The Star Formation Newsletter

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

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Cover Picture

This image from NASA’s Wide-field Infrared Survey Explorer (WISE) shows the ring G159.6–18.5 discovered by IRAS and centered around HD 278942, a heavily obscured O9.5–B0 V star. The ring has a radius of 0.75° and is located in Perseus close to the Barnard 3 cloud. Blue and cyan (blue-green) represent light emitted at wavelengths of 3.4 and 4.6 microns, while green and red represent light from 12 and 22 microns, respectively.

Image credit: NASA/JPL-Caltech/WISE Team.

Submitting your abstracts

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

Q: What was your thesis about and who was your adviser?
A: I started my PhD in 1986, under the supervision of Alfred Vidal-Madjar, at Institut d’Astrophysique de Paris, after two internships in 1985 and 1986. My thesis was mainly focused on \( \beta \) Pic, a star that since then has become a proxy for studies of planetary system formation and evolution. The IRAS satellite had discovered, in 1984, an excess of infrared emission from \( \beta \) Pic and a few other Main Sequence stars that was tentatively attributed to circumstellar dust, maybe related to planetary systems. A few months later, Brad Smith and Richard Terrile observed the star with a coronagraph from Las Campanas Observatory and discovered an edge-on disk of dust, seen from 100 to 400 AU. It was quite soon realized that the dust responsible for the scattered light was made of small grains whose lifetime was short against radiation pressure; so the disk had to be permanently replenished in grains. Back in 1984, the age of the star was not known (it is now estimated to be about 20 Myr), so the connection to planetary systems was rather vague: was planet formation on-going? was the disk a remnant of planetary formation? Shortly after, Lew Hobbs and Alfred Vidal-Madjar found gaseous CaII absorption features in the star spectrum. I started working on \( \beta \) Pic in 1985. This was the beginning of a long effort. Thanks to IUE and to ESO CAT/CES spectrograph, we could detect and study sporadic infalls of ionized gas at high velocity towards the star. We attributed these infalls to evaporation of star grazing comets. This was the first evidence, in the late eighties, of extrasolar cometary bodies towards \( \beta \) Pic and other stars. One recent nice example is HD172555, an A type star member of the BPIC moving group which also experiences FEB events, as revealed by Flavien Kiefer and co-workers. However, in no other cases have exactly similar strong signatures been found.

The existence of hot Jupiters and misaligned planets bring growing evidence that the early evolution of planets and planetary systems is probably quite dynamically active; so the FEB phenomenon (if we suppose that, like in the case of \( \beta \) Pic, it is due to the gravitational perturbation of planetesimals by massive bodies) should not be rare if planets are not rare. Yet, we do not know how long it lasts; also, the detectability of FEBs depends on the system viewing geometry. This may explain why the phenomenon is still rarely observed.

Q: You have been working on \( \beta \) Pictoris for 30 years.
A: The very presence of a dust disk discovered in 1984 already made the star very special, with a possible connection to planetary systems. The discovery of the very peculiar spectral variability made it even more special. The very peculiar shape (inner warp) of the disk when imaged at high angular resolution by HST or by ground-based adaptive optics imaging was puzzling. In the late nineties, together with my PhD students David Moullet and then Jean-Charles Augereau, in collaboration with John Papaloizou, we explained the observed inner warp by the presence of a still unseen companion. An additional puzzling observational result was the discovery in 1995 of a single photometric variable event by A. Lecavelier and collaborators that had happened back in 1981, and was tentatively attributed to a comet cloud, or a transiting planet, well before transiting planets were detected!

The subsequent imaging of a planet probably responsible for the warp makes the system quite unique so far: a disk well resolved at optical/nearIR wavelengths, an imaged planet, and comets. An exquisite laboratory for detailed dynamical studies and studies of the early evolution of planetary systems.

Q: You and your collaborators Alfred Vidal-Madjar and Roger Ferlet have devoted much effort to study infalling cometary bodies towards \( \beta \) Pic. What is the latest insight on this phenomenon, and do you think this is special for \( \beta \) Pic, or a general phenomenon?
A: The FEB scenario on \( \beta \) Pic has survived more than 25 years; this is nice! Of course, we and other teams searched for FEB phenomena on other stars, either A-type stars, like \( \beta \) Pic, or young stars, using ground based or space based (IUE, HST) high resolution spectrographs. A few other stars showed signs of infalling gas, or signs of variability that could be connected as well to FEB. One recent nice example is HD172555, an A type star member of the BPIC moving group which also experiences FEB events, as revealed by Flavien Kiefer and co-workers. However, in no other cases have exactly similar strong signatures been found.

The existence of hot Jupiters and misaligned planets bring growing evidence that the early evolution of planets and planetary systems is probably quite dynamically active; so the FEB phenomenon (if we suppose that, like in the case of \( \beta \) Pic, it is due to the gravitational perturbation of planetesimals by massive bodies) should not be rare if planets are not rare. Yet, we do not know how long it lasts; also, the detectability of FEBs depends on the system viewing geometry. This may explain why the phenomenon is still rarely observed.
disk of β Pic. What is known today about this planet, and should we be surprised to find this planet around such a young star?

A: It was not a surprise to find a giant planet around the star, as we expected the presence of a massive companion to β Pic to explain the inner disk warp. The difficulty was to see it, as its projected separation was small and as we did not have as good instruments, observing techniques and reduction algorithms to reach the high contrasts as we have today.

After 12 years of monitoring, we know that β Pictoris b has a semimajor axis of about 9 AU, and a small eccentricity, if any. We predict that it will more or less cross our line of sight in 2017. With the currently available data, whether it will actually precisely transit is still debated; yet we believe that, even if the planet does not exactly transit, we might see photometric variations, perhaps similar to those that occurred back in 1981. It would be great to observe such a phenomenon!

Also, β Pic b is orbiting quite close to its star (about 9 AU, it is the closest exoplanet imaged until now). Its relatively short period will allow to measure its dynamical mass (so far we have only an upper limit). This, in turns, will allow calibrating the brightness-mass relations that we use to estimate the masses of directly imaged planets, that dramatically lack calibrations.

The photometric and low resolution near IR spectroscopic data indicate a $T_{\text{eff}} = 1650 \pm 150$ K and a $\log g \leq 4.7$ (Mickael Bonnefoy and co-workers). Globally, the planet properties are well reproduced assuming warm-start or hot-start tracks with initial entropies $\geq 10.5$ kB/baryon.

Q: Last fall you organized a conference in Paris on β Pic. In what direction is research on this star moving now?

A: The conference I organized with Anthony Boccaletti and colleagues was meant to review 30 years of discoveries and studies of debris disks around β Pic and other stars. It was a great occasion to look back on these 30 years, with many scientists who have participated in this adventure. It was just amazing to see the progress that had been done from both observational and modelling points of view! The experience gained working on β Pic has of course been used to study many other systems. ALMA, Sphere on the VLT and GPI on Gemini have already started to reveal debris disks as well as transition disks or even younger disks at unprecedented resolutions. It can be expected that many more will be discovered and studied in the near future.

There is still a lot to learn concerning the β Pic disk properties. We have to test the various scenarios proposed to explain puzzling asymmetries seen at thermal or millimeter wavelengths, to study the disk innermost component (at less than 1 AU), search for other planets lighter than β Pic b, etc.

Q: Together with your former student Gael Chauvin and your group you have found several very low-mass companions. What is the status of this work?

A: With Gael Chauvin, Mickael Bonnefoy, Julien Rameau, and Philippe Delorme, we detected several low-mass companions to young stars using NaCo on the VLT. The latest planet we found, HD98086 b, has a relatively low mass, about 5 $M_{\text{Jup}}$ and is located at $\simeq 45$ AU in projected separation from its star. We also imaged a planet around a double system. There are now enough data to make first estimates of the rates of massive giant planets further than typically 10-20 AU around stars of different masses. Yet, these estimates should be viewed with caution as they are very model-dependent. Thanks to Sphere and GPI, the detection limits will be lowered, and the ambitious surveys currently underway on hundreds of targets will undoubtedly bring much better constraints on giant planet rates in the near future.

Q: What are you working on at the moment?

A: Sphere (PI J.L. Beuzit) has been installed in 2014 at the VLT. It is equipped with an extreme adaptive optics system and a suite of high-performance coronagraphs. It provides exquisite image quality as well as very high contrasts close to the stars. We have started the Guaranteed Time Observations, with more than 200 nights devoted to the search for planets around young stars, mostly members of close, nearby associations. I am deeply involved in this project, especially in the organisation of the observations and of the data reduction. We started to work on the project of extreme AO imagers in 2002, and it is a great time for us. So far, we have discovered a few new debris disks and lots of companion candidates. Second epoch measurements will tell us whether they are physically bound or just background or foreground objects.

As a complement to high contrast imaging, I started a few years ago large radial velocity surveys to search for giant planets on closer orbits around young stars targeted by Sphere or NaCo on the VLT. My aim is to combine both types of data to explore the environment of these young stars as fully as possible. This is needed to get an accurate estimate of the rate of giant planets around stars.

Q: What is your latest discovery?

A: We discovered recently with Sphere a debris disk around HD106906 (also detected with GPI by Kalas and colleagues). This young star, member of LCC, is already known to host a planet on a very distant orbit (650 AU projected separation) imaged by Vanessa Bailey and colleagues in 2014. The formation process of the planet is still far from clear at the moment. We also demonstrated, using Harps and PIONIER interferometric data, that the star is a binary. A very complex system, offering precious opportunities of dynamical studies!
My Favorite Object
The Serpens South Cluster
Adele Plunkett

A recently discovered cluster with exciting potential for greatness

In the study of clustered star formation, proximity and star formation activity are two aspects of a cluster that make it particularly attractive for further study. While it is unlikely that any two clusters are experiencing star formation in an identical manner, observations of nearby, active clusters spanning a range of evolutionary stages provide evidence for an evolutionary scenario for clustered star formation. One cluster that deserves attention is Serpens South. The Serpens South cluster was relatively recently discovered in IRAC mid-infrared imaging of the Serpens-Aquila Rift that Gutermuth et al. (2008) obtained as part of the Spitzer Gould Belt Legacy Survey. The Spitzer image is shown in Figure 1, where one can see the numerous young stars situated amidst a filamentary infrared dark cloud structure (see the following sections for further discussion).

Serpens South can be considered a low- to intermediate-mass star forming region, providing a bridge between the low- and high-mass star forming regimes. Gutermuth et al. (2008) explain that this region is flanked by two IRAS sources: IRAS 18275-0203 and IRAS 18274-0205. With a number of young stellar objects (YSOs), and particular Class 0 and I protostellar sources (see following section), this is an interesting region to study individual sources as they accrete mass and simultaneously drive outflows in a cluster environment. Additionally, the region has been studied in the context of cluster formation, referred to in some cases as a “protocluster” (e.g. Nakamura et al. 2011).

A very young membership census

The youthfulness of Serpens South is apparent based on the high protostar fraction (the ratio of Class 0/I sources to all YSOs) among its members. Gutermuth et al. (2008) classified sources in Serpens South following the data reduction pipeline (Evans et al. 2007) developed for the Spitzer Cores to Disks (c2d) and Gould Belt projects, incorporating 2MASS and Spitzer 1.25 – 70 µm photometry. Within an approximately 14' × 10' region reside 54 Class I protostars (including flat-spectrum sources) and 37 Class II YSOs; in other words, about 60% of the YSOs are protostars, and at the cluster center this fraction rises to about 80 – 90%. Additionally, the YSOs reside in close proxim-
ity, with a nearest neighbor spacing of 13″2, which corresponds to a physical spacing of about 4000 – 6000 AU (depending on distance to the region, see following section). The mean surface density of YSOs is high, about 160 – 430 pc\(^{-2}\) (again, the range depends on distance).

The proximity of Serpens South

Serpens South is one of only a few protostellar clusters known within a distance of about 500 pc. One complication in the study of Serpens South and its members is that different publications adopt different distances to the cluster. Hence, making comparisons of physical characteristics presented throughout the literature, one must take into account the assumed distance and perhaps scale consistently. Here I include a summary of the various distances (to my knowledge) that have been adopted.

The distance to Serpens South is based on the distance determined for its neighbor, Serpens Main. The Serpens Main cluster is located just 3° north of Serpens South, and both have approximately the same local standard of rest velocity (\(V_{LSR} \sim 8 \text{ km s}^{-1}\)). Early measurements determined a distance to Serpens Main of 311 ± 38 pc based on near-IR photometry of stars with reflection nebulosity (de Lara et al. 1991), and until that time distance estimates ranged from 245 pc to 700 pc. Subsequent studies of Serpens South assumed a distance of 260 ± 37 pc, which is the distance determined using photometry of Serpens Main by Straizys et al. (1996) and consistent with the distance determined for the Serpens-Aquila Rift by Straizys et al. (2003).

Trigonometric parallax measurements using the Very Long Baseline Array (Dzib et al. 2010), however, revealed a further distance of 415 ± 5 pc to the YSO EC 95 associated with Serpens Main, and this was updated slightly to a distance of 429 ± 2 pc by Dzib et al. (2011). Most recently, Ortiz-León et al. (2015) again adopted the distance of 415 pc for a study of three regions in the Aquila complex, including Serpens, Serpens South, and W40.

A filamentary structure, and magnetic fields

Given a growing discussion of the ubiquity of filaments in star forming regions (e.g. André et al. 2014, and numerous references therein), it is worth noting that Serpens South is a superb example of star formation along a filamentary structure. In infrared images, the hub of the cluster coincides with a dark filamentary structure that appears as absorption in the 8 \(\mu\)m band. The filament morphology can be described as a hub-like structure with several spokes. Dust continuum maps (André et al. 2010; Maury et al. 2011) and molecular line emission maps (Kirk et al. 2013; Tanaka et al. 2013; Fernández-López et al. 2014) also show filamentary structure.
Fernández-López et al. (2014) showed that several narrow N$_2$H$^+$ filaments (see Figure 2) can comprise a single dust continuum filament observed with Herschel, furthering the discussion of sub-structures within filaments. High resolution observations by Fernández-López et al. (2014) show that the kinematics are consistent with local collapse of filaments, rather than with ordered infall motions towards the hub of star formation proposed by previous authors (see also Kirk et al. 2013) based on velocity gradients along the filaments. Recently, filament collisions were proposed as a scenario for cluster formation in Serpens South by Nakamura et al. (2014). Based on polarization observations, Sugitani et al. (2011) suggest that magnetic fields – well-ordered and oriented perpendicular to the main filament – are important for forming and shaping the filamentary structure.

A complex web of outflow activity

Carbon monoxide emission is prevalent in Serpens South (Figure 3), signifying many outflows, as can be expected from so many Class 0 and I sources. CO (3-2) and HCO$^+$ (4-3) were observed in this region with an angular resolution of 22" by Nakamura et al. (2011), and the outflows were presented in the context of the filamentary 1.1 mm dust continuum image by ASTE. Complementing the molecular outflow studies, near-IR observations by Teixeira et al. (2012) show corresponding molecular hydrogen emission-line objects as well.

We mapped the CO (1-0) emission using CARMA and IRAM (Plunkett et al. 2015a), and the combination of interferometer observations (with a resolution of 5") and single dish data allowed us to probe physical size scales of 0.01 pc to 0.8 pc. We also utilized $^{12}$CO and $^{13}$CO data for the $J = 1-0$ and $J = 3-2$ transitions (using Atacama Pathfinder Experiment and Caltech Submillimeter Observatory observations for the higher CO transitions) in order to account for effects of line opacity and excitation temperature variations, and subsequently determined cumulative mass, momentum and energy of the molecular outflows. We found that outflows drive a sufficient amount of energy to sustain turbulence, but not enough energy to substantially counter the gravitational potential energy and disrupt the clump (assessing diagnostics including mass loss rate, force, and luminosity, compared with diagnostics of turbulence and gravity; please see Plunkett et al. 2015a for further details).

Investigating outflow-driving sources

As can be seen in Figure 3, CARMA observations with 5" resolution could not sufficiently disentangle the complex web of outflows at the hub of Serpens South, yet we still hoped to identify individual outflow-driving protostellar sources and characterize their outflows. We initiated an
Figure 4: CO (2-1) outflow from the Class 0 source CARMA-7 at the center of Serpens South, observed with ALMA (Plunkett et al. 2015b). Panels (a) and (c) show high-velocity blueshifted and redshifted channels, respectively, while panel (b) shows low-velocity channels to feature the cavity surrounding collimated ejecta. Labels (beginning with “B” and “R”) indicate 22 ejecta features, and we studied the episodic nature of these ejecta.

