, or that they are unstable and thus on the verge of collapse.

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Multiwavelength interferometric observations and modeling of circumstellar disks
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We investigate the structure of the innermost region of three circumstellar disks around pre-main sequence stars HD 142666, AS 205 N, and AS 205 S. We determine the inner radii of the dust disks and, in particular, search for transition objects where dust has been depleted and inner disk gaps have formed at radii of a few tenths of AU up to several AU.

We performed interferometric observations with IOTA, AMBER, and MIDI in the infrared wavelength ranges $1.6 - 2.5 \mu m$ and $8 - 13 \mu m$ with projected baseline lengths between 25 m and 102 m. The data analysis was based on radiative transfer simulations in 3D models of young stellar objects (YSOs) to reproduce the spectral energy distribution and the interferometric visibilities simultaneously. Accretion effects and disk gaps could be considered in the modeling approach. Results from previous studies restricted the parameter space.

The objects of this study were spatially resolved in the infrared wavelength range using the interferometers. Based on these observations, a disk gap could be found for the source HD 142666 that classifies it as transition object. There is a disk hole up to a radius of $R_{in} = 0.3$ AU and a (dust-free) ring between 0.35 AU and 0.80 AU in the disk of HD 142666. The classification of AS 205 as a system of classical T Tauri stars could be confirmed using the canonical model approach, i.e., there are no hints of disk gaps in our observations.

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The PdBI Arcsecond Whirlpool Survey (PAWS): A Cloud-Scale/Multi-Wavelength View of the Interstellar Medium in a Grand-Design Spiral Galaxy
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The PdBI (Plateau de Bure Interferometer) Arcsecond Whirlpool Survey (PAWS) has mapped the molecular gas in the central ∼ 9 kpc of M 51 in its $^{12}$CO(1-0) line emission at cloud-scale resolution of ∼40 pc using both IRAM telescopes. We utilize this dataset to quantitatively characterize the relation of molecular gas (or CO emission) to other tracers of the interstellar medium (ISM), star formation and stellar populations of varying ages. Using 2-dimensional maps, a polar cross-correlation technique and pixel-by-pixel diagrams, we find: (a) that (as expected) the distribution of the molecular gas can be linked to different components of the gravitational potential, (b) evidence for a physical link between CO line emission and radio continuum that seems not to be caused by massive stars, but rather depend on the gas density, (c) a close spatial relation between the PAH and molecular gas emission, but no predictive power of PAH emission for the molecular gas mass, (d) that the I-H color map is an excellent predictor of the distribution (and to a lesser degree the brightness) of CO emission, and (e) that the impact of massive (UV-intense) young star-forming regions on the bulk of the molecular gas in central ∼9 kpc can not be significant due to a complex spatial relation between molecular gas and star-forming regions that ranges from co-spatial to spatially offset to absent. The last point, in particular, highlights the importance of galactic environment – and thus the underlying gravitational potential – for the distribution of molecular gas and star formation.

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For more information on the PAWS project, preprints and public data access see http://www.mpia.de/PAWS

What determines the density structure of molecular clouds? A case study of Orion B with Herschel

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A key parameter to the description of all star formation processes is the density structure of the gas. In this letter, we make use of probability distribution functions (PDFs) of Herschel column density maps of Orion B, Aquila, and Polaris, obtained with the Herschel Gould Belt survey (HGBS). We aim to understand which physical processes influence the PDF shape, and with which signatures. The PDFs of Orion B (Aquila) show a lognormal distribution for low column densities until $A_v \sim 3$ (6), and a power-law tail for high column densities, consistent with a $\rho \propto r^{-2}$ profile for the equivalent spherical density distribution. The PDF of Orion B is broadened by external compression due to the nearby OB stellar aggregates. The PDF of a quiescent subregion of the non-star-forming Polaris cloud is nearly lognormal, indicating that supersonic turbulence governs the density distribution. But we also observe a deviation from the lognormal shape at $A_v > 1$ for a subregion in Polaris that includes a prominent filament. We conclude that (i) the point where the PDF deviates from the lognormal form does not trace a universal $A_v$-threshold for star formation, (ii) statistical density fluctuations, intermittency and magnetic fields can cause excess from the lognormal PDF at an early cloud formation stage, (iii) core formation and/or global collapse of filaments and a non-isothermal gas distribution lead to a power-law tail, and (iv) external compression broadens the column density PDF, consistent with numerical simulations.
HD depletion in starless cores
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Aims: We aim to investigate the abundances of light deuterium-bearing species such as HD, H₂D⁺, and D₂H⁺ in a gas-grain chemical model that includes an extensive description of deuterium and spin-state chemistry, in physical conditions appropriate to the very centers of starless cores.

