THE STAR FORMATION NEWSLETTER

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

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The Star Formation Newsletter

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

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Cover Picture

The Orion Molecular Cloud 2/3 region is here seen from a widefield image obtained with ESO's VISTA telescope. The picture is composed from images taken through z, J, and K_s filters, exposure time 10 minutes per filter. The field is about 15 arcminutes high, corresponding to about 2 pc. The region is located in the north-south oriented filament of dense gas and dust stretching north of the Orion Nebula Cluster. It is particularly rich in embedded protostars, which produce a wealth of Herbig-Haro objects and molecular hydrogen objects. Prominently visible in the center of the image is the bipolar reflection nebula Haro 5a/6a, which hosts a luminous source with spectral characteristics of an FU Orionis object.

Credit: ESO/J. Emerson/VISTA.
Acknowledgment: Cambridge Astronomical Survey Unit

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

Lynne Hillenbrand

in conversation with Bo Reipurth

Q: *A very highly cited paper you have written is on Herbig Ae/Be stars, resulting from your thesis. What do you see as the current main scientific issues in the study of these stars?*

A: Actually, that 1992 paper was my "second year project" as a graduate student working with Steve Strom, and my very first first-author publication! We presented a mix of new observations and lots of literature data plus some simple modeling of the spectral energy distributions of the Herbig stars. Others quickly jumped in with more realistic treatments of the radiative transfer and the geometry of the circumstellar material. But I think the paper did a lot to solidify from an empirical perspective the connection between lower mass T Tauri stars and higher mass Herbig Ae/Be stars. Of course, exactly that had been the aim of Herbig's seminal 1960 publication identifying the class. But much debate ensued and disbelief was frequent, even though the number of examples of these T Tauri-like but early-type stars had grown by a factor of several due to cataloging work by e.g. Finkenzeller & Mundt and later by P.S. Thé et al. Many papers, though, focused on just one particular aspect of the Herbig stars, and although the evidence was all there in the literature, no one had put the pieces together. I fondly recall many late nights tearing down the paper trails – literally, since there was no ADS at that time and SIMBAD was only just beginning to be available in a format that gave references but, in the pre-www days, didn't click through to them. I was attempting to weave a consistent story that accounted for all the observations we had of these Herbig stars. Some of the assessments in my paper were right, some wrong, but the work seemed to spur a lot of subsequent activity that has furthered our understanding.

Today, I think there is even more rationale for studies of these intermediate-mass young stars given the widespread evidence – from both Spitzer debris disk studies and ongoing high contrast direct imaging work – for planetary mass objects around their older analogs. Back then, we had pretty much just the IRAS results on Vega and Beta Pic, the existence of the Herbig Ae/Be stars, and a lot of speculation on the inbetween! I also think that we – still – have not figured out the geometry and other physical characteristics of the disk-to-star accretion flows for the Ae/Be stars, and also whether $dM_{acc}/dt \propto M^2$ is the appropriate scaling.

Q: *Your PhD thesis was on Herbig Ae/Be stars. How did you choose that subject, and what do you see today as the main open questions in this area?*

A: My thesis project was on the small clusters of stars that appear to be associated with most Herbig Ae/Be stars. The project began, literally, inspired by what was seen one night on the guider camera at the KPNO 4m telescope. I was along on an observing run with Steve (Strom) to take optical spectra for use, as I recall, in the paper by Hartigan, Strom, and Strom on the Taurus wide binaries. I had been working on the Herbig Ae/Be star spectral energy distributions, as just mentioned, and one of the lingering questions was whether the available stellar parameters were accurate or could we do anything to better establish the locations of these stars in the HR diagram (specifically, were they definitively pre-main sequence based on log g considerations).

So after Taurus set for the night, we took some Ae/Be spectra and noticed that there were close-by faint objects around many of the Ae/Be stars. So we took spectra of some of those too, and found they were all emission-line stars. And thus my thesis was born! It consisted of an optical and an infrared imaging campaign as well as lots of spectroscopy, to identify the partially embedded clusters and their stellar content, whether it was consistent with the IMF, etc. This work was never published since I got to working on the all-consuming Orion Nebula Cluster pretty soon thereafter, but several years later something similar on the Ae/Be small-N clusters was done by Leonardo Testi. I do still hope that some day the spectroscopy and photometry will make it into the literature, since others may be interested.

Q: *Back in 1997 you wrote one of the classic papers on the Orion Nebula Cluster that is still being cited today as much as when it was published. How did that project start, and what accounts for its popularity?*

A: Before the Ae/Be work, the very first exploration that I was asked to undertake as a graduate student was typing in and plotting data (again, there were no electronic tables available to download, or automatic column plotting routines) from Merle Walker's classic papers on Orion and

NGC 2264. So I had a literature introduction to Orion. But that particular project started because I wanted to understand some of the interesting patterns that I had noticed in the small clusters associated with Herbig Ae/Be stars and so I decided that better statistics from a larger cluster were necessary. Specifically what was bothering me were some of the things that we (or at least I) still don't understand today about the luminosity spreads and the seemingly mass-dependent ages inferred from HR diagrams. These non-intuitive trends were apparent back then, and seemed to demand putting more stars on the HRD to be sure. Separately, there was also some of the first wide-field infrared imaging data posted in the hallway at UMass, as part of testing for 2MASS. This served as great motivation for studying the ONC since a large-scale view of the *stars* in the greater Orion region (as opposed to the nebulosity that dominates optical imaging) had not been available before.

I figured we could learn a lot from that cluster, so got to work assembling new photometry and spectroscopy. I should also say that I had been talking with John Stauffer and Lee Hartmann quite a bit about the ONC as a student. Later, as a postdoc, I put together everything we knew from the literature about ONC stars, combined it with the new data, and embarked on a top-to-bottom study of the IMF along with the age distribution. This paper, like the Ae/Be star paper, was heavily inspired by the previous work of George Herbig, in this case the 1986 paper by Herbig & Terndrup.

Q: *A wealth of data have been accumulated on the ONC in recent years. What do you think are the key remaining unsolved questions regarding the ONC?*

A: The issue of the cluster dynamics is still wide open in my mind, in part because it is a hard problem to address! We are seeing the ONC at a time when the stars still trace the gas, to some extent, but the cluster is massive enough and dense enough that it is in the process of establishing itself, dynamically. We need both multi-epoch radial velocities (to account for binarity) and sufficiently precise astrometry over a wide field. Also, the mass and age distributions are still lingering issues in their details, with the main empirical uncertainties now in the realm of systematics rather than observational statistics or completeness. Our theoretical understanding of the luminosity and temperature evolution of accreting stars is developing, and even the influence of magnetic fields has begun to be addressed.

Q: *A decade ago John Carpenter and you used the southern 2MASS telescope to monitor the ONC. In that context you discovered a periodic variability in the BN protostellar object. Have you followed up on this discovery, and what do you think is the cause of this surprising variability?*

A: Yes, John led the fabulous analysis of the 2MASS variability data overall. The context for this project is that there had been various hints over the decades for near-infrared variability in young stars, but never adequate sampling, precision, or duration in the data streams to make much sense of it. Furthermore, 2MASS was the first data set in which I really believed the infrared variability. From the earlier data, we (and I can implicate Michael Meyer here too) had been postulating things like inner disk radius oscillations to explain the color trends, but we couldn't really prove anything like this with the results in hand. The 2MASS data made quite clear the case for different kinds of variability (periodic/colorless, along reddening vectors, and along other vectors possibly related to accretion or geometry). Then, besides the overall diversity of the light curves in this data set, we wrote a separate paper on the BN object because we thought it unusual that a high luminosity (implying high mass) object would exhibit a periodic signature. I've tried to revisit this result a few times with near-infrared spectrophotometric monitoring to try to figure out what is going on, but have yet to obtain a good data set.

Q: *You are also involved with the Spitzer Warm Mission, looking at star forming regions. What are the key results?*

A: This project is led by John Stauffer, who has coordinated an international effort to obtain data as close to simultaneous as possible at x-ray, optical, near-infrared, and mid-infrared (3.6 and 4.5 μm) wavelengths. Now certain of the reality of near-infrared variability, the obvious next step is to well-characterize the behavior out at longer wavelengths which are more sensitive to (cooler) disk effects than the shorter wavelengths that measure (hotter) stellar effects. Besides revealing the mid-infrared signatures of phenomena we already know about from the shorter wavelength studies, this YSOVAR data set opens our eyes to newly appreciated circumstances. Some of the interesting results have to do with variability in the earlier stage objects, many of which are periodic as we found for BN in the near-infrared. Circumstellar environments are obviously complex in terms of geometry, relevant physics, and radiative transfer issues. Hopefully this multi-wavelength monitoring data set can help elucidate some of the unknowns. The light curves are just thrilling!

Q: *Recently you and your students have been active in studying young variables with the Palomar Transient Factory. How did that come about, what kind of data sets are you getting, and what are you finding?*

A: The PTF project itself began as a "real time" transient detector, and it has been very successful in that regard, notably with supernovae. However, as with most astronomical facilities, a wide range of science can be done even with a single mode of operations. For the mere price of about 90 seconds of wall clock time per night, we convinced the project to obtain R-band imaging photometry in a star forming region. We now have over 1000 epochs spanning 3 years in the North America / Pelican Nebula region. My hope with this data set is that we can begin to fill in the vast parameter space of amplitude vs time scale for young star variability. The field has now matured to the point that variability is widely recognized as a phenomenon to be explained, rather than the curiosity (at best) or annoyance (more commonly) status to which it typically was relegated over the decades. While we have made quite a lot of progress in explaining periodic variability due to rotating spots (either cool, like enhanced sun spots, or hot, from accretion), the aperiodic variability is rather poorly characterized. It is typically referred to as "activity" related to accretion, and may be low amplitude flickering all the way up to large-amplitude outbursts. I think there is a lot of science in between these behavior extremes.

Q: *More and more FUors are being discovered, and you and your students have studied a number of them. There is little consensus on the triggering mechanism. What do you think initiates an eruption?*

A: I'll leave this one to the theorists. But I will say that there are several aspects of the small sample of FU Ori stars we have that do not seem entirely consistent with the mainstream models. So there is a clear need for more attention in this area, both to the details of the small number of individual sources that we know about, and to the statistics of the class as a whole.

Q: *Most recently you have found two protostars with TiO and VO in emission. This is extremely rare. What conditions are needed for this to transpire?*

A: I haven't yet decided whether this phenomenon is an interesting peculiarity or something truly meaningful in our understanding of circumstellar environments. Again, though, I am following up on something George Herbig had already noted in a more minor way for one object that we saw much more readily as full-band emission in TiO/VO for several objects. My reading and discussions with others suggests that these molecules are not generally included in disk chemistry calculations. Yet, they are apparently there, in at least some objects. As we all know, they are quite common molecules in the atmospheres of low mass stars, which have temperatures and densities not so much unlike the inner regions of circumstellar disks. All of the sources in which this molecular emission has been seen are Class I type, and that is probably an important clue. Back when I was a postdoc I had noticed that most of the 2 μm CO emission objects had Class I like SEDs, though typically with high luminosity too, so maybe these recent results are not too surprising. But it's something that has not yet generated any theoretical interest.

Q: *What are you currently working on?*

A: All of the above !! Old topics of interest die hard, and new ones keep surfacing. My biggest struggle right now is actually finalizing projects all the way to publication since it is so easy to get distracted with new and interesting pursuits. I love to learn.

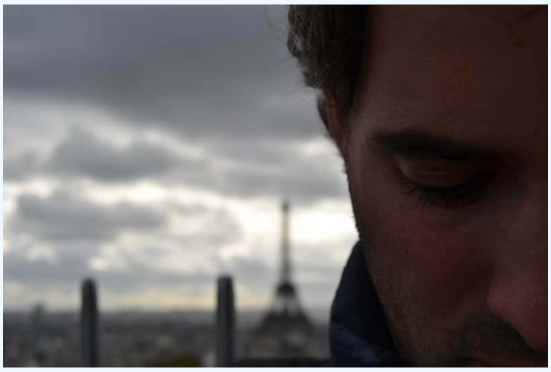
Q: *You have been studying the progress of women in astronomy. What is the status now, how do you yourself juggle work and family, and would you recommend young women to start a career in astronomy?*

A: An astronomical research and/or teaching career has no particular barriers these days for women, as far as I know. However, it is certainly a challenge for all of us, whether female/male, purple/orange, or otherwise to balance the joys of inquiry with the demands of obligations. And I am referring here to both astronomical pursuits and those outside of our vocation. Many aspects of what we do as astronomers and as human beings each could be 3/4-time jobs, and so the trick for every one of us is to take on only a few of these! Obviously this means that we are all working very hard, for the most part because we love what we do. I worry quite a bit about the astronomical infrastructure, however. We are quite strained now and for the forseeable future along several resource axes - including human. But our aspirations as a scientific community in pursuit of knowledge about the universe are (justifiably!) large. Women share equally in these quests and challenges.

My Favorite Object

The σ Orionis Cluster: A Space Odyssey

José A. Caballero



The constellation of Orion has pulled in the attention of astronomers and sky watchers since the ancient times: it was mentioned in the Bible, Homer's Odyssey and Virgil's Aeneid, has been widely used in celestial navigation, and represented important characters, deities, or tools in mythologies all over the world (it was the Babylonian Shepherd of Anu, the Finnish Väinämöinen, and the Julpan, a canoe of the Australian aborigines). Within the constellation, the prominent Orion Belt, formed by Alnitak (ζ Ori), Alnilam (ϵ Ori), and Mintaka (δ Ori), is perhaps the most famous asterism in the sky. Thought to be mapped in the Giza pyramid complex by the ancient Egyptians, the Orion Belt has also been of great significance in other cultures: it was the Scandinavian Freyja's distaff, the Iberian Tres Marías, the Northern-European Three Kings, and the Chinese lunar mansion Shen (literally "three" in Chinese).

The fourth brightest star in the Orion Belt, about 2 mag fainter than the three main stars, is σ Ori (Fig. 1). The star, which is actually the hierarchical multiple Trapezium-like stellar system that illuminates the famous Horsehead Nebula (see *The Horsehead's Mane*, Jérôme Pety's favorite object – Star Formation Newsletter #242), has taken a great importance in the last fifteen years. Its significance lies in the very early spectral type of the hottest component (σ Ori A, O9.5 V) and in the homonymous star cluster that surrounds the multiple system. The σ Orionis star cluster in the Ori OB1b association, although already identified by Garrison (1967) and catalogued by Lyngå (1981), was re-discovered in the early '90s by Scott J. Wolk, by that time a PhD student, and Fred M. Walter, who was his supervisor (Wolk 1996; Walter et al.1998). Using *ROSAT*, they detected an over-density of X-ray sources around the cluster center, and identified and characterized spectro-photometrically a population of low-mass pre-main sequence stars.

Approximate canonical ages, heliocentric distances and visual extinctions of the σ Orionis cluster are $\tau \sim 3$ Ma, $d \sim 385$ pc and $A_V \sim 0.3$ mag.

Figure 1: The reddish bright background of the IC 434 emission nebula against which the famous dark nebula Barnard 33 (the Horsehead Nebula) stands out in the centre of the image, surrounded by Alnitak to the north, NGC 2024 (the Flame Nebula) to the north-east, the reflection nebulae NGC 2023 and IC 435 (illuminated by the stars HD 37903 and HD 38087) to the east, and the σ Orionis cluster to the west (to the center right in the image). Picture courtesy by Raúl Alcaraz Gómez.

The σ Orionis cluster has become one of the best laboratories in the sky to study star formation. As well as the many readers of The Star Formation Newsletter have different interests, the researchers of the cluster are attracted by different topics, too. If one asked several astronomers worldwide about *why σ Orionis is so important*, he would get something like this:

- *Because it illuminates the Horsehead Nebula* (e.g., Pound et al. 2003; Pety et al. 2005; Goicoechea et al. 2006). For those interested in this topic, I suggest them to look at Fig. 2 in Ogura & Sugitani (1998). It shows the tail directions of remnant molecular clouds in the Ori OB1 association. Remarkably, most bright-rimmed clouds, cometary globules, and small reflection clouds in the area, even as far as near Mintaka (on the other side of the Orion Belt), are oriented towards the σ Ori stellar system. The Horsehead is only the most prominent of such remnant clouds. Regarding this issue, perhaps some reader of The Star Formation Newsletter may solve a doubt that I have had for years: why do these remnant clouds point towards σ Ori instead of to Alnitak, Alnilam, and Mintaka, which are by far brighter in the far- and near-ultraviolet? Is it a power matter (i.e., energy $\times$ time)?