ALMA Cycle 1 study (Plunkett et al. 2015b) to map the central region of Serpens South where many Class 0 protostars reside and the bulk of outflow emission appears to originate (Figure 4). With 1″ resolution we discovered an episodic outflow driven in the north-south direction by the Class 0 source CARMA-7, the strongest mm-wavelength continuum source; this outflow contains at least 22 distinct clumps, 11 in the northern lobe and 11 in the southern lobe. Assuming that outflows are driven by corresponding accretion events, we suggest that accretion occurs episodically – either with varying velocity and/or mass-loss rate. In this and other cases, outflows are useful observational signposts for studying star formation. Outflows that are powerful and intact like this one likely provide efficient momentum transfer to drive turbulence in a cluster. Studies of this and neighboring outflows in this region are ongoing with ALMA observations.

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HD144548: A young triply eclipsing system in the Upper Scorpius OB association
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The star HD144548 (=HIP 78977; TYP 6212-1273-1) has been known as a detached eclipsing binary and a bona-fide member of the Upper Scorpius OB association. Continuous photometry from the K2 mission on Campaign Two has revealed the presence of additional eclipses due to the presence of a third star in the system. These are explained by a system composed of the two previously known members of the eclipsing system (Ba and Bb) with a period of 1.63 d, orbiting around an F7–F8V star with a period of 33.945±0.002 d in an eccentric orbit ($e_A = 0.2652 \pm 0.0003$). The timing of the eclipses of Ba and Bb reveals the same 33.9 d periodicity, which we interpret as the combination of a light time effect combined with dynamical perturbations on the close system. Here we combine radial velocities and analytical approximations for the timing of the eclipses to derive masses and radii for the three components of the system. We obtain a mass of $1.44 \pm 0.04 M_\odot$ and radius of $2.41 \pm 0.03 R_\odot$ for the A component, and almost identical masses and radii of about $0.96 M_\odot$ and $1.33 R_\odot$ for each of the two components of the close binary. HD144548 is the first triply eclipsing system for which radial velocities of all components could be measured.

Accepted by A&A Letters

\url{http://arxiv.org/pdf/1510.03773}

Finding Distant Galactic HII Regions
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The WISE Catalog of Galactic H II Regions contains $\sim 2000$ HII region candidates lacking ionized gas spectroscopic observations. All candidates have the characteristic HII region mid-infrared morphology of WISE 12\,$\mu$m emission surrounding 22\,$\mu$m emission, and additionally have detected radio continuum emission. We here report Green Bank Telescope (GBT) hydrogen radio recombination line (RRL) and radio continuum detections at X-band (9 GHz; 3 cm) of 302 WISE HII region candidates (out of 324 targets observed) in the zone $225^\circ \geq l \geq -20^\circ, |b| \leq 6^\circ$. Here we extend the sky coverage of our HII region Discovery Survey (HRDS), which now contains nearly 800 HII regions distributed across the entire northern sky. We provide LSR velocities for the 302 detections and kinematic distances for 131 of these. Of the 302 new detections, five have $(l,b,v)$ coordinates consistent with the Outer Scutum-Centaurus Arm (OSC), the most distant molecular spiral arm of the Milky Way. Due to the Galactic warp, these nebulae are found at Galactic latitudes $> 1^\circ$ in the first Galactic quadrant, and therefore were missed in previous surveys of the Galactic plane. One additional region has a longitude and velocity consistent with the OSC but lies at a negative Galactic latitude (G039.183−01.422; −54.9 km/s). With Heliocentric distances $> 22$ kpc and Galactocentric distances $> 16$ kpc, the OSC HII regions are the most distant known in the Galaxy. We detect an additional three HII regions near $l \approx 150^\circ$ whose LSR velocities place them at Galactocentric radii $> 19$ kpc. If their distances are correct, these
nebulae may represent the limit to Galactic massive star formation.

Accepted by ApJS

http://arxiv.org/pdf/1510.07347

Understanding the water emission in the mid- and far-IR from protoplanetary disks around T Tauri stars

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We investigate which properties of protoplanetary disks around T Tauri stars affect the physics and chemistry in the regions where mid- and far-IR water lines originate and their respective line fluxes. We search for diagnostics for future observations. With the code ProDiMo, we build a series of models exploring a large parameter space, computing rotational and rovibrational transitions of water in non local thermodynamic equilibrium (non-LTE). We select a sample of transitions in the mid- IR regime and the fundamental ortho and para water transitions in the far-IR. We investigate the chemistry and the local physical conditions in the line emitting regions. We calculate Spitzer spectra for each model and compare far-IR and mid-IR lines. In addition, we use mid-IR colors to tie the water line predictions to the dust continuum. Parameters affecting the water line fluxes in disks by more than a factor of three are: the disk gas mass, the dust-to-gas mass ratio, the dust maximum grain size, ISM (InterStellarMedium) UV radiation field, the mixing parameter of Dubrulle settling, the disk flaring parameter, and the dust size distribution. The first four parameters affect the mid-IR lines much more than the far-IR lines. A key driver behind water spectroscopy is the dust opacity, which sets the location of the water line emitting region. We identify three types of parameters. Parameters, such as dust-to-gas ratio, ISM radiation field, and dust size distribution, affect the mid-IR lines more, while the far-IR transitions are more affected by the flaring index. The gas mass greatly affects lines in both regimes. Higher spectral resolution and line sensitivities, like from the James Webb Space Telescope, are needed to detect a statistically relevant sample of individual water lines to distinguish further between these types of parameters.

Accepted by A&A

http://arxiv.org/pdf/1510.01482

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

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The classic question that how young massive star clusters attain their shapes and sizes, as we find them today, remains to be a challenge. Both observational and computational studies of star-forming massive molecular gas clouds infer that massive cluster formation is primarily triggered along the small-scale (≤0.3 pc) filamentary substructures within the clouds. The present study is intended to investigate the possible ways in which a filament-like-compact, massive star cluster (effective radius 0.1–0.3 pc) can expand ≥10 times, still remaining massive enough (≥104 $M_\odot$), to become a young massive star cluster, as we observe today. To that end, model massive clusters (of initially $10^4$–$10^5$ $M_\odot$) are evolved using Sverre Aarseth’s state-of-the-art N-body code NBODY7. All the computed clusters expand with time, whose sizes (effective radii) are compared with those observed for young massive clusters, of age ≤100 Myr, in the
Milky Way and other nearby galaxies. It is found that beginning from the above compact sizes, a star cluster cannot expand by its own, i.e., due to two-body relaxation, stellar-evolutionary mass loss, dynamical heating by primordial binaries and stellar-mass black holes, up to the observed sizes of young massive clusters; they always remain much more compact compared to the observed ones. This calls for additional mechanisms that can boost the expansion of a massive cluster after its assembly. Using further N-body calculations, it is shown that a substantial residual gas expulsion, with ≈30% star formation efficiency, can indeed swell the newborn embedded cluster adequately. The limitations of the present calculations and their consequences are discussed.

Accepted by A&A

http://arxiv.org/pdf/1510.04293

Variability in a Young, L/T Transition Planetary-Mass Object

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As part of our ongoing NTT SoFI survey for variability in young free-floating planets and low mass brown dwarfs, we detect significant variability in the young, free-floating planetary mass object PSO J318.5−22, likely due to rotational modulation of inhomogeneous cloud cover. A member of the 23±3 Myr β Pic moving group, PSO J318.5−22 has $T_{\text{eff}} = 1160_{-40}^{+30}$ K and a mass estimate of 8.3±0.5 $M_{\text{Jup}}$ for a 23±3 Myr age. PSO J318.5−22 is intermediate in mass between 51 Eri b and β Pic b, the two known exoplanet companions in the β Pic moving group. With variability amplitudes from 7–10% in $J_S$ at two separate epochs over 3–5 hour observations, we constrain the rotational period of this object to >5 hours. In $K_S$, we marginally detect a variability trend of up to 3% over a 3 hour observation. This is the first detection of weather on an extrasolar planetary mass object. Among L dwarfs surveyed at high-photometric precision (<3%) this is the highest amplitude variability detection. Given the low surface gravity of this object, the high amplitude preliminarily suggests that such objects may be more variable than their high mass counterparts, although observations of a larger sample is necessary to confirm this. Measuring similar variability for directly imaged planetary companions is possible with instruments such as SPHERE and GPI and will provide important constraints on formation. Measuring variability at multiple wavelengths can help constrain cloud structure.

Accepted by ApJL

http://arxiv.org/pdf/1510.07625

Spectroscopic confirmation of M-dwarf candidate members of the Beta Pictoris and AB Doradus Moving Groups

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Optical spectroscopic observations are reported for 24 and 23, nearby, proper-motion-selected M-dwarf candidate members of the Beta Pictoris and AB Doradus moving groups (BPMG and ABDMG). Using kinematic criteria, the presence of both Hα emission and high X-ray-to-bolometric luminosity, and position in absolute colour-magnitude diagrams, 10 and 6 of these candidates are confirmed as likely members of the BPMG and ABDMG respectively. Equivalent widths or upper limits for the Li I 6708 Å line are reported and the lithium depletion boundary (LDB) age of the BPMG is revisited. Whilst non-magnetic evolutionary models still yield an estimated age of 21±4 Myr, models that incorporate magnetic inhibition of convection imply an older age of 24±4 Myr. A similar systematic increase would be inferred if the stars were 25 per cent covered by dark magnetic starspots. Since young, convective M-dwarfs are magnetically active and do have starspots, we suggest that the original LDB age estimate is a lower limit. The LDB age of the ABDMG is still poorly constrained – non-magnetic evolutionary models suggest an age in the range 35–150 Myr, which could be significantly tightened by new measurements for existing candidate members.

Accepted by MNRAS

http://arxiv.org/pdf/1510.06987

Dust Evolution Can Produce Scattered Light Gaps in Protoplanetary Disks

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Recent imaging of protoplanetary disks with high resolution and contrast have revealed a striking variety of substructure. Of particular interest are cases where near-infrared scattered light images show evidence for low-intensity annular “gaps.” The origins of such structures are still uncertain, but the interaction of the gas disk with planets is a common interpretation. We study the impact that the evolution of the solid material can have on the observable properties of disks in a simple scenario without any gravitational or hydrodynamical disturbances to the gas disk structure. Even with a smooth and continuous gas density profile, we find that the scattered light emission produced by small dust grains can exhibit ring-like depressions similar to those presented in recent observations. The physical mechanisms responsible for these features rely on the inefficient fragmentation of dust particles. The occurrence and position of the proposed “gap” features depend most strongly on the dust-to-gas ratio, the fragmentation threshold velocity, the strength of the turbulence, and the age of the disk, and should be generic (at some radius) for typically adopted disk parameters. The same physical processes can affect the thermal emission at optically thin wavelengths (∼1 mm), although the behavior can be more complex; unlike for disk-planet interactions, a “gap” should not be present at these longer wavelengths.

Accepted by ApJL

http://arxiv.org/pdf/1510.05660

Ethyl alcohol and sugar in comet C/2014 Q2 (Lovejoy)

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The presence of numerous complex organic molecules (COMs; defined as those containing six or more atoms) around protostars shows that star formation is accompanied by an increase of molecular complexity. These COMs may be part of the material from which planetesimals and, ultimately, planets formed. Comets represent some of the oldest and most primitive material in the solar system, including ices, and are thus our best window into the volatile composition of the solar protoplanetary disk. Molecules identified to be present in cometary ices include water, simple hydrocarbons, oxygen, sulfur, and nitrogen-bearing species, as well as a few COMs, such as ethylene glycol and glycine. We report the detection of 21 molecules in comet C/2014 Q2 (Lovejoy), including the first identification of ethyl alcohol (ethanol, \( \text{C}_2\text{H}_5\text{OH} \)) and the simplest monosaccharide sugar glycolaldehyde (\( \text{CH}_2\text{OHCHO} \)) in a comet. The abundances of ethanol and glycolaldehyde, respectively 5 and 0.8% relative to methanol (0.12 and 0.02% relative to water), are somewhat higher than the values measured in solar-type protostars. Overall, the high abundance of COMs in cometary ices supports the formation through grain-surface reactions in the solar system protoplanetary disk.

Accepted by Science Advances (23 Oct 2015 issue)
http://advances.sciencemag.org/content/1/9/e1500863.full

Cosmography of OB stars in the solar neighborhood
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We construct a 3D map of the spatial density of OB stars within 500 pc from the Sun using the Hipparcos catalogue and find three large-scale stream-like structures that allow a new view on the solar neighbourhood. The spatial coherence of these blue streams and the monotonic age sequence over hundreds of parsecs suggest that they are made of young stars, similar to the young streams that are conspicuous in nearby spiral galaxies. The three streams are 1) the Scorpius to Canis Majoris stream, covering 350 pc and 65 Myr of star formation history, 2) the Vela stream, encompassing at least 150 pc and 25 Myr of star formation history, and 3) the Orion stream, including not only the well-known Orion OB1abcd associations, but also a large previously unreported foreground stellar group lying only 200 pc from the Sun. The map also reveals a remarkable and previously unknown nearby OB association, between the Orion stream and the Taurus molecular clouds, which might be responsible for the observed structure and star formation activity in this cloud complex. This new association also appears to be the birthplace of Betelgeuse, as indicated by the proximity and velocity of the red giant. If this is confirmed, it would solve the long-standing puzzle of the origin of Betelgeuse. The well-known nearby star-forming low-mass clouds, including the nearby T and R associations Lupus, Cha, Oph, CrA, Taurus, Vela R1, and various low-mass cometary clouds in Vela and Orion, appear in this new view of the local neighbourhood to be secondary star formation episodes that most likely were triggered by the feedback from the massive stars in the streams. We also recover well-known star clusters of various ages that are currently cruising through the solar neighbourhood. Finally, we find no evidence of an elliptical structure such as the Gould Belt, a structure we suggest is a 2D projection effect, and not a physical ring. The PDF must be opened in Acrobat for the interactive 3D figure to display properly

Accepted by Astronomy & Astrophysics
https://cloud.cab.inta-csic.es/public.php?service=files&t=c35f0492645dbae7be64d772629482b2

Impact of an inhomogeneous density distribution on selected observational characteristics of circumstellar disks
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Context. Analysis of observations of circumstellar disks around young stellar objects is often based on disk models
with smooth and continuous density distribution. However, spatially resolved observations with increasing angular resolution and dynamical models indicate that circumstellar disks are highly structured. 

**Aims.** We investigate the influence of different clumpy density distributions on selected physical properties and on the observable characteristics of circumstellar disks. In particular, these are the temperature distribution, the spectral energy distribution, the radial brightness profile and the degree of polarization of scattered stellar radiation. 

**Methods.** Based on radiative transfer modeling we calculated the temperature structure of the disk and simulate observational quantities in the thermal re-emission and scattering regime. The clumpy density distributions are realized using a two-phase medium approach with phases for the clumps and the medium in between. We compared our results to those obtained for a smooth and continuous density distribution to quantify the influence of clumps on internal physical parameters and observable quantities of circumstellar disks. 

**Results.** Within the considered model space, the clumpiness has a significant impact on the disk temperature distribution. For instance, in the transition region from the optically thin upper disk layers to the disk interior, it causes a decrease in the mean temperature by up to 12 K (corresponding to ~ 15 %), if compared to continuous disks. In addition, circumstellar disks with clumpy density distributions generally feature a lower spectral index in the submm/mm range of the SED than continuous disks. The strength of this decrease can be varied by changing the dust mass or grain size, but not by changing the inclination of the disk. As a consequence of the lower spectral index, the dust grain size derived from the submm/mm-slope of the SED may be overestimated, if the inhomogeneity of the disk density distribution is not taken into account. Furthermore, the scattered light brightness distribution of clumpy disks shows a steeper radial decrease than in the case of continuous disks. The azimuthal variations in the scattered flux, resulting from inhomogeneous density distributions, have their maximum at the medium radial extent of the disks. Additionally, clumpy density distributions change the degree of polarization of the scattered light in the optical compared to continuous disks. The quantitative level of this variation increases with the optical depth of the clumps. 

