THE STAR FORMATION NEWSLETTER

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

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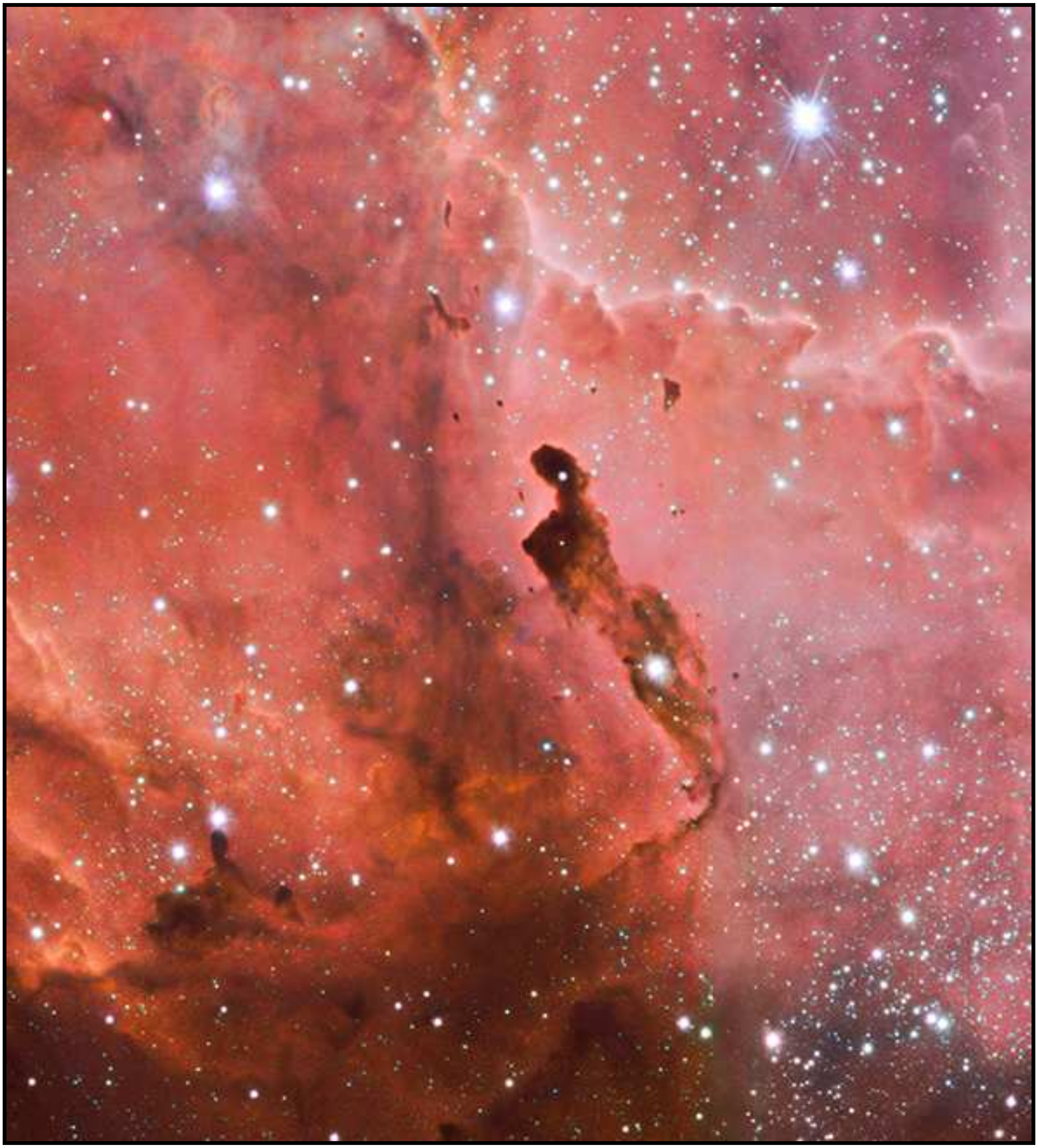

The Star Formation Newsletter

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

Newsletter Archive

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List of Contents

Cover Picture

The VLT Survey Telescope (VST) at ESO's Paranal Observatory has imaged large swaths of the southern sky, including a large mosaic of Messier 8, from which en enlargement of a prominent elephant trunk is shown here. Located at a distance of about 1.3 kpc, M8 is associated with the young (1-3 Myr) open cluster NGC 6530 containing several O stars and several dozen B stars. The elephant trunk shown here does not point to NGC 6530, but towards an isolated massive star in the eastern part of M8.

Image courtesy ESO/VPHAS+ team.

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

Francesco Palla (1954 – 2016)

The star formation community has been shocked and saddened by the passing of Francesco Palla, who unexpectedly died on January 26, in Rolle, Switzerland. He had just arrived to attend a meeting of the European Astronomical Society, of which he was to be named the new President the following day. The Newsletter has asked two people who knew him especially well, Daniele Galli (Arcetri) and Steve Stahler (U. C. Berkeley) to share their memories. For an account of Francesco's research career, in his own words, see the August 2014 issue.

DG: Let's begin at the beginning, Steve. How did you and Francesco first meet?

SS: In the summer of 1980, a month or two after I obtained my doctorate in physics from Berkeley, I received a postcard from Italy. Someone named Francesco wrote that, like me, he was going to Cornell in the fall to do research in star formation. I learned later that there had been a long connection between Arcetri and Cornell, forged by Franco Pacini in his famous collaboration on pulsars with Tommy Gold. In any case, Francesco suggested that we meet up. In September, I moved to Ithaca, and we soon met. Francesco later told me that he was very insecure about his English at the time, but I never noticed any problem. All I saw was someone who was as enthusiastic about the field as I was, and was extremely personable, as well. We immediately began intense discussions on how we could contribute. I remember long lunches and long walks. Our close personal friendship was also born then.

How about you? Tell me your own origins story.

DG: I vividly recall our first meeting. I was a graduate student, and went to see Francesco because he was going to be my research supervisor. We chatted in his office about star formation in the early Universe and the search for Population III stars. At one point, he asked me to follow him downstairs. I thought he was taking me to the library to show me some papers, but he passed by the entrance and went outside. When we reached the parking lot, he handed me a pair of pliers and asked me to help him replace the steel wire connecting the brakes to the handle of his motor scooter. Perhaps this was some kind of entrance exam. If so, it was an easy one, because Francesco's manual skills were not great! The noise and smoke from this old motorino had announced his arrival at the Observatory for many years. But soon after our repair, it breathed its last while attempting to climb the long Arcetri hill.

Later, Francesco sent me to Berkeley to work with Frank Shu. I will always be grateful to him for having given me this opportunity. After I returned, we resumed research on the chemistry of the early Universe. We published an article that was honestly nothing special, but nevertheless is the most cited of all my papers, and the fourth most cited of Francesco. The project was exhilarating for both of us, since it led to our meeting many colleagues from abroad. Some, who were still students at the time, later became quite attached to Francesco (a common occurrence), and therefore to me as well.

SS: Yes, Francesco made friends with remarkable ease. He was so outgoing and curious that it was impossible not to like him.

DG: Agreed. But returning to his extramural life, I recall that you and Francesco once performed on stage together.

SS: For some years during the 1980s, I was part of a comedy/music group that played at various places in New England. There was a U.S. election in 1984, and the group's leader, David, decided he would announce his bid for President during a performance at a church in Cambridge. He asked me to nominate him, and I insisted on doing this with Francesco, who was then visiting me at CfA. David was a bit puzzled, but agreed.

When Francesco and I took the stage, I began a dull speech extolling David's many presidential qualities. Simultaneously, Francesco translated my remarks into Italian. Like David, the audience was baffled and a bit embarrassed. There were just a few scattered chuckles. Gradually, the correspondence between my English speech and Francesco's Italian version began to slip. When I spoke a few words, Francesco would turn them into a paragraph, and vice versa. Now we were getting real laughs, and they kept building right to the end. After the show, a beaming Francesco gave me a bear hug; he was ecstatic. For years afterward, he displayed the advertising poster in his Arcetri office.

DG: Writing your tome, The Formation of Stars, must have been quite an undertaking. Francesco and I shared an office during that time, and it was crammed with his notes and drafts of chapters. Big vertical folders labeled 'The Book' kept adding up on the shelves. Once we measured the length of this growing pile; it was two meters! My fondest memory is of Francesco standing at the office window, copying a collage of maps onto tracing paper taped to the window. Did you know this was the high-tech system used to produce some of your four hundred figures?

SS: I'm not surprised. Writing our book, a task that required ten years, was the most difficult thing either of us had ever attempted. There was an enormous amount of information to be collated and somehow organized into a coherent whole. When we began, in 1993, there was email but no Web, so looking up references was slow and tedious. I remember telling Francesco that I felt like an ant crawling along the Great Wall of China. I knew that an end existed in theory, but could not even imagine attaining that goal. We both often fell into despair, but always recovered and pushed on, concentrating on the immediate task at hand rather than the distant goal.

During that decade, we traded visits frequently, and I spent long periods with Francesco, his wife Sylvie, and their two growing daughters. I immersed myself not only in star formation, but also in the Italian culture and language. When it was all over, we were exhausted and happy. After our publisher, Wiley, sent Francesco the first printed copies, he wrote 'This is the best present of my life!'

All this was meant to be Phase I. Two years ago, we started writing the second edition of our book. Naturally, things went more quickly than the first time; we were building on a solid foundation . After much experimentation, we had worked out a smooth and efficient system for the writing. Both of us were very excited to revise both the text and figures, reflecting the big advances in our field. Tragically, this process was cut short with Francesco's passing.

DG: You mentioned Francesco's family, and I want to add how devoted he was to them. Even when he was director of the Observatory (2005-2011), their care was always his primary concern. I remember his radiant expression every time he talked about Barbara and Arianne, their studies and their future. He was the official cook at home, and quite a good one. Indeed, he cared for two families, because he often traveled to Rome to see his parents and brother. In some periods, he spent more time in Rome than in Florence.

SS: Francesco was more than a good cook. He was a proud Roman who loved both the food and other delights of his country. More generally, he was a man of deep and broad cultural interests: art, music, film, politics, and literature. (We were always trading books.) This description makes him sound like a snob, but he was just the opposite. In art, for example, he loved and knew well the Renaissance treasures of Florence. But he also delighted in modern works. During my last visit, Francesco and Sylvie showed me and Linda the Rose Garden overlooking the city. Newly featured were works by the sculptor Folon, spare and witty. Francesco told me that Folon was his favorite contemporary sculptor, and I immediately saw why.

DG: And don't forget history. With others, Francesco fashioned a replica of one of Galileo's telescopes at the Museum of Science in Florence. It was impressive seeing the Moon and planets exactly as Galileo first did. Francesco also loved playing the historical detective. During a recent visit to a friend in a country house near Florence, he saw an old piano and asked about it. To his surprise, he was told that this piano was originally owned by Albert Einstein, who gave it as a gift to his sister Maja. Francesco immediately dove into the full, tragic story. He eventually wrote a beautiful essay, 'Einstein's Piano,' that will appear this spring in 'Il Colle di Galileo' (The Hill of Galileo), a semi-annual publication from Arcetri that Francesco helped launch.

SS: I enjoyed that essay, and I know that Francesco spoke about the piano at other observatories. He was a gifted speaker, and loved to excite others, especially the general public, about astronomy. Daniele, you can say more about this side of our friend.

DG: Francesco was a passionate teacher and communicator who used many approaches. He organized astronomy courses for high school students, rewarding them at the end with a trip to an observatory in Italy or Spain. Here in Arcetri, he was in charge of the public outreach program. He started a summer festival of astronomical activities, including not only public talks, but also book presentations, short films, and concerts, followed by observations with our old refractor. In his own talks, he always placed astronomy in the broader cultural landscape. When Francesco was the main speaker in our open-air theater, a full house was guaranteed, since his enthusiasm was contagious. He was, as we say in Italian, "una bella persona".

Rolf Chini

in conversation with Bo Reipurth

Q: *You got your PhD on a study of young stars in dark clouds. What were the main results?*

A: I started my PhD in 1976 at the Max-Planck-Institute for Astronomy in Heidelberg with Hans Elsässer. My subject was *Young Stellar Objects in Dark Clouds and HII Regions* and this research was driven by a new image tube camera which allowed imaging at 0.70 and 0.9 μm – at that time a major step forward. With this camera I investigated a number of star forming regions from dark clouds to HII regions. In particular the I-band option brought us beyond the Palomar R survey, which was for decades the treasure box for the star formation community, and allowed us to image for the first time deeply embedded objects and stars with IR-excess.

Q: *You have had a lifelong interest in M17, and have published many papers on this region. What have you learnt?*

A: In fact, M 17 was the major star forming region in my thesis. When I started, neither its distance nor its exciting stars were known, despite the fact that M 17 is an optically bright HII region and one of the strongest radio sources in the sky. Likewise, the bright and extended IR peak and the radio peak are displaced from the Hα peak, suggesting that a substantial fraction of the HII region must be hidden behind a dense dust cloud.

There were various distance estimates until 1976 which placed M 17 within a range of 0.8 – 2.9 kpc. I am proud to say that the old-fashioned photometric distance from my thesis (2.2 ± 0.2 kpc) persisted over three decades and was recently corroborated by sophisticated trigonometric maser parallaxes. Concerning the exciting stars I found dozens of heavily embedded O- and early B-type stars, sufficient to explain the energy balance of M 17. As observational techniques advanced, IR-imaging showed that the majority of medium-to-low mass stars in M 17 had circumstellar dust emission, making this cluster one of the youngest high-mass aggregates known in the Galaxy.

Q: *You have vigorously pursued the question of abnormal extinction in star forming regions. Is this a common phenomenon?*

A: The abnormal reddening law I found in M 17 was not welcomed by my supervisor Elsässer; shortly before, he had published a paper claiming that R, the ratio of total-to-selective extinction, was uniform across the Galaxy and that its numerical value was 3.1. He encouraged me to not publish my result of $R_{\rm M\,17} = 4.2$ with the words: "Don't touch the dust – there are brighter guys than you who failed with this issue." His remark was aimed at Harold Johnson who misinterpreted the IR-excess of some young stars in Orion as due to an abnormal extinction law. I published anyway.

After M 17 we investigated other HII regions and dark clouds with qualitatively similar results: $R > 3.1$. From what we believe to know about star formation, grain growth is certainly a process that happens in a collapsing cloud. The properties of protoplanetary disks also point in this direction. Therefore, it is evident that the grain size distribution in star forming regions must be different from that of the diffuse interstellar medium. I should mention that the normal $R = 3.1$ value would have yielded a wrong distance of M 17.

Q: *Back in 1993 you discovered a Class 0 source, at the same time as the famous André, Ward-Thompson, Barsony paper. How did that come about?*

A: This discovery was achieved with our first 7-channel bolometer camera operating at 1300 μm and attached to the 30 m IRAM telescope. We were searching for disks around HH energy sources. In the course of this survey we discovered a strong, previously unknown source of dust emission near HH 24 which was later named as HH 24 MMS. Subsequent observations at 450, 800, and 1100 μm were carried out at the James Clerk Maxwell Telescope on Mauna Kea, Hawaii and yielded a very low dust temperature of 10 K. These observations led us to suggest that we had detected a cold and gravitationally unstable cloud fragment which might be a protostar.

Q: *You were among the first to use submillimeter array detectors to map star forming regions, like OMC 2-3 and Corona Australis. Please tell more about this work.*

A: At the Max-Planck-Institute for Radioastronomy in Bonn we were one of the leading groups in building bolometers for the mm/submm range. In the very beginning we travelled with our single-channel bolometers from one optical observatory to the next because there were no dedicated submillimeter telescopes around. However, working with 2 – 4 m class telescope meant: low spatial resolution (arcminutes) and poor sensitivity (Jansky). With time the situation improved tremendously in two aspects: First, it was possible to increase the number of bolometers leading to small arrays of 7 and 19 channels. Second, the 30 m IRAM telescope came into operation and suddenly we enjoyed a resolution of 11" and a sensitivity to detect faint sources of a few mJy. Now we were in a position to map huge dark cloud complexes and search systematically for cold, dense dust fragments or even collapsing protostars.

Obvious regions for this purpose were the huge molecular clouds in Orion. Our 1300 μm maps revealed extended filamentary structures with at least 11 embedded condensations in OMC-2 and 10 in OMC-3. As it turned out by subsequent spectroscopy and MIR imaging, not all of them were classical protostars; there was also a number of Class-I and Class-II sources with disks and outflows. Six close MIR binary sources could be resolved at locations where existing (sub)mm maps only show single emission peaks.

Some years later the Swedish-ESO-Submillimetre Telescope (SEST) was built at La Silla and gave us the opportunity to explore the southern sky. ESO asked us to build a bolometer array as a facility instrument for the SEST; this led to the construction of a 37-channel system operating at 1200 μm and yielding a resolution of 24". With these specifications it was possible to conduct systematic surveys of southern dark clouds, one of them being the R Coronae Australis Cloud. Within an area of 2000" $\times$ 1000" we detected 25 dust emission peaks. Interestingly, some of them – similarly as in OMC-2 and 3 – were offset from CO peaks.

Q: *Back in 2004 you discovered a massive protostar in M17 with a circumstellar disk. What is known about this object and what are the implications?*

A: As mentioned before M 17 is one of my favourite objects for studying the formation of high-mass stars. The NIR camera ISAAC at the ESO VLT gave me the opportunity to mosaic the M 17 cluster at three wavebands. Apart from hundreds of cluster members the images showed a huge, flared silhouette disk with a diameter of 20,000 AU. A second morphological structure was an hourglass-shaped nebula perpendicular to the plane of the disk. Its spectrum was dominated by emission lines of Hα, the Ca II triplet, and He I which provide indirect evidence for ongoing accretion from the inner disk onto a central star. Adaptive optics imaging at 2.2 μm showed an elongated central feature (maybe a high-mass binary?) from where two perpendicular jets emerged. All these observations point towards the formation of a high-mass object.

On the other hand, all submm/radio data existing so far – among them various molecular data from the silhouette disk – yielded inconsistent or even negative results, like e.g. an early ALMA observation. Therefore, reliable interferometer data are urgently required to obtain the mass of this huge disk and its kinematics.

Q: *Most recently you have completed a major survey for spectroscopic binaries among massive stars. What are the implications for massive star formation?*

A: Using our high-resolution spectrograph BESO which is a clone of ESO's FEROS instrument we have performed a complete survey of about 250 southern O and 540 B-type stars. In the first place, our survey was aimed at studying the multiplicity among high-mass stars rather than investigating individual systems in detail. The major result was that more than 80% of the stars with masses above 16 solar masses form close binary systems while this fraction drops to 20% for stars of 3 solar masses. The high frequency of close pairs with components of similar mass argues in favour of a multiplicity originating from the formation process rather than from a tidal capture in a dense cluster. Likewise, the low orbital periods of a couple of days suggest that these high-mass binaries will undergo mass transfer and might finally merge into a single object.