- *Because of its X-ray emitter population* (e.g., Mokler & Stelzer 2002; Wolk 1996; Sanz-Forcada et al. 2004; Franciosini et al. 2006; Skinner et al. 2008; López-Santiago & Caballero 2008). The cluster centre has been targeted by numerous X-ray instruments onboard space missions: IPC/*Einstein*, HRI/*ROSAT*, ACIS-S+HETG and HRC-I/*Chandra*, and EPIC/*XMM-Newton*. Three X-ray brown dwarfs are known in σ Orionis, which makes the cluster one of the few regions where an X-ray luminosity function from spectral type O9.5 to M6.5 has been derived. See Caballero et al. (2010) for a comprehensive summary of X-ray analyses in the cluster.

- *Because of its well-known disk frequency* (e.g., Oliveira et al. 2006; Hernández et al. 2007; Zapatero Osorio et al. 2007; Scholz & Jayawardhana et al. 2008; Luhman et al. 2008). With an age of about 3 Ma, σ Orionis is one of the few clusters where the disk frequency has been measured for high-, intermediate- and low-mass stars, brown dwarfs, and the high end of planetary-mass objects. Actually, it was the first star-forming region where the disk frequency in the whole brown dwarf domain was measured (Caballero et al. 2007). The combination of relative nearness, extreme youth, good knowledge of the stellar and substellar population and, especially, low extinction facilitates the identification of infrared flux excesses in spectral energy distributions, which do not need any previous extinction correction as in other well-known star-forming regions.

- *Because of σ Ori E* (e.g., Walborn 1974; Landstreet & Borra 1978; Groote & Hunger 1982; Reiners et al. 2000; Towsend et al. 2005; Oksala et al. 2012). It is a helium-rich, magnetically-active, B2 Vp star. Before the '90s, σ Ori E alone attracted roughly 90 % of all citations to objects in the cluster. In spite of the many extensive, deep studies on the star that have been done and the several complex, disputable magnetospheric models that have been proposed, nobody has accounted yet for its known resolved companion at $\rho \approx 0.33$ arcsec (Bouy et al. 2009).

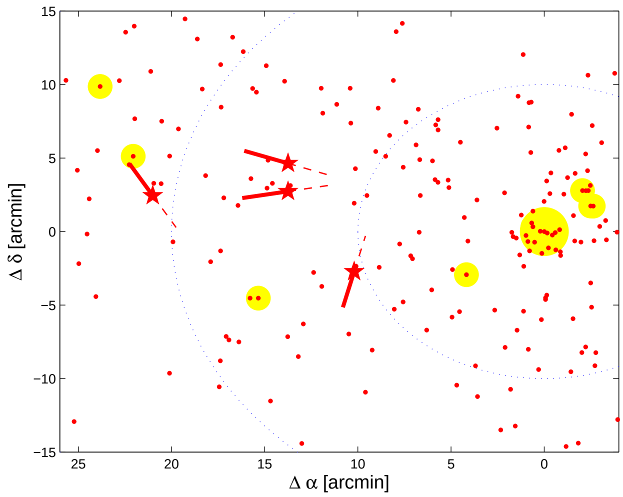


Figure 2: Orientation of the Herbig-Haro objects in σ Orionis. Filled stars: the four Herbig-Haro objects; thick solid and thin dashed lines: jets and counterjets (not to scale); dots: cluster members and candidates from the Mayrit catalogue; big filled circles: stars with B spectral type; the largest filled circle: the σ Ori multiple system; dotted ellipses: 10 and 20 arcmin-radius circles centred on σ Ori (previously unpublished figure by the author).

- *Because of its Herbig-Haro objects* (e.g., Reipurth et al. 1998; Raga et al. 2000; Andrews et al. 2004). Whereas most jet sources in other star-forming regions are "shrouded from view at optical wavelength by opaque clouds of gas and dust", the driving sources of three of the four Herbig-Haro objects in σ Orionis discovered by Reipurth et al. (1998) are quite bright ($J \sim 11.5$–12.2 mag). The remaining object, associated with HH 446, is very faint in the optical and near-infrared for its "bolometric" mass, of about $0.85\,M_{\odot}$; it seems, thus, that the driving source of HH 446 is obscured by a large edge-on disc. All four flows are highly asymmetric, with the jets about ten times brighter than the counterjets (Fig. 2). The most evident counterjet is in the HH 446 system, which suggests that the jet-counterjet axis is close to be perpendicular to the line of sight; this fact backs the edge-on hypothesis.

There might be other unknown Herbig-Haro objects in σ Orionis. The driving sources should be the stars with the strongest near-infrared excesses and symmetric, wide Hα emission, as for the known hosts. Caballero (2006) reported two faint structures at identical position angle, $PA \sim 240$ deg, and at $\sim$7.6 and $\sim$3.5 arcsec to the active, red, classical T Tauri star Mayrit 609206 (V505 Ori, $J - K_{\rm s} = 2.01 \pm 0.04$ mag). The structures, which I associated with an unconfirmed Herbig-Haro object candidate, were detected in the J band on deep Isaac/VLT images (the emission may come thus from [Fe II] λ1256.7 nm; Reipurth et al. 2000). This hypothesis could be supported by an [N II] nebular emission surrounding Mayrit 609206 found by D. Barrado y Navascués (priv. comm.).

- *Because of the photometric variability studies in its substellar domain* (e.g., Bailer-Jones & Mundt 2001; Zapatero Osorio et al. 2003; Scholz & Eislöffel 2004; Scholz et al. 2009; Cody & Hillenbrand 2010, 2011). Just as an example, a body in σ Orionis, Mayrit 495126 (V2728 Ori, S Ori J053825.4–024241, $J = 14.88 \pm 0.03$ mag), is the most variable T Tauri brown dwarf found to date in the whole sky. Its light curve at different wavebands displays an amplitude of aperiodic variability of up to 0.7 mag on scales of hours, days, months and years (Caballero et al. 2004, 2006). However, the hypothetical pulsations induced by deuterium burning in σ Orionis brown dwarfs have not been confirmed (Palla & Baraffe 2005).

- *Because σ Ori is the most massive "binary" with an astrometric orbit* (e.g., Heintz 1974, 1997; Hartkopf et al. 1996; Mason et al. 1998, 2009; Turner et al. 2008). At the end of the 19th century, Burnham (1892) discovered that the brightest star in the cluster was actually a very close binary of $\rho \sim 0.25$ arcsec. With a period of about 157 a, the pair has not completed a full orbit since its discovery. Simón-Díaz et al. (2011) confirmed a one-century conjecture (e.g., Frost & Adams 1904), which is that the primary is in its turn a double-line spectroscopic binary with a period of 143.5±0.5 d. The triple system (Aa: O9.5 V, Ab: B0.5 V, B: B2: V) contains over 40 $M_\odot$, which increases to over 60 $M_\odot$ if we also take into account σ Ori C, D and E. But the tight system hides more secrets, such as the nearby binary proplyd Mayrit 3030 AB (σ Ori IRS1 – van Loon & Oliveira 2003; Caballero 2005; Hodapp et al. 2009) or a poorly-investigated gas shell surrounding the Trapezium-like system (Caballero et al. 2008b).

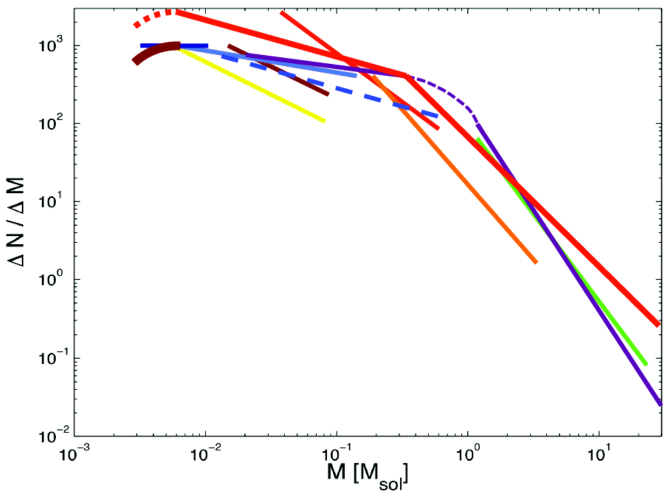


Figure 3: Collage of different σ Orionis mass spectrum slopes as shown by the author at *50 Years of Brown Dwarfs: from Theoretical Prediction to Astrophysical Studies* on 21–24 Oct. 2012 at Schloss Ringberg, Bayern, Germany.

- *Because of the works on its accretion rates and frequency at low stellar and substellar masses* (e.g., Zapatero Osorio et al. 2002a; Muzerolle et al. 2003; Barrado y Navascués et al. 2003; Kenyon et al. 2005; Sacco et al. 2008; Rigliaco et al. 2011). The σ Orionis cluster contains some strong Hα emitters at the deuterium-burning mass limit (the "brown dwarf-planet" boundary), or even below (Zapatero Osorio et al. 2002b; Barrado y Navascués et al. 2002).

- *Because of its well-studied mass function, especially in the low-mass stellar and substellar domain* (the rest of the world: e.g., Béjar et al. 1999, 2001; Tej et al. 2002; Caballero 2006, 2007, 2009, 2011; González-García et al. 2006; Caballero et al. 2007; Lodieu et al. 2009; Bihain et al. 2009; Peña Ramírez et al. 2011, 2012). In short, the average cluster mass spectrum matches the Salpeter's slope from about 19 to 1 $M_\odot$, has a shoulder between 1 and 0.5 $M_\odot$, gets much flatter (around $\alpha = +0.3$) between about 0.5 and 0.006 $M_\odot$, and *seems* to have a sharp drop below that value (see Fig. 3). As also noticed by Peña Ramírez et al. (2012), a log-normal function does not fit the observed mass function, especially at the lowest mass bins. In order to confirm the flatness, or even the cut-off, at the bottom of the mass spectrum at 3–5 $M_{\rm Jup}$, we need a bigger observational effort for getting new methane imaging, astrometry, and low-resolution spectroscopy of isolated planetary-mass candidates. However, as quantified by Caballero et al. (2008a), the deeper the surveys, the larger the number of interloper contaminants. Therefore, such observational effort is absolutely mandatory for confirming or discarding cluster membership and, to sum up, constraining star-formation and evolution models. Regarding this issue, some "rogue planets" in Peña Ramírez et al. (2012) are currently under investigation by a Spanish team (Zapatero Osorio, priv. comm.). A last remark: *the famous S Ori 70 object is a peculiar field T dwarf, not an ultra-low-mass cluster member!*

But do not think that σ Orionis is an impoverished land with nothing new to harvest: there are new forthcoming analyses, and studies that YOU can do!

- Study of close resolved multiplicity ($\rho \sim 0.4$–4.0 arcsec) using data from UKIDSS (Caballero et al., to be submitted), VISTA (Béjar et al., in prep.), and FastCam (a "lucky imager" at the 1.5 m Telescopio Carlos Sánchez on the Observatorio del Teide, Spain).
- Low-resolution optical spectroscopy of the Hα emitters in Haro & Moreno (1955), many of which still miss a detailed spectroscopic study, with Osiris at the 10.4 m Gran Telescopio Canarias (Caballero et al., in prep.).
- A new deep X-ray survey, wider than previous ones; a study of winds and radiation from σ Ori AabB; a determination of the parallactic distance to the cluster with *Gaia*; an investigation of the near- and far-ultraviolet emission from cluster brown dwarfs with the imager instrument onboard the Spanish-Russian *WSO-UV* space mission, etc.

Do you have any fresh idea on σ Orionis and do not know how to implement it? Just visit http://exoterrae.eu and drop me an e-mail.

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Perspective

The Power of Pebbles

by Anders Johansen

Planetesimals: The formation of planetesimals of kilometer sizes or larger marks an important transition in the planet formation process. Smaller bodies – μm-sized dust grains and agglomerates, cm-sized pebbles and m-sized boulders – have negligible cross section enhancement from gravity. One can choose to define a *planetesimal* as a solid body whose gravitational cross section is significant. However, the exact definition would then depend on the specific planet formation model that one adopts (i.e. at what size does the gravitational cross section become "significant"?). It also hides the important fact that gravity can play a crucial role already for the dynamics of much smaller pebble-sized particles. In that case it is the collective gravity of an extremely large number of solid bodies, rather than their two-body gravitational interaction, which determines their dynamics and accumulation.

A more pragmatic definition of a planetesimal is that the formation of planetesimal belts marks the first growth to solid sizes which can survive collisional grinding for billions of years – allowing astronomers studying planetesimal belts to peek into the long since passed planet formation process of that particular system. The asteroid belt orbiting the Sun contains millions of bodies, with a size distribution which decreases steeply towards larger radii. NASA's Dawn mission recently left its 13-months orbit of Vesta, the third-largest asteroid with a radius of 260 km, and is now en route to Ceres. Measuring the gravitational moments of Vesta, Dawn confirmed that Vesta is differentiated into an iron core and a silicate mantle (Russell et al. 2010). This makes Vesta a primordial body which formed together with the planets and somehow avoided both collisional grinding and becoming part of the growing planets.

The Kuiper belt is the second major planetesimal belt in the Solar System. The Kuiper belt contains no less than 5,000 bodies larger than 100 km in radius, but this high number is spread over a much larger volume than the asteroid belt, so large Kuiper belt objects have very long collision times. Other stars boast significant planetesimal belts too. Young FGK stars host warm planetesimal belts in 20%–40% of the cases and 16% host detectable, cold planetesimal belts (Kuiper belt analogues, Wyatt 2008).

Streaming instability: Planetesimal belts are ubiquitous, but are planetesimals really the building blocks of planets? Should Vesta only be noted for its failure to participate in the accumulation of a planet? To answer that question we should first understand how planetesimals form. That is a long-standing problem in theoretical, observational and experimental astrophysics. Dust grains collide and stick to form larger agglomerates. Sticking becomes less efficient as the particles grow (Blum & Wurm 2008). However, particle growth will slow down beyond a few dm even with perfect sticking, as the collision frequency drops. Condensation and sublimation near ice-lines can help the growth (Ros & Johansen 2013; see this edition of the Star Formation Newsletter) – but efficient condensation is limited to particle sizes below cm-dm.

The toughest barrier for planetesimal formation is arguably radial drift. The gas in the protoplanetary disc is pressure-supported in the radial direction, resulting in gas motion slower than the Keplerian speed by around 25 to 50 m/s The headwind robs particles of angular momentum and causes their orbits to decay within a few thousand years. The radial drift speed is highest for m-sized boulders in the inner disc and for mm/cm-sized pebbles in the tenuous outer parts of protoplanetary discs.

Ironically the radial drift problem may provide the solution to itself. Youdin & Goodman (2005) discovered a linearly unstable mode of inwards-drifting particles and outwards-drifting gas, the two components coupled via drag forces. The streaming mode grows exponentially in time and leads to axisymmetric particle concentration. In the non-linear regime the growth can be understood as follows: a higher density patch of particles at a certain distance from the star will locally accelerate the gas towards the Keplerian speed, slowing both the headwind and the radial drift, and isolated particles, which do not benefit from collective drag, will drift into the overdense region, adding more and more mass to the overdense seed.