Accepted by Astronomy & Astrophysics (A&A)


**Massive open star clusters using the VVV survey IV. WR 62-2, a new very massive star in the core of the VVV CL041 cluster**

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**Context.** The ESO Public Survey VISTA Variables in the Vía Láctea (VVV) provides deep multi-epoch infrared observations for an unprecedented 562 sq. degrees of the Galactic bulge and adjacent regions of the disk. Nearly 150 new open clusters and cluster candidates have been discovered in this survey. 

**Aims.** We present the fourth article in a series of papers focussed on young and massive clusters discovered in the VVV survey. This article is dedicated to the cluster VVV CL041, which contains a new very massive star candidate, WR 62-2. 

**Methods.** Following the methodology presented in the first paper of the series, wide-field, deep JHKs VVV observations, combined with new infrared spectroscopy, are employed to constrain fundamental parameters (distance, reddening,
mass, age) of VVV CL041.

Results. We confirm that the cluster VVV CL041 is a young (less than 4 Myrs) and massive \(3 \pm 2 \times 10^3 \, M_\odot\) cluster, and not a simple asterism. It is located at a distance of \(4.2 \pm 0.9 \, \text{kpc}\), and its reddening is \(A_V = 8.0 \pm 0.2 \, \text{mag}\), which is slightly lower than the average for the young clusters towards the centre of the Galaxy. Spectral analysis shows that the most luminous star of the cluster, of the WN8h spectral type, is a candidate to have an initial mass larger than \(100 \, M_\odot\). Accepted by A&A

K2 Discovery of Young Eclipsing Binaries in Upper Scorpius: Direct Mass and Radius Determinations for the Lowest Mass Stars and Initial Characterization of an Eclipsing Brown Dwarf Binary

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We report the discovery of three low-mass double-lined eclipsing binaries in the pre-main sequence Upper Scorpius association, revealed by K2 photometric monitoring of the region over \(~78\) days. The orbital periods of all three systems are \(<5\) days. We use the K2 photometry plus multiple Keck/HIRES radial velocities and spectroscopic flux ratios to determine fundamental stellar parameters for both the primary and secondary components of each system, along with the orbital parameters. We present tentative evidence that EPIC 203868608 is a hierarchical triple system comprised of an eclipsing pair of \(~25\) \(M_{\text{Jup}}\) brown dwarfs with a wide M-type companion. If confirmed, it would constitute only the second double-lined eclipsing brown dwarf binary system discovered to date. The double-lined system EPIC 203710387 is composed of nearly identical M4.5–M5 stars with fundamentally determined masses and radii measured to better than 3\% precision \((M_1 = 0.1183 \pm 0.0028 \, M_\odot, M_2 = 0.1076 \pm 0.0031 \, M_\odot\) and \(R_1 = 0.417 \pm 0.010 \, R_\odot, R_2 = 0.450 \pm 0.012 \, R_\odot\)) from combination of the light curve and radial velocity time series. These stars have the lowest masses of any stellar mass double-lined eclipsing binary to date. Finally, EPIC 203476597 is a compact single-lined system with a G8-K0 primary and a likely mid-K secondary whose line are revealed in spectral ratios. Continued measurement of radial velocities and spectroscopic flux ratios will better constrain fundamental parameters and should elevate the objects to benchmark status. We also present revised parameters for the double-lined eclipsing binary UScoCTIO 5 \((M_1 = 0.3336 \pm 0.0022 \, M_\odot, M_2 = 0.32000 \pm 0.0022 \, M_\odot\) and \(R_1 = 0.862 \pm 0.012 \, R_\odot, R_2 = 0.852 \pm 0.013 \, R_\odot\)). We discuss the implications of our results on these \(~0.1–1.5\) \(M_\odot\) stars for pre-main-sequence evolutionary models. Accepted by ApJ

Detection of Infall in the Protostar B335 with ALMA

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Observations of the isolated globule B335 with ALMA have yielded absorption features against the continuum that are redshifted from the systemic velocity in both HCN and HCO$^+$ lines. These features provide unambiguous evidence for infall toward a central luminosity source. Previously developed models of inside-out collapse can match the observed line profiles of HCN and HCO$^+$ averaged over the central 50 AU. At the new distance of 100 pc, the inferred infall radius is 0.012 pc, the mass infall rate is $3 \times 10^{-6} \, M_\odot \, yr^{-1}$, the age is $5 \times 10^4$ years, and the accumulated mass in the central zone is $0.15 \, M_\odot$, most of which must be in the star or in parts of a disk that are opaque at 0.8 mm. The continuum detection indicates an optically thin mass (gas and dust) of only $7.5 \times 10^{-4} \, M_\odot$ in the central region, consistent with only a very small disk mass.

Accepted by Astrophysical Journal

http://adsabs.harvard.edu/pdf/2015arXiv151003476E

Weak Turbulence in the HD 163296 Protoplanetary Disk Revealed by ALMA CO Observations

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Turbulence can transport angular momentum in protoplanetary disks and influence the growth and evolution of planets. With spatially and spectrally resolved molecular emission line measurements provided by (sub)millimeter interferometric observations, it is possible to directly measure non-thermal motions in the disk gas that can be attributed to this turbulence. We report a new constraint on the turbulence in the disk around HD 163296, a nearby young A star, determined from ALMA Science Verification observations of four CO emission lines (the CO(3–2), CO(2–1), $^{13}$CO(2–1), and C$^{18}$O(2–1) transitions). The different optical depths for these lines permit probes of non-thermal line-widths at a range of physical conditions (temperature and density) and depths into the disk interior. We derive stringent limits on the non-thermal motions in the upper layers of the outer disk such that any contribution to the line-widths from turbulence is $<3\%$ of the local sound speed. These limits are approximately an order of magnitude lower than theoretical predictions for full-blown MHD turbulence driven by the magneto-rotational instability, potentially suggesting that this mechanism is less efficient in the outer ($R > 30$ AU) disk than has been previously considered.

Accepted by ApJ

http://arxiv.org/pdf/1510.01375

Large-scale numerical simulations of star formation put to the test: Comparing synthetic images and actual observations for statistical samples of protostars

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Context. Both observations and simulations of embedded protostars have progressed rapidly in recent years. Bringing
them together is an important step in advancing our knowledge about the earliest phases of star formation.

Aims. To compare synthetic continuum images and spectral energy distributions (SEDs), created from large-scale numerical simulations, to observational studies – thereby aiding both in the interpretation of the observations and in testing the fidelity of the simulations.

Methods. The adaptive mesh refinement code, RAMSES, is used to simulate the evolution of a 5 pc × 5 pc × 5 pc molecular cloud. The simulation has a maximum resolution of 8 AU, resolving simultaneously the molecular cloud on parsec scales and individual protostellar systems on AU scales. The simulation is post-processed with the radiative transfer code RADMC-3D, which is used to create synthetic continuum images and SEDs of the protostellar systems. In this way more than 13 000 unique radiative transfer models of a variety of different protostellar systems are produced.

Results. Over the course of 0.76 Myr more than 500 protostars form in the simulation – primarily within two subclusters. Synthetic SEDs are used to calculate evolutionary tracers $T_{\text{bol}}$ and $L_{\text{smm}}/L_{\text{bol}}$. It is shown that, while the observed distributions of tracers are well matched by the simulation, they generally do a poor job of tracking the protostellar ages. Disks form early in the simulation, with 40% of Class 0 objects containing one. The flux emission from the simulated disk is found to be a factor $\sim 6$ too low when compared to real observations; an issue that can be traced back to numerical effects on the smallest scales in the simulation. The luminosity distribution of the protostars in the simulation spans three order of magnitudes, similar to the observed distribution. Cores and protostars are found to be closely associated with one-another, with the distance distribution between them being in excellent agreement with observations.

Conclusions. The analysis and statistical comparison of synthetic observations to real ones is established as a powerful tool in the interpretation of observational results. This approach goes beyond comparing single selected objects with isolated models of star-forming cores by using a large set of post-processed protostars that make statistical comparisons with observational surveys possible.

Accepted by A&A

http://arxiv.org/pdf/1510.07827

Water deuteration and ortho-to-para nuclear spin ratio of H$_2$ in molecular clouds formed via accumulation of H$_2$ gas

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We investigate the water deuteration ratio and ortho-to-para nuclear spin ratio of H$_2$ (OPR(H$_2$)) during the formation and early evolution of a molecular cloud, following the scenario that accretion flows sweep and accumulate H$_2$ gas to form molecular clouds. We follow the physical evolution of post-shock materials using a one-dimensional shock model, with post-processing gas-ice chemistry simulations. This approach allows us to study the evolution of the OPR(H$_2$) and water deuteration ratio without an arbitrary assumption concerning the initial molecular abundances, including the initial OPR(H$_2$). When the conversion of hydrogen into H$_2$ is almost complete, the OPR(H$_2$) is already much smaller than the statistical value of three due to the spin conversion in the gas phase. As the gas accumulates, the OPR(H$_2$) decreases in a non-equilibrium manner. We find that water ice can be deuterium-poor at the end of its main formation stage in the cloud, compared to water vapor observed in the vicinity of low-mass protostars where water ice is sublimated. If this is the case, the enrichment of deuterium in water should mostly occur at somewhat later evolutionary stages of star formation, i.e., cold prestellar/protostellar cores. The main mechanism to suppress water ice deuteration in the cloud is the cycle of photodissociation and reformation of water ice, which efficiently removes deuterium from water ice chemistry. The removal efficiency depends on the main formation pathway of water ice. The OPR(H$_2$) plays a minor role in water ice deuteration at the main formation stage of water ice.

Accepted by A&A
Solving the excitation and chemical abundances in shocks: the case of HH1
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We present deep spectroscopic (3600–24700 \textmu{}A) X-shooter observations of the bright Herbig-Haro object HH1, one of the best laboratories to study the chemical and physical modifications caused by protostellar shocks on the natal cloud. We observe atomic fine structure lines, HI, and He, recombination lines and H\textsubscript{2}, ro-vibrational lines (more than 500 detections in total). Line emission was analyzed by means of Non Local Thermal Equilibrium codes to derive the electron temperature and density, and, for the first time, we are able to accurately probe different physical regimes behind a dissociative shock. We find a temperature stratification in the range 4000–80000 K, and a significant correlation between temperature and ionization energy. Two density regimes are identified for the ionized gas, a more tenuous, spatially broad component (density about $10^3$ cm\textsuperscript{-3}), and a more compact component (density $>10^5$ cm\textsuperscript{-3}) likely associated with the hottest gas. A further neutral component is also evidenced, having temperature less than 10000 K and density $>10^4$ cm\textsuperscript{-3}. The gas fractional ionization was estimated solving the ionization equilibrium equations of atoms detected in different ionization stages. We find that neutral and fully ionized regions co-exist inside the shock. Also, indications in favor of at least partially dissociative shock as the main mechanism for molecular excitation are derived. Chemical abundances are estimated for the majority of the detected species. On average, abundances of non-refractory/refractory elements are lower than solar of about 0.15/0.5 dex. This testifies the presence of dust inside the medium, with a depletion factor of Iron of about 40%.

Accepted by ApJ

http://arxiv.org/pdf/1510.06880

Far-Infrared Dust Temperatures and Column Densities of the MALT90 Molecular Clump Sample
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We present dust column densities and dust temperatures for $\sim$ 3000 young high-mass molecular clumps from the Millimetre Astronomy Legacy Team 90 GHz (MALT90) survey, derived from adjusting single temperature dust emission models to the far-infrared intensity maps measured between 160 and 870 \textmu{}m from the Herschel/Hi-Gal and APEX/ATLASGAL surveys. We discuss the methodology employed in analyzing the data, calculating physical parameters, and estimating their uncertainties. The population average dust temperature of the clumps are: 16.8 $\pm$ 0.2 K for the clumps that do not exhibit mid-infrared signatures of star formation (Quiescent clumps), 18.6 $\pm$ 0.2 K for the clumps that display mid-infrared signatures of ongoing star formation but have not yet developed an HII region (Protostellar clumps), and 23.7 $\pm$ 0.2 and 28.1 $\pm$ 0.3 K for clumps associated with HII and photo-dissociation regions, respectively. These four groups exhibit large overlaps in their temperature distributions, with dispersions ranging between 4 and 6 K. The median of the peak column densities of the Protostellar clump population is 0.20 $\pm$ 0.02 gr cm\textsuperscript{-2}, which is about 50% higher compared to the median of the peak column densities associated with clumps in the other evolutionary stages. We compare the dust temperatures and column densities measured toward the center of the clumps with the mean values of each clump. We find that in the Quiescent clumps the dust temperature increases toward the outer regions and that they are associated with the shallowest column density profiles. In contrast, molecular clumps in the Protostellar or HII region phase have dust temperature gradients more consistent with internal heating and are associated with steeper column density profiles compared with the Quiescent clumps.
Light curves of the latest FUor: Indication of a close binary

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We monitored the recent FUor 2MASS J06593158−0405277 (V960 Mon) since November 2009 at various observatories and multiple wavelengths. After the outburst by nearly 2.9 mag in r around September 2014 the brightness gently fades until April 2015 by nearly 1 mag in U and 0.5 mag in z. Thereafter the brightness at λ > 5000 Å was constant until June 2015 while the shortest wavelengths (U,B) indicate a new rise, similar to that seen for the FUor V2493 Cyg (HBC722). Our near-infrared (NIR) monitoring between December 2014 and April 2015 shows a smaller outburst amplitude (∼2 mag) and a smaller (0.2–0.3 mag) post-outburst brightness decline. Optical and NIR color-magnitude diagrams indicate that the brightness decline is caused by growing extinction. The post-outburst light curves are modulated by an oscillating color-neutral pattern with a period of about 17 days and an amplitude declining from ∼0.08 mag in October 2014 to ∼0.04 mag in May 2015. The properties of the oscillating pattern lead us to suggest the presence of a close binary with eccentric orbit.

Accepted by A&A

On the accretion process in a high-mass star forming region - A multitransitional THz Herschel-HIFI study of ammonia toward G34.26+0.15

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Our aim is to explore the gas dynamics and the accretion process in the early phase of high-mass star formation. The inward motion of molecular gas in the massive star forming region G34.26+0.15 is investigated by using high-resolution profiles of seven transitions of ammonia at THz frequencies observed with Herschel-HIFI. The shapes and intensities of these lines are interpreted in terms of radiative transfer models of a spherical, collapsing molecular envelope. An accelerated Lambda Iteration (ALI) method is used to compute the models. The seven ammonia lines show mixed absorption and emission with inverse P-Cygni-type profiles that suggest infall onto the central source. A trend toward absorption at increasingly higher velocities for higher excitation transitions is clearly seen in the line profiles. The J = 3 ← 2 lines show only very weak emission, so these absorption profiles can be used directly to analyze the inward motion of the gas. This is the first time a multitransitional study of spectrally resolved rotational ammonia lines has been used for this purpose. Broad emission is, in addition, mixed with the absorption in the 1₀ − 0₀ ortho-NH₃...
line, possibly tracing a molecular outflow from the star forming region. The best-fitting ALI model reproduces the continuum fluxes and line profiles, but slightly underpredicts the emission and absorption depth in the ground-state ortho line $^{1}_0 - ^0_0$. An ammonia abundance on the order of $10^{-9}$ relative to $H_2$ is needed to fit the profiles. The derived ortho-to-para ratio is approximately 0.5 throughout the infalling cloud core similar to recent findings for translucent clouds in sight lines toward W31C and W49N. We find evidence of two gas components moving inwards toward the central region with constant velocities: 2.7 and 5.3 km s$^{-1}$, relative to the source systemic velocity. Attempts to model the inward motion with a single gas cloud in free-fall collapse did not succeed.

Accepted by Astronomy and Astrophysics


Chemical Tracers of Pre-Brown Dwarf Cores Formed Through Turbulent Fragmentation
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A gas-grain time dependent chemical code, UCL CHEM, has been used to investigate the possibility of using chemical tracers to differentiate between the possible formation mechanisms of brown dwarfs. In this work, we model the formation of a pre-brown dwarf core through turbulent fragmentation by following the depth-dependent chemistry in a molecular cloud through the step change in density associated with an isothermal shock and the subsequent freefall collapse once a bound core is produced. Trends in the fractional abundance of molecules commonly observed in star forming cores are then explored to find a diagnostic for identifying brown dwarf mass cores formed through turbulence. We find that the cores produced by our models would be bright in CO and $NH_3$ but not in $HCO^+$. This differentiates them from models using purely freefall collapse as such models produce cores that would have detectable transitions from all three molecules.

