THE STAR FORMATION NEWSLETTER

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The Star Formation Newsletter

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

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Cover Picture

The reflection nebula vdB 4 surrounds the Herbig Ae/Be star V594 Cas (= MWC 419 = BD +61°154) located in Cassiopeia at a distance of about 650 pc. The star is of type B8 with a luminosity of about 330 $L_\odot$, and possibly belongs to the young loose cluster NGC 225 seen towards the lower right. The field shown is about 11.5 × 13 arcmin, with north up and east left.

Image courtesy Adam Block
http://www.caelumobservatory.com
http://www.adamblockphotos.com

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

Vladimir Grinin

in conversation with Bo Reipurth

Q: *What were your earliest interests in astronomy, and who were important influences at that time?*

A: Already at school I was curious about how the world works, and my interest in astronomy emerged at that time. Later when I studied astronomy at the Leningrad (now St. Petersburg) University, discoveries were made of the cosmic microwave background radiation, quasars, and powerful cosmic masers, and we had lively discussions on these findings at seminars. It was a fantastic time! My astrophysical education was concentrated towards theoretical astrophysics (interaction of radiation with matter, radiative transfer theory etc) under the strong influence of professor Victor V. Sobolev.

Q: *You worked for some time on flare stars. What were your main findings?*

A: I started to work at the Crimean Astrophysical Observatory in the group by Dr. R.E. Gershberg. He suggested me to investigate the non-stationary response of the atmosphere of a flare star (cool dwarf) due to the temperature perturbation of the outer layers. When solving this problem I took for the first time into account the opacity perturbations in the stellar atmosphere. The result was very surprising: after the impulsive heating of the upper layers, the brightness of the perturbed atmosphere decreased for some time comparable to the characteristic time of the temperature relaxation in the upper layers of the atmosphere. The reason for such an unusual reaction was the negative ion of hydrogen H^-. It is the main source of opacity at low temperatures, and when the temperature increases, the opacity increases very rapidly. This impedes for some time the escape of radiation from the deeper layers of atmosphere. This result became part of my PhD thesis (1972, adviser V.V. Sobolev). It was used to explain the negative pre-flares in flare stars and related phenomena in solar flares.

Another contribution to the physics of flare stars was made in 1977 in collaboration with V.V. Sobolev. At that time it was assumed that the source of the optical emission of flares was the bremsstrahlung radiation of the very hot ($T \sim 10^6 K$) gas. We showed that this interpretation is wrong and that the optical emission of flares is a sum of the radiation of hydrogen and its negative ion. It arises in the transition region between chromosphere and photosphere, which is heated from the top (up to $\sim 10^4 K$) by the high-energy proton and electron beams. So, we showed that the flares on UV Ceti stars are very similar to the "white" solar flares. This point of view is now widely accepted.

Q: *Radiative transfer in spectral lines in moving media has been the focus of much of your work. What did you learn?*

A: At around the same time I became interested in radiative transfer in spectral lines in moving media. An effective method of solution of such problems for media with large velocity gradients was developed by V.V. Sobolev in 1947. It became especially popular after publication of the papers by John Castor and his co-authors, in which they used the Sobolev approximation for modelling stellar winds from hot stars. In 1975 I found that this approximation has a non-trivial continuation in the case of envelopes in which the radial velocity decreases with distance. In this case, the additional (integral) term appears in the equation for the source function, which makes the radiative coupling in the envelope in the line frequencies essentially non-local. I asked my colleague Stanislav Grachev to check this equation and make some calculations. Three years after publication of our resulting paper a similar equation was obtained by Rybicki and Hummer. At the end of the eighties Donald Hummer visited the Leningrad University and gave a talk about their work at the Sobolev seminar series. I remember with great pleasure our short meeting with him on that occasion.

When continuing this work I showed that in envelopes with axial-symmetric motions, the radiative force caused by radiation in the spectral lines can have an azimuthal component. Under certain conditions it can be comparable to the radial component and can accelerate or decelerate rotation of the gas. I investigated this mechanism under different situations in three papers. The result was unexpected: radiation in the line frequencies is either due to electron impacts or due to recombination. In any case atoms radiate isotropically in a co-moving frame. What is, in such a case, the source of the azimuthal force? The answer is: the medium itself. It organizes the non-radial force due to the influence of the gradient velocity on the optical thickness of the gas. As a result the photon stream lines deviate from the radial direction. Many years later (in 1995) Stan Owocki and his collaborators independently discovered a similar effect in a numerical solution of the radiative hydrodynamics equations in the envelopes of Be stars.

Q: *How did you get interested in young stars?*

A: For a long time, a key problem in understanding T Tauri stars was related to a search for the energy source of the intense emission and outflow activity. Two possibilities were discussed: the energy of the convective zone (stellar magnetic fields, chromosphere, etc), or kinetic energy of the accreting gas. Using the observations by Zaitseva and Lyutyi, I showed in 1980 that the flare-like activity observed in the T Tauri star DF Tau is caused by hot, compact and unstable spots on the stellar surface. I connected the origin of such spots to the accretion activity in the spirit of the model by Lynden-Bell and Pringle. Further investigations by Jerome Bouvier, Claude Bertout and others have shown that such hot spots exist in all TTSs with intense gas accretion and are formed in the interaction of an accretion disc with the stellar magnetic fields.

Q: *You have for a long time been interested in UX Orionis stars. What is special about these stars?*

A: I started to work on UX Ori stars in the middle of the eighties. Most of these stars are associated with star forming regions and have the spectral type Ae. Nevertheless, at that time they were not included in the lists of Herbig AeBe stars because they were not associated with nebulosity (Herbig used this criterium as a signature of youth of stars). Therefore, the evolutionary status of UXORs was unclear. The most popular model of their photometric activity assumed that it was caused by surface magnetic activity. The alternative model (suggested by Wenzel in 1968) assumed that these stars were surrounded by spherical dust envelopes, the fragments of which from time to time screened the star from the observer. This model was subjected to criticism because it could not explain two important observational properties of UXORs: the limitation on the amplitudes of the photometric minima (they do not usually exceed 2-3^m), and the so called, "blueing effect" (observed for the first time by Götz and Wenzel in 1969).

In 1986 I modified Wenzel's model: I introduced a circumstellar (CS) disk instead of the spherical envelope and added the scattered light from CS dust. Scattered light in young stars usually adds only a very small contribution to the stellar flux. But it is formed in the extended region of the CS disk which cannot be screened by the dust clouds. Therefore its contribution to the observed radiation should increase during eclipses. This model has explained the abovementioned properties of UXORs and predicted an increase of the linear polarization during brightness minima.

Q: *Polarimetry has played an important role in the work that you and your collaborators have done on the Herbig Ae/Be stars. What are your main conclusions?*

A: In 1986 I organized with the help of my colleagues Nikolai Kiselev, Galina Chernova and Nasridin Minikulov a campaign of photopolarimetric monitoring of UXORs. The observations were obtained at two locations: at Sunglok Observatory (Tajikistan) and at the Crimean Astrophysical Observatory. I also invited Nikolai Voshchinnikov and Vladimir Il'in (from Leningrad University) to be involved in modelling the observations. After five years of intensive work we found that all the UX Ori stars that we investigated became highly polarized objects during their deep minima, and the polarimetric response on the brightness changes agreed well with the model predictions. So we have proven that the main reason for the photometric activity of UXORs is variable CS extinction. Additionally we argued that the UX Ori stars differ from the "normal" (photometrically quiet) Herbig AeBe stars only in the orientation of their CS disks relative to the line of sight (nearly edge-on). This conclusion was supported in 1997 by mm-observations organized by Antonella Natta. They showed that the mass of CS disks around UXORs and "normal" Herbig Ae stars are practically the same.

At about the same time Alla Rostopchna and I found an important difference between these groups of young stars, namely a statistical dependence of the shape of the $H\alpha$ line profiles on the inclination of the CS disk: the photometrically quiet Herbig stars demonstrate predominantly P Cygni or single line profiles, while the UX Ori stars usually have double-peaked lines. Such a dependence agrees qualitatively well with the expected one based on the models of disk accretion.

Q: *You are the head of the star formation group at the Pulkovo Observatory. What is the focus of the work in this group?*

A: My group consists now of seven astronomers, two graduate students and one aspirant. We continue our studies of the CS disks around UXOrs and related objects with a focus on long-term photometric observations in the optical and near-infrared spectral ranges. In several targets we have found indications of cyclic activity. These findings motivated us to start modelling of hydrodynamic perturbations in CS disks caused by stellar companions and planets. The other direction of our work is connected with studies of the interaction of CS disks with the central stars and their magnetospheres. We cooperate successfully with our colleagues from CrAO, St. Petersburg University, and Sternberg Astronomical Institute. Our collaboration with Gerd Weigelt (MPIFR-Bonn) and his team and with the group of Tom Ray from DIAS (Ireland) opened for us new possibilities for studies of CS disks and emitting regions of young stars at high angular resolution.

My Favorite Object

IC1396A: Star formation in a surprise box

Aurora Sicilia-Aguilar

A well-known BRC... with hidden surprises

IC1396A is a textbook example of a cometary-shaped, bright-rimmed cloud (BRC) at the edge of an H II region (Sharpless 1959; Osterbrock et al. 1989). The structure consists of a dark cloud about ∼5.4 arcmin in size (∼1.4 pc at 870 pc distance; Contreras et al. 2002), pointing away from the O6.5 star HD 202627 in the center of the Tr37 cluster (Kun & Pásztor 1990). Behind this cloud, extended dark globules and ionized rims can be seen over more than half a degree in the sky (Fig. 1). These structures form only a small part of the large bubble-shaped nebula around the Tr37 cluster, which has been beautifully imaged by several missions, such as Spitzer and AKARI.

The search for young stars in IC1396A started with Loren et al. (1975), who proposed a source of internal heating in the globule. At that time, the emission line star V 390 Cep (Lk Hα 349), located inside the *eye* of the globule (Fig. 2), was considered one of the potential contributors to local heating in the cloud, together with at least one deeply embedded IR source. The molecular-line observations of Loren et al. (1975) also showed that the cloud contained enough material to host further star formation. Although the IC1396A treasure box started opening more than 40 years ago, it continues to surprise us up to this date.

Opening the treasure chest: From few to hundreds of young stars

The first embedded IR sources were discovered with IRAS (Sugitani et al. 1991). IRAS found numerous IR sources associated to several of the well-known BRC. This was a confirmation of the association between dark clouds and the young clusters that illuminate them, and also suggested an ongoing process of star formation lasting for a few Myr. Nevertheless, due to the large beam of IRAS and to the strong emission from dust in the region, only one point source could be clearly identified in IC1396A.

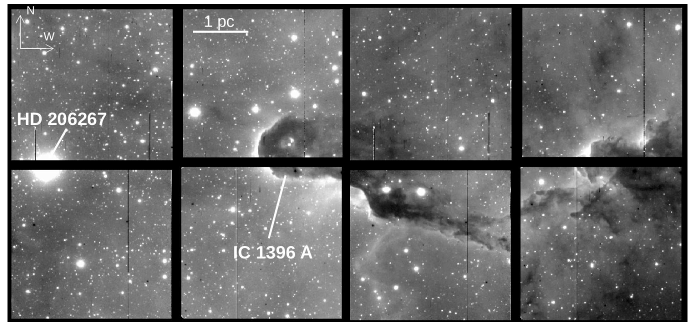

Figure 1: Hα image of the IC1396 region. The O6.5 star HD 206267 appears as a large, saturated dot. IC1396A shows a bright rim facing HD 206267. The tail of the dark cloud merges with other brightly illuminated structures to the west. The black lines correspond to the gaps between the CCDs. Adapted from Sicilia-Aguilar et al. (2004).

Optical photometry and spectroscopy around HD 206267 revealed a rich cluster with hundreds of low-mass stars, with a mean isochronal age of 4 Myr (Sicilia-Aguilar et al. 2004, 2005). Although optical wavelengths were not able to penetrate the depths of IC1396A, the presence of younger stars (aged ∼1 Myr) distributed along an arc-shaped structure around IC1396A (Sicilia-Aguilar et al. 2005) suggested that a rich young stellar population awaited us, hidden inside the globule.

The Spitzer Space Telescope revealed the IR treasure embedded in the cloud head. Looking through Spitzer in the IR, the dark areas in the optical images became transparent - and full of newborn stars! Reach et al. (2004) and Sicilia-Aguilar et al. (2006) identified more than 40 embedded young stars, most of them low-mass Class I protostars and T Tauri stars. Spitzer also confirmed the presence of disks (indirectly inferred from accretion signatures; Sicilia-Aguilar et al. 2005) in many of the young T Tauri stars around the globule, and of variable accretion/variable obscuration in some of them (Morales-Calderón et al. 2009). The interaction and connection between the optical stars and the nebula was also clear. Spitzer revealed a delicate structure of filaments and red objects interlaced within the globule, including heated structures behind the ionization rim (and around the *eye* surrounding V 390 Cep), sometimes also containing protostars and knots suggestive of heating by jets and outflows from the

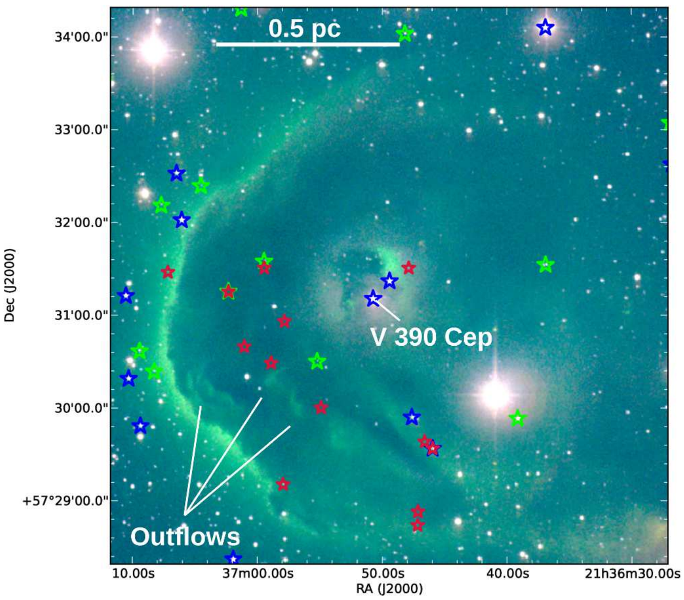

Figure 2: RGB image of IC1396A (narrow-band 6750Å in red, [S II] combined at 6716 and 6731Å in green, Johnsons R filter in blue). Identified young objects are marked with stars. The ionized rim, illuminated by HD 206267, appears very bright in [S II], together with the rim of the opening around the Herbig A star V 390 Cep. Several outflows are also detected in [S II] bordering the darkest part of the cloud and also protruding through the *eye*-shaped hole in the nebula. Adapted from Sicilia-Aguilar et al. (2013).

embedded population. Hα imaging revealed the population in the extended region (Barentsen et al. 2011). X-ray mapping doubled the known members, including objects with very low masses ($\sim$0.1 $M_\odot$; Getman et al. 2012). Imaging in [S II] showed jets and outflows emerging from the darkest places of the globule and often associated to some of the optical and IR sources, and completed the census and properties of the very low-mass stars (Fig. 2; Sicilia-Aguilar et al. 2013). The IC1396A globule appeared as a very rich and active region.