Together with my collaborators, I have studied the non-linear evolution of streaming instabilities since we identified the mechanism for the first time in computer simulations (Youdin & Johansen 2007; Johansen & Youdin 2007; Johansen et al. 2007). Other mechanisms for concentrating particles – in vortices (Barge & Sommeria 1995; Klahr & Bodenheimer 2003) and in pressure bumps (Whipple 1972; Johansen et al. 2009a) – are certainly relevant too,

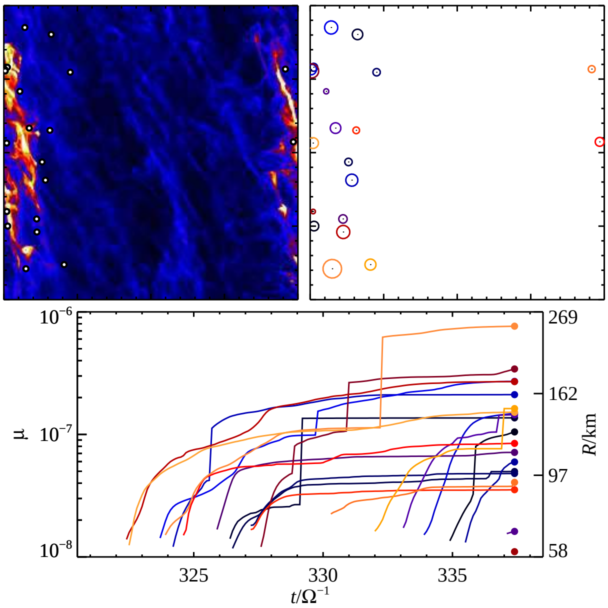

Figure 1: Formation of planetesimals from an overdense filament of cm-sized pebbles. *Top left panel:* column density of pebbles. *Top right panel:* positions and Hill radii of the newly born planetesimals. *Bottom panel:* masses and radii of the planetesimals. Masses are given in a natural unit and correspond to bodies of approximate size 50–200 km in the asteroid belt.

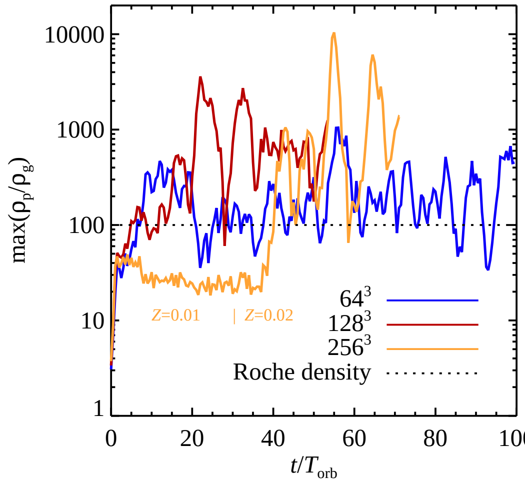

Figure 2: The maximum density of particles which are 10 cm in size at 5 AU and 1 cm in size at 30 AU. The maximum density increases from 1000 times the gas density at 64^3 resolution to 4000 and 12000 at 128^3 and 256^3. This increase is caused by resolution of increasingly finer filamentary structure in the overdense regions (Johansen et al. 2012). The particle mass-loading in the 256^3 simulation was increased from $Z = 0.01$ to $Z = 0.02$ after thirty orbits running time, to illustrate the threshold behaviour of the background abundance of heavy elements.

but I focus in this text on the streaming instability, because the growth of this instability is so intimately linked with particle concentration. The full story of how particle concentration in turbulence shapes planet formation is still unfolding and far from finished. Figure 1 shows the results of a 3-D simulation (with 256^3 grid cells and 19.2 million particles) of streaming instabilities in cm-sized pebbles. This simulation takes into account the stellar gravity component which causes sedimentation of particles towards the mid-plane (Johansen et al. 2009b; Bai & Stone 2010b), an effect that is not included in the linear stability analysis. Surprisingly the inclusion of vertical gravity leads to much higher particle concentration than the unstratified cases (Johansen & Youdin 2007; Bai & Stone 2010a), also for particle sizes much smaller than the optimally concentrated dm/m-sized boulders. This increased particle concentration can come about because traffic jams are much more efficient in a narrow mid-plane layer than in an extended layer with more paths around obstacles. Figure 2 shows the maximum particle density versus time for three different resolutions of the underlying gas grid. The 256^3 simulation has particle concentrations of up to 10^6 over the canonical disc value (0.01), with a factor of 100 from the sedimentation and an additional factor of 10^4 from particle traffic jams. The densities easily reach beyond the Roche density at $\rho_{\rm R}{\approx}100\rho_{\rm g}$ – the criterion for gravitational contraction of the particle component.

Pebble accretion: The reason that I am hesitant to call planetesimals the building blocks of planets is an ongoing realisation that newly formed planetesimals can accrete unbound pebbles very, very efficiently. In this picture planetesimal-planetesimal collisions play a minor role compared to the ubiquitous planetesimal-pebble interaction. We observed this very efficient pebble accretion in computer simulations presented in Johansen & Lacerda (2010), and the growth mode was subsequently confirmed and expanded on by Ormel & Klahr (2010), Lambrechts & Johansen (2012), and Morbidelli & Nesvorny (2012). The idea of gas-drag-assisted accretion has roots further back in time (Weidenschilling & Davis 1985), but has lived a shadow life compared to the prevailing picture that planets and cores grow by accreting planetesimals.

Pebble accretion can be divided into two regimes. Planetesimals with masses below the *transition mass*, corresponding to a 1000-km-radius body in the asteroid belt or a 2000-km-radius body in the Kuiper belt, accrete pebbles moving past with the headwind of the gas. Gravitationally scattered pebbles lose energy by friction and fall on the rear side of the planetesimal. This process is related to *Bondi-Hoyle accretion* in star formation (Bonnell et al. 2001) and has a mass growth rate proportional to the planetesimal mass squared. The resulting growth is

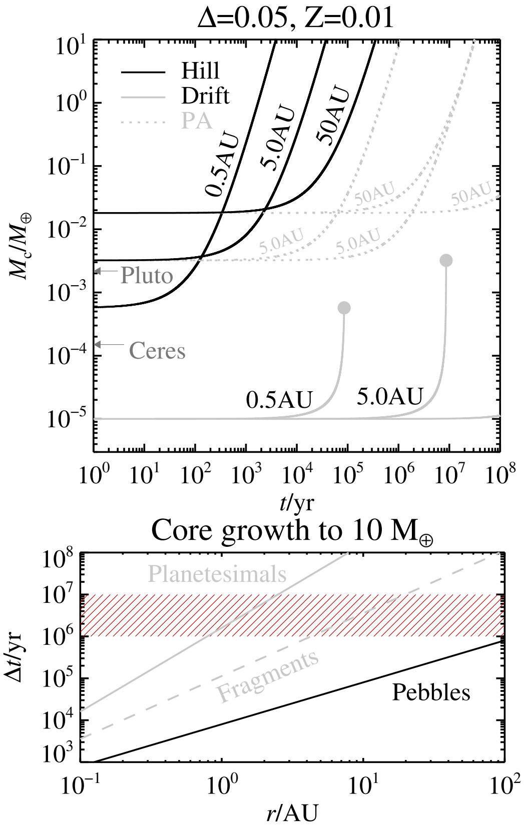

Figure 3: *Top panel:* Growth of gas-giant cores by pebble accretion starting at 10^{-5} Earth masses (gray lines) and at the respective transition mass at 0.5 AU, 5 AU and 50 AU (black lines). *Bottom panel:* Growth to ten Earth masses can be achieved within 10^6 years even in orbits as distant as 100 AU (from Lambrechts & Johansen 2012).

extremely slow to begin with, but then diverges rapidly above a threshold mass. The Bondi (or *drift*) accretion stage provides a physical picture of how some planetesimals formed by gravitational collapse manage to avoid growth to planet-sized bodies, since small 50–100 km sized bodies grow very slowly by pebble accretion. Pebble accretion in the Bondi regime would also give a very steep size distribution of planetesimals, in agreement with what is measured for large asteroids and Kuiper belt objects.

Above the transition mass planetesimals enter the *Hill accretion* regime. From this point on, any pebble that enters the planetesimal's Hill sphere – the region where planetary gravity dominates over stellar tidal force – is accreted (Figure 3). This is again explained by energy dissipation through friction with the gas. While in the classical core accretion picture the core of Jupiter has just about time to grow before the gas of the protoplanetary disc is dissipated, according to the calculations by Pollack et al. (1996), the time-scales for growing the cores of Saturn, Uranus and Neptune get increasingly absurd. Pebble accretion speeds up the core formation process by a factor between 1,000 (at 5 AU) and 10,000 (at 50 AU). The efficiency of pebble accretion can explain both the formation of the giant planets in the Solar System as well as exoplanets at wide separations from their host stars.

Outlook: Planet formation by particle concentration and pebble accretion is a research topic still in its infancy. An important immediate goal is to be able to produce the observed size distributions of the asteroid belt and the Kuiper belt. This requires very-high-resolution simulations (512^3 grid cells and beyond) to be able to quantify the size distribution of newly born planetesimals down to 25 km in radius. Such simulations are ongoing.

It is also unclear how the nucleated instability for gas giant formation operates under pebble accretion. A high mass accretion rate heats the gas envelope of the core and delays the run-away gas accretion phase. On the other hand, sublimation of icy pebbles would pollute the envelope with heavy water vapour, which can lead to significant reduction in the critical core mass (Hori & Ikoma 2010).

Finally there is the elephant in the room: the majority of the mass in meteorites from the asteroid belt is in mm-sized *chondrules*. Such particles are tightly coupled to the dense gas present in the solar nebula at 2–3 AU, and thus they are very hard to pull out of the gas flow. Chondrules are much smaller than the typically cm/dm particles that have been the focus of streaming instabilities until now. Finding out under what conditions streaming instabilities can concentrate chondrule-sized particles is an important priority for the future, as that would put a firm link between planet formation theories and the wealth of information that the cosmochemistry community has about the prevalent conditions in the solar nebula.

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Abstracts of recently accepted papers

Structure of CB 26 Protoplanetary Disk Derived from Millimeter Dust Continuum Maps

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Observations of the circumstellar disk in the Bok globule CB 26 at 110, 230, and 270 GHz are presented together with the results of the simulations and estimates of the disk parameters. These observations were obtained using the SMA, IRAM Plateau de Bure, and OVRO interferometers. The maps have relatively high angular resolutions (0.4-1″), making it possible to study the spatial structure of the gas-dust disk. The disk parameters are reconstructed via a quantitative comparison of observational and theoretical intensity maps. The disk model used to construct the theoretical maps is based on the assumption of hydrostatic and radiative equilibrium in the vertical direction, while the radial surface density profile is described phenomenologically. The system of equations for the transfer of the infrared and ultraviolet radiation is solved in the vertical direction, in order to compute the thermal structure of the disk. The disk best-fit parameters are derived for each map and all the maps simultaneously, using a conjugate gradient method. The degrees of degeneracy of the parameters describing the thermal structure and density distribution of the disk are analyzed in detail. All three maps indicate the presence of an inner dust-free region with a radius of approximately 35 AU, in agreement with the conclusions of other studies. The inclination of the disk is 78°, which is smaller than the value adopted in our earlier study of rotating molecular outflows from CB 26. The model does not provide any evidence for the growth of dust particles above $a_{\max} \approx 0.02$ cm.

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Protoplanetary Disk Structure With Grain Evolution: the ANDES Model

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We present a self-consistent model of a protoplanetary disk: 'ANDES' ('AccretioN disk with Dust Evolution and Sedimentation'). ANDES is based on a flexible and extendable modular structure that includes 1) a 1+1D frequency-dependent continuum radiative transfer module, 2) a module to calculate the chemical evolution using an extended gas-grain network with UV/X-ray-driven processes surface reactions, 3) a module to calculate the gas thermal energy balance, and 4) a 1+1D module that simulates dust grain evolution. For the first time, grain evolution and time-dependent molecular chemistry are included in a protoplanetary disk model. We find that grain growth and sedimentation of large grains to the disk midplane lead to a dust-depleted atmosphere. Consequently, dust and gas temperatures become higher in the inner disk (R < 50 AU) and lower in the outer disk (R > 50 AU), in comparison with the disk model with pristine dust. The response of disk chemical structure to the dust growth and sedimentation is twofold. First, due to higher transparency a partly UV-shielded molecular layer is shifted closer to the dense midplane. Second, the presence of big grains in the disk midplane delays the freeze-out of volatile gas-phase species such as CO there, while in adjacent upper layers the depletion is still effective. Molecular concentrations and thus column densities of many species are enhanced in the disk model with dust evolution, e.g., CO_2, NH_2CN, HNO, H_2O, HCOOH, HCN, CO. We also show that time-dependent chemistry is important for a proper description of gas thermal balance.

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A Hi-GAL study of the high-mass star-forming region G29.96−0.02

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Context. G29.96−0.02 is a high-mass star-forming cloud observed at 70, 160, 250, 350, and 500 μm as part of the *Herschel* survey of the Galactic Plane (Hi-GAL) during the Science Demonstration Phase.
Aims. We wish to conduct a far-infrared study of the sources associated with this star-forming region by estimating their physical properties and evolutionary stage, and investigating the clump mass function, the star formation efficiency and rate in the cloud.
Methods. We have identified the Hi-GAL sources associated with the cloud, searched for possible counterparts at centimeter and infrared wavelengths, fitted their spectral energy distribution and estimated their physical parameters.
Results. A total of 198 sources have been detected in all 5 Hi-GAL bands, 117 of which are associated with 24 μm emission and 87 of which are not associated with 24 μm emission. We called the former sources 24 μm-bright and the latter ones 24 μm-dark. The [70–160] color of the 24 μm-dark sources is smaller than that of the 24 μm-bright ones. The 24 μm-dark sources have lower $L_{\rm bol}$ and $L_{\rm bol}/M_{\rm env}$ than the 24 μm-bright ones for similar $M_{\rm env}$, which suggests that they are in an earlier evolutionary phase. The G29-SFR cloud is associated with 10 NVSS sources and with extended centimeter continuum emission well correlated with the 70 μm emission. Most of the NVSS sources appear to be early B or late O-type stars. The most massive and luminous Hi-GAL sources in the cloud are located close to the G29-UC region, which suggests that there is a privileged area for massive star formation towards the center of the G29-SFR cloud. Almost all the Hi-GAL sources have masses well above the Jeans mass but only 5% have masses above the virial mass, which indicates that most of the sources are stable against gravitational collapse. The sources with $M_{\rm env} > M_{\rm virial}$ and that should be undergoing collapse and forming stars are preferentially located at $\lesssim 4'$ of the G29-UC region, which is the most luminous source in the cloud. The overall SFE of the G29-SFR cloud ranges from 0.7 to 5%, and the SFR ranges from 0.001 to 0.008 $M_\odot\,{\rm yr}^{-1}$, consistent with the values estimated for Galactic HII regions. The mass spectrum of the sources with masses above 300 $M_\odot$, well above the completeness limit, can be well-fitted with a power law of slope $\alpha = 2.15 \pm 0.30$, consistent with the values obtained for the whole $l = 30°$, associated with high-mass star formation, and $l = 59°$, associated with low- to intermediate-mass star formation, Hi-GAL SDP fields.

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An Old Disk That Can Still Form a Planetary System

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From the masses of planets orbiting our Sun, and relative elemental abundances, it is estimated that at birth our Solar System required a minimum disk mass of ∼0.01 $M_\odot$ within ∼100 AU of the star. The main constituent, gaseous molecular hydrogen, does not emit from the disk mass reservoir, so the most common measure of the disk mass is dust thermal emission and lines of gaseous carbon monoxide. Carbon monoxide emission generally probes the disk surface, while the conversion from dust emission to gas mass requires knowledge of the grain properties and gas-to-dust mass ratio, which likely differ from their interstellar values. Thus, mass estimates vary by orders of magnitude, as exemplified by the relatively old (3–10 Myr) star TW Hya, with estimates ranging from 0.0005 to 0.06 $M_\odot$. Here we report the detection the fundamental rotational transition of hydrogen deuteride, HD, toward TW Hya. HD is a good tracer of disk gas because it follows the distribution of molecular hydrogen and its emission is sensitive to the total mass. The HD detection, combined with existing observations and detailed models, implies a disk mass >0.05 $M_\odot$, enough to form a planetary system like our own.