Meanwhile we have studied some of these systems in more detail. Interestingly, in all cases the radial velocity curves yield evidence for further, unseen companions suggesting that many high-mass binaries are even systems of higher multiplicity.

Q: *You have several small robotic telescopes at Cerro Armazones in Chile. What do you use them for?*

A: In 2006 the Ruhr-University Bochum in collaboration with Universidad Católica del Norte, Antofagasta, started to construct a small observatory on a side-hill of Cerro Armazones. At an altitude of 2817 m we operate meanwhile five telescopes from 15 cm to 1.5 m. The observatory is powered by regenerative energies and is connected via a fast 1 Gb/s fiber link. This allows a remotely-controlled operation for most of the telescopes. There are various optical cameras and an IR camera provided by the Institute for Astronomy, Hawaii, plus the above-mentioned high-resolution spectrograph BESO.

The major purpose of this observatory is to perform long-term projects like variability studies or huge imaging surveys. The Bochum Galactic Disk Survey monitors the southern Galactic disk in a strip $\pm 3°$ simultaneously in various filters. The survey covers a brightness range from 6 to 18 mag and the typical number of frames for individual fields is about 250; this ongoing project started in 2009.

Additionally the observatory provides an ideal opportunity to train students in all aspects of astronomical observing techniques including practical issues like producing liquid nitrogen and cooling the various cameras.

Perspective

The EXor Phenomenon

Dario Lorenzetti

1. Introduction

Young stellar objects (YSOs) of low-to-intermediate mass (0.5-8 $M_\odot$) accumulate most of their final mass during the so-called main accretion phase, lasting about 10^5 yrs. After this protostellar stage, the stars appear as pre-main sequence objects and the mass accretion process continues at lower rates from their circumstellar disks. According to a widely accepted picture, the material moves through the viscous disk and eventually falls onto the stellar surface following the magnetic interconnection lines (Shu et al. 1994). Observations show that the disk accretion process takes place through rapid and intermittent outbursts, usually detected at optical and near-IR wavelengths, which can be related to a sudden increase of the mass accretion rate by orders of magnitude (e.g. Hartmann & Kenyon 1985). Although only a minor fraction of the total mass is accumulated during these last disk accretion events, nevertheless an in-depth study of them is crucial to understand how the accretion process eventually halts (thus determining the observed Initial Mass Function), and also because these bursts substantially alter the physical and chemical properties of the circumstellar environment, which has major effects on the formation of proto-planetary systems around young stars.

A small and irregular photometric variability (typically 0.2-1 mag) attributable to disk accretion is a defining feature of all the classical T Tauri stars (CTTSs). However, several young sources display powerful outbursts of much larger intensity (up to 4-5 mag). These objects are usually classified into two major classes (see also the review by Audard et al. 2014): (1) FUors (Hartmann & Kenyon 1985) characterized by bursts of long duration (tens of years) with accretion rates of the order of 10^{-4}-10^{-5} $M_\odot$ yr^{-1} and spectra dominated by absorption lines; (2) EXors (Herbig 1989) with shorter outbursts (months–one year) with a recurrence time of years, showing accretion rates of the order of 10^{-6}-10^{-7} $M_\odot$ yr^{-1}, and characterized by emission line spectra (e.g. Herbig 2008, Lorenzetti et al. 2009, Kóspál et al. 2011, Sicilia-Aguilar et al. 2012, Antoniucci et al. 2013a). Such features make EXors the ideal candidates to investigate their quiescence vs. outburst properties with the same instrumentation on relatively short time scales, thus allowing evolutionary studies (based on individual objects) more than statistical ones (based on a class of different sources).

So far, around two dozens EXor systems are known which can be grouped into two sub-classes: the classical EXor (Herbig 1989, 2008), and the new identifications (see Audard et al. 2014 and Lorenzetti et al. 2012 for the list of references). Historically, the first group was identified in the visual band and, consequently, these accretion-disk systems are essentially unobscured (i.e. without significant envelopes). Later, the increasing availability of near-IR facilities quite naturally favoured the identification of more embedded eruptive variables, typically associated with an optical-IR nebula (second sub-class). The membership to this latter class often relies on sporadic events and does not stem from a comprehensive analysis aimed at checking whether the object presents all the properties typical of the classical prototypes (i.e. repetitive outbursts, rapid brightening and slower fading, colors pre- and post-outburst). In this scenario, the classical EXors, having already emerged from their dust cocoons, might be associated with later phases of the pre-main sequence evolution.

Currently, doubts exist about the classification as EXor or FUor of some recently detected outbursts (see e.g. the case of V2493 Cyg - Miller et al. 2011; Semkov & Peneva 2010; Kóspál et al. 2011). Sometimes even the origin of the observed variability (accretion or extinction driven) is matter of debate (see e.g. the case of GM Cep - Sicilia-Aguilar et al. 2008; Xiao et al. 2010). These dubious circumstances arise from observations often relying on a single event and not on a long lasting photometric and/or spectroscopic monitoring.

The nature of EXors is still very uncertain: *i*) they resemble CTTSs in quiescence (e.g. Lorenzetti et al. 2007, Sipos et al. 2009); *ii*) they could represent an intermediate stage between the strong FUor eruptions and the more quiescent CTTSs, or, alternately, an enhanced version of the latter class (see Figure 1 - Herbig 1977; Hartmann et al. 1993); *iii*) one could speculate that EXor events represent an infrequent manifestation of a rather common phenomenology displayed by all CTTSs. In this context, the rarity of EXor objects could be due to the lack of systematic monitoring.

EXORCISM: A Monitoring Program

The very uncertain picture that emerges when interpreting the EXor events depends not only on the small number of known EXor objects, but stems also from the lack of a proper long-term multi-wavelength monitoring and from the fact that only a limited number of studies were able to analyse photometry and/or spectroscopy of the outburst phase and compare it (at least partially) to quiescence phases. For these reasons, our group started an observational program dubbed EXORCISM (EXOR optiCal and Infrared Systematic Monitoring - Antoniucci et al. 2014) that is intended to perform a photometric and spectroscopic monitoring in the range 0.4-2.5 μm of about 30 objects identified as known eruptive variables or candidates. Some results of this project will be commented on in the following.

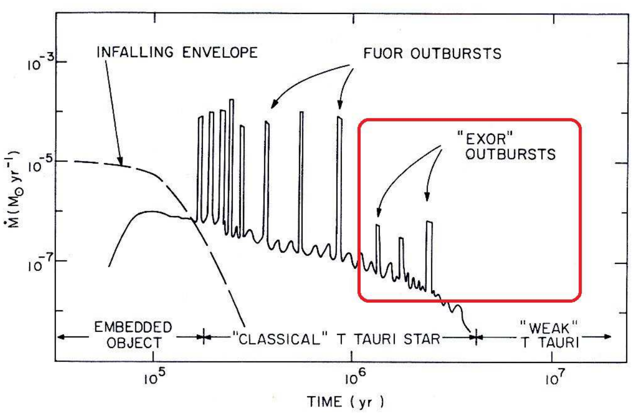

Figure 1: Schematic illustration of the variation of the mass accretion rate vs. time for a young star. EXor events are framed in red. (*Adapted from Hartmann et al. 1993*).

2. Theoretical View

Indeed, no detailed analysis or modelling of the disk structure in EXors has been performed so far, thus all the theoretical ideas cited below originate from efforts to explain the FUor events. Nowadays the most successful model remains that by Hartmann & Kenyon (1985): accretion matter viscously migrates through the circumstellar disk toward its inner edge from where this matter is intermittently channelled along the magnetic field lines to the central star; the fall onto the stellar surface produces a shock that cools by emitting a hot continuum. More recently, D'Angelo & Spruit (2010) provided quantitative predictions for the episodic accretion of piled-up material at the inner edge of the disk whenever this crosses the co-rotation radius; they also give indication that the cycle time of the bursts increases with a decreasing accretion rate. However, the mechanism responsible for the onset of EXor accretion outbursts is not known: two proposed scenarios involve essentially *i*) disk instability and *ii*) perturbation (of the disk) by an external body. While gravitational instabilities (e.g. Adams & Lin 1993) is unlikely to account for the observed short time-scale of the photometric variations, the thermal ones (Bell & Lin 1994) offer a more acceptable explanation. They occur when the disk temperature reaches a value of about 5000 K and its opacity becomes a strong function of any (even very small) temperature fluctuation. Thermal models, however, present some difficulties and limitations mainly dealing with the unrealistic constraints to impose on the disk viscosity. As a consequence, other relevant mechanisms have been considered, such as the presence of a massive planet that opens up a gap in the disk (Lodato & Clarke 2004) able to trigger thermal instabilities at the gap itself. Alternatively, accretion bursts can be caused by an external trigger such as a close encounter in a binary system (Bonnell & Bastien 1992; Reipurth & Aspin 2004). Indeed, many EXors are binary systems and a small body has been recently detected by Kóspál et al. (2014) as close as 0.06 AU from the central star EX Lup that is considered just the prototype of the EXor class.

3. Observational View: quiescence vs. outburst

A large part of the literature on EXor systems concerns observational studies typically dealing with individual objects, whereas fewer papers investigate significant (sub-)samples of the whole class; nevertheless it is still possible to recognize some common traits among different sources. In the following a limited set of observational data will be mentioned by assembling them per spectral band and trying to identify the relevance of each of them in building-up a consistent framework of the EXor phenomenology.

3.1 High-Energy

Although strong X-ray emission is typical for young stars (Feigelson & Montmerle 1999), few data exist for the EXor variables. In particular, debate exists on whether the X-ray emission is due to the accretion shock and, as such, correlates with outburst and fading, or, alternatively, it is a result of the coronal activity and thus unrelated to any accretion-driven fluctuations. Unambiguous results have been obtained by Kastner et al. (2004) and Teets at al. (2012), who monitored the source V1647 Ori during the increasing and decreasing phases, respectively. A strong correlation is found between the decreasing optical and X-ray fluxes following the peak of the outburst in the optical, which suggests that the declining fluxes in both bands are the result of a declining accretion rate. However, the membership of V1647 Ori to the EXor class (instead of the FUor one) is debated (Aspin et al. 2011). The X-ray observational scenario for sources recognized as true EXors is not any clearer. The prototype EX Lup shows a soft X-ray spectral component most likely associated with accretion shocks. The hard X-ray component is most likely associated with a smothered stellar corona (Grosso et al. 2010). The return to quiescence of the classical EXor V1118 Ori displayed a correlation between the decreasing optical/near-IR and X-ray fluxes (Lorenzetti et al. 2006; Audard et al. 2005). However, the (coronal) plasma temperature was variable with some indication of a cooling in the early phase of the outburst with a gradual return to normal values (Audard et al. 2010). Further X-ray observations triggered by optical burst events, and thus simultaneous (as much as possible) with them, are in order to firmly ascertain whether or not plasma temperature can be considered a parameter sensitive to the mass accretion.

3.2 Optical and near-IR

3.2.1 Photometry - Optical (UBVRI) and near-IR (JHK) photometric data are widely used to build-up:

- light-curves of individual EXors. Such plots illustrate the different phases of the outburst process: *i*) duration and recurrence of the events (e.g. Aspin et al. 2010, 2011; Hillenbrand et al. 2013), sometime evidencing how the flux increase is typically more rapid than the subsequent fading (e.g. Kóspál et al 2011); *ii*) the appearance of spikes, attributed to hot/cool spots onto the stellar surface (Tackett et al. 2003); *iii*) the shapes of the flux variations that allow to distinguish between true EXors and UXors objects (e.g. Grinin et al. 2000; Kóspál et al. 2013; Miller et al. 2011); *iv*) clues of some temporal lag shown by two EXors between light-curves in different bands (Lorenzetti et al. 2011), that, if confirmed by future observations, indicates that a common property (e.g. grains thermal capacitance) regulates the emitting matter response of all EXor sources; *v*) a small scale variability related to some periodicity, intermittent obscuration by geometrical effects are often observed in connection with accretion events, but it will not be discussed in the following.

- Spectral Energy Distributions (SEDs). Given the intrinsic nature of an EXor system (typically composed of a visible star and its circumstellar accretion disk), optical and near-IR photometry form an important part of their SEDs. Very often, quiescence and outburst SED are jointly presented to evaluate the differences between both states: L_{bol} typically increases from 1-2 (or even fractional values) to tens of $L_\odot$. (e.g. the cases of V2493 Cyg - Kóspál et al. 2011, V1118 Ori - Lorenzetti et al. 2006, EX Lup - Sipos et al. 2009). Also the shape of the SED changes, becoming bluer while the source brightens. The differential SED between the outburst and the quiescence can be well fitted with a single blackbody component with temperatures varying from 1000 K to 4500 K and emitting radii of 0.01 to 0.1 AU, as if an additional thermal component appears during the outburst phase (Lorenzetti et al. 2012). A hotspot model can fit the outburst SED, although large coverage factors are required (Audard et al. 2010). To extend such analysis to the entire sample is mandatory to better investigate the origin of the observed evidence. Notably, many EXors are optically invisible in quiescence, suggesting that a variable extinction may have also a role.

- Color-color and color-magnitude diagrams are reliable and widely used tools to evaluate the main mechanism(s) responsible for the SED evolution. Optical and near-IR plots both show that all the EXors (classical and candidates) are bluer when brighter, likely indicating that a hotter stellar component prevails during the most active phases while a colder disk dominates the least active phases. However, the plots based on optical colors are sensitive to the extinction parameter A_V toward the objects, hence well suited to determine its variations during the different phases. Conversely, near-IR diagrams ([J-H] vs. [H-K] - see Figure 2) clearly demonstrates that those color variations are not related to extinction phenomena, but are likely due to temperature stratifications (Lorenzetti et al. 2012). Two main differences are recognizable between classical and new EXors: the latter occupy a redder portion of the plot, and their color fluctuations are larger. The first is an obvious consequence of their location within more obscured regions, being often associated with IR nebulae (Connelley et al. 2007); the second one stems from the fact that the new source events were followed entirely in the near-IR from quiescence to outburst, thus providing the full (i.e. maximum) range of color variations.

3.2.2 Spectroscopy - A large database of low ($\mathcal{R} \lesssim 2000$) and high ($\mathcal{R} \gtrsim 10000$) resolution spectra (both optical and near-IR) has been collected so far that allows a meaningful comparison between pre-outburst, outburst, and post-outburst phases.

- Optical spectroscopy - Collection of many spectra of the same source (see e.g. the cases of the prototype EX Lup - Sicilia-Aguilar et al. 2012 and the new candidate V2492 Cyg - Hillenbrand et al. 2013). In both quiescence and outburst many permitted emission lines are present (e.g. CaII, HeI), which (together with Balmer HI recombination lines) are used as a proxy for deriving estimates of the accretion luminosity (L_{acc}) and the mass accretion rate (Alcalá et al 2014; Antoniucci et al. 2011): typical values of this latter parameter span from 10^{-10}-10^{-8} $M_\odot$ yr^{-1} in quiescence to 10^{-8}-10^{-6} $M_\odot$ yr^{-1} in outburst (Audard

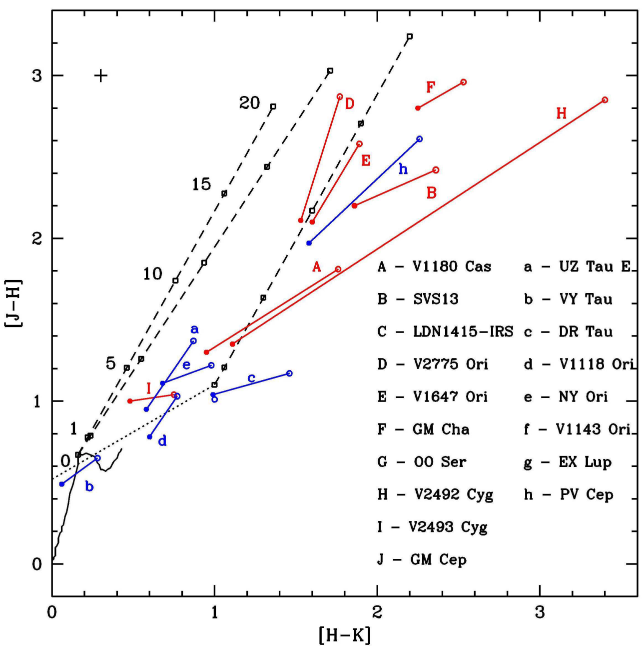

Figure 2: Near-IR two-colors plot of classical (blue) and new candidates (red) EXor in two different epochs. The solid black line (low left corner) marks the unreddened main sequence, whereas the dotted one is the locus of the T Tauri stars (Meyer et al. 1997). The dashed lines represent two reddening laws (Rieke & Lebofsky 1985 and Cardelli et al. 1989). Solid (open) circles identify the outburst (quiescence) colors. Cassical EXor overlap much better with the T Tauri locus.

et al. 2010; Lorenzetti et al. 2015; Sicilia-Aguilar et al. 2012). An active chromosphere can explain the metallic neutral and ionized lines (mostly FeI and FeII) typical of quiescence and narrow outburst components (v_{peak} = 5-10 km/s), whereas broad component profiles (v_{peak} = 50-200 km/s) suggest they originate in hot dense accretion columns that suffer velocity variations. The similarity between the pre-outburst and post-outburst states suggest that the accretion channels are similar during the whole period, and only the accretion rate varies. Photospheric signatures (typically LiI λ6707) observed at high S/N are typically highly veiled, hence used to evaluate this parameter that shows values up to 20 (Alencar et al. 2001). The most embedded EXors display several TiO/VO band heads in emission, indicating an amount of dense ($> 10^{10}$ cm^{-3}), warm (1500-4000 K) circumstellar material (Covey et al. 2011).

During the outburst, the number of emission lines increases dramatically, showing strong intensity variations and largely asymmetric profiles that testify a dynamic interaction between star and disk (Aspin & Reipurth 2009). P-Cyg profiles (both direct and inverse) indicate the presence of ejection and accretion flows at velocities up to hundreds km/s. Accurate correlations between accretion and ejection signatures investigated at high spectral resolution will be fundamental to ascertain quantitative relationships between both phenomena. Forbidden line emission (such as [OI], [SII], [FeII]) is often detected on the continuum source position and in some cases also offset from that. These lines exhibit blueshifted profiles and trace the shocked gas accelerated by protostellar winds and jets which are usual by-products of the accretion process.