Triggered or sequential star formation?

Finding new IR sources within IC1396A, younger than the main Tr37 cluster that contains HD 206267, was also a strong sign of triggered or sequential star formation. Gas dynamics showed expansion of the H II region around HD 206267, which could lead to interaction with the surrounding dense ISM. The expansion of the ionizing front could also lead to triggered or sequential star formation in the dense globules around the massive star (Patel et al. 1995). In fact, the entire Cep OB2 region ($\sim$120 pc in diameter) shows several consecutive episodes of star formation starting some 10-12 Myr ago (with the cluster NGC7160, in the center of the region) and still active in the denser regions, such as IC1396A (Patel et al. 1998), which still contains about 200$M_\odot$ of gas (Patel et al. 1995). The ages derived from gas dynamics are also in agreement with the isochronal ages of young stars in Tr37 and IC1396A and with the evolutionary status of the stars and disks as seen with Spitzer (Sicilia-Aguilar et al. 2005, 2006).

But even if the age and evolutionary stage of the objects in IC1396A and the shape of the globule all pointed to triggered star formation, there was still no direct evidence of whether the young stars in the globule had been triggered by the action of a previously-formed population and the expansion of the H II region in a radiation-driven implosion scenario (RDI; Sandford et al. 1982; Bertoldi 1898), or if star formation was merely sequential in time across the molecular cloud. With the Spitzer, optical, Hα, X-ray, and millimeter studies, the census of members in and around the globule seemed to be fairly complete, but there was no conclusive proof of triggering yet. Catching a protostar in the act of being triggered by an external mechanism is not easy, as the early phases of star formation are expected to happen quickly and in embedded regions. The objects found with Spitzer in IC1396A are also relatively evolved, well after the initial core collapse phases. In addition, dynamical evidence of triggering is usually elusive, and velocity observations in clouds similar to IC1396A are often inconclusive regarding triggering on large scales (Mookerjea et al. 2012).

And then the Herschel data came.

Herschel: Catching a triggered protostar

We mapped IC1396A with Herschel/PACS at 70 and 160μm as part of a GO program to study young stars and protostars with circumstellar material in the Tr37 region (PI Sicilia-Aguilar). In addition to nearly hundred protoplanetary disks detected, Herschel revealed amazing details that had been hidden even to Spitzer: the first mass loss episodes of HD 206267, a (probably unrelated) pacifier-shaped planetary nebula amidst the stellar nursery to the north of Tr37, underlying nebular structures connecting some of the youngest Tr37 members and... yet another very embedded star at the very tip of IC1396A (Fig. 3; Sicilia-Aguilar et al. 2014). And this time, it was not just another protostar to add to the already very long list, but the first Class 0 object detected in the region and clearly connected to the dusty, dense filament that is being swept behind the ionization rim of IC1396A (Fig. 4).

The new Class 0 object, named IC1396A-PACS-1, is not even detected with MIPS at 24μm, where the region behind the ionization rim appears smooth and dark (and not

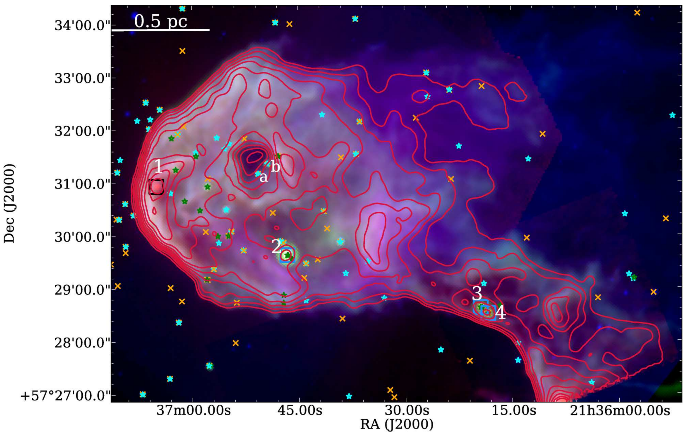

Figure 3: Spitzer/Herschel combined image (8μm as blue, 24μm as green, 70μm as red, plus 160μm contours in crimson; Sicilia-Aguilar et al. 2014). While the Class I/II population dominates the shorter wavelengths, the Herschel data revealed a Class 0 object behind the ionization rim (labeled 1), which was not detectable with optical nor Spitzer data, nor indirectly inferred from the shocks observed in [S II].

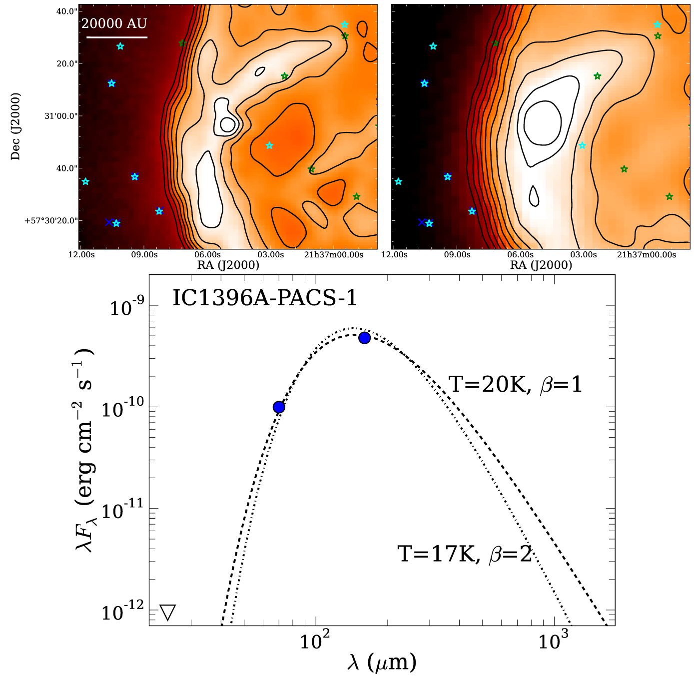

Figure 4: **Top:** IC1396A-PACS-1 seen with Herschel at 70μm (left) and 160μm (right). Other young objects are marked as small star symbols. **Bottom:** SED of IC1396A-PACS-1 with Herschel data and MIPS upper limit. Sicilia-Aguilar et al. (2014).

seen in the MIPS 70μm image due to its poor quality). This allows us to place a very stringent constraint on the 24μm flux of the source, with a 3σ upper limit of 7.5mJy (Sicilia-Aguilar et al. 2014). Nevertheless, the flux raises steeply, reaching 2.3 Jy at 70μm. Its spectral energy distribution (SED) is consistent with bolometric temperatures ∼17-20 K, depending on the adopted dust model, and masses consistent with intermediate-mass stars. Among the shocks and outflows detected at optical and Spitzer wavelengths, none of them seems associated with the Class 0 source. Existing millimeter studies lacked the resolution needed for the detection of a point-like source, simply showing a smooth, large density enhancement behind the ionization rim. Before Herschel, the only evidence of the missing protostar was a border-line X-ray detection (a 2σ detection with only 3 X-ray counts) at the same location (Getman et al. 2012), which was ignored due to its low significance. If the X-ray detection could be confirmed, it would be one of the first evidences of X-ray emission in protostars (or associated shocks) at a very early evolutionary stage.

IC1396A-PACS-1 is marginally resolved with Herschel at 70μm, and is clearly resolved at 160μm, suggesting a cool envelope about ∼13000 AU×17000 AU in size. Two large filaments (forming an arc-shaped structure with the Class 0 source in the center) and a shorter "tail" (to the north of the point-like source), running parallel to the ionization rim, are also clearly resolved with Herschel. Herschel does not only confirm the overdensity behind the rim as it had been inferred from molecular-line observations (Patel et al. 1995), but also reveals with unprecedented spatial resolution where the collapse of this new Class 0 source started: in the densest and coolest place of IC1396A (Fig. 5). The more evolved Class I protostars and young stars are located in significantly less dense, warmer areas of the cloud, which could either indicate short-range feedback by intermediate-mass members (such as in the *eye* of IC1396A) or an early cloud removal/heating by HD 206267, which could have penetrated faster through these less dense structures.

The arc-shaped structure around IC1396A-PACS-1 and the temperature structure in the region where it is forming provide the first strong hint of RDI triggering in the globule. The shape of the rim and the formation of a protostar in its center is in full agreement with the expectations of RDI models in oblate clouds (Kinnear et al. 2014, 2015), considering that the density distribution at the rim of IC1396A has its longer axis nearly perpendicular to the incoming radiation front. While the mechanism that originated the Class I/II sources in the globule is not clear (could be triggering, could be simply sequential recent star formation that is now becoming evident as the ionizing effect of HD 206267 clears up the surrounding

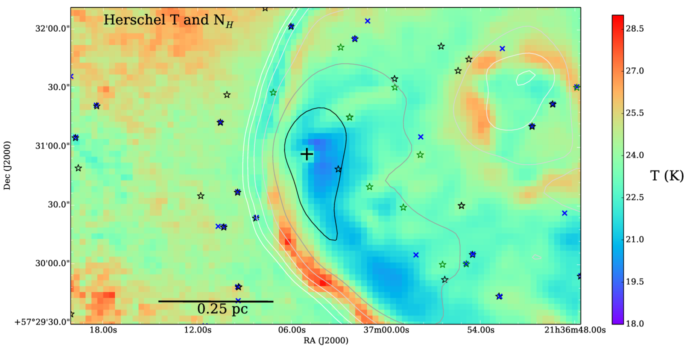

Figure 5: Herschel temperature and column density map around IC1396A-PACS-1 (marked with a cross). The warm rim of IC1396A and the *eye* around V 390 Cep are also visible. Other known members are marked with small star symbols. Adapted from Sicilia-Aguilar et al. (2014).

cloud), the Herschel data revealed that more than one star-forming episode can happen in a relatively small globule, that stars responding to different formation mechanisms can be found at distances well below fractions of pc, and that at least the one episode that originated the Class 0 source is consistent with triggering by RDI.

The formation history of Tr37/IC1396: Mini-clusters and multi-episodic star formation

If the relatively small IC1396A globule contains stars formed in at least two distinct star formation episodes, the next question would be whether this is a unique case or whether there is evidence of multi-episodic star formation in Tr37. This question is also important to understand to which extent IC1396A can be representative for the formation conditions that occurred in the main part of Tr37, which could also have affected the properties of protostars and the initial conditions of protoplanetary disks.

The idea that large clusters and associations are constructed in several episodes of star formation, leading to grouplets, sub-clusters, or mini-clusters with distinct ages, is gaining acceptance. Having various grouplets of stars with different ages is not only a characteristic of Tr37 (Getman et al. 2012), but also found in other OB associations (Kuhn et al. 2014). The mechanism(s) behind the multi-episodic collapse in molecular clouds is uncertain.

Besides the age differences between stars close to the center and close to IC1396A and other globules (Sicilia-Aguilar et al. 2005, Getman et al. 2012), Spitzer revealed diffuse, faint structures that surrounded some grouplets of young stars. These structures, which we call mini-clusters, are recovered with Herschel, allowing to estimate their temperatures and densities, together with the properties

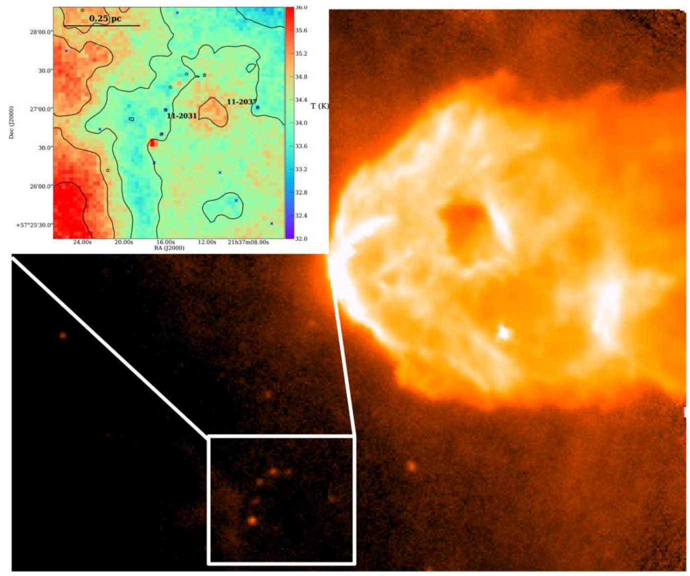

Figure 6: Background: A filament-shaped structure in Tr37 to the south of IC1396A, with bright disks at 70μm. Inset: The Herschel data show extended dust emission, revealing associated material cooler and denser than the background. All the stars have roughly the same spectral type (late K), similar projected separation, and massive, full disks, and are connected through a nebular structure, resembling fragmentation of a thin filament. Adapted from Sicilia-Aguilar et al. (2015).

of the disks of the sources contained in them (Sicilia-Aguilar et al. 2015). Herschel revealed different patterns of nebulosity around grouplets of stars, ranging from filamentary mini-clusters with stars with very similar masses and disk properties, to irregular grouplets containing both intermediate-mass and very low-mass stars (Fig. 6). Although mini-clusters are similar in size and in number of stars, their shapes, stellar population, and cloud densities and temperatures can be very different. This is a sign that not only star formation follows multiple clumpy episodes, but that the fragmentation mechanisms within the same cloud and at relatively close distances can be very diverse.