Accepted by MNRAS

http://arxiv.org/pdf/1510.06576

HARPS spectropolarimetry of three sharp-lined Herbig Ae stars: New insights
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Recently, several arguments have been presented that favour a scenario in which the low detection rate of magnetic fields in Herbig Ae stars can be explained by the weakness of these fields and rather large measurement uncertainties. Spectropolarimetric studies involving sharp-lined Herbig Ae stars appear to be a promising approach for the detection of such weak magnetic fields. These studies offer a clear spectrum interpretation with respect to the effects of blending, local velocity fields, and chemical abundances, and allow us to identify a proper sample of spectral lines appropriate for magnetic field determination. High-resolution spectropolarimetric observations of the three sharp-lined ($v \sin i < 15$ km s$^{-1}$) Herbig Ae stars HD 101412, HD 104237, and HD 190073 have been obtained in recent years with the HARPS spectrograph in polarimetric mode. We used these archival observations to investigate the behaviour of their longitudinal magnetic fields. To carry out the magnetic field measurements, we used the multi-line singular value decomposition (SVD) method for Stokes profile reconstruction. We carried out a high-resolution spectropolarimetric analysis of the Herbig Ae star HD 101412 for the first time. We discovered that different line lists yield differences in
both the shape of the Stokes V signatures and their field strengths. They could be interpreted in the context of the impact of the circumstellar matter and elemental abundance inhomogeneities on the measurements of the magnetic field. On the other hand, due to the small size of the Zeeman features on the first three epochs and the lack of near-IR observations, circumstellar and photospheric contributions cannot be estimated unambiguously. In the SVD Stokes V spectrum of the SB2 system HD 104237, we detect that the secondary component, which is a T Tauri star, possesses a rather strong magnetic field \( \langle B_z \rangle = 129 \pm 12 \) G, while no significant field is present in the primary component. Our measurements of HD 190073 confirm the presence of a variable magnetic field and indicate that the circumstellar environment may have a significant impact on the observed polarization features.

Accepted by A&A

Direct imaging of an asymmetric debris disk in the HD 106906 planetary system

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We present the first scattered light detections of the HD 106906 debris disk using Gemini/GPI in the infrared and HST/ACS in the optical. HD 106906 is a 13 Myr old F5V star in the Sco-Cen association, with a previously detected planet-mass candidate HD 106906b projected 650 AU from the host star. Our observations reveal a near edge-on debris disk that has a central cleared region with radius $\sim 50$ AU, and an outer extent $> 500$ AU. The HST data show the outer regions are highly asymmetric, resembling the “needle” morphology seen for the HD 15115 debris disk. The planet candidate is oriented $\sim 21^\circ$ away from the position angle of the primary’s debris disk, strongly suggesting non-coplanarity with the system. We hypothesize that HD 106906b could be dynamically involved in the perturbation of the primary’s disk, and investigate whether or not there is evidence for a circumplanetary dust disk or cloud that is either primordial or captured from the primary. We show that both the existing optical properties and near-infrared colors of HD 106906b are weakly consistent with this possibility, motivating future work to test for the observational signatures of dust surrounding the planet.

Accepted by ApJ

http://arxiv.org/pdf/1510.02747

Measurement of $[\text{HDCO}]/[\text{H}_2\text{CO}]$ Ratios in the Envelopes of Extremely Cold Protostars in Orion

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We present observations of HDCO and H$_2$CO emission toward a sample of 15 Class 0 protostars in the Orion A and B clouds. Of these, eleven protostars are Herschel-identified PACS Bright Red Sources (PBRS) and four are previously identified protostars. Our observations revealed the chemical properties of the PBRS envelope for the first time. The column densities of HDCO and H$_2$CO are derived from single dish observations at an angular resolution of $\sim 20''$ ($\sim 8400$ AU). The degree of deuteration in H$_2$CO ($[\text{HDCO}]/[\text{H}_2\text{CO}]$) was estimated to range from 0.03 to 0.31. The deuterium fractionation of most PBRS (70%) is similar to that of the non-PBRS sources. Three PBRS (30%) exhibit high deuterium fractionation, larger than 0.15. The large variation of the deuterium fractionation of H$_2$CO in the whole PBRS sample may reflect the diversity in the initial conditions of star forming cores. There is no clear correlation between the [HDCO]/[H$_2$CO] ratio and the evolutionary sequence of protostars.

Accepted by ApJ

http://arxiv.org/pdf/1510.03532

A Targeted Search for Peculiarly Red L and T Dwarfs in SDSS, 2MASS, and WISE: Discovery of a Possible L7 Member of the TW Hydrae Association

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We present first results from a targeted search for brown dwarfs with unusual red colors indicative of peculiar atmospheric characteristics. These include objects with low surface gravities or with unusual dust content or cloud properties. From a positional cross-match of SDSS, 2MASS and WISE, we have identified 40 candidate peculiar early L to early T dwarfs that are either new objects or have not been identified as peculiar through prior spectroscopy. Using low resolution spectra, we confirm that 10 of the candidates are either peculiar or potential L/T binaries. With a $J-K_s$ color of $2.62\pm0.15$ mag, one of the new objects — the L7 dwarf 2MASS J11193254−1137466 — is among the reddest field dwarfs currently known. Its proper motion and photometric parallax indicate that it is a possible member of the TW Hydrae moving group. If confirmed, it would its lowest-mass (5–6 MJup) free-floating member. We also report a new T dwarf, 2MASS J22153705+2110554, that was previously overlooked in the SDSS footprint. These new discoveries demonstrate that despite the considerable scrutiny already devoted to the SDSS and 2MASS surveys, our exploration of these data sets is not yet complete.

Accepted by AJ

http://arxiv.org/pdf/1510.08464

Kinematics of the Envelope and Two Bipolar Jets in the Class 0 Protostellar System L1157

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A massive envelope and a strong bipolar outflow are the two main structures characterizing the youngest protostellar systems. In order to understand the physical properties of a bipolar outflow and the relationship with those of the envelope, we obtained a mosaic map covering the whole bipolar outflow of the youngest protostellar system L1157 with about 5″ angular resolution in CO $J=2−1$ using the Combined Array for Research in Millimeter-wave Astronomy. By utilizing these observations of the whole bipolar outflow, we estimate its physical properties and show that they are consistent with multiple jets. We also constrain a preferred precession direction. In addition, we observed the central envelope structure with 2″ resolution in the $\lambda=1.3$ and 3 mm continua and various molecular lines: $^{17}$O, $^{18}$O, $^{13}$CO, CS, CN, N$_2$H$^+$, CH$_3$OH, H$_2$O, SO, and SO$_2$. All the CO isotopes and CS, CN, and N$_2$H$^+$ have been detected and imaged. We marginally detected the features that can be interpreted as a rotating inner envelope in C$^{17}$O and C$^{18}$O and as an infalling outer envelope in N$_2$H$^+$. We also estimated the envelope and central protostellar masses and found that the dust opacity spectral index changes with radius.

Accepted by ApJ

http://arxiv.org/pdf/1510.02155

Signatures of star formation by cold collapse

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Sub-virial gravitational collapse is one mechanism by which star clusters may form. Here we investigate whether this mechanism can be inferred from observations of young clusters. To address this question, we have computed SPH simulations of the initial formation and evolution of a dynamically young star cluster through cold (sub-virial) collapse, starting with an ellipsoidal, turbulently seeded distribution of gas, and forming sink particles representing (proto)stars. While the initial density distributions of the clouds do not have large initial mass concentrations, gravitational focusing due to the global morphology leads to cluster formation. We use the resulting structures to extract observable morphological and kinematic signatures for the case of sub-virial collapse. We find that the signatures of the initial conditions can be erased rapidly as the gas and stars collapse, suggesting that kinematic observations need to be made either early in cluster formation and/or at larger scales, away from the growing cluster core. Our results emphasize that a dynamically young system is inherently evolving on short timescales, so that it can be highly misleading to use current-epoch conditions to study aspects such as star formation rates as a function of local density. Our simulations serve as a starting point for further studies of collapse including other factors such as magnetic fields and stellar feedback.

Accepted by ApJ

http://arxiv.org/pdf/1510.08478

A narrow, edge-on disk resolved around HD 106906 with SPHERE


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HD 106906AB is so far the only young binary system around which a planet has been imaged and a debris disk evidenced thanks to a strong IR excess. As such, it represents a unique opportunity to study the dynamics of young planetary systems. We aim at further investigating the close (tens of au scales) environment of the HD 106906AB system. We used the extreme AO fed, high contrast imager SPHERE recently installed on the VLT to observe HD 106906. Both the IRDIS imager and the Integral Field Spectrometer were used. We discovered a very inclined, ring-like disk at a distance of 65 AU from the star. The disk shows a strong brightness asymmetry with respect to its semi-major axis. It shows a smooth outer edge, compatible with ejection of small grains by the stellar radiation pressure. We show furthermore that the planet’s projected position is significantly above the disk’s PA. Given the determined disk inclination, it is not excluded though that the planet could still orbit within the disk plane if at a large separation (2000–3000 AU). We identified several additional point sources in the SPHERE/IRDIS field-of-view, that appear to be background objects. We compare this system with other debris disks sharing similarities, and we briefly discuss the present results in the framework of dynamical evolution.

Accepted by A&A

http://arxiv.org/pdf/1510.02511

On the convective overstability in protoplanetary discs
Henrik N. Latter

This paper explores the driving of low-level hydrodynamical activity in protoplanetary-disc dead zones. A small adverse radial entropy gradient, ordinarily stabilised by rotation, excites oscillatory convection (‘convective overstability’) when thermal diffusion, or cooling, is neither too strong nor too weak. I revisit the linear theory of the instability, discuss its prevalence in protoplanetary discs, and show that unstable modes are exact nonlinear solutions in the local Boussinesq limit. Overstable modes cannot grow indefinitely, however, as they are subject to a secondary parametric instability that limits their amplitudes to relatively low levels. If parasitics set the saturation level of the ensuing turbulence then the convective overstability is probably too weak to drive significant angular momentum transport or to generate vortices. But I also discuss an alternative, and far more vigorous, saturation route that generates radial ‘layers’ or ‘zonal flows’ (witnessed also in semiconvection). Numerical simulations are required to determine which outcome is favoured in realistic discs, and consequently how important the instability is for disc dynamics.

Accepted by MNRAS

http://arxiv.org/pdf/1510.06247

Physical conditions in the central molecular zone inferred by H$_3^+$
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The H$_3^+$ molecule has been detected in many lines of sight within the central molecular zone (CMZ) with exceptionally large column densities and unusual excitation properties compared to diffuse local clouds. The detection of the (3,3) metastable level has been suggested to be the signature of warm and diffuse gas in the CMZ. We aim to determine the physical conditions and processes in the CMZ that explain the ubiquitous properties of H$_3^+$ in this medium and to constrain the value of the cosmic-ray ionization rate. We use the Meudon PDR code (photodissociation region code) in which H$_3^+$ excitation has been implemented. We re-examine the relationship between the column density of H$_3^+$ and the cosmic-ray ionization rate, $\zeta$, up to large values of $\zeta$ in the frame of this full chemical model. We study the impact of the various mechanisms that can excite H$_3^+$ in its metastable state. We produce grids of PDR models.
exploring different parameters (\(\zeta\), size of clouds, metallicity) and infer the physical conditions that best match the observations toward ten lines of sight in the CMZ. For one of them, Herschel observations of HF, OH\(^+\), H\(_2\)O\(^+\), and H\(_3\)O\(^+\) can be used as additional constraints. We check that the results found for H\(_3\)O\(^+\) also account for the observations of these molecules. We find that the linear relationship between \(N(H_3O^+)\) and \(\zeta\) only holds up to a certain value of the cosmic-ray ionization rate, which depends on the proton density. A value \(\zeta \approx 1 - 11 \times 10^{-14} \text{ s}^{-1}\) explains both the large observed H\(_3\)O\(^+\) column density and its excitation in the metastable level (3,3). This \(\zeta\) value agrees with that derived from synchrotron emission and Fe K\(\alpha\) line. It also reproduces \(N(\text{OH}^+)\), \(N(H_2O^+)\) and \(N(H_3O^+)\) detected toward Sgr B2(N). We confirm that the CMZ probed by H\(_3\)O\(^+\) is diffuse, \(n_H < 100 \text{ cm}^{-3}\) and warm, \(T \sim 212-505 \text{ K}\). This warm medium is due to cosmic-ray heating. We also find that the diffuse component probed by H\(_3\)O\(^+\) must fill a large fraction of the CMZ. Finally, we suggest the warm gas in the CMZ enables efficient H\(_2\) formation via chemisorption sites as in PDRs. This contributes to enhance the abundance of H\(_3\)O\(^+\) in this high cosmic-ray flux environment.

Accepted by Astronomy and Astrophysics

http://fr.arxiv.org/pdf/1510.02221

Spectroscopic infrared extinction mapping as a probe of grain growth in IRDCs

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We present spectroscopic tests of MIR to FIR extinction laws in IRDC G028.36+00.07, a potential site of massive star and star cluster formation. Lim & Tan (2014) developed methods of FIR extinction mapping of this source using Spitzer-MIPS 24 \(\mu\)m and Herschel-PACS 70 \(\mu\)m images, and by comparing to MIR Spitzer-IRAC 3–8 \(\mu\)m extinction maps, found tentative evidence for grain growth in the highest mass surface density regions. Here we present results of spectroscopic infrared extinction (SIREX) mapping using Spitzer-IRS (14 to 38 \(\mu\)m) data of the same IRDC. These methods allow us to first measure the SED of the diffuse Galactic ISM that is in the foreground of the IRDC. We then carry out our primary investigation of measuring the MIR to FIR opacity law and searching for potential variations as a function of mass surface density within the IRDC. We find relatively flat, featureless MIR-FIR opacity laws that lack the \(\sim 12 \mu\)m and \(\sim 35 \mu\)m features associated with the thick water ice mantle models of Ossenkopf & Henning (1994). Their thin ice mantle models and the coagulating aggregate dust models of Ormel et al. (2011) are a generally better match to the observed opacity laws. We also find evidence for generally flatter MIR to FIR extinction laws as mass surface density increases, strengthening the evidence for grain and ice mantle growth in higher density regions.

Accepted by ApJ

http://arxiv.org/pdf/1508.02816v2.pdf

Search for HOOH in Orion

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Context. The abundance of key molecules determines the level of cooling that is necessary for the formation of stars and planetary systems. In this context, one needs to understand the details of the time dependent oxygen chemistry, leading to the formation of molecular oxygen and water.

Aims. We aim to determine the degree of correlation between the occurrence of O\(_2\) and HOOH (hydrogen peroxide) in star-forming molecular clouds. We first detected O\(_2\) and HOOH in the \(\rho\) Ophiuchi cloud (core A), we now search for HOOH in Orion Molecular Cloud OMC A, where O\(_2\) has also been detected.

Methods. We mapped a \(3' \times 3'\) region around Orion H\(_2\)-Peak 1 with the Atacama Pathfinder Experiment (APEX). In addition to several maps in two transitions of HOOH, viz. 219.17 GHz and 251.91 GHz, we obtained single-point
spectra for another three transitions towards the position of maximum emission.

Results. Line emission at the appropriate LSR-velocity (Local Standard of Rest) and at the level of greater or equal to 4σ was found for two transitions, with lower S/N (2.8–3.5σ) for another two transitions, whereas for the remaining transition, only an upper limit was obtained. The emitting region, offset 18″ south of H2-Peak 1, appeared point-like in our observations with APEX.

Conclusions. The extremely high spectral line density in Orion makes the identification of HOOH much more difficult than in ρ Oph A. As a result of having to consider the possible contamination by other molecules, we left the current detection status undecided.

