THE STAR FORMATION NEWSLETTER

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

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The Star Formation Newsletter

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

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Cover Picture

NGC 2071 is a reflection nebula in the L1630 cloud in Orion, and illuminated by the B2-B3 star HD 290861 that also excites a small HII region. The region is at a distance of about 400 pc. The cluster of nebulae to the upper right surrounds the embedded source NGC 2071 IR. The image is an excerpt from a panoramic image obtained by ESO's Visible and Infrared Survey Telescope for Astrophysics (VISTA). North is up and east is left.

Image courtesy ESO.

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

Marina Romanova

in conversation with Bo Reipurth

Q: *Your earliest work deals with inelastic collisions of stars in dense rotating star clusters. How did you pick that subject?*

A: In the late 1970's, when I studied at the Moscow State University, many scientists were fascinated with cosmology, black holes and neutron stars, quasars, active galactic nuclei and X-ray binaries. Academician Zeldovich led a very active and popular astrophysics seminar at the astronomical institute (GAISH) on Thursdays. The scientific atmosphere was extremely dynamic, and many new theories were reported. I remember very complex talks on cosmology, relativity, gravitational waves and black holes. I tried to get good grades so as to be accepted into Zeldovich's group and I succeeded. I worked mainly with Drs. Bisnovatyi-Kogan and Illarionov.

I was intrigued by quasars and was particularly interested in the question of how massive black holes form so rapidly (quasars are relatively young objects) in the centers of galaxies. This is, why for my Thesis, I decided to check whether black holes could form in dense stellar clusters, where stars collide inelastically and release gas which may form a black hole. Soon, I realized that, in the presence of angular momentum, the released gas forms a disk, which is unstable to star formation. It is interesting to note that star formation was not a fashionable topic around me back then, but I ended up working on this topic for my thesis by accident. We studied gaseous disks and the formation of stars in these extraordinary environments, and concluded that the disks break up into stars of relatively small masses. It was interesting to see the formation of these "boring" low-mass stars in the centers of extremely dense clusters! In 1987 there was an international meeting in Czechoslovakia (Prague) on stellar clusters. As a young scientist, a recent PhD, I wanted to go there very much. However, I did not get permission to go. At that time, only a few people were permitted to go abroad.

The next step would have been to model dense stellar clusters using numerical simulations. However, computers were not powerful enough back then to model such complex systems. This is why I started learning about different properties of quasars and AGNs. In particular, I was fascinated with jets. The main question was: if quasars and AGNs are associated with massive black holes, then why does matter in jets move out of them at high, relativistic velocities ? I checked the literature, but found that people mainly discussed and modeled propagation of hydrodynamic jets and formation of shocks. Finally, I found a promising mechanism for the formation of jets: a magnetic mechanism, where a large-scale magnetic field threading the accretion disk of a black hole acts to convert the rotational energy of the disk matter into high velocity jets. This mechanism has been proposed by Richard Lovelace and Roger Blandford in 1976.

Q: *Back in 1992, you and Richard Lovelace studied models of extragalactic jets in which the jet magnetic field is dragged out from the central rotating source. This paper is increasingly cited in recent years, how does it relate to current research?*

A: In 1990, I participated in a plasma astrophysics meeting in Telavi (Soviet Georgia back then). I did not know most of the people there and many topics were not of interest to me. However, Richard Lovelace was there, and we began discussing magnetic jets and started a collaboration. Richard is very personable and it was a pleasure to learn from him different aspects of plasma astrophysics. At the Moscow State University, I received a good background in different areas of astronomy. However, plasma astrophysics was not a popular subject back then. Our first paper was on the mechanism of collisionless reconnection, which we studied using numerical simulations. I performed the simulations at a PC 386 computer - the only personal computer in our department at the Space Research Institute (IKI) where I worked. The computer was occupied during the day time, so I used it at night. It was amazing to see particles accelerating in the neutral layer which formed between the layers of plasma threaded by oppositely-directed magnetic field. I should note that at my institute (IKI), many people have worked and continue working on the details of the Earth's magnetosphere, including plasma flow around the magnetosphere, and the reconnection of the magnetic field lines in the magnetotail. Looking at their research, I realized that astrophysicists were much behind in their understanding of the plasma processes in different astronomical objects, and that plasma astrophysics is an important research field.

Next, we worked on a model of extragalactic jets where the dipole-shaped magnetic field lines threading the central object and the disk inflate (due to the differential rotation of the foot-points of the field), and extended regions of the neutral layer form between plasmas with an oppositely-directed magnetic field. We investigated the acceleration of particles in jets due to reconnection. The idea of inflation of loop-shaped field lines was originally proposed by P.A. Sturrock and by J.J. Aly to explain solar flares. This idea of inflation strongly influenced our subsequent research.

In 1995, we published a somewhat revolutionary paper (with Lovelace and Bisnovatyi-Kogan) where the central idea was the inflation of the field lines in disk-accreting magnetized stars. Earlier, Max Camenzind (1990) and Frank Shu (1989, 1994) suggested partial inflation of the field lines. However, the importance of inflation has not been stressed, and many people continued using models where the field lines do not change their dipole shape, as in the models of Ghosh & Lamb (1978). After our paper came out, the approach towards the disk-magnetosphere interaction had changed: people started to consider inflation in theoretical studies and also observed it in the first axisymmetric magnetohydrodynamic (MHD) simulations of magnetized stars. Anthony Goodson and collaborators observed inflation up to large distances from the star and also observed outflows along inflated field lines. In other research (Hayashi et al. 1996) it has been shown that the reconnection during inflation may lead to acceleration of matter to the wind.

We were interested in the numerical modeling of different processes in astrophysics. However, such modeling required complex numerical codes, which were still under development in the early 1990s. This is why we started a collaboration with two mathematicians from Russia, at the Keldysh Institute of Applied Mathematics in Moscow, Galina Ustyugova and Alexander Koldoba. They developed one of the first Godunov-type MHD codes. With these codes, we started modeling magneto-centrifugally-driven winds from accretion disks, and performed the first steps in the modeling of plasma accretion onto rotating magnetized stars.

Q: *After you moved to USA, you and your collaborators turned to studying disk accretion onto a rotating star with a dipole magnetic field, which of course is highly relevant for funnel flows to T Tauri stars.*

A: When I moved to the USA, we continued working on magnetically driven winds from accretion disks. At the same time, we started modeling accretion onto rotating magnetized stars, such as T Tauri stars. For this, we used a special three-dimensional code based on the cubed sphere grid developed by Alexander Koldoba in 2002. We were able to tilt the magnetic axis and modeled accretion onto a star with a tilted dipole magnetic field. Initially, the code had not been parallelized yet, the grid was very coarse, and a simple PC computer was used. I adjusted the parameters of the problem so as to see magnetospheric accretion sooner. I was shocked and excited when I observed accretion in two ordered funnel streams in full three dimensions, for the first time! I realized that this was a very important first step in the modeling of T Tauri stars. I was aware of multiple observations of T Tauri stars by many observers, performed at different telescopes around the globe during many nights, years and decades. I knew about the heroic efforts of observers, who monitored the light curves of these stars in hope that in the future these light curves will help understand these stars. Now, I had this tool at hand and felt a responsibility to study T Tauri stars numerically with this "numerical telescope". Later, we developed a parallel version of the code, used finer grids, etc., and found many interesting features relevant to the magnetospheric accretion onto stars with dipole and more complex fields.

Q: *Through magnetohydrodynamic simulations you have explored the so-called 'propeller regime'. How does accretion differ from a weak to a strong propeller regime?*

A: If the magnetosphere of a star rotates more rapidly than the inner disk, then the star is in the propeller regime. If the magnetosphere rotates much more rapidly than the inner disk, then we call it the "strong" propeller regime. If the magnetosphere rotates only slightly faster than the inner disk, then we call it the "weak" propeller regime. In our prior papers we studied both regimes, but most of the results were shown for the strong propeller regime. During the last couple of years we have studied the properties of strong and weak propellers more systematically, and a paper will be submitted soon (with Blinova, Ustyugova, Koldoba, Lovelace). Here, I briefly summarize the differences between the two regimes: in the strong propeller regime, a significant part of the inner disk matter is redirected into conically-shaped winds from the inner disk. In addition, the stellar field lines are twisted rapidly, giving rise to the magnetically-dominated (Poynting flux) jet, in which a small amount of matter is accelerated rapidly by the magnetic force. In the weak propeller regime, matter also flows into the conically-shaped wind, but the velocities are usually lower than the escape velocity, and the cone has a large opening angle. Most of this matter accretes onto the star. The magnetic jet does not form. In both the strong and weak regimes, accretion is blocked by the centrifugal barrier most of the time, so that matter accretes onto the star during brief episodes. Accretion usually becomes more favorable when the inner disk moves closer to the star. The details of accretion strongly depend on the diffusivity at the disk-magnetosphere boundary, which is determined by instabilities.

Q: *In subsequent papers, you and your collaborators have studied the role of a stellar misaligned dipole magnetic field. How important is this misalignment for the resulting system?*

A: In our simulations we observed that, at a large misalignment angle $\Theta > 20° - 30°$, matter flows onto the star in two ordered funnel streams, and forms two hot spots on the stellar surface which are located at some definite azimuthal positions. The rotation of the star provides ordered sinusoidal light curves. However, if the tilt of the dipole is small, $\Theta \sim 5°$, then another, unstable regime of accretion has been observed, where matter penetrates through the magnetosphere in "tongues" due to the magnetic Rayleigh-Taylor instability, forming hot spots at random places on the star. The resulting light curve looks irregular. Subsequent analyses have shown that this instability is stronger when the star rotates more slowly. Detailed analyses of the light curves have shown that these unstable tongues often rotate with the frequency of the inner disk, and this frequency can sometimes be seen in the power spectra. In the cases of large misalignment angles (and slowly rotating stars), accretion through instabilities is also present. However, magnetospheric accretion in two funnel streams and the sinusoidal signal in the light curves dominates over the irregular component associated with unstable accretion. The properties of stars in stable and unstable regimes have been studied in collaboration with A. Kulkarni and R. Kurosawa.

Q: *In your numerical simulations you have discovered what you call conical winds. What are the similarities and differences to X-winds?*

A: Both conical and X-winds form at the disk-magnetosphere boundary when the magnetic flux is compressed by the disk. However, in the model of X-winds (Shu et al. 1994), it is required that the inner disk should corotate with the magnetosphere. It is suggested that the main force driving matter into the winds is the centrifugal force, as in the case of the propeller regime. However, in the conical winds model, a star may rotate much more slowly than the inner disk, because the main driving force is the magnetic force resulting from the winding of the magnetic field lines threading the inner disc. Conical winds are expected, for example, when the accretion rate is enhanced due to some instability. Other differences are the following: matter in the conical winds flows into a relatively narrow conically-shaped shell, while in the X-winds it has a variety of ejection angles; conical winds gradually collimate due to the magnetic force, while X-winds do not collimate.

Q: *Your simulations show that disks can be warped by the magnetosphere of the star. How do models and observations compare?*

A: A star with a tilted dipole magnetic field exerts magnetic force on the matter of the inner disk, causing it to lift above the equatorial plane (forming a warp). This mechanism was understood theoretically in the 1970s (Aly 1978, Lipunov 1978). It has been further developed more recently (e.g., Lai 1999, Terquem 2000). On the other hand, observations of the T Tauri star AA Tau have shown regular dips in the light curve, which have been interpreted as possible obscuration by a warp (Bouvier et al. 1997). Our 3D simulations have confirmed the formation of warps. They have also shown that the warp is not homogeneous and, depending on the density, the dips in the light curve can be wide or narrow. Very narrow dips were recently observed by the *MOST* and *Kepler* telescopes and were interpreted as some kind of warps (Stauffer et al. 2015). Our model can explain dips of different widths.

Q: *Your models allow an interpretation of the accretion-induced variability of young stars. What are the key insights you can derive from comparison with time-series photometry of T Tauri stars?*

A: Comparison of our 3D models with the time-series photometry of T Tauri stars may provide us with information about the properties of these stars. Recent analysis of the light curves, provided by the *MOST* and *Kepler* instruments have shown that the light curves can be periodic, irregular, or AA Tau type; the main features in the light curves usually have the shapes of bursts or dips (e.g., S. Alencar, J. Stauffer, A. M. Cody).