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Independent confirmation of β Pictoris b imaging with NICI

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Context. β Pictoris b is one of the most studied objects nowadays since it was identified with VLT/NaCo as a bona-fide exoplanet with a mass of about 9 times that of Jupiter at an orbital separation of 8-9 AU. The link between the planet and the dusty disk is unambiguously attested and this system provides an opportunity to study the disk/planet interactions and to constrain formation and evolutionary models of gas giant planets. Still, β Pictoris b had never been confirmed with other telescopes so far.
Aims. We aimed at an independent confirmation using a different instrument.
Methods. We retrieved archive images from Gemini South obtained with the instrument NICI, which is designed for high contrast imaging. The observations combine coronagraphy and angular differential imaging and were obtained at three epochs in Nov. 2008, Dec. 2009 and Dec. 2010.
Results. We report the detection with NICI of the planet β Pictoris b in Dec. 2010 images at a separation of 404 $\pm$ 10 mas and $PA = 212.1 \pm 0.7°$. It is the first time this planet is observed with a telescope different than the VLT.

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Probing dust settling in proto-planetary discs with ALMA

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Investigating the dynamical evolution of dust grains in proto-planetary disks is a key issue to understand how planets should form. We identify under which conditions dust settling can be constrained by high angular resolution observations at mm wavelengths, and which observational strategies are suited for such studies. Exploring a large range of models, we generate synthetic images of disks with different degrees of dust settling, and simulate high angular resolution (∼ 0.05-0.3") ALMA observations of these synthetic disks. The resulting data set are then analyzed blindly with homogeneous disk models (where dust and gas are totally mixed) and the derived disk parameters are used as tracers of the settling factor. Our dust disks are partially resolved by ALMA and present some specific behaviors on radial and mainly vertical directions, which can be used to quantified the level of settling. We find out that an angular resolution better than or equal to ∼ 0.1" (using 2.3 km baselines at 0.8mm) allows us to constrain the dust scale height and flaring index with sufficient precision to unambiguously distinguish between settled and non-settled disks, provided the inclination is close enough to edge-on (i ≥ 75°). Ignoring dust settling and assuming hydrostatic equilibrium when analyzing such disks affects the derived dust temperature and the radial dependency of the dust emissivity index. The surface density distribution can also be severely biased at the highest inclinations. However, the derived dust properties remain largely unaffected if the disk scale height is fitted separately. ALMA has the potential to test some of the dust settling mechanisms, but for real disks, deviations from ideal geometry (warps, spiral waves) may provide an ultimate limit on the dust settling detection.

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The near-infrared spectral energy distribution of β Pictoris b

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A gas giant planet has previously been directly seen orbiting at 8-10 AU within the debris disk of the ∼12 Myr old star β Pictoris. The β Pictoris system offers the rare opportunity to study the physical and atmospheric properties of an exoplanet placed on a wide orbit and to establish its formation scenario. We obtained J (1.265 μm), H (1.66 μm), and M′ (4.78 μm) band angular differential imaging of the system between 2011 and 2012. We detect the planetary companion in our four-epoch observations. We estimate J = 14.0 ± 0.3, H = 13.5 ± 0.2, and M′ = 11.0 ± 0.3 mag. Our new astrometry consolidates previous semi-major axis ($sma = 8 - 10$ AU) and execentricity ($e \leq 0.15$) estimates of the planet. These constraints, and those derived from radial velocities of the star provides independent upper limits on the mass of β Pictoris b of 12 and 15.5 $M_{\rm Jup}$ for semi-major axis of 9 and 10 AU. The location of β Pictoris b in color-magnitude diagrams suggests it has spectroscopic properties similar to L0-L4 dwarfs. This enables to derive $\log_{10}(L/L_{\odot}) = -3.87 \pm 0.08$ for the companion. The analysis with 7 PHOENIX-based atmospheric models reveals the planet has a dusty atmosphere with $T_{\rm eff} = 1700 \pm 100$ K and $\log g = 4.0 \pm 0.5$. "Hot-start" evolutionary models give a

new mass of 10^{+3}_{-2} $M_{\rm Jup}$ from $T_{\rm eff}$ and 9^{+3}_{-2} $M_{\rm Jup}$ from luminosity. Predictions of "cold-start" models are inconsistent with independent constraints on the planet mass. "Warm-start" models constrain the mass to $M \geq 6M_{\rm Jup}$ and the initial entropies to values ($S_{\rm init} \geq 9.3K_{\rm b}$/baryon), intermediate between those considered for cold/hot-start models, but likely closer to those of hot-start models.

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High-Resolution Near Infrared Spectroscopy of HD 100546: II. Analysis of variable ro-vibrational CO emission lines

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We present observations of ro-vibrational CO in HD 100546 from four epochs spanning January 2003 through December 2010. We show that the equivalent widths of the CO lines vary during this time period with the v=1-0 CO lines brightening more than the UV fluoresced lines from the higher vibrational states. While the spectroastrometric signal of the hot band lines remains constant during this period, the spectroastrometric signal of the v=1–0 lines varies substantially. At all epochs, the spectroastrometric signals of the UV fluoresced lines are consistent with the signal one would expect from gas in an axisymmetric disk. In 2003, the spectroastrometric signal of the v=1-0 P26 line was symmetric and consistent with emission from an axisymmetric disk. However, in 2006, there was no spatial offset of the signal detected on the red side of the profile, and in 2010, the spectroastrometric offset was yet more strongly reduced toward zero velocity. A model is presented that can explain the evolution of the equivalent width of the v=1-0 P26 line and its spectroastrometric signal by adding to the system a compact source of CO emission that orbits the star near the inner edge of the disk. We hypotheize that such emission may arise from a circumplanetary disk orbiting a gas giant planet near the inner edge of the circumstellar disk. We discuss how this idea can be tested observationally and be distinguished from an alternative interpretation of random flucuations in the disk emission.

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Characterization of Infrared Dark Clouds – NH_3 Observations of an Absorption-contrast Selected IRDC Sample

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Context. Despite increasing research in massive star formation, little is known about its earliest stages. Infrared Dark Clouds (IRDCs) are cold, dense and massive enough to harbour the sites of future high-mass star formation. But up to now, mainly small samples have been observed and analysed.
Aims. To understand the physical conditions during the early stages of high-mass star formation, it is necessary to learn more about the physical conditions and stability in relatively unevolved IRDCs. Thus, for characterising IRDCs studies of large samples are needed.
Methods. We investigate a complete sample of 218 northern hemisphere high-contrast IRDCs using the ammonia (1,1)-

and (2,2)-inversion transitions.
Results. We detected ammonia (1,1)-inversion transition lines in 109 of our IRDC candidates. Using the data we were able to study the physical conditions within the star-forming regions statistically. We compared them with the conditions in more evolved regions which have been observed in the same fashion as our sample sources. Our results show that IRDCs have, on average, rotation temperatures of 15 K, are turbulent (with line width FWHMs around 2 km s^{-1}), have ammonia column densities on the order of 10^{14} cm^{-2} and molecular hydrogen column densities on the order of 10^{22} cm^{-2}. Their virial masses are between 100 and a few 1000 $M_\odot$. The comparison of bulk kinetic and potential energies indicate that the sources are close to virial equilibrium.
Conclusions. IRDCs are on average cooler and less turbulent than a comparison sample of high-mass protostellar objects, and have lower ammonia column densities. Virial parameters indicate that the majority of IRDCs are currently stable, but are expected to collapse in the future.

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Time Variability of Emission Lines for Four Active T Tauri Stars (I): October–December in 2010

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We present optical spectrophotometric monitoring of four active T Tauri stars (DG Tau, RY Tau, XZ Tau, RW Aur A) at high spectral resolution ($R \geq 1 \times 10^4$), to investigate the correlation between time variable mass ejection seen in the jet/wind structure of the driving source and time variable mass accretion probed by optical emission lines. This may allow us to constrain the understanding of the jet/wind launching mechanism, the location of the launching region, and the physical link with magnetospheric mass accretion. In 2010, observations were made at six different epochs to investigate how daily and monthly variability might affect such a study. We perform comparisons between the line profiles we observed and those in the literature over a period of decades and confirm the presence of time variability separate from the daily and monthly variability during our observations. This is so far consistent with the idea that these line profiles have a long term variability (3-20 years) related to episodic mass ejection suggested by the structures in the extended flow components. We also investigate the correlations between equivalent widths and between luminosities for different lines. We find that these correlations are consistent with the present paradigm of steady magnetospheric mass accretion and emission line regions that are close to the star.

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Ionization–induced star formation V: Triggering in partially unbound clusters

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We present the fourth in a series of papers detailing our SPH study of the effects of ionizing feedback from O–type stars on turbulent star forming clouds. Here, we study the effects of photoionization on a series of initially partially unbound clouds with masses ranging from 10^4–10^6 $M_\odot$ and initial sizes from 2.5-45 pc. We find that ionizing feedback profoundly affects the structure of the gas in most of our model clouds, creating large and often well-cleared bubble structures and pillars. However, changes in the structures of the embedded clusters produced are much weaker and

not well correlated to the evolution of the gas. We find that in all cases, star formation efficiencies and rates are reduced by feedback and numbers of objects increased, relative to control simulations. We find that local triggered star formation does occur and that there is a good correlation between triggered objects and pillars or bubble walls, but that triggered objects are often spatially-mixed with those formed spontaneously. Some triggered objects acquire large enough masses to become ionizing sources themselves, lending support to the concept of propagating star formation. We find scant evidence for spatial age gradients in most simulations, and where we do see them, they are not a good indicator of triggering, as they apply equally to spontaneously-formed objects as triggered ones. Overall, we conclude that inferring the global or local effects of feedback on stellar populations from observing a system at a single epoch is very problematic.

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A Very Long Baseline Interferometry Detection of the Class I Protostar IRS 5 in Corona Australis

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Aims. Very Long Baseline Interferometry yields physical constraints on the compact radio emission of young stellar objects. At the same time, such measurements can be used for precise astrometric measurements of parallaxes and proper motions. Here, we aimed to make the first detections of very compact radio emission from class I protostars in the Corona Australis star-forming region.
Methods. We have used the Long Baseline Array (LBA) to observe the protostars IRS 5 and IRS 7 in the Corona Australis star-forming region in three separate epochs.
Results. We report the first firm radio detection of a class I protostar using very long baseline interferometry. We have detected the previously known non-thermal source IRS 5b, part of a binary system. IRS 5a and IRS 5N were undetected, as were all sources in the IRS 7 region.
Conclusions. These results underline the unusual nature of IRS 5b as a genuine protostar with confirmed non-thermal radio emission. Also, these observations highlight the potential of the LBA as a tool to provide precision astrometric measurements of individual young stellar objects in southern star-forming regions that are not accessible to the Very Long Baseline Array in the northern hemisphere.

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On the nature of veiling of classical T Tauri stars spectra in the near-IR spectral band

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It is shown that the existence of a hot accretion spot on the surface of classical T Tauri stars allows to explain observed veiling of their photospheric spectrum not only in the visible but also in the near infrared spectral band.

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A non-LTE modeling of narrow emission components of He and Ca lines in optical spectra of CTTS

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A spectrum of a hot spot, produced by radiation of accretion shock at T Tauri star's surface, has been calculated taking into account non-LTE effects for He I, He II, Ca I and Ca II, using LTE-calculations of spot's atmospheric structure, calculated by Dodin & Lamzin (2012). Assuming that pre-shock gas number density N_0 and its velocity V_0 are the same across the accretion column, we calculated spectra of a system "star + round spot" for a set of N_0, V_0 values and parameters, which characterized the star and the spot.
It has been shown that theoretical spectra with an appropriate choice of the parameters reproduce well observed veiling of photospheric absorption lines in optical band as well as profiles and intensities of so-called narrow components of He II and Ca I emission lines in spectra of 9 stars. We found that the accreted gas density $N_0 > 10^{12}$ cm^{-3} for all considered stars except DK Tau. Observed spectra of 8 stars were successfully fitted, assuming solar abundance of calcium, but it appeared possible to fit TW Hya spectrum only under assumption that calcium abundance in accreted gas was three times less than solar. We derive spot's parameters by comparison of theoretical and observed spectra, normalised to continuum level, so our results are independent on unknown value of interstellar extinction.
We have found that the predicted flux in Ca II lines is less than observed one, but this discrepancy can be resolved if not only high-density but also lower density gas falls onto the star. Theoretical equivalent widths as well as relative intensities of He I subordinate lines disagree significantly with observations, presumbly due to a number of reasons: necessity to take into account non-LTE thermal structure of upper layers of a hot spot, poorly known collisional atomic data for He I upper levels and inhomogeneity of the hot spot.

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Star formation in Galactic spiral arms and the inter-arm regions

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The line of sight through the Galactic Plane between longitudes $l = 37.83°$ and $l = 42.50°$ allows for the separation of Galactic Ring Survey molecular clouds into those that fall within the spiral arms and those located in the inter-arm regions. By matching these clouds in both position and velocity with dense clumps detected in the mm continuum by the Bolocam Galactic Plane Survey, we are able to look for changes in the clump formation efficiency (CFE), the ratio of clump-to-cloud mass, with Galactic environment. We find no evidence of any difference in the CFE between the inter-arm and spiral-arm regions along this line of sight. This is further evidence that, outside the Galactic Centre region, the large-scale structures of the Galaxy play little part in changing the dense, potentially star-forming structures within molecular clouds.

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A Mathematical Model for an Hourglass Magnetic Field

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Starting with a mathematical boundary value problem for the magnetic vector potential in an axisymmetric cylindrical coordinate system, we derive a general solution for any arbitrary current distribution using the method of Green's functions. We use this to derive an analytic form for an hourglass magnetic field pattern created by electrical currents that are concentrated near (but not confined within) the equatorial plane of a cylindrical coordinate system. Our solution is not characterized by a cusp at the equatorial plane, as in previous solutions based on a current sheet. The pattern we derive provides a very good fit to hourglass magnetic field patterns emerging from three-dimensional numerical simulations of core formation, and can in principle be used for source-fitting of observed magnetic hourglass patterns.

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The 2013 Release of Cloudy

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This is a summary of the 2013 release of the plasma simulation code Cloudy. Cloudy models the ionization, chemical, and thermal state of material that may be exposed to an external radiation field or other source of heating, and predicts observables such as emission and absorption spectra. It works in terms of elementary processes, so is not limited to any particular temperature or density regime. This paper summarizes advances made since the last major review in 1998. Much of the recent development has emphasized dusty molecular environments, improvements to the ionization / chemistry solvers, and how atomic and molecular data are used. We present two types of simulations to demonstrate the capability of the code. We consider a molecular cloud irradiated by an X-ray source such as an Active Nucleus and show how treating EUV recombination lines and the full SED affects the observed spectrum. A second example illustrates the very wide range of particle and radiation density that can be considered.

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Spatially resolved H_2 emission from a very low-mass star

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Molecular outflows from very low-mass stars (VLMSs) and brown dwarfs have been studied very little. So far, only a few CO outflows have been observed, allowing us to map the immediate circumstellar environment. We present the first spatially resolved H_2 emission around IRS54 (YLW 52), a $\sim$0.1-0.2 $M_\odot$ Class I source. By means of VLT SINFONI K-band observations, we probed the H_2 emission down to the first $\sim$50 AU from the source. The molecular emission shows a complex structure delineating a large outflow cavity and an asymmetric molecular jet. Thanks to the detection of several H_2 transitions, we are able to estimate average values along the jet-like structure (from source position to knot D) of $A_V \sim 28$ mag, T $\sim$2000-3000 K, and H_2 column density $N(H_2) \sim 1.7\times10^{17}$ cm^{-2}. This allows us to estimate a mass loss rate of $\sim 2\times10^{-10}\, M_\odot\, yr^{-1}$ for the warm H_2 component . In addition, from the total flux of the Br γ line, we infer an accretion luminosity and mass accretion rate of 0.64 $L_\odot$ and $\sim 3\times10^{-7}\, M_\odot\, yr^{-1}$, respectively. The outflow structure is similar to those found in low-mass Class I and CTTS. However, the L_{acc}/L_{bol} ratio is very

high (∼80%), and the mass accretion rate is about one order of magnitude higher when compared to objects of roughly the same mass, pointing to the young nature of the investigated source.