Accepted by A&A

http://arxiv.org/pdf/1510.01461

Deeply Embedded Protostellar Population in the 20 km s⁻¹ Cloud of the Central Molecular Zone

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We report the discovery of a population of deeply embedded protostellar candidates in the 20 km s⁻¹ cloud, one of the massive molecular clouds in the Central Molecular Zone (CMZ) of the Milky Way, using interferometric submillimeter continuum and H₂O maser observations. The submillimeter continuum emission shows five 1-pc scale clumps, each of which further fragments into several 0.1-pc scale cores. We identify 17 dense cores, among which 12 are gravitationally bound. Among the 18 H₂O masers detected, 13 coincide with the cores and probably trace outflows emanating from the protostars. There are also 5 gravitationally bound dense cores without H₂O maser detection. In total the 13 masers and 5 cores may represent 18 protostars with spectral types later than B1 or potential growing more massive stars at earlier evolutionary stage, given the non-detection in the centimeter radio continuum. In combination with previous studies of CH₃OH masers, we conclude that the star formation in this cloud is at an early evolutionary phase, before the presence of any significant ionizing or heating sources. Our findings indicate that star formation in this cloud may be triggered by a tidal compression as it approaches pericenter, similar to the case of G0.253+0.016 but with a higher star formation rate, and demonstrate that high angular resolution, high sensitivity maser and submillimeter observations are a promising technique to unveil deeply embedded star formation in the CMZ.

Accepted by ApJ Letters

http://arxiv.org/pdf/1510.04901v1

X-Shooter study of accretion in Chamaeleon I

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We present the analysis of 34 new VLT/X-Shooter spectra of young stellar objects in the Chamaeleon I star forming region, together with four more spectra of stars in Taurus and two in Chamaeleon II. The broad wavelength coverage and accurate flux calibration of our spectra allow us to estimate stellar and accretion parameters for our targets by fitting the photospheric and accretion continuum emission from the Balmer continuum down to 700 nm. The dependence of accretion with stellar properties for this sample is consistent with previous results from the literature. The accretion rates for transitional disks are consistent with those of full disks in the same region. The spread of mass accretion rates at any given stellar mass is found to be smaller than in many studies, but is larger than that derived in the Lupus clouds using similar data and techniques. Differences in the stellar mass range and in the environmental conditions between our sample and that of Lupus may account for the discrepancy in scatter between Chamaeleon I and Lupus. Complete samples in Chamaeleon I and Lupus are needed to determine whether the difference in scatter of accretion rates and the lack of evolutionary trends are robust to sample selection.

Accepted by Astronomy & Astrophysics

http://arxiv.org/pdf/1510.08255

Proper motions of the outer knots of the HH 80/81/80N radio-jet

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The HH 80/81/80N jet extends from the HH 80 object to the recently discovered Source 34 and has a total projected jet size of 10.3 pc, constituting the largest collimated radio-jet system known so far. It is powered by IRAS 18162–2048 associated with a massive young stellar object. We report 6 cm JVLA observations that, compared with previous 6 cm VLA observations carried out in 1989, allow us to derive proper motions of the HH 80, HH 81 and HH 80N radio knots located about 2.5 pc away in projection from the powering source. For the first time, we measure proper motions of the optically obscured HH 80N object providing evidence that HH 81, 80 and 80N are associated with the same radio-jet. We derived tangential velocities of these HH objects between 260 and 350 km s⁻¹, significantly lower than those for the radio knots of the jet close to the powering source (600–1400 km s⁻¹) derived in a previous work, suggesting that the jet material is slowing down due to a strong interaction with the ambient medium. The HH 80 and HH 80N emission at 6 cm is, at least in part, probably synchrotron radiation produced by relativistic electrons in a magnetic field of 1 mG. If these electrons are accelerated in a reverse adiabatic shock, we estimate a jet total density of ∼1000 cm⁻³. All these features are consistent with a jet emanating from a high mass protostar and make evident its capability of accelerating particles up to relativistic velocities.

Accepted by ApJ

http://arxiv.org/pdf/1510.01769

Inner disk clearing around the Herbig Ae star HD 139614: Evidence for a planet-induced gap?

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Spatially resolving the inner dust cavity of the transitional disks is a key to understanding the connection between planetary formation and disk dispersal. The disk around the Herbig star HD 139614 is of particular interest since it presents a pretransitional nature with an AU-sized gap, in the dust, that was spatially resolved by mid-IR interferometry. Using new NIR interferometric observations, we aim to characterize the 0.1–10 AU region of the HD 139614 disk further and identify viable mechanisms for the inner disk clearing. We report the first multiwavelength radiative transfer modeling of the interferometric data acquired on HD 139614 with PIONIER, AMBER, and MIDI, complemented by Herschel/PACS photometries. We confirm a gap structure in the um-sized dust, extending from about 2.5 au to 6 AU, and constrained the properties of the inner dust component: e.g., a radially increasing surface density profile, and a depletion of 10^3 relative to the outer disk. Since self-shadowing and photoevaporation appears unlikely to be responsible for the AU-sized gap of HD 139614, we thus tested if dynamical clearing could be a viable mechanism using hydrodynamical simulations to predict the gaseous disk structure. Indeed, a narrow AU-sized gap is expected when a single giant planet interacts with the disk. Assuming that small dust grains are well coupled to the gas, we found that a ∼3 M_{Jup} planet located at 4.5 AU from the star could, in less than 1 Myr, reproduce most of the aspects of the dust surface density profile, while no significant depletion in gas occurred in the inner disk, in contrast to the dust. However, the dust-depleted inner disk could be explained by the expected dust filtration by the gap and the efficient dust growth/fragmentation in the inner disk regions. Our results support the hypothesis of a giant planet opening a gap and shaping the inner region of the HD 139614 disk.

Accepted by A&A

http://arxiv.org/pdf/1510.03093

The Spitzer Space Telescope Survey of the Orion A and B Molecular Clouds II: the Spatial Distribution and Demographics of Dusty Young Stellar Objects

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We analyze the spatial distribution of dusty young stellar objects (YSOs) identified in the Spitzer Survey of the Orion
Molecular clouds, augmenting these data with Chandra X-ray observations to correct for incompleteness in dense clustered regions. We also devise a scheme to correct for spatially varying incompleteness when X-ray data are not available. The local surface densities of the YSOs range from $1 \text{ pc}^{-2}$ to over $10,000 \text{ pc}^{-2}$, with protostars tending to be in higher density regions. This range of densities is similar to other surveyed molecular clouds with clusters, but broader than clouds without clusters. By identifying clusters and groups as continuous regions with surface densities $\geq 10 \text{ pc}^{-2}$, we find that 59% of the YSOs are in the largest cluster, the Orion Nebular Cluster (ONC), while 13% of the YSOs are found in a distributed population. A lower fraction of protostars in the distributed population is evidence that it is somewhat older than the groups and clusters. An examination of the structural properties of the clusters and groups show that the peak surface densities of the clusters increase approximately linearly with the number of members. Furthermore, all clusters with more than 70 members exhibit asymmetric and/or highly elongated structures. The ONC becomes azimuthally symmetric in the inner 0.1 pc, suggesting that the cluster is only $\sim 2$ Myr in age. We find the star formation efficiency (SFE) of the Orion B cloud is unusually low, and that the SFEs of individual groups and clusters are an order of magnitude higher than those of the clouds. Finally, we discuss the relationship between the young low mass stars in the Orion clouds and the Orion OB 1 association, and we determine upper limits to the fraction of disks that may be affected by UV radiation from OB stars or by dynamical interactions in dense, clustered regions.

Accepted by Astron. J.


Discovery of molecular gas around HD 131835 in an APEX molecular line survey of bright debris disks

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Debris disks are considered to be gas-poor, but recent observations revealed molecular or atomic gas in several 10–40 Myr old systems. We used the APEX and IRAM 30 m radio telescopes to search for CO gas in 20 bright debris disks. In one case, around the 16 Myr old A-type star HD 131835, we discovered a new gas-bearing debris disk, where the CO 3–2 transition was successfully detected. No other individual system exhibited a measurable CO signal. Our Herschel Space Observatory far-infrared images of HD 131835 marginally resolved the disk at both 70 and 100 µm, with a characteristic radius of 170 au. While in stellar properties HD 131835 resembles β Pic, its dust disk properties are similar to those of the most massive young debris disks. With the detection of gas in HD 131835 the number of known debris disks with CO content has increased to four, all of them encircling young ($\leq 40$ Myr) A-type stars. Based on statistics within 125 pc, we suggest that the presence of detectable amount of gas in the most massive debris disks around young A-type stars is a common phenomenon. Our current data cannot conclude on the origin of gas in HD 131835. If the gas is secondary, arising from the disruption of planetesimals, then HD 131835 is a comparably young and, in terms of its disk, more massive analog of the β Pic system. However, it is also possible that this system, similarly to HD 21997, possesses a hybrid disk, where the gas material is predominantly primordial, while the dust grains are mostly derived from planetesimals.

Accepted by The Astrophysical Journal

An Increase in the Mass of Planetary Systems around Lower-Mass Stars

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Trends in the planet population with host star mass provide an avenue to constrain planet formation theories. We derive the planet radius distribution function for Kepler stars of different spectral types, sampling a range in host star masses. We find that M dwarf stars have 3.5 times more small planets (1.0 – 2.8 $R_\oplus$) than main-sequence FGK stars, but two times fewer Neptune-sized and larger (> 2.8$R_\oplus$) planets. We find no systematic trend in the planet size distribution between spectral types F, G, and K to explain the increasing occurrence rates. Taking into account the mass-radius relationship and heavy-element mass of observed exoplanets, and assuming those are independent of spectral type, we derive the inventory of the heavy-element mass locked up in exoplanets at short orbits. The overall higher planet occurrence rates around M stars are not consistent with the redistribution of the same mass into more, smaller planets. At the orbital periods and planet radii where Kepler observations are complete for all spectral types, the average heavy-element mass locked up in exoplanets increases roughly inversely with stellar mass from 4 $M_\oplus$ in F stars to 5 $M_\oplus$ in G and K stars to 7 $M_\oplus$ in M stars. This trend stands in stark contrast with observed protoplanetary disk masses that decrease towards lower mass stars, and provides a challenge for current planet formation models. Neither models of in situ formation nor migration of fully-formed planets are consistent with these results. Instead, these results are indicative of large-scale inward migration of planetary building blocks — either through type-I migration or radial drift of dust grains — that is more efficient for lower mass stars, but does not result in significantly larger or smaller planets.

Accepted by ApJ

http://arxiv.org/pdf/1510.02481

Hierarchical gravitational fragmentation. I. Collapsing cores within collapsing clouds

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We investigate the Hierarchical Gravitational Fragmentation scenario through numerical simulations of the prestellar stages of the collapse of a marginally gravitationally unstable isothermal sphere immersed in a strongly gravitationally unstable, uniform background medium. The core develops a Bonnor-Ebert (BE)-like density profile, while at the time of singularity (the protostar) formation the envelope approaches a singular-isothermal-sphere (SIS)-like $r^{-2}$ density profile. However, these structures are never hydrostatic. In this case, the central flat region is characterized by an infall speed, while the envelope is characterized by a uniform speed. This implies that the hydrostatic SIS initial condition leading to Shu's classical inside-out solution is not expected to occur, and therefore neither should the inside-out solution. Instead, the solution collapses from the outside-in, naturally explaining the observation of extended infall velocities. The core, defined by the radius at which it merges with the background, has a time-variable mass, and evolves along the locus of the ensemble of observed prestellar cores in a plot of $M/M_{BE}$ vs. $M$, where $M$ is the core’s mass and $M_{BE}$ is the critical Bonnor-Ebert mass, spanning the range from the ”stable” to the ”unstable” regimes, even though it is collapsing at all times. We conclude that the presence of an unstable background allows a core to evolve dynamically from the time when it first appears, even when it resembles a pressure-confined, stable BE-sphere. The core can be thought of as a ram-pressure confined BE-sphere, with an increasing mass due to the accretion from the unstable background.

Accepted by the Astrophysical Journal.

http://arxiv.org/pdf/1510.05617
V899 Mon: An Outbursting Protostar With Peculiar Light Curve And Its Transition Phases

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We present a detailed study of V899 Mon (a new member in the FUors/EXors family of young low-mass stars undergoing outburst), based on our long-term monitoring of the source starting from November 2009 to April 2015. Our optical and near-infrared photometric and spectroscopic monitoring recorded the source transitioning from its first outburst to a short duration quiescence phase (< 1 year), and then returning to a second outburst. We report here the evolution of the outflows from inner region of the disk as the accretion rate evolved in various epochs. Our high resolution (R∼37000) optical spectrum could resolve interesting clumpy structures in the outflow traced by various lines. Change in far-infrared flux was also detected between two outburst epochs. Based on our observations we constrained various stellar and envelope parameters of V899 Mon, as well as the kinematics of its accretion and outflow. The photometric and spectroscopic properties of this source fall between classical FUors and EXors. Our investigation of V899 Mon hints instability associated with magnetospheric accretion to be the physical cause of the sudden short duration pause of outburst in 2011. It is also a good candidate to explain similar short duration pauses in outburst of some other FUors/EXors sources.

Accepted by ApJ

Impact of supernova and cosmic-ray driving on the surface brightness of the galactic halo in soft X-rays

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The halo of the Milky Way contains a hot plasma with a surface brightness in soft X-rays of the order 10^{−12} erg cm^{−2} s^{-1} deg^{−2}. The origin of this gas is unclear, but so far numerical models of galactic star formation have failed to reproduce such a large surface brightness by several orders of magnitude. In this paper, we analyze simulations of the turbulent, magnetized, multi-phase interstellar medium including thermal feedback by supernova explosions as well as cosmic-ray feedback. We include a time-dependent chemical network, self-shielding by gas and dust, and self-gravity. Pure thermal feedback alone is sufficient to produce the observed surface brightness, although it is very sensitive to the supernova rate. Cosmic rays suppress this sensitivity and reduce the surface brightness because they drive cooler outflows. Self-gravity has by far the largest effect because it accumulates the diffuse gas in the disk in dense clumps and filaments, so that supernovae exploding in voids can eject a large amount of hot gas into the halo. This can boost the surface brightness by several orders of magnitude. Although our simulations do not reach a steady state,
all simulations produce surface brightness values of the same order of magnitude as the observations, with the exact value depending sensitively on the simulation parameters. We conclude that star formation feedback alone is sufficient to explain the origin of the hot halo gas, but measurements of the surface brightness alone do not provide useful diagnostics for the study of galactic star formation.

Accepted by ApJ Letters

http://arxiv.org/pdf/1510.06563

How do giant planetary cores shape the dust disk? HL Tau system

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We are observing, thanks to ALMA, the dust distribution in the region of active planet formation around young stars. This is a powerful tool to connect observations with theoretical models and improve our understandings of the processes at play. We want to test how a multi-planetary system shapes its birth disk and study the influence of the planetary masses and particle sizes on the final dust distribution. Moreover, we apply our model to the HL Tau system in order to obtain some insights on the physical parameters of the planets that are able to create the observed features. We follow the evolution of a population of dust particles, treated as Lagrangian particles, in two-dimensional, locally isothermal disks where two equal mass planets are present. The planets are kept in fixed orbits and they do not accrete mass. The outer planet plays a major role removing the dust particles in the co-orbital region of the inner planet and forming a particle ring which promotes the development of vortices respect to the single planetary case. The ring and gaps width depends strongly on the planetary mass and particle stopping times, and for the more massive cases the ring clumps in few stable points that are able to collect a high mass fraction. The features observed in the HL Tau system can be explained through the presence of several massive cores that shape the dust disk, where the inner planet(s) should have a mass on the order of 0.07 Jupiter masses and the outer one(s) on the order of 0.35 Jupiter masses. These values can be significantly lower if the disk mass turns out to be less than previously estimated. Decreasing the disk mass by a factor 10 we obtain similar gap widths for planets with a mass of 10 and 20 Earth masses respectively. Although the particle gaps are prominent, the expected gaseous gaps would be barely visible.

Accepted by A&A

http://arxiv.org/pdf/1510.01498

Variability and dust filtration in the transition disk J160421.7-213028 observed in optical scattered light

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**Context.** Protoplanetary disks around young stars are the birth-sites of planets. Spectral energy distributions and direct images of a subset of disks known as transition disks reveal dust-depleted inner cavities. Some of these disks
show asymmetric structures in thermal submillimetre emission and optical scattered light. These structures can be the result of planet(s) or companions embedded in the disk.

**Aims.** We aim to detect and analyse the scattered light of the transition disk J160421.7-213028, identify disk structures, and compare the results with previous observations of this disk at other wavelengths.

**Methods.** We obtained and analysed new polarised intensity observations of the transition disk J160421.7-213028 with VLT/SPHERE using the visible light instrument ZIMPOL at R'-band (0.626 μm). We probed the disk gap down to a radius of confidence of 0.1" (~15 AU at 145 pc). We interpret the results in the context of dust evolution when planets interact with the parental disk.