Our models of accreting T Tauri stars also provide us with different types of light curves, which can reproduce the main observational features. In our recent work (with A. Blinova and other collaborators), we selected two main parameters of the system which determine the main properties of modeled stars: the tilt of the dipole Θ and the fastness parameter, $\omega_s = \Omega_\star/\Omega_{\rm disk}$. Accretion becomes systematically more stable (and the light curves are more sinusoidal) with increase of both, Θ and ω_s (up to $\omega_s \sim 1$). At smaller values of Θ and ω_s, accretion becomes more irregular, and more irregular light curves are expected.

Simulations also show that significant warps form around stars with sufficiently large misalignment angle of the dipole, $\Theta > 15°$ and at condition $\omega_s \approx 1$. If the magnetosphere rotates much slower or faster than the inner disk, then the warp does not form. These conditions restrict properties of stars with AA Tau type light curves.

In the propeller regime ($\omega_s > 1$) the accretion onto a star is blocked during a number of stellar rotations, and matter accretes in rare bursts. To observe these bursts, one requires long-term uninterrupted monitoring of T Tauri stars with some ground-based robotic telescopes. Such long-term monitoring would also help to analyze the irregular and quasi-periodic oscillations observed in the unstable regimes of accretion.

Abstracts of recently accepted papers

Protoplanetary and Transitional Disks in the Open Stellar Cluster IC 2395

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We present new deep UBVRI images and high-resolution multi-object optical spectroscopy of the young (∼6–10 Myr old), relatively nearby (800 pc) open cluster IC 2395. We identify nearly 300 cluster members and use the photometry to estimate their spectral types, which extend from early B to middle M. We also present an infrared imaging survey of the central region using the IRAC and MIPS instruments on board the Spitzer Space Telescope, covering the wavelength range from 3.6 to 24 μm. Our infrared observations allow us to detect dust in circumstellar disks originating over a typical range of radii ∼0.1 to ∼10AU from the central star. We identify 18 Class II, 8 transitional disk, and 23 debris disk candidates, respectively 6.5%, 2.9%, and 8.3% of the cluster members with appropriate data. We apply the same criteria for transitional disk identification to 19 other stellar clusters and associations spanning ages from ∼1 to ∼18 Myr. We find that the number of disks in the transitional phase as a fraction of the total with strong 24 μm excesses ($[8] - [24] > 1.5$) increases from 8.4±1.3% at ∼3 Myr to 46±5% at ∼10 Myr. Alternative definitions of transitional disks will yield different percentages but should show the same trend.

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http://arxiv.org/pdf/1609.05798

Star formation around mid-infrared bubble N37: Evidence of cloud-cloud collision

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We have performed a multi-wavelength analysis of a mid-infrared (MIR) bubble N37 and its surrounding environment. The selected $15' \times 15'$ area around the bubble contains two molecular clouds (N37 cloud; V_{lsr} ∼37–43 km s^{-1}, and C25.29+0.31; V_{lsr} ∼43–48 km s^{-1}) along the line of sight. A total of seven OB stars are identified towards the bubble N37 using photometric criteria, and two of them are spectroscopically confirmed as O9V and B0V stars. Spectro-photometric distances of these two sources confirm their physical association with the bubble. The O9V star is appeared to be the primary ionizing source of the region, which is also in agreement with the desired Lyman continuum flux analysis estimated from the 20 cm data. The presence of the expanding HII region is revealed in the N37 cloud which could be responsible for the MIR bubble. Using the ^{13}CO line data and photometric data, several cold molecular condensations as well as clusters of young stellar objects (YSOs) are identified in the N37 cloud, revealing ongoing star formation (SF) activities. However, the analysis of ages of YSOs and the dynamical age of the HII region do not support the origin of SF due to the influence of OB stars. The position-velocity analysis of ^{13}CO data reveals that two molecular clouds are inter-connected by a bridge-like structure, favoring the onset of a cloud-cloud collision process. The SF activities (i.e. the formation of YSOs clusters and OB stars) in the N37 cloud are possibly influenced by the cloud-cloud collision.

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http://arxiv.org/pdf/1609.06440.pdf

Hydrocarbon emission rings in protoplanetary disks induced by dust evolution

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We report observations of resolved C_2H emission rings within the gas-rich protoplanetary disks of TW Hya and DM Tau using the Atacama Large Millimeter Array (ALMA). In each case the emission ring is found to arise at the edge of the observable disk of mm-sized grains (pebbles) traced by (sub)mm-wave continuum emission. In addition, we detect a C_3H_2 emission ring with an identical spatial distribution to C_2H in the TW Hya disk. This suggests that these are hydrocarbon rings (i.e. not limited to C_2H). Using a detailed thermo-chemical model we show that reproducing the emission from C_2H requires a strong UV field and $C/O > 1$ in the upper disk atmosphere and outer disk, beyond the edge of the pebble disk. This naturally arises in a disk where the ice-coated dust mass is spatially stratified due to the combined effects of coagulation, gravitational settling and drift. This stratification causes the disk surface and outer disk to have a greater permeability to UV photons. Furthermore the concentration of ices that transport key volatile carriers of oxygen and carbon in the midplane, along with photochemical erosion of CO, leads to an elemental C/O ratio that exceeds unity in the UV-dominated disk. Thus the motions of the grains, and not the gas, lead to a rich hydrocarbon chemistry in disk surface layers and in the outer disk midplane.

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http://arxiv.org/pdf/1609.06337

The HI/OH/Recombination line survey of the inner Milky Way (THOR): Survey overview and data release 1

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Context: The past decade has witnessed a large number of Galactic plane surveys at angular resolutions below $20''$. However, no comparable high-resolution survey exists at long radio wavelengths around 21cm in line and continuum emission.
Methods: Employing the Very Large Array (VLA) in the C-array configuration and a large program, we observe the HI 21cm line, four OH lines, nineteen Hα radio recombination lines as well as the continuum emission from 1 to 2GHz in full polarization over a large part of the first Galactic quadrant.
Results: Covering Galactic longitudes from 14.5 to 67.4deg and latitudes between $\pm$1.25deg, we image all of these lines and the continuum at $\sim 20''$ resolution. These data allow us to study the various components of the interstellar medium (ISM): from the atomic phase, traced by the HI line, to the molecular phase, observed by the OH transitions, to the ionized medium, revealed by the cm continuum and the Hα radio recombination lines. Furthermore, the polarized continuum emission enables magnetic field studies. In this overview paper, we discuss the survey outline and present the first data release as well as early results from the different datasets. We now release the first half of the survey; the second half will follow later after the ongoing data processing has been completed. The data in fits format (continuum images and line data cubes) can be accessed through the project web-page http://www.mpia.de/thor.
Conclusions: The HI/OH/Recombination line survey of the Milky Way (THOR) opens a new window to the different parts of the ISM. It enables detailed studies of molecular cloud formation, conversion of atomic to molecular gas, and feedback from HII regions as well as the magnetic field in the Milky Way. It is highly complementary to other surveys of our Galaxy, and comparing different datasets allows us to address many open questions.

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http://www.mpia.de/homes/beuther/papers.html and http://www.mpia.de/thor

The disappearing act: A dusty wind eclipsing RW Aur

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RW Aur is a young binary star that experienced a deep dimming in 2010-11 in component A and a second even deeper dimming from summer 2014 to summer 2016. We present new unresolved multi-band photometry during the 2014-16 eclipse, new emission line spectroscopy before and during the dimming, archive infrared photometry between 2014-15, as well as an overview of literature data.
Spectral observations were carried out with the Fibre-fed RObotic Dual-beam Optical Spectrograph on the Liverpool Telescope. Photometric monitoring was done with the Las Cumbres Observatory Global Telescope Network and James Gregory Telescope. Our photometry shows that RW Aur dropped in brightness to R = 12.5 in March 2016. In addition to the long-term dimming trend, RW Aur is variable on time scales as short as hours. The short-term variation is

most likely due to an unstable accretion flow. This, combined with the presence of accretion-related emission lines in the spectra suggest that accretion flows in the binary system are at least partially visible during the eclipse.
The equivalent width of [O I] increases by a factor of ten in 2014, coinciding with the dimming event, confirming previous reports. The blue-shifted part of the $H\alpha$ profile is suppressed during the eclipse. In combination with the increase in mid-infrared brightness during the eclipse reported in the literature and seen in WISE archival data, and constraints on the geometry of the disk around RW Aur A we arrive at the conclusion that the obscuring screen is part of a wind emanating from the inner disk.

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Late veneer and late accretion to the terrestrial planets

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It is generally accepted that silicate-metal ('rocky') planet formation relies on coagulation from a mixture of sub-Mars sized planetary embryos and (smaller) planetesimals that dynamically emerge from the evolving circum-solar disc in the first few million years of our Solar System. Once the planets have, for the most part, assembled after a giant impact phase, they continue to be bombarded by a multitude of planetesimals left over from accretion. Here we place limits on the mass and evolution of these planetesimals based on constraints from the highly siderophile element (HSE) budget of the Moon. Outcomes from a combination of N-body and Monte Carlo simulations of planet formation lead us to four key conclusions about the nature of this early epoch. First, matching the terrestrial to lunar HSE ratio requires either that the late veneer on Earth consisted of a single lunar-size impactor striking the Earth before 4.45 Ga, or that it originated from the impact that created the Moon. An added complication is that analysis of lunar samples indicates the Moon does not preserve convincing evidence for a late veneer like Earth. Second, the expected chondritic veneer component on Mars is 0.06 weight percent. Third, the flux of terrestrial impactors must have been low ($\leq 10^{-6}$ $M_\oplus$ Myr^{-1}) to avoid wholesale melting of Earth's crust after 4.4 Ga, and to simultaneously match the number of observed lunar basins. This conclusion leads to an Hadean eon which is more clement than assumed previously. Last, after the terrestrial planets had fully formed, the mass in remnant planetesimals was $\sim 10^{-3}$ $M_\oplus$, lower by at least an order of magnitude than most previous models suggest. Our dynamically and geochemically self-consistent scenario requires that future N-body simulations of rocky planet formation either directly incorporate collisional grinding or rely on pebble accretion.

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The Massive Protostellar Cluster NGC6334I at 220 AU Resolution: Discovery of Further Multiplicity, Diversity and a Hot Multi-Core

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We present VLA and ALMA imaging of the deeply-embedded protostellar cluster NGC6334I from 5 cm to 1.3 mm at angular resolutions as fine as 0.″17 (220 AU). The dominant hot core MM1 is resolved into seven components at 1.3 mm, clustered within a radius of 1000 AU. Four of the components have brightness temperatures > 200 K, radii ~ 300 AU, minimum luminosities $\sim 10^4\ L_\odot$, and must be centrally heated. We term this new phenomenon a "hot multi-core". Two of these objects also exhibit compact free-free emission at longer wavelengths, consistent with a hypercompact HII region (MM1B) and a jet (MM1D). The spatial kinematics of the water maser emission centered on MM1D are consistent with it being the origin of the high-velocity bipolar molecular outflow seen in CO. The close proximity of MM1B and MM1D (440 AU) suggests a proto-binary or a transient bound system. Several components of MM1 exhibit steep millimeter SEDs indicative of either unusual dust spectral properties or time variability. In addition to resolving MM1 and the other hot core (MM2) into multiple components, we detect five new millimeter and two new centimeter sources. Water masers are detected for the first time toward MM4A, confirming its membership in the protocluster. With a 1.3 mm brightness temperature of 97 K coupled with a lack of thermal molecular line emission, MM4A appears to be a highly optically-thick 240 $L_\odot$ dust core, possibly tracing a transient stage of massive protostellar evolution. The nature of the strongest water maser source CM2 remains unclear due to its combination of non-thermal radio continuum and lack of dust emission.