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Spitzer-IRAC survey of molecular jets in Vela-D

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We present a survey of H_2 jets from young protostars in the Vela-D molecular cloud (VMR-D), based on Spitzer -IRAC data between 3.6 and 8.0 micron. Our search has led to the identification of 15 jets and about 70 well aligned knots within 1.2 squared degree. We compare the IRAC maps with observations of the H_2 1-0 S(1) line at 2.12 micron, with a Spitzer-MIPS map at 24 and 70 micron, and with a map of the dust continuum emission at 1.2 mm. We find a association between molecular jets and dust peaks. The jet candidate exciting sources have been searched for in the published catalog of the Young Stellar Objects of VMR-D. We selected all the sources of Class II or earlier which are located close to the jet center and aligned with it.The association between jet and exciting source was validated by estimating the differential extinction between the jet opposite lobes. We are able to find a best-candidate exciting source in all but two jets. Four exciting sources are not (or very barely) observed at wavelengths shorter than 24 micron, suggesting they are very young protostars. Three of them are also associated with the most compact jets. The exciting source Spectral Energy Distributions have been modeled by means of the photometric data between 1.2 micron and 1.2 mm. From SEDs fits we derive the main source parameters, which indicate that most of them are low-mass protostars. A significant correlation is found between the projected jet length and the [24] - [70] color, which is consistent with an evolutionary scenario according to which shorter jets are associated with younger sources. A rough correlation is found between IRAC line cooling and exciting source bolometric luminosity, in agreement with the previous literature. The emerging trend suggests that mass loss and mass accretion are tightly related phenomena and that both decrease with time.

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The evolution of the jet from Herbig Ae star HD 163296 from 1999 to 2011

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Young A and B stars, the so-called Herbig Ae/Be stars (HAeBe), are surrounded by an active accretion disk and drive outflows. We study the jet HH 409, which is launched from the HAeBe star HD 163296, using new and archival observations from Chandra and HST/STIS. In X-rays we can show that the central source is not significantly extended.

The approaching jet, but not the counter-jet, is detected in Ly alpha. In addition, there is red-shifted Ly alpha emission extended in the same direction as the jet, that is also absent in the counter-jet. We can rule out an accretion or disk-wind origin for this feature. In the optical we find the knots B and B2 in the counter-jet. Knot B has been observed previously, so we can derive its proper motion of 0.37 ± 0.01 arcsec/yr. Its electron density is 3000 cm^{-3}, thus the cooling time scale is a few months only, so the knot needs to be reheated continuously. The shock speed derived from models of H alpha and forbidden emission lines (FELs) decreased from 50 km/s in 1999 to 30 km/s in 2011 because the shock front loses energy as it travels along the jet. Knot B2 is observed at a similar position in 2011 as knot B was in 1999, but shows a lower ionization fraction and higher mass loss rate, proving variations in the jet launching conditions.

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Probing the Earliest Stage of Protostellar Evolution – Barnard 1-bN and Barnard 1-bS

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Two submm/mm sources in the Barnard 1b (B1-b) core, B1-bN and B1-bS, have been observed with the Submillimeter Array (SMA) and the Submillimeter Telescope (SMT). The 1.1 mm continuum map obtained with the SMA reveals that the two sources contain spatially compact components, suggesting that they harbor protostars. The N_2D^+ and N_2H^+ J=3–2 maps were obtained by combining the SMA and SMT data. The N_2D^+ map clearly shows two peaks at the continuum positions. The N_2H^+ map also peaks at the continuum positions, but is more dominated by the spatially extended component. The N_2D^+/N_2H^+ ratio was estimated to be ~ 0.2 at the positions of both B1-bN and B1-bS. The derived N_2D^+/N_2H^+ ratio is comparable to those of the prestellar cores in the late evolutionary stage and the class 0 protostars in the early evolutionary stage. Although B1-bN is bright in N_2H^+ and N_2D^+, this source was barely seen in $H^{13}CO^+$. This implies that the depletion of carbon-bearing molecules is significant in B1-bN. The chemical property suggests that B1-bN is in the earlier evolutionary stage as compared to B1-bS with the $H^{13}CO^+$ counterpart. The N_2H^+ and N_2D^+ lines show that the radial velocities of the two sources are different by ~ 0.9 km s^{-1}. However, the velocity pattern along the line through B1-bN and B1-bS suggests that these two sources were not formed out of a single rotating cloud. It is likely that the B1-b core consists of two velocity components, each of which harbors a very young source.

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Interferometric Upper Limits on Millimeter Polarization of the Disks around DG Tau, GM Aur, and MWC 480

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Millimeter-wavelength polarization measurements offer a promising method for probing the geometry of magnetic fields in circumstellar disks. Single dish observations and theoretical work have hinted that magnetic field geometries might be predominantly toroidal, and that disks should exhibit millimeter polarization fractions of 2-3%. While subsequent work has not confirmed these high polarization fractions, either the wavelength of observation or the target sources differed from the original observations. Here we present new polarimetric observations of three nearby circumstellar disks at 2" resolution with the Submillimeter Array (SMA) and the Combined Array for Research in Millimeter Astronomy (CARMA). We reobserve GM Aur and DG Tau, the systems in which millimeter polarization detections have been claimed. Despite higher resolution and sensitivity at wavelengths similar to the previous observations, the new observations do not show significant polarization. We also add observations of a new HAeBe system, MWC 480. These observations demonstrate that a very low (<0.5%) polarization fraction is probably common at large (>100 AU) scales in bright circumstellar disks. We suggest that high-resolution observations may be worthwhile to probe magnetic field structure on linear distances smaller than the disk scale height, as well as in regions closer to the star that may have larger MRI-induced magnetic field strengths.

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Accretion disc viscosity: what do warped discs tell us?

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Standard, planar accretion discs operate through a dissipative mechanism, usually thought to be turbulent, and often modeled as a viscosity. This acts to take energy from the radial shear, enabling the flow of mass and angular momentum in the radial direction. In a previous paper we discussed observational evidence for the magnitude of this viscosity, and pointed out discrepancies between these values and those obtained in numerical simulations. In this paper we discuss the observational evidence for the magnitude of the dissipative effects which act in non–planar discs, both to transfer and to eliminate the non–planarity. Estimates based on the model by Ogilvie (1999), which assumes a small–scale, isotropic viscosity, give alignment timescales for fully ionized discs which are apparently too short by a factor of a few compared with observations, although we emphasize that more detailed computations as well as tighter observational constraints are required to verify this conclusion. For discs with low temperature and conductivity, we find that the timescales for disc alignment based on isotropic viscosity are too short by around two orders of magnitude. This large discrepancy suggests that our understanding of viscosity in quiescent discs is currently inadequate.

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Unveiling the detailed density and velocity structures of the protostellar core B335

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We present an observational study of the protostellar core B335 harboring a low-mass Class 0 source. The observations of the $H^{13}CO^+(J = 1–0)$ line emission were carried out using the Nobeyama 45 m telescope and Nobeyama Millimeter Array. Our combined image of the interferometer and single-dish data depicts detailed structures of the dense envelope within the core. We found that the core has a radial density profile of $n(r) \propto r^{-p}$ and a reliable difference in the power-law indices between the outer and inner regions of the core: $p \approx 2$ for $r \geq 4000$ AU and $p \approx 1.5$ for $r \leq 4000$ AU. The dense core shows a slight overall velocity gradient of $\sim 1.0\,\mathrm{km\,s^{-1}}$ over the scale of 20,000 AU across the outflow axis. We believe that this velocity gradient represents a solid-body-like rotation of the core. The dense envelope has a quite symmetrical velocity structure with a remarkable line broadening toward the core center, which is especially prominent in the position–velocity diagram across the outflow axis. The model calculations of position–velocity diagrams do a good job of reproducing observational results using the collapse model of an isothermal sphere in which the core has an inner free-fall region and an outer region conserving the conditions at the formation stage of a central stellar object. We derived a central stellar mass of $\sim 0.1 M_\odot$, and suggest a small inward velocity, $v_{r \geq r_{\rm inf}} \sim 0\,\mathrm{km\,s^{-1}}$ in the outer core at ≥ 4000 AU. We concluded that our data can be well explained by gravitational collapse with a quasi-static initial condition, such as Shu's model, or by the isothermal collapse of a marginally critical Bonnor–Ebert sphere.

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Near Infrared Circular Polarization Images of NGC 6334-V

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We present results from deep imaging linear and circular polarimetry of the massive star-forming region NGC 6334-V. These observations show high degrees of circular polarization (CP), as much as 22 % in the K_s band, in the infrared nebula associated with the outflow. The CP has an asymmetric positive/negative pattern and is very extended ($\sim 80''$ or 0.65 pc). Both the high CP and its extended size are larger than those seen in the Orion CP region. Three-dimensional Monte Carlo light-scattering models are used to show that the high CP may be produced by scattering from the infrared nebula followed by dichroic extinction by an optically thick foreground cloud containing aligned dust grains. Our results show not only the magnetic field orientation of around young stellar objects but also the structure of circumstellar matter such as outflow regions and their parent molecular cloud along the line of sight. The detection of the large and extended CP in this source and the Orion nebula may imply the CP origin of the biological homochirality on Earth.

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Evolution of Protostellar Outflow around Low-mass Protostar

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The evolution of protostellar outflow is investigated with resistive magneto-hydrodynamic nested-grid simulations that cover a wide range of spatial scales ($\sim$ 1 AU - 1 pc). We follow cloud evolution from the pre-stellar core stage until the infalling envelope dissipates long after the protostar formation. We also calculate protostellar evolution to derive protostellar luminosity with time-dependent mass accretion through a circumstellar disk. The protostellar outflow is driven by the first core prior to protostar formation and is directly driven by the circumstellar disk after protostar formation. The opening angle of the outflow is large in the Class 0 stage. A large fraction of the cloud mass is ejected in this stage, which reduces the star formation efficiency to $\sim$ 50%. After the outflow breaks out from the natal cloud, the outflow collimation is gradually improved in the Class I stage. The head of the outflow travels more than $\sim 10^5$ AU in $\sim 10^5$ yr. The outflow momentum, energy and mass derived in our calculations agree well with observations. In addition, our simulations show the same correlations among outflow momentum flux, protostellar luminosity and envelope mass as those in observations. These correlations differ between Class 0 and I stages, which is explained by different evolutionary stages of the outflow; in the Class 0 stage, the outflow is powered by the accreting mass and acquires its momentum from the infalling envelope; in the Class I stage, the outflow enters the momentum-driven snow-plough phase. Our results suggest that protostellar outflow should determine the final stellar mass and significantly affect the early evolution of low-mass protostars.

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Probing the Inner Regions of Protoplanetary Disks with CO Absorption Line Spectroscopy

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Carbon monoxide (CO) is the most commonly used tracer of molecular gas in the inner regions of protoplanetary disks. CO can be used to constrain the excitation and structure of the circumstellar environment. Absorption line spectroscopy provides an accurate assessment of a single line-of-sight through the protoplanetary disk system, giving more straightforward estimates of column densities and temperatures than CO and molecular hydrogen emission line studies. We analyze new observations of ultraviolet CO absorption from the Hubble Space Telescope along the sightlines to six classical T Tauri stars. Gas velocities consistent with the stellar velocities, combined with the moderate-to-high disk inclinations, argue against the absorbing CO gas originating in a fast-moving disk wind. We conclude that the far-ultraviolet observations provide a direct measure of the disk atmosphere or possibly a slow disk wind. The CO absorption lines are reproduced by model spectra with column densities in the range $N(^{12}\mathrm{CO}) \sim 10^{16} - 10^{18}$ cm^{-2} and $N(^{13}\mathrm{CO}) \sim 10^{15} - 10^{17}$ cm^{-2}, rotational temperatures $T_{\mathrm{rot}}(\mathrm{CO}) \sim 300 - 700$ K, and Doppler b-values, $b \sim 0.5 - 1.5$ km s^{-1}. We use these results to constrain the line-of-sight density of the warm molecular gas ($n_{\mathrm{CO}} \sim 70 - 4000$ cm^{-3}) and put these observations in context with protoplanetary disk models.

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Simulations of the non-linear thin shell instability

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We use three-dimensional smoothed particle hydrodynamics simulations to study the non-linear thin shell instability (NTSI) in supersonic colliding flows. We show that for flows with monochromatic perturbations and for flows with white-noise perturbations, growth speeds approximate quite well to the analytic predictions of Vishniac.
For flows with subsonic turbulence, growth speeds match Vishniac's predictions only at short wavelengths where the turbulence is weaker. We find that supersonic turbulence, of a lower Mach number than the colliding flows, completely suppresses the NTSI. Our results provide a diagnostic for identifying the presence of the NTSI in colliding flows with turbulence.

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Dynamics during outburst: VLTI observations of the young eruptive star V1647 Ori during its 2003-2006 outburst

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Context It is hypothesized that low-mass young stellar objects undergo eruptive phases during their early evolution. These eruptions are thought to be caused by highly increased mass accretion from the disk onto the star, and therefore play an important role in the early evolution of Sun-like stars, of their circumstellar disks (structure, dust composition), and in the formation of their planetary systems. The outburst of V1647 Ori between 2003 and 2006 offered a rare opportunity to investigate such an accretion event.
Aims By means of our interferometry observing campaign during this outburst, supplemented by other observations, we investigate the temporal evolution of the inner circumstellar structure of V1647 Ori, the region where Earth-like planets could be born. We also study the role of the changing extinction in the brightening of the object and separate it from the accretional brightening.
Methods We observed V1647 Ori with MIDI on the VLTI at two epochs in this outburst. First, during the slowly fading plateau phase (2005 March) and second, just before the rapid fading of the object (2005 September), which ended the outburst. We used the radiative transfer code MC3D to fit the interferometry data and the spectral energy distributions from five different epochs at different stages of the outburst. The comparison of these models allowed us to trace structural changes in the system on AU-scales. We also considered qualitative alternatives for the interpretation of our data.
Results We found that the disk and the envelope are similar to those of non-eruptive young stars and that the accretion rate varied during the outburst. We also found evidence for the increase of the inner radii of the circumstellar disk and envelope at the beginning of the outburst. Furthermore, the change of the interferometric visibilities indicates structural changes in the circumstellar material. We test a few scenarios to interpret these data. We also speculate that the changes are caused by the fading of the central source, which is not immediately followed by the fading of the outer regions.
Conclusions We found that most of our results fit in the canonical picture of young eruptive stars. Our study provided dynamical information from the regions of the innermost few AU of the system: changes of the inner radii of the disk and envelope. However, if the delay in the fading of the disk is responsible for the changes seen in the MIDI data, the effect should be confirmed by dynamical modeling.

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Hydrogen-losing planets in transition discs around young protostars

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We point out that protoplanets created in the framework of the Tidal Downsizing (TD) theory for planet formation play a very important role for the evolution of accretion discs hosting them. Since all TD protoplanets are initially as massive as $\sim$ 10 Jupiter masses, they are able to open very deep gaps in their discs, and even completely isolate the inner disc flows from the outer ones. Furthermore, in contrast to other planet formation theories, TD protoplanets are mass donors for their protostars. One potentially observable signature of planets being devoured by their protostars are FU Ori like outbursts, and episodic protostar accretion more generally, as discussed by a number of authors recently. Here we explore another observational implication of TD hypothesis: dust poor inner accretion flows, which we believe may be relevant to some of the observed mm-bright transitional discs around protostars. In our model, a massive protoplanet interrupts the flow of the outer dust-rich disc on its protostar, and at the same time loses a part of its dust-poor envelope into the inner disc. This then powers the observed gas-but-no-dust accretion onto the star. Upon a more detailed investigation, we find that this scenario is quite natural for young massive discs but is less so for

older discs, e.g., those whose self-gravitating phase has terminated a fraction of a Million year or more ago. This stems from the fact that TD protoplanets of such an age should have contracted significantly, and so are unlikely to lose much mass. Therefore, we conclude that either (i) the population of "transition discs" with large holes and dust-poor accretion is much younger than generally believed; or (ii) there is a poorly understood stage for late removal of dust-poor envelopes from TD planets; (iii) another explanation for the observations is correct.