Methods: We combined a gas-grain chemical model with radiative transfer calculations to simulate density and temperature structure in starless cores. The chemical model includes new reaction sets for both gas phase and grain surface chemistry, including deuterated forms of species with up to 4 atoms and the spin states of the light species H₂, H₂⁺, and H₃⁺ and their deuterated forms.

Results: We find that in the dense and cold environments attributed to the centers of starless cores, HD eventually depletes from the gas phase because deuterium is efficiently incorporated into grain-surface HDO, resulting in inefficient HD production on grains for advanced core ages. HD depletion has consequences not only on the abundances of, e.g., H₂D⁺ and D₂H⁺, whose production depends on the abundance of HD, but also on the spin state abundance ratios of the various light species, when compared with the complete depletion model where heavy elements do not influence the chemistry.

Conclusions: While the eventual HD depletion leads to the disappearance of light deuterium-bearing species from the gas phase on a relatively short timescale at high density, we find that at late stages of core evolution, the abundances of H₂D⁺ and D₂H⁺ increase toward the core edge, and the distributions become extended. The HD depletion timescale increases if less oxygen is initially present in the gas phase, owing to chemical interaction between the gas and the dust preceding the starless core phase. Our results are greatly affected if H₂ is allowed to tunnel on grain surfaces, and therefore more experimental data is needed not only on tunneling but also on the O + H₂ surface reaction in particular.
massive protostar in the Kleinmann-Low Nebula in Orion using imaging with laser guide star adaptive optics on the Keck II telescope. The infrared emission is evident in images acquired using $L'$ (3.8 $\mu$m) and $M_s$ (4.7 $\mu$m) filters and is not detectable at $K'$ (2.1 $\mu$m). The observed morphology strongly suggests that we are seeing some combination of scattered and thermal light emanating from the disk. The disk is also manifest in the $L'/M_s$ flux ratio image. We interpret the near-infrared emission as the illuminated surface of a nearly edge-on disk, oriented so that only the northern face is visible; the opposite surface remains hidden by the disk. We do not see infrared radiation associated directly with the star proposed to be associated with Source "I." The data also suggest that there is a cavity above and below the disk that is oriented perpendicular to the disk, and is sculpted by the known, strong outflow from the inner disk of Source I. We compare our data to models of a protostar with a surrounding disk, envelope, and wind-blown cavity in order to elucidate the nature of the disk around Radio Source I.

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Magnetic fields in cometary globules - IV. LBN 437
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We present results of our $R$–band polarimetry of a cometary globule, LBN 437 (Gal96-15, $\ell = 96^\circ$, $b = -15^\circ$), to study magnetic field geometry of the cloud. We estimated a distance of $360 \pm 65$ pc to LBN 437 (also one additional cloud, CB 238) using near-IR photometric method. Foreground contribution to the observed polarisation values was subtracted by making polarimetric observations of stars that are located in the direction of the cloud and with known distances from the Hipparcos parallax measurements. The magnetic field geometry of LBN 437 is found to follow the curved shape of the globule head. This could be due to the drag that the magnetic field lines could have experienced because of the ionisation radiation from the same exciting source that caused the cometary shape of the cloud. The orientation of the outflow from the Herbig A4e star, LkH$\alpha$ 233 (or V375 Lac), located at the head of LBN 437, is found to be parallel to both the initial (prior to the ionising source was turned on) ambient magnetic field (inferred from a star HD 214243 located just in front of the cloud) and the Galactic plane.