- Near-IR spectroscopy

In this spectral range one finds the Paschen and Brackett HI recombination lines that represent a complementary probe to the Balmer ones to investigate the mass accretion rate variability, especially for highly obscured EXors. In such cases (see e.g. V1647 Ori - Aspin et al. 2008), near-IR spectroscopy is the only mean to identify photospheric absorption features that allow to constrain the classification of the young star. Paδ and Brγ emission lines share the same upper levels (7-3 and 7-4 transitions, respectively), hence, neglecting collisional effects, their strength ratio depends only on atomic physics parameters. This is the reason why such a ratio provides an estimate of the extinction (A_V) toward the star (Covey et al. 2011). The same is true for the [FeII] lines at 1.25 and 1.64 μm, but their forbidden nature make them ideally suited to trace the extinction in less dense and shocked regions (jets, HH objects) often found around EXors (Aspin et al. 2008, Reipurth & Bally 2001, Giannini et al. 2015). HeI 1.08μm provides evidence for a substantial wind associated with the outburst of both classical (DR Tau - Edwards et al. 2003) and new EXors (V2492 Cyg - Covey et al. 2011), showing strong blueshifted absorption out to about 300 km/s which dips to more than 50% of the continuum level. Concerning the molecular lines, H_2 1-0 S(1) quadrupole transition at 2.12 μm and CO overtone bandheads 2-0 and 3-1 at 2.29 and 2.32 μm, respectively, are often recurring features. The first line (in emission) traces possible HH objects close to the star and emitted as a consequence of an accretion event. CO is present in EXor spectra both in absorption and in emission: it is believed to originate in the gaseous inner disk where it traces zones relatively warm (being CO completely dissociated at $\sim$4000 K) at high densities ($>10^7$ cm^{-3}). As the outburst proceeds toward the quiescence, the spectrum displays strong CO emission, absence, and finally CO absorption. Further observations should clarify whether we are observing the internal heating of the disk that dominates the radiation transfer, or simply different regions (emission in the inner disk and absorption in the stellar photosphere (Aspin et al. 2008; Hillenbrand et al. 2013; Biscaya et al. 1997). Figure 3 depicts optical and near-IR spectra of the representative EXor V1118 Ori obtained during its very recent 2015 outburst (Giannini et al. 2016). The comparison with the quiescence spectra (obtained with very similar instrumentation) illustrates the variations mentioned above.

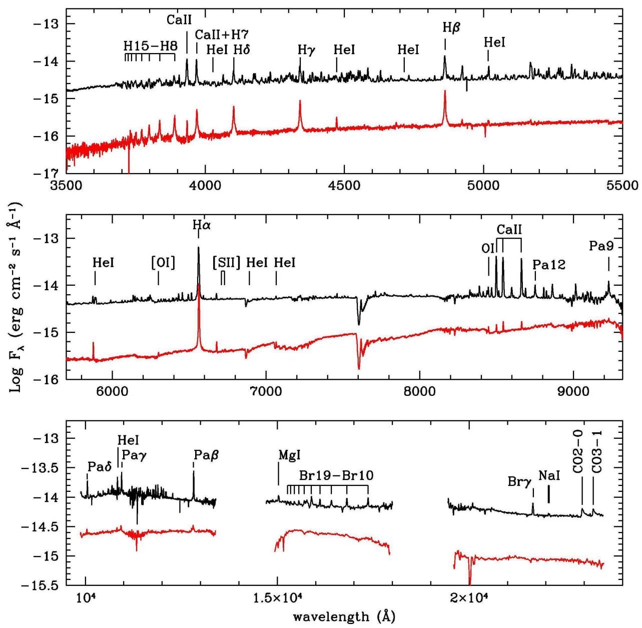

Figure 3: Optical (LBT/MODS) and near-IR spectrum (LBT/LUCIFER) of V1118 Ori in outburst (black) shown in comparison with the quiescence spectrum (red - Lorenzetti et al. 2015). (*from Giannini et al. 2016*).

3.3 Mid-and Far-IR

High sensitivity observations of EXors in this spectral region are not as common as at shorter wavelengths, since the limited lifetime of IR satellites (ISO, *Spitzer*, WISE, Herschel) combined with the cadence and duration of the EXor events, did not allow to follow their entire evolution. Nevertheless, one specific source (V2492 Cyg) has been studied in detail (Aspin 2011; Covey et al. 2011; Hillenbrand et al. 2013; Kóspál et al. 2013). Enlarging its available SED (up to 100-200 μm) more accurate parameters are derived by model fitting and the mid- to far-IR variability demonstrates that it is not exclusively related to changing accretion, but also to asymmetric structures in the inner disk: V2492 Cyg exhibits both accretion- and extinction-driven high-amplitude variability phenomena (more reminiscent of UXor objects). Beside this specific case, surveys of more numerous samples have been presented. The results of an *ISOPHOT* survey of young sources (including 7 EXors) carried out by Kóspál et al. (2012) suggest that mid-IR variability is more ubiquitous than was known before. Interpreting this variability is a new possibility for exploring the structure of the disk and its dynamical processes. A complete *WISE* (3.4-22 μm) survey of all the EXor has been presented (Antoniucci et al. 2013b) showing SED's compatible with the existence of an inner hole in the circumstellar disk. This compilation is intended as a first step toward the construction of a significant database in this spectral regime. As noted above, any discovery of a new EXor outburst has been done so far in the optical/near-IR band although, in principle, there is no physical reason preventing the EXor phenomenum from occurring also during the more embedded (i.e. earlier) phase. Indeed, a new outbursting object (HOPS 383), invisible at shorter wavelengths, has been recently found in the 24μm images of Orion (see Figure 4 - Safron et al. 2015). Such a discovery, suggesting that accretion outbursts occur even in the earliest phases of the pre-main sequence evolution, could open a new investigative approach.

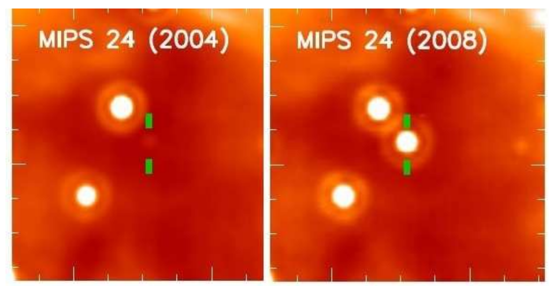

Figure 4: MIPS 24μm image of the field in two different epochs. (*from Safron et al. 2015*).

3.4 Sub-mm regime

A survey of EXors at (sub-)mm wavelengths does not exist at the moment. A few objects have been individually observed: V2492 Cyg at 1.1 mm (Aspin 2011) and 2.7 mm (Hillenbrand et al. 2012); GM Cep at 1.3 mm (Sicilia-Aguilar et al. 2008); OO Ser at 800 μm (Hodapp et al. 1996). Submillimeter Array (SMA) 1.3 mm high angular resolution observations of four EXors (VY Tau, V1118 Ori, V1143 Ori and NY Ori) (Liu et al. 2016) mostly show very low dust masses M_{dust} ($\lesssim 10^{-5}$-10^{-6} $M_\odot$) in the associated circumstellar disks. These findings suggest that the gas and dust reservoirs that feed the repetitive outbursts may be limited to the small-scale innermost region of their circumstellar disks (smaller than the resolution limit). ALMA will be needed to improve our understanding of the triggering mechanisms of EXor outbursts.

4. Other perspectives

Open questions and observational perspectives have been mentioned through all the sections above, here some further points that could be addressed in the near future are listed.

- Large-field monitoring of substantial portions of already known star forming regions are fundamental to enlarge the EXor sample.

- Models of magnetized accretion disks have been recently proposed (Lizano et al. 2016): ALMA will provide direct measurements of magnetic fields and their morphology at disk scales.

- EXors are too faint for the current sensitivity of interferometric facilities, but an improved instrumentation (e.g. *LINC-NIRVANA* at LBT) combined with deconvolution algorithms of high contrast images, already developed (La Camera et al. 2014), will be used to recover information on both disk morphology and presence of close companions.

- Several processes, such as crystallization (Juhász et al. 2012), flickering (Baek et al. 2015), extinction by dust, mass loss, are not merely concomitant with matter accretion, but intimately related to it, hence advanced studies on these subjects are essential to reach a consistent view of the EXor key parameters.

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Abstracts of recently accepted papers

FUV Irradiated Disk Atmospheres: Lyα and the Origin of Hot H_2 Emission

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Protoplanetary disks are strongly irradiated by a stellar FUV spectrum that is dominated by Lyα photons. We investigate the impact of stellar Lyα irradiation on the terrestrial planet region of disks ($\lesssim$1AU) using an updated thermal-chemical model of a disk atmosphere irradiated by stellar FUV and X-rays. The radiative transfer of Lyα is implemented in a simple approach that includes scattering by H I and absorption by molecules and dust. Because of their non-radial propagation path, scattered Lyα photons deposit their energy deeper in the disk atmosphere than the radially propagating FUV continuum photons. We find that Lyα has a significant impact on the thermal structure of the atmosphere. Photochemical heating produced by scattered Lyα photons interacting with water vapor and OH leads to a layer of hot (1500 - 2500 K) molecular gas. The temperature in the layer is high enough to thermally excite the H_2 to vibrational levels from which they can be fluoresced by Lyα to produce UV fluorescent H_2 emission. The resulting atmospheric structure may help explain the origin of UV fluorescent H_2 that is commonly observed from classical T Tauri stars.

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The origin of gas-phase HCO and CH_3O radicals in prestellar cores

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The recent unexpected detection of terrestrial complex organic molecules in the cold ($\sim$10 K) gas has cast doubts on the commonly accepted formation mechanisms of these species. Standard gas-phase mechanisms are inefficient and tend to underproduce these molecules, and many of the key reactions involved are unconstrained. Grain-surface mechanisms, which were presented as a viable alternative, suffer from the fact that they rely on grain surface diffusion of heavy radicals, which is not possible thermally at very low temperatures. One of the simplest terrestrial complex organic molecules, methanol is believed to form on cold grain surfaces following from successive H atom additions on CO. Unlike heavier species, H atoms are very mobile on grain surfaces even at 10 K. Intermediate species involved in grain surface methanol formation by CO hydrogenation are the radicals HCO and CH_3O, as well as the stable species formaldehyde H_2CO. These radicals are thought to be precursors of complex organic molecules on grain surfaces. We present new observations of the HCO and CH_3O radicals in a sample of prestellar cores and carry out an analysis of the abundances of the species HCO, H_2CO, CH_3O, and CH_3OH, which represent the various stages of grain-surface hydrogenation of CO to CH_3OH. The abundance ratios between the various intermediate species in the hydrogenation reaction of CO on grains are similar in all sources of our sample, HCO:H_2CO:CH_3O:CH_3OH $\sim$ 10:100:1:100. We argue that these ratios may not be representative of the primordial abundances on the grains but, rather, suggest that the radicals HCO and CH_3O are gas-phase products of the precursors H_2CO and CH_3OH, respectively. Gas-phase pathways are considered and simple estimates of HCO and CH_3O abundances are compared to the observations. Critical reaction rate constants, branching ratios, and intermediate species are finally identified.

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Planetary Signatures in the SAO 206462 (HD 135344B) Disk: A Spiral Arm Passing Through Vortex?

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The disk surrounding SAO 206462, a 8 Myr-old Herbig Ae star, has been recently reported to exhibit spiral arms, an asymmetric dust continuum, and a dust-depleted inner cavity. By carrying out two-dimensional, two-fluid hydrodynamic calculations we find that a planetary-mass companion located at the outer disk could be responsible for these observed structures. In this model, the planet excites primary and secondary arms interior to its orbit. It also carves a gap and generates a local pressure bump at the inner gap edge where a vortex forms through Rossby wave instability. The vortex traps radially drifting dust particles, forming a dust-depleted cavity in the inner disk. We propose that the vortex is responsible for the brightest southwestern peak seen in infrared scattered light and sub-mm dust continuum emission. In particular, it is possible that the scattered light is boosted as one of the spiral arms passes through the high density vortex region, although the vortex alone may be able to explain the peak. We suggest that a planetary companion with mass of $10 - 15\ M_J$ is orbiting SAO 206462 at $100 - 120$ AU. Monitoring of the brightest peak over the next few years will help reveal its origin as spiral arms and vortex will show distinguishable displacement.

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How can young massive clusters reach their present-day sizes?

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The classic question that how young massive star clusters attain their shapes and sizes, as we find them today, remains to be a challenge. Both observational and computational studies of star-forming massive molecular gas clouds infer that massive cluster formation is primarily triggered along the small-scale (< 0.3 pc) filamentary substructures within the clouds. The present study is intended to investigate the possible ways in which a filament-like-compact, massive star cluster (effective radius 0.1-0.3 pc) can expand > 10 times, still remaining massive enough ($> 10^4 M_\odot$), to become a young massive star cluster, as we observe today. To that end, model massive clusters (of initially $10^4 M_\odot - 10^5 M_\odot$) are evolved using Sverre Aarseth's state-of-the-art N-body code `NBODY7`. Apart from the accurate calculation of two-body relaxation of the constituent stars, these evolutionary models take into account stellar-evolutionary mass loss and dynamical energy injection, due to massive, tight primordial binaries and stellar-remnant black holes and neutron stars. These calculations also include a solar-neighbourhood-like external tidal field. All the computed clusters expand with time, whose sizes (effective radii) are compared with those observed for young massive clusters, of age < 100 Myr, in the Milky Way and other nearby galaxies. It is found that beginning from the above compact sizes, a star cluster cannot expand by its own, i.e., due to two-body relaxation, stellar mass loss, dynamical heating by primordial binaries and compact stars, up to the observed sizes of young massive clusters; they always remain much more compact compared to the observed ones. This calls for additional mechanisms that boost the expansion of a massive cluster after its assembly. Using further N-body calculations, it is shown that a substantial residual gas expulsion, with $\approx 30\%$ star formation efficiency, can indeed swell the newborn embedded cluster adequately. The limitations of the present calculations and their consequences are discussed.

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European VLBI Network imaging of 6.7 GHz methanol masers

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Methanol masers at 6.7 GHz are well known tracers of high-mass star-forming regions (HMSFRs). However, their origin is still not clearly understood. Using the European VLBI Network (EVN) we imaged the remaining sources from a sample of sources that were selected from the unbiased survey using the Torun 32 m dish. In this paper we report the results for 17 targets. Together they form a database of a total of 63 source images with high sensitivity ($3\sigma_{rms}$=15–30 mJy beam^{-1}), milliarcsecond angular resolution (6–10 mas) and very good spectral resolution (0.09 km s^{-1} or 0.18 km s^{-1}) for detailed studies. We studied in detail the properties of the maser clouds and calculated the mean and median values of the projected size (17.4±1.2 au and 5.5 au, respectively) as well as the FWHM of the line (0.373±0.011 km s^{-1} and 0.315 km s^{-1} for the mean and median values, respectively), testing whether it was consistent with Gaussian profile. We also found maser clouds with velocity gradients (71%) that ranged from 0.005 km s^{-1} au^{-1} to 0.210 km s^{-1} au^{-1}. We tested the kinematic models to explain the observed structures of the 6.7 GHz emission. There were targets where the morphology supported the scenario of a rotating and expanding disk or a bipolar outflow. Comparing the interferometric and single-dish spectra we found that, typically, 50–70% of the flux was missing. This phenomena is not strongly related to the distance of the source. The EVN imaging reveals that in the complete sample of 63 sources the ring-like morphology appeared in 17% of sources, arcs were seen in a further 8%, and the structures were complex in 46% cases. The ultra-compact (UC) H II regions coincide in position in the sky for 13% of the sources. They are related both to extremely high and low luminosity masers from the sample.

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A young bipolar outflow from IRAS 15398-3359

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Changing physical conditions in the vicinity of protostars allow for a rich and interesting chemistry to occur. Heating and cooling of the gas allows molecules to be released from and frozen out on dust grains. These changes in physics, traced by chemistry, as well as the kinematical information allows us to distinguish between different scenarios describing the infall of matter and the launching of molecular outflows and jets.
We aim at determining the spatial distribution of different species, of different chemical origin. This is to examine the physical processes in play in the observed region. From the kinematical information of the emission lines we aim at determining the nature of the infalling and outflowing gas in the system. We also aim at determining the physical properties of the outflow.
Maps from the Sub-Millimeter Array (SMA) reveal the spatial distribution of the gaseous emission toward IRAS 15398. The line radiative transfer code LIME is used to construct a full 3D model of the system taking all relevant components and scales into account.
CO, HCO^+ and N_2H^+ are detected and is shown to trace the motions of the outflow. For CO, also the circumstellar envelope and the surrounding cloud have a profound impact on the observed line profiles. N_2H^+ is detected in the outflow, but is suppressed towards the central region, perhaps due to the competing reaction between CO and H_3^+ in the densest regions as well as destruction of N_2H^+ by CO. N_2D^+ is detected in a ridge south-west from the protostellar condensation and is not associated with the outflow. The morphology and kinematics of the CO emission suggests that the source is younger than 1000 years. The mass, momentum, momentum rate, mechanical luminosity, kinetic energy and mass-loss rate are also all estimated to be low. A full 3D radiative transfer model of the system can explain all the kinematical and morphological features in the system.

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Efficient ortho-para conversion of H2 on interstellar grain surfaces

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Context: Fast surface conversion between ortho- and para-H2 has been observed in laboratory studies, and this mechanism has been proposed to play a role in the control of the ortho-para ratio in the interstellar medium. Observations of rotational lines of H2 in Photo-Dissociation Regions (PDRs) have indeed found significantly lower ortho-para ratios than expected at equilibrium. The mechanisms controlling the balance of the ortho-para ratio in the interstellar medium thus remain incompletely understood, while this ratio can affect the thermodynamical properties of the gas (equation of state, cooling function).
Aims: We aim to build an accurate model of ortho-para conversion on dust surfaces based on the most recent experimental and theoretical results, and to validate it by comparison to observations of H2 rotational lines in PDRs.
Methods: We propose a statistical model of ortho-para conversion on dust grains with fluctuating dust temperatures, based on a master equation approach. This computation is then coupled to full PDR models and compared to PDR observations.
Results: We show that the observations of rotational H2 lines indicate a high conversion efficiency on dust grains, and that this high efficiency can be accounted for if taking dust temperature fluctuations into account with our statistical model of surface conversion. Simpler models neglecting the dust temperature fluctuations do not reach the high efficiency deduced from the observations. Moreover, this high efficiency induced by dust temperature fluctuations is quite insensitive to the values of microphysical parameters of the model.
Conclusions: Ortho-para conversion on grains is thus an efficient mechanism in most astrophysical conditions that can play a significant role in controlling the ortho-para ratio.