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Sculpting the disk around T Cha: an interferometric view

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Context. Circumstellar disks are believed to be the birthplace of planets and are expected to dissipate on a timescale of a few Myr. The processes responsible for the removal of the dust and gas will strongly modify the radial distribution of the circumstellar matter and consequently the spectral energy distribution. In particular, a young planet will open a gap, resulting in an inner disk dominating the near-IR emission and an outer disk emitting mostly in the far-IR.
Aims. We analyze a full set of data involving new near-infrared data obtained with the 4-telescope combiner (VLTI/PIONIER), new mid-infrared interferometric VLTI/MIDI data, literature photometric and archival data from VLT/NaCo/SAM to constrain the structure of the transition disk around T Cha.
Methods. After a preliminary analysis with a simple geometric model, we used the MCFOST radiative transfer code to simultaneously model the SED and the interferometric observables from raytraced images in the H-, L'-, and N-bands.
Results. We find that the dust responsible for the strong emission in excess in the near-IR must have a narrow temperature distribution with a maximum close to the silicate sublimation temperature. This translates into a narrow inner dusty disk (0.07–0.11 AU), with a significant height ($H/r \sim 0.2$) to increase the geometric surface illuminated by the central star. We find that the outer disk starts at about 12 AU and is partially resolved by the PIONIER, SAM, and MIDI instruments. We discuss the possibility of a self-shadowed inner disk, which can extend to distances of several AU. Finally, we show that the SAM closure phases, interpreted as the signature of a candidate companion, may actually trace the asymmetry generated by forward scattering by dust grains in the upper layers of the outer disk. These observations help constrain the inclination and position angle of the disk to about $+58^\circ$ and -70°, respectively.
Conclusions. The circumstellar environment of T Cha appears to be best described by two disks spatially separated by a large gap. The presence of matter (dust or gas) inside the gap is, however, difficult to assess with present-day observations. Our model suggests the outer disk contaminates the interferometric signature of any potential companion that could be responsible for the gap opening, and such a companion still has to be unambiguously detected. We stress the difficulty to observe point sources in bright massive disks, and the consequent need to account for disk asymmetries (e.g. anisotropic scattering) in model-dependent search for companions.

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Coronal Mass Ejections As a Mechanism for Producing IR Variability in Debris Disks

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Motivated by recent observations of short-timescale variations in the infrared emission of circumstellar disks, we propose that coronal mass ejections can remove dust grains on timescales as short as a few days. Continuous monitoring of stellar activity, coupled to infrared observations, can place meaningful constraints on the proposed mechanism.

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Water vapor in the protoplanetary disk of DG Tau

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Water is key in the evolution of protoplanetary disks and the formation of comets and icy/water planets. While high excitation water lines originating in the hot inner disk have been detected in several T Tauri stars (TTSs), water vapor from the outer disk, where most of water ice reservoir is stored, was only reported in the closeby TTS TW Hya. We present spectrally resolved *Herschel*/HIFI observations of the young TTS DG Tau in the ortho- and para- water ground-state transitions at 557, 1113 GHz. The lines show a narrow double-peaked profile, consistent with an origin in the outer disk, and are $\sim 19-26$ times brighter than in TW Hya. In contrast, CO and [C II] lines are dominated by emission from the envelope/outflow, which makes H_2O lines a unique tracer of the disk of DG Tau. Disk modeling with the thermo-chemical code ProDiMo indicates that the strong UV field, due to the young age and strong accretion of DG Tau, irradiates a disk upper layer at 10–90 AU from the star, heating it up to temperatures of 600 K and producing the observed bright water lines. The models suggest a disk mass of 0.015–0.1 $M_\odot$, consistent with the estimated minimum mass of the solar nebula before planet formation, and a water reservoir of $\sim 10^2-10^3$ Earth oceans in vapour, and $\sim$ 100 times larger in the form of ice. Hence, this detection supports the scenario of ocean delivery on terrestrial planets by impact of icy bodies forming in the outer disk.

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Anomalous CO_2 Ice Toward HOPS-68: A Tracer of Protostellar Feedback

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We report the detection of a unique CO_2 ice band toward the deeply embedded, low-mass protostar HOPS-68. Our spectrum, obtained with the Infrared Spectrograph onboard the *Spitzer Space Telescope*, reveals a 15.2 μm CO_2 ice bending mode profile that cannot modeled with the same ice structure typically found toward other protostars. We develop a modified CO_2 ice profile decomposition, including the addition of new high-quality laboratory spectra of pure, crystalline CO_2 ice. Using this model, we find that 87-92% of the CO_2 is sequestered as spherical, CO_2-rich mantles, while typical interstellar ices show evidence of irregularly-shaped, hydrogen-rich mantles. We propose that (1) the nearly complete absence of unprocessed ices along the line-of-sight is due to the flattened envelope structure of HOPS-68, which lacks cold absorbing material in its outer envelope, and possesses an extreme concentration of material within its inner (10 AU) envelope region and (2) an energetic event led to the evaporation of inner envelope ices, followed by cooling and re-condensation, explaining the sequestration of spherical, CO_2 ice mantles in a hydrogen-poor mixture. The mechanism responsible for the sublimation could be either a transient accretion event or shocks in the interaction region between the protostellar outflow and envelope. The proposed scenario is consistent with the rarity of the observed CO_2 ice profile, the formation of nearly pure CO_2 ice, and the production of spherical ice mantles. HOPS-68 may therefore provide a unique window into the protostellar feedback process, as outflows and heating shape the physical and chemical structure of protostellar envelopes and molecular clouds.

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A young protoplanet candidate embedded in the circumstellar disk of HD100546

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We present high-contrast observations of the circumstellar environment of the Herbig Ae/Be star HD100546. The final 3.8 μm image reveals an emission source at a projected separation of $0.48''\pm0.04''$ (corresponding to $\sim$47$\pm$4 AU) at a position angle of $8.9°\pm0.9°$. The emission appears slightly extended with a point source component with an apparent magnitude of 13.2 ± 0.4 mag. The position of the source coincides with a local deficit in polarization fraction in near-infrared polarimetric imaging data, which probes the surface of the well-studied circumstellar disk of HD100546. This suggests a possible physical link between the emission source and the disk. Assuming a disk inclination of $\sim$47° the de-projected separation of the object is $\sim$68 AU. Assessing the likelihood of various scenarios we favor an interpretation of the available high-contrast data with a planet in the process of forming. Follow-up observations in the coming years can easily distinguish between the different possible scenarios empirically. If confirmed, HD100546 "b" would be a unique laboratory to study the formation process of a new planetary system, with one giant planet currently forming in the disk and a second planet possibly orbiting in the disk gap at smaller separations.

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Gaps in the HD169142 protoplanetary disk revealed by polarimetric imaging: Signs of ongoing planet formation?

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We present H-band VLT/NACO polarized light images of the Herbig Ae/Be star HD169142 probing its protoplanetary disk as close as $\sim$0.1″ to the star. Our images trace the face-on disk out to $\sim$1.7″ ($\sim$250 AU) and reveal distinct sub-structures for the first time: 1) the inner disk ($\lesssim$20 AU) appears to be depleted in scattering dust grains; 2) an unresolved disk rim is imaged at $\sim$25 AU; 3) an annular gap extends from $\sim 40-70$ AU; 4) local brightness asymmetries are found on opposite sides of the annular gap. We discuss different explanations for the observed morphology among which ongoing planet formation is a tempting – but yet to be proven – one. Outside of $\sim$85 AU the surface brightness drops off roughly $\propto r^{-3.3}$, but describing the disk regions between 85–120 AU / 120–250 AU separately with power-laws $\propto r^{-2.6}/\propto r^{-3.9}$ provides a better fit hinting towards another discontinuity in the disk surface. The flux ratio between the disk integrated polarized light and the central star is $\sim 4.1 \cdot 10^{-3}$. Finally, combining our results with those from the literature, $\sim$40% of the scattered light in the H-band appears to be polarized. Our results emphasize that HD169142 is an interesting system for future planet formation or disk evolution studies.

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A survey of young, nearby, and dusty stars to understand the formation of wide-orbit giant planets

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Direct imaging has confirmed the existence of substellar companions on wide orbits. To understand the formation and evolution mechanisms of these companions, the full population properties must be characterized. We aim at detecting giant planet and/or brown dwarf companions around young, nearby, and dusty stars. Our goal is also to provide statistics on the population of giant planets at wide-orbits and discuss planet formation models. We report a deep survey of 59 stars, members of young stellar associations. The observations were conducted with VLT/NaCo at L'-band (3.8 micron). We used angular differential imaging to reach optimal detection performance. A statistical analysis of about 60 % of the young and southern A-F stars closer than 65 pc allows us to derive the fraction of giant planets on wide orbits. We use gravitational instability models and planet population synthesis models following the core-accretion scenario to discuss the occurrence of these companions. We resolve and characterize new visual binaries and do not detect any new substellar companion. The survey's median detection performance reaches contrasts of 10 mag at 0.5″ and 11.5 mag at 1″. We find the occurrence of planets to be between 10.8-24.8 % at 68 % confidence level assuming a uniform distribution of planets in the interval 1-13 M_J and 1-1000 AU. Considering the predictions of formation models, we set important constraints on the occurrence of massive planets and brown dwarf companions that would have formed by GI. We show that this mechanism favors the formation of rather massive clump ($M_{clump} >$ 30 M_J) at wide ($a >$ 40 AU) orbits which might evolve dynamically and/or fragment. For the population of close-in giant planets that would have formed by CA, our survey marginally explore physical separations ($<$ 20 AU) and cannot

constrain this population.

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CO Abundance Variations in the Orion Molecular Cloud

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Infrared stellar photometry from 2MASS and spectral line imaging observations of ^{12}CO and ^{13}CO J = 1-0 line emission from the FCRAO 14m telescope are analysed to assess the variation of the CO abundance with physical conditions throughout the Orion A and Orion B molecular clouds. Three distinct A_v regimes are identified in which the ratio between the ^{13}CO column density and visual extinction changes corresponding to the photon dominated envelope, the strongly self-shielded interior, and the cold, dense volumes of the clouds. Within the strongly self-shielded interior of the Orion A cloud, the ^{13}CO abundance varies by 100% with a peak value located near regions of enhanced star formation activity. The effect of CO depletion onto the ice mantles of dust grains is limited to regions with $A_v >$ 10 mag and gas temperatures less than 20 K as predicted by chemical models that consider thermal-evaporation to desorb molecules from grain surfaces.
Values of the molecular mass of each cloud are independently derived from the distributions of A_v and ^{13}CO column densities with a constant ^{13}CO-to-H_2 abundance over various extinction ranges. Within the strongly self-shielded interior of the cloud ($A_v > 3$ mag), ^{13}CO provides a reliable tracer of H_2 mass with the exception of the cold, dense volumes where depletion is important. However, owing to its reduced abundance, ^{13}CO does not trace the H2 mass that resides in the extended cloud envelope, which comprises 40-50% of the molecular mass of each cloud. The implied CO luminosity to mass ratios, $M/L_{\rm CO}$, are 3.2 and 2.9 for Orion A and Orion B respectively, which are comparable to the value (2.9), derived from gamma-ray observations of the Orion region. Our results emphasize the need to consider local conditions when applying CO observations to derive H_2 column densities.

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The role of low-mass star clusters in massive star formation. The Orion Case.

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Context: Different theories have been proposed to explain the formation of massive stars: two are based on accretion processes (monolithic core accretion and competitive accretion), and another on coalescence of low- and intermediate-mass stars. To distinguish between these theories, it is crucial to establish the distribution, the extinction, and the density of young low-mass stars in massive star-forming regions. X-ray observations can penetrate the very obscured cradles of massive stars, directly sampling the distribution of the population of pre-main sequence (PMS) low-mass stars in these regions.
Aim: Our aim is to analyze deep X-ray observations of the Orion massive star-forming region using the Chandra Orion Ultradeep Project (COUP) catalog, to reveal the distribution of the population and clustering of PMS low-mass stars, and to study their possible role in massive star formation.
Methods: We studied the distribution of PMS low-mass stars with X-ray emission in Orion as a function of extinction with two different methods: a spatial gridding and a close-neigbors method, with cells of $\sim$0.03$\times$0.03 pc^2, the typical size of protostellar cores. We derived density maps of the stellar population and calculated cluster stellar densities.
Results: Consistent with previous studies, we found that PMS low-mass stars cluster toward the three massive star-forming regions: the Trapezium Cluster (TC), the Orion Hot Core (OHC), and the OMC1-S region. We derived PMS low-mass stellar densities of 10^5 stars pc^{-3} in the TC and OMC1-S, and of 10^6 stars pc^{-3} in the OHC. The

close association between the low-mass star clusters with massive star cradles supports the role of these clusters in the formation of massive stars. The X-ray observations show for the first time in the TC that low-mass stars with intermediate extinction are clustered toward the position of the most massive star θ^1 Ori C, which is surrounded by a ring of non-extincted PMS low-mass stars. This 'envelope-core' structure is also supported by infrared and optical observations. Our analysis suggests that at least two basic ingredients are needed in massive star formation: the presence of dense gas and a cluster of low-mass stars. The scenario that better explains our findings assumes high fragmentation in the parental core, accretion at subcore scales that forms a low-mass stellar cluster, and subsequent competitive accretion. Finally, although coalescence does not seem a common mechanism for building up massive stars, we show that a single stellar merger may have occurred in the evolution of the OHC cluster, favored by the presence of disks, binaries, and gas accretion.

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Ice condensation as a planet formation mechanism

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We show that condensation is an efficient particle growth mechanism, leading to growth beyond decimeter-sized pebbles close to an ice line in protoplanetary discs. As coagulation of dust particles is frustrated by bouncing and fragmentation, condensation could be a complementary, or even dominant, growth mode in the early stages of planet formation. Ice particles diffuse across the ice line and sublimate, and vapour diffusing back across the ice line recondenses onto already existing particles, causing them to grow. We develop a numerical model of the dynamical behaviour of ice particles close to the water ice line, approximately 3 AU from the host star. Particles move with the turbulent gas, modelled as a random walk. They also sediment towards the midplane and drift radially towards the central star. Condensation and sublimation are calculated using a Monte Carlo approach. Our results indicate that, with a turbulent α-value of 0.01, growth from millimeter to at least decimeter-sized pebbles is possible on a time scale of 1000 years. We find that particle growth is dominated by ice and vapour transport across the radial ice line, with growth due to transport across the atmospheric ice line being negligible. Ice particles mix outwards by turbulent diffusion, leading to net growth across the entire cold region. The resulting particles are large enough to be sensitive to concentration by streaming instabilities, and in pressure bumps and vortices, which can cause further growth into planetesimals. In our model, particles are considered to be homogeneous ice particles. Taking into account the more realistic composition of ice condensed onto rocky ice nuclei might affect the growth time scales, by release of refractory ice nuclei after sublimation. We also ignore sticking and fragmentation in particle collisions. These effects will be the subject of future investigations.

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RX J0513.1+0851 AND RX J0539.9+0956: Two Young, Rapidly Rotating, Spectroscopic Binary Stars

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RX J0513.1+0851 and RX J0539.9+0956 were previously identified as young, low-mass, single-lined spectroscopic binary systems and classified as weak-lined T Tauri stars at visible wavelengths. Here we present radial velocities, spectral types, $v \sin i$ values, and flux ratios for the components in these systems resulting from two-dimensional cross-correlation analysis. These results are based on high-resolution, near-infrared spectroscopy taken with the Keck II telescope to provide a first characterization of these systems as double-lined rather than single-lined. It applies the power of infrared spectroscopy to the detection of cool secondaries; the flux scales as a less steep function of mass in the infrared than in the visible, thus enabling an identification of low-mass secondaries. We found that the RX J0513.1+0851 and RX J0539.9+0956 primary stars are fast rotators, 60 km s^{-1} and 80 km s^{-1} respectively; this introduces extra difficulty in the detection of the secondary component as a result of the quite broad absorption lines. To date, these are the highest rotational velocities measured for a pre-main sequence spectroscopic binary. The orbital parameters and mass ratios were determined by combining new visible light spectroscopy with our infrared data for both systems. For RX J0513.1+0851, we derived a period of ∼4 days and a mass ratio of $q = 0.46 \pm 0.01$ and for RX J0539.9+0956, a period of ∼1117 days and a mass ratio of $q = 0.66 \pm 0.01$. Based on our derived properties for the stellar components, we estimate the luminosities and hence distances to these binaries at 220 pc and 90 pc. They appear to be significantly closer than previously estimated.