The stars, the disks, and their environment

Having several age sequences in the same cluster offers a great chance to make a disk evolution study under homogeneous conditions. The possibility of the star formation process affecting the disks is also an intriguing one. By tracking simultaneously protostars and protoplanetary disks, Herschel data point out the properties of both. In addition to revealing the properties of cloud and protostars, Herschel data also traces the global disk structure

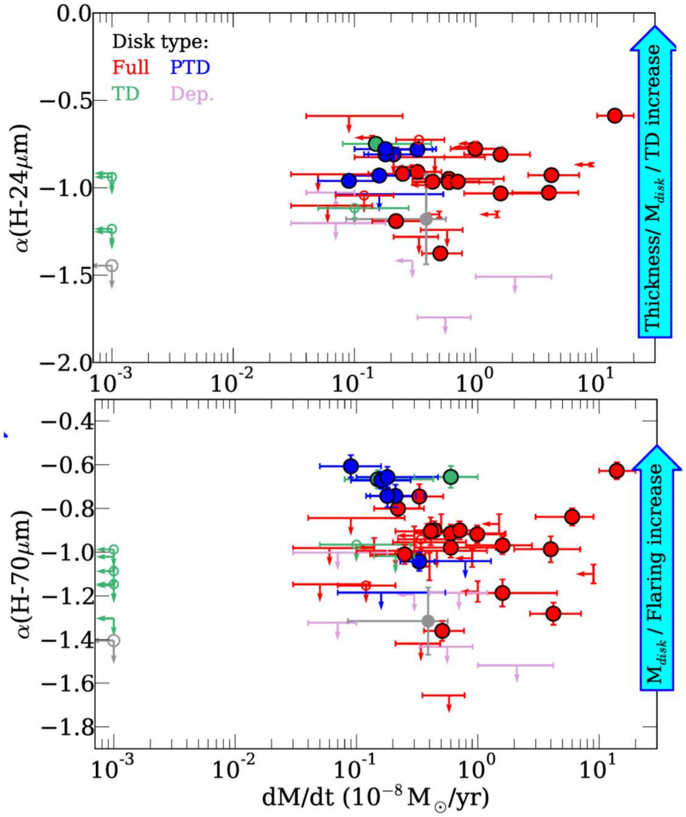

Figure 7: **Top:** Spitzer disk slope vs accretion rate for disks with different morphologies (full disks, transitional disks [TD], pre-transitional disks [PTD], and depleted disks [Dep]). Detections are marked by dots, upper limits are marked by downward-pointing arrows. **Bottom:** Herschel disk slope vs accretion rate. Although the differences in Spitzer colors are not significant between disks with inside-out evolution and without, Herschel shows consistently higher fluxes at 70μm suggestive of structural and/or mass differences for accreting TD and PTD, compared to full disks. Non-accreting disks (upper limits at 10^{-11}M$_\odot$/yr) are also significantly fainter in the far-IR. Sicilia-Aguilar et al. (2015).

and can detect the dust content down to very low masses, which are hard to track with millimeter data. In case of the Tr37/IC1396A region, Herschel has solved the puzzle of transition and dust-depleted disks with low accretion. While accreting transition and pre-transition disks have larger 70μm fluxes than normal ones, non-accreting disks are barely detected, suggesting a significantly lower mass content even if their Spitzer fluxes were not remarkably different. Generalized mass depletion seems thus a requirement to stop accretion onto the star. The differences in the far-IR between disks with gaps and inside-out evolution (transition and pre-transition disks) vs normal, full disks also points to global structural differences at large radial scales (more mass, larger scale heights) that could be connected with the development of holes and gaps in the disk (Sicilia-Aguilar et al. 2015; Fig. 7). Although the Herschel mission has already concluded, its data will still have a large impact on the understanding of protostars and disks in the coming years.

Conclusions and outlook

IC1396A is not only an amazing star-forming site, but a live proof of the surprises hidden at different wavelengths, even in BRC that have been known for more than half a century. Herschel data revealed amazing details about IC1396A and the Tr37 cluster, in both the fields of star formation and protoplanetary disk evolution. We are now doing a high spatial and spectral resolution followup of the Class 0 source IC1396A-PACS-1 in molecular lines (Patel et al. 2015; Sicilia-Aguilar et al. in prep) using IRAM and SMA data. The Class 0, intermediate-mass nature of the source, the presence of an outflow, and the structure around it have been confirmed. The dynamical picture of how the collapse of IC1396A-PACS-1 happened is now on the way.

Acknowledgments: I want to thank the people with whom I have been collaborating in unveiling the IC1396A globule and Tr37 cluster: Lee, Thomas, Nimesh, Kosta, Serena, Min, Veronica, ...

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Abstracts of recently accepted papers

ALMA Observations of the Largest Proto-Planetary Disk in the Orion Nebula, 114-426: A CO Silhouette

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We present ALMA observations of the largest protoplanetary disk in the Orion Nebula, 114-426. Detectable 345 GHz (856 μm) dust continuum is produced only in the 350 AU central region of the $\sim$1000 AU diameter silhouette seen against the bright Hα background in HST images. Assuming optically thin dust emission at 345 GHz, a gas-to-dust ratio of 100, and a grain temperature of 20 K, the disk gas-mass is estimated to be 3.1$\pm$0.6 Jupiter masses. If most solids and ices have have been incorporated into large grains, however, this value is a lower limit. The disk is not detected in dense-gas tracers such as HCO$^+$ J=4$-$3, HCN J=4$-$3, or CS =7$-$6. These results may indicate that the 114-426 disk is evolved and depleted in some light organic compounds found in molecular clouds. The CO J=3$-$2 line is seen in absorption against the bright 50 to 80 K background of the Orion A molecular cloud over the full spatial extent and a little beyond the dust continuum emission. The CO absorption reaches a depth of 27 K below the background CO emission at V$_{LSR} \approx$ 6.7 km s^{-1} $\sim$0.52 arcsec (210 AU) northeast and 12 K below the background CO emission at V$_{LSR} \approx$ 9.7 km s^{-1} $\sim$0.34 arcsec (140 AU) southwest of the suspected location of the central star, implying that the embedded star has a mass less than 1 M$_\odot$.

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Bondi-Hoyle-Littleton accretion and the upper mass stellar IMF

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We report on a series of numerical simulations of gas clouds with self-gravity forming sink particles, adopting an isothermal equation of state to isolate the effects of gravity from thermal physics on the resulting sink mass distributions. Simulations starting with supersonic velocity fluctuations develop sink mass functions with a high-mass power-law tail $dN/d\log M \propto M^\Gamma$, $\Gamma = 1 \pm 0.1$, independent of the initial Mach number of the velocity field. Similar results but with weaker statistical significance hold for a simulation starting with initial density fluctuations. This mass function power-law dependence agrees with the asymptotic limit found by Zinnecker assuming Bondi-Hoyle-Littleton (BHL) accretion, even though the mass accretion rates of individual sinks show significant departures from the predicted $\dot{M} \propto M^2$ behavior. While BHL accretion is not strictly applicable due to the complexity of the environment, we argue that the final mass functions are the result of a *relative* M^2 dependence resulting from gravitationally-focused accretion. Our simulations may show the power-law mass function particularly clearly compared with others because our adoption of an isothermal equation of state limits the effects of thermal physics in producing a broad initial fragmentation spectrum; $\Gamma \to -1$ is an asymptotic limit found only when sink masses grow well beyond their initial values. While we have purposely eliminated many additional physical processes (radiative transfer, feedback) which can affect the stellar mass function, our results emphasize the importance of gravitational focusing for massive star formation.

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Magnetic Field Structures in Star Forming Regions: Mid-Infrared Imaging Polarimetry of K3-50

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We report new imaging polarimetry observations of the Galactic compact HII region K3-50 using CanariCam at the Gran Telescopio Canarias. We use a standard polarimetric analysis technique, first outlined by Aitken, to decompose the observed polarisation images centred at 8.7, 10.3, and 12.5 μm into the emissive and absorptive components from silicate grains that are aligned with the local magnetic field. These components reveal the spatially-resolved magnetic field structures across the mid-infrared emission area of K3-50. We examine these structures and show that they are consistent with previously observed features and physical models of K3-50, such as the molecular torus and the ionised outflow. We propose a 3D geometry for all the structures seen at different wavelengths. We also compute relevant physical quantities in order to estimate the associated magnetic field strengths that would be implied under various physical assumptions. We compare these results with MHD simulations of protostar formation that predict the magnetic field strength and configuration. We find that the magnetic field may be dynamically important in the innermost 0.2 pc of the molecular torus, but that the torus is more likely to be rotationally-supported against gravity outside this radius. Similarly, magnetic fields are unlikely to dominate the *global* physics of the ionised outflow, but they may be important in helping confine the flow near the cavity wall in some locations. Ours is the first application of the Aitken technique to spatially-resolved magnetic field structures in multiple layers along the line of sight, effectively a method of "polarisation tomography."

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A Kinematically Unbiased Search for Nearby Young Stars in the Northern Hemisphere Selected Using SuperWASP Rotation Periods

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We present a kinematically-unbiased search to identify young, nearby low-mass members of kinematic moving groups (MGs). Objects with both rotation periods shorter than 5 days in the SuperWASP All-Sky Survey and X-ray counterparts in the ROSAT All-Sky Survey were chosen to create a catalog of several thousand rapidly-rotating, X-ray active FGK stars. These objects are expected to be either young single stars or tidally-locked spectroscopic binaries. We obtained optical spectra for a sub-sample of 146 stars to determine their ages and kinematics, and in some cases repeat radial velocity (RV) measurements were used to identify binarity. Twenty-six stars are found to have lithium abundances consistent with an age of ≤200 Myr, and show no evidence for binarity and in most cases measurements of Hα and $v \sin i$ support their youthful status. Based on their youth, their radial velocities and estimates of their 3-dimensional kinematics, we find 11 objects that may be members of known MGs, 8 that do not appear associated with any young MG and a further 7 that are close to the kinematics of the recently proposed "Octans-Near" MG, and which may be the first members of this MG found in the northern hemisphere. The initial search mechanism was ∼18 per cent efficient at identifying likely-single stars younger than 200 Myr, of which 80 per cent were early-K spectral types.

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Spectral optical monitoring of Be Herbig binary star HD 200775: a new maximum of activity and refinement of the binary star period

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We refined the orbital period of the Herbig Be binary star HD 200775 using both new and archive observational data which were obtained with high-resolution spectrometers at optical wavelengths over a 20 year time interval. New spectral observations were performed with the 1.2-m telescope of the Kourovka Astronomical Observatory of the Ural Federal University in 2012-2014 and the 6-m BTA telescope of the SAO RAS in 2013. We have found that the period of these observations includes a new maximum of HD 200775 activity in 2012 and following transition to quiescent state. We confirmed that maximums of HD 200775 activity, which are characterized by the increase of the Hα equivalent width, appear with a period of about 3.7 years.

Stable orbital period of the system equal to 1361.1 ± 2.0 days was found on the basis of radial velocity obtained for He I 5876 Å line. It was shown, that the radial velocity values determined for both the Hα emission line and the He I 5876 Å absorption line, formed in the photosphere of more massive primary component of the system, have close values and are changing synchronously with time. Presence of this synchronization tells that the main part of the HD 200775 Hα emission originates in the material associated with the more massive component of the system.

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Optical Mass Flow Diagnostics in Herbig Ae/Be Stars

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We examine a broad range of mass flow diagnostics in a large sample of Herbig Ae/Be stars (HAEBES) using high resolution optical spectra. The Hβ and He I 5876 Å lines show the highest incidence of P-Cygni (30%) and inverse P-Cygni (14%) morphologies, respectively. The Fe II 4924 Å line also shows a large incidence of P-Cygni profiles (11%). We find support for many of the conclusions reached in a study based on the analysis of the He I 10830 Å line in a large sample of HAEBES. Namely, HAEBES exhibit smaller fractions of both blue-shifted absorption (i.e. mass outflow) and red-shifted absorption (i.e. mass infall or accretion) than their lower mass cousins, the classical T Tauri stars (CTTSs). In particular, the optical data supports the conclusion that HAEBES displaying red-shifted absorption, in

general, show maximum red-shifted absorption velocities that are smaller fractions of their stellar escape velocities than is found for CTTSs. This suggests that HAEBE accretion flows are originating deeper in the gravitational potentials of their stars than in CTTS systems. In addition, we find a lack of inner disk wind signatures in the blue-shifted absorption objects; only stellar wind signatures are clearly observed. These findings, along with the lack of detected magnetic fields around HAEBES, support the idea that large magnetospheres are not prevalent around HAEBES and that accretion flows are instead mediated by significantly smaller magnetospheres with relatively smaller truncation radii (e.g. 1–2 stellar radii). Red-shifted absorption is much more common around Herbig Ae stars than Be stars, suggesting that Herbig Be stars may accrete via a boundary layer rather than along magnetic field lines.