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Nature of the gas and dust around 51 Oph
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Circumstellar disc evolution is paramount for the understanding of planet formation. The GASPS program aims at determining the circumstellar gas and solid mass around ~250 pre-main-sequence Herbig Ae and T Tauri stars. We aim to understand the origin and nature of the circumstellar matter orbiting 51 Oph, a young (< 1 Myr) luminous B9.5 star. We obtained continuum and line observations with the PACS instrument on board the Herschel Space Observatory and continuum data at 1.2 mm with the IRAM 30m telescope. The SED and line fluxes were modelled using the physico-chemo radiative transfer code ProDiMo. We detected a strong emission by [O I] at 63 \mu m using the Herschel Space Observatory. The [O I] emission at 145 \mu m, the [C II] emission at 158 \mu m, the high-J CO emissions, and the warm water emissions were not detected. Continuum emission was detected at 1.2 mm. The continuum from the near- to the far-infrared and the [O I] emission are well explained by the emission from a compact hydrostatic disc model with a gas mass of 5 \times 10^{-6} M_\odot, 100 times that of the solid mass. However, this model fails to match the continuum millimeter flux, which hints at a cold outer disc with a mass in solids of 10^{-6} M_\odot or free-free emission from a photoevaporative disc wind. This outer disc can either be devoid of gas and/or is to cold to emit in the [O I] line. A very flat extended disc model (R_{out} = 400 AU) with a fixed vertical structure and dust settling matches all photometric points and most of the [O I] flux. The observations can be explained by an extended flat disc where dust grains have settled. However, a flat gas disc cannot be reproduced by hydrostatic disc models. The low mass of the 51 Oph inner disc in gas and dust may be explained either by the fast dissipation of an initial massive disc or by a very small initial disc mass.

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Water in star-forming regions with Herschel (WISH). IV. A survey of low-J H_2O line profiles toward high-mass protostars

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Context: Water is a key constituent of star-forming matter, but the origin of its line emission and absorption during high-mass star formation is not well understood.

Aims: We study the velocity profiles of low-excitation H_2O lines toward 19 high-mass star-forming regions and search for trends with luminosity, mass, and evolutionary stage.

Methods: We decompose high-resolution Herschel-HIFI line spectra near 990, 1110 and 1670 GHz into three distinct physical components. Dense cores (protostellar envelopes) are usually seen as narrow absorptions in the H_2O 1113 and 1669 GHz ground-state lines, the H_2O 987 GHz excited-state line, and the H_2^18O 1102 GHz ground-state line. In a few sources, the envelopes appear in emission in some or all studied lines, indicating higher temperatures or densities. Broader features due to outflows are usually seen in absorption in the H_2O 1113 and 1669 GHz lines, in 987 GHz emission, and not seen in H_2^18O, indicating a lower column density and a higher excitation temperature than the envelope component. A few outflows are detected in H_2O, indicating higher column densities of shocked gas. In addition, the H_2O 1113 and 1669 GHz spectra show narrow absorptions by foreground clouds along the line of sight. The lack of corresponding features in the 987 GHz and H_2^18O lines indicates a low column density and a low excitation temperature for these clouds, although their derived H_2O ortho/para ratios are close to 3.

Results: The intensity of the ground state lines of H_2O at 1113 and 1669 GHz does not show significant trends with source luminosity, envelope mass, or evolutionary state. In contrast, the flux in the excited-state 987 GHz line appears correlated with luminosity and the H_2O line flux appears correlated with the envelope mass. Furthermore, appearance of the envelope in absorption in the 987 GHz and H_2^18O lines seems to be a sign of an early evolutionary stage, as probed by the mid-infrared brightness and the L_{bol}/M_{env} ratio of the source.

Conclusions: The ground state transitions of H_2O trace the outer parts of the envelopes, so that the effects of star
formation are mostly noticeable in the outflow wings. These lines are heavily affected by absorption, so that line ratios of H$_2$O involving the ground states must be treated with caution, especially if multiple clouds are superposed as in the extragalactic case. The isotopic H$_2^{18}$O line appears to trace the mass of the protostellar envelope, indicating that the average H$_2$O abundance in high-mass protostellar envelopes does not change much with time. The excited state line at 987 GHz increases in flux with luminosity and appears to be a good tracer of the mean weighted dust temperature of the source, which may explain why it is readily seen in distant galaxies.

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Star formation in the luminous YSO IRAS 18345-0641

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Aims: We aim to understand the star formation associated with the luminous young stellar object (YSO) IRAS 18345-0641, and to address the complications arising from unresolved multiplicity in interpreting the observations of massive star-forming regions.

Methods: New infrared imaging data at sub-arcsec spatial resolution are obtained for IRAS 18345-0641. The new data are used along with mid- and far-IR imaging data, and CO ($J = 3 - 2$) spectral line maps downloaded from archives to identify the YSO and study the properties of the outflow. Available radiative-transfer models are used to analyze the spectral energy distribution (SED) of the YSO.