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Herschel-HIFI observations of high-*J* CO and isotopologues in star-forming regions: from low to high mass

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Context. Our understanding of the star formation process has traditionally been confined to certain mass or luminosity boundaries because most studies focus only on low-, intermediate- or high-mass star-forming regions. Therefore, the processes that regulate the formation of these different objects have not been effectively linked. As part of the "Water In Star-forming regions with *Herschel*" (WISH) key programme, water and other important molecules, such as CO and OH, have been observed in 51 embedded young stellar objects (YSOs). The studied sample covers a range of luminosities from < 1 to $> 10^5$ $L_\odot$.
Aims. We analyse the CO line emission towards a large sample of embedded protostars in terms of both line intensities and profiles. This analysis covers a wide luminosity range in order to achieve a better understanding of star formation without imposing luminosity boundaries. In particular, this paper aims to constrain the dynamics of the environment in which YSOs form.
Methods. *Herschel*-HIFI spectra of the ^{12}CO J=10–9, ^{13}CO J=10–9 and C^{18}O J=5–4, J=9–8 and J=10–9 lines were analysed for a sample of 51 embedded protostars. In addition, JCMT spectra of ^{12}CO J=3–2 and C^{18}O J=3–2 extend this analysis to cooler gas components. We focused on characterising the shape and intensity of the CO emission line profiles by fitting the lines with one or two Gaussian profiles. We compared the values and results of these fits across the entire luminosity range covered by WISH observations. The effects of different physical parameters as a function of luminosity and the dynamics of the envelope-outflow system were investigated.
Results. All observed CO and isotopologue spectra show a strong linear correlation between the logarithms of the line and bolometric luminosities across six orders of magnitude on both axes. This suggests that the high-*J* CO

lines primarily trace the amount of dense gas associated with YSOs and that this relation can be extended to larger (extragalactic) scales. The majority of the detected ^{12}CO line profiles can be decomposed into a broad and a narrow Gaussian component, while the C^{18}O spectra are mainly fitted with a single Gaussian. For low- and intermediate-mass protostars, the width of the C^{18}O J=9–8 line is roughly twice that of the C^{18}O J=3–2 line, suggesting increased turbulence/infall in the warmer inner envelope. For high-mass protostars, the line widths are comparable for lower- and higher-J lines. A broadening of the line profile is also observed from pre-stellar cores to embedded protostars, which is due mostly to non-thermal motions (turbulence/infall). The widths of the broad ^{12}CO J=3–2 and J=10–9 velocity components correlate with those of the narrow C^{18}O J=9–8 profiles, suggesting that the entrained outflowing gas and envelope motions are related but independent of the mass of the protostar. These results indicate that physical processes in protostellar envelopes have similar characteristics across the studied luminosity range.

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Deciphering the ionized gas content in the massive star forming complex G75.78+0.34

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We present sub-arcsecond observations toward the massive star forming region G75.78+0.34. We used the Very Large Array to study the centimeter continuum and H_2O and CH_3OH maser emission, and the Owens Valley Radio Observatory and Submillimeter Array to study the millimeter continuum and recombination lines (H40α and H30α). We found radio continuum emission at all wavelengths, coming from three components: (1) a cometary ultracompact (UC) HII region with an electron density $\sim 3.7 \times 10^4$ cm^{-3}, excited by a B0 type star, and with no associated dust emission; (2) an almost unresolved UC HII region (EAST), located ∼6 arcsec to the east of the cometary UC HII region, with an electron density $\sim 1.3 \times 10^5$ cm^{-3}, and associated with a compact dust clump detected at millimeter and mid-infrared wavelengths; and (3) a compact source (CORE), located ∼2 arcsec to the southwest of the cometary arc, with a flux density increasing with frequency, and embedded in a dust condensation of 30 $M_\odot$. The CORE source is resolved into two compact and unresolved sources which can be well-fit by two homogeneous hypercompact HII regions each one photo-ionized by a B0.5 ZAMS star, or by free-free radiation from shock-ionized gas resulting from the interaction of a jet/outflow system with the surrounding environment. The spatial distribution and kinematics of water masers close to the CORE-N and S sources, together with excess emission at 4.5 μm and the detected dust emission, suggest that the CORE source is a massive protostar driving a jet/outflow.

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VLA OH Zeeman Observations of the star forming region S88B

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We present observations of the Zeeman effect in OH thermal absorption main lines at 1665 and 1667 MHz taken with the Very Large Array (VLA) toward the star forming region S88B. The OH absorption profiles toward this source are complicated, and contain several blended components toward a number of positions. Almost all of the OH absorbing gas is located in the eastern parts of S88B, toward the compact continuum source S88B-2 and the eastern parts of the extended continuum source S88B-1. The ratio of 1665/1667 MHz OH line intensities indicates the gas is likely highly clumped, in agreement with other molecular emission line observations in the literature. S88-B appears to present a similar geometry to the well-known star forming region M17, in that there is an edge-on eastward progression from ionized to molecular gas. The detected magnetic fields appear to mirror this eastward transition; we detected line-of-sight magnetic fields ranging from 90-400 μG, with the lowest values of the field to the southwest of the S88B-1 continuum peak, and the highest values to its northeast. We used the detected fields to assess the importance of the magnetic field in S88B by a number of methods; we calculated the ratio of thermal to magnetic pressures, we calculated the critical field necessary to completely support the cloud against self-gravity and compared it to the observed field, and we calculated the ratio of mass to magnetic flux in terms of the critical value of this parameter. All these methods indicated that the magnetic field in S88B is dynamically significant, and should provide an important source of support against gravity. Moreover, the magnetic energy density is in approximate equipartition with the turbulent energy density, again pointing to the importance of the magnetic field in this region.

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The Galactic Center Cloud G2 – a Young Low-Mass Star with a Stellar Wind

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We explore the possibility that the G2 gas cloud falling in towards SgrA* is the mass loss envelope of a young TTauri star. As the star plunges to smaller radius at 1000 to 6000 km s^{-1}, a strong bow shock forms where the stellar wind is impacted by the hot X-ray emitting gas in the vicinity of SgrA*. For a stellar mass loss rate of 4×10^{-8} $M_\odot$ per yr and wind velocity 100 km s^{-1}, the bow shock will have an emission measure ($EM = n^2 vol$) at a distance $\sim 10^{16}$ cm, similar to that inferred from the IR emission lines. The ionization of the dense bow shock gas is potentially provided by collisional ionization at the shock front and cooling radiation (X-ray and UV) from the post shock gas. The former would predict a constant line flux as a function of distance from SgrA*, while the latter will have increasing emission at lesser distances. In this model, the star and its mass loss wind should survive pericenter passage since the wind is likely launched at 0.2 AU and this is much less than the Roche radius at pericenter ($\sim$ 3 AU for a stellar mass of $2M_\odot$). In this model, the emission cloud will probably survive pericenter passage, discriminating this scenario from others.

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The Evolution of Circumplanetary Disks around Planets in Wide Orbits: Implications for Formation Theory, Observations, and Moon Systems

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Using radiation hydrodynamics simulations, we explore the evolution of circumplanetary disks around wide-orbit proto-gas giants. At large distances from the star (∼100 AU), gravitational instability followed by disk fragmentation can form low-mass substellar companions (massive gas giants and/or brown dwarfs) that are likely to host large disks. We examine the initial evolution of these subdisks and their role in regulating the growth of their substellar companions, as well as explore consequences of their interactions with circumstellar material. We find that subdisks that form in the context of GIs evolve quickly from a very massive state. Long-term accretion rates from the subdisk onto the proto-gas giant reach ∼0.3 Jupiter masses per kyr. We also find consistency with previous simulations, demonstrating that subdisks are truncated at ∼1/3 of the companion's Hill radius and are thick, with (h/r) of great than or equal to 0.2. The thickness of subdisks draws to question the use of thin-disk approximations for understanding the behavior of subdisks, and the morphology of subdisks has implications for the formation and extent of satellite systems. These subdisks create heating events in otherwise cold regions of the circumstellar disk, and serve as planet formation beacons that can be detected by instruments such as ALMA.

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X-ray Irradiation of the LkCa 15 Protoplanetary Disk

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LkCa 15 in the Taurus star-forming region has recently gained attention as the first accreting T Tauri star likely to host a young protoplanet. High spatial resolution infrared observations have detected the suspected protoplanet within a dust-depleted inner gap of the LkCa 15 transition disk at a distance of 15 AU from the star. If this object's status as a protoplanet is confirmed, LkCa 15 will serve as a unique laboratory for constraining physical conditions within a planet-forming disk. Previous models of the LkCa 15 disk have accounted for disk heating by the stellar photosphere but have ignored the potential importance of X-ray ionization and heating. We report here the detection of LkCa 15 as a bright X-ray source with Chandra. The X-ray emission is characterized by a cool heavily-absorbed plasma component at kT_{cool} ∼0.3 keV and a harder component at kT_{hot} ∼5 keV. We use the observed X-ray properties to provide initial estimates of the X-ray ionization and heating rates within the tenuous inner disk. These estimates and the observed X-ray properties of LkCa 15 can be used as a starting point for developing more realistic disk models of this benchmark system.

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A Herschel and APEX Census of the Reddest Sources in Orion: Searching for the Youngest Protostars

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We perform a census of the reddest, and potentially youngest, protostars in the Orion molecular clouds using data obtained with the PACS instrument onboard the Herschel Space Observatory and the LABOCA and SABOCA instruments on APEX as part of the Herschel Orion Protostar Survey (HOPS). A total of 55 new protostar candidates are detected at 70 μm and 160 μm that are either too faint ($m24 > 7$ mag) to be reliably classified as protostars or undetected in the Spitzer/MIPS 24 μm band. We find that the 11 reddest protostar candidates with $\log(\lambda F_\lambda 70)/(\lambda F_\lambda 24) > 1.65$ are free of contamination and can thus be reliably explained as protostars. The remaining 44 sources have less extreme 70/24 colors, fainter 70 μm fluxes, and higher levels of contamination. Taking the previously known sample of Spitzer protostars and the new sample together, we find 18 sources that have $\log(\lambda F_\lambda 70)/(\lambda F_\lambda 24) > 1.65$; we name these sources "PACS Bright Red sources", or PBRs. Our analysis reveals that the PBRs sample is composed of Class 0 like sources characterized by very red SEDs ($T_{bol} < 45$ K) and large values of sub-millimeter fluxes ($L_{smm}/L_{bol} > 0.6\%$). Modified black-body fits to the SEDs provide lower limits to the envelope masses of 0.2 $M_\odot$ to 2 $M_\odot$ and luminosities of 0.7 $L_\odot$ to 10 $L_\odot$. Based on these properties, and a comparison of the SEDs with radiative transfer models of protostars, we conclude that the PBRs are most likely extreme Class 0 objects distinguished by higher than typical envelope densities and hence, high mass infall rates.

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The eclipsing binary TY CrA revisited: What near-IR light curves tell us

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New photometric observations of the hierarchical eclipsing TY CrA system were taken in the optical with VYSOS6 and in the near-IR with SOFI and REMIR. They are the first observations showing the deep eclipse minimum of the pre-main sequence secondary in the near-IR. For the first time, the secondary minimum can be reliably used in the calculation of the O-C diagram of TY CrA. By now, the O-C diagram can be studied on a time basis of about two decades. We confirm, that the O-C diagram cannot be explained by the spectroscopic tertiary. For the first time, the light curve of the inner eclipsing binary is analysed in both optical and near-IR bands simultaneously. In combination with already published spectroscopic elements, precise absolute dimensions and masses of the primary and the secondary component are obtained using the ROCHE code. The inclusion of the near-IR data puts strong constraints on the third light which is composed of the reflection nebula, the spectroscopic tertiary and a visual fourth component. The absolute parameters of the inner eclipsing binary agree very well with previous work except of the primary radius ($1.46 \pm 0.15\ R_\odot$) and luminosity ($40 \pm 10\ L_\odot$) which are clearly smaller. While the parameters of the secondary are well understood when assuming an age of about 3-5 Myrs, the primary seems considerably undersized. Low metallicity cannot explain the parameters of the primary.

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The Distance to the Massive Galactic Cluster Westerlund 2 from a Spectroscopic and HST Photometric Study

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We present a spectroscopic and photometric determination of the distance to the young Galactic open cluster Westerlund 2 using WFPC2 imaging from the Hubble Space Telescope and ground-based optical spectroscopy. HST imaging in the F336W, F439W, F555W, and F814W filters resolved many sources previously undetected in ground-based observations and yielded photometry for 1136 stars. We identified fifteen new O-type stars, along with two probable binary systems, including MSP 188 (O3 + O5.5). We fit reddened SEDs based on the Padova isochrones to the photometric data to determine individual reddening parameters R_V and A_V for O-type stars in Wd2. We find average values $\langle R_V \rangle = 3.77 \pm 0.09$ and $\langle A_V \rangle = 6.51 \pm 0.38$ mag, which result in a smaller distance than most other spectroscopic and photometric studies. After a statistical distance correction accounting for close unresolved binaries (factor of 1.08), our spectroscopic and photometric data on 29 O-type stars yield that Westerlund 2 has a distance $\langle d \rangle = 4.16 \pm 0.07$ (random) $+0.26$ (systematic) kpc. The cluster's age remains poorly constrained, with an upper limit of 3 Myr. Finally, we report evidence of a faint mid-IR PAH ring surrounding the well-known binary candidate MSP 18, which appears to lie at the center of a secondary stellar grouping within Westerlund 2.

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Formation of giant planets and brown dwarfs on wide orbits

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Context. We studied numerically the formation of giant planet (GP) and brown dwarf (BD) embryos in gravitationally unstable protostellar disks and compared our findings with directly-imaged, wide-orbit ($\geq$ 50 AU) companions known to-date.
Aims. The viability of the disk fragmentation scenario for the formation of wide-orbit companions in protostellar disks around (sub-)solar mass stars was investigated. The particular emphasis was paid to the survivability of GP/BD embryos formed via disk gravitational fragmentation.
Methods. We used numerical hydrodynamics simulations of disk formation and evolution with an accurate treatment of disk thermodynamics. The use of the thin-disk limit allowed us to probe the long-term evolution of protostellar disks, starting from the gravitational collapse of a pre-stellar core and ending in the T Tauri phase after at least 1.0 Myr of disk evolution. We focused on models that produced wide-orbit GP/BD embryos, which opened a gap in the disk and showed radial migration timescales similar to or longer than the typical disk lifetime.
Results. While disk fragmentation was seen in the majority of our models, only 6 models out of 60 revealed the formation of quasi-stable, wide-orbit GP/BD embryos. The low probability for the fragment survival is caused by efficient inward migration/ejection/dispersal mechanisms which operate in the embedded phase of star formation. We found that only massive and extended protostellar disks ($\geq 0.2\ M_\odot$), experiencing gravitational fragmentation not only in the embedded but also in the T Tauri phases of star formation, can form wide-orbit companions. Disk fragmentation produced GP/BD embryos with masses in the 3.5–43 $M_{\rm J}$ range, covering the whole mass spectrum of directly-imaged, wide-orbit companions to (sub-)solar mass stars. On the other hand, our modelling failed to produce embryos on orbital distances $\leq$ 170 AU, whereas several directly-imaged companions were found at smaller orbits down

to a few AU. Disk fragmentation also failed to produce wide-orbit companions around stars with mass $\leq 0.7\ M_\odot$, in disagreement with observations.
Conclusions. Disk fragmentation is unlikely to explain the whole observed spectrum of wide-orbit companions to (sub-)solar-mass stars and other formation mechanisms, e.g., dynamical scattering of closely-packed companions onto wide orbits, should be invoked to account for companions at orbital distance from a few tens to ≈ 150 AU and wide-orbit companions with masses of the host star $\leq 0.7\ M_\odot$. Definite measurements of orbit eccentricities and a wider sample of numerical models are needed to distinguish between the formation scenarios of GP/BD on wide orbits.