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Ambipolar diffusion regulated collapse of filaments threaded by perpendicular magnetic fields

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Context. In giant molecular clouds (GMCs), the fractional ionisation is low enough that the neutral and charged particles are weakly coupled. A consequence of this is that the magnetic flux redistributes within the cloud, allowing an initially magnetically supported region to collapse.
Aims. We aim to elucidate the effects of ambipolar diffusion on the evolution of infinitely long filaments and the effect of decaying turbulence on that evolution.
Methods. First, in ideal magnetohydrodynamics (MHD), a two-dimensional cylinder of an isothermal magnetised plasma with initially uniform density was allowed to evolve to an equilibrium state. Then, the response of the filament to ambipolar diffusion was followed using an adaptive mesh refinement multifluid MHD code. Various ambipolar resistivities were chosen to reflect different ratios of Jeans length to ambipolar diffusion length scale. To study the effect of turbulence on the ambipolar diffusion rate, we perturbed the equilibrium filament with a turbulent velocity field quantified by a rms sonic Mach number, $M_{\rm rms}$, of 10, 3 or 1.
Results. We numerically reproduce the density profiles for filaments that are in magnetohydrostatic and pressure equilibrium with their surroundings obtained in a published model and show that these equilibria are dynamically stable. If the effect of ambipolar diffusion is considered, these filaments lose magnetic support initiating cloud collapse. The filaments do not lose magnetic flux. Rather the magnetic flux is redistributed within the filament from the dense centre towards the diffuse envelope.
The rate of the collapse is inversely proportional to the fractional ionisation and two gravitationally-driven ambipolar diffusion regimes for the collapse are observed as predicted in a published model. For high values of the ionisation coefficient, that is $X \geq 10^{-7}$, the gas is strongly coupled to the magnetic field and the Jeans length is larger than the ambipolar diffusion length scale. Then the collapse is governed by magnetically-regulated ambipolar diffusion. The gas collapses at velocities much lower than the sound speed. For $X \lesssim 10^{-8}$, the gas is weakly coupled to the magnetic field and the magnetic support is removed by gravitationally-dominated ambipolar diffusion. Here, neutrals and ions only collide sporadically, that is the ambipolar diffusion length scale is larger than the Jeans length, and the gas can attain high collapse velocities.
When decaying turbulence is included, additional support is provided to the filament. This slows down the collapse of the filament even in the absence of a magnetic field. When a magnetic field is present, the collapse rate increases by a ratio smaller than for the non-magnetic case. This is because of a speed-up of the ambipolar diffusion due to

larger magnetic field gradients generated by the turbulence and because the ambipolar diffusion aids the dissipation of turbulence below the ambipolar diffusion length scale. The highest increase in the rate is observed for the lowest ionisation coefficient and the highest turbulent intensity.

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A gas density drop in the inner 6 AU of the transition disk around the Herbig Ae star HD 139614: Further evidence for a giant planet inside the disk?

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Context. Quantifying the gas content inside the dust gaps of transition disks is important to establish their origin.
Aims. We seek to constrain the surface density of warm gas in the disk of HD 139614, a Herbig Ae star with a transition disk exhibiting a dust gap from 2.3 to 6 AU.
Methods. We have obtained ESO/VLT CRIRES high-resolution spectra of CO ro-vibrational emission. We derive disk structure constraints by modeling the line profiles, the spectroastrometric signal, and the rotational diagrams using flat Keplerian disk models.
Results. We detected v=1–0 ^{12}CO, 2–1 ^{12}CO, 1–0 ^{13}CO, 1–0 C^{18}O, and 1–0 C^{17}O ro-vibrational lines. ^{12}CO v=1–0 lines have an average width of 14 km s^{-1}, $T_{\rm gas}$ of 450 K and an emitting region from 1 to 15 AU. ^{13}CO and C^{18}O lines are on average 70 and 100 K colder, 1 and 4 km s^{-1} narrower, and are dominated by emission at $R > 6$ AU. The ^{12}CO v=1–0 line profile indicates that if there is a gap in the gas it must be narrower than 2 AU. We find that a drop in the gas surface density ($\delta_{\rm gas}$) at $R = 5$–6 AU is required to reproduce the line profiles and rotational diagrams of the three CO isotopologues simultaneously. $\delta_{\rm gas}$ can range from 10^{-2} to 10^{-4} depending on the outer disk's gas-to-dust ratio. We find that at $1 < R < 6$ AU the gas surface density profile is flat or increases with radius. We derive a gas column density at $1 < R < 6$ AU of $N_{\rm H} = 5 \times 10^{19}$–$10^{21}$ cm^{-2}. We find a 5σ upper limit on $N_{\rm CO}$ at $R < 1$ AU of 5×10^{15} cm^{-2} ($N_{\rm H} < 5 \times 10^{19}$ cm^{-2}).
Conclusions. The dust gap in the disk of HD 139614 has gas. The gas surface density in the disk at $R < 6$ AU is significantly lower than the surface density expected from HD 139614's accretion rate assuming a viscous α-disk model. The gas density drop, the non-negative density gradient of the gas inside 6 AU, and the absence of a wide (>2 AU) gas gap suggest the presence of an embedded <2 $M_{\rm J}$ planet at around 4 AU.

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Transverse velocity shifts in protostellar jets: rotation or velocity asymmetries?

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Observations of several protostellar jets show systematic differences in radial velocity transverse to the jet propagation direction, which have been interpreted as evidence of rotation in the jets. In this paper we discuss the origin of these velocity shifts, and show that they could be originated by rotation in the flow, or by side to side asymmetries in the shock velocity, which could be due to asymmetries in the jet ejection velocity/density or in the ambient medium. For typical poloidal jet velocities ($\sim 100 - 200$ km s^{-1}), an asymmetry $\gtrsim 10\%$ can produce velocity shifts comparable to those observed. We also present three dimensional numerical simulations of rotating, precessing and asymmetric jets, and show that, even though for a given jet there is a clear degeneracy between these effects, a statistical analysis of jets with different inclination angles can help to distinguish between the alternative origins of transverse velocity shifts. Our analysis indicate that side to side velocities asymmetries could represent an important contribution to transverse velocity shifts, being the most important contributor for large jet inclination angles (with respect the the plane of the sky), and can not be neglected when interpreting the observations.

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Massive stars reveal variations of the stellar initial mass function in the Milky Way stellar clusters

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We investigate whether the stellar initial mass function (IMF) is universal, or whether it varies significantly among young stellar clusters in the Milky Way. We propose a method to uncover the range of variation of the parameters that describe the shape of the IMF for the population of young Galactic clusters. These parameters are the slopes in the low and high stellar mass regimes, γ and Γ, respectively, and the characteristic mass, M_{ch}. The method relies exclusively on the high mass content of the clusters, but is able to yield information on the distributions of parameters that describe the IMF over the entire stellar mass range. This is achieved by comparing the fractions of single and lonely massive O stars in a recent catalog of the Milky Way clusters with a library of simulated clusters built with various distribution functions of the IMF parameters. The synthetic clusters are corrected for the effects of the binary population, stellar evolution, sample incompleteness, and ejected O stars. Our findings indicate that broad distributions of the IMF parameters are required in order to reproduce the fractions of single and lonely O stars in Galactic clusters. They also do not lend support to the existence of a cluster mass-maximum stellar mass relation. We propose a probabilistic formulation of the IMF whereby the parameters of the IMF are described by Gaussian distribution functions centered around $\gamma = 0.91$, $\Gamma = 1.37$, and $M_{ch} = 0.41$ M$_\odot$, and with dispersions of $\sigma_\gamma = 0.25$, $\sigma_\Gamma = 0.60$, and $\sigma_{M_{ch}} = 0.27$ M$_\odot$ around these values.

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HCO^+ Detection of Dust-Depleted Gas in the Inner Hole of the LkCa 15 Pre-Transitional Disk

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LkCa 15 is an extensively studied star in the Taurus region known for its pre-transitional disk with a large inner cavity in dust continuum and normal gas accretion rate. The most popular hypothesis to explain the LkCa 15 data invokes one or more planets to carve out the inner cavity, while gas continues to flow across the gap from the outer disk onto the central star. We present spatially unresolved HCO^+ J=4–3 observations of the LkCa 15 disk from the JCMT and model the data with the ProDiMo code. We find that: (1) HCO^+ line-wings are clearly detected, certifying the presence of gas in the cavity within <50 AU of the star. (2) Reproducing the observed line-wing flux requires both a significant suppression of cavity dust (by a factor $>10^4$ compared to the ISM) and a substantial increase in the gas scale-height within the cavity ($H_0/R_0 \sim 0.6$). An ISM dust-to-gas ratio ($\mathrm{d} : \mathrm{g} = 10^{-2}$) yields too little line-wing flux regardless of the scale-height or cavity gas geometry, while a smaller scale-height also under predicts the flux even with a reduced d:g. (3) The cavity gas mass is consistent with the surface density profile of the outer disk extended inwards to the sublimation radius (corresponding to mass $M_\mathrm{d} \sim 0.03\ M_\odot$), and masses lower by a factor >10 appear to be ruled out.

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Proper motion survey and kinematic analysis of the Rho Ophiuchi embedded cluster

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The ρ Ophiuchi molecular complex and in particular the Lynds L1688 dark cloud is unique in its proximity (∼130 pc), in its richness in young stars and protostars, and in its youth (0.5 Myr). It is certainly one of the best targets currently accessible from the ground to study the early phases of star-formation. Proper motion analysis is a very efficient tool for separating members of clusters from field stars, but very few proper motions are available in the ρ Ophiuchi region since most of the young sources are deeply embedded in dust and gas. We aim at performing a kinematic census of young stellar objects (YSOs) in the ρ Ophiuchi F core and partially in the E core of the L1688 dark cloud. We run a proper motion program at the ESO New Technology Telescope (NTT) with the Son of ISAAC (SOFI) instrument over nine years in the near-infrared. We complemented these observations with various public image databases to enlarge the time base of observations and the field of investigation to $0.5^\circ \times 0.5^\circ$. We derived positions and proper motions for 2213 objects. From these, 607 proper motions were derived from SOFI observations with a ∼1.8 mas/yr accuracy while the

remaining objects were measured only from auxiliary data with a mean precision of about ∼3 mas/yr. We performed a kinematic analysis of the most accurate proper motions derived in this work, which allowed us to separate cluster members from field stars and to derive the mean properties of the cluster. From the kinematic analysis we derived a list of 68 members and 14 candidate members, comprising 26 new objects with a high membership probability. These new members are generally fainter than the known ones. We measured a mean proper motion of ($\mu_\alpha \cos\delta$, μ_δ)=(-8.2, -24.3)±0.8 mas/yr for the L1688 dark cloud. A supervised classification was applied to photometric data of members to allocate a spectral energy distribution (SED) classification to the unclassified members. We kinematically confirmed that the 56 members that were known from previous studies of the ρ Ophiuchi F cluster and that were also part of our survey are members of the cluster, and we added 26 new members. We defined the evolutionary status of the unclassified members of the cluster. We showed that a large part (23) of these new members are probably brown dwarfs, which multiplies the number of known substellar objects in the cluster by a factor of 3.3.

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A photo-evaporative gap in the closest planet forming disc

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The dispersal of the circumstellar discs of dust and gas surrounding young low- mass stars has important implications for the formation of planetary systems. Photo- evaporation from energetic radiation from the central object is thought to drive the dispersal in the majority of discs, by creating a gap which disconnects the outer from the inner regions of the disc and then disperses the outer disc from the inside-out, while the inner disc keeps draining viscously onto the star. In this Letter we show that the disc around TW Hya, the closest protoplanetary disc to Earth, may be the first object where a photoevaporative gap has been imaged around the time at which it is being created. Indeed the detected gap in the ALMA images is consistent with the expectations of X-ray photoevaporation models, thus not requiring the presence of a planet. The photoevaporation model is also consistent with a broad range of properties of the TW Hya system, e.g. accretion rate and the location of the gap at the onset of dispersal. We show that the central, unresolved 870 μm continuum source might be produced by free free emission from the gas and/or residual dust inside the gap.