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Radio Observations of the Star Formation Activities in the NGC 2024 FIR 4 Region

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Star formation activities in the NGC 2024 FIR 4 region were studied by imaging centimeter continuum sources and water maser sources using several archival data sets from the Very Large Array. The continuum source VLA 9 is elongated in the northwest-southeast direction, consistent with the FIR 4 bipolar outflow axis, and has a flat spectrum in the 6.2-3.6 cm interval. The three water maser spots associated with FIR 4 are also distributed along the outflow axis. One of the spots is located close to VLA 9, and another one is close to an X-ray source. Examinations of the positions of compact objects in this region suggest that the FIR 4 cloud core contains a single low-mass protostar. VLA 9 is the best indicator of the protostellar position. VLA 9 may be a radio thermal jet driven by this protostar, and it is unlikely that FIR 4 contains a high-mass young stellar object (YSO). A methanol 6.7 GHz maser source is located close to VLA 9, at a distance of about 100 AU. The FIR 4 protostar must be responsible for the methanol maser action, which suggests that methanol class II masers are not necessarily excited by high-mass YSOs. Also discussed are properties of other centimeter continuum sources in the field of view and the water masers associated with FIR 6n. Some of the continuum sources are radio thermal jets, and some are magnetically active young stars.

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Follow-Up Observations of PTFO 8-8695: A 3 Myr Old T-Tauri Star Hosting a Jupiter-mass Planetary Candidate

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We present Spitzer 4.5 μm light curve observations, Keck NIRSPEC radial velocity observations, and LCOGT optical light curve observations of PTFO 8-8695, which may host a Jupiter-sized planet in a very short orbital period (0.45 days). Previous work by van Eyken et al. (2012) and Barnes et al. (2013) predicts that the stellar rotation axis and the planetary orbital plane should precess with a period of 300–600 days. As a consequence, the observed transits should change shape and depth, disappear, and reappear with the precession. Our observations indicate the long-term presence of the transit events (>3 years), and that the transits indeed do change depth, disappear and reappear. The Spitzer observations and the NIRSPEC radial velocity observations (with contemporaneous LCOGT optical light curve data) are consistent with the predicted transit times and depths for the $M_* = 0.34\ M_\odot$ precession model and demonstrate the disappearance of the transits. An LCOGT optical light curve shows that the transits do reappear approximately 1 year later. The observed transits occur at the times predicted by a straight-forward propagation of the transit ephemeris. The precession model correctly predicts the depth and time of the Spitzer transit and the lack of a transit at the time of the NIRSPEC radial velocity observations. However, the precession model predicts the return of the transits approximately 1 month later than observed by LCOGT. Overall, the data are suggestive that the planetary interpretation of the observed transit events may indeed be correct, but the precession model and data are currently insufficient to confirm firmly the planetary status of PTFO 8-8695b.

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Does the CO-to-H_2 conversion factor depend on the star formation rate?

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We present a series of numerical simulations that explore how the 'X-factor', $X_{\rm CO}$ – the conversion factor between the observed integrated CO emission and the column density of molecular hydrogen – varies with the environmental conditions in which a molecular cloud is placed. Our investigation is centred around two environmental conditions in particular: the cosmic ray ionisation rate (CRIR) and the strength of the interstellar radiation field (ISRF). Since both these properties of the interstellar medium have their origins in massive stars, we make the assumption in this paper that both the strength of the ISRF and the CRIR scale linearly with the local star formation rate (SFR). The cloud modelling in this study first involves running numerical simulations that capture the cloud dynamics, as well as the time-dependent chemistry, and ISM heating and cooling. These simulations are then post-processed with a line radiative transfer code to create synthetic ^{12}CO (1-0) emission maps from which $X_{\rm CO}$ can be calculated. We find that for $10^4\,{\rm M}_\odot$ virialised clouds with mean density 100 cm^{-3}, $X_{\rm CO}$ is only weakly dependent on the local SFR, varying by a factor of a few over two orders of magnitude in SFR. In contrast, we find that for similar clouds but with masses of $10^5\,{\rm M}_\odot$, the X-factor will vary by an order of magnitude over the same range in SFR, implying that extra-galactic star formation laws should be viewed with caution. However, for denser ($10^4\,{\rm cm}^{-3}$), super-virial clouds such as those found at the centre of the Milky Way, the X-factor is once again independent of the local SFR.

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IN-SYNC III: The dynamical state of IC 348 - A super-virial velocity dispersion and a puzzling sign of convergence

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Most field stars will have encountered the highest stellar density and hence the largest number of interactions in their birth environment. Yet the stellar dynamics during this crucial phase are poorly understood. Here we analyze the radial velocities measured for 152 out of 380 observed stars in the 2-6 Myr old star cluster IC 348 as part of the SDSS-III APOGEE. The radial velocity distribution of these stars is fitted with one or two Gaussians, convolved with the measurement uncertainties including binary orbital motions. Including a second Gaussian improves the fit; the high-velocity outliers that are best fit by this second component may either (1) be contaminants from the nearby Perseus OB2 association, (2) be a halo of ejected or dispersing stars from IC 348, or (3) reflect that IC 348 has not relaxed to a Gaussian velocity distribution. We measure a velocity dispersion for IC 348 of 0.72 ± 0.07 km s^{-1} (or 0.64 ± 0.08 km s^{-1} if two Gaussians are fitted), which implies a supervirial state, unless the gas contributes more to the gravitational potential than expected. No evidence is found for a dependence of this velocity dispersion on distance from the cluster center or stellar mass. We also find that stars with lower extinction (in the front of the cloud) tend to be redshifted compared with stars with somewhat higher extinction (towards the back of the cloud). This data suggests that the stars in IC 348 are converging along the line of sight. We show that this correlation between radial velocity and extinction is unlikely to be spuriously caused by the small cluster rotation of 0.024 ± 0.013 km s^{-1} arcmin^{-1} or by correlations between the radial velocities of neighboring stars. This signature, if confirmed, will be the first detection of line-of-sight convergence in a star cluster. Possible scenarios for reconciling this convergence with IC 348's observed supervirial state include: a) the cluster is fluctuating around a new virial equilibrium after a recent disruption due to gas expulsion or a merger event, or b) the population we identify as IC 348 results from the chance alignment of two sub-clusters converging along the line of sight. Additional measurements of tangential and radial velocities in IC 348 will be important for clarifying the dynamics of this region, and informing models of the formation and evolution of star clusters. The radial velocities analyzed in this paper have been made available online.

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Herschel observations of EXtra-Ordinary Sources: Analysis of the HIFI 1.2 THz Wide Spectral Survey Toward Orion KL II. Chemical Implications

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We present chemical implications arising from spectral models fit to the Herschel/HIFI spectral survey toward the Orion Kleinmann-Low nebula (Orion KL). We focus our discussion on the eight complex organics detected within the HIFI survey utilizing a novel technique to identify those molecules emitting in the hottest gas. In particular, we find the complex nitrogen bearing species CH_3CN, C_2H_3CN, C_2H_5CN, and NH_2CHO systematically trace hotter gas than the oxygen bearing organics CH_3OH, C_2H_5OH, CH_3OCH_3, and CH_3OCHO, which do not contain nitrogen. If these complex species form predominantly on grain surfaces, this may indicate N-bearing organics are more difficult to remove from grain surfaces than O-bearing species. Another possibility is that hot ($T_{\rm kin} \sim 300$ K) gas phase chemistry naturally produces higher complex cyanide abundances while suppressing the formation of O-bearing complex organics. We compare our derived rotation temperatures and molecular abundances to chemical models, which include gas-phase and grain surface pathways. Abundances for a majority of the detected complex organics can be reproduced over timescales $\gtrsim 10^5$ years, with several species being under predicted by less than 3σ. Derived rotation temperatures for most organics, furthermore, agree reasonably well with the predicted temperatures at peak abundance. We also find that sulfur bearing molecules which also contain oxygen (i.e. SO, SO_2, and OCS) tend to probe the hottest gas toward Orion KL indicating the formation pathways for these species are most efficient at high temperatures.

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Bipolar HII regions - Morphology and star formation in their vicinity I - G319.88+00.79 and G010.32-00.15

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Our goal is to identify bipolar HII regions and to understand their morphology, their evolution, and the role they play in the formation of new generations of stars. We use the Spitzer-GLIMPSE, -MIPSGAL, and Herschel Hi-GAL surveys to identify bipolar HII regions, looking for (ionized) lobes extending perpendicular to dense filamentary structures. We search for their exciting star(s) and estimate their distances using near-IR data from the 2MASS or UKIDSS surveys. Dense molecular clumps are detected using Herschel-SPIRE data, and we estimate their temperature, column density, mass, and density. MALT90 observations allow us to ascertain their association with the central HII region (association based on similar velocities). We identify Class 0/I young stellar objects (YSOs) using their Spitzer and Herschel-PACS emissions. These methods will be applied to the entire sample of candidate bipolar HII regions to be presented in a forthcoming paper. This paper focuses on two bipolar HII regions, one that is especially interesting in terms of its morphology, G319.88+00.79, and one in terms of its star formation, G010.32-00.15. Their exciting clusters are identified and their photometric distances estimated to be 2.6 kpc and 1.75 kpc, respectively; thus G010.32-00.15 (known as W31 north) lies much closer than previously assumed. We suggest that these regions formed in dense and flat structures that contain filaments. They have a central ionized region and ionized lobes extending perpendicular to the parental cloud. The remains of the parental cloud appear as dense (more than 10^4 per cm^3) and cold (14-17 K) condensations. The dust in the photodissociation regions (in regions adjacent to the ionized gas) is warm (19-25 K). Dense massive clumps are present around the central ionized region. G010.32-00.14 is especially remarkable because five clumps of several hundred solar masses surround the central HII region; their peak column density is a few 10^{23} per cm^2, and the mean density in their central regions reaches several 10^5 per cm^3. Four of them contain at least one massive YSO (including an ultracompact HII region and a high-luminosity Class I YSO); these clumps also contain extended green objects and Class II methanol masers. This morphology suggests that the formation of a second generation of massive stars has been triggered by the central bipolar HII region. It occurs in the compressed material of the parental cloud.

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Volatile depletion in the TW Hydrae disk atmosphere

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An abundance decrease in carbon- and oxygen-bearing species relative to dust has been frequently found in planet-forming disks, which can be attributed to an overall reduction of gas mass. However, in the case of TW Hya, the only disk with gas mass measured directly with HD rotational lines, the inferred gas mass ($\lesssim$0.005 $M_\odot$) is significantly below the directly measured value ($\gtrsim$0.05 $M_\odot$). We show that this apparent conflict can be resolved if the elemental abundances of carbon and oxygen are reduced in the upper layers of the outer disk but are normal elsewhere (except for a possible enhancement of their abundances in the inner disk). The implication is that in the outer disk, the main reservoir of the volatiles (CO, water, ...) resides close to the midplane, locked up inside solid bodies that are too heavy to be transported back to the atmosphere by turbulence. An enhancement in the carbon and oxygen abundances in the inner disk can be caused by inward migration of these solid bodies. This is consistent with estimates based on previous models of dust grain dynamics. Indirect measurements of the disk gas mass and disk structure from species such as CO will thus be intertwined with the evolution of dust grains, and possibly also with the formation of planetesimals.

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Star formation scales and efficiency in Galactic spiral arms

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We positionally match a sample of infrared-selected young stellar objects (YSOs), identified by combining the *Spitzer* GLIMPSE, WISE and *Herschel Space Observatory* Hi-GAL surveys, to the dense clumps identified in the millimetre continuum by the Bolocam Galactic Plane Survey in two Galactic lines of sight centred towards $l = 30°$ and $l = 40°$. We calculate the ratio of infrared luminosity, L_{IR}, to the mass of the clump, M_{clump}, in a variety of Galactic environments and find it to be somewhat enhanced in spiral arms compared to the interarm regions when averaged over kiloparsec scales. We find no compelling evidence that these changes are due to the mechanical influence of the spiral arm on the star-formation efficiency rather than, e.g., different gradients in the star-formation rate due to patchy or intermittent star formation, or local variations that are not averaged out due to small source samples. The largest variation in L_{IR}/M_{clump} is found in individual clump values, which follow a log-normal distribution and have a range of over three orders of magnitude. This spread is intrinsic as no dependence of L_{IR}/M_{clump} with M_{clump} was found. No difference was found in the luminosity distribution of sources in the arm and interarm samples and a strong linear correlation was found between L_{IR} and M_{clump}

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The distribution of deuterated formaldehyde within Orion-KL

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We report the first high angular resolution imaging (3.″4 × 3.″0) of deuterated formaldehyde (HDCO) toward Orion–KL, carried out with the Submillimeter Array (SMA). We find that the spatial distribution of the formaldehyde emission systematically differs from that of methanol: while methanol is found towards the inner part of the region, HDCO is found in colder gas that wraps around the methanol emission on four sides. The HDCO/H_2CO ratios are determined to be 0.003–0.009 within the region, up to an order of magnitude higher than the D/H measured for methanol. These findings strengthen the previously suggested hypothesis that there are differences in the chemical pathways leading to HDCO (via deuterated gas phase chemistry) and deuterated methanol (through conversion of formaldehyde into methanol on the surface of icy grain mantles).