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What is controlling the fragmentation in the Infrared Dark Cloud G14.225-0.506? Different level of fragmentation in twin hubs

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We present observations of the 1.3 mm continuum emission toward hub-N and hub-S of the infrared dark cloud G14.225–0.506 carried out with the Submillimeter Array, together with observations of the dust emission at 870 μm and 350 μm obtained with APEX and CSO telescopes. The large scale dust emission of both hubs consists of a single peaked clump elongated in the direction of the associated filament. At small scales, the SMA images reveal that both hubs fragment into several dust condensations. The fragmentation level was assessed under the same conditions and we found that hub-N presents 4 fragments while hub-S is more fragmented, with 13 fragments identified. We studied the density structure by means of a simultaneous fit of the radial intensity profile at 870 and 350 μm and the spectral energy distribution adopting a Plummer-like function to describe the density structure. The parameters inferred from the model are remarkably similar in both hubs, suggesting that density structure could not be responsible in determining the fragmentation level. We estimated several physical parameters such as the level of turbulence and the magnetic field strength, and we found no significant differences between these hubs. The Jeans analysis indicates that the observed fragmentation is more consistent with thermal Jeans fragmentation compared with a scenario that turbulent support is included. The lower fragmentation level observed in hub-N could be explained in terms of stronger UV radiation effects from a nearby HII region, evolutionary effects, and/or stronger magnetic fields at small scales, a scenario that should be further investigated.

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Contraction Signatures Toward Dense Cores in the Perseus Molecular Cloud

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We report the results of an HCO^+ (3–2) and N_2D^+ (3–2) molecular line survey performed toward 91 dense cores in the Perseus molecular cloud using the James Clerk Maxwell Telescope, to identify the fraction of starless and protostellar cores with systematic radial motions. We quantify the HCO^+ asymmetry using a dimensionless asymmetry parameter δ_v, and identify 20 cores with significant blue or red line asymmetries in optically-thick emission indicative of collapsing or expanding motions, respectively. We separately fit the HCO^+ profiles with an analytic collapse model and determine contraction (expansion) speeds toward 22 cores. Comparing the δ_v and collapse model results, we find that δ_v is a good tracer of core contraction if the optically-thin emission is aligned with the model-derived systemic velocity. The contraction speeds range from subsonic (0.03 km s^{-1}) to supersonic (0.4 km s^{-1}), where the supersonic contraction speeds may trace global rather than local core contraction. Most cores have contraction speeds significantly less than their free-fall speeds. Only 7 of 28 starless cores have spectra well-fit by the collapse model, which more than doubles (15 of 28) for protostellar cores. Starless cores with masses greater than the Jeans mass ($M/M_{\rm J} > 1$) are somewhat more likely to show contraction motions. We find no trend of optically-thin non-thermal line width with $M/M_{\rm J}$, suggesting that any undetected contraction motions are small and subsonic. Most starless cores in Perseus are either not in a state of collapse or expansion, or are in a very early stage of collapse.

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Helical Magnetic Fields in the NGC1333 IRAS 4A Protostellar Outflows

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We present Submillimeter Array (SMA) polarization observations of the CO $J = 3$–2 line toward the NGC1333 IRAS 4A. The CO Stokes I maps at an angular resolution of $\sim 1''$ reveal two bipolar outflows from the binary sources of the NGC 1333 IRAS 4A. The kinematic features of the CO emission can be modeled by wind-driven outflows at $\sim 20''$ inclined from the plane of the sky. Close to the protostars the CO polarization, at an angular resolution of $\sim 2\farcs3$, has a position angle approximately parallel to the magnetic field direction inferred from the dust polarizations. The CO polarization direction appears to vary smoothly from an hourglass field around the core to an arc-like morphology wrapping around the outflow, suggesting a helical structure of magnetic fields that inherits the poloidal fields at the launching point and consists of toroidal fields at a farther distance of outflow. The helical magnetic field is consistent with the theoretical expectations for launching and collimating outflows from a magnetized rotating disk. Considering that the CO polarized emission is mainly contributed from the low-velocity and low-resolution data, the helical magnetic field is likely a product of the wind-envelope interaction in the wind-driven outflows. The CO data reveal a PA of $\sim 30°$ deflection in the outflows. The variation in the CO polarization angle seems to correlate with the deflections. We speculate that the helical magnetic field contributes to $\sim 10°$ deflection of the outflows by means of Lorenz force.

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Red supergiants and the past of Cygnus OB2

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Context: Red supergiants are the evolved descendants of massive stars with initial masses between 7 and 40 $M_\odot$. Their brightness makes them easily detectable in the near infrared, making them useful probes of star formation that occurred several tens of Myr ago.
Aims: We investigate the past star formation history of Cygnus OB2, the nearest very massive OB association, using red supergiants as a probe. Our aim is to confirm the evidence, found by previous studies, that star formation in the Cygnus OB2 region started long before the latest burst that gave rise to the dense aggregate of early O-type stars that dominate the appearance of the association at present.
Methods: Near-infrared star counts in the Cygnus region reveal moderate evidence for a peak in the areal density of bright, reddened stars approximately coincident with Cygnus OB2. A total of 11 sources are found within a circle of 1° radius centered on the association, of which 4 are non-supergiants based on existing observations. Near-infrared spectroscopy is presented of the remaining seven candidates, including four that have been already classified as M supergiants in the literature.
Results: We confirm the presence of seven red supergiants in the region and argue that they are probably physically associated with Cygnus OB2. Their location is roughly coincident with that of the older population identified by previous studies, supporting the scenario in which the main star formation activity in the association has been shifting toward higher Galactic longitudes with time. Their luminosities are compared with the predictions of evolutionary tracks with and without rotation to estimate the mass of their progenitors and ages. In this way, we confirm that massive star formation was already taking place in the area of Cygnus OB2 over 20 Myr ago, and we estimate that the star formation rate in the latest 6 Myr represents a six-fold increase over the massive star formation rate at the time when the progenitors of the current red supergiants were formed.
Conclusions: The Cygnus OB2 association has a history of star formation extending into the past for at least about 20 Myr, probably dovetailing with the general history of star formation in the region that gave rise to other associations

like the neighboring Cygnus OB9. The sustained massive star formation history also argues for a long lifetime of the giant molecular complex from which Cygnus OB2 formed, whose remnants constitute the present-day Cygnus X complex.

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Dust photophoretic transport around a T Tauri star: Implications for comets composition

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There is a growing body of evidences for the presence of crystalline material in comets. These crystals are believed to have been annealed in the inner part of the proto-solar nebula, while comets should have been formed in the outer regions. Several transport processes have been proposed to reconcile these two facts; among them a migration driven by photophoresis. The primarily goal of this work is to assess whether disk irradiation by a Pre-Main Sequence star would influence the photophoretic transport. To do so, we have implemented an evolving 1+1D model of an accretion disk, including advanced numerical techniques, undergoing a time-dependent irradiation, consistent with the evolution of the proto-Sun along the Pre-Main Sequence. The photophoresis is described using a formalism introduced in several previous works. Adopting the opacity prescription used in these former studies, we find that the disk irradiation enhances the photophoretic transport: the assumption of a disk central hole of several astronomical units in radius is no longer strictly required, whereas the need for an ad hoc introduction of photoevaporation is reduced. However, we show that a residual trail of small particles could annihilate the photophoretic driven transport via their effect on the opacity. We have also confirmed that the thermal conductivity of transported aggregates is a crucial parameter which could limit or even suppress the photophoretic migration and generate several segregation effects.

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The JCMT Gould Belt Survey: the effect of molecular contamination in SCUBA-2 observations of Orion A

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Thermal emission from cold dust grains in giant molecular clouds can be used to probe the physical properties, such as density, temperature and emissivity in star-forming regions. We present the SCUBA-2 shared-risk observations at 450 μm and 850 μm of the Orion A molecular cloud complex taken at the James Clerk Maxwell Telescope (JCMT). Previous studies showed that molecular emission lines can contribute significantly to the measured fluxes in those continuum bands. We use the HARP ^{12}CO J=3-2 integrated intensity map for Orion A in order to evaluate the molecular line contamination and its effects on the SCUBA-2 maps. With the corrected fluxes, we have obtained a new spectral index α map for the thermal emission of dust in the well-known integral-shaped filament. Furthermore, we compare a sample of 33 sources, selected over the Orion A molecular cloud complex for their high ^{12}CO J=3-2 line contamination, to 27 previously identified clumps in OMC-4. This allows us to quantify the effect of line contamination on the ratio of 850 μm to 450 μm flux densities and how it modifies the deduced spectral index of emissivity β for the dust grains. We also show that at least one Spitzer-identified protostellar core in OMC-5 has a ^{12}CO J=3-2 contamination level of 16%. Furthermore, we find the strongest contamination level (44%) towards a young star with disk near OMC-2. This work is part of the JCMT Gould Belt Legacy Survey.

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A Disk-based Dynamical Constraint on the Mass of the Young Binary DQ Tau

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We present new ALMA observations of CO J=2–1 line emission from the DQ Tau circumbinary disk. These data are used to tomographically reconstruct the Keplerian disk velocity field in a forward-modeling inference framework, and thereby provide a dynamical constraint on the mass of the DQ Tau binary of $M_* = 1.27^{+0.46}_{-0.27}\ M_\odot$. Those results are compared with an updated and improved orbital solution for this double-lined system based on long-term monitoring of its stellar radial velocities. Both of these independent dynamical constraints on the binary mass are in excellent agreement: taken together, they demonstrate that the DQ Tau system mass is 1.21$\pm$0.26 $M_\odot$ and that the disk and binary orbital planes are aligned within 3° (at 3σ confidence). The predictions of various theoretical models for pre-main sequence stellar evolution are also consistent with these masses, although more detailed comparisons are difficult due to lingering uncertainties in the photospheric properties of the individual components. DQ Tau is the third nearly equal-mass double-lined spectroscopic binary with a circumbinary disk that has been dynamically "weighed" with these two independent techniques: all show consistent results, validating the overall accuracy of the disk-based approach and demonstrating that it can be robustly applied to large samples of young, single stars as ALMA ramps up to operations at full capacity.

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Collisions of solid ice in planetesimal formation

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We present collision experiments of centimetre projectiles on to decimetre targets, both made up of solid ice, at velocities of 15 m s^{-1} to 45 m s^{-1} at an average temperature of $T_{\rm avg} = 255.8 \pm 0.7$ K. In these collisions the centimetre body gets disrupted and part of it sticks to the target. This behaviour can be observed up to an upper threshold, that

depends on the projectile size, beyond which there is no mass transfer. In collisions of small particles, as produced by the disruption of the centimetre projectiles, we also find mass transfer to the target. In this way the larger body can gain mass, although the efficiency of the initial mass transfer is rather low. These collision results can be applied to planetesimal formation near the snowline, where evaporation and condensation is expected to produce solid ice. In free fall collisions at velocities up to about 7 m s^{-1}, we investigated the threshold to fragmentation and coefficient of restitution of centimetre ice spheres.

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A nearby young M dwarf with a wide, possibly planetary-mass companion

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We present the identification of two previously known young objects in the solar neighbourhood as a likely very wide binary. TYC 9486-927-1, an active, rapidly rotating early-M dwarf, and 2MASS J21265040−8140293, a low-gravity L3 dwarf previously identified as candidate members of the ∼45 Myr old Tucana Horologium association (TucHor). An updated proper motion measurement of the L3 secondary, and a detailed analysis of the pair's kinematics in the context of known nearby, young stars, reveals that they share common proper motion and are likely bound. New observations and analyses reveal the primary exhibits Li 6708 Å absorption consistent with M dwarfs younger than TucHor but older than the ∼10 Myr TW Hydra association yielding an age range of 10–45 Myr. A revised kinematic analysis suggests the space motions and positions of the pair are closer to, but not entirely in agreement with, the ∼24 Myr old β Pictoris moving group. This revised 10–45 Myr age range yields a mass range of 11.6–15 $M_{\rm J}$ for the secondary. It is thus likely 2MASS J21265040−8140293short is the widest orbit planetary mass object known (>4500AU) and its estimated mass, age, spectral type, and $T_{\rm eff}$ are similar to the well-studied planet β Pictoris b. Because of their extreme separation and youth, this low-mass pair provide an interesting case study for very wide binary formation and evolution.

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A multi-wavelength study of star formation activity in the S235 complex

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We have carried out an extensive multi-wavelength study to investigate the star formation process in the S235 complex. The S235 complex has a sphere-like shell appearance at wavelengths longer than 2 μm and harbors an O9.5V type star approximately at its center. Near-infrared extinction map traces eight subregions (having $A_V > 8$ mag), and five of them appear to be distributed in an almost regularly spaced manner along the sphere-like shell surrounding the ionized emission. This picture is also supported by the integrated ^{12}CO and ^{13}CO intensity maps and by Bolocam 1.1 mm continuum emission. The position-velocity analysis of CO reveals an almost semi-ring like structure, suggesting an expanding H II region. We find that the Bolocam clump masses increase as we move away from the location of the ionizing star. This correlation is seen only for those clumps which are distributed near the edges of the shell.

Photometric analysis reveals 435 young stellar objects (YSOs), 59% of which are found in clusters. Six subregions (including five located near the edges of the shell) are very well correlated with the dust clumps, CO gas, and YSOs. The average values of Mach numbers derived using NH_3 data for three (East 1, East 2, and Central E) out of these six subregions are 2.9, 2.3, and 2.9, indicating these subregions are supersonic. The molecular outflows are detected in these three subregions, further confirming the on-going star formation activity. Together, all these results are interpreted as observational evidence of positive feedback of a massive star.

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On the universality of interstellar filaments: theory meets simulations and observations

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Filaments are ubiquitous in the universe. Recent observations have revealed that stars and star clusters form preferentially along dense filaments. Understanding the formation and properties of filaments is therefore a crucial step in understanding star formation. Here we perform three-dimensional high-resolution magnetohydrodynamical simulations that follow the evolution of molecular clouds and the formation of filaments and stars. We apply a filament detection algorithm and compare simulations with different combinations of physical ingredients: gravity, turbulence, magnetic fields and jet/outflow feedback. We find that gravity-only simulations produce significantly narrower filament profiles than observed, while simulations that include turbulence produce realistic filament properties. For these turbulence simulations, we find a remarkably universal filament width of 0.10 ± 0.02 pc, which is independent of the star formation history of the clouds. We derive a theoretical model that provides a physical explanation for this characteristic filament width, based on the sonic scale ($\lambda_{\rm sonic}$) of molecular cloud turbulence. Our derivation provides $\lambda_{\rm sonic}$ as a function of the cloud diameter L, the velocity dispersion σ_v, the gas sound speed c_s, and the ratio of thermal to magnetic pressure, plasma β. For typical cloud conditions in the Milky Way spiral arms, we find $\lambda_{\rm sonic} = 0.04$–$0.16$ pc, in excellent agreement with the filament width of 0.05–0.15 pc from observations. Consistent with the theoretical model assumptions, we find that the velocity dispersion inside the filaments is subsonic and supersonic outside. We further explain the observed $p = 2$ scaling of the filament density profile, $\rho \propto r^{-p}$ with the collision of two planar shocks forming a filament at their intersection.

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The SPHERE view of the planet-forming disk around HD100546

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The mechanisms governing planet formation are not fully understood. A new era of high-resolution imaging of protoplanetary disks has recently started, thanks to new instruments such as SPHERE, GPI and ALMA. The planet formation process can now be directly studied by imaging both planetary companions embedded in disks and their effect on disk morphology.
We image with unprecedented spatial resolution and sensitivity disk features that could be potential signs of planet-disk interaction. Two companion candidates have been claimed in the disk around the young Herbig Ae/Be star HD100546. Thus, this object serves as an excellent target for our investigation of the natal environment of giant planets.
We exploit the power of extreme adaptive optics operating in conjunction with the new high-contrast imager SPHERE to image HD100546 in scattered light. We obtain the first polarized light observations of this source in the visible (with resolution as fine as 2 AU) and new H and K band total intensity images that we analyze with the PYNPOINT package.
The disk shows a complex azimuthal morphology, where multiple scattering of photons most likely plays an important role. High brightness contrasts and arm-like structures are ubiquitous in the disk. A double-wing structure (partly due to ADI processing) resembles a morphology newly observed in inclined disks. Given the cavity size in the visible (11 AU), the CO emission associated to the planet candidate *c* might arise from within the circumstellar disk. We find an extended emission in the K band at the expected location of *b*. The surrounding large-scale region is the brightest in scattered light. There is no sign of any disk gap associated to *b*.

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On the 2015 outburst of the EXor variable star V1118 Ori

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After a long-lasting period of quiescence of about a decade, the source V1118 Ori, one of the most representative members of the EXor variables, is now outbursting. Since the initial increase of the near-infrared flux of about 1 mag (JHK bands) registered on 2015 September 22, the source brightness has remained fairly stable. We estimate ΔV $\sim$ 3 mag with respect to the quiescence phase. An optical/near-IR low-resolution spectrum has been obtained with the Large Binocular Telescope instruments MODS and LUCI2, and compared with a spectrum of similar spectral resolution and sensitivity level taken during quiescence. Together with the enhancement of the continuum, the outburst spectrum presents a definitely higher number of emission lines, in particular HI recombination lines of the Balmer, Paschen, and Brackett series, along with bright permitted lines of several species, forbidden atomic lines, and CO ro-vibrational lines. Both mass accretion and mass loss rates have significantly increased (by to about an order of magnitude: $M_{acc} = 1.2\text{-}4.8\ 10^{-8}\ M_{\odot}/yr$, $M_{loss} = 0.8{-}2\ 10^{-9}\ M_{\odot}/yr$) with respect to the quiescence phase. If compared with previous outbursts, the present one appears less energetic. Alternatively, it could already be in the fading phase (with the maximum brightness level reached when the source was not visible), or, viceversa, still in the rising phase.

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A new insight into the V1184 Tau variability

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V1184 Tau is a young variable for long time monitored at optical wavelengths. Its variability has been ascribed to a sudden and repetitive increase of the circumstellar extinction (UXor-type variable), but the physical origin of such variation, although hypothesized, has not been fully supported on observational basis. With the aim to get a new insight into the variability of V1184 Tau, we present here new photometric and spectroscopic observations taken in the period 2008−2015. During these years the source has reached the same high brightness level that had before the remarkable fading of about 5 mag undergone in 2004. The optical spectrum is the first obtained when the continuum is at its maximum level. All the observational data are interpreted in the framework of extinction driven variability. In particular, we analyze light curves, optical and near-infrared colors, spectral energy distribution and optical spectrum. The emerging picture indicates that the source fading is due to an extinction increase of $\Delta A_V \sim 5$ mag, associated with the appearance of a strong infrared excess, attributable to a thermal component a T$\sim$ 1000 K. From the flux of Hα we derive a mass accretion rate in the range $10^{-11}{-}\ 5\ 10^{-10}\ M_{\odot}\ yr^{-1}$ s, marginally consistent with what is expected for a classical T Tauri star of similar mass. The source spectral energy distribution was fitted for both the high and low level of brightness. Remarkably, a scenario consistent with the known stellar properties (such as spectral type, mass and radius) is obtained only if the distance to the source is of few hundreds of parsecs, in contrast with the commonly assumed value of ~ 1.5 kpc. Our analysis partially supports that presented by Grinin (2009), according to which the circumstellar disk undergoes a periodical puffing, whose observational effects are both to shield the central star and to evidence a disk wind activity. However, since the mass accretion rate remains almost constant with time, the source is likely not subject to accretion bursts.