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The link between turbulence, magnetic fields, filaments, and star formation in the Central Molecular Zone cloud G0.253+0.016

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Star formation is primarily controlled by the interplay between gravity, turbulence, and magnetic fields. However, the turbulence and magnetic fields in molecular clouds near the Galactic Center may differ substantially from spiral-arm clouds. Here we determine the physical parameters of the central molecular zone (CMZ) cloud G0.253+0.016, its turbulence, magnetic field and filamentary structure. Using column-density maps based on dust-continuum emission observations with ALMA+*Herschel*, we identify filaments and show that at least one dense core is located along them. We measure the filament width $W_{\mathrm{fil}} = 0.17 \pm 0.08\,\mathrm{pc}$ and the sonic scale $\lambda_{\mathrm{sonic}} = 0.15 \pm 0.11\,\mathrm{pc}$ of the turbulence, and find $W_{\mathrm{fil}} \approx \lambda_{\mathrm{sonic}}$. A strong velocity gradient is seen in the HNCO intensity-weighted velocity maps obtained with ALMA+Mopra. The gradient is likely caused by large-scale shearing of G0.253+0.016, producing a wide double-peaked velocity PDF. After subtracting the gradient to isolate the turbulent motions, we find a nearly Gaussian velocity PDF typical for turbulence. We measure the total and turbulent velocity dispersion, $8.8 \pm 0.2\,\mathrm{km\,s^{-1}}$ and $3.9 \pm 0.1\,\mathrm{km\,s^{-1}}$, respectively. Using magnetohydrodynamical turbulence simulations, we find that G0.253+0.016's turbulent magnetic field $B_{\mathrm{turb}} = 130 \pm 50\,\mu\mathrm{G}$ is only $\lesssim$1/10 of the ordered field component. Combining these measurements, we reconstruct the dominant turbulence driving mode in G0.253+0.016 and find a driving parameter $b = 0.22 \pm 0.12$, indicating solenoidal (divergence-free) driving. We compare this to spiral-arm clouds, which typically have a significant compressive (curl-free) driving component ($b > 0.4$). Motivated by previous reports of strong shearing motions in the CMZ, we speculate that shear causes the solenoidal driving in G0.253+0.016 and show that this reduces the star formation rate (SFR) by a factor of 6.9 compared to typical nearby clouds.

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Spitzer Observations of Long Term Infrared Variability Among Young Stellar Objects in Chamaeleon I

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Infrared variability is common among young stellar objects, with surveys finding daily to weekly fluctuations of a few tenths of a magnitude. Space-based observations can produce highly sampled infrared light curves, but are often limited to total baselines of about a month due to the orientation of the spacecraft. Here we present observations of the Chameleon I cluster whose low declination makes it observable by the Spitzer space telescope over a 200 day period. We observe 30 young stellar objects with a daily cadence to better sample variability on timescales of months. We find such variability is common, occurring in $\sim$80% of the detected cluster members. The change in $[3.6] - [4.5]$ color over 200 days for many of the sources falls between that expected for extinction and fluctuations in disk emission. With our high cadence and long baseline we can derive power spectral density curves covering two orders of magnitude in frequency and find significant power at low frequencies, up to the boundaries of our 200 day survey. Such long timescales are difficult to explain with variations driven by the interaction between the disk and stellar magnetic field, which has a dynamical timescale of days to weeks. The most likely explanation is either structural or temperature fluctuations spread throughout the inner ∼0.5 au of the disk, suggesting that the intrinsic dust structure is highly dynamic.

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CO observations and investigation of triggered star formation towards N10 infrared bubble and surroundings

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We studied the environment of the dust bubble N10 in molecular emission. Infrared bubbles, first detected by the GLIMPSE survey at 8.0 μm, are ideal regions to investigate the effect of the expansion of the HII region on its surroundings eventual triggered star formation at its borders. In this work, we present a multi-wavelength study of N10. This bubble is especially interesting as infrared studies of the young stellar content suggest a scenario of ongoing star formation, possibly triggered, on the edge of the HII region. We carried out observations of ^{12}CO(1-0) and ^{13}CO(1-0) emission at PMO 13.7-m towards N10. We also analyzed the IR and sub-mm emission on this region and compare those different tracers to obtain a detailed view of the interaction between the expanding HII region and the molecular gas. We also estimated the parameters of the denser cold dust condensation and of the ionized gas inside the shell. Bright CO emission was detected and two molecular clumps were identified, from which we have derived physical parameters. We also estimate the parameters for the densest cold dust condensation and for the ionized gas inside the shell. The comparison between the dynamical age of this region and the fragmentation time scale favors the "Radiation-Driven Implosion" mechanism of star formation. N10 reveals to be specially interesting case with gas structures in a narrow frontier between HII region and surrounding molecular material, and with a range of ages of YSOs situated in region indicating triggered star formation.

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Direct detection of scattered light gaps in the transitional disk around HD 97048 with VLT/SPHERE

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We studied the well known circumstellar disk around the Herbig Ae/Be star HD 97048 with high angular resolution to reveal undetected structures in the disk, which may be indicative of disk evolutionary processes such as planet formation. We used the IRDIS near-IR subsystem of the extreme adaptive optics imager SPHERE at the ESO/VLT to study the scattered light from the circumstellar disk via high resolution polarimetry and angular differential imaging. We imaged the disk in unprecedented detail and revealed four ring-like brightness enhancements and corresponding gaps in the scattered light from the disk surface with radii between 39 au and 341 au. We derived the inclination and position angle as well as the height of the scattering surface of the disk from our observational data. We found that the surface height profile can be described by a single power law up to a separation ∼270 au. Using the surface height profile we measured the scattering phase function of the disk and found that it is well consistent with theoretical models of compact dust aggregates. We discuss the origin of the detected features and find that low mass ($<1\ M_{\rm Jup}$) nascent planets are a possible explanation.

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The Mid-Infrared Evolution of the FU Orionis Disk

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We present new SOFIA-FORCAST observations obtained in Feburary 2016 of the archetypal outbursting low mass young stellar object FU Orionis, and compare the continuum, solid state, and gas properties with mid-IR data obtained at the same wavelengths in 2004 with Spitzer-IRS. In this study, we conduct the first mid-IR spectroscopic comparison of an FUor over a long time period. Over a 12 year period, UBVR monitoring indicates that FU Orionis has continued its steady decrease in overall brightness by $\sim 14\%$. We find that this decrease in luminosity occurs only at wavelengths $\lesssim 20\ \mu$m. In particular, the continuum short ward of the silicate emission complex at 10 μm exhibits a $\sim 12\%$ ($\sim 3\sigma$) drop in flux density, but no apparent change in slope; both the Spitzer and SOFIA spectra are consistent with a 7200 K blackbody. Additionally, the detection of water absorption is consistent with the Spitzer spectrum. The silicate emission feature at 10 μm continues to be consistent with unprocessed grains, unchanged over 12 years. We conclude that either the accretion rate in FU Orionis has decreased by $\sim$ 12-14% over this time baseline, or that the inner disk has cooled, but the accretion disk remains in a superheated state outside of the innermost region.

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The Bok Globule BHR 160: structure and star formation

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BHR 160 is a virtually unstudied cometary globule within the Sco OB4 association in Scorpius at a distance of 1600pc. It is part of a system of cometary clouds which face the luminous O star HD155806. BHR 160 is special because it has

an intense bright rim. We attempt to derive physical parameters for BHR 160 and to understand its structure and the origin of its peculiar bright rim. BHR 160 was mapped in the ^{12}CO, ^{13}CO and C^{18}O (2-1) and (1-0) and CS (3-2) and (2-1) lines. These data, augmented with stellar photometry derived from the ESO VVV survey, were used to derive the mass and distribution of molecular material in BHR 160 and its surroundings. Archival mid-infrared data from the WISE satellite was used to find IR excess stars in the globule and its neighbourhood. An elongated 1' by 0.6' core lies adjacent to the globule bright rim. ^{12}CO emission covers the whole globule, but the ^{13}CO, C^{18}O and CS emission is more concentrated to the core. The ^{12}CO line profiles indicate the presence of outflowing material near the core, but the spatial resolution of the mm data is not sufficient for a detailed spatial analysis. The BHR 160 mass estimated from the C^{18}O mapping is 100 ± 50M$_\odot$(d/1.6kpc)^2 where d is the distance to the globule. Approximately 70% of the mass lies in the dense core. The total mass of molecular gas in the direction of BHR 160 is $210\pm$(d/1.6kpc)^2 M$_\odot$ when estimated from the more extended VVV NIR photometry. We argue that the bright rim of BHR 160 is produced by a close-by early B-type star, HD 319648, that was likely recently born in the globule. This star is likely to have triggered the formation of a source, IRS 1, that is embedded within the core of the globule and detected only in Ks and by WISE and IRAS.

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Photochemical-dynamical models of externally FUV irradiated protoplanetary discs

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There is growing theoretical and observational evidence that protoplanetary disc evolution may be significantly affected by the canonical levels of far ultraviolet (FUV) radiation found in a star forming environment, leading to substantial stripping of material from the disc outer edge even in the absence of nearby massive stars. In this paper we perform the first full radiation hydrodynamic simulations of the flow from the outer rim of protoplanetary discs externally irradiated by such intermediate strength FUV fields, including direct modelling of the photon dominated region (PDR) which is required to accurately compute the thermal properties. We find excellent agreement between our models and the semi-analytic models of Facchini et al. (2016) for the profile of the flow itself, as well as the mass loss rate and location of their "critical radius". This both validates their results (which differed significantly from prior semi-analytic estimates) and our new numerical method, the latter of which can now be applied to elements of the problem that the semi–analytic approaches are incapable of modelling. We also obtain the composition of the flow, but given the simple geometry of our models we can only hint at some diagnostics for future observations of externally irradiated discs at this stage. We also discuss the potential for these models as benchmarks for future photochemical-dynamical codes.

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Seeding the Galactic Centre gas stream: gravitational instabilities set the initial conditions for the formation of protocluster clouds

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Star formation within the Central Molecular Zone (CMZ) may be intimately linked to the orbital dynamics of the gas. Recent models suggest that star formation within the dust ridge molecular clouds (from G0.253+0.016 to Sgr B2) follows an evolutionary time sequence, triggered by tidal compression during their preceding pericentre passage. Given that these clouds are the most likely precursors to a generation of massive stars and extreme star clusters, this scenario would have profound implications for constraining the time-evolution of star formation. In this Letter, we search for the initial conditions of the protocluster clouds, focusing on the kinematics of gas situated upstream from pericentre. We observe a highly-regular corrugated velocity field in $\{l, v_{\rm LSR}\}$ space, with amplitude and wavelength $A = 3.7 \pm 0.1\,\mathrm{km/s}$ and $\lambda_{\rm vel,i} = 22.5 \pm 0.1\,\mathrm{pc}$, respectively. The extremes in velocity correlate with a series of massive ($\sim 10^4\,\mathrm{M}_\odot$) and compact ($R_{\rm eq} \sim 2\,\mathrm{pc}$), quasi-regularly spaced ($\sim 8\,\mathrm{pc}$), molecular clouds. The corrugation wavelength and cloud separation closely agree with the predicted Toomre ($\sim 17\,\mathrm{pc}$) and Jeans ($\sim 6\,\mathrm{pc}$) lengths, respectively. We conclude that gravitational instabilities are driving the condensation of molecular clouds within the Galactic Centre gas stream. Furthermore, we speculate these seeds are the historical analogue of the dust-ridge molecular clouds, representing the initial conditions of star and cluster formation in the CMZ.

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The Gaia-ESO Survey: Lithium depletion in the Gamma Velorum cluster and inflated radii in low-mass pre-main-sequence stars

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We show that non-magnetic models for the evolution of pre-main-sequence (PMS) stars *cannot* simultaneously describe the colour-magnitude diagram (CMD) and the pattern of lithium depletion seen in the cluster of young, low-mass stars surrounding γ^2 Velorum. The age of $7.5 \pm 1\,\mathrm{Myr}$ inferred from the CMD is much younger than that implied by the strong Li depletion seen in the cluster M-dwarfs and the Li depletion occurs at much redder colours than predicted. The epoch at which a star of a given mass depletes its Li and the surface temperature of that star are both dependent on its radius. We demonstrate that if the low-mass stars have radii ~ 10 per cent larger at a given mass and age, then both the CMD and Li depletion pattern of the Gamma Vel cluster are explained at a common age of $\simeq 18$–$21\,\mathrm{Myr}$. This radius inflation could be produced by some combination of magnetic suppression of convection and extensive cool starspots. Models that incorporate radius inflation suggest that PMS stars similar to those in the Gamma Vel cluster, in the range $0.2 < M/M_\odot < 0.7$, are at least a factor of two older and ~ 7 per cent cooler than previously thought and that their masses are much larger (by > 30 per cent) than inferred from conventional, non-magnetic models in the Hertzsprung-Russell diagram. Systematic changes of this size may be of great importance in understanding the

evolution of young stars, disc lifetimes and the formation of planetary systems.