**Results.** We observe a gap from 0.1 to 0.3" (~15 to 40 AU) and a bright annulus as previously detected by HI-CIAO H-band observations at ~1.65 μm. The radial width of the annulus is around 40 AU, and its centre is at ~61 AU from the central star. The peak of the reflected light at 0.626 μm is located 20 AU inward of the cavity detected in the submillimetre. In addition, we detect a dip at a position angle of ~46.2 ± 5.4°. A dip was also detected with HI-CIAO, but located at ~85°. If the dip observed with HI-CIAO is the same, this suggests an average dip rotation of ~12°/year, which is inconsistent with the local Keplerian angular velocity of ~0.8°/yr at ~61 AU.

**Conclusions.** The spatial discrepancy in the radial emission in J160421.7-213028 at different wavelengths is consistent with dust filtration at the outer edge of a gap carved by a massive planet. The dip rotation can be interpreted as fast variability of the inner disk and/or the presence of a warp or circumplanetary material of a planet at ~9.6 AU.

Accepted by A&A Letters

http://arxiv.org/pdf/1510.00412

**Episodic molecular outflow in the very young protostellar cluster Serpens South**

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The loss of mass from protostars, in the form of a jet or outflow, is a necessary counterpart to protostellar mass accretion. Outflow ejection events probably vary in their velocity and/or in the rate of mass loss. Such ‘episodic’ ejection events have been observed during the Class 0 protostellar phase (the early accretion stage), and continue during the subsequent class I phase that marks the first one million years of star formation. Previously observed episodic-ejection sources were relatively isolated; however, the most common sites of star formation are clusters. Outflows link protostars with their environment and provide a viable source of turbulence that is necessary for regulating star formation in clusters, but it is not known how an accretion-driven jet or outflow in a clustered environment manifests itself in its earliest stage. This early stage is important in establishing the initial conditions for momentum and energy transfer to the environment as the protostar and cluster evolve. Here we report that an outflow from a very young class 0 protostar, at the hub of the very active and filamentary Serpens South protostellar cluster, shows unambiguous episodic events. The 12CO (J=2-1) emission from the protostar reveals 22 distinct features of outflow ejecta, the most recent having the highest velocity. The outflow forms bipolar lobes — one of the first detectable signs of star formation — which originate from the peak of 1-mm continuum emission. Emission from the surrounding C18O envelope shows kinematics consistent with rotation and an infall of material onto the protostar. The data suggest that episodic accretion-driven outflow begins in the earliest phase of protostellar evolution, and that the outflow remains intact in a very clustered environment, probably providing efficient momentum transfer for driving turbulence.

Accepted by Nature

http://arxiv.org/pdf/1511.01100
The VLT/NaCo large program to probe the occurrence of exoplanets and brown dwarfs at wide orbits. III. The frequency of brown dwarfs and giant planets as companions to solar-type stars


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In recent years there have been many attempts to characterize the occurrence and distribution of stellar, brown dwarf (BD) and planetary-mass companions to solar-type stars, with the aim of constraining formation mechanisms. From radial velocity observations a dearth of companions with masses between 10-40 $M_{\text{Jupiter}}$ has been noticed at close separations, suggesting the possibility of a distinct formation mechanism for objects above and below this range. We present a model for the substellar companion mass function (CMF). It consists of the superposition of the planet and BD companion mass distributions, assuming that we can extrapolate the radial velocity measured companion mass function for planets to larger separations and the stellar companion mass-ratio distribution over all separations into the BD mass regime. By using both the results of the VLT/NaCo large program (NaCo-LP, P.I. J. L. Beuzit) and the complementary archive datasets that probe the occurrence of planets and BDs on wide orbits around solar-type stars, we place some constraints on the planet and BD distributions. We developed a Monte Carlo simulation tool to predict the outcome of a given survey, depending on the shape of the orbital parameter distributions (mass, semi-major axis, eccentricity and inclination). Comparing the predictions with the results of the observations, we calculate how likely different models are and which can be ruled out. Current observations are consistent with the proposed model for the CMF, as long as a sufficiently small outer truncation radius ($\lesssim$100 AU) is introduced for the planet separation distribution. Some regions of parameter space can be excluded by the observations. We conclude that the results of the direct imaging surveys searching for substellar companions around Sun-like stars are consistent with a combined substellar mass spectrum of planets and BDs. This mass distribution has a minimum between 10 and 50 $M_{\text{Jupiter}}$, in agreement with radial velocity measurements. In this picture the dearth of objects in this mass range would naturally arise from the shape of the mass distribution, without the introduction of any distinct formation mechanism for BDs. Such a model for the CMF allows to determine what is the probability for a substellar companion as a function of mass to have formed in a disk or from protostellar core fragmentation, as such mechanisms overlap in this mass range.
The Young Stellar Population of the Cygnus-X DR15 Region
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We present a multi-wavelength study of the young stellar population in the Cygnus-X DR15 region. We studied young stars forming or recently formed at and around the tip of a prominent molecular pillar and an infrared dark cloud. Using a combination of ground based near-infrared, space based infrared and X-ray data, we constructed a point source catalog from which we identified 226 young stellar sources, which we classified into evolutionary classes. We studied their spatial distribution across the molecular gas structures and identified several groups possibly belonging to distinct young star clusters. We obtained samples of these groups and constructed K-band luminosity functions that we compared with those of artificial clusters, allowing us to make first order estimates of the mean ages and age spreads of the groups. We used a $^{13}$CO(1-0) map to investigate the gas kinematics at the prominent gaseous envelope of the central cluster in DR15, and we infer that the removal of this envelope is relatively slow compared to other cluster regions, in which gas dispersal timescale could be similar or shorter than the circumstellar disk dissipation timescale. The presence of other groups with slightly older ages, associated with much less prominent gaseous structures may imply that the evolution of young clusters in this part of the complex proceeds in periods that last 3 to 5 Myr, perhaps after a slow dissipation of their dense molecular cloud birthplaces.

Complex molecules in W51 North region
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We present Submillimeter Array (SMA) molecular line observations in two 2 GHz-wide bands centered at 217.5 and 227.5 GHz, toward the massive star forming region W51 North. We identified 84 molecular line transitions from 17 species and their isotopologues. The molecular gas distribution of these lines mainly peaks in the continuum position of W51 North, and has a small tail extending to the west, probably associated with W51 d2. In addition to the commonly detected nitrogen and oxygen-bearing species, we detected a large amount of transitions of the Acetone (CH$_3$COCH$_3$) and Methyl Formate (CH$_3$OCHO), which may suggest that these molecules are present in an early evolutionary stage of the massive stars. We also found that W51 North is an ethanol-rich source. There is no obvious difference in the molecular gas distributions between the oxygen-bearing and nitrogen-bearing molecules. Under the assumption of Local Thermodynamic Equilibrium (LTE), with the XCLASS tool, the molecular column densities, and rotation temperatures are estimated.
We found that the oxygen-bearing molecules have considerably higher column densities and fractional abundances than the nitrogen-bearing molecules. The rotation temperatures range from 100 to 200 K, suggesting that the molecular emission could be originated from a warm environment. Finally, based on the gas distributions, fractional abundances and the rotation temperatures, we conclude that CH$_3$OH, C$_2$H$_5$OH, CH$_3$COCH$_3$ and CH$_3$CH$_2$CN might be synthesized on the grain surface, while gas phase chemistry is responsible for the production of CH$_3$OCH$_3$, CH$_3$OCHO and CH$_2$CHCN.

Accepted by MNRAS

http://arxiv.org/pdf/1510.05641

Radially Magnetized Protoplanetary Disk: Vertical Profile

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This paper studies the response of a thin accretion disk to an external radial magnetic field. Our focus is on protoplanetary disks (PPDs), which are exposed during their later evolution to an intense, magnetized wind from the central star. A radial magnetic field is mixed into a thin surface layer, is wound up by the disk shear, and is pushed downward by a combination of turbulent mixing and ambipolar and Ohmic drift. The toroidal field reaches much greater strengths than the seed vertical field that is usually invoked in PPD models, even becoming superthermal. Linear stability analysis indicates that the disk experiences the magnetorotational instability (MRI) at a higher magnetization than a vertically magnetized disk when both the effects of ambipolar and Hall drift are taken into account. Steady vertical profiles of density and magnetic field are obtained at several radii between 0.06 and 1 AU in response to a wind magnetic field $B_r \sim (10^{-4} - 10^{-2}) (r/\text{AU})^{-2} \text{ G}$. Careful attention is given to the radial and vertical ionization structure resulting from irradiation by stellar X-rays. The disk is more strongly magnetized closer to the star, where it can support a higher rate of mass transfer. As a result, the inner $\sim$1 AU of a PPD is found to evolve toward lower surface density. Mass transfer rates around $10^{-8} M_\odot \text{ yr}^{-1}$ are obtained under conservative assumptions about the MRI-generated stress. The evolution of the disk, and the implications for planet migration, are investigated in the accompanying paper.

Accepted by ApJ

http://arxiv.org/pdf/1510.04258

Herschel HIFI observations of the Sgr A +50 km s$^{-1}$ Cloud. Deep searches for O$_2$ in emission and foreground absorption

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The Herschel Oxygen Project (HOP) is an Open Time Key Program, awarded 140 hours of observing time to search
for molecular oxygen ($O_2$) in a number of interstellar sources. To date $O_2$ has definitely been detected in only two sources, namely $\rho$ Oph A and Orion, reflecting the extremely low abundance of $O_2$ in the interstellar medium. One of the sources in the HOP program is the +50 km/s Cloud in the Sgr A Complex in the centre of the Milky Way. Its environment is unique in the Galaxy and this property is investigated to see if it is conducive to the presence of $O_2$. The *Herschel* Heterodyne Instrument for the Far Infrared (HIFI) is used to search for the 487 and 774 GHz emission lines of $O_2$. No $O_2$ emission is detected towards the Sgr A +50 km/s Cloud, but a number of strong emission lines of methanol ($CH_3OH$) and absorption lines of chloronium ($H_2Cl^+$) are observed. A $3\sigma$ upper limit for the fractional abundance ratio of $[O_2]/[H_2]$ in the Sgr A +50 km/s Cloud is found to be $X(O_2) \leq 5 \times 10^{-8}$. However, since we can find no other realistic molecular candidate than $O_2$ itself, we very tentatively suggest that two weak absorption lines at 487.261 and 487.302 GHz may be caused by the 487 GHz line of $O_2$ in two foreground spiral arm clouds. By considering that the absorption may only be apparent, the estimated upper limit to the $O_2$ abundance of $\leq (10−20) \times 10^{-6}$ in these foreground clouds is very high, as opposed to the upper limit in the Sgr A +50 km/s Cloud itself, but similar to what has been reached in recent chemical shock models for Orion. This abundance limit was determined also using *Odin* non-detection limits, and assumes that $O_2$ fills the beam. If the absorption is due to a differential *Herschel* OFF-ON emission, the $O_2$ fractional abundance may be of the order of $\approx (5−10) \times 10^{-6}$. With the assumption of pure absorption by foreground clouds, the unreasonably high abundance of $(1.4−2.8) \times 10^{-4}$ was obtained. The rotation temperatures for $CH_3OH$-$A$ and $CH_3OH$-$E$ lines in the +50 km/s Cloud are found to be $\approx 64$ and 79 K, respectively, and the fractional abundance of $CH_3OH$ is approximately $5 \times 10^{-7}$.

Accepted by Astronomy & Astrophysics

http://arxiv.org/pdf/1510.06620

The PMS star V1184 Tau (CB 34V) at the end of prolonged eclipse

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V1184 Tau (CB 34V) lies in the field of the Bok globule CB 34 and was discovered as a large amplitude variable in 1993. According to the first hypothesis of the variability of the star, it is a FU Orionis candidate erupted between 1951 and 1993. During subsequent observations, the star manifests large amplitude variability interpreted as obscuration from circumstellar clouds of dust. We included V1184 Tau (CB 34V) in our target list of highly variable pre-main-sequence stars to determine the reasons for the variations in the brightness of this object. Data from BVRI photometric observations of the young stellar object V1184 Tau, obtained in the period 2008–2015, are presented in the paper. These data are a continuation of our optical photometric monitoring of the star began in 2000 and continuing to date. The photometric observations of V1184 Tau were performed in two observatories with two medium-sized and two small telescopes. Our results indicate that during periods of maximum light the star shows characteristics typical of T Tauri stars. During the observed deep minimum in brightness, however, V1184 Tau is rather similar to UX Orionis objects. The deep drop in brightness began in 2003 ended in 2015 as the star has returned to maximum light. The light curve during the drop is obviously asymmetric as the decrease in brightness lasts two times longer than the rise. The observed colour reverse on the colour-magnitude diagrams is also confirmation of obscuration from circumstellar clouds of dust as a reason for the large amplitude variability in the brightness.

Accepted by A&A

http://arxiv.org/pdf/1510.00416

Wobbling and precessing jets from warped disks in binary systems

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We present results of the first ever three-dimensional (3D) magnetohydrodynamic (MHD) simulations of the accretion-ejection structure. We investigate the 3D evolution of jets launched symmetrically from single stars but also jets from warped disks in binary systems. We have applied various model setups and tested them by simulating a stable and bipolar symmetric 3D structure from a single star-disk-jet system. Our reference simulation maintains a good axial symmetry and also a bipolar symmetry for more than 600 rotations of the inner disk confirming the quality of our model setup. We have then implemented a 3D gravitational potential (Roche potential) due to a companion star and run a variety of simulations with different binary separations and mass ratios. These simulations show typical 3D deviations from axial symmetry, such as jet inclination outside the Roche lobe or spiral arms forming in the accretion disk. In order to find indication for precession effects, we have also run an exemplary parameter setup, essentially governed by a small binary separation of only \( \sim 200 \) inner disk radii. This simulation shows strong indication that we observe the onset of a jet precession caused by the wobbling of the jet launching disk. We estimate an opening angle of the precession cone defined by the lateral motion of the jet axis of about 4 degree after 5000 dynamical time steps.

Accepted by ApJ

http://arxiv.org/pdf/1510.07645

Spectral-Line Survey at Millimeter and Submillimeter Wavelengths toward an Outflow-Shocked Region, OMC 2-FIR 4

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We performed the first spectral-line survey at 82–106 GHz and 335–355 GHz toward the outflow-shocked region, OMC 2-FIR 4, the outflow driving source, FIR 3, and the northern outflow lobe, FIR 3N. We detected 120 lines of 20 molecular species. The line profiles are found to be classifiable into two types: one is a single Gaussian component with a narrow (\(< 3 \text{ km s}^{-1}\)) width and another is two Gaussian components with narrow and wide (\(> 3 \text{ km s}^{-1}\)) widths. The narrow components for the most of the lines are detected at all positions, suggesting that they trace the ambient dense gas. For CO, CS, HCN, and HCO\(^+\), the wide components are detected at all positions, suggesting the outflow origin. The wide components of C\(^34\)S, SO, SiO, H\(^{12}\)CN, H\(^{13}\)N, H\(^2\)CO, H\(_2\)CS, HC\(_3\)N, and CH\(_3\)OH are detected only at FIR 4, suggesting the outflow-shocked gas origin. The rotation diagram analysis revealed that the narrow components of C\(_2\)H and H\(^{13}\)CO\(^+\) show low temperatures of 12.5±1.4 K, while the wide components show high temperatures of 20–70 K. This supports our interpretation that the wide components trace the outflow and/or outflow-shocked gas. We compared observed molecular abundances relative to H\(^{13}\)CO\(^+\) with those of the outflow-shocked region, L1157 B1, and the hot corino, IRAS 16293-2422. Although we cannot exclude a possibility that the chemical enrichment in FIR 4 is caused by the hot core chemistry, the chemical compositions in FIR 4 are more similar to those in L1157 B1 than those in IRAS 16293-2422.
Resolved Millimeter-Wavelength Observations of Debris Disks around Solar-Type Stars
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The presence of debris disks around young main sequence stars hints at the existence and structure of planetary systems. Millimeter-wavelength observations probe large grains that trace the location of planetesimal belts. The FEPS (Formation and Evolution of Planetary Systems) Spitzer Legacy survey of nearby young solar analogues yielded a sample of five debris disk-hosting stars with millimeter flux suitable for interferometric follow-up. We present observations with the Submillimeter Array (SMA) and the Combined Array for Research in Millimeter-wave Astronomy (CARMA) at $\sim 2''$ resolution that spatially resolve the debris disks around these nearby ($d \sim 50$ pc) stars. Two of the five disks (HD 377, HD 8907) are spatially resolved for the first time and one (HD 104860) is resolved at millimeter wavelengths for the first time. We combine our new observations with archival SMA and Atacama Large Millimeter/Submillimeter Array (ALMA) data to enable a uniform analysis of the full five-object sample. We simultaneously model the broad-band photometric data and resolved millimeter visibilities to constrain the dust temperatures and disk morphologies, and perform an MCMC analysis to fit for basic structural parameters. We find that the radii and widths of the cold outer belts exhibit properties consistent with scaled-up versions of the Solar System’s Kuiper Belt. All the disks exhibit characteristic grain sizes comparable to the blowout size, and all the resolved observations of emission from large dust grains are consistent with an axisymmetric dust distribution to within the uncertainties. These results are consistent with comparable studies carried out at infrared wavelengths.