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Hot ammonia around young O-type stars.
III. High-mass star formation and hot core activity in W51 Main

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This paper is the third in a series of ammonia multilevel imaging studies in well-known high-mass star forming regions. Using the JVLA, we have mapped the hot and dense molecular gas in W51 Main, with about 0.″2 angular resolution, in five highly-excited metastable inversion transitions of NH_3 (ammonia): (J,K)=(6,6), (7,7), (9,9), (10,10), and (13,13). We have identified and characterised two main centers of high-mass star formation in W51-Main: the W51e2 complex and the W51e8 core (6″ southward of W51e2). The former breaks down into three further sub-cores: W51e2-W, which surrounds the well known HC HII region, where hot ammonia is observed in absorption, and two additional dusty cores, W51e2-E (∼0.″8 to the East) and W51e2-NW (∼1″ to the North), where hot ammonia is observed in emission. The velocity maps towards the HC HII region show a clear velocity gradient that may indicate rotation, though we do not directly observe a Keplerian velocity profile. The absence of outflow and/or maser activity and the low amount of molecular gas available for accretion (∼5 $M_\odot$) with respect to the mass of the central YSO (>20 $M_\odot$), both indicate that the central YSO has already accreted most of its final mass. On the other hand, in the nearby W51e2-E object, the relatively large amount of hot molecular gas available for accretion (∼20 $M_\odot$, within about half an arcsecond or 2500 AU), along with strong outflow and maser activity, indicates that the main accretion center in the W51e2 complex is W51e2-E rather than W51e2-W. Finally, W51e2-NW and W51e8, although less dense, are also hot cores and contain a significant amount of molecular gas (∼30 $M_\odot$ and ∼70 $M_\odot$, respectively). We speculate that they may host high-mass YSOs either at a previous evolutionary stage or with lower mass than W51e2-E and W51e2-W.

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Protoplanetary disk shadowing by gas infalling onto the young star AK Sco

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Young solar-type stars grow through the accretion of material from the circumstellar disk during pre-main sequence (PMS) evolution. The ultraviolet radiation generated in this process plays a key role in the chemistry and evolution of young planetary disks. In particular, the hydrogen Lyman-α line (Lyα) etches the disk surface by driving photoevaporative flows that control disk evolution. Using the Hubble Space Telescope, we have monitored the PMS binary star AK Sco during the periastron passage and have detected a drop of the H_2 flux by up to 10% lasting 5.9 hours. We show that the decrease of the H_2 flux can be produced by the occultation of the stellar Lyα photons by a gas stream in free fall from 3 R_*. Given the high optical depth of the Lyα line, a very low gas column of $N_H > 5 \times 10^{17}$ cm^{-2} suffices to block the Lyα radiation without producing noticeable effects in the rest of the stellar spectral tracers.

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The influence of radiative core growth on coronal X-ray emission from pre-main sequence stars

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Pre-main sequence (PMS) stars of mass $\gtrsim$0.35 $M_\odot$ transition from hosting fully convective interiors to configurations with a radiative core and outer convective envelope during their gravitational contraction. This stellar structure change influences the external magnetic field topology and, as we demonstrate herein, affects the coronal X-ray emission as a stellar analog of the solar tachocline develops. We have combined archival X-ray, spectroscopic, and photometric data for ∼1000 PMS stars from five of the best studied star forming regions; the ONC, NGC 2264, IC 348, NGC 2362, and NGC 6530. Using a modern, PMS calibrated, spectral type-to-effective temperature and intrinsic colour scale, we deredden the photometry using colours appropriate for each spectral type, and determine the stellar mass, age, and internal structure consistently for the entire sample. We find that PMS stars on Henyey tracks have, on average, lower fractional X-ray luminosities (L_X/L_*) than those on Hayashi tracks, where this effect is driven by changes in L_X. X-ray emission decays faster with age for higher mass PMS stars. There is a strong correlation between L_* and L_X for Hayashi track stars but no correlation for Henyey track stars. There is no correlation between L_X and radiative core mass or radius. However, the longer stars have spent with radiative cores, the less X-ray luminous they become. The decay of coronal X-ray emission from young early K to late G-type PMS stars, the progenitors of main sequence A-type stars, is consistent with the dearth of X-ray detections of the latter.

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Dust properties across the CO snowline in the HD 163296 disk from ALMA and VLA observations

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To characterize the mechanisms of planet formation it is crucial to investigate the properties and evolution of protoplanetary disks around young stars, where the initial conditions for the growth of planets are set. Our goal is to study grain growth in the disk of the young, intermediate mass star HD163296 where dust processing has already been observed, and to look for evidence of growth by ice condensation across the CO snowline, already identified in this disk with ALMA. Under the hypothesis of optically thin emission we compare images at different wavelengths from ALMA and VLA to measure the opacity spectral index across the disk and thus the maximum grain size. We also use a Bayesian tool based on a two-layer disk model to fit the observations and constrain the dust surface density.

The measurements of the opacity spectral index indicate the presence of large grains and pebbles (≥1 cm) in the inner regions of the disk (inside ∼50 AU) and smaller grains, consistent with ISM sizes, in the outer disk (beyond 150 AU). Re-analysing ALMA Band 7 Science Verification data we find (radially) unresolved excess continuum emission centered near the location of the CO snowline at ∼90 AU. Our analysis suggests a grain size distribution consistent with an enhanced production of large grains at the CO snowline and consequent transport to the inner regions. Our results combined with the excess in infrared scattered light found by Garufi et al. (2014) suggests the presence of a structure at 90 AU involving the whole vertical extent of the disk. This could be evidence for small scale processing of dust at the CO snowline.

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The shadow of the Flying Saucer: A very low temperature for large dust grains.

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Context: Dust determines the temperature structure of protoplanetary disks, however, dust temperature determinations almost invariably rely on a complex modeling of the Spectral Energy Distribution.
Aims: We attempt a direct determination of the temperature of large grains emitting at mm wavelengths.
Methods: We observe the edge-on dust disk of the Flying Saucer, which appears in silhouette against the CO J=2-1 emission from a background molecular cloud in ρ Oph. The combination of velocity gradients due to the Keplerian rotation of the disk and intensity variations in the CO background as a function of velocity allows us to directly measure the dust temperature. The dust opacity can then be derived from the emitted continuum radiation.
Results: The dust disk absorbs the radiation from the CO clouds at several velocities. We derive very low dust temperatures, 5 to 7 K at radii around 100 au, which is much lower than most model predictions. The dust optical depth is > 0.2 at 230 GHz, and the scale height at 100 au is at least 8 au (best fit 13 au). However, the dust disk is very flat (flaring index -0.35), which is indicative of dust settling in the outer parts.

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Molecular gas kinematics within the central 250 pc of the MilkyWay

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Using spectral-line observations of HNCO, N_2H^+, and HNC, we investigate the kinematics of dense gas in the central $\sim$ 250 pc of the Galaxy. We present SCOUSE (**S**emi-automated multi-**CO**mponent **U**niversal **S**pectral-line fitting **E**ngine), a line-fitting algorithm designed to analyse large volumes of spectral-line data efficiently and systematically. Unlike techniques which do not account for complex line profiles, SCOUSE accurately describes the $\{l,\, b,\, v_{\rm LSR}\}$ distribution of CMZ gas, which is asymmetric about Sgr A* in both position and velocity. Velocity dispersions range from $2.6\,{\rm km\,s^{-1}} < \sigma < 53.1\,{\rm km\,s^{-1}}$. A median dispersion of $9.8\,{\rm km\ s^{-1}}$, translates to a Mach number, $\mathcal{M}_{\rm 3D} \geq 28$. The gas is distributed throughout several "streams", with projected lengths $\sim 100-250$ pc. We link the streams to individual clouds and sub-regions, including Sgr C, the 20 and $50\,{\rm km\,s^{-1}}$ clouds, the dust ridge, and Sgr B2. Shell-like emission features can be explained by the projection of independent molecular clouds in Sgr C and the newly identified conical profile of Sgr B2 in $\{l,\, b,\, v_{\rm LSR}\}$ space. These features have previously invoked supernova-driven shells and cloud-cloud collisions as explanations. We instead caution against structure identification in velocity-integrated emission maps. Three geometries describing the 3-D structure of the CMZ are investigated: i) two spiral arms; ii) a closed elliptical orbit; iii) an open stream. While two spiral arms and an open stream qualitatively reproduce the gas distribution, the most recent parameterisation of the closed elliptical orbit does not. Finally, we discuss how proper motion measurements of masers can distinguish between these geometries, and suggest that this effort should be focused on the $20\,{\rm km\,s^{-1}}$ and $50\,{\rm km\,s^{-1}}$ clouds and Sgr C.

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Herschel-HIFI view of mid-IR quiet massive protostellar objects

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We present Herschel/HIFI observations of 14 water lines in a small sample of Galactic massive protostellar objects: NGC6334I(N), DR21(OH), IRAS16272-4837, and IRAS05358+3543. Using water as a tracer of the structure and kinematics, we individually study each of these objects with the aim to estimate the amount of water around them, but to also to shed light on the high-mass star formation process. We analyzed the gas dynamics from the line profiles using Herschel-HIFI observations acquired as part of the WISH key-project of 14 far-IR water lines ($H_2^{16}O$, $H_2^{17}O$, $H_2^{18}O$) and several other species. Then through modeling the observations using the RATRAN radiative transfer code, we estimated outflow, infall, turbulent velocities, and molecular abundances and investigated the correlation with the evolutionary status of each source. The four sources (and the previously studied W43-MM1) have been ordered in terms of evolution based on their spectral energy distribution from youngest to older: 1) NGC64334I(N), 2) W43-MM1, 3) DR21(OH), 4) IRAS16272-4837, 5) IRAS05358+3543. The molecular line profiles exhibit a broad component coming from the shocks along the cavity walls that is associated with the protostars, and an infalling (or expanding, for IRAS05358+3543) and passively heated envelope component, with highly supersonic turbulence that probably increases with the distance from the center. Accretion rates between 6.3×10^{-5} and 5.6×10^{-4} $M_\odot$ yr^{-1} are derived from the infall observed in three of our sources. The outer water abundance is estimated to be at the typical value of a few 10^{-8} , while the inner abundance varies from 1.7×10^{-6} to 1.4×10^{-4} with respect to H_2 depending on the source. We confirm that regions of massive star formation are highly turbulent and that the turbulence probably increases in the envelope with the distance to the star. The inner abundances are lower than the expected, 10^{-4} , perhaps because our observed lines do not probe deep enough into the inner envelope or because photodissociation through protostellar UV photons is more efficient than expected. We show that the higher the infall or expansion velocity in the protostellar envelope, the higher the inner abundance. This may indicate that higher infall or expansion velocities generate shocks that will sputter water from the ice mantles of dust grains in the inner region. High-velocity water must be formed in the gas phase from shocked material.

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Modeling Dust Emission of HL Tau Disk Based on Planet-Disk Interactions

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We use extensive global two-dimensional hydrodynamic disk gas+dust simulations with embedded planets, coupled with three dimensional radiative transfer calculations, to model the dust ring and gap structures in the HL Tau protoplanetary disk observed with the Atacama Large Millimeter/Submillimeter Array (ALMA). We include the self-gravity of disk gas and dust components and make reasonable choices of disk parameters, assuming an already settled dust distribution and no planet migration. We can obtain quite adequate fits to the observed dust emission using three planets with masses 0.35, 0.17, and 0.26 $M_{\rm Jup}$ at 13.1, 33.0, and 68.6 AU, respectively. Implications for the planet formation as well as the limitations of this scenario are discussed.

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The JCMT Gould Belt Survey: Dense Core Clusters in Orion B

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The JCMT Gould Belt Legacy Survey obtained SCUBA-2 observations of dense cores within three sub-regions of Orion B: LDN 1622, NGC 2023/2024, and NGC 2068/2071, all of which contain clusters of cores. We present an analysis of the clustering properties of these cores, including the two-point correlation function and Cartwright's Q parameter. We identify individual clusters of dense cores across all three regions using a minimal spanning tree technique, and find that in each cluster, the most massive cores tend to be centrally located. We also apply the independent M–Σ technique and find a strong correlation between core mass and the local surface density of cores. These two lines of evidence jointly suggest that some amount of mass segregation in clusters has happened already at the dense core stage.

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Global High-resolution N-body Simulation of Planet Formation I. Planetesimal Driven Migration

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We investigated whether outward Planetesimal Driven Migration (PDM) takes place or not in simulations when the self gravity of planetesimals is included. We performed N-body simulations of planetesimal disks with large width (0.7–4 AU) which ranges over the ice line. The simulations consisted of two stages. The first stage simulations were carried out to see the runaway growth phase using the planetesimals of initially the same mass. The runaway growth took place both at the inner edge of the disk and at the region just outside the ice line. This result was utilized for the initial setup of the second stage simulations in which the runaway bodies just outside the ice line were replaced by the protoplanets with about the isolation mass. In the second stage simulations, the outward migration of the protoplanet was followed by the stopping of the migration due to the increase of the random velocity of the planetesimals. Due to this increase of random velocities, one of the PDM criteria derived in Minton and Levison (2014) was broken. In the current simulations, the effect of the gas disk is not considered. It is likely that the gas disk plays an important role in planetesimal driven migration, and we plan to study its effect in future papers.

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The Deuterium Fraction in Massive Starless Cores and Dynamical Implications

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We study deuterium fractionation in two massive starless/early-stage cores C1-N and C1-S in Infrared Dark Cloud (IRDC) G028.37+00.07, first identified by Tan et al. (2013) with *ALMA*. Line emission from multiple transitions of N_2H^+ and N_2D^+ were observed with the *ALMA*, *CARMA*, *SMA*, *JCMT*, *NRO 45m* and *IRAM 30m* telescopes. By simultaneously fitting the spectra, we estimate the excitation conditions and deuterium fraction, $D_{\rm frac}^{\rm N_2H^+} \equiv [N_2D^+]/[N_2H^+]$, with values of $D_{\rm frac}^{\rm N_2H^+} \simeq 0.2$–$0.7$, several orders of magnitude above the cosmic [D]/[H] ratio. Additional observations of o-H_2D^+ are also presented that help constrain the ortho-to-para ratio of H_2, which is a key quantity affecting the degree of deuteration. We then present chemodynamical modeling of the two cores, exploring especially the implications for the collapse rate relative to free-fall, $\alpha_{\rm ff}$. In order to reach the high level of observed deuteration of N_2H^+, we find that the most likely evolutionary history of the cores involves collapse at a relatively slow rate, $\lesssim$1/10th of free-fall.

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Discovery of an Inner Disk Component around HD 141569 A

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We report the discovery of a scattering component around the HD 141569 A circumstellar debris system, interior to the previously known inner ring. The discovered inner disk component, obtained in broadband optical light with HST/STIS coronagraphy, was imaged with an inner working angle of $0\farcs25$, and can be traced from $0\farcs4$ ($\sim$46 AU) to $1\farcs0$ ($\sim$116 AU) after deprojection using $i = 55°$. The inner disk component is seen to forward scatter in a manner similar to the previously known rings, has a pericenter offset of $\sim$6 AU, and break points where the slope of the surface brightness changes. It also has a spiral arm trailing in the same sense as other spiral arms and arcs seen at larger stellocentric distances. The inner disk spatially overlaps with the previously reported warm gas disk seen in thermal emission. We detect no point sources within $2''$ ($\sim$232 AU), in particular in the gap between the inner disk component and the inner ring. Our upper limit of $9\pm3\ M_{\rm J}$ is augmented by a new dynamical limit on single planetary mass bodies in the gap between the inner disk component and the inner ring of 1 $M_{\rm J}$, which is broadly consistent with previous estimates.

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Probing the wind launching regions of the Herbig Be star HD 58647 with high spectral resolution interferometry

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We present a study of the wind launching region of the Herbig Be star HD 58647 using high angular ($\lambda/2B = 0''.003$) and high spectral ($R = 12000$) resolution interferometric VLTI-AMBER observations of the near-infrared hydrogen emission line, Brγ. The star displays double peaks in both Brγ line profile and wavelength-dependent visibilities. The wavelength-dependent differential phases show S-shaped variations around the line centre. The visibility level increases in the line (by ~ 0.1) at the longest projected baseline (88 m), indicating that the size of the line emission region is smaller than the size of the K-band continuum-emitting region, which is expected to arise near the dust sublimation radius of the accretion disc. The data have been analysed using radiative transfer models to probe the geometry, size and physical properties of the wind that is emitting Brγ. We find that a model with a small magnetosphere and a disc wind with its inner radius located just outside of the magnetosphere can well reproduce the observed Brγ profile, wavelength-dependent visibilities, differential and closure phases, simultaneously. The mass-accretion and mass-loss rates adopted for the model are $\dot{M}_{\rm a} = 3.5 \times 10^{-7}$ and $\dot{M}_{\rm dw} = 4.5 \times 10^{-8}\,{\rm M_\odot\,yr^{-1}}$, respectively ($\dot{M}_{\rm dw}/\dot{M}_{\rm a} = 0.13$). Consequently, about 60 per cent of the angular momentum loss rate required for a steady accretion with the measured accretion rate is provide by the disc wind. The small magnetosphere in HD 58647 does not contribute to the Brγ line emission significantly.

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Molecular emission in dense massive clumps from the star-forming regions S231-S235

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The article deals with observations of star-forming regions S231-S235 in 'quasi-thermal' lines of ammonia (NH_3), cyanoacetylene (HC_3N) and maser lines of methanol (CH_3OH) and water vapor (H_2O). S231-S235 regions is situated in the giant molecular cloud G174+2.5. We selected all massive molecular clumps in G174+2.5 using archive CO data. For the each clump we determined mass, size and CO column density. After that we performed observations of these clumps. We report about first detections of NH_3 and HC_3N lines toward the molecular clumps WB89 673 and WB89 668. This means that high-density gas is present there. Physical parameters of molecular gas in the clumps were estimated using the data on ammonia emission. We found that the gas temperature and the hydrogen number density are in the ranges 16-30 K and 2.8-7.2$\times 10^3$ cm^{-3}, respectively. The shock-tracing line of CH_3OH molecule at 36.2 GHz is newly detected toward WB89 673.