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The Spatial Distribution of Complex Organic Molecules in the L1544 Pre-stellar Core

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The detection of complex organic molecules (COMs) toward cold sources such as pre-stellar cores (with T<10 K), has challenged our understanding of the formation processes of COMs in the interstellar medium. Recent modelling on COM chemistry at low temperatures has provided new insight into these processes predicting that COM formation depends strongly on parameters such as visual extinction and the level of CO freeze out. We report deep observations of COMs toward two positions in the L1544 pre-stellar core: the dense, highly-extinguished continuum peak with $A_V \geq 30$ mag within the inner 2700 au; and a low-density shell with average $A_V \sim 7.5$-8 mag located at 4000 au from the core's center and bright in CH_3OH. Our observations show that CH_3O, CH_3OCH_3 and CH_3CHO are more abundant (by factors ∼2-10) toward the low-density shell than toward the continuum peak. Other COMs such as CH_3OCHO, c-C_3H_2O, HCCCHO, CH_2CHCN and HCCNC show slight enhancements (by factors ≤3) but the associated uncertainties are large. This suggests that COMs are actively formed and already present in the low-density shells of pre-stellar cores. The modelling of the chemistry of O-bearing COMs in L1544 indicates that these species are enhanced in this shell because i) CO starts freezing out onto dust grains driving an active surface chemistry; ii) the visual extinction is sufficiently high to prevent the UV photo-dissociation of COMs by the external interstellar radiation field; and iii) the density is still moderate to prevent severe depletion of COMs onto grains.

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A correlation between chemistry, polarization and dust properties in the Pipe Nebula starless core FeSt 1-457

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Pre-stellar cores within molecular clouds provide the very initial conditions in which stars are formed. We use the IRAM 30m telescope and the PdBI to study the chemical and physical properties of the starless core FeSt 1-457 (Core 109), in the Pipe nebula. We fit the hyperfine structure of the N2H+(1-0) IRAM 30m data. This allow us to measure with high precision the velocity field, line widths and opacity and derive the excitation temperature and column density in the core. We use a modified Bonnor-Ebert sphere model adding a temperature gradient towards the center to fit the 1.2 mm continuum emission and visual extinction maps. Using this model, we estimate the abundances of the N2H+ and the rest of molecular lines detected in the 30 GHz wide line survey performed at 3 mm with IRAM 30m using ARTIST software. The core presents a rich chemistry with emission from early (C3H2, HCN, CS) and late-time molecules (e.g., N2H+), with a clear chemical spatial differentiation for nitrogen, oxygen and sulphurated molecules. For most of the molecules detected (HCN, HCO+, CH3OH, CS, SO, 13CO and C18O), abundances are best fitted with three values, presenting a clear decrease of abundance of at least 1 or 2 orders of magnitude towards the center of the core. The Bonnor-Ebert analysis indicates the core is gravitationally unstable and the magnetic field is not strong enough to avoid the collapse. Depletion of molecules onto the dust grains occurs at the interior of the core, where dust grain growth and dust depolarization also occurs. This suggests that these properties may be related. On the other hand, some molecules exhibit asymmetries in their integrated emission maps, which appear to be correlated with a previously reported submillimeter polarization asymmetry. These asymmetries could be due to a stronger interstellar radiation field in the western side of the core.

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Large-scale magnetic field in the accretion discs of young stars: the influence of magnetic diffusion, buoyancy and Hall effect

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We investigate the fossil magnetic field in the accretion and protoplanetary discs using the Shakura and Sunyaev approach. The distinguishing feature of this study is the accurate solution of the ionization balance equations and the induction equation with Ohmic diffusion, magnetic ambipolar diffusion, buoyancy and the Hall effect. We consider the ionization by cosmic rays, X-rays and radionuclides, radiative recombinations, recombinations onto dust grains, and also thermal ionization. The buoyancy appears as the additional mechanism of magnetic flux escape in the steady-state solution of the induction equation. Calculations show that Ohmic diffusion and magnetic ambipolar diffusion constraint the generation of the magnetic field inside the 'dead' zones. The magnetic field in these regions is quasi-vertical. The buoyancy constraints the toroidal magnetic field strength close to the disc inner edge. As a result, the toroidal and vertical magnetic fields become comparable. The Hall effect is important in the regions close to the borders of the 'dead' zones because electrons are magnetized there. The magnetic field in these regions is quasi-radial. We calculate the magnetic field strength and geometry for the discs with accretion rates $(10^{-8} - 10^{-6})\,\mathrm{M}_\odot\,\mathrm{yr}^{-1}$. The fossil magnetic field geometry does not change significantly during the disc evolution while the accretion rate decreases. We construct the synthetic maps of dust emission polarized due to the dust grain alignment by the magnetic field. In the polarization maps, the 'dead' zones appear as the regions with the reduced values of polarization degree in comparison to those in the adjacent regions.

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The Gould's Belt Distances Survey (GOBELINS) III. Distances and structure towards the Orion Molecular Clouds

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We present the results of the Gould's Belt Distances Survey (GOBELINS) of young star forming regions towards the Orion Molecular Cloud Complex. We detected 36 YSOs with the Very Large Baseline Array (VLBA), 27 of which have been observed in at least 3 epochs over the course of 2 years. At least half of these YSOs belong to multiple systems. We obtained parallax and proper motions towards these stars to study the structure and kinematics of the Complex. We measured a distance of 388±5 pc towards the Orion Nebula Cluster, 428±10 pc towards the southern portion L1641, 388±10 pc towards NGC 2068, and roughly ∼420 pc towards NGC 2024. Finally, we observed a strong degree of plasma radio scattering towards λ Ori.

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Orion revisited III. The Orion Belt population

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This paper continues our study of the foreground population to the Orion molecular clouds. The goal is to characterize the foreground population north of NGC 1981 and to investigate the star formation history in the large Orion star-forming region. We focus on a region covering about 25 square degrees, centered on the epsilon Orionis supergiant (HD 37128, B0 Ia) and covering the Orion Belt asterism. We used a combination of optical (SDSS) and near-infrared (2MASS) data, informed by X-ray (*XMM-Newton*) and mid-infrared (WISE) data, to construct a suite of color-color and color-magnitude diagrams for all available sources. We then applied a new statistical multiband technique to isolate a previously unknown stellar population in this region. We identify a rich and well-defined stellar population in the surveyed region that has about 2 000 objects that are mostly M stars. We infer the age for this new population to be at least 5 Myr and likely ∼10 Myr and estimate a total of about 2 500 members, assuming a normal IMF. This new population, which we call the Orion Belt population, is essentially extinction-free, disk-free, and its spatial distribution is roughly centered near epsilon Ori, although substructure is clearly present. The Orion Belt population is likely the low-mass counterpart to the Ori OB Ib subgroup. Although our results do not rule out Blaauw's sequential star formation scenario for Orion, we argue that the recently proposed blue streams scenario provides a better framework on which one can explain the Orion star formation region as a whole. We speculate that the Orion Belt population could represent the evolved counterpart of an Orion nebula-like cluster.

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Protostellar Outflows and Radiative Feedback from Massive Stars. II. Feedback, Star Formation Efficiency, and Outflow Broadening

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We perform two-dimensional axially symmetric radiation-hydrodynamic simulations to assess the impact of outflows and radiative force feedback from massive protostars by varying when the protostellar outflow starts, the ratio of ejection to accretion rates, and the strength of the wide angle disk wind component. The star formation efficiency, i.e. the ratio of final stellar mass to initial core mass, is dominated by radiative forces and the ratio of outflow to accretion rates. Increasing this ratio has three effects: First, the protostar grows slower with a lower luminosity at any given time, lowering radiative feedback. Second, bipolar cavities cleared by the outflow are larger, further diminishing radiative feedback on disk and core scales. Third, the higher momentum outflow sweeps up more material from the collapsing envelope, decreasing the protostar's potential mass reservoir via entrainment. The star formation efficiency varies with the ratio of ejection to accretion rates from 50% in the case of very weak outflows to as low as 20% for very strong outflows. At latitudes between the low density bipolar cavity and the high density accretion disk, wide angle disk winds remove some of the gas, which otherwise would be part of the accretion flow onto the disk; varying the strength of these wide angle disk winds, however, alters the final star formation efficiency by only ±6%. For all cases, the opening angle of the bipolar outflow cavity remains below 20° during early protostellar accretion phases, increasing rapidly up to 65° at the onset of radiation pressure feedback.

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

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The Orion A molecular cloud is one of the most well-studied nearby star-forming regions, and includes regions of both highly clustered and more dispersed star formation across its full extent. Here, we analyze dense, star-forming cores identified in the 850 μm and 450 μm SCUBA-2 maps from the JCMT Gould Belt Legacy Survey. We identify dense cores in a uniform manner across the Orion A cloud and analyze their clustering properties. Using two independent lines of analysis, we find evidence that clusters of dense cores tend to be mass segregated, suggesting that stellar clusters may have some amount of primordial mass segregation already imprinted in them at an early stage. We also demonstrate that the dense core clusters have a tendency to be elongated, perhaps indicating a formation mechanism linked to the filamentary structure within molecular clouds.

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On dust-gas gravitational instabilities in protoplanetary discs

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In protoplanetary disks the aerodynamical friction between particles and gas induces a variety of instabilities that facilitate planet formation. Of these we examine the so-called 'secular gravitational instability' (SGI) in the two-fluid approximation, deriving analytical expressions for its stability criteria and growth rates. Concurrently, we present a physical explanation of the instability that shows how it manifests upon an intermediate range of lengthscales exhibiting geostrophic balance in the gas component. In contrast to a single-fluid treatment, the SGI is quenched within a critical disk radius, as large as 10 AU and 30 AU for cm and mm sized particles respectively, although establishing robust estimates is hampered by uncertainties in the parameters (especially the strength of turbulence) and deficiencies in the razor-thin disk model we employ. It is unlikely, however, that the SGI is relevant for well-coupled dust. We conclude by applying these results to the question of planetesimal formation and the provenance of large-scale dust rings.

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An Ordered Magnetic Field in the Protoplanetary Disk of AB Aur Revealed by Mid-Infrared Polarimetry

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Magnetic fields (B-fields) play a key role in the formation and evolution of protoplanetary disks, but their properties are poorly understood due to the lack of observational constraints. Using CanariCam at the 10.4-m Gran Telescopio Canarias, we have mapped out the mid-infrared polarization of the protoplanetary disk around the Herbig Ae star AB Aur. We detect ∼0.44% polarization at 10.3 micron from AB Aur's inner disk ($r < 80$ AU), rising to ∼1.4% at larger radii. Our simulations imply that the mid-infrared polarization of the inner disk arises from dichroic emission of elongated particles aligned in a disk B-field. The field is well ordered on a spatial scale commensurate with our resolution (∼50 AU), and we infer a poloidal shape tilted from the rotational axis of the disk. The disk of AB Aur is optically thick at 10.3 micron, so polarimetry at this wavelength is probing the B-field near the disk surface. Our observations therefore confirm that this layer, favored by some theoretical studies for developing magneto-rotational instability and its resultant viscosity, is indeed very likely to be magnetized. At radii beyond ∼80 AU, the mid-infrared polarization results primarily from scattering by dust grains with sizes up to ∼1 μm, a size indicating both grain growth and, probably, turbulent lofting of the particles from the disk mid-plane.