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Hyperfine transitions of ^{13}CN from pre-protostellar sources

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Recent quantum mechanical calculations of rate coefficients for collisional transfer of population between the hyperfine states of ^{13}CN enable their population densities to be determined. We have computed the relative populations of the hyperfine states of the $N = 0, 1, 2$ rotational states for kinetic temperatures $5 \leq T \leq 20$ K and molecular hydrogen densities $1 \leq n(\mathrm{H_2}) \leq 10^{10}\,\mathrm{cm^{-3}}$. Spontaneous and induced radiative transitions were taken into account. Our calculations show that, if the lines are optically thin, the populations of the hyperfine states, F, within a given rotational manifold are proportional to their statistical weights, $(2F + 1)$ – i.e. in local thermodynamic equilibrium – over the entire range of densities. We have re-analysed IRAM/30m telescope observations of ^{13}CN hyperfine transitions ($N = 1 \rightarrow 0$) in four starless cores. A comparison of these observations with our calculations confirms that the hyperfine states are statistically populated in these sources.

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First measurements of ^{15}N fractionation in N_2H^+ toward high-mass star forming cores

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We report on the first measurements of the isotopic ratio ^{14}N/^{15}N in N_2H^+ toward a statistically significant sample of high-mass star forming cores. The sources belong to the three main evolutionary categories of the high-mass star formation process: high-mass starless cores, high-mass protostellar objects, and ultracompact HII regions. Simultaneous measurements of ^{14}N/^{15}N in CN have been made. The ^{14}N/^{15}N ratios derived from N_2H^+ show a large spread (from ∼180 up to ∼1300), while those derived from CN are in between the value measured in the terrestrial atmosphere

(∼270) and that of the proto-Solar nebula (∼440) for the large majority of the sources within the errors. However, this different spread might be due to the fact that the sources detected in the N_2H^+ isotopologues are more than those detected in the CN ones. The $^{14}N/^{15}N$ ratio does not change significantly with the source evolutionary stage, which indicates that time seems to be irrelevant for the fractionation of nitrogen. We also find a possible anticorrelation between the $^{14}N/^{15}N$ (as derived from N_2H^+) and the H/D isotopic ratios. This suggests that ^{15}N enrichment could not be linked to the parameters that cause D enrichment, in agreement with the prediction by recent chemical models. These models, however, are not able to reproduce the observed large spread in $^{14}N/^{15}N$, pointing out that some important routes of nitrogen fractionation could be still missing in the models.

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High-mass star formation triggered by collision between CO filaments in N159 West in the Large Magellanic Cloud

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We have carried out $^{13}CO(J{=}2–1)$ observations of the active star-forming region N159 West in the LMC with ALMA. We have found that the CO distribution at a sub-pc scale is highly elongated with a small width. These elongated clouds called "filaments" show straight or curved distributions with a typical width of 0.5–1.0 pc and a length of 5–10 pc. All the known infrared YSOs are located toward the filaments. We have found broad CO wings of two molecular outflows toward young high-mass stars in N159W-N and N159W-S, whose dynamical timescale is $\sim 10^4$ yrs. This is the first discovery of protostellar outflow in external galaxies. For N159W-S which is located toward an intersection of two filaments we set up a hypothesis that the two filaments collided with each other $\sim 10^5$ yrs ago and triggered formation of the high-mass star having $\sim 37\ M_\odot$. The colliding clouds show significant enhancement in linewidth in the intersection, suggesting excitation of turbulence in the shocked interface layer between them as is consistent with the magneto-hydro-dynamical numerical simulations (Inoue & Fukui 2013). This turbulence increases the mass accretion rate to $\sim 6 \times 10^{-4}\ M_\odot\ \mathrm{yr}^{-1}$, which is required to overcome the stellar feedback to form the high-mass star.

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BANYAN. VII. A New Population of Young Substellar Candidate Members of Nearby Moving Groups from the BASS Survey

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We present the results of a near-infrared (NIR) spectroscopic follow-up survey of 182 M4-L7 low-mass stars and brown dwarfs (BDs) from the BANYAN All-Sky Survey (BASS) for candidate members of nearby, young moving groups (YMGs). We confirm signs of low-gravity for 42 new BD discoveries with estimated masses between 8–75 $M_{\rm Jup}$ and identify previously unrecognized signs of low gravity for 24 known BDs. This allows us to refine the fraction of low-gravity dwarfs in the high-probability BASS sample to ∼82%. We use this unique sample of 66 young BDs, supplemented with 22 young BDs from the literature, to construct new empirical NIR absolute magnitude and color sequences for low-gravity BDs. We obtain a spectroscopic confirmation of low-gravity for 2MASS J14252798−3650229, which is a new ∼27 $M_{\rm Jup}$, L4 γ bona fide member of AB Doradus. We identify a total of 19 new low-gravity candidate members of YMGs with estimated masses below 13 $M_{\rm Jup}$, seven of which have kinematically estimated distances within 40 pc. These objects will be valuable benchmarks for a detailed atmospheric characterization of planetary-mass objects with the next generation of instruments. We find 16 strong candidate members of the Tucana-Horologium association with estimated masses between 12.5–14 $M_{\rm Jup}$, a regime where our study was particularly sensitive. This would indicate that for this association there is at least one isolated object in this mass range for every $17.5^{+6.6}_{-5.0}$ main-sequence stellar member, a number significantly higher than expected based on standard log-normal initial mass function, however in the absence of radial velocity and parallax measurements for all of them, it is likely that this over-density is caused by a number of young interlopers from other moving groups. We identify 12 new L0–L5 field BDs, seven of which display peculiar properties.

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Evolution of the T Tauri star population in the Lupus association

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Aims: In a recent study, we derived individual distances for 109 pre-main sequence stars that define the Lupus kinematic association of young stars. Here, we use these new distances to derive the masses and ages of Lupus T Tauri stars with the aim of better constraining the lifetime of their circumstellar disks.
Methods: Using the photometric and spectroscopic information available in the literature, we computed the photo-

spheric luminosity of 92 T Tauri stars in the Lupus association. Then, we estimated their masses and ages from theoretical evolutionary models. Based on Monte Carlo simulations and statistical tests, we compare the mass and age distribution of the classical T Tauri stars (CTTS) and weak-line T Tauri (WTTS) in our sample.
Results: We show that the CTTSs are on average younger than the WTTSs and that the probability that both T Tauri subclasses are drawn from the same mass and age parental distribution is very low. Our results favor the scenario proposed earlier for the Taurus-Auriga association, where the CTTSs evolve into WTTSs when their disks are fully accreted by the star. Based on an empirical disk model, we find that the average disk lifetime for the T Tauri stars in the Lupus association is $\tau_d = 3 \times 10^6\,(M_*/M_\odot)^{0.55}$ yr.
Conclusions: We find evidence that the average lifetime of the circumstellar disks in the Lupus association is shorter than in the Taurus-Auriga association and discuss the implications of this result.

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Pre- and Post-burst Radio Observations of the Class 0 Protostar HOPS 383 in Orion

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There is increasing evidence that episodic accretion is a common phenomenon in Young Stellar Objects (YSOs). Recently, the source HOPS 383 in Orion was reported to have a ×35 mid-infrared – and bolometric – luminosity increase between 2004 and 2008, constituting the first clear example of a class 0 YSO (a protostar) with a large accretion burst. The usual assumption that in YSOs accretion and ejection follow each other in time needs to be tested. Radio jets at centimeter wavelengths are often the only way of tracing the jets from embedded protostars. We searched the Very Large Array archive for the available observations of the radio counterpart of HOPS 383. The data show that the radio flux of HOPS 383 varies only mildly from January 1998 to December 2014, staying at the level of $\sim$ 200 to 300 μJy in the X band ($\sim$ 9 GHz), with a typical uncertainty of 10 to 20 μJy in each measurement. We interpret the absence of a radio burst as suggesting that accretion and ejection enhancements do not follow each other in time, at least not within timescales shorter than a few years. Time monitoring of more objects and specific predictions from simulations are needed to clarify the details of the connection betwen accretion and jets/winds in YSOs.

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A 1.3 cm Line Survey toward Orion KL

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Orion KL has served as a benchmark for spectral line searches throughout the (sub)millimeter regime. The main goal is to systematically study spectral characteristics of Orion KL in the 1.3 cm band. We carried out a spectral line survey (17.9 GHz to 26.2 GHz) with the Effelsberg-100 m telescope towards Orion KL. We find 261 spectral lines, yielding an average line density of about 32 spectral features per GHz above 3σ. The identified lines include 164 radio recombination lines (RRLs) and 97 molecular lines. A total of 23 molecular transitions from species known to exist in Orion KL are detected for the first time in the interstellar medium. Non-metastable $^{15}NH_3$ transitions are detected in Orion KL for the first time. Based on the velocity information of detected lines and the ALMA images, the spatial origins of molecular emission are constrained and discussed. A narrow feature is found in SO_2 ($8_{1,7}$–$7_{2,6}$), possibly suggesting the presence of a maser line. Column densities and fractional abundances relative to H_2 are estimated for 12 molecules with LTE methods. Rotational diagrams of non-metastable $^{14}NH_3$ transitions with $J = K + 1$ to $J = K + 4$ yield different results; metastable $^{15}NH_3$ is found to have a higher excitation temperature than non-metastable $^{15}NH_3$, indicating that they may trace different regions. Elemental and isotopic abundance ratios are estimated: $^{12}C/^{13}C = 63\pm17$, $^{14}N/^{15}N = 100\pm51$, $D/H = 0.0083\pm0.0045$. The dispersion of the He/H ratios derived from $H\alpha/He\alpha$ pairs to $H\delta/He\delta$ pairs is very small, which is consistent with theoretical predictions that the departure coefficients b_n factors for hydrogen and helium are nearly identical. Based on a non-LTE code neglecting excitation by the infrared radiation field and a likelihood analysis, we find that the denser regions have lower kinetic temperature, which favors an external heating of the Hot Core.

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HNC in Protoplanetary Disks

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The distributions and abundances of small organics in protoplanetary disks are potentially powerful probes of disk physics and chemistry. HNC is a common probe of dense interstellar regions and the target of this study. We use the Submillimeter Array (SMA) to observe HNC 3–2 towards the protoplanetary disks around the T Tauri star TW Hya and the Herbig Ae star HD 163296. HNC is detected toward both disks, constituting the first spatially resolved observations of HNC in disks. We also present SMA observations of HCN 3–2, and IRAM 30m observations of HCN and HNC 1–0 toward HD 163296. The disk-averaged HNC/HCN emission ratio is 0.1–0.2 toward both disks. Toward TW Hya, the HNC emission is confined to a ring. The varying HNC abundance in the TW Hya disk demonstrates that HNC chemistry is strongly linked to the disk physical structure. In particular, the inner rim of the HNC ring can be explained by efficient destruction of HNC at elevated temperatures, similar to what is observed in the ISM. To realize the full potential of HNC as a disk tracer requires, however, a combination of high SNR spatially resolved observations of HNC and HCN, and disk specific HNC chemical modeling.

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The Giant Molecular Cloud Environments of Infrared Dark Clouds

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We study Giant Molecular Cloud (GMC) environments surrounding 10 Infrared Dark Clouds (IRDCs), using $^{13}CO(1-0)$ emission from the Galactic Ring Survey. We measure physical properties of these IRDCs/GMCs on a range of scales extending to radii, R, of 30 pc. By comparing different methods for defining cloud boundaries and for deriving mass surface densities and velocity dispersions, we settle on a preferred "CE,τ,G" method of "Connected Extraction" in position-velocity space plus Gaussian fitting to opacity-corrected line profiles for velocity dispersion and mass estimation. We examine how cloud definition affects measurements of the magnitude and direction of line-of-sight velocity gradients and velocity dispersions, including associated dependencies on size scale. CE,τ,G-defined GMCs show velocity dispersion versus size relations $\sigma \propto s^{1/2}$, which are consistent with the large-scale gradients being caused by turbulence. However, IRDCs have velocity dispersions that are moderately enhanced above those predicted by this scaling relation. We examine the dynamical state of the clouds finding mean virial parameters $\bar{\alpha}_{\rm vir} \simeq 1.0$ for GMCs and 1.6 for IRDCs, broadly consistent with models of magnetized virialized pressure-confined polytropic clouds, but potentially indicating that IRDCs have more disturbed kinematics. CE,τ,G-defined clouds exhibit a tight correlation of $\sigma/R^{1/2} \propto \Sigma^n$, with $n \simeq 0.7$ for GMCs and 1.3 for IRDCs (c.f., a value of 0.5 expected for a population of virialized clouds). We conclude that while GMCs show evidence for virialization over a range of scales, IRDCs may be moderately super virial. Alternatively, IRDCs could be virialized but have systematically different ^{13}CO gas phase abundances, i.e., due to freeze-out, affecting mass estimations.

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Massive envelopes and filaments in the NGC 3603 star forming region

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The formation of massive stars and their arrival on the zero-age main-sequence occurs hidden behind dense clouds of gas and dust. In the giant HII region NGC 3603, the radiation of a young cluster of OB stars has dispersed dust and gas in its vicinity. At a projected distance of 2.5 pc from the cluster, a bright mid-infrared (mid-IR) source (IRS 9A) had been identified as a massive young stellar object (MYSO), located on the side of a molecular clump (MM2) of gas facing the cluster. We investigated the physical conditions in MM2, based on APEX sub-mm observations using the SABOCA and SHFI instruments, and archival ATCA 3 mm continuum and CS spectral line data. We resolved MM2 into several compact cores, one of them closely associated with IRS 9A. These are likely infrared dark clouds as they do not show the typical hot-core emission lines and are mostly opaque against the mid-IR background. The compact cores have masses of up to several hundred times the solar mass and gas temperatures of about 50 K, without evidence of internal ionizing sources. We speculate that IRS 9A is younger than the cluster stars, but is in an evolutionary state after that of the compact cores.