Accepted by ApJ

Dispersing Envelope around the Keplerian Circumbinary Disk in L1551 NE and its Implications for the Binary Growth
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We performed mapping observations of the Class I protostellar binary system L1551 NE in the C$^{18}$O ($J=3-2$), $^{13}$CO ($J=3-2$), CS ($J=7-6$), and SO ($J_N=7_N-6_N$) lines with Atacama Submillimeter Telescope Experiment (ASTE). The ASTE C$^{18}$O data are combined with our previous SMA C$^{18}$O data, which show a $r \sim 300$-AU scale Keplerian disk
around the protostellar binary system. The C\(^{18}\)O maps show a \(~20000\)-AU scale protostellar envelope surrounding the central Keplerian circumbinary disk. The envelope exhibits a northeast (blue) - southwest (red) velocity gradient along the minor axis, which can be interpreted as a dispersing gas motion with an outward velocity of 0.3 km s\(^{-1}\), while no rotational motion in the envelope is seen. In addition to the envelope, two \(<4000\) AU scale, high-velocity (\(>1.3\) km s\(^{-1}\)) redshifted \(^{13}\)CO and CS emission components are found to \(~40\) arcsec southwest and \(~20\) arcsec west of the protostellar binary. These redshifted components are most likely outflow components driven from the neighboring protostellar source L1551 IRS 5, and are colliding with the envelope in L1551 NE. The net momentum, kinetic and internal energies of the L1551 IRS 5 outflow components are comparable to those of the L1551 NE envelope, and the interactions between the outflows and the envelope are likely to cause the dissipation of the envelope and thus suppression of the further growth of the mass and mass ratio of the central protostellar binary in L1551 NE.

Accepted by ApJ

http://arxiv.org/pdf/1510.08353

Accreting pre-main sequence models and abundance anomalies in globular clusters

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We investigated the possibility of producing helium enhanced stars in globular clusters by accreting polluted matter during the pre-main sequence phase. We followed the evolution of two different classes of pre-main sequence accreting models, one which neglects and the other that takes into account the protostellar evolution.

We analysed the dependence of the final central helium abundance, of the tracks position in the HR diagram and of the surface lithium abundance evolution on the age at which the accretion of polluted material begins and on the main physical parameters that govern the protostellar evolution. The later is the beginning of the late accretion and the lower are both the central helium and the surface lithium abundances at the end of the accretion phase and in ZAMS (Zero Age Main Sequence). In order to produce a relevant increase of the central helium content the accretion of polluted matter should start at ages lower than 1 Myr. The inclusion of the protostellar evolution has a strong impact on the ZAMS models too. The adoption of a very low seed mass (i.e. 0.001 \(M_\odot\)) results in models with the lowest central helium and surface lithium abundances. The higher is the accretion rate and the lower is the final helium content in the core and the residual surface lithium. In the worst case – i.e. seed mass 0.001 \(M_\odot\) and accretion rate \(>10^{-5}\) \(M_\odot\) yr\(^{-1}\) – the central helium is not increased at all and the surface lithium is fully depleted in the first few million years.

Accepted by MNRAS

http://arxiv.org/pdf/1510.02620

Discovery of a Two-Armed Spiral Structure in the Gapped Disk in HD 100453

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We present VLT/SPHERE adaptive optics imaging in \(Y\), \(J\), \(H\), and \(K\)-bands of the HD 100453 system and the discovery of a two-armed spiral structure in a disk extending to \(0^\prime\)37 \((\sim 42\) AU\) from the star, with highly symmetric arms to the Northeast and Southwest. Inside of the spiral arms, we resolve a ring of emission from \(0^\prime\)18–\(0^\prime\)25 \((\sim 21–29\) AU\)
AU). By assuming that the ring is intrinsically circular we estimate an inclination of \(\sim 34^\circ\) from face-on. We detect dark crescents on opposite sides (NW and SE) which begin at 0''18 and continue to radii smaller than our inner working angle of 0''15, which we interpret as the signature of a gap at \(\leq 21\) AU that has likely been cleared by forming planets. We also detect the \(\sim 120\) AU companion HD 100453 B, and by comparing our data to 2003 HST/ACS and VLT/NACO images we estimate an orbital period of \(\sim 850\) yr. We discuss what implications the discovery of the spiral arms and finer structures of the disk may have on our understanding of the possible planetary system in HD 100453, and how the morphology of this disk compares to other related objects.

Accepted by ApJL

http://arxiv.org/pdf/1510.02212

A Survey for Hydroxyl in the THOR Pilot Region around W43

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We report on observations of the hydroxyl radical (OH) within The HI, OH Recombination line survey (THOR) pilot region. The region is bounded approximately between Galactic coordinates \(l=29.2\) to 31.5\(^\circ\) and \(b=-1.0\) to +1.0\(^\circ\) and includes the high-mass star forming region W43. We identify 103 maser sites, including 72 with 1612 MHz masers, 42 showing masers in either of the main line transitions at 1665 and 1667 MHz and four showing 1720 MHz masers. Most maser sites with either main-line or 1720 MHz emission are associated with star formation, whereas most of the 1612 MHz masers are associated with evolved stars. We find that nearly all of the main-line maser sites are co-spatial with an infrared source, detected by GLIMPSE. We also find diffuse OH emission, as well as OH in absorption towards selected unresolved or partially resolved sites. Extended OH absorption is found towards the well known star forming complex W43 Main.

Accepted by MNRAS

http://arxiv.org/pdf/1510.06125
The molecular composition of the planet-forming regions of protoplanetary disks across the luminosity regime

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\textbf{Context.} Near- to mid-infrared observations of molecular emission from protoplanetary disks show that the inner regions are rich in small organic volatiles (e.g., C\textsubscript{2}H\textsubscript{2} and HCN). Trends in the data suggest that disks around cooler stars (\(T_{\text{eff}} \approx 3000\) K) are potentially (i) more carbon-rich; and (ii) more molecule-rich than their hotter counterparts (\(T_{\text{eff}} > 4000\) K).

\textbf{Aims.} We explore the chemical composition of the planet-forming region (<10 AU) of protoplanetary disks around stars over a range of spectral types (from M dwarf to Herbig Ae) and compare with the observed trends.

\textbf{Methods.} Self-consistent models of the physical structure of a protoplanetary disk around stars of different spectral types are coupled with a comprehensive gas-grain chemical network to map the molecular abundances in the planet-forming zone. The effects of (i) N\textsubscript{2} self shielding; (ii) X-ray-induced chemistry; and (iii) initial abundances, are investigated. The chemical composition in the “observable” atmosphere is compared with that in the disk midplane where the bulk of the planet-building reservoir resides.

\textbf{Results.} M dwarf disk atmospheres are relatively more molecule rich than those for T Tauri or Herbig Ae disks. The weak far-UV flux helps retain this complexity which is enhanced by X-ray-induced ion-molecule chemistry. N\textsubscript{2} self shielding has only a small effect in the disk molecular layer and does not explain the higher C\textsubscript{2}H\textsubscript{2}/HCN ratios observed towards cooler stars. The models underproduce the OH/H\textsubscript{2}O column density ratios constrained in Herbig Ae disks, despite reproducing (within an order of magnitude) the absolute value for OH: the inclusion of self shielding for H\textsubscript{2}O photodissociation only increases this discrepancy. One possible explanation is the adopted disk structure. Alternatively, the “hot” H\textsubscript{2}O (\(T > 300\) K) chemistry may be more complex than assumed. The results for the atmosphere are independent of the assumed initial abundances; however, the composition of the disk midplane is sensitive to the initial main elemental reservoirs. The models show that the gas in the inner disk is generally more carbon rich than the midplane ices. This effect is most significant for disks around cooler stars. Furthermore, the atmospheric C/O ratio appears larger than it actually is when calculated using observable tracers only. This is because gas-phase O\textsubscript{2} is predicted to be a significant reservoir of atmospheric oxygen.

\textbf{Conclusions.} The models suggest that the gas in the inner regions of disks around cooler stars is more carbon rich; however, calculations of the molecular emission are necessary to definitively confirm whether the chemical trends reproduce the observed trends.

\textsuperscript{a}Accepted by A&A, 582, A88

Ongoing star formation in the proto-cluster IRAS 22134+5834

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\textsuperscript{a}Ongoing star formation in the proto-cluster IRAS 22134+5834

http://cdsads.u-strasbg.fr/abs/2015arXiv150708544W
IRAS 22134+5834 was observed in the centimeter with (E)VLA, 3 mm with CARMA, 2 mm with PdBI, and 1.3 mm with SMA, to study the continuum emission as well as the molecular lines that trace different physical conditions of the gas to study the influence of massive YSOs on nearby starless cores, and the possible implications in the clustered star formation process. The multi-wavelength centimeter continuum observations revealed two radio sources within the cluster, VLA1 and VLA2. VLA1 is considered to be an optically thin UCHII region with a size of 0.01 pc and sits at the edge of the near-infrared (NIR) cluster. The flux of ionizing photons of the VLA1 corresponds to a B1 ZAMS star. VLA2 is associated with an infrared point source and has a negative spectral index. We resolved six millimeter continuum cores at 2 mm, MM2 is associated with the UCHII region VLA1, and other dense cores are distributed around the UCHII region. Two high-mass starless clumps (HMSC), HMSC-E (east) and HMSC-W (west), are detected around the NIR cluster with N2H+(1–0) and NH3 emission, and show different physical and chemical properties. Two N2D+ cores are detected on an NH3 filament close to the UCHII region, with a projected separation of ~8000 AU at the assumed distance of 2.6 kpc. The kinematic properties of the molecular line emission confirm the expansion of the UCHII region and that the molecular cloud around the near infrared (NIR) cluster is also expanding. Our multi-wavelength study has revealed different generations of star formation in IRAS 22134+5834. The formed intermediate- to massive stars show strong impact on nearby starless clumps. We propose that while the stellar wind from the UCHII region and the NIR cluster drives the large scale bubble, the starless clumps and HMPOs formed at the edge of the cluster.

Accepted by A&A

http://arxiv.org/pdf/1510.02251

Integral Field Spectroscopy of Massive Young Stellar Objects in the N113 H II Region in the Large Magellanic Cloud

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The Spitzer SAGE survey has allowed the identification and analysis of ignificant samples of Young Stellar Object (YSO) candidates in the Large Magellanic Cloud (LMC). However the angular resolution of Spitzer is relatively poor meaning that at the distance of the LMC, it is likely that many of the Spitzer YSO candidates in fact contain multiple components. We present high resolution K-band integral field spectroscopic observations of the three most prominent massive YSO candidates in the N113 H II region using VLT/SINFONI. We have identified six K-band continuum sources within the three Spitzer sources and we have mapped the morphology and velocity fields of extended line emission around these sources. Brγ, Hei and H2 emission is found at the position of all six K-band sources; we discuss whether the emission is associated with the continuum sources or whether it is ambient emission. H2 emission appears to be mostly ambient emission and no evidence of CO emission arising in the discs of YSOs has been found. We have mapped the centroid velocities of extended Brγ emission and Hei emission and found evidence of two expanding compact H II regions. One source shows compact and strong H2 emission suggestive of a molecular outflow. The diversity of spectroscopic properties observed is interpreted in the context of a range of evolutionary stages associated with massive star formation.

Accepted by MNRAS

http://arxiv.org/pdf/1510.05585
Turbulent mixing layers in supersonic protostellar outflows, with application to DG Tauri

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Turbulent entrainment processes may play an important role in the outflows from young stellar objects at all stages of their evolution. In particular, lateral entrainment of ambient material by high-velocity, well-collimated protostellar jets may be the cause of the multiple emission-line velocity components observed in the microjet-scale outflows driven by classical T Tauri stars. Intermediate-velocity outflow components may be emitted by a turbulent, shock-excited mixing layer along the boundaries of the jet. We present a formalism for describing such a mixing layer based on Reynolds decomposition of quantities measuring fundamental properties of the gas. In this model, the molecular wind from large disc radii provides a continual supply of material for entrainment. We calculate the total stress profile in the mixing layer, which allows us to estimate the dissipation of turbulent energy, and hence the luminosity of the layer. We utilize MAPPINGS IV shock models to determine the fraction of total emission that occurs in [Fe II] 1.644 μm line emission in order to facilitate comparison to previous observations of the young stellar object DG Tauri. Our model accurately estimates the luminosity and changes in mass outflow rate of the intermediate-velocity component of the DG Tau approaching outflow. Therefore, we propose that this component represents a turbulent mixing layer surrounding the well-collimated jet in this object. Finally, we compare and contrast our model to previous work in the field.

Accepted by MNRAS
http://arxiv.org/pdf/1510.01394

Relative Proper Motions in the Rho Ophiuchi Cluster

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Near-infrared images optimized for astrometry have been obtained for 4 fields in the high density L 1688 cloud core over a 12-year period. The targeted regions include deeply embedded young stellar objects (YSOs) and very low luminosity objects too faint and/or heavily veiled for spectroscopy. Relative proper motions in R.A. and Decl. were computed for 111 sources and again for a subset of 65 YSOs, resulting in a mean proper motion of (0,0) for each field. Assuming each field has the same mean proper motion, YSOs in the four fields were combined to yield estimates of the velocity dispersions in R.A. and Decl. that are consistent with 1.0 km s⁻¹. These values appear to be independent of the evolutionary state of the YSOs. The observed velocity dispersions are consistent with the dispersion in radial velocity derived for optically-visible YSOs at the periphery of the cloud core and are consistent with virial equilibrium. The higher velocity dispersion of the YSOs in the plane of the sky relative to that of dense cores may be a consequence of stellar encounters due to dense cores and filaments fragmenting to form small groups of stars or the global collapse of the L 1688 cloud core. An analysis of the differential magnitudes of objects over the 12-year baseline has not only confirmed the near-infrared variability for 29 YSOs established by prior studies, but also identified 18 new variability candidates. Three of these have not been previously identified as YSOs and may be newly identified cluster members.

Accepted by ApJ

Infall through the evolution of high-mass star-forming clumps

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With the GREAT receiver at the Stratospheric Observatory for Infrared Astronomy (SOFIA), nine massive molecular clumps have been observed in the ammonia $3_{2+}-2_{2-}$ line at 1.8 THz in a search for signatures of infall. The sources were selected from the ATLASGAL submillimeter dust continuum survey of our Galaxy. Clumps with high masses covering a range of evolutionary stages based on their infrared properties were chosen. The ammonia line was detected in all sources, leading to five new detections and one confirmation of a previous detection of redshifted absorption in front of their strong THz continuum as a probe of infall in the clumps. These detections include two clumps embedded in infrared dark clouds. The measured velocity shifts of the absorptions compared to optically thin C$^{17}$O (3–2) emission are 0.3–2.8 km s$^{-1}$, corresponding to fractions of 3% to 30% of the free-fall velocities of the clumps. The ammonia infall signature is compared with complementary data of different transitions of HCN, HNC, CS, and HCO$^+$, which are often used to probe infall via their blue-skewed line profiles. The best agreement with the ammonia results is found for the HCO$^+$ (4–3) transitions, but the latter is still strongly blended with emission from associated outflows. This outflow signature is far less prominent in the THz ammonia lines, which confirms it as a powerful probe of infall in molecular clumps. Infall rates in the range from 0.3 to $16 \times 10^{-3} \, M_\odot \, yr^{-1}$ were derived with a tentative correlation with the virial parameters of the clumps. The new observations show that infall on clump scales is ubiquitous through a wide range of evolutionary stages, from $L/M$ covering about ten to several hundreds.