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Stellar models simulating the disk-locking mechanism and the evolutionary history of the Orion Nebula cluster and NGC 2264

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By assuming that disk-locking is the regulation mechanism for the stellar angular velocity during the early stages of pre-main sequence evolution, we use our rotating models and observational data to constrain disk lifetimes (T_{disk}) of a representative sample of low-mass stars in two young clusters, the Orion Nebula cluster (ONC) and NGC 2264, and to better understand their rotational evolution. The period distributions of the ONC and NGC 2264 are known to be bimodal and to depend on the stellar mass. To follow the rotational evolution of these two clusters' stars, we generated sets of evolutionary tracks from a fully convective configuration with low central temperatures (before D- and Li-burning). We assumed that the evolution of fast rotators can be represented by models considering conservation of angular momentum during all stages and of moderate rotators by models considering conservation of angular velocity during the first stages of evolution. With these models we estimate a mass and an age for all stars. The resulting mass distribution for the bulk of the cluster population is in the ranges of 0.2-0.4 $M_\odot$ and 0.1-0.6 $M_\odot$ for the ONC and NGC 2264, respectively. For the ONC, we assume that the secondary peak in the period distribution is due to high-mass objects still locked in their disks, with a locking period (P_{lock}) of ~8 days. For NGC 2264 we make two hypotheses: (1) the stars in the secondary peak are still locked with P_{lock}=5 days, and (2) NGC 2264 is in a later stage in the rotational evolution. Hypothesis 2 implies in a disk-locking scenario with P_{lock}=8 days, a disk lifetime of 1 Myr and, after that, constant angular momentum evolution. We then simulated the period distribution of NGC 2264 when the mean age of the cluster was 1 Myr. Dichotomy and bimodality appear in the simulated distribution, presenting one peak at 2 days and another one at 5-7 days, indicating that the assumption of P_{lock}=8 days is plausible. Our hypotheses are compared with observational disk diagnoses available in the literature for the ONC and NGC 2264, such as near-infrared excess, $H\alpha$ emission, and spectral energy distribution slope in the mid-infrared. Disk-locking models with P_{lock}=8 days and 0.2 Myr$\leq T_{\rm disk} \leq$3 Myr are consistent with observed periods of moderate rotators of the ONC. For NGC 2264, the more promising explanation for the observed period distribution is an evolution with disk-locking (with P_{lock} near 8 days) during the first 1 Myr, approximately, but after this, the evolution continued with constant angular momentum.

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A rotating helical filament in the L1251 dark cloud

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Aims. We derive the physical properties of a filament discovered in the dark cometary-shaped cloud L1251.
Methods. Mapping observations in the NH_3 (1,1) and (2,2) inversion lines, encompassing 300 positions toward L1251, were performed with the Effelsberg 100-m telescope at a spatial resolution of 40″ and a spectral resolution of 0.045 km s^{-1}.
Results. The filament L1251A consists of three condensations (α, β, and γ) of elongated morphology, which are combined in a long and narrow structure covering a 38′ by 3′ angular range. The opposite chirality (dextral and sinistral) of the α+β and γ condensations indicates magnetic field helicities of two types, negative and positive, which were most probably caused by dynamo mechanisms. We estimated the magnetic Reynolds number $R_{\rm m} > 600$ and the

Rossby number $R < 1$, which means that dynamo action is important.

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Interactions of the Infrared bubble N4 with the surroundings

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The physical mechanisms that induce the transformation of a certain mass of gas in new stars are far from being well understood. Infrared bubbles associated with H II regions have been considered to be good samples for investigating triggered star formation. In this paper we report on the investigation of the dust properties of the infrared bubble N4 around the H II region G11.898+0.747, analyzing its interaction with its surroundings and star formation histories therein, with the aim of determining the possibility of star formation triggered by the expansion of the bubble. Using *Herschel* PACS and SPIRE images with a wide wavelength coverage, we reveal the dust properties over the entire bubble. Meanwhile, we are able to identify six dust clumps surrounding the bubble, with a mean size of 0.50 pc, temperature of about 22 K, mean column density of 1.7 $\times 10^{22}$ cm^{-2}, mean volume density of about 4.4 $\times 10^{4}$ cm^{-3}, and a mean mass of 320 $M_{\odot}$. In addition, from PAH emission seen at 8 μm, free-free emission detected at 20 cm and a probability density function in special regions, we could identify clear signatures of the influence of the H II region on the surroundings. There are hints of star formation, though further investigation is required to demonstrate that N4 is the triggering source.

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The evolution of the Sun's birth cluster and the search for the solar siblings with Gaia

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We use self-consistent numerical simulations of the evolution and disruption of the Sun's birth cluster in the Milky Way potential to investigate the present-day phase space distribution of the Sun's siblings. The simulations include the gravitational N-body forces within the cluster and the effects of stellar evolution on the cluster population. In addition the gravitational forces due to the Milky Way potential are accounted for in a self-consistent manner. Our aim is to understand how the astrometric and radial velocity data from the Gaia mission can be used to pre-select solar sibling candidates. We vary the initial conditions of the Sun's birth cluster, as well as the parameters of the Galactic potential. We show that the disruption time-scales of the cluster are insensitive to the details of the non-axisymmetric components of the Milky Way model and we make predictions, averaged over the different simulated possibilities, about the number of solar siblings that should appear in surveys such as Gaia or GALAH. We find a large variety of present-day phase space distributions of solar siblings, which depend on the cluster initial conditions and the Milky Way model parameters. We show that nevertheless robust predictions can be made about the location of the solar siblings in the space of parallaxes (ϖ), proper motions (μ) and radial velocities ($V_{\rm r}$). By calculating the ratio of the number of simulated solar siblings to that of the number of stars in a model Galactic disk, we find that this ratio is above 0.5 in the region given by: $\varpi \geq 5$ mas, $4 \leq \mu \leq 6$ mas yr^{-1}, and $-2 \leq V_{\rm r} \leq 0$ km s^{-1}. Selecting stars from this region should increase the probability of success in identifying solar siblings through follow up observations.

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A symmetric inner cavity in the HD 141569A transitional disk

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Some circumstellar disks, called transitional or hybrid disks, present characteristics of both protoplanetary disks (significant amount of gas) and debris disks (evolved structures around young main-sequence stars, composed of second generation dust, from collisions between planetesimals). Therefore, they are an ideal astrophysical laboratory to witness the last stages of planet formation. The circumstellar disk around HD 141569A was intensively observed and resolved in the past from space but also from the ground but the recent implementation of high contrast imaging systems opens new opportunities to re-analyze this object. We analyzed Gemini archival data from the Near-Infrared Coronagraphic Imager (NICI) obtained in 2011 in the H band, using several angular differential imaging techniques (classical ADI, LOCI, KLIP). These images reveal the complex structures of this disk with an unprecedented resolution. We also include archival Hubble Space Telescope (HST) images as an independent dataset to confirm these findings. Using an analysis of the inner edge of the disk, we show that the inner disk is almost axisymmetrical. The measurement of an offset towards the East observed by previous authors is likely due to the fact that the Eastern part of this disk is wider and more complex in substructure. Our precise re-analysis of the eastern side shows several structures including a splitting of the disk and a small finger detached from the inner edge on the southeast. Finally, we find that the arc at 250 AU is unlikely to be a spiral, at least not at the inclination derived from the first ring, but instead could be interpreted as a third belt at a different inclination. If the very symmetrical inner disk edge is carved by a companion, the data presented here put additional constraints on its position.

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Near-Infrared Imaging Polarimetry of LkCa 15: A Possible Warped Inner Disk

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We present high-contrast *H*-band polarized intensity images of the transitional disk around the young solar-like star LkCa 15. By utilizing Subaru/HiCIAO for polarimetric differential imaging, both the angular resolution and the inner working angle reach $0\farcs07$ and $r = 0\farcs1$, respectively. We obtained a clearly resolved gap (width $\lesssim 27$ AU) at ~ 48 AU from the central star. This gap is consistent with images reported in previous studies. We also confirmed the existence of a bright inner disk with a misaligned position angle of $13^\circ \pm 4^\circ$ with respect to that of the outer disk, i.e., the inner disk is possibly warped. The large gap and the warped inner disk both point to the existence of a multiple planetary system with a mass of $\lesssim 1\ M_{\rm jup}$.

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IGRINS Near-IR High-Resolution Spectroscopy of Multiple Jets around LkHα 234

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We present the results of high-resolution near-IR spectroscopy toward the multiple outflows around the Herbig Be star LkHα 234 using the Immersion Grating Infrared Spectrograph (IGRINS). Previous studies indicate that the region around LkHα 234 is complex, with several embedded YSOs and the outflows associated with them. In simultaneous H$-$ and K$-$band spectra from HH 167, we detected 5 [FeII] and 14 H_2 emission lines. We revealed a new [FeII] jet driven by radio continuum source VLA 3B. Position-velocity diagrams of H_2 1$-$0 S(1) λ2.122 μm line show multiple velocity peaks. The kinematics may be explained by a geometrical bow shock model. We detected a component of H_2 emission at the systemic velocity ($V_{LSR} = -10.2$ km s^{-1}) along the whole slit in all slit positions, which may arise from the ambient photodissociation region. Low-velocity gas dominates the molecular hydrogen emission from knots A and B in HH 167, which is close to the systemic velocity, [FeII] emission lines are detected at farther from the systemic velocity, at $V_{LSR} = -100 - -130$ km s^{-1}. We infer that the H_2 emission arises from shocked gas entrained by a high-velocity outflow. Population diagrams of H_2 lines imply that the gas is thermalized at a temperature of 2,500 $-$ 3,000 K and the emission results from shock excitation.

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Dynamical evolution of star forming regions - II. Basic kinematics

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We follow the dynamical evolution of young star-forming regions with a wide range of initial conditions and examine how the radial velocity dispersion, σ, evolves over time. We compare this velocity dispersion to the theoretically expected value for the velocity dispersion if a region were in virial equilibrium, $\sigma_{\rm vir}$ and thus assess the virial state ($\sigma/\sigma_{\rm vir}$) of these systems. We find that in regions that are initially subvirial, or in global virial equilibrium but subvirial on local scales, the system relaxes to virial equilibrium within several million years, or roughly 25 – 50 crossing times, according to the measured virial ratio. However, the measured velocity dispersion, σ, appears to be a bad diagnostic of the current virial state of these systems as it suggests that they become supervirial when compared to the velocity dispersion estimated from the virial mass, $\sigma_{\rm vir}$. We suggest that this discrepancy is caused by the fact that the regions are never fully relaxed, and that the early non-equilibrium evolution is imprinted in the one-dimensional velocity dispersion at these early epochs. If measured early enough ($<$2 Myr in our simulations, or $\sim$20 crossing times), the velocity dispersion can be used to determine whether a region was highly supervirial at birth without the risk of degeneracy. We show that combining σ, or the ratio of σ to the interquartile range (IQR) dispersion, with measures

of spatial structure, places stronger constraints on the dynamical history of a region than using the velocity dispersion in isolation.

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2D condensation model for the inner Solar Nebula: an enstatite-rich environment

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Infrared observations provide the dust composition in the protoplanetary discs surface layers, but can not probe the dust chemistry in the midplane, where planet formation occurs. Meteorites show that dynamics was important in determining the dust distribution in the Solar Nebula and needs to be considered if we are to understand the global chemistry in discs. 1D radial condensation sequences can only simulate one disc layer at a time and cannot describe the global chemistry or the complexity of meteorites. To address these limitations, we compute for the first time the two dimensional distribution of condensates in the inner Solar Nebula using a thermodynamic equilibrium model, and derive timescales for vertical settling and radial migration of dust.
We find two enstatite-rich zones within 1 AU from the young Sun: a band ∼0.1 AU thick in the upper optically-thin layer of the disc interior to 0.8 AU, and in the optically-thick disc midplane out to ∼0.4 AU. The two enstatite-rich zones support recent evidence that Mercury and enstatite chondrites shared a bulk material with similar composition. Our results are also consistent with infrared observation of protoplanetary disc which show emission of enstatite-rich dust in the inner surface of discs.
The resulting chemistry and dynamics suggests that the formation of the bulk material of enstatite chondrites occurred in the inner surface layer of the disc, within 0.4 AU. We also propose a simple alternative scenario in which gas fractionation and vertical settling of the condensates lead to an enstatite-chondritic bulk material.

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The Gaia-ESO Survey: membership and Initial Mass Function of the Gamma Velorum cluster

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Understanding the properties of young open clusters, such as the Initial Mass Function (IMF), star formation history and dynamic evolution, is crucial to obtain reliable theoretical predictions of the mechanisms involved in the star formation process. We want to obtain a list, as complete as possible, of confirmed members of the young open cluster Gamma Velorum, with the aim of deriving general cluster properties such as the IMF. We used all available spectroscopic membership indicators within the Gaia-ESO public archive together with literature photometry and X-ray data and, for each method, we derived the most complete list of candidate cluster members. Then, we considered photometry, gravity and radial velocities as necessary conditions to select a subsample of candidates whose membership was confirmed by using the lithium and Hα lines and X-rays as youth indicators. We found 242 confirmed and 4 possible cluster members for which we derived masses using very recent stellar evolutionary models. The cluster IMF in the mass range investigated in this study shows a slope of $\alpha = 2.6 \pm 0.5$ for $0.5 < M/M_{\odot} < 1.3$ and $\alpha = 1.1 \pm 0.4$ for $0.16 < M/M_{\odot} < 0.5$ and is consistent with a standard IMF. The similarity of the IMF of the young population around γ^2Vel to that in other star forming regions and the field suggests it may have formed through very similar processes.

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Investigating Particle Acceleration in Protostellar Jets: The Triple Radio Continuum Source in Serpens

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While most protostellar jets present free-free emission at radio wavelengths, synchrotron emission has been also proposed to be present in a handful of these objects. The presence of non-thermal emission has been inferred by negative spectral indices at centimeter wavelengths. In one case (the HH 80-81 jet arising from a massive protostar), its synchrotron nature was confirmed by the detection of linearly polarized radio emission. One of the main consequences of these results is that synchrotron emission implies the presence of relativistic particles among the non-relativistic material of these jets. Therefore, an acceleration mechanism should be taking place. The most probable scenario is that particles are accelerated when the jets strongly impact against the dense envelope surrounding the protostar. Here, we present an analysis of radio observations obtained with the Very Large Array of the Triple Radio Source in the Serpens star-forming region. This object is known to be a radio jet arising from an intermediate-mass proto- star. It is also one of the first protostellar jets where the presence of non-thermal emission was proposed. We analysed the dynamics of the jet as well as the nature of the emission and discuss these issues in the context of the physical parameters of the jet and the particle acceleration phenomenon.

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Embedded Clusters in the Large Magellanic Cloud Using the VISTA Magellanic Clouds Survey

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We present initial results of the first large scale survey of embedded star clusters in molecular clouds in the Large Magellanic Cloud (LMC) using near-infrared (NIR) imaging from the VISTA Magellanic Clouds Survey (Cioni et al. 2011). We have explored a 1.65 deg2 area of the LMC, which contains the well-known star-forming region 30 Doradus as well as 14% of the galaxy's CO clouds (Wong et al. 2011), and have identified 67 embedded cluster candidates, 45 of which are newly discovered as clusters. We have determined sizes, luminosities and masses for these embedded clusters, examined the star formation rates (SFRs) of their corresponding molecular clouds, and made a comparison between the LMC and the Milky Way. Our preliminary results indicate that embedded clusters in the LMC are generally larger, more luminous and more massive than those in the local Milky Way. We also find that the surface densities of both embedded clusters and molecular clouds is 3 times higher than in our local environment, the embedded cluster mass surface density is 40 times higher, the SFR is 20 times higher, and the star formation efficiency is 10 times higher. Despite these differences, the SFRs of the LMC molecular clouds are consistent with the SFR scaling law presented in Lada et al. (2012). This consistency indicates that while the conditions of embedded cluster formation may vary between environments, the overall process within molecular clouds may be universal.

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Dust Emissivity in the Star-Forming Filament OMC 2/3

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We present new measurements of the dust emissivity index, β, for the high-mass, star-forming OMC 2/3 filament. We combine $160-500$ μm data from *Herschel* with long-wavelength observations at 2 mm and fit the spectral energy distributions across a $\simeq 2$ pc long, continuous section of OMC 2/3 at 15000 AU (0.08 pc) resolution. With these data, we measure β and reconstruct simultaneously the filtered-out large-scale emission at 2 mm. We implement both variable and fixed values of β, finding that $\beta = 1.7-1.8$ provides the best fit across most of OMC 2/3. These β values are consistent with a similar analysis carried out with filtered *Herschel* data. Thus, we show that β values derived from spatial filtered emission maps agree well with those values from unfiltered data at the same resolution. Our results contradict the very low β values (~ 0.9) previously measured in OMC 2/3 between 1.2 mm and 3.3 mm data, which we attribute to elevated fluxes in the 3.3 mm observations. Therefore, we find no evidence or rapid, extensive dust grain growth in OMC 2/3. Future studies with *Herschel* data and complementary ground-based long-wavelength data can apply our technique to obtain robust determinations of β in nearby cold molecular clouds.

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A temperature condensation trend in the debris-disk binary system Zet2 Ret

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We explore condensation temperature Tc trends in the unique binary system Zet1 Ret - Zet2 Ret, to determine whether there is a depletion of refractories, which could be related to the planet formation process. The star Zet2 Ret hosts a debris disk which was detected by an IR excess and confirmed by direct imaging and numerical simulations, while Zet1 Ret does not present IR excess nor planets. We carried out a high-precision abundance determination in both components of the binary system via a line-by-line strictly differential approach. First, we used the Sun as a reference and then we used Zet2 Ret. The stellar parameters were determined by imposing differential ionization and excitation equilibrium of Fe I and Fe II lines, with an updated version of the program FUNDPAR, together with ATLAS9 model atmospheres and the MOOG code. Then, we derived detailed abundances of 24 different species with equivalent widths and spectral synthesis. The star Zet1 Ret resulted slightly more metal rich than Zet2 Ret by 0.02 dex. In the differential calculation of Zet1 Ret using Zet2 Ret as reference, the abundances of the refractory elements resulted higher than the volatile elements, and the trend of the refractory elements with Tc showed a positive slope. These facts together show a lack of refractory elements in Zet2 Ret (a debris-disk host) relative to Zet1 Ret. The Tc trend would be in agreement with the proposed signature of planet formation (Melendez et al. 2009) rather than possible Galactic Chemical Evolution or age effects, which are largely diminished here. Then, following the interpretation of Melendez et al. (2009), we propose an scenario in which the refractory elements depleted in Zet2 Ret are possibly locked-up in the rocky material that orbits this star and produce the debris disk observed around this object. We estimated a lower limit of Mrock = 3 Me for the rocky mass of depleted material, which is compatible with a rough estimation of 3-50 Me of a debris disk mass around a solar-type star (Krivov et al. 2008).