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Probing the multi-scale interplay between gravity and turbulence – Power-law like gravitational energy spectra of the Orion Complex

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Gravity plays a determining role in the evolution of the molecular ISM. In arXiv:1603.04342, we proposed a measure called gravitational energy spectrum to quantify the importance of gravity on multiple physical scales. In this work, using a wavelet-based decomposition technique, we derive the gravitational energy spectra of the Orion A and the Orion B molecular cloud from observational data. The gravitational energy spectra exhibit power-law-like behaviours. From a few pc down to ~ 0.1 pc scale, the Orion A and Orion B molecular cloud have $E_{\rm p}(k) \sim k^{-1.88}$ and $E_{\rm p}(k) \sim k^{-2.09}$, respectively. These scaling exponents are close to the scaling exponents of the kinetic energy power spectrum of compressible turbulence (where $E \sim k^{-2}$), with a near-equipartition of turbulent versus gravitational energy on multiple scales. This provides a clear evidence that gravity is able to counteract effectively against turbulent motion for these length scales. The results confirm our earlier analytical estimates. For the Orion A molecular cloud, gravity inevitably dominates over turbulence inside the cloud. Our results provide a clear observational proof that gravity is playing a determining role in the evolution these molecular clouds from the cloud scale down to ~ 0.1 pc. However, turbulence is likely to dominate in clouds like California. The method is general and should be applicable to all the astrophysical problems where gravity plays a role.

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The chemistry and kinematics of two molecular clouds near Sagittarius A*

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We have analysed the chemical and kinematic properties of the 20 and 50 km s^{-1} molecular clouds in the Central Molecular Zone of the Milky Way Galaxy, as well as those of the molecular ridge bridging these two clouds. Our work has utilized 37 molecular transitions in the 0.65, 3 and 7-mm wavebands, from the Mopra and NANTEN2 telescopes. The 0.65-mm NANTEN2 data highlights a dense condensation of emission within the western part of the 20 km s^{-1} cloud, visible in only four other transitions, which are 3-mm H^{13}CN (1–0), H^{13}CO^{+} (1–0), HNC (1–0) and N$_2$H^{+} (1–0), suggesting that the condensation is moderately optically thick and cold. We find that while the relative chemical abundances between both clouds are alike in many transitions, suggesting little variation in the chemistry between both clouds; the 20 km s^{-1}, cold cloud is brighter than the 50 km s^{-1} cloud in shock and high density tracers. The spatial distribution of enhanced emission is widespread in the 20 km s^{-1} cloud, as shown via line ratio maps. The position velocity diagrams across both clouds indicate that the gas is well mixed. We show that the molecular ridge is most likely part of the 20 km s^{-1} cloud and that both of them may possibly extend to include the 50 km s^{-1} cloud, as part of one larger cloud. Furthermore, we expect that the 20 km s^{-1} cloud is being tidally sheared as a result of the gravitational potential from Sgr A*.

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G345.45+1.50: An expanding ring-like structure with massive star formation

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Ring-like structures in the ISM are commonly associated with high-mass stars. Kinematic studies of large structures in GMCs toward these ring-like structures may help us to understand how massive stars form. The origin and properties of the ring-like structure G345.45+1.50 is investigated through observations of the ^{13}CO(3–2) line. The aim of the observations is to determine the kinematics in the region and to compare physical characteristics estimated from gas emission with those previously determined using dust continuum emission. The ^{13}CO(3–2) line was mapped toward the whole ring using the APEX telescope. The ring is found to be expanding with a velocity of 1.0 km s^{-1}, containing a total mass of 6.9 × 10^{3} $M_{\odot}$, which agrees well with that determined using 1.2 mm dust continuum emission. An expansion timescale of 3 × 10^{6} yr and a total energy of 7 × 10^{46} erg are estimated. The origin of the ring might have been a supernova explosion, since a 35.5 cm source, J165920−400424, is located at the center of the ring without an infrared counterpart. The ring is fragmented, and 104 clumps were identified with diameters of between 0.3 and 1.6 pc, masses of between 2.3 and 7.5 × 10^{2} $M_{\odot}$, and densities of between 10^{2} and 10^{4} cm^{-3}. At least 18% of the clumps are forming stars, as is shown in infrared images. Assuming that the clumps can be modeled as Bonnor-Ebert spheres, 13 clumps are collapsing, and the rest of them are in hydrostatic equilibrium with an external pressure with a median value of 4 × 10^{4} K cm^{-3}. In the region, the molecular outflow IRAS 16562−3959 is identified, with a velocity range of 38.4 km s^{-1}, total mass of 13 $M_{\odot}$, and kinematic energy of 7 × 10^{45} erg. Finally, five filamentary structures were found at the edge of the ring with an average size of 3 pc, a width of 0.6 pc, a mass of 2 × 10^{2} $M_{\odot}$, and a column density of 6 × 10^{21} cm^{-2}.

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Exocometary gas structure, origin and physical properties around β Pictoris through ALMA CO multi-transition observations

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Recent ALMA observations unveiled the structure of CO gas in the 23 Myr-old β Pictoris planetary system, a component that has been discovered in many similarly young debris disks. We here present ALMA CO J=2–1 observations, at an improved spectro-spatial resolution and sensitivity compared to previous CO J=3–2 observations. We find that 1) the CO clump is radially broad, favouring the resonant migration over the giant impact scenario for its dynamical origin, 2) the CO disk is vertically tilted compared to the main dust disk, at an angle consistent with the scattered light warp. We then use position-velocity diagrams to trace Keplerian radii in the orbital plane of the disk. Assuming a perfectly edge-on geometry, this shows a CO scale height increasing with radius as $R^{0.75}$, and an electron density (derived from CO line ratios through NLTE analysis) in agreement with thermodynamical models. Furthermore, we show how observations of optically thin line ratios can solve the primordial versus secondary origin dichotomy in gas-bearing debris disks. As shown for β Pictoris, subthermal (NLTE) CO excitation is symptomatic of H_2 densities that are insufficient to shield CO from photodissociation over the system's lifetime. This means that replenishment from exocometary volatiles must be taking place, proving the secondary origin of the disk. In this scenario, assuming steady state production/destruction of CO gas, we derive the CO+CO_2 ice abundance by mass in β Pic's exocomets to be at most $\sim$6%, consistent with comets in our own Solar System and in the coeval HD181327 system.

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The β Pictoris association: catalog of photometric rotational periods of the low-mass members and candidate members

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We intended to compile the most complete catalog of bona fide members and candidate members of the β Pictoris association, and to measure their rotation periods and basic properties from our own observations, public archives, and exploring the literature. We carried out a multi-observatories campaign to get our own photometric time series and collected all archived public photometric data time series for the stars in our catalog. Each time series was analyzed with the Lomb-Scargle and CLEAN periodograms to search for the stellar rotation periods. We complemented the measured rotational properties with detailed information on multiplicity, membership, and projected rotational velocity available in the literature and discussed star by star. We measured the rotation periods of 112 out of 117 among bona fide members and candidate members of the β Pictoris association and, whenever possible, we also measured the luminosity, radius, and inclination of the stellar rotation axis. This represents to date the largest catalog of rotation periods of any young loose stellar association. We provided an extensive catalog of rotation periods together with other relevant basic properties useful to explore a number of open issues such as the causes of spread of rotation periods among coeval stars, evolution of angular momentum, and lithium-rotation connection.

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The rotation - Lithium depletion correlation in the β Pictoris association and the LDB age determination

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There is evidence in the 125-Myr Pleiades cluster, and more recently in the 5-Myr NGC 2264 cluster, that rotation plays a key role in the Lithium (Li) depletion processes among low-mass stars. Fast rotators appear to be less Li-depleted than equal-mass slow rotators. We intend to explore the existence of a Li depletion - rotation connection among the β Pictoris members at an age of about 24 Myr, and to use such correlation either to confirm or to improve the age estimate based on the Lithium Depletion Boundary (LDB) modeling. We have photometrically monitored all the known members of the β Pictoris association with at least one Lithium equivalent width (Li EW) measurement from the literature. We measured the rotation periods of 30 members for the first time and retrieved from the literature the rotation periods for other 36 members, building a catalogue of 66 members with measured rotation period and Li EW. We find that in the $0.3 < M < 0.8\ M_\odot$ range, there is a strong correlation between rotation and Li EW. For higher mass stars, no significant correlation is found. For very low mass stars in the Li depletion onset, at about 0.1 $M_\odot$, data are too few to infer a significant correlation. The observed Li EWs are compared with those predicted by the Dartmouth stellar evolutionary models that incorporate the effects of magnetic fields. After decorrelating the Li EW from the rotation period, we find that the hot side of the LDB is fitted well by Li EW values corresponding to an age of 25±3 Myr in good agreement with independent estimates from the literature.

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The triple system AT Mic AB + AU Mic in the β Pictoris Association

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Equal-mass stars in young open clusters and loose associations exhibit a wide spread of rotation periods, which likely originates from differences in the initial rotation periods and in the primordial disc lifetimes. We want to explore if the gravitational effects by nearby companions may play an additional role in producing the observed rotation period spread. We measure the photometric rotation periods of components of multiple stellar systems and look for correlations of the period differences among the components to their reciprocal distances. In this paper, we analysed the triple system AU Mic + AT Mic A&B in the 25-Myr β Pictoris Association. We have retrieved from the literature the rotation period of AU Mic (P = 4.85d) and measured from photometric archival data the rotation periods of both components of AT Mic (P = 1.19d and P = 0.78d) for the first time. Moreover, we detected a high rate of flare events from AT Mic. Whereas the distant component AU Mic has evolved rotationally as a single star, the A and B components of AT Mic, separated by about 27 AU, exhibit a rotation rate a factor 5 larger than AU Mic. Moreover, the A and B components, despite have about equal mass, show a significant difference (about 40%) between their rotation periods. A possible explanation is that the gravitational forces between the A and B components of AT Mic (that are a factor about 7.3×10^6 more intense than those between AU Mic and AT Mic) have enhanced the dispersal of the AT Mic primordial disc, shortening its lifetime and the disc-locking phase duration, making the component A and B of AT Mic to rotate faster than the more distant AU Mic. We suspect that a different level of magnetic activity between the A and B components of AT Mic may be the additional parameter responsible for the difference between their rotation periods.

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On the existence of accretion-driven bursts in massive star formation

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Accretion-driven luminosity outbursts are a vivid manifestation of variable mass accretion onto protostars. They are known as the so-called FU Orionis phenomenon in the context of low-mass protostars. More recently, this process has been found in models of primordial star formation. Using numerical radiation hydrodynamics simulations, we stress that present-day forming massive stars also experience variable accretion and show that this process is accompanied by luminous outbursts induced by the episodic accretion of gaseous clumps falling from the circumstellar disk onto the protostar. Consequently, the process of accretion-induced luminous flares is also conceivable in the high-mass regime of star formation and we propose to regard this phenomenon as a general mechanism that can affect protostars regardless of their mass and/or the chemical properties of the parent environment in which they form. In addition to the commonness of accretion-driven outbursts in the star formation machinery, we conjecture that luminous flares from regions hosting forming high-mass star may be an observational implication of the fragmentation of their accretion disks.

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Do individual Spitzer young stellar object candidates enclose multiple UKIDSS sources?

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We analyze near-infrared UKIDSS observations of a sample of 8325 objects taken from a catalog of intrinsically red sources in the Galactic plane selected in the Spitzer-GLIMPSE survey. Given the differences in angular resolution (factor >2 better in UKIDSS), our aim is to investigate whether there are multiple UKIDSS sources that might all contribute to the GLIMPSE flux, or there is only one dominant UKIDSS counterpart. We then study possible corrections to estimates of the SFR based on counts of GLIMPSE young stellar objects (YSOs). This represents an exploratory work towards the construction of a hierarchical YSO catalog. After performing PSF fitting photometry in the UKIDSS data, we implemented a technique to automatically recognize the dominant UKIDSS sources by evaluating their match with the spectral energy distribution (SED) of the associated GLIMPSE red sources. This is a generic method which could be robustly applied for matching SEDs across gaps at other wavelengths. We found that most (87.0%±1.6%) of the candidate YSOs from the GLIMPSE red source catalog have only one dominant UKIDSS counterpart which matches the mid-infrared SED (fainter associated UKIDSS sources might still be present). Though at first sight this could seem surprising, given that YSOs are typically in clustered environments, we argue that within the mass range covered by the GLIMPSE YSO candidates (intermediate to high masses), clustering with objects with comparable mass is unlikely at the GLIMPSE resolution. Indeed, by performing simple clustering experiments based on a population synthesis model of Galactic YSOs, we found that although ∼60% of the GLIMPSE YSO enclose at least two UKIDSS sources, in general only one dominates the flux. No significant corrections are needed for estimates of the SFR of the Milky Way based on the assumption that the GLIMPSE YSOs are individual objects.