Results: Previous tentative detection of an outflow in the H$_2$ (1-0) S1 line (2.122 $\mu$m) is confirmed through new and deeper observations. The outflow appears to be associated with a YSO discovered at infrared wavelengths. At high angular resolution, we see that the YSO is probably a binary. The CO (3–2) lines also reveal a well defined outflow. Nevertheless, the direction of the outflow deduced from the H$_2$ image does not agree with that mapped in CO. In addition, the age of the YSO obtained from the SED analysis is far lower than the dynamical time of the outflow. We conclude that this is probably caused by the contributions from a companion. High-angular-resolution observations at mid-IR through mm wavelengths are required to properly understand the complex picture of the star formation happening in this system, and generally in massive star forming regions, which are located at large distances from us.

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Three dimensional geometries and the analysis of HII regions

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We compare emission line intensities from photoionization models of smooth and fractal shell geometries for low density HII regions, with particular focus on the low-ionization diagnostic diagram [NII]/Hα vs Hα. Building on previously published models and observations of Barnard’s Loop, we show that the observed range of intensities and variations in the line intensity ratios may be reproduced with a three dimensional shell geometry. Our models adopt solar abundances throughout the model nebula, in contrast with previous one dimensional modeling which suggested the variations in line intensity ratios could only be reproduced if the heavy element abundances were increased by a factor of 1.4. For spatially resolved HII regions, the multiple sightlines that pierce and sample different ionization and temperature conditions within smooth and fractal shells produce a range of line intensities that are easily overlooked.
if only the total integrated intensities from the entire nebula model are computed. Our conclusion is that inference of H\textsc{ii} region properties, such as elemental abundances, via photoionization models of one dimensional geometries must be treated with caution and further tested through three dimensional modeling.

Accepted by ApJ

http://arxiv.org/pdf/1304.1689

Proper motions of molecular hydrogen outflows in the $\rho$ Ophiuchi molecular cloud

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We aim to take a census of molecular hydrogen emission line objects (MHOs) in the $\rho$ Ophiuchi molecular cloud and to make the first systematic proper motion measurements of these objects in this region. Deep $\text{H}_2$ near-infrared imaging is performed to search for molecular hydrogen emission line objects. Multi-epoch data are used to derive the proper motions of the features of these objects, and the lengths and opening angles of the molecular hydrogen outflows. Our imaging covers an area of about $0.11^\circ$ toward the L1688 core in the $\rho$ Ophiuchi molecular cloud. In total, six new MHOs are discovered, 32 previously known MHOs are detected, and the proper motions for 86 features of the MHOs are measured. The proper motions lie in the range of 14 to 247 mas yr$^{-1}$, corresponding to transversal velocities of 8 to 140 km s$^{-1}$ with a median velocity of about 35 km s$^{-1}$. Based on morphology and proper motion measurements, 27 MHOs are ascribed to 21 driving sources. The molecular hydrogen outflows have a median length of about 0.04 pc and random orientations. We find no obvious correlation between $\text{H}_2$ jet length, jet opening angle, and the evolutionary stage of the driving sources as defined by their spectral indices. We find that the fraction of protostars (23%) that drive molecular hydrogen outflows is similar to the one for Class II sources (15%). For most molecular hydrogen outflows, no obvious velocity variation along the outflow has been found. In Ophiuchus the frequency of occurrence of molecular hydrogen outflows has no strong dependency on the evolutionary stage of the driving source during the evolution from the protostellar stage to the classical T Tauri stage.

Accepted by A&A

http://arxiv.org/pdf/1304.0195
The Current State of Cluster Formation Simulations

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Numerical simulations of star cluster formation have advanced greatly during the past decade, covering increasingly massive gas clouds while accounting for more and more complex physics. In this review, I discuss the present state of the field, paying particular attention to the key physics that need to be included in cluster formation simulations. The main numerical techniques are summarized for a broad audience, before evaluating their application to the problem of cluster formation. A faithful reproduction of the observed characteristics of cluster formation can presently be achieved in numerical simulations. Ideally, this requires turbulent initial conditions to be combined with radiative feedback, protostellar outflows, and magnetic fields. With the exciting prospect in mind that our understanding of cluster formation will soon be revolutionized by facilities like ALMA, JWST, and the EVLA, this review also identifies a number of areas that would particularly benefit from a joint observational and theoretical effort.