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IRS Spectra of Debris Disks in the Scorpius-Centaurus OB Association

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We analyze Spitzer/IRS spectra of 110 B-, A-, F-, and G-type stars with optically thin infrared excess in the Scorpius-Centaurus (ScoCen) OB association. The age of these stars ranges from 11–17 Myr. We fit the infrared excesses observed in these sources by Spitzer/IRS and Spitzer/MIPS to simple dust models according to Mie theory. We find that nearly all the objects in our study can be fit by one or two belts of dust. Dust around lower mass stars appears to be closer in than around higher mass stars, particularly for the warm dust component in the two-belt systems, suggesting mass-dependent evolution of debris disks around young stars. For those objects with stellar companions, all dust distances are consistent with trunction of the debris disk by the binary companion. The gaps between several of the two-belt systems can place limits on the planets that might lie between the belts, potentially constraining the mass and locations of planets that may be forming around these stars.

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Tracing Embedded Stellar Populations in Clusters and Galaxies using Molecular Emission: Methanol as a Signature of the Low-Mass End of the IMF

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Most low-mass protostars form in clusters, in particular high-mass clusters; however, how low-mass stars form in high-mass clusters and what the mass distribution is are still open questions both in our own Galaxy and elsewhere. To access the population of forming embedded low-mass protostars observationally, we propose using molecular outflows as tracers. Because the outflow emission scales with mass, the effective contrast between low-mass protostars and their high-mass cousins is greatly lowered. In particular, maps of methanol emission at 338.4 GHz ($J = 7_0$–6_0 A^+) in low-mass clusters illustrate that this transition is an excellent probe of the low-mass population. We present here a model of a forming cluster where methanol emission is assigned to every embedded low-mass protostar. The resulting model image of methanol emission is compared to recent ALMA observations toward a high-mass cluster and the similarity is striking: the toy model reproduces observations to better than a factor of two and suggests that approximately 50% of the total flux originates in low-mass outflows. Future fine-tuning of the model will eventually make it a tool for interpreting the embedded low-mass population of distant regions within our own Galaxy and ultimately higher-redshift starburst galaxies, not just for methanol emission but also water and high-J CO.

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Resolving Protoplanetary Disks at Millimeter Wavelengths by CARMA

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We present continuum observations at 1.3 and 2.7 mm using the Combined Array for Research in Millimeter-wave Astronomy (CARMA) toward six protoplanetary disks in the Taurus molecular cloud: CI Tau, DL Tau, DO Tau, FT Tau, Haro 6-13, and HL Tau. We constrain physical properties of the disks with Bayesian inference using two disk models; flared power-law disk model and flared accretion disk model. Comparing the physical properties, we find that the more extended disks are less flared and that the dust opacity spectral index (β) is smaller in the less massive disks. In addition, disks with a steeper mid-plane density gradient have a smaller β, which suggests that grains grow and radially move. Furthermore, we compare the two disk models quantitatively and find that the accretion disk model provides a better fit overall. We also discuss the possibilities of substructures on three extended protoplanetary disks.

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Star formation in the S233 region

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The main objective of this paper is to study the possibility of triggered star formation on the border of the HII region S233, which is formed by a B-star. Using high-resolution spectra we determine the spectral class of the ionizing star as B0.5 V and the radial velocity of the star to be -17.5 ± 1.4 km s^{-1}. This value is consistent with the velocity of gas in a wide field across the S233 region, suggesting that the ionizing star was formed from a parent cloud belonging to the S233 region. By studying spatial-kinematic structure of the molecular cloud in the S233 region, we detected an isolated clump of gas producing CO emission red-shifted relative to the parent cloud. In the UKIDSS and WISE images, the clump of gas coincides with the infrared source containing a compact object and bright-rimmed structure. The bright-rimmed structure is perpendicular to the direction of the ionizing star. The compact source coincides in position with IRAS source 05351+3549. All these features indicate a possibility of triggering formation of a next-generation star in the S233 region. Within the framework of a theoretical one-dimensional model we conclude that the 'collect-and-collapse process is not likely to take place in the S233 region. The presence of the bright-rimmed structure and the compact infrared source suggest that the "collapse of the pre-existing clump" process is taking place.

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X-raying the coronae of HD 155555

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We present an analysis of the high-resolution Chandra observation of the multiple system, HD 155555 (an RS CVn type binary system, HD 155555 AB, and its spatially resolved low-mass companion HD 155555 C). This is an intriguing system which shows properties of both an active pre-main sequence star and a synchronised (main sequence) binary. We obtain the emission measure distribution, temperature structures, plasma densities, and abundances of this system and compare them with the coronal properties of other young/active stars. HD 155555 AB and HD 155555 C produce copious X-ray emission with $\log L_x$ of 30.54 and 29.30, respectively, in the 0.3–6.0 keV energy band. The light curves of individual stars show variability on timescales of few minutes to hours. We analyse the dispersed spectra and reconstruct the emission measure distribution using spectral line analysis. The resulting elemental abundances exhibit inverse first ionisation potential effect in both cases. An analysis of He-like triplets yields a range of coronal electron densities $\sim 10^{10}$–10^{13} cm^{-3}. Since HD 155555 AB is classified both as an RS CVn and a PMS star, we compare our results with those of other slightly older active main-sequence stars and T Tauri stars, which indicates that the coronal properties of HD 155555 AB closely resemble that of an older RS CVn binary rather than a younger PMS star. Our results also suggests that the properties of HD 155555 C is very similar to those of other active M dwarfs.

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Numerically Predicted Indirect Signatures of Terrestrial Planet Formation

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The intermediate phases of planet formation are not directly observable due to lack of emission from planetesimals. Planet formation is, however, a dynamically active process resulting in collisions between the evolving planetesimals and the production of dust. Thus, indirect observation of planet formation may indeed be possible in the near future. In this paper we present synthetic observations based on numerical N-body simulations of the intermediate phase of planet formation including a state-of-the-art collision model, EDACM, which allows multiple collision outcomes, such as, accretion, erosion, and bouncing events. We show that the formation of planetary embryos may be indirectly observable by a fully functioning ALMA telescope if the surface area involved in planetesimal evolution is sufficiently large and/or the amount of dust produced in the collisions is sufficiently high in mass.

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Magnetized Interstellar Molecular Clouds. I. Comparison Between Simulations and Zeeman Observations

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The most accurate measurements of magnetic fields in star-forming gas are based on the Zeeman observations analyzed by Crutcher et al. (2010). We show that their finding that the 3D magnetic field scales approximately as density$^{0.65}$ can also be obtained from analysis of the observed line-of-sight fields. We present two large-scale AMR MHD simulations of several thousand $M_\odot$ of turbulent, isothermal, self-gravitating gas, one with a strong initial magnetic field (Alfvén Mach number $\mathcal{M}_{\rm A,0} = 1$) and one with a weak initial field ($\mathcal{M}_{\rm A,0} = 10$). We construct samples of the 100 most massive clumps in each simulation and show that they exhibit a power-law relation between field strength and density ($\bar{n}_{\rm H}$) in excellent agreement with the observed one. Our results imply that the average field in molecular clumps in the interstellar medium is $\langle B_{tot}(\bar{n}_{\rm H})\rangle \approx 42\bar{n}_{\rm H,4}^{0.65}\mu G$. Furthermore, the median value of the ratio of the line-of-sight field to density$^{0.65}$ in the simulations is within a factor of about (1.3, 1.7) of the observed value for the strong and weak field cases, respectively. The median value of the mass-to-flux ratio, normalized to the critical value, is 70 per cent of the line-of-sight value. This is larger than the 50 per cent usually cited for spherical clouds because the actual mass-to-flux ratio depends on the volume-weighted field, whereas the observed one depends on the mass-weighted field. Our results indicate that the typical molecular clump in the ISM is significantly supercritical ($\sim$ factor of 3). The results of our strong-field model are in very good quantitative agreement with the observations of Li et al. (2009), which show a strong correlation in field orientation between small and large scales. Because there is a negligible correlation in the weak-field model, we conclude that molecular clouds form from strongly magnetized (although magnetically supercritical) gas, in agreement with the conclusion of Li et al. (2009).

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CO Core Candidates in the Gemini Molecular Cloud

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We present observations of a 4 squared degree area toward the Gemini cloud obtained using J = 1–0 transitions of ^{12}CO, ^{13}CO and C^{18}O. No C^{18}O emission was detected. This region is composed of 36 core candidates of ^{13}CO. These core candidates have a characteristic diameter of 0.25 pc, excitation temperatures of 7.9 K, line width of 0.54 km s^{-1} and a mean mass of 1.4 M$_{\odot}$. They are likely to be starless core candidates, or transient structures, which probably disperse after $\sim$10^{6} yr.

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The dynamical evolution of low-mass hydrogen-burning stars, brown dwarfs and planetary-mass objects formed through disc fragmentation

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Theory and simulations suggest that it is possible to form low-mass hydrogen-burning stars, brown dwarfs and planetary-mass objects via disc fragmentation. As disc fragmentation results in the formation of several bodies at comparable distances to the host star, their orbits are generally unstable. Here, we study the dynamical evolution of these objects. We set up the initial conditions based on the outcomes of the smoothed-particle hydrodynamics (SPH) simulations of Stamatellos & Whitworth (2009), and for comparison we also study the evolution of systems resulting from lower-mass fragmenting discs. We refer to these two sets of simulations as set 1 and set 2, respectively. At 10 Myr, approximately half of the host stars have one companion left, and approximately 22% (set 1) to 9.8% (set 2) of the host stars are single. Systems with multiple secondaries in relatively stable configurations are common (about 30% and 44%, respectively). The majority of the companions are ejected within 1 Myr with velocities mostly below 5 km s^{-1}, with some runaway escapers with velocities over 30 km s^{-1}. Roughly 6% (set 1) and 2% (set 2) of the companions pair up into very low-mass binary systems, resulting in respective binary fractions of 3.2% and 1.2%. The majority of these pairs escape as very low-mass binaries, while others remain bound to the host star in hierarchical configurations (often with retrograde inner orbits). Physical collisions with the host star (0.43 and 0.18 events per host star for set 1 and set 2, respectively) and between companions (0.08 and 0.04 events per host star for set 1 and set 2, respectively) are relatively common and their frequency increases with increasing disc mass. Our study predicts observable properties of very low-mass binaries, low-mass hierarchical systems, the brown dwarf desert, and free-floating brown dwarfs and planetary-mass objects in and near young stellar groupings, which can be used to distinguish between different formation scenarios of very low-mass stars, brown dwarfs and planetary-mass objects.

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M-dwarf binaries as tracers of star and brown dwarf formation

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The separation distribution for M-dwarf binaries in the ASTRALUX survey is narrower and peaking at smaller separations than the distribution for solar-type binaries. This is often interpreted to mean that M-dwarfs constitute a continuous transition from brown dwarfs (BDs) to stars. Here a prediction for the M-dwarf separation distribution is presented, using a dynamical population synthesis (DPS) model in which "star-like" binaries with late-type primaries ($\lesssim$1.5 $M_{\odot}$) follow universal initial distribution functions and are dynamically processed in their birth embedded clusters. A separate "BD-like" population has both its own distribution functions for binaries and initial mass function (IMF), which overlaps in mass with the IMF for stars. Combining these two formation modes results in a peak on top of a wider separation distribution for late M-dwarfs consistent with the late ASTRALUX sample. The DPS separation distribution for early M-dwarfs shows no such peak and is in agreement with the M-dwarfs in Multiples (MinMS) data. We note that the latter survey is potentially in tension with the early ASTRALUX data. Concluding, the ASTRALUX and MinMS data are unable to unambiguously distinguish whether or not BDs are a continuous extension of the stellar IMF. Future observational efforts are needed to fully answer this interesting question. The DPS model predicts that binaries outside the sensitivity range of the ASTRALUX survey remain to be detected. For application to future data, we present a means to observationally measure the overlap of the putative BD-like branch and the stellar branch. We discuss the meaning of universal star formation and distribution functions.

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The structure of disks around intermediate-mass young stars from mid-infrared interferometry. Evidence for a population of group II disks with gaps

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The disks around Herbig Ae/Be stars are commonly divided into group I and group II based on their far-infrared spectral energy distribution, and the common interpretation for that is flared and flat disks. Recent observations suggest that many flaring disks have gaps, whereas flat disks are thought to be gapless. The different groups of objects can be expected to have different structural signatures in high-angular-resolution data. Over the past 10 years, the MIDI instrument on the Very Large Telescope Interferometer has collected observations of several tens of protoplanetary disks. We model the large set of observations with simple geometric models. A population of radiative-transfer models is synthesized for interpreting the mid-infrared signatures. Objects with similar luminosities show very different disk sizes in the mid-infrared. Restricting to the young objects of intermediate mass, we confirm that most group I disks are in agreement with being transitional. We find that several group II objects have mid-infrared sizes and colors overlapping with sources classified as group I, transition disks. This suggests that these sources have gaps, which has been demonstrated for a subset of them. This may point to an intermediate population between gapless and transition disks. Flat disks with gaps are most likely descendants of flat disks without gaps. Gaps, potentially related to the formation of massive bodies, may therefore even develop in disks in a far stage of grain growth and settling. The evolutionary implications of this new population could be twofold. Either gapped flat disks form a separate population of evolved disks, or some of them may further evolve into flaring disks with large gaps. The latter transformation may be governed by the interaction with a massive planet, carving a large gap and dynamically exciting the grain population in the disk.