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A Super-Solar Metallicity For Stars With Hot Rocky Exoplanets

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The host star metallicity provide a measure of the conditions in protoplanetary disks at the time of planet formation. Using a sample of over 20,000 *Kepler* stars with spectroscopic metallicities from the `LAMOST` survey, we explore how the exoplanet population depends on host star metallicity as a function of orbital period and planet size. We find that exoplanets with orbital periods less than 10 days are preferentially found around metal-rich stars ([Fe/H]$\simeq 0.15 \pm 0.05$ dex). The occurrence rates of these hot exoplanets increases to $\sim 30\%$ for super-solar metallicity stars from $\sim 10\%$ for stars with a sub-solar metallicity. Cooler exoplanets, that reside at longer orbital periods and constitute the bulk of the exoplanet population with an occurrence rate of $\gtrsim$90%, have host-star metallicities consistent with solar. At short orbital periods, $P < 10$ days, the difference in host star metallicity is largest for hot rocky planets ($< 1.7\ R_\oplus$), where the metallicity difference is [Fe/H]$\simeq 0.25 \pm 0.07$ dex. The excess of hot rocky planets around metal-rich stars implies they either share a formation mechanism with hot Jupiters, or trace a planet trap at the protoplanetary disk inner edge which is metallicity-dependent. We do not find statistically significant evidence for a previously identified trend that small planets toward the habitable zone are preferentially found around low-metallicity stars. Refuting or confirming this trend requires a larger sample of spectroscopic metallicities.

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The location, clustering, and propagation of massive star formation in giant molecular clouds

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Massive stars are key players in the evolution of galaxies, yet their formation pathway remains unclear. In this work, we use data from several galaxy-wide surveys to build an unbiased dataset of ~ 700 massive young stellar objects (MYSOs), ~ 200 giant molecular clouds (GMCs), and ~ 100 young (< 10 Myr) optical stellar clusters (SCs) in the Large Magellanic Cloud. We employ this data to quantitatively study the location and clustering of massive star formation and its relation to the internal structure of GMCs. We reveal that massive stars do not typically form at the highest column densities nor centers of their parent GMCs at the ~ 6 pc resolution of our observations. Massive star formation clusters over multiple generations and on size scales much smaller than the size of the parent GMC. We find that massive star formation is significantly boosted in clouds near SCs. Yet, whether a cloud is associated with a SC does not depend on either the cloud's mass or global surface density. These results reveal a connection between different generations of massive stars on timescales up to 10 Myr. We compare our work with Galactic studies and discuss our findings in terms of GMC collapse, triggered star formation, and a potential dichotomy between low- and high-mass star formation.

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Efficiency of Planetesimal Ablation in Giant Planetary Envelopes

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Observations of exoplanetary spectra are leading to unprecedented constraints on their atmospheric elemental abundances, particularly O/H, C/H, and C/O ratios. Recent studies suggest that elemental ratios could provide important constraints on formation and migration mechanisms of giant exoplanets. A fundamental assumption in such studies is that the chemical composition of the planetary envelope represents the sum-total of compositions of the accreted gas and solids during the formation history of the planet. We investigate the efficiency with which accreted planetesimals ablate in a giant planetary envelope thereby contributing to its composition rather than sinking to the core. From considerations of aerodynamic drag causing 'frictional ablation' and the envelope temperature structure causing 'thermal ablation', we compute mass ablations for impacting planetesimals of radii 30 m to 1 km for different compositions (ice to iron) and a wide range of velocities and impact angles, assuming spherical symmetry. Icy impactors are fully ablated in the outer envelope for a wide range of parameters. Even for Fe impactors substantial ablation occurs in the envelope for a wide range of sizes and velocities. For example, iron impactors of sizes below $\sim$0.5 km and velocities above $\sim$30 km s^{-1} are found to ablate by $\sim$60–80% within the outer envelope at pressures below 10^3 bar due to frictional ablation alone. For deeper pressures ($\sim 10^7$ bar), substantial ablation happens over a wider range of parameters. Therefore, our exploratory study suggests that atmospheric abundances of volatile elements in giant planets reflect their accretion history during formation.

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The time evolution of HH 2 from four epochs of HST images

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We have analyzed four epochs of Hα and [S II] HST images of the HH 1/2 outflow (covering a time interval from 1994 to 2014) to determine proper motions and emission line fluxes of the knots of HH 2. We find that our new proper motions agree surprisingly well with the motions measured by Herbig & Jones (1981), although there is partial evidence for a slight deceleration of the motion of the HH 2 knots from 1945 to 2014. We also measure the time-variability of the Hα intensities and the [S II]/Hα line ratios, and find that knots H and A have the largest intensity variabilities (in 1994 $\rightarrow$ 2014). Knot H (which now dominates the HH 2 emission) has strengthened substantially, while keeping an approximately constant [S II]/Hα ratio. Knot A has dramatically faded, and at the same time has had a substantial increase in its [S II]/Hα ratio. Possible interpretations of these results are discussed.

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http://arXiv.org/pdf/1610.01951, http://bigbang.nucleares.unam.mx/astroplasmas/

On the origin of horseshoes in transitional discs

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We investigate whether the rings, lopsided features and horseshoes observed at millimetre wavelengths in transitional discs can be explained by the dynamics of gas and dust at the edge of the cavity in circumbinary discs. We use 3D dusty smoothed particle hydrodynamics calculations to show that binaries with mass ratio $q > 0.04$ drive eccentricity in the central cavity, naturally leading to a crescent-like feature in the gas density, which is accentuated in the mm dust grain population with intensity contrasts in mm-continuum emission of 10 or higher. We perform mock observations to demonstrate that these features closely match those observed by ALMA, suggesting that the origin of rings, dust horseshoes and other non-axisymmetric structures in transition discs can be explained by the presence of massive companions.

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[Fe II] jets from intermediate-mass protostars in Carina

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We present new HST/WFC3-IR narrowband [Fe II] images of protostellar jets in the Carina Nebula. Combined with 5 previously published sources, we have a sample of 18 jets and 2 HH objects. All of the jets we targeted with WFC3 show bright infrared [Fe II] emission, and a few Hα candidate jets are confirmed as collimated outflows based on the morphology of their [Fe II] emission. Continuum-subtracted images clearly separate jet emission from the adjacent ionization front, providing a better tracer of the collimated jet than Hα and allowing us to connect these jets with their embedded driving sources. The [Fe II] 1.64 μm/Hα flux ratio measured in the jets is $\gtrsim$5 times larger than in the adjacent ionization fronts. The low-ionization jet core requires high densities to shield Fe^+ against further ionization by the FUV radiation from O-type stars in the H II region. High jet densities imply high mass-loss rates, consistent with the intermediate-mass driving sources we identify for 13 jets. The remaining jets emerge from opaque globules that obscure emission from the protostar. In many respects, the HH jets in Carina look like a scaled-up version of the jets driven by low-mass protostars. Altogether, these observations suggest that [Fe II] emission is a reliable tracer of dense, irradiated jets driven by intermediate-mass protostars. We argue that highly collimated outflows are common to more massive protostars, and that they suggest the outflow physics inferred for low-mass stars formation scales up to at least ~ 8 $M_\odot$.

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A multi-wavelength characterization of proto-brown dwarf candidates in Serpens

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We present results from a deep sub-millimeter survey in the Serpens Main and Serpens/G3-G6 clusters, conducted with the Submillimetre Common-User Bolometer Array (SCUBA-2) at the James Clerk Maxwell Telescope. We have combined near- and mid-infrared spectroscopy, *Herschel* PACS far-infrared photometry, sub-millimeter continuum and molecular gas line observations, with the aim to conduct a detailed multi-wavelength characterization of 'proto-brown dwarf' candidates in Serpens. We have performed continuum and line radiative transfer modeling, and have considered various classification schemes to understand the structure and the evolutionary stage of the system. We have identified four proto-brown dwarf candidates, of which the lowest luminosity source has an $L_{\rm bol}$ ~0.05 $L_{\odot}$. Two of these candidates show characteristics consistent with Stage 0/I systems, while the other two are Stage I-T/Class Flat systems with tenuous envelopes. Our work has also revealed a ~20% fraction of mis-identified Class 0/I/Flat sources that show characteristics consistent with Class II edge-on disk systems. We have set constraints on the mass of the central object using the measured bolometric luminosities and numerical simulations of stellar evolution. Considering the available gas+dust mass reservoir and the current mass of the central source, three of these candidates are likely to evolve into brown dwarfs.

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Constraints on the size and dynamics of the J1407b ring system

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Context. J1407 (1SWASP J140747.93-394542.6 in full) is a young star in the Scorpius-Centaurus OB association that underwent a series of complex eclipses over 56 days in 2007. To explain these, it was hypothesised that a secondary substellar companion, J1407b, has a giant ring system filling a large fraction of the Hill sphere, causing the eclipses. Observations have not successfully detected J1407b, but do rule out circular orbits for the companion around the primary star.
Aims. We test to what degree the ring model of J1407b could survive in an eccentric orbit required to fit the observations.
Methods. We run N-body simulations under the AMUSE framework to test the stability of Hill radius-filling systems where the companion is on an eccentric orbit.
Results. We strongly rule out prograde ring systems and find that a secondary of 60 to 100$M_{\rm Jup}$ with an 11 year orbital period and retrograde orbiting material can survive for at least 10^4 orbits and produce eclipses with similar durations as the observed one.

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Young Stellar Populations in MYStIX Star Forming Regions: Candidate Protostars

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The Massive Young Star Forming Complex in Infrared and X-ray (MYStIX) project provides a new census on stellar members of massive star forming regions within 4 kpc. Here the MYStIX Infrared Excess catalog (MIRES) and *Chandra*-based X-ray photometric catalogs are mined to obtain high-quality samples of Class I protostars using criteria designed to reduce extragalactic and Galactic field star contamination. A total of 1,109 MYStIX Candidate Protostars (MCPs) are found in 14 star forming regions. Most are selected from protoplanetary disk infrared excess emission, but 20% are found from their ultrahard X-ray spectra from heavily absorbed magnetospheric flare emission. Two-thirds of the MCP sample is newly reported here. The resulting samples are strongly spatially associated with molecular cores and filaments on *Herschel* far-infrared maps. This spatial agreement and other evidence indicate that the MCP sample has high reliability with relatively few 'false positives' from contaminating populations. But the limited sensitivity and sparse overlap among the infrared and X-ray subsamples indicate that the sample is very incomplete with many 'false negatives'. Maps, tables, and source descriptions are provided to guide further study of star formation in these regions. In particular, the nature of ultrahard X-ray protostellar candidates without known infrared counterparts needs to be elucidated.

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http://www.astro.psu.edu/mystix
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The origin of the eccentricity of the hot Jupiter in CI Tau

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Following the recent discovery of the first radial velocity planet in a star still possessing a protoplanetary disc (CI Tau), we examine the origin of the planet's eccentricity ($e \sim 0.3$). We show through long timescale (105 orbits) simulations that the planetary eccentricity can be pumped by the disc, even when its local surface density is well below the threshold previously derived from short timescale integrations. We show that the disc may be able to excite the planet's orbital eccentricity in $<$ a Myr for the system parameters of CI Tau. We also perform two planet scattering experiments and show that alternatively the observed planet may plausibly have acquired its eccentricity through dynamical scattering of a migrating lower mass planet, which has either been ejected from the system or swallowed by the central star. In the latter case the present location and eccentricity of the observed planet can be recovered if it was previously stalled within the disc's magnetospheric cavity.