Keynote talk at the Sexten Workshop ”The Formation and Early Evolution of Stellar Clusters”

http://arxiv.org/pdf/1304.4600
New Jobs

Senior research fellow (planet formation) at Lund Observatory

Research on the formation and evolution of planetary systems is in rapid development, fueled by the wealth of new observational data and the advent of more and more powerful supercomputers. Lund University invites applicants to a researcher position within the topic of planet formation around the sun and around other stars.

The researcher will work on theoretical/computational models of planet formation around the sun and around other stars.

Applicants must have a PhD in astronomy or astrophysics and a proven track record in the research methods related to planetesimals, planet formation or exoplanets. Previous experience in computational astrophysics is an extra merit.

Part of the research can consist of own, independent projects. Please contact Anders Johansen (anders@astro.lu.se) for details.

The application should contain:

- A cover letter describing the applicant’s background and motivation for applying for the job
- A CV with information about previous positions (if applicable)
- List of publications
- Name and contact information of at least two reference persons

Applications should be submitted electronically - please follow this link: http://www.astro.lu.se/vacancies. The application deadline is 31 May 2013.

Infrared Instrumentation/Exoplanet Science

Infrared Astronomer/Instrumentation Scientist at Institute for Astronomy, ETH Zurich
Position/Title: Infrared Instrumentation/Exoplanet Science
Institution: Institute for Astronomy, ETH Zurich
Submit Resumes To:
Attention: Mrs. Marianne Chiesi
Institute for Astronomy, ETH Zurich
Wolfgang-Pauli-Strasse 27, HIT J 21.2
Star and Planet Formation Research Group
8093 Zurich, Switzerland
Switzerland
Tel: +41 (0)44 632 38 13
Job Description:
The Institute for Astronomy at the Swiss Federal Institute of Technology in Zurich (ETH Zurich) is searching for an infrared astronomer to help lead our Laboratory for Astronomical Instrumentation with a scientific focus on the search for, and characterization of extra-solar planets. Current projects include development of high contrast imagers and spectrographs in the infrared for existing large telescopes, as well as the next generation ELTs. Our group is involved in: i) SPHERE (a soon to be commissioned second-generation instrument for the VLT); ii) ERIS, a new infrared camera/spectrograph to take advantage of the new adaptive secondary for the VLT; iii) METIS (a planned mid-IR instrument for the E-ELT); and iv) EPICS (a proposed high-contrast instrument for the E-ELT). We are also involved in CHEOPS, a Swiss-led exoplanet characterization space mission, as well as the NIRCam and NIRISS instrument science teams for the NASA/ESA/CSA JWST. Key activities in the next two years include: a) design and testing of filters, grisms, and diffraction-suppression optics from 1-5 microns in support of the ERIS project; and b) work on METIS including local project management, hardware development, interface with department workshop and industry partners, and project level support.

International applications are invited for positions ranging from Postdoctoral Fellow to Assistant Scientist capable of directing the lab. Salary will be commensurate with experience (starting at CHF 85’300 to over CHF 100’000) with junior appointments for a minimum of two years, and up to six+ years for senior candidates. Successful applicants will have the opportunity to: i) carry-out independent research; ii) work with students and other members of the group; and iii) access the full resources of the Star and Planet Formation Research Group. Switzerland is a member of ESO and ESA, and successful applicants will have full access to their facilities, as well as data from ongoing programs utilizing the Spitzer Space Telescope, HST, Herschel, the VLT, and other telescopes.

Applications should consist of a CV, past research and instrumentation experience, and proposed future activities (combined length not to exceed 10 pages) with a separate publication list. These materials (as a single pdf file) as well as up to three letters of reference (directly from the referees) should be sent via email. Review of applications will begin immediately and continue until the position is filled.

Included Benefits:
The ETH will provide benefits for maternity leave, retirement, accident insurance, and relocation costs. Weblink: http://www.pa.ethz.ch/
RT13 Workshop on
Dust Radiative Transfer - Codes and Benchmarks
October, 9 - 11, 2013
Institut de Planetologie et d’Astrophysique de Grenoble IPAG, France

Scientific Advisory Committee:
M. Baes (Belgium), A.C. Carciofi (Brasil), K. Gordon (USA), M. Juvela (Finland), K. Misselt (USA), T. Robitaille (Germany), J. Steinacker (France)

Organized by J. Steinacker, K. Gordon & M. Baes.