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Testing 24 micron and Infrared Luminosity as Star Formation Tracers for Galactic Star Forming Regions

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We have tested some relations for star formation rates used in extra-galactic studies for regions within the Galaxy. In nearby molecular clouds, where the IMF is not fully-sampled, the dust emission at 24 μm greatly underestimates star formation rates (by a factor of 100 on average) when compared to star formation rates determined from counting YSOs. The total infrared emission does no better. In contrast, the total far-infrared method agrees within a factor of 2 on average with star formation rates based on radio continuum emission for massive, dense clumps that are forming enough massive stars to have the total infrared luminosity exceed $10^{4.5}$ $L_\odot$. The total infrared and 24 μm also agree well with each other for both nearby, low-mass star forming regions and the massive, dense clumps regions.

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The evolution of planetesimal swarms in self-gravitating protoplanetary discs

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We investigate the kinematic evolution of planetesimals in self-gravitating discs, combining Smoothed Particle Hydrodynamical (SPH) simulations of the disc gas with a gravitationally coupled population of test particle planetesimals. We find that at radii of 10s of au (which is where we expect planetesimals to be possibly formed in such discs) the planetesimals' eccentricities are rapidly pumped to values > 0.1 within the timescales for which the disc is in the self-gravitating regime. The high resulting velocity dispersion and the lack of planetesimal concentration in the spiral arms means that the collision timescale is very long and that the effect of those collisions that do occur is destructive rather than leading to further planetesimal growth. We also use the SPH simulations to calibrate Monte Carlo dynamical experiments: these can be used to evolve the system over long timescales and can be compared with analytical solutions of the diffusion equation in particle angular momentum space. We find that if planetesimals are only formed in a belt at large radius then there is significant scattering of objects to small radii; nevertheless the majority of planetesimals remain at large radii. If planetesimals indeed form at early evolutionary stages, when the disc is strongly self-gravitating, then the results of this study constrain their spatial and kinematic distribution at the end of the self-gravitating phase.

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Near-IR Field Variable Stars in Cygnus OB7

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We present a subset of the results of a three season, 124 night, near-infrared monitoring campaign of the dark clouds Lynds 1003 and Lynds 1004 in the Cygnus OB7 star forming region. In this paper, we focus on the field star population. Using three seasons of UKIRT J, H and K band observations spanning 1.5 years, we obtained high-quality photometry on 9,200 stars down to J=17 mag, with photometric uncertainty better than 0.04 mag. After excluding known disk bearing stars we identify 149 variables - 1.6% of the sample. Of these, about 60 are strictly periodic, with periods predominantly < 2 days. We conclude this group is dominated by eclipsing binaries. A few stars have long period signals of between 20 and 60 days. About 25 stars have weak modulated signals, but it was not clear if these were periodic. Some of the stars in this group may be diskless young stellar objects with relatively large variability due to cool star spots. The remaining $\sim$60 stars showed variations which appear to be purely stochastic.

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Interaction between massive planets on inclined orbits and circumstellar discs

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We study the interaction between massive planets and a gas disc with a mass in the range expected for protoplanetary discs. We use SPH simulations to study the orbital evolution of a massive planet as well as the dynamical response of the disc for planet masses between 1 and 6 M_J and the full range of initial relative orbital inclinations. Gap formation can occur for planets in inclined orbits. For given planet mass, a threshold relative orbital inclination exists under which a gap forms. At high relative inclinations, the inclination decay rate increases for increasing planet mass and decreasing initial relative inclination. For an initial semi-major axis of 5 AU and relative inclination of $i_0 = 80°$, the times required for the inclination to decay by 10° is $\sim 10^6$ yr and $\sim 10^5$ yr for 1 M_J and 6 M_J. Planets on inclined orbits warp the disc by an extent that is negligible for 1 M_J but increases with increasing mass becoming quite significant for a planet of mass 6 M_J. We also find a solid body precession of both the total disc angular momentum vector and the planet orbital momentum vector about the total angular momentum vector. Our results illustrate that the influence of an inclined massive planet on a protoplanetary disc can lead to significant changes of the disc structure and orientation which can in turn affect the orbital evolution of the planet significantly.

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A 10,000 Years Old Explosion in DR21

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Sensitive high angular resolution ($\sim 2''$) CO(2-1) line observations made with the Submillimeter Array (SMA) of the flow emanating from the high-mass star forming region DR21 located in the Cygnus X molecular cloud are presented. These new interferometric observations indicate that this well known enigmatic outflow appears to have been produced by an explosive event that took place about 10,000 years ago, and that might be related with the disintegration of a massive stellar system, as the one that occurred in Orion BN/KL 500 years ago, but about 20 times more energetic. This result therefore argues in favor of the idea that the disintegration of young stellar systems perhaps is a frequent phenomenon present during the formation of the massive stars. However, many more theoretical and observational studies are still needed to confirm our hypothesis.

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Evidence for a Snow Line Beyond the Transitional Radius in the TW Hya Protoplanetary Disk

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We present an observational reconstruction of the radial water vapor content near the surface of the TW Hya transitional protoplanetary disk, and report the first localization of the snow line during this phase of disk evolution. The observations are comprised of Spitzer-IRS, Herschel-PACS, and Herschel-HIFI archival spectra. The abundance structure is retrieved by fitting a two-dimensional disk model to the available star+disk photometry and all observed H_2O lines, using a simple step-function parameterization of the water vapor content near the disk surface. We find that water vapor is abundant ($\sim 10^{-4}$ per H_2) in a narrow ring, located at the disk transition radius some 4AU from the central star, but drops rapidly by several orders of magnitude beyond 4.2 AU over a scale length of no more than 0.5 AU. The inner disk (0.5-4 AU) is also dry, with an upper limit on the vertically averaged water abundance of 10^{-6} per H_2. The water vapor peak occurs at a radius significantly more distant than that expected for a passive continuous disk around a 0.6 $M_\odot$ star, representing a volatile distribution in the TW Hya disk that bears strong similarities to that of the solar system. This is observational evidence for a snow line that moves outward with time in passive disks, with a dry inner disk that results either from gas giant formation or gas dissipation and a significant ice reservoir at large radii. The amount of water present near the snow line is sufficient to potentially catalyze the (further) formation of planetesimals and planets at distances beyond a few AU.

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A Massive Protostar Forming by Ordered Collapse of a Dense, Massive Core

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We present 30 and 40 μm imaging of the massive protostar G35.20-0.74 with SOFIA-FORCAST. The high surface density of the natal core around the protostar leads to high extinction, even at these relatively long wavelengths, causing the observed flux to be dominated by that emerging from the near-facing outflow cavity. However, emission from the far-facing cavity is still clearly detected. We combine these results with fluxes from the near-infrared to mm to construct a spectral energy distribution (SED). For isotropic emission the bolometric luminosity would be $3.3 \times 10^4 L_\odot$. We perform radiative transfer modeling of a protostar forming by ordered, symmetric collapse from a massive core bounded by a clump with high mass surface density, $\Sigma_{\rm cl}$. To fit the SED requires protostellar masses $\sim 20-34\,M_\odot$ depending on the outflow cavity opening angle ($35^\circ - 50^\circ$), and $\Sigma_{\rm cl} \sim 0.4 - 1\,{\rm g\,cm^{-2}}$. After accounting for the foreground extinction and the flashlight effect, the true bolometric luminosity is $\sim (0.7 - 2.2) \times 10^5 L_\odot$. One of these models also has excellent agreement with the observed intensity profiles along the outflow axis at 10, 18, 31 and 37 μm. Overall our results support a model of massive star formation involving the relatively ordered, symmetric collapse of a massive, dense core and the launching bipolar outflows that clear low density cavities. Thus a unified model may apply for the formation of both low and high mass stars.

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Low mass planets in protoplanetary disks with net vertical magnetic fields: the Planetary Wake and Gap Opening

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We study wakes and gap opening by low mass planets in gaseous protoplanetary disks threaded by net vertical magnetic fields which drive magnetohydrodynamical (MHD) turbulence through the magnetorotational instability (MRI), using three dimensional simulations in the unstratified local shearing box approximation. The wakes, which are excited by the planets, are damped by shocks similar to the wake damping in inviscid hydrodynamic (HD) disks. Angular momentum deposition by shock damping opens gaps in both MHD turbulent disks and inviscid HD disks even for low mass planets, in contradiction to the "thermal criterion" for gap opening. To test the "viscous criterion", we compared gap properties in MRI-turbulent disks to those in viscous HD disks having the same stress, and found that the same mass planet opens a significantly deeper and wider gap in net vertical flux MHD disks than in viscous HD disks. This difference arises due to the efficient magnetic field transport into the gap region in MRI disks, leading to a larger effective α within the gap. Thus, across the gap, the Maxwell stress profile is smoother than the gap density profile, and a deeper gap is needed for the Maxwell stress gradient to balance the planetary torque density. We also confirmed the large excess torque close to the planet in MHD disks, and found that long-lived density features (termed zonal flows) produced by the MRI can affect planet migration. The comparison with previous results from net toroidal flux/zero flux MHD simulations indicates that the magnetic field geometry plays an important role in the gap opening process. Overall, our results suggest that gaps can be commonly produced by low mass planets in realistic protoplanetary disks, and caution the use of a constant α-viscosity to model gaps in protoplanetary disks.

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Regular frequency patterns in the young δ Scuti star HD 261711 observed by the CoRoT and MOST satellites

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We concentrate on an asteroseismological study of HD 261711, a rather hot δ Scuti type pulsating member of the young open cluster NGC 2264 located at the blue border of the instability region. HD 261711 was discovered to be a pre-main sequence δ Scuti star using the time series photometry obtained by the MOST satellite in 2006. High-precision, time-series photometry of HD 261711 was obtained by the MOST and CoRoT satellites in 4 separate new observing runs that are put into context with the star's fundamental atmospheric parameters obtained from spectroscopy. With the new MOST data set from 2011/12 and the two CoRoT light curves from 2008 and 2011/12, the delta Scuti variability was confirmed and regular groups of frequencies were discovered. The two pulsation frequencies identified in the data from the first MOST observing run in 2006 are confirmed and 23 new delta Scuti-type frequencies were discovered using the CoRoT data. Weighted average frequencies for each group are related to l=0 and l=1 p-modes. Evidence for amplitude modulation of the frequencies in two groups is seen. The effective temperature was derived to be 8600±200 K, log g is 4.1±0.2, and the projected rotational velocity is 53±1 km/s. Using our Teff value and the radius of 1.8±0.5 $R_\odot$ derived from SED fitting, we get a log $L/L_\odot$ of 1.20±0.14 which agrees well to the seismologically determined values of 1.65 $R_\odot$ and, hence, a log $L/L_\odot$ of 1.13. The radial velocity of 14±2 km/s we derived for HD 261711, confirms the star's membership to NGC 2264. Our asteroseismic models suggest that HD 261711 is a delta Scuti-type star close to the zero-age main sequence (ZAMS) with a mass of 1.8 to 1.9 $M_\odot$. HD 261711 is either a young ZAMS star or a late PMS star just before the onset of hydrogen-core burning.

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Meeting Announcements

Brown Dwarfs come of Age

20-24 May 2013
Fuerteventura, Canary Islands, Spain

Registration is now open, at http://bdofage.tng.iac.es/registration/

Main Topics:

- Formation and early evolution of brown dwarfs
- Angular momentum and disk evolution in very low mass systems
- Large scale surveys
- Deep surveys
- Brown dwarfs in binary systems
- The lower end of the IMF
- Planets around brown dwarfs
- Ultracool atmospheres
- Spectroscopy of brown dwarfs
- Time domain phenomena in brown dwarfs: activity and weather
- Oncoming and future projects in the substellar world
- The brown dwarfs-exoplanet connection

Invited Speakers:

France Allard, Catarina Alves de Oliveira, Jean-Philippe Beaulieu, Ben Burningham, Gaël Chauvin, Avril Day-Jones, Philippe Delorme, John Gizis, Quinn Konopacky, Eduardo L. Martín, Francesco Palla, David Pinfield, Basmah Riaz, Víctor Sánchez Béjar, Aleks Scholz, Eduard I. Vorobyov

Scientific Organizing Committee:

Juan M. Alcalá, Gibor Basri, Phan Bao Ngoc, Michael Bessel, Adam Burgasser, Christiane Helling, Antonio Magazzù (co-chair), Eduardo L. Martín (co-chair), Estelle Moraux, Rafael Rebolo, Beate Stelzer

An early registration fee of 320 euro will be charged before April 21. After this date, a registration fee of 420 euro will be applied.

Abstract submission and hotel booking are also open. We recommend the R2 Rio Calma Hotel, where special fares for participants in this conference have been negotiated. Since the number of rooms at our disposal is limited, **early** hotel bookings are strongly advised. **Early** flights bookings are also recommended.

Proceedings will be published in the Memorie della Società Astronomica Italiana (Journal of the Italian Astronomical Society).

See our webpage for details:

http://bdofage.tng.iac.es/

Looking forward to seeing you next May in Fuerteventura,

Antonio Magazzù & Eduardo L. Martín
(on behalf of the Organizing Committees)

Meetings of Possible Interest

Characterising Exoplanets: Detection, Formation, Interiors, Atmospheres and Habitability
11 - 12 March 2013 The Royal Society, London, UK
http://royalsociety.org/events/2013/exoplanets/

43nd Saas-Fee Course: Star Formation in Galaxy Evolution: Connecting Numerical Models to Reality
11 - 16 March 2013 Villars-sur-Ollon, Switzerland
http://lastro.epfl.ch/conferences/sf2013

Infrared and Submillimeter Probes of Gas in Galaxies: From the Milky Way to the Distant Universe
17 - 20 March 2013 Pasadena, CA USA
http://conference.ipac.caltech.edu/gasconf/

From Stars to Life - Connecting our Understanding of Star Formation, Planet Formation, Astrochemistry and Astrobiology
3 - 6 April 2013 Gainesville, Florida, USA
http://conference.astro.ufl.edu/STARSTOLIFE/

StarBench: A Workshop for the Benchmarking of Star Formation Codes
8 - 11 April 2013 University of Exeter, UK
http://www.astro.ex.ac.uk/people/haworth/workshop_bench/index.html

Transformational Science with ALMA: From Dust to Rocks to Planets - Formation and Evolution of Planetary Systems
8 - 12 April 2013 Hilton Waikoloa Village, The Big Island of Hawaii, USA
http://www.cv.nrao.edu/rocks/index.html

International Young Astronomer School on Exploiting the Herschel and Planck data
15 - 19 April 2013 Meudon, France
http://ufe.obspm.fr/rubrique344.html

Habitable Worlds Across Time and Space
29 April - 2 May 2013 Space Telescope Science Institute, Baltimore, USA
http://www.stsci.edu/institute/conference/habitable-worlds

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

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

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

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

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

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

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

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

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

Dust Growth in Star & Planet Formation 2013
22 - 25 July 2013 MPIA, Heidelberg, Germany
no web site yet

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

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

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

Exoplanets and Brown Dwarfs
2 - 5 September 2013 de Havilland, University of Hertfordshire, Hatfield, Nr. London, UK
no web site yet

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

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

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

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

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

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

Short Announcements

SONYC (Substellar Objects in Nearby Young Clusters): Data release

SONYC - short for Substellar Objects in Nearby Young Clusters - is a long-term project to study the frequency and properties of brown dwarfs in star forming regions. SONYC was initiated in 2006; the main contributors are Aleks Scholz (Dublin Institute for Advanced Studies), Ray Jayawardhana (University of Toronto), Koraljka Muzic (ESO), Vincent Geers (DIAS), and Motohide Tamura (NAOJ). As of today, we have published results for three regions: NGC1333, Chamaeleon-I, and Rho Ophiuchus. Here we announce the first public release of SONYC data. Under the following URL we provide links to the most important catalogues and to the reduced spectra of confirmed very low mass objects in our target regions.

http://browndwarfs.org/sonyc

The repository currently contains 71 near-infrared spectra for young brown dwarfs and very low mass stars with spectral types between mid M and early L. This website will be updated as new results are coming in. If you find our data useful, please make sure to cite the original references.

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.