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On the rotation periods of the components of the triple system TYC9300-0891-1AB/TYC9300-0529-1 in the Octans Association

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Stellar rotation depends on different parameters. The range of values of these parameters causes the dispersion in the rotation period distributions observed in young stellar clusters/associations. We focus our investigation on the effects of different circumstellar environments on stellar rotation. More specifically, we are searching in stellar Associations for visual triple systems where all stellar parameters are similar, with the only exceptions of the unknown initial rotation period, and of the circum-stellar environment, in the sense that one of the two about equal-mass components has a close-by third 'perturber' component. In the present study we analyse the 35-Myr old visual triple system TYC 9300-0891-1AB + TYC 9300-0529-1 in the young Octans stellar association consisting of three equal-mass K0V components. We collected from the literature all information that allowed us to infer that the three components are actually physically bound forming a triple system and are members of the Octans Association. We collected broad-band photometric timeseries in two observation seasons. We discovered that all the components are variable, magnetically active, and from periodogram analysis we found the unresolved components TYC 9300-0891-1AB to have a rotation period P = 1.383d and TYC 9300-0529-1 a rotation period P = 1.634d. TYC 9300-0891-1A, TYC 9300-0891-1B, and TYC 9300-0529-1 have same masses, ages, and initial chemical compositions. The relatively small 16% rotation period difference measured by us indicates that all components had similar initial rotation periods and disc lifetimes, and the separation of 157AU between the component A and the 'perturber' component B (or vice-versa) has been sufficiently large to prevent any significant perturbation/shortening of the accretion-disc lifetime.

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Nested shells reveal the rejuvenation of the Orion-Eridanus superbubble

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The Orion-Eridanus superbubble is the prototypical superbubble due to its proximity and evolutionary state. Here, we provide a synthesis of recent observational data from WISE and Planck with archival data, allowing to draw a new and more complete picture on the history and evolution of the Orion-Eridanus region. We discuss the general morphological structures and observational characteristics of the superbubble, and derive quantitative properties of the gas- and dust inside Barnard's Loop. We reveal that Barnard's Loop is a complete bubble structure which, together with the lambda Ori region and other smaller-scale bubbles, expands within the Orion-Eridanus superbubble. We argue that the Orion-Eridanus superbubble is larger and more complex than previously thought, and that it can be viewed as a series of nested shells, superimposed along the line of sight. During the lifetime of the superbubble, HII region champagne flows and thermal evaporation of embedded clouds continuously mass-load the superbubble interior, while winds or supernovae from the Orion OB association rejuvenate the superbubble by sweeping up the material from the interior cavities in an episodic fashion, possibly triggering the formation of new stars that form shells of their own. The steady supply of material into the superbubble cavity implies that dust processing from interior supernova remnants is more efficient than previously thought. The cycle of mass-loading, interior cleansing, and star formation repeats until the molecular reservoir is depleted or the clouds have been disrupted. While the nested shells come and go, the superbubble remains for tens of millions of years.

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Optical polarization map of the Polaris Flare with RoboPol

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The stages before the formation of stars in molecular clouds are poorly understood. Insights can be gained by studying the properties of quiescent clouds, such as their magnetic field structure. The plane-of-the-sky orientation of the field can be traced by polarized starlight. We present the first extended, wide-field ($\sim$10 deg^2) map of the Polaris Flare cloud in dust-absorption induced optical polarization of background stars, using the RoboPol polarimeter at the Skinakas Observatory. This is the first application of the wide-field imaging capabilities of RoboPol. The data were taken in the R-band and analysed with the automated reduction pipeline of the instrument. We present in detail optimizations in the reduction pipeline specific to wide-field observations. Our analysis resulted in reliable measurements of 641 stars with median fractional linear polarization 1.3%. The projected magnetic field shows a large scale ordered pattern. At high longitudes it appears to align with faint striations seen in the *Herschel*-SPIRE map of dust emission (250 μm), while in the central 4-5 deg^2 it shows an eddy-like feature. The overall polarization pattern we obtain is in good agreement with large scale measurements by Planck of the dust emission polarization in the same area of the sky.

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On the spatial distributions of stars and gas in numerical simulations of molecular clouds

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We compare the spatial distribution of stars which form in hydrodynamical simulations to the spatial distribution of the gas, using the $\mathcal{Q}$-parameter. The $\mathcal{Q}$-parameter enables a self-consistent comparison between the stars and gas because it uses a pixelated image of the gas as a distribution of points, in the same way that the stars (sink particles in the simulations) are a distribution of points. We find that, whereas the stars have a substructured, or hierarchical spatial distribution ($\mathcal{Q} \sim 0.4 - 0.7$), the gas is dominated by a smooth, concentrated component and typically has $\mathcal{Q} \sim 0.9$. We also find no statistical difference between the structure of the gas in simulations that form with feedback, and those that form without, despite these two processes producing visually different distributions. These results suggest that the link between the spatial distributions of gas, and the stars which form from them, is non-trivial.

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Sequential planet formation in the HD 100546 protoplanetary disk?

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Context. The disk around the Herbig Ae star, HD 100546, shows structures that suggest the presence of two companions in the disk at ∼10 and ∼70 AU. The outer companion seems to be in the act of formation.
Aims. Our aims are to provide constraints on the age of the planets in HD 100546 and to explore the potential evidence for sequential planet formation in transition disks such as HD 100546.
Methods. We compare the recent resolved continuum observations of the disk around HD 100546 with the results of dust evolution simulations using an analytical prescription for the shapes of gaps carved by massive planets.
Results. An inner pressure bump must have been present since early in the disk lifetime to have good agreement between the dust evolution models and the continuum observations of HD 100546. This pressure bump may have resulted from the presence of a very massive planet (∼20 $M_{\rm Jup}$), which formed early in the inner disk ($r \sim 10$ AU). If only this single planet exists, the disk is likely to be old, comparable to the stellar age (∼5–10 Myr). Another possible explanation is an additional massive planet in the outer disk ($r \sim 70$ AU): either a low-mass outer planet ($\lesssim 5$ $M_{\rm Jup}$) injected at early times, or a higher mass outer planet ($\gtrsim 15$ $M_{\rm Jup}$) formed very recently, traps the right amount of dust in pressure bumps to reproduce the observations. In the latter case, the disk could be much younger (∼3.0 Myr).
Conclusions. In the case in which two massive companions are embedded in the disk around HD 100546, as suggested in the literature, the outer companion could be at least $\gtrsim$2.5 Myr younger than the inner companion.

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Structures in circumbinary disks: Prospects for observability

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During the past decade circumbinary disks have been discovered around various young binary stars. Hydrodynamical calculations indicate that the gravitational interaction between the central binary star and the surrounding disk results in global perturbations of the disk density profile.
We study the observability of characteristic large-scale disk structures resulting from the binary-disk interaction in the case of close binary systems.
We derived the structure of circumbinary disks from smoothed-particle hydrodynamic simulations. Subsequently, we performed radiative transfer simulations to obtain scattered light and thermal reemission maps. We investigated the influence of the binary mass ratio, the inclination of the binary orbit relative to the disk midplane, and the eccentricity of the binary orbit on observational quantities.
We find that ALMA will allow tracing asymmetries of the inner edge of the disk and potentially resolving spiral arms if the disk is seen face-on. For an edge-on orientation, ALMA will allow detecting perturbations in the disk density distribution through asymmetries in the radial brightness profile. Through the asymmetric structure of the disks, areas are formed with a temperature 2.6 times higher than at the same location in equivalent unperturbed disks. The time-dependent appearance of the density waves and spiral arms in the disk affects the total re-emission flux of the object by a few percent.

Accepted by Astronomy and Astrophysics

http://dx.doi.org/10.1051/0004-6361/201321770
http://arXiv.org/pdf/1506.04373

Rotation Periods of Young Brown Dwarfs: K2 Survey in Upper Scorpius

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We report rotational periods for 16 young brown dwarfs in the nearby Upper Scorpius association, based on 72 days of high-cadence, high-precision photometry from the Kepler space telescope's K2 mission. The periods range from a few hours to two days (plus one outlier at 5 days), with a median just above one day, confirming that brown dwarfs, except at the very youngest ages, are fast rotators. Interestingly, four of the slowest rotators in our sample exhibit mid-infrared excess emission from disks; at least two also show signs of disk eclipses and accretion in the lightcurves. Comparing these new periods with those for two other young clusters and simple angular momentum evolution tracks, we find little or no rotational braking in brown dwarfs between 1-10 Myr, in contrast to low-mass stars. Our findings show that disk braking, while still at work, is inefficient in the substellar regime, thus provide an important constraint on the mass dependence of the braking mechanism.

Accepted by ApJ Letters

http://arxiv.org/pdf/1506.06771

Collisional modelling of the AU Microscopii debris disc

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The spatially resolved AU Mic debris disc is among the most famous and best-studied debris discs. We aim at a comprehensive understanding of the dust production and the dynamics of the disc objects with in depth collisional modelling including stellar radiative and corpuscular forces. Our models are compared to a suite of observational data for thermal and scattered light emission, ranging from the ALMA radial surface brightness profile at 1.3 mm to polarisation measurements in the visible. Most of the data can be reproduced with a planetesimal belt having an outer edge at around 40au and subsequent inward transport of dust by stellar winds. A low dynamical excitation of the planetesimals with eccentricities up to 0.03 is preferred. The radial width of the planetesimal belt cannot be constrained tightly. Belts that are 5 AU and 17 AU wide, as well as a broad 44 AU-wide belt are consistent with observations. All models show surface density profiles increasing with distance from the star as inferred from observations. The best model is achieved by assuming a stellar mass loss rate that exceeds the solar one by a factor of 50. While the SED and the shape of the ALMA profile are well reproduced, the models deviate from the scattered light data more strongly. The observations show a bluer disc colour and a lower degree of polarisation for projected distances <40 AU than predicted by the models. The problem may be mitigated by irregularly-shaped dust grains which have scattering properties different from the Mie spheres used. From tests with a handful of selected dust materials, we derive a preference for mixtures of silicate, carbon, and ice of moderate porosity. We address the origin

of the unresolved central excess emission detected by ALMA and show that it cannot stem from an additional inner belt alone. Instead, it should derive, at least partly, from the chromosphere of the central star.

Accepted by A&A

http://arxiv.org/pdf/1506.04564

Rapid Dissipation of Protoplanetary Disks in Ophiuchus

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We present the results of an age determination study for pre-main sequence stars in the Ophiuchus molecular cloud. The ages of eight pre-main sequence stars were estimated from surface gravities derived from high-resolution spectroscopy. The average age of the target stars was 0.7 Myr. By comparing the individual age and the near-infrared color excess, we found that color excess decreases gradually with a constant rate and the lifetime of the inner disk was determined to be 1.2 Myr. The estimated lifetime is nearly a half of the time compared to that of the pre-main sequence stars in the Taurus molecular cloud estimated with the same method. This result indicates that the disk evolution timescale depends on the environment of the star-forming region.

Accepted by PASJ

http://arxiv.org/pdf/1506.04363

UV variability and accretion dynamics in the young open cluster NGC 2264

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Photometric variability is a distinctive feature of young stellar objects; exploring variability signatures at different wavelengths provides insight into the physical processes at work in these sources.We explore the variability signatures at ultraviolet (UV) and optical wavelengths for several hundred accreting and non-accreting members of the star-forming region NGC 2264 (∼3 Myr).We performed simultaneous monitoring of u- and r-band variability for the cluster population with CFHT/MegaCam. The survey extended over two full weeks, with several flux measurements per observing night. A sample of about 750 young stars is probed in our study, homogeneously calibrated and reduced, with internally consistently derived stellar parameters. Objects span the mass range 0.1–2 $M_\odot$; about 40% of them show evidence for active accretion based on various diagnostics (H_α, UV, and IR excesses).Statistically distinct variability properties are observed for accreting and non-accreting cluster members. The accretors exhibit a significantly higher level of variability than the non-accretors, in the optical and especially in the UV. The amount of u-band variability is found to correlate statistically with the median amount of UV excess in disk-bearing objects, which suggests that mass accretion and star-disk interaction are the main sources of variability in the u band. Spot models are applied to account for the amplitudes of variability of accreting and non-accreting members, which yields different results for each group. Cool magnetic spots, several hundred degrees colder than the stellar photosphere and covering from 5 to 30% of the stellar surface, appear to be the leading factor of variability for the non-accreting stars. In contrast, accretion spots with a temperature a few thousand degrees higher than the photospheric temperature and that extend over a few percent of the stellar surface best reproduce the variability of accreting objects. The color behavior is also found to be different between accreting and non-accreting stars. While objects commonly become redder when fainter, typical amplitudes of variability for accreting members rapidly increase from the r to the u band, which indicates a much stronger contrast at short wavelengths; a lower color dependence in the photometric amplitudes is instead measured for diskless stars. Finally, we compare the u-band variability monitored here on two-week timescales with that measured on both shorter (hours) and longer (years) timescales. We find that variability on timescales of hours is typically ~10% of the peak-to-peak variability on day timescales, while longer term variability on a timescale of years is consistent with amplitudes measured over weeks.We conclude that for both accreting and non-accreting stars, the mid-term rotational modulation by hot and cold spots is the leading timescale for a variability of up to several years. In turn, this suggests that the accretion process is essentially stable over years, although it exhibits low-level shorter term variations in single accretion events.

Accepted by Astronomy & Astrophysics

http://arxiv.org/pdf/1506.06858

A deep near-infrared survey toward the Aquila molecular cloud - I. Molecular hydrogen outflows

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We have performed an unbiased deep near-infrared survey toward the Aquila molecular cloud with a sky coverage of ~1 deg^2. We identified 45 molecular hydrogen emission-line objects (MHOs), of which only 11 were previously known. Using the Spitzer archival data we also identified 802 young stellar objects (YSOs) in this region. Based on the morphology and the location of MHOs and YSO candidates, we associate 43 MHOs with 40 YSO candidates. The distribution of jet length shows an exponential decrease in the number of outflows with increasing length and the molecular hydrogen outflows seem to be oriented randomly. Moreover, there is no obvious correlation between jet lengths, jet opening angles, or jet H_2 1–0 $S(1)$ luminosities and spectral indices of the possible driving sources in this region. We also suggest that molecular hydrogen outflows in the Aquila molecular cloud are rather weak sources of turbulence, unlikely to generate the observed velocity dispersion in the region of survey.