Objectives of the workshop:
For many astronomical objects, the radiation carrying most of the information is heavily processed before it hits our telescopes. Cosmic dust particles are especially efficient in altering radiation due to absorption, scattering, and re-emission. Consequently, radiative transfer (RT) modeling of spectra and images is one of the basic standard technique of astrophysical research. Moreover, RT is an important physical process to transport energy and momentum, often controlling the energy balance of the object, or altering its appearance by radiation pressure.

Unfortunately, the solution of the dust RT problems is still one of the outstanding challenges in computational astrophysics due to its high dimensionality and the underlying integro-differential transport equation.

The workshops aims to be the major assembly of coders dealing with this non-linear and non-local problem dust RT. It aims to discuss the state-of-the-art, to highlight unsolved problems, to consider how benchmarks can test the codes, and to discuss what future perspectives are promising.

RT13 plans to address the following topics: Solution methods, resolution and grids, error control, acceleration, boundary conditions, thermal equilibrium and non-equilibrium, heating mechanisms, sublimation border, opacities, connection to other codes, fitting data, distributed codes, time-dependence.

Workshop location:
The workshop will be held in the IPAG main conference room in Grenoble. IPAG and IRAM form one of the centers for astrophysical research in Europe, with research themes spanning from planetary subsurfaces to the edge of the universe. Located in the Rhone-Alpes region, the proximity of the mountains, as well as its size, has led to Grenoble being known in France as the ”Capital of the Alps”. It can easily be reached by train from Paris, or by airplane via Lyon.

Logistics/Dates:
Relevant information about deadlines, registration, program etc. can be found at http://ipag.osug.fr/RT13/index.php
Registration is open.

The deadline for registration and abstract submission is the 31st of May 2013, 12:00 CET.
The number of participants is limited to 30. The Scientific Advisory Committee will decide about participation soon after the deadline.

There is no registration fee for RT13.
Looking forward to welcoming you in Grenoble
J. Steinacker, K. Gordon, and M. Baes
IAU Symposium 302 - Magnetic Fields Throughout Stellar Evolution
(Second announcement)

http://iaus302.sciencesconf.org

This is the second announcement for the Symposium 302 of the International Astronomical Union, entitled "Magnetic fields throughout stellar evolution". The conference will be held in Biarritz (France), 26-30 August 2013.

Presentation

Magnetic fields are key actors in the evolution of all stellar objects, through their ability to influence the angular momentum evolution, internal mixing or mass-loss of stars, as well as their activity phenomena or star-planet interactions. The present Symposium is aimed at offering a synthetic view of recent progresses in the young and growing domain of stellar magnetism. This research area is now benefiting from the rapid, combined development of observations and numerical simulations, enabling stellar physicists to take magnetic fields into account in most models of stellar structure and evolution.

Topics

- Stellar structure and evolution
- Magnetized accretion and outflows in young stellar objects
- Magnetic braking of PMS stars
- Solar and stellar activity in photospheres, chromospheres and coronae, and stellar cycles
- Magnetism in very low-mass stars and brown dwarfs
- Star-planet interaction
- Stellar dynamos across the HR diagram
- Magnetic field origin and stability in massive stars
- Magnetically-confined winds of massive stars
- Cool active subgiants and giants
- Dynamo and mass-loss in giant and supergiant stars
- Final phases of stellar evolution: magnetism in compact objects

Scientific Organizing Committee

Gibor Basri (Univ. California, USA), Matthew Browning (Univ. Toronto, Canada), Corinne Charbonnel (Geneva Observatory, Switzerland), Jose-Dias do Nascimento (Univ. Natal, Brazil), Siraj Hasan (IIA, India), Moira Jardine (Univ. Saint Andrews, Scotland, co-chair), Oleg Kochukhov (Univ. Uppsala, Sweden), Renada Konstantinova-Antova (Bulgarian Academy of Sciences, Bulgaria), Hiroaki Isobe (Univ. Kyoto, Japan), Stephen Marsden (James Cook University, Australia), Pascal Petit (Univ. Toulouse, France, chair), Sami Solanki (MPS, Germany), Henk Spruit (MPA, Germany, co-chair), Klaus Strassmeier (AIP, Germany), Asif ud-Doula (Penn State, USA), Gregg Wade (RMC, Canada)