Accepted by A&A

http://arxiv.org/pdf/1510.08374

Molecule survival in magnetized protostellar disk winds. II. Predicted H$_2$O profiles vs Herschel/HIFI Observations

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We show that a dusty magneto-centrifugal disk wind launched from 0.2–0.6 AU AU to 3–25 AU is able to reproduce to a remarkable degree the observed shapes and intensities of the broad H$_2$O component observed towards low-mass protostars by Herschel/HIFI in the WISH Key Program, both in the fundamental 557 GHz line and in more excited lines. This model also readily reproduces the observed correlation of 557 GHz line luminosity with envelope density, if the infall rate at 1000 AU is 1–3 times the disk accretion rate in the wind ejection region. It is also compatible with the typical disk size and bolometric luminosity in the observed targets. However, the narrower line profiles in Class 1 sources suggest that MHD disk winds in these sources, if present, would have to be slower and/or less water rich than in Class 0 sources. MHD disk winds thus appear as a valid (though not unique) option to consider for the origin of the ubiquitous broad H$_2$O component in low-mass protostars.

Accepted by A&A

Accretion disks in luminous young stellar objects

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An observational review is provided of the properties of accretion disks around young stars. It concerns the primordial disks of intermediate- and high-mass young stellar objects in embedded and optically revealed phases. The properties were derived from spatially resolved observations and therefore predominantly obtained with interferometric means, either in the radio/(sub)millimeter or in the optical/infrared wavelength regions. We make summaries and comparisons of the physical properties, kinematics, and dynamics of these circumstellar structures and delineate trends where possible. Amongst others, we report on a quadratic trend of mass accretion rates with mass from T Tauri stars to the highest mass young stellar objects and on the systematic difference in mass infall and accretion rates.

Accepted by Astronomy and Astrophysics Review

http://arxiv.org/pdf/1509.08335
Protoplanetary disks around young stars are the birth cradles of planets. Disks with inner dust cavities, the so-called transition disks, are good candidates to search for young planets that have recently been formed and cleared out their orbit. Transition disks were originally identified through a deficit in the mid infrared part of the SED, due to the lack of hot dust close to the star. Millimeter imaging by pioneering interferometers such as SMA and CARMA has confirmed the presence of the dust cavities in the brightest disks. ALMA (Atacama Large Millimeter/submillimeter Array) provides a much higher sensitivity and spatial resolution, to image both the dust continuum and the gas (molecular lines) in these disks. The imaging of the gas is crucial to distinguish between the different possible clearing mechanisms that could cause the appearance of a cavity: photo-evaporation, grain growth, dynamical clearing by a companion (e.g. a planet) and instabilities at the edges of dead zones, which all have different effects on the gas inside the cavity.

I present ALMA Early Science observations of several transition disks in spatially resolved (∼0.2") submillimeter continuum and CO and CO isotopologue line images. Oph IRS 48, one of the main targets of study, reveals a small gas cavity in CO emission, indicating that a recently formed planet has cleared its orbit in the inner part of the disk. In contrast, the continuum emission reveals that the millimeter dust is concentrated on one side of the disk much further out. This azimuthal asymmetry is interpreted as a dust trap in a vortex, formed by a Rossby instability of a gas pressure bump at the edge of the gas cavity. Dust trapping had been predicted in theoretical models of dust evolution for several decades as a solution for the radial drift problem, preventing dust particles to grow, but had not been confirmed observationally before. VLA centimeter emission confirms that larger dust grains are even more concentrated inside the dust trap.

Also several other transition disks reveal CO emission inside the dust cavities in spatially resolved ALMA observations. Using the physical-chemical modeling tool DALI, I analyzed and quantified the gas density in each of these disks, and
found also here evidence of the planet clearing scenario: the drop inside the cavity in the dust density is several orders of magnitude deeper than the drop in gas density and optically thin CO isotopologues reveal that the gas cavities are smaller than the dust cavities.

Finally, I present the SED analysis of a large sample of transition disk candidates based on data from the *Spitzer* catalogs.

The full PhD thesis can be downloaded here:
[https://www.strw.leidenuniv.nl/events/phdtheses/nmarel/](https://www.strw.leidenuniv.nl/events/phdtheses/nmarel/)

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**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.
New Jobs

Postdoctoral position in the ERC group From Cloud to Star Formation in the Planet and Star Formation Department at the Max Planck Institute for Astronomy (MPIA) in Heidelberg (Reference number 15-16)

The Max Planck Institute for Astronomy (MPIA) in Heidelberg is seeking an enthusiastic, highly qualified postdoctoral researcher to work in a newly established ERC group led by Henrik Beuther that targets the formation processes of molecular clouds and high-mass stars. Two large projects are conducted in that group: (1) a large program at the Janesky Very Large Array designed to study cloud formation and feedback processes: THOR: The HI/OH/Recombination line survey of the Milky Way, and (2) a large program at the IRAM Plateau de Bure Interferometer addressing the fragmentation and kinematic processes during the birth of the most massive stars: Fragmentation and disk formation during high-mass star formation. The successful candidate is expected to spend ~50% of the research time on projects that are related to one and/or both large programs, depending on expertise and interest. The other 50% of their time the applicant can spend on research projects of their like. This position is part of the ERC group connecting the cloud and star formation processes. Furthermore, it is embedded in the research of the whole Planet and Star Formation department at MPIA where active collaborations are strongly supported.

The Planet and Star Formation Department at MPIA is pursuing a wide range of astrophysical research along the lines of star and planet formation, encompassing large observing programs, instrument development, and theoretical modelling (see http://www.mpia.de for details). In addition to the ERC group research outlined above, the successful candidate will also have access to the Large Binocular Telescope (LBT), the 2.2m and 3.5m telescopes on Calar Alto, to the Very Large Telescope, the Very Large Telescope Interferometer facility, and the APEX sub-millimeter telescope in Chile. MPIA astronomers also extensively use the 2.2m MPG telescope on La Silla and the IRAM and ALMA facilities. MPIA is also a Co-I of the Matisse and Gravity instruments for the VLTI as well as of METIS for the ELT and MIRI for JWST.

Applicants should have a PhD in astronomy, astrophysics, or a closely related field, and ideally some background in the research of the interstellar medium and star formation. Furthermore, experience in mm/radio interferometry is considered an asset. The appointment will be for an initial period of two years, with a potential extension of up to four years, and MPIA provides funds for publications, travel, etc.. The position is available from Oct. 2016 and will be remunerated according to the German TVD scheme in level E13/E14. Interested candidates who submit a curriculum vitae, publication list, and a brief statement of research interests by December 15th, 2015, will receive full consideration. The position will remain open until filled. Applicants should also arrange for three letters of reference to be provided separately by the same date. All applications and reference letters need to be submitted using MPIAs online application system at: https://s-lotus.gwdg.de/mpg/mhas/psf_pd_15_16_in.nsf/portal

Candidates should first register with our online system to generate a registration code, which must be sent to referees for letter submission. Please concatenate CV, publication list, and research statement into a single PDF file.

For scientific enquires please contact: Henrik Beuther  beuther@mpia.de
For submission enquires please contact: Carola Jordan  jordan@mpia.de

The Max Planck Society is an equal opportunity employer. Applications from women, disabled people and minority groups are particularly welcome. The MPIA supports its employees in their search for suitable child care.
VIDA Postdoctoral Fellowship

The Vanderbilt Initiative in Data-Intensive Astrophysics (VIDA) announces the 2016 VIDA Postdoctoral Research Fellowship. Successful VIDA fellows will be expected to conduct original research in observational, theoretical, or computational astrophysics and will have the freedom to work on any of the broad VIDA research efforts. Candidates with an interest in simulations of data and/or theory, experience with multiwavelength observations, developing novel approaches to data visualization and multi-sensory perception, and/or using large surveys to study star-formation or exoplanet astronomy, are especially encouraged to apply. VIDA fellows will be appointed to renewable one-year terms, for up to three years. The VIDA fellowship comes with a competitive salary, benefits, and research budget.

VIDA operates within the department of Physics and Astronomy at Vanderbilt University. VIDA research is focused on the emerging area of astro-informatics, which deals with the challenges in analyzing massive datasets, often employs simulation-based methods, and lives at the interface between astronomy, computer science, statistics, and information science. Vanderbilt is an institutional member of the Sloan Digital Sky Survey IV (SDSS IV) and Transiting Exoplanet Survey Satellite (TESS) collaborations, and also houses state-of-the-art computational facilities, such as the Advanced Computing Center for Research and Education (ACCRE). VIDA faculty regularly use national supercomputing facilities, such as Titan, Stampede, and Pleiades. VIDA also engages in significant efforts to increase diversity in science through the Fisk-Vanderbilt Bridge Program and VIDA fellows will have the opportunity to participate. For more information about VIDA, visit http://as.vanderbilt.edu/astronomy/vida.

Candidates must have a Ph.D. in astronomy, physics, or equivalent, by the date of appointment. Applications should send a curriculum vitae, a list of publications, and a short description of research interests and skills, and arrange for three letters of recommendation to be sent to: Professor Kelly Holley-Bockelmann, Department of Physics and Astronomy, P.O. Box 351807-B, Vanderbilt University, Nashville, TN 37235-1807, or electronically to k.holley@vanderbilt.edu.

Review of applications will begin in December and continue until the position is filled. Vanderbilt University is an equal employment opportunity/affirmative action employer. Women and minority candidates are encouraged to apply.

Postdoctoral Fellowship in Star Formation

Applications are invited for a postdoctoral fellowship in observational studies of low-mass star formation. The fellow will work with Dr. Phil Myers, Dr. Michael M. Dunham, and collaborators on studies of protostellar accretion and outflows, multiplicity in dense molecular cloud cores, and accretion stopping. He or she will analyze SMA data obtained through MASSES, a large-scale program surveying all protostars in the Perseus Molecular Cloud, and will lead follow-up proposals to ALMA and other telescopes. He or she will have access to all CfA facilities, funds for research and travel, and opportunities to pursue independent research projects.

The position is available starting as early as spring 2016, with the exact start date negotiable. The initial appointment will extend for two years, with possible renewal for a third year. The annual stipend for 2016 is $60,000, plus relocation reimbursement up to $4,000. Smithsonian group health insurance coverage is fully paid for individuals and families; group dental health insurance is offered with a monthly co-pay.

The applicant must have a Ph.D. in astronomy, physics, or a related field by the start date. Experience in star formation studies, in observations at millimeter and submillimeter wavelengths, and in interferometry are desirable. To apply, combine into one pdf a cover letter, CV, publication list, and a description of current research and plans (up to three pages in length) and submit via e-mail to cores_fellow@cfa.harvard.edu. The applicant should arrange for three letters of reference to be submitted to the same address. Complete applications, including letters of reference, received before January 15, 2016 will receive full consideration, but review of applications will continue until the position is filled.

The Harvard-Smithsonian Center for Astrophysics is an Equal Opportunity/Affirmative Action Employer where all qualified applicants receive equal consideration for employment without regard to race, creed, color, gender, or national origin.
POST-DOCTORAL RESEARCH POSITIONS IN EXOPLANET SCIENCE AT THE UNIVERSITY OF MICHIGAN

The Department of Astronomy at the University of Michigan welcomes applications for one (or more) post-doctoral research positions in exoplanet science. Applications are especially welcome in the areas of exoplanet population statistics, high contrast imaging and infrared instrumentation, spectral characterization, and planet formation (theory and observation). Successful applicants will have access to departmental facilities such as the Magellan Telescopes, the MDM Observatories, high performance computing clusters, and other facilities (please see http://www.lsa.umich.edu/astro/). Members of the research team will have a chance to collaborate on on-going projects (such as preparing for planned observations with the James Webb Space Telescope), initiate new ones, conduct their own independent research, and work with students (if appropriate). Interdisciplinary collaborations with faculty in the Departments of Astronomy, Physics, Earth Sciences, as well as Climate and Space Sciences, are encouraged (and supported) through the MIRA initiative. The University of Michigan is recognized as a top academic employer and Ann Arbor, Michigan is routinely recognized for its high quality of life. Please send a cover letter, CV, description of research accomplishments and plans (suggested length 8 pages total), list of publications, and arrange for three letters of recommendation to be sent directly to Professor Michael R. Meyer at mrmeyer@umich.edu by 4 January 2016 for full consideration. The University is a equal opportunity/affirmative action employer and women and minorities are encouraged to apply.
Water in the Universe - from clouds to oceans

*ESA/ESTEC, Noordwijk, The Netherlands, 12-15 April 2016*

**Important date: Abstract submission deadline 11 December 2015**

The conference will cover all astrophysical aspects of water, including the water trail, from the formation of water in molecular clouds to water on planetary bodies, including in our own solar system; water as a probe of physics and and chemistry; and water in nearby to water in extra-galactic and high redshift sources.

Topics are meant to be wide in scope, and include the following broad science areas:

- Formation and destruction of water and its chemistry: theory, laboratory work, and models
- Water excitation and its relation to other ISM tracers
- Water in star formation
- Water in disks and planet formation
- Water in the solar system and exo-solar systems
- Extra-galactic and high-redshift water

The objective of the meeting is to bring together astronomers interested in all astrophysical aspects of water, and aims to facilitate cross-fertilization between researchers with different observational, experimental, and theoretical backgrounds.

Science Organising Committee:
Yuri Aikawa, Ted Bergin, Cecilia Ceccarelli, Ewine van Dishoeck, Yu Gao, Paul Hartogh, Darek Lis, Göran Pilbratt, and Axel Weiss.

Confirmed invited speakers:

The First Announcement has been issued on 12 June 2015. The Second Announcement and Call for Papers has been issued on 29 September 2015. All information about the meeting is available on the conference website below.

Website: [http://www.congrexprojects.com/2016-events/16A06/](http://www.congrexprojects.com/2016-events/16A06/)
Contact: esa.conference.bureau@esa.int

Welcome!
Summary of Upcoming Meetings

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

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

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

Workshop on Young Solar Systems
18 - 22 April 2016, Barcelona, Spain

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

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

Diffuse Matter in the Galaxy, Magnetic Fields, and Star Formation - A Conference Honoring the Contributions of Richard Crutcher & Carl Heiles
23 - 26 May 2015, Madison, USA
no URL yet

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

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

EPoS 2016 The Early Phase of Star Formation - Progress after 10 years of EPoS
26 June - 1 July 2016, Ringberg Castle, Germany

The role of feedback in the formation and evolution of star clusters
18 - 22 July 2016 Sexten, Italy

Star Formation in Different Environments
25 - 29 July 2016 Quy Nhon, Viet Nam
website to be announced

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

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

Dynamics of Young Star Clusters and Associations
Cathie J. Clarke, Robert D. Mathieu, I. Neill Reid

Saas-Fee Advanced Courses have been organized every year since 1971 by the Swiss Society for Astrophysics and Astronomy. The 42nd course was held in March 2012 in Villars-sur-Ollon in the Swiss Alps. The subject was the formation and dynamical evolution of clusters and associations. Lectures were given by Cathie Clarke, Robert Mathieu, and I. Neill Reid to more than 60 participants, mostly graduate students and postdocs. The lectures were transcribed and the lecturers used this material to prepare the written version presented here. The book offers an excellent and wide-ranging overview of multiple and clustered star formation from both theoretical and observational points of view.

The following lists the chapters of the book:

Part I (Cathie J. Clarke):
1. The Raw Material of Cluster Formation: Observational Constraints
2. The Numerical Tools for Star Cluster Formation Simulations
3. The Comparison of Observational and Simulation Data
4. The Role of Feedback and Magnetic Fields
5. The Formation of Multiple Systems in Clusters
6. The Role of N-body Dynamics in Early Cluster Evolution
7. Concluding Issues

Part II (Robert D. Mathieu):
8. Introduction to Open Clusters
9. Overview of Multiple Star Systems
10. Overview of Collisional Stellar Dynamics
11. λ Ori: A Case Study in Star Formation
12. Overview of Star-Forming Regions
13. Kinematics of Star-Forming Regions
14. Pre-main-sequence Binaries

Part III (I. Neill Reid):
15. Galactic Demographics: Setting the Scene
16. The Solar Neighbourhood
17. Stellar Kinematics and the Dynamical Evolution of the Disc
18. Clusters and the Galactic Halo
19. Star Formation over Time
20. Where Do Stars Form?
21. Where Was the Sun Born?

348 pages, hardcover US$99.00 – eBook US$69.99