Accepted by ApJS

http://arxiv.org/pdf/1506.08372

Submm Observations of Massive Star Formation in the Giant Molecular Cloud NGC 6334 : Gas Kinematics with Radiative Transfer Models

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Ph.D dissertation directed by: Prof. Dr. Peter Schilke

Ph.D degree awarded: May 2015

Context. How massive stars (M >8 Ms) form and how they accrete gas is still an open research field, but it is known that their influence on the ISM is immense. Star formation involves the gravitational collapse of gas from scales of GMCs down to dense HMCs. Thus, it is important to understand the mass flows and kinematics in the ISM.
Aims. This dissertation focuses on the detailed study of the region NGC 6334, located in the Galaxy at a distance of 1.7 kpc. It is aimed to trace the gas velocities in the filamentary, massive star-forming region NGC 6334 at several scales and to explain its dynamics. For that purpose, different scales are examined from 0.01–10 pc to collect information about the density, molecular abundance, temperature and velocity, and consequently to gain insights about the physio-chemical conditions of molecular clouds. The two embedded massive protostellar clusters NGC 6334I and I(N), which are at different stages of development, were selected to determine their infall velocities and mass accretion rates.
Methods. This source was surveyed by a combination of different observatories, namely with the SMA, APEX, and Herschel. It was mapped with APEX in 13CO(J=2–1) at 220 GHz to study the filamentary structure and turbulent kinematics on the largest scales of 10 pc. The line profiles are decomposed by Gaussian fitting and a dendrogram algorithm is applied to distinguish velocity-coherent structures and to derive statistical properties. The velocity gradient method is used to derive mass flow rates. The main filament was mapped with APEX in HCO+,J=3–2 at 268 GHz to trace the dense gas. To reproduce the position-velocity diagram, a cylindrical model with the radiative transfer code `LIME` is created with a collapsing velocity field. Both clusters NGC 6334I and I(N) were observed with SMA in HCN(J=4–3) at 355 GHz at the smallest scales of 0.01 pc. The combination of interferometric and multi-frequency single-dish data gives a wide range of rotational transitions, tracing radii of a HMC from 1.0–0.01 pc by a range of level energies (E_u=4–1067 K) and optical depths (τ=100–0.1). The HMC spectra are analyzed by using 1D (`myXCLASS`) and 3D numerical radiative transfer codes (`RADMC-3D` and `LIME`) in and outside of LTE. Multiple components and the fragmentation of the clusters are modeled with these tools. Together with the optimization package `MAGIX`, the data are compared and reproduced with synthetic maps and spectra from these models.
Results. 1. The main filament shows a velocity gradient from the end toward its center, where the most massive clumps accumulate at both ends, in accordance to predictions of a longitudinal contraction. The 3D structure is determined by taking the inclination and curvature of the filament into account, and the free-fall time is estimated to ∼1 Myr; 2. The total gas mass is 2.3E5 Ms and the average temperature 20 K. The majority of the velocity gradients are aligned with the magnetic field, which runs perpendicular to the filaments. The calculation of the average Mach numbers yields a turbulence which is super-sonic ($M_{\rm S}$=5.7) and sub-Alfvénic ($M_{\rm A}$=0.86).The derived scaling relations are in agreement with Larson's relations. 3. The SMA observations reveal multiple bipolar molecular outflows, blue asymmetric infall profiles, rotating cores and an UC HII region in NGC 6334I which affects the surrounding gas. The average mass accretion rates are 1E-3 Ms/yr for the envelopes and 3E-4 Ms/yr for the cores, where the latter are derived from modified Bondi-Hoyle models. The orientation of the magnetic field is in NGC 6334I(N) consistent over all scales and most outflows are aligned perpendicular to it.
Conclusions. The combination of single-dish with interferometric data is helpful to constrain the parameter space of a model. The envelope hinders the determination of infall velocities in HMCs via line profiles. Systematic motions as a result of gravitational attraction are difficult to find because of the turbulent nature of the ISM. The magnetic field energy in NGC 6334 is as important as the kinetic energy and regulates partly the direction of the inflowing gas and thus the geometry and collapse of the molecular clouds. NGC 6334 is heavily affected by the HII regions (produced by the OB stars), and the free-fall time and mass surface density suggest that it classifies as a starburst system.

http://kups.ub.uni-koeln.de/6138/

New Jobs

Tenure Track Position in Star Formation Astrophysics at Instituto de Astronomia, UNAM, Mexico

DEADLINE: September 30th 2015 for April 2016 start date

The Instituto de Astronomia of the Universidad Nacional Autonoma de Mexico (IA-UNAM) has an opening for a tenure track junior faculty position in Astrophysics, at its branch in Ensenada, B.C. in Star Formation Astrophysics.

A background in the study of star formation, ionized regions and the interstellar medium is preferred. Experience in optical, infrared, sub- millimeter and millimeter wavelength observations and projects, and knowledge or participation in instrumentation projects and the handling of large data sets and parallel computing will be valuable assets.

Applicants should hold a Ph.D. degree in Astronomy or Physics, and have at least two years of Postdoctoral experience. Preference will be given to candidates less than 40 years old by the start date. Mexican citizens are particularly encouraged to apply.

The main selection criteria will be outstanding research accomplishments and promise of future achievements. Faculty members are expected to carry out original research, collaborate with fellow members and must teach Astronomy and/or Physics courses at the graduate and/or undergraduate level, as well as mentor students.

Institute members have access to Observatorio Astronomico Nacional in San Pedro Martir (OAN-SPM), Baja California, which is operated and maintained by the Instituto de Astronomia. Astronomers at Mexican institutions can compete for the Mexican share of observing time on the 10.4-m Gran Telescopio Canarias (GTC), the Large Millimeter Telescope (LMT), and also have competitive access to the EVLA, the VLBA, and to ALMA, via collaboration with the USA National Radio Astronomy Observatory. The Institute is a member of the Transneptunian Automated Occultation Survey-II (TAOS-II) which is being constructed at OAN-SPM, the HAWC (High Altitude Water Cerenkov) Observatory and the Cerenkov Telescope Array collaboration, as well as a funding partner of the Sloan Digital Sky Survey, which executes the SDSS-IV. The Institute has extensive computing facilities of its own and members have access to general UNAM supercomputers.

Members of the Institute conduct research in most major astronomical and astrophysical fields. Candidates are encouraged to contact individual faculty members to explore potential collaborations as well as review the facilities and instrumentation at the OAN-SPM to identify research opportunities at the site.

Candidates must send a complete Curriculum Vitae, including a full list of publications, a statement of previous experience, research and teaching interests, and a statement of collaborative integration within the Institute, and arrange for three letters of recommendation to be sent to Dr. Leonardo Sanchez at the IA-UNAM (leonardo@astro.unam.mx) by September 30th 2015.

Candidates are expected to be able to begin no later than April 2016. Unsigned material can be sent by e-mail; letters can be sent by e-mail (scanned) or by courier. Please do not use regular post mail.

Inquiries can be made by email to leonardo@astro.unam.mx Additional information can be found at:

http://www.astroscu.unam.mx/job_ia

http://www.astrosen.unam.mx

http://www.astrossp.unam.mx

INCLUDED BENEFITS
Salary and benefits are competitive with international standards. Health insurance is provided by UNAM.

Meetings

Star Formation 2016

University of Exeter

21-26 August 2016

A Preliminary Announcement

The University of Exeter in the southwest of England will host an international conference devoted to star formation.

Our aim is to bring the community together to discuss and consolidate the results of large scale surveys and prepare for the era of targeted, high-resolution exploitation of this knowledge. Equal emphasis will be placed on theoretical and numerical research, with a particular focus on the interface between observations and theory.

The scope of the 5-day programme will cover GMC formation, cloud structure and filaments, core formation, accretion and outflow processes, emergent stellar populations and the IMF, discs across the mass spectrum, finishing with structured discs as signatures of planet formation.

To receive announcements and updates please register your interest via the website below.

Website: http://www.astro.ex.ac.uk/sf2016

e-mail: sf2016@astro.ex.ac.uk

Facebook: https://www.facebook.com/groups/starformation2016/

Twitter: https://twitter.com/sf2016_exeter

Scientific Organising Committee

Philippe André, CEA-Saclay, France
Crystal Brogan, NRAO, USA
Chris Brunt, University of Exeter, UK
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Tim Harries, University of Exeter, UK
Lynne Hillenbrand, Caltech, USA
Shu-ichiro Inutsuka, Nagoya University, Japan
John Monnier, University of Michigan, USA

Conference organisers: Chris Brunt & Tim Harries

Protoplanetary Discussions

7th - 11th March 2016
John McIntyre Conference Centre, Edinburgh, UK

Recent observations of protoplanetary discs revealed intriguing and frequent non-symmetric structures including spiral arms, gaps and rings, holes, and warps. These structures are detected in the gas and dust, in scattered light and thermal emission. Identifying their nature, whether they are caused by disc-planet interactions or by other physical processes remains challenging and controversial.

In this conference, we invite observers from all wavelength regimes to share their latest results with modellers from the thermo-chemical and hydrodynamic communities in order to foster collaboration across this exciting and rapidly expanding field. What observational quantities are essential to constrain the models? How can models help to guide future observational campaigns? What do different wavelength regimes reveal? What are the possible interpretations from hydrodynamic, chemical and radiative transfer modelling? What are the signposts for planet formation?

The conference will consist of invited/contributed talks and posters sessions, but will also include time for participant-led open discussion and collaboration sessions, with the goal of exploring common ground between the communities and discovering new avenues for investigation.

SOC members are Peter Woitke (St Andrews, UK, chair); Ken Rice (Edinburgh, UK); Francois Menard (IPAG, Grenoble, FR); Rens Waters (Amsterdam, NL); Karin Oeberg (CfA, USA); Antonella Natta (DIAS, IE); Eric Herbst (Virginia, USA) and Gregory Herczeg (KIAA/Peking University, CN).

LOC members are John Ilee (St Andrews, UK, chair); Ken Rice (Edinburgh, UK); Peter Woitke (St Andrews, UK); Duncan Forgan (St Andrews, UK) and Cassandra Hall (Edinburgh, UK)

Social activities will include arrival welcome drinks, a conference dinner in the historic Playfair Library Hall, a whisky tasting evening, and a choice of various excursions to historic sites around Edinburgh and a whisky distillery.

Detailed information is available on our website: http://www-star.st-and.ac.uk/ppdiscs

Please send any queries to: ppdiscs@st-andrews.ac.uk

Early bird registration and abstract submission will be opened in mid-July 2015. A limited amount of financial support will be available for students and young researchers.

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.

STAR FORMATION IN DIFFERENT ENVIRONMENTS

Quy Nhon, Viet Nam
25 - 29 July, 2016

This is the first conference in star formation in Vietnam. The last few years have changed drastically the landscape of star formation research, thanks to the successful operations of Herschel Space Observatory, ALMA, JCMT, PdBI, IRAM 30m, SMA...and the new development in numerical simulations and theory. We aim at to bringing together theorists and observers working on star formation, who would address the most recent advances in our knowledge of filament, core, cloud evolution and their interconnection. The conference will target to all aspects of star formation, including low-mass star formation, massive star formation, filamentary structure, giant molecular clouds, and galaxy-scale star formation. The workshop also aims at fostering close collaboration via smaller size focus groups.

The meeting consists of several invited talks (25min including 5min for Q&A), contributed talk (15min including 5min for Q&A), and posters. Selection of contributed talks will be done by the SOC by the end of May 2016. There will be time for focus group meetings and a half-day excursion. For young astronomers from developing countries, there will be also two days star formation bootcamp prior to the conference which cover fundamental knowledge of star formation.

SCIENTIFIC ORGANIZING COMMITTEE:

Philippe Andreé (CEA, FR)

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NOTE: Website will be announced later

Summary of Upcoming Meetings

From Interstellar Clouds to Star-forming Galaxies: Universal Processes?
3 - 7 August 2015 http://astronomy2015.org/symposium_315

Cosmic Dust
17 - 21 August 2015 Tokyo, Japan
https://www.cps-jp.org/~dust/

6th Zermatt ISM Symposium: Conditions and Impact of Star Formation - From Lab to Space
7 - 11 September 2015 Zermatt, Switzerland
http://www.astro.uni-koeln.de/zermatt2015

Cloudy Workshop
21 - 26 September 2015 Pune, India
http://cloud9.pa.uky.edu/?gary/cloudy/CloudySummerSchool/

From Clouds to Protoplanetary Disks: the Astrochemical Link
5 - 8 October 2015 Berlin, Germany
https://cas-events.mpe.mpg.de/astrolink

Exchanging Mass, Momentum and Ideas: Connecting Accretion and Outflows in Young Stellar Objects
27 - 29 October 2015 Noordwijk, The Netherlands
http://www.cosmos.esa.int/web/accretion-outflow-workshop

Extreme Solar Systems III 29 November - 4 December 2015 Hawaii, USA
http://ciera.northwestern.edu/Hawaii2015.php

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/

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

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

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

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

Short Announcements

‘*An Introduction to Star Formation*’ now out in paperback

The popular and highly-acclaimed text-book ‘*An Introduction to Star Formation*’ by Ward-Thompson and Whitworth is now out in paperback. For more details, see:

http://www.cambridge.org/gb/academic/subjects/astronomy/astrophysics/introduction-star-formation?format=PB

For reviews of the text-book, see:

http://www.cambridge.org/us/academic/subjects/astronomy/astrophysics/introduction-star-formation

The book won an ‘Outstanding Academic Title Award’ for 2012 from US on-line text-book reviewer service ‘Choice’.

It is suitable for final year undergraduate courses, Masters courses, or first-year PhD level.