Confirmed speakers

Jonathan Braithwaite - Sacha Brun - Rim Fares - Jason Grunhut - Gaitee Hussain - Oleg Kochukhov - Heidi Korhonen - Ryuichi Kurosawa - Norbert Langer - Francois Lignieres - Stuart Littlefair - Stan Owocki - Ralph Pudritz - Nanda Rea - Ansgar Reiners - Andreas Reisenegger - Karel Schrijver - Saku Tsuneta - Aline Vidotto - Wouter Vlemmings - Lucianne Walkowicz

Venue

The conference will be held at Casino Municipal, Biarritz (France). Situated on the French Atlantic coast, at the western end of the Pyrnes mountain range, Biarritz is a friendly and attractive town benefiting from the mild weather
of southern France. It can be easily reached by plane or train and offers more than 2,300 hotel rooms. With 6 km of beaches, Biarritz is the historical capital of surfing in Europe. You can also find there the secondoldest golf course in Europe, 5 thalassotherapy centres and a casino.

The town is just a stone’s throw away from Spain and is less than 150 km away from Bilbao and its famous Guggenheim museum. Biarritz is also located at less than 200 km from Bordeaux and its world-famous wineries. It is a perfect starting point to explore the Basque country, with its authentic countryside and charming villages. A half-day excursion will bring the participants to selected spots around the town, and the symposium diner will be the opportunity to enjoy French gastronomy.

**Accommodation**

Biarritz is very attractive during the month of August, and hotels get fully booked very early. We therefore very strongly recommend to book your hotel as soon as possible! A list of hotels is available here: http://iaus302.sciencesconf.org/resource/page/id/9

**Registration**

Registration fee is 350EUR per participant. The fee allows access to the conference venue, the welcome cocktail on Sunday night, the coffee breaks, four lunches, and a hard copy of proceedings. Additional fee is requested for conference dinner (40EUR) and Wednesday tours (20EUR).

The online payment interface is available here: http://iaus302.irap.omp.eu

Cancellations: Requests for cancellation with a 50% fee refund will only be accepted through 01 Jul 2013.

**Abstract submission**

Abstracts can be submitted at the following address: http://iaus302.sciencesconf.org/submission/submit

**Important dates**

- Abstract deadline for contributed talks: 13 May 2013
- Abstract deadline for posters: 21 Jun 2013
- Deadline for registration: 15 Jul 2013
- Deadline for proceedings submission: 30 Sep 2013

**Contact**

Any inquiry about the conference should be addressed to iaus302@sciencesconf.org

We hope to see as many of you as possible in Biarritz this summer!

Best regards,
the SOC and LOC
Evolution of Star Clusters: From Star Formation to Cosmic Ages
Splinter Meeting E at the Annual Meeting of the Astronomische Gesellschaft
24 - 27 September 2013, Tübingen, Germany

Scientific Rationale:
A large fraction of stars is born in clusters consisting of few tens to many thousands of stars, embedded in dense molecular gas. Most young clusters dissolve at an early stage, only few per cent may survive the embedded phase to become gravitationally bound open clusters. They dissolve over time due to internal and external mechanisms, but some of them survive for several Gyr. Star clusters contain various types of roughly coeval stars, making them excellent laboratories to study a wide range of processes from star formation over stellar evolution to galactic dynamics.

In recent years, many exciting new results from observations and models of star clusters have improved our understanding of their evolution but have also raised new questions and challenges. At this meeting, we would like to bring together observers and theoreticians for in-depth discussions on the evolution of star clusters addressing the following questions:

• Young star clusters
  – What is a representative initial density distribution? Is spherical symmetry a reasonable assumption?
  – Is the observed mass function universal? How strong is the dynamical impact on the mass function?
  – Is there evidence for primordial mass segregation? Is it possible to trace its effect at all?
  – Is the observed multiplicity of massive stars primordial?
  – Do young star clusters show bulk rotation?
  – How does our understanding of high-mass stellar evolution influence cluster ages?

• Open clusters
  – What fraction of young star clusters survive the embedded phase to become open clusters?
  – Do encounters with molecular clouds contribute to the dissolution process of open clusters?
  – What fraction of open clusters are supposed to have dissolved due to the Galactic tidal field?
  – Are the observed stellar mass functions of old clusters consistent with present-day star forming regions?
  – Do open clusters show multiple age stellar populations as found in globular clusters?