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The physical and chemical structure of Sagittarius B2, I. Three-dimensional thermal dust and free-free continuum modeling on 100 au to 45 pc scales

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Context: We model the dust and free-free continuum emission in the high-mass star-forming region Sagittarius B2.
Aims: We want to reconstruct the three-dimensional density and dust temperature distribution, as a crucial input to follow-up studies of the gas velocity field and molecular abundances.
Methods: We employ the three-dimensional radiative transfer program RADMC-3D to calculate the dust temperature self-consistently, provided a given initial density distribution. This density distribution of the entire cloud complex is then recursively reconstructed based on available continuum maps, including both single-dish and high-resolution interferometric maps covering a wide frequency range (ν = 40 GHz – 4 THz). The model covers spatial scales from 45 pc down to 100 au, i.e. a spatial dynamic range of 10^5.
Results: We find that the density distribution of Sagittarius B2 can be reasonably well fitted by applying a superposition of spherical cores with Plummer-like density profiles. In order to reproduce the spectral energy distribution, we position Sgr B2(N) along the line of sight behind the plane containing Sgr B2(M). We find that the entire cloud complex comprises a total gas mass of 8.0×10^6 $M_{\odot}$within a diameter of 45 pc. This corresponds to an averaged gas density of 170 $M_{\odot}$pc^{-3}. We estimate stellar masses of 2400 $M_{\odot}$and 20700 $M_{\odot}$and luminosities of 1.8×10^6 $L_{\odot}$ and 1.2×10^7 $L_{\odot}$ for Sgr B2(N) and Sgr B2(M), respectively. We report H_2 column densities of 2.9×10^{24} cm^{-2} for Sgr B2(N) and 2.5×10^{24} cm^{-2} for Sgr B2(M) in a 40 ″beam. For Sgr B2(S), we derive a stellar mass of 1100 $M_{\odot}$, a

luminosity of 6.6×10^5 L$_\odot$ and a H_2 column density of 2.2×10^{24} cm^{-2} in a 40 ″beam. We calculate a star formation efficiency of 5 % for Sgr B2(N) and 50 % for Sgr B2(M). This indicates that most of the gas content in Sgr B2(M) has already been converted to stars or dispersed.

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Understanding star formation in molecular clouds III. Probability distribution functions of molecular lines in Cygnus X

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The probability distribution function of column density (N-PDF) serves as a powerful tool to characterise the various physical processes that influence the structure of molecular clouds. Studies that use extinction maps or H_2 column-density maps (N) that are derived from dust show that star-forming clouds can best be characterised by lognormal PDFs for the lower N range and a power-law tail for higher N, which is commonly attributed to turbulence and self-gravity and/or pressure, respectively. While PDFs from dust cover a large dynamic range (typically $N \sim 10^{20-24}$ cm^{-2} or Av$\sim$0.1–1000), PDFs obtained from molecular lines - converted into H_2 column density - potentially trace more selectively different regimes of (column) densities and temperatures. They also enable us to distinguish different clouds along the line of sight through using the velocity information. We report here on PDFs that were obtained from observations of ^{12}CO, ^{13}CO, C^{18}O, CS, and N_2H^+ in the Cygnus X North region, and make a comparison to a PDF that was derived from dust observations with the *Herschel* satellite. The PDF of ^{12}CO is lognormal for Av$\sim$1–30, but is cut for higher A_V because of optical depth effects. The PDFs of C^{18}O and ^{13}CO are mostly lognormal up to Av$\sim$1–15, followed by excess up to Av$\sim$40. Above that value, all CO PDFs drop, which is most likely due to depletion. The high density tracers CS and N_2H^+ exhibit only a power law distribution between Av$\sim$15 and 400, respectively. The PDF from dust is lognormal for Av$\sim$3–15 and has a power-law tail up to Av$\sim$500. Absolute values for the molecular line column densities are, however, rather uncertain because of abundance and excitation temperature variations. If we take the dust PDF at face value, we 'calibrate' the molecular line PDF of CS to that of the dust and determine an abundance [CS]/[H_2] of 10^{-9}. The slopes of the power-law tails of the CS, N_2H^+, and dust PDFs are -1.6, -1.4, and -2.3, respectively, and are thus consistent with free-fall collapse of filaments and clumps. A quasi static configuration of filaments and clumps can also possibly account for the observed N-pdfs, providing they have a sufficiently condensed density structure and external ram pressure by gas accretion is provided. The somehow flatter slopes of N_2H^+ and CS can reflect an abundance change and/or subthermal excitation at low column densities.

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The VLA Nascent Disk and Multiplicity Survey: First Look at Resolved Candidate Disks around Class 0 and I Protostars in the Perseus Molecular Cloud

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We present the first dust emission results toward a sample of seven protostellar disk candidates around Class 0 and I sources in the Perseus molecular cloud from the VLA Nascent Disk and Multiplicity (VANDAM) survey with $\sim 0.''05$ or 12 AU resolution. To examine the surface brightness profiles of these sources, we fit the Ka-band 8 mm dust-continuum data in the u,v-plane to a simple, parametrized model based on the Shakura-Sunyaev disk model. The candidate disks are well-fit by a model with a disk-shaped profile and have masses consistent with known Class 0 and I disks. The inner-disk surface densities of the VANDAM candidate disks have shallower density profiles compared to disks around more evolved Class II systems. The best-fit model radii of the seven early-result candidate disks are $R_c > 10$ AU; at 8 mm, the radii reflect lower limits on the disk size since dust continuum emission is tied to grain size and large grains radially drift inwards. These relatively large disks, if confirmed kinematically, are inconsistent with theoretical models where the disk size is limited by strong magnetic braking to < 10 AU at early times.

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CSI 2264: Characterizing Young Stars in NGC 2264 with Stochastically Varying Light Curves

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We provide CoRoT and Spitzer light curves, as well as broad-band multi-wavelength photometry and high resolution, multi- and single-epoch spectroscopy for 17 classical T Tauris in NGC 2264 whose CoRoT light curves (LCs) exemplify the "stochastic" LC class as defined in Cody et al. (2014). The most probable physical mechanism to explain the optical variability in this LC class is time-dependent mass accretion onto the stellar photosphere, producing transient hot spots. As evidence in favor of this hypothesis, multi-epoch high resolution spectra for a subset of these stars shows that their veiling levels also vary in time and that this veiling variability is consistent in both amplitude and timescale with the optical LC morphology. Furthermore, the veiling variability is well-correlated with the strength of the He I 6678 Å emission line, a feature predicted by models to arise in accretion shocks on or near the stellar photosphere. Stars with accretion burst LC morphology (Stauffer et al. 2014) are also attributed to variable mass accretion. Both the stochastic and accretion burst LCs can be explained by a simple model of randomly occurring flux bursts, with the stochastic LC class having a higher frequency of lower amplitude events. Based on their UV excesses, veiling, and mean Hα equivalent widths, members of the stochastic LC class have only moderate time-averaged mass accretion rates. The most common feature of their Hα profiles is for them to exhibit blue-shifted absorption features, most likely originating in a disk wind. The lack of periodic signatures in the LCs suggests that little of the variability is due to long-lived hot spots rotating into or out of our line of sight; instead, the primary driver of the observed photometric variability is likely to be instabilities in the inner disk that lead to variable mass accretion.

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Outflow-Confined H II Regions. I. First Signposts of Massive Star Formation

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We present an evolutionary sequence of models of the photoionized disk-wind outflow around forming massive stars based on the Core Accretion model. The outflow is expected to be the first structure to be ionized by the protostar and can confine the expansion of the H II region, especially in lateral directions in the plane of the accretion disk. The ionizing luminosity increases as Kelvin-Helmholz contraction proceeds, and the H II region is formed when the stellar mass reaches $\sim 10-20M_{\odot}$ depending on the initial cloud core properties. Although some part of outer disk surface remains neutral due to shielding by the inner disk and the disk wind, almost the whole of the outflow is ionized in 10^3–10^4yr after initial H II region formation. Having calculated the extent and temperature structure of the H II region within the immediate protostellar environment, we then make predictions for the strength of its free-free continuum and recombination line emission. The free-free radio emission from the ionized outflow has a flux density of $\sim (20-200) \times (\nu/10\mathrm{GHz})^p$ mJy for a source at a distance of 1 kpc with a spectral index $p \simeq 0.4-0.7$, and the apparent size is typically ∼500 AU at 10 GHz. The H40α line profile has a width of about 100 km/s. These properties of our model are consistent with observed radio winds and jets around forming massive protostars.

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Dust production in debris discs: constraints on the smallest grains

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The surface energy constraint puts a limit on the smallest fragment s_{surf} that can be produced after a collision. Based on analytical considerations, this mechanism has been recently identified as being having the potential to prevent the production of small dust grains in debris discs and to cut off their size distribution at sizes larger than the blow-out size. We numerically investigate the importance of this effect to find out under which conditions it can leave a signature in the small-size end of a disc's particle size distribution (PSD). An important part of this work is to map out, in a disc at steady-state, what is the most likely collisional origin for μm-sized dust grains, in terms of the sizes of their collisional progenitors. For the first time, we implement the surface energy constraint into a collisional evolution code. We consider a typical debris disc extending from 50 to 100au and two different stellar types: sun-like and A star. We also consider two levels of stirring in the disc: dynamically 'hot' ($\langle e \rangle$=0.075) and 'cold' ($\langle e \rangle$=0.01). In all cases, we derive s_{surf} maps as a function of target and projectile sizes, s_t and s_p, and compare them to equivalent maps for the dust-production rate. We then compute disc-integrated profiles of the PSD and estimate the imprint of the surface energy constraint. We find that the (s_p,s_t) regions of high s_{surf} values do not coincide with those of high dust production rates. As a consequence, the surface energy constraint generally has a weak effect on the system's PSD. The maximum s_{surf}-induced depletion of μm-sized grains is $\sim$ 30% and is obtained for a sun-like star and a dynamically 'hot' case. For the e=0.01 cases, the surface energy effect is negligible compared to the massive small grain depletion that is induced by another mechanism: the 'natural' imbalance between dust production and destruction rates in low-stirring discs identified by Thebault & Wu(2008).

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Dust masses of disks around 8 Brown Dwarfs and Very Low-Mass Stars in Upper Sco OB1 and Ophiuchus

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We present the results of ALMA band 7 observations of dust and CO gas in the disks around 7 objects with spectral types ranging between M5.5 and M7.5 in Upper Scorpius OB1, and one M3 star in Ophiuchus. We detect unresolved continuum emission in all but one source, and the ^{12}CO J=3-2 line in two sources. We constrain the dust and gas content of these systems using a grid of models calculated with the radiative transfer code MCFOST, and find disk dust masses between 0.1 and 1 $M_{\oplus}$, suggesting that the stellar mass / disk mass correlation can be extrapolated for brown dwarfs with masses as low as 0.05 $M_{\odot}$. The one disk in Upper Sco in which we detect CO emission, 2MASS J15555600, is also the disk with warmest inner disk as traced by its H - [4.5] photometric color. Using our radiative transfer grid, we extend the correlation between stellar luminosity and mass-averaged disk dust temperature originally derived for stellar mass objects to the brown dwarf regime to $\langle T_{dust} \rangle \approx 22(L_*/L_{\odot})^{0.16} K$, applicable to spectral types of M5 and later. This is slightly shallower than the relation for earlier spectral type objects and yields warmer low-mass disks. The two prescriptions cross at 0.27 $L_{\odot}$, corresponding to masses between 0.1 and 0.2 $M_{\odot}$ depending on age.

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Periodic methanol masers in G9.62+0.20E

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A number of mechanisms for understanding the periodic class II methanol masers associated with some high-mass star forming regions have been proposed in the past. Two recent proposals by Parfenov and Sobolev (2014) and Sanna et al. (2015) have been presented in order to explain the periodic masers in sources with light curves similar to the methanol masers in G9.62+0.20E. We evaluate to what extent the proposals and models presented by these authors can explain the light curve of the methanol masers in G9.62+0.20E. It is argued that neither of the proposed mechanisms can reproduce the light curves of the methanol masers in G9.62+0.20E.

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An alternative model for the origin of gaps in circumstellar disks

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Motivated by recent observational and numerical studies suggesting that collapsing protostellar cores may be replenished from the local environment, we explore the evolution of protostellar cores submerged in the external counter-rotating environment. These models predict the formation of counter-rotating disks with a deep gap in the gas surface density separating the inner disk (corotating with the star) and the outer counter-rotating disk. The properties of these gaps are compared to those of planet-bearing gaps that form in disks hosting giant planets. We employ numerical hydrodynamics simulations of collapsing cores that are replenished from the local counter-rotating environment and numerical hydrodynamics simulations of isolated disks hosting giant planets to derive the properties of the gaps that form in both cases. Our numerical simulations demonstrate that counter-rotating disks can form for a wide range of mass and angular momentum available in the local environment. The gap that separates both disks has a depletion factor smaller than 1%, can be located at a distance from ten to over a hundred AU from the star, and can propagate inward with velocity ranging from 1 AU Myr^{-1} to $>$ 100 AU Myr^{-1}. Unlike our previous conclusion, the gap can therefore be a long-lived phenomenon that is, in some case, comparable to the lifetime of the disk itself. For a proper choice of the planetary mass, the viscous α-parameter and disk mass, the planet-bearing gaps and gaps in counter-rotating disks may show a remarkable similarity in the gas density profile and depletion factor, which may complicate their observational differentiation.

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Water Abundance in Four of the Brightest Water Sources in the Southern Sky

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We estimated the ortho-H_2O abundances of G267.9-1.1, G268.4-0.9, G333.1-0.4 and G336.5-1.5, four of the brightest ortho-H_2O sources in the southern sky observed by the Submillimeter Wave Astronomy Satellite (ortho-H_2O 1_{10} - 1_{01} line, 556.936 GHz). The typical molecular clumps in our sample have H_2 column densities of 10^{22} to 10^{23}cm^{-2} and ortho-H_2O abundances of 10^{-10}. Compared with previous studies, the ortho-H_2O abundances are at a low level, which can be caused by the low temperatures of these clumps. To estimate the ortho-H_2O abundances, we used the CS $J = 2 \to 1$ line (97.98095 GHz) and CS $J = 5 \to 4$ (244.93556 GHz) line observed by Swedish-ESO 15 m Submillimeter Telescope (SEST) to calculate the temperatures of the clumps and the 350 μm dust continuum observed by Caltech Submillimeter Observatory (CSO) telescope to estimate the H_2 column densities. The observations of N_2H^+ ($J = 1 \to 0$) for these clumps were also acquired by SEST and the corresponding abundances were estimated. The N_2H^+

abundance in each clump shows a common decreasing trend toward the center and the typical abundance ranges from 10^{-11} to 10^{-9}.

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The PDS 66 Circumstellar Disk as seen in Polarized Light with the Gemini Planet Imager

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We present H and K band imaging polarimetry for the PDS 66 circumstellar disk obtained during the commissioning of the Gemini Planet Imager (GPI). Polarization images reveal a clear detection of the disk in to the $0\farcs12$ inner working angle (IWA) in H band, almost 3 times as close to the star as the previous HST observations with NICMOS and STIS ($0\farcs35$ effective IWA). The centro-symmetric polarization vectors confirm that the bright inner disk detection is due to circumstellar scattered light. A more diffuse disk extends to a bright outer ring centered at 80 AU. We discuss several physical mechanisms capable of producing the observed ring + gap structure. GPI data confirm enhanced scattering on the East side of the disk which is inferred to be nearer to us. We also detect a lateral asymmetry in the South possibly due to shadowing from material within the inner working angle. This likely corresponds to a temporally variable azimuthal asymmetry observed in HST/STIS coronagraphic imaging.

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Sgr A* and its Environment: Low Mass Star Formation, the Origin of X-ray Gas and Collimated Outflow

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We present high-resolution multiwavelength radio continuum images of the region within 150″ of Sgr A*, revealing a number of new extended features and stellar sources in this region. First, we detect a continuous 2″ east-west ridge of radio emission, linking Sgr A* and a cluster of stars associated with IRS 13N and IRS 13E. The ridge suggests that an outflow of east-west blob-like structures is emerging from Sgr A*. In particular, we find arc-like radio structures within the ridge with morphologies suggestive of photoevaporative protoplanetary disks. We use infrared K_s and L′ fluxes to show that the emission has similar characteristics to those of a protoplanetary disk irradiated by the intense radiation field at the Galactic center. This suggests that star formation has taken place within the S cluster 2″ from Sgr A*. We suggest that the diffuse X-ray emission associated with Sgr A* is due to an expanding hot wind produced by the mass loss from B-type main sequence stars, and/or the disks of photoevaporation of low mass young stellar objects (YSOs) at a rate $\sim 10^{-6} M_\odot\,yr^{-1}$. The proposed model naturally reduces the inferred accretion rate and is an alternative to the inflow-outflow style models to explain the underluminous nature of Sgr A*. Second, on a scale of 5″ from Sgr A*, we detect new cometary radio and infrared sources at a position angle PA$\sim 50^\circ$ which is similar to that of two other cometary sources X3 and X7, all of which face Sgr A*. In addition, we detect a striking tower of radio emission at a PA$\sim 50^\circ - 60^\circ$ along the major axis of the Sgr A East SNR shell on a scale of 150″ from Sgr A*. We suggest that the cometary sources and the tower feature are tracing interaction sites of a mildly relativistic jet from Sgr A* with the atmosphere of stars and the nonthermal Sgr A East shell at a PA$\sim 50 - 60^\circ$ with $\dot{M} \sim 1 \times 10^{-7}$ star formation rate per year, and opening angle 10 degrees. Lastly, we suggest that the east-west ridge of radio emission traces an outflow that is potentially associated with past flaring activity from Sgr A*. The position angle of the outflow driven by flaring activity is close to -90°.

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Herbig Ae/Be candidate stars in the innermost Galactic disk: Quartet cluster

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In order to investigate the Galactic-scale environmental effects on the evolution of protoplanetary disks, we explored the near-infrared (NIR) disk fraction of the Quartet cluster, which is a young cluster in the innermost Galactic disk at the Galactocentric radius $R_g \sim 4$ kpc. Because this cluster has a typical cluster mass of $\sim 10^3\,M_\odot$ as opposed to very massive clusters, which have been observed in previous studies ($>10^4\,M_\odot$), we can avoid intra-cluster effects such as strong UV field from OB stars. Although the age of the Quartet is previously estimated to be 3–8 Myr old, we find that it is most likely ∼3–4.5 Myr old. In moderately deep *JHK* images from the United Kingdom Infrared Telescope Infrared Deep Sky Survey, we found eight HAeBe candidates in the cluster, and performed *K*-band medium-resolution ($R \equiv \Delta\lambda/\lambda \sim 800$) spectroscopy for three of them with the Subaru 8.2 m telescope. These are found to have both Brγ absorption lines as well as CO bandhead emission, suggesting that they are HAeBe stars with protoplanetary

disks. We estimated the intermediate-mass disk fraction (IMDF) to be ∼25 % for the cluster, suggesting slightly higher IMDF compared to those for young clusters in the solar neighborhood with similar cluster age, although such conclusion should await future spectroscopic study of all candidates of cluster members.