• Globular clusters
  – How can we explain the existence of multiple stellar populations?
  – How important are cluster dynamics for the formation of stellar exotica?
  – What is the impact of stellar exotica on the dynamical cluster evolution?
  – How do stellar exotica shape our understanding of stellar evolution?

Organisers:
Stefan Harfst, Christoph Olczak, Stefan Schmeja, Andrea Stolte

More information:
http://www-astro.physik.tu-berlin.de/~harfst/AG2013_SplinterE/
Meetings of Possible Interest

Ice and Planet Formation
15 - 17 May 2013 Lund Observatory, Sweden
http://www.astro.lu.se/~anders/IPF2013/

IAU Symposium 297: The Diffuse Interstellar Bands
20 - 24 May 2013 Noordwijkerhout, The Netherlands
http://iau297.nl/

Brown Dwarfs come of Age
20 - 24 May 2013 Fuerteventura, Canary Islands, Spain
http://bdofage.tng.iac.es/

The Origins of Stellar Clustering - from Fragmenting Clouds to the Build-up of Galaxies
26 May 2013 - 16 June 2013 Aspen, Colorado, USA
http://www.mpa-garching.mpg.de/~diederik/aspen2013

IAU Symposium 299: Exploring the Formation and Evolution of Planetary Systems
2 - 7 June 2013 Victoria, BC, Canada
http://www.iaus299.org

Massive Stars: From alpha to Omega
10 - 14 June 2013 Rhodes, Greece
http://a2omega.astro.noa.gr

Lin-Shu Symposium: Celebrating the 50th Anniversary of the Density-Wave Theory
24 - 28 June 2013 Beijing, China
http://events.asiaa.sinica.edu.tw/conference/20130624/

Physics at the Magnetospheric Boundary
25 - 28 June 2013 Geneva, Switzerland
http://www.isdc.unige.ch/magbound/

Protostars and Planets VI
15 - 20 July 2013 Heidelberg, Germany
http://www.ppvi.org

Dust Growth in Star & Planet Formation 2013
22 - 25 July 2013 MPIA, Heidelberg, Germany
http://www.mpia.de/DO13/

2013 Sagan Summer Workshop: Imaging Planets and Disks
29 July - 2 August 2013 Pasadena, CA, USA
http://nexsci.caltech.edu/workshop/2013/

IAUS 302 - Magnetic Fields Throughout Stellar Evolution
26 - 30 August 2013 Biarritz, France
http://iaus302.sciencesconf.org

Meteoroids 2013. An International Conference on Minor Bodies in the Solar System
26 - 30 August 2013 Dept. of Physics, A.M. University, Poznan, Poland
http://www.astro.amu.edu.pl/Meteoroids2013/index.php

Exoplanets and Brown Dwarfs
2 - 5 September 2013 de Havilland, University of Hertfordshire, Hatfield, Nr. London, UK
no web site yet
Evolution of Star Clusters: From Star Formation to Cosmic Ages
24 - 27 September 2013
Splinter Meeting E at the Annual Meeting of the Astronomische Gesellschaft, Tübingen, Germany
http://www-astro.physik.tu-berlin.de/~harfst/AG2013_SplinterE/

Dust Radiative Transfer - Codes and Benchmarks 9 - 11 October 2013
http://ipag.osug.fr/RT13/index.php

400 Years of Stellar Rotation
17 - 22 November 2013, Natal, Brazil
http://www.dfte.ufrn.br/400rotation/

The Life Cycle of Dust in the Universe: Observations, Theory, and Laboratory Experiments
18 - 22 November 2013 Taipei, Taiwan
http://events.asiaa.sinica.edu.tw/meeting/20131118/

The 18th Cambridge Workshop on Cool Stars, Stellar Systems and the Sun
9 - 13 June 2014 Flagstaff, Arizona, USA
http://www2.lowell.edu/workshops/coolstars18/

Living Together: Planets, Stellar Binaries and Stars with Planets
8 - 12 September 2014 Litomysl Castle, Litomysl, Czech Republic
http://astro.physics.muni.cz/kopal2014/

Towards Other Earths II. The Star-Planet Connection
15 - 19 September 2014 Portugal
http://www.astro.up.pt/toe2014

Other meetings: http://www1.cadc-ccda.hia-iha.nrc-cnrc.gc.ca/meetings/