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Dense gas in molecular cores associated with Planck Galactic cold clumps

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We present the first survey of dense gas towards *Planck* Galactic Cold Clumps (PGCCs). Observations in the $J = 1-0$ transitions of HCO^+ and HCN towards 621 molecular cores associated with PGCCs were performed using the Purple Mountain Observatory 13.7-m telescope. Among them, 250 sources have detection, including 230 cores detected in HCO^+ and 158 in HCN. Spectra of the $J = 1 - 0$ transitions from ^{12}CO, ^{13}CO, and $C^{18}O$ at the centers of the 250 cores were extracted from previous mapping observations to construct a multi-line data set. The significantly low detection rate of asymmetric double-peaked profiles, together with the well consistence among central velocities of CO, HCO^+, and HCN spectra, suggests that the CO-selected *Planck* cores are more quiescent compared to classical star-forming regions. The small difference between line widths of $C^{18}O$ and HCN indicates that the inner regions of CO-selected *Planck* cores are not more turbulent than the exterior. The velocity-integrated intensities and abundances of HCO^+ are positively correlated with those of HCN, suggesting these two species are well coupled and chemically connected. The detected abundances of both HCO^+ and HCN are significantly lower than values in other low- to high-mass star-forming regions. The low abundances may be due to beam dilution. On the basis of the inspection of the parameters given in the PGCC catalog, we suggest that there may be about 1 000 PGCC objects having sufficient reservoir of dense gas to form stars.

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On the Commonality of 10–30 AU Sized Axisymmetric Dust Structures in Protoplanetary Disks

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An unsolved problem in step-wise core-accretion planet formation is that rapid radial drift in gas-rich protoplanetary disks should drive mm-/meter-sized particles inward to the central star before large bodies can form. One promising solution is to confine solids within small scale structures. Here we investigate dust structures in the (sub)mm continuum emission of four disks (TW Hya, HL Tau, HD 163296 and DM Tau), a sample of disks with the highest spatial resolution ALMA observations to date. We retrieve the surface brightness distributions using synthesized images and fitting visibilities with analytical functions. We find that the continuum emission of the four disks is ∼axi-symmetric

but rich in 10–30 AU-sized radial structures, possibly due to physical gaps, surface density enhancements or localized dust opacity variations within the disks. These results suggest that small scale axi-symmetric dust structures are likely to be common, as a result of ubiquitous processes in disk evolution and planet formation. Compared with recent spatially resolved observations of CO snowlines in these same disks, all four systems show enhanced continuum emission from regions just beyond the CO condensation fronts, potentially suggesting a causal relationship between dust growth/trapping and snowlines.

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Abstracts of recently accepted major reviews

Formation of Very Young Massive Clusters and implications for globular clusters

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How Very Young Massive star Clusters (VYMCs; also known as "starburst" clusters), which typically are of $> 10^4 M_\odot$ and are a few Myr old, form out of Giant Molecular Clouds is still largely an open question. Increasingly detailed observations of young star clusters and star-forming molecular clouds and computational studies provide clues about their formation scenarios and the underlying physical processes involved. This chapter is focused on reviewing the decade-long studies that attempt to computationally reproduce the well-observed nearby VYMCs, such as the Orion Nebula Cluster, R136 and NGC 3603 young cluster, thereby shedding light on birth conditions of massive star clusters, in general. On this regard, focus is given on direct N-body modeling of real-sized massive star clusters, with a monolithic structure and undergoing residual gas expulsion, which have consistently reproduced the observed characteristics of several VYMCs and also of young star clusters, in general. The connection of these relatively simplified model calculations with the structural richness of dense molecular clouds and the complexity of hydrodynamic calculations of star cluster formation is presented in detail. Furthermore, the connections of such VYMCs with globular clusters, which are nearly as old as our Universe, is discussed. The chapter is concluded by addressing long-term deeply gas-embedded (at least apparently) and substructured systems like W3 Main. While most of the results are quoted from existing and up-to-date literature, in an integrated fashion, several new insights and discussions are provided.

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Disc accretion in star-forming regions

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The disc accretion process is an essential component of star and planet formation theories. This process balances the inflow of material against the outward spread of angular momentum, facilitating mass gain from a circumstellar disc which determines the main-sequence position of the central star and its planetary system configuration. Much of the detailed knowledge of the physical processes involved in disc accretion have been gained through observations of nearby (< 1 kpc) pre-main sequence (PMS) stars, in low mass star-forming regions (SFR). Stars formed in such regions are not representative of the massive, dense, and metal-poor environments in which the majority of stars in the Galaxy, and in previous epochs have formed. In particular, ionising radiation from nearby massive stars, and the metallicity (Z) of the local environment are thought to affect PMS disc accretion rates, and disc evolutionary timescales. Therefore, understanding the effect of the surrounding environment on the disc accretion process in PMS stars is necessary to develop a global picture of star formation.

In this thesis, I present new ultraviolet/optical/infrared photometric and spectroscopic observations of pre-main sequence stars that have formed in either metal-poor conditions, or in the vicinity of strong ionising radiation. This includes observations of 235 Classical T Tauri stars in the Lagoon Nebula; 63 Classical T Tauri/Herbig Ae stars in the Carina Nebula open cluster Trumpler 14; 24 intermediate mass T Tauri stars in the low-Z Sh 2-284 SFR; and one Herbig B[e] PMS candidate in the metal-poor 30 Doradus SFR. I measure the accretion rates of these PMS stars using the intensities of the U/Hα band excess measured through either optical spectra or imaging. Where possible, I use archive infrared photometry in the 1.2-8 μm wavelength range to measure the PMS disc evolutionary stage. The influence of the surrounding environment on the accretion rate evolution of pre-main sequence stars in these regions is explored using the spatial, and temporal distributions of accretion rate, mass, age and disc stage of PMS stars. In wide-field photometric data of the Lagoon Nebula, I find that the spatial distributions of PMS stars is a continuum,

ranging from dense clustering to relative isolation. Strongly accreting PMS stars are generally clumped together, in close proximity to their natal molecular cloud, whereas weaker, older accretors are relatively spaced apart. Ionising radiation from early-type stars appears to positively affect accretion rates on scales of 2-3 pc, but no evidence for trig- gered star formation is found. In addition, I find that the accretion rates measured from Hα imaging are well correlated to the accretion rates estimated using U-band photometry. In wide-field photometric data of Trumpler 14, I discover a population of PMS candidates using UV/optical/near-infrared photometry nearly 25 Myrs old. I argue that these PMS candidate stars are a foreground PMS population, approximately 5 Myrs old that belong to the Carina Nebula cluster Trumpler 16. Using Hα spectra of 24 intermediate T Tauri stars in Sh 2-284 (where $Z \sim 0.004$), I demonstrate that there is no evidence for a systematic change in accretion rates with metallicity, contrary to previous literature results at $Z \sim 0.0060.002$ in the Magellanic clouds. I suggest that previous studies are affected by detection limits and biases. I also present ultraviolet/optical spectra of the Herbig B[e] PMS candidate VFTS 822 located in the 30 Doradus SFR of the Large Magellanic Cloud. I discuss the impact of the discovery of VFTS 822 for star formation studies in the Magellanic Clouds, and external Galaxies.

http://star.arm.ac.uk/~vek/thesis.html

Meetings

Linking Exoplanet and Disk Compositions
Workshop at Space Telescope Science Institute
September 12-14, 2016

This workshop will gather scientists working on the compositional characterization of planets and planet-forming regions in protoplanetary disks. Recent and upcoming advancements make it timely to have a round-table conversation among the several communities involved, to join forces in tackling our most compelling questions on the origins of exoplanet diversity. Do exoplanet compositions retain the imprint of large-scale disk processes? Do disks include compositional trends that imprint on planets? What do we learn in this context from observations of Solar System bodies? And what can we test with observations of disks and exoplanets in the near future? We intend to identify long-lasting and observable links between exoplanet and disk compositions, to help the community in shaping ongoing modeling efforts as well as the essential parameter space to cover with existing and upcoming observatories for exoplanet and disk characterization.

Details and abstract submission will follow in a second announcement. For early inquiries, feel free to send us an email at banzatti@stsci.edu or nlewis@stsci.edu. Webpage: http://www.stsci.edu/~banzatti/images/workshop.pdf

SOC: Daniel Apai (Univ. of Arizona), Andrea Banzatti (STScI, chair), Fred Ciesla (Univ. of Chicago), Jonathan Fortney (UCSC), Sarah Horst (JHU), Inga Kamp (Kapteyn Inst., Groningen), Nikole Lewis (STScI, co-chair), Amaya Moro-Martin (STScI), Karin Oberg (Harvard CfA), Klaus Pontoppidan (STScI), Olivia Venot (Katholieke Univ. Leuven), Marie Ygouf (STScI)

The ISM-SPP Olympian School of Astrophysics 2016
Paralia Katerini, Mt Olympus, Greece. 3-7 October 2016

The School focuses on the physics and chemistry of the galactic and extragalactic interstellar medium including star formation, and on astrochemistry from photoionized to photodissociation and molecular regions. The scope of the school is to gather young researchers particularly PhD students and early career scientists to discuss about theoretical and numerical aspects of the general field of the interstellar medium, in a pleasant area located next to the sea and at the foot of world's famous Mt. Olympus. Topics include:

- Physics and Dynamics of the Interstellar Medium (galactic, extragalactic)
- Astrochemistry (photoionization, photodissociation, molecular regions)
- Hydrodynamics (instabilities, turbulence, magnetic fields)
- Star formation (from low-mass to high-mass stars, triggered and non-triggered)
- Hydrodynamical simulations and the comparison with observations

Invited key speakers:

- Robi Banerjee (University of Hamburg, Germany)
- Andreas Burkert (Ludwig-Maximilians Universitt Mnchen, Germany)
- Kalliopi Dasyra (National and Kapodistrian University of Athens, Greece)
- Simon Glover (University of Heidelberg, Germany)
- Peter Schilke (University of Cologne, Germany)
- Kostas Tassis (University of Crete, Greece)

For further information please visit the link: http://school2016.olympiancfa.org/

Star Clusters: from Infancy to Teenagehood
Max-Planck Haus, Heidelberg, Germany 8 - 12 August 2016

Star cluster research is experiencing a very exciting decade. With the Atacama Large Millimeter / submillimeter Array and the Gaia astrometric satellite, we are now equipped to probe the full lifecycle of star clusters, from the properties of the molecular gas in which they form, to the properties of the stellar streams which dying clusters leave in their wake. To exploit fully and meaningfully these huge data flows, the active collaboration of observers and modellers is critically needed. What theoretical predictions are we able to make? What are the observable quantities? How well do we understand observational data?

Moreover, the time is ripe for a hard look at the physical conditions leading to the formation of clusters in the Galaxy and the Magellanic Clouds, and their imprint on the long term evolution of clusters. Our aim is therefore also to bring together experts working on the formation of the cluster gaseous precursors with those studying the latest stages of cluster dissolution.

Particular attention will be given to the first Gyr of cluster evolution, that is, the infancy and teenagehood of clusters. This is over that age range that most clusters in the Galactic disc dissolve and, therefore, the age range over which a good understanding of cluster mass-loss mechanisms is most critically needed. Moreover, this is by that cluster age that the intriguing multiple stellar populations of globular clusters have formed. A related question is thus whether their formation can be witnessed directly in massive clusters currently in their teenagehood, or whether a key role was played by the different environmental conditions at the time of their formation.

Conference website: http://wwwstaff.ari.uni-heidelberg.de/infant_clusters_2016/

Abstract submission deadline: April 3, 2016

SOC: Geneviève Parmentier (Heidelberg, co-Chair), Franca d'Antona (Roma, co-Chair), Christian Boily (Strasbourg), Thomas Henning (Heidelberg), Marco Lombardi (Milano), Tom Megeath (Toledo), Alison Sills (McMaster)

Resolving planet formation in the era of ALMA and extreme AO
May 16-20, 2016, Santiago, Chile

ALMA Long Baseline observations and high-contrast AO instruments such as SPHERE, GPI and others can now image disks around young stars with resolutions of a few tens of milliarcseconds. Complex structures including gaps, rings, spiral wave patterns, and extreme asymmetries can be seen in the dust and gas, and the first evidence for the detection of young planets is starting to emerge.

With the few-AU scales now achievable, it may be possible to unravel the complex dynamical interaction between the Keplerian disks, accretion, jets and winds, and how these affect the growing planets. Some of these features had been predicted by theory but confrontation of the latest results with current models indicates clearly that we still have much to learn.

This conference aims to discuss the state of the art results in this field, to bring the sub-mm and AO communities together with theorists, and offer a panchromatic view of planet formation.

More information, including the list of invited speakers and registration details are available on the web page: http://www.eso.org/sci/meetings/2016/Planet-Formation2016.html

Conference email: planet-formation2016@eso.org

XIIe Rencontres du Vietnam

Search for life: from early Earth to exoplanets

December 12th-16th 2016, Quy Nhon, Vietnam

The program of the conference will focus on 4 main themes:
- Formation, evolution and habitability of planetary systems
- Early Earth environment
- From prebiotic chemistry to early Earth
- Life in Universe, societal impacts and ethical issues

A 2-days Training School on the 'Basics in Astrobiology' will be organized before the conference (December 9th-11th)

IMPORTANT DEADLINES:
- Training school registration: June 15th
- Application for contributed talk: June 15th
- Early bird conference registration fee: September 15th
- Application for poster: November 1st
- Registration and hotel booking: November 1st

http://rencontresduvietnam.org/conferences/2016/search-for-life

Contact: Muriel Gargaud (gargaud@obs.u-bordeaux1.fr) and Nikos Prantzos (prantzos@iap.fr), co-chairs of the conference.

Moving ... ??

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

Summary of Upcoming Meetings

Protoplanetary Discussions
7 - 11 March 2016, Edinburgh, UK
http://www-star.st-and.ac.uk/ppdiscs

Molecular Gas in Galactic Environments
4 - 7 April 2016, Charlottesville, USA
https://science.nrao.edu/science/meetings/2016/molecular-gas-in-galactic-environments/

From Stars to Massive Stars
6 - 9 April 2016, Gainesville, Florida, USA
http://conference.astro.ufl.edu/STARSTOMASSIVE/

Water in the Universe - from Clouds to Oceans
12 - 15 April 2016, Noordwijk, The Netherlands
http://www.congrexprojects.com/2016-events/16A06/

Workshop on Young Solar Systems
18 - 22 April 2016, Barcelona, Spain
http://www.ice.csic.es/research/forum/Forum/2016a.html

From Star and Planet Formation to Early Life
25 - 28 April 2016 Vilnius, Lithuania
http://www.vilnius2016.eu

Resolving planet formation in the era of ALMA and extreme AO
16 - 20 May 2016, Santiago, Chile
http://www.eso.org/sci/meetings/2016/Planet-Formation2016.html

Diffuse Matter in the Galaxy, Magnetic Fields, and Star Formation - A Conference Honoring the Contributions of Richard Crutcher & Carl Heiles
22 - 25 May 2016, Madison, USA
http://www.astro.wisc.edu/ch16/

The 19th Cambridge Workshop on Cool Stars, Stellar Systems, and the Sun
6 - 10 June 2016 Uppsala, Sweden
http://www.coolstars19.com

Cloudy Workshop
20 - 24 June 2016 Weihai, China
http://cloudy2016.csp.escience.cn/dct/page/1

EPoS 2016 The Early Phase of Star Formation - Progress after 10 years of EPoS
26 June - 1 July 2016, Ringberg Castle, Germany
http://www.mpia.de/homes/stein/EPoS/2016/2016.php

The role of feedback in the formation and evolution of star clusters
18 - 22 July 2016 Sexten, Italy
http://www.sexten-cfa.eu/en/conferences/2016/details/72-the-role-of-feedback-in-the-formation-and-evolution-

Binary Stars
24 - 30 July 2016, Cambridge, UK
http://www.ast.cam.ac.uk/meetings/2016/binary.stars.cambridge.2016

First Stars V
1 - 5 August 2016 Heidelberg, Germany
http://www.lsw.uni-heidelberg.de/FirstStarsV

Star Clusters: from Infancy to Teenagehood
8 - 12 August 2016, Heidelberg, Germany
http://wwwstaff.ari.uni-heidelberg.de/infant_clusters_2016/

CLOUDY: Emission Lines in Astrophysics
8 - 12 August 2016, Mexico City, Mexico
https://sites.google.com/a/astro.unam.mx/cloudy2016/

Cosmic Dust
15 - 19 August 2016, Sendaai, Japan
https://www.cps-jp.org/~dust/

Star Formation 2016
21-26 August 2016 Exeter, UK
http://www.astro.ex.ac.uk/sf2016

Linking Exoplanet and Disk Compositions
12 - 14 September, 2016 Baltimore, USA
http://www.stsci.edu/~banzatti/images/workshop.pdf

Interstellar shocks: models, observations & experiments
14-16 September 2016, Torun, Poland
http://shocks2016.faj.org.pl

Half a Decade of ALMA: Cosmic Dawns Transformed 20 - 23 September 2016 Indian Wells, USA
http://www.cvent.com/events/half-a-decade-of-alma-cosmic-dawns-transformed/event-summary-12c52aba23024057862

VIALACTEA2016: The Milky Way as a Star Formation Engine
26 - 30 September 2016, Rome, Italy
http://vialactea2016.iaps.inaf.it

The ISM-SPP Olympian School of Astrophysics 2016
3 - 7 October 2016, Mt. Olympus, Greece
http://school2016.olympiancfa.org/

The Local Truth: Galactic Star-formation and Feed-back in the SOFIA Era - Celebrating 50 years of airborne astronomy
16 - 20 October 2016, Pacific Grove, USA
http://www.sofia.usra.edu/Science/workshops/SOFIA_Conference_2016

Search for life: from early Earth to exoplanets
12 - 16 December 2016, Quy Nhon, Vietnam
http://rencontresduvietnam.org/conferences/2016/search-for-life

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

Short Announcements

RADEX and RATRAN have moved!

As of 2016, the radiative transfer tools RADEX and RATRAN have moved to a new web server.

The on-line RADEX calculator (for quick results) is now at `http://var.sron.nl/radex/radex.php`

The off-line RADEX program (for full functionality) is now at `https://personal.sron.nl/~vdtak/radex/index.shtml`

The RATRAN program is now at `https://personal.sron.nl/~vdtak/ratran/frames.html`

Please update your bookmarks!

Happy modeling,

Floris van der Tak

Fizeau exchange visitors program - call for applications

Dear colleagues!

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

The deadline for applications is March 15. Fellowships can be awarded for missions starting in May 2016.

Further informations and application forms can be found at www.european-interferometry.eu and vltischool.sciencesconf.org

The program is funded by OPTICON/FP7.

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

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

Electronic mail: fizeau@european-interferometry.eu