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The IRAS 08589−4714 star-forming region

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We present an analysis of the IRAS 08589−4714 star-forming region. This region harbors candidate young stellar objects identified in the WISE and Herschel images using color index criteria and spectral energy distributions (SEDs). The SEDs of some of the infrared sources and the 70 μm radial intensity profile of the brightest source (IRS 1) are modeled from Herschel fluxes using the one-dimensional radiative transfer DUSTY code. For these objects, we estimate the envelope masses, sizes, densities, and luminosities which suggest that they are very young, massive and luminous objects at early stages of the formation process. Color-color diagrams in the bands of WISE and 2MASS are used to identify potential young objects in the region. Those identified in the bands of WISE would be contaminated by the emission of PAHs. We use the emission distribution in the infrared at 70 and 160 μm, to estimate the dust temperature gradient. This suggests that the nearby massive star-forming region RCW 38, located $\sim$10 pc of the IRAS source position may be contributing to the photodissociation of the molecular gas and to the heating of the interstellar dust in the environs of the IRAS source.

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Molecular gas in the star-forming region IRAS 08589−4714

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We present an analysis of the region IRAS 08589−4714 with the aim of characterizing the molecular environment. We observed the CO(3–2), ^{13}CO(3–2), C^{18}O(3–2), HCO^{+}(3–2), and HCN(3–2) molecular lines in a region of $150'' \times 150''$, centered on the IRAS source, to analyze the distribution and characteristics of the molecular gas linked to the IRAS source. The molecular gas distribution reveals a molecular clump that is coincident with IRAS 08589−4714 and with a dust clump detected at 1.2 mm. The molecular clump is 0.45 pc in radius and its mass and H_2 volume density are 310 $M_\odot$ and 1.2×10^4 cm^{-3}, respectively. Two overdensities were identified within the clump in HCN and HCO lines. A comparison of the LTE and virial masses suggests that the clump is collapsing in regions that harbor young stellar objects. An analysis of the molecular lines suggests that they are driving molecular outflows.

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Orbits, Distance, and Stellar Masses of the Massive Triple Star σ Orionis

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We present interferometric observations of the σ Orionis triple system using the CHARA Array, NPOI, and VLTI. Using these measurements, we spatially resolve the orbit of the close spectroscopic binary (Aa,Ab) for the first time and present a revised orbit for the wide pair (A,B). Combining the visual orbits with previously published radial velocity measurements and new radial velocities measured at CTIO, we derive dynamical masses for the three massive stars in the system of $M_{\rm Aa} = 16.99 \pm 0.20\ M_\odot$, $M_{\rm Ab} = 12.81 \pm 0.18\ M_\odot$, and $M_{\rm B} = 11.5 \pm 1.2\ M_\odot$. The inner and outer orbits in the triple are not coplanar, with a relative inclination of 120°–127°. The orbital parallax provides a precise distance of 387.5 ± 1.3 pc to the system. This is a significant improvement over previous estimates of the distance to the young σ Orionis cluster.

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How bright are the gaps in circumbinary disk systems?

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When a circumbinary disk surrounds a binary whose secondary's mass is at least $\sim 10^{-2}\times$ the primary's mass, a nearly empty cavity with radius a few times the binary separation is carved out of the disk. Narrow streams of material pass from the inner edge of the circumbinary disk into the domain of the binary itself, where they eventually join onto the small disks orbiting the members of the binary. Using data from 3-d MHD simulations of this process, we determine the luminosity of these streams; it is mostly due to weak laminar shocks, and is in general only a few percent of the luminosity of adjacent regions of either the circumbinary disk or the "mini-disks". This luminosity therefore hardly affects the deficit in the thermal continuum predicted on the basis of a perfectly dark gap region.

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Discovery of Infalling Motion with Rotation of the Cluster-Forming Clump S235AB and Its Implication to the Clump Structures

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We report the discovery of infalling motion with rotation of S235AB the massive cluster-forming clump ($sim1times10^3$ $Msun$) in the S235 region. Our $C^{18}O$ observations with the 45m telescope at the Nobeyama Radio Observatory have revealed the elliptical shape of the clump. Position-velocity (PV) diagram taken along its major axis exhibits two well-defined peaks symmetrically located with respect to the clump center, which is similar to that found for a dynamically infalling envelope with rotation around a single protostar modeled by N. Ohashi and his collaborators, indicating that the cluster-forming clump is also collapsing by the self-gravity toward the clump center. With analogue to Ohashi 's model, we made a simple model of an infalling, rotating clump to fit the observed data. Based on the inferred model parameters as well as results of earlier observations and simulations in the literature, we discuss structures of the

clump such as the relation among the global mass infall rate (*sim1times*10^{-3} *Msun* yr^{-1}), formation of a compact core (with a mass and size of *sim*4 *Msun* and *lesssim*0.1 pc) at the center, and a massive star (*sim*11 *Msun*) forming in the core.

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Chandra and XMM-Newton X-Ray Observations of the Hyperactive T Tauri Star RY Tau

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We present results of pointed X-ray observations of the accreting jet-driving T Tauri star RY Tau using Chandra and XMM-Newton. We obtained high-resolution grating spectra and excellent-quality CCD spectra and light curves with the objective of identifying the physical mechanisms underlying RY Tau's bright X-ray emission. Grating spectra reveal numerous emission lines spanning a broad range of temperature superimposed on a hot continuum. The X-ray emission measure distribution is dominated by very hot plasma at $T_{hot} \sim 50$ MK, but higher temperatures were present during flares. A weaker cool plasma component is also present as revealed by low-temperature lines such as O VIII. X-ray light curves show complex variability consisting of short-duration (∼hours) superhot flares accompanied by fluorescent Fe emission at 6.4 keV superimposed on a slowly varying (∼one day) component that may be tied to stellar rotation. The hot flaring component is undoubtedly of magnetic (e.g., coronal) origin. Soft- and hard-band light curves undergo similar slow variability implying that at least some of the cool plasma shares a common magnetic origin with the hot plasma. Any contribution to the X-ray emission from cool shocked plasma is small compared to the dominant hot component but production of individual low-temperature lines such as O VIII in an accretion shock is not ruled out.

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Stellar clusterings around "Isolated" Massive YSOs in the LMC

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Observations suggest that there is a significant fraction of O-stars in the field of the Milky Way that appear to have formed in isolation or in low mass clusters (<100 $M_\odot$). The existence of these high-mass stars that apparently formed in the field challenges the generally accepted paradigm, which requires star formation to occur in clustered environments. In order to understand the physical conditions for the formation of these stars, it is necessary to observe isolated high-mass stars while they are still forming. With the Hubble Space Telescope, we observe the seven most isolated massive (>8 $M_\odot$) young stellar objects (MYSOs) in the Large Magellanic Cloud (LMC). The observations show that while these MYSOs are remote from other MYSOs, OB associations, and even from known giant molecular clouds, they are actually not isolated at all. Imaging reveals ∼100 to several hundred pre–main-sequence (PMS) stars in the vicinity of each MYSO. These previously undetected PMS stars form prominent compact clusters around the MYSOs, and in most cases they are also distributed sparsely across the observed regions. Contrary to what previous high-mass field star studies show, these observations suggest that high-mass stars may not be able to form in clusters with masses less than 100 $M_\odot$. If these MYSOs are indeed the best candidates for isolated high-mass star formation, then the lack of isolation is at odds with random sampling of the IMF. Moreover, while isolated MYSOs may not exist, we find evidence that isolated clusters containing O-stars can exist, which in itself is rare.

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Scattered light mapping of protoplanetary disks

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High-contrast scattered light observations have revealed the surface morphology of several dozens of protoplanetary disks at optical and near-infrared wavelengths. Inclined disks offer the opportunity to measure part of the phase function of the dust grains that reside in the disk surface which is essential for our understanding of protoplanetary dust properties and the early stages of planet formation. We aim to construct a method which takes into account how the flaring shape of the scattering surface of an (optically thick) protoplanetary disk projects onto the image plane of the observer. This allows us to map physical quantities (scattering radius and scattering angle) onto scattered light images and retrieve stellar irradiation corrected (r^2-scaled) images and dust phase functions. We apply the method on archival polarized intensity images of the protoplanetary disk around HD 100546 that were obtained with VLT/SPHERE in R'-band and VLT/NACO in H- and K_s-band. The brightest side of the r^2-scaled R'-band polarized intensity image of HD 100546 changes from the far to the near side of the disk when a flaring instead of a geometrically flat disk surface is used for the r^2-scaling. The decrease in polarized surface brightness in the scattering angle range of ∼40°–70° is likely a result of the dust phase function and degree of polarization which peak in different scattering angle regimes. The derived phase functions show part of a forward scattering peak which indicates that large, aggregate dust grains dominate the scattering opacity in the disk surface. Projection effects of a protoplanetary disk surface need to be taken into account to correctly interpret scattered light images. Applying the correct scaling for the correction of stellar irradiation is crucial for the interpretation of the images and the derivation of the dust properties in the disk surface layer.

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Evolution of Protoplanetary Discs with Magnetically Driven Disc Winds

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Aims. We investigate the evolution of protoplanetary discs (PPDs hereafter) with magnetically driven disc winds and viscous heating.
Methods. We consider an initially massive disc with $\sim$0.1 $M_{\odot}$ to track the evolution from the early stage of PPDs. We solve the time evolution of surface density and temperature by taking into account viscous heating and the loss of the mass and the angular momentum by the disc winds within the framework of a standard α model for accretion discs. Our model parameters, turbulent viscosity, disc wind mass loss, and disc wind torque, which are adopted from local magnetohydrodynamical simulations and constrained by the global energetics of the gravitational accretion, largely depends on the physical condition of PPDs, particularly on the evolution of the vertical magnetic flux in weakly ionized PPDs.
Results. Although there are still uncertainties concerning the evolution of the vertical magnetic flux remaining, surface densities show a large variety, depending on the combination of these three parameters, some of which are very different from the surface density expected from the standard accretion. When a PPD is in a "wind-driven accretion" state with the preserved vertical magnetic field, the radial dependence of the surface density can be positive in the inner region <1–10 au. The mass accretion rates are consistent with observations, even in the very low level of magnetohydrodynamical turbulence. Such a positive radial slope of the surface density gives a great impact on planet formation because (i) it inhibits the inward drift or even results in the outward drift of pebble/boulder-sized solid bodies, and (ii) it also makes the inward type-I migration of proto-planets slower or even reversed.
Conclusions. The variety of our calculated PPDs should yield a wide variety of exoplanet systems.

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Anatomy of the internal bow shocks in the IRAS 04166+2706 protostellar jet

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Context. Highly collimated jets and wide-angle outflows are two related components of the mass-ejection activity associated with stellar birth. Despite decades of research, the relation between these two components remains poorly understood.

Aims. We study the relation between the jet and the outflow in the IRAS 04166+2706 protostar. This Taurus protostar drives a molecular jet that contains multiple emission peaks symmetrically located from the central source. The protostar also drives a wide-angle outflow consisting of two conical shells.
Methods. We have used the Atacama Large Millimeter/submillimeter Array (ALMA) interferometer to observe two fields along the IRAS 04166+2706 jet. The fields were centered on a pair of emission peaks that correspond to the same ejection event. The observations were carried out in CO(2–1), SiO(5–4), and SO(J_N=6_5–5_4).
Results. Both ALMA fields present spatial distributions that are approximately elliptical and have their minor axes aligned with the jet direction. As the velocity increases, the emission in each field moves gradually across the elliptical region. This systematic pattern indicates that the emitting gas in each field lies in a disk-like structure that is perpendicular to the jet axis and whose gas is expanding away from the jet. A small degree of curvature in the first-moment maps indicates that the disks are slightly curved in the manner expected for bow shocks moving away from the IRAS source. A simple geometrical model confirms that this scenario fits the main emission features.
Conclusions. The emission peaks in the IRAS 04166+2706 jet likely represent internal bow shocks where material is being ejected laterally away from the jet axis. While the linear momentum of the ejected gas is dominated by the component in the jet direction, the sideways component is not negligible, and can potentially affect the distribution of gas in the surrounding outflow and core.

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On the formation of planetary systems in photoevaporating transition discs

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In protoplanetary discs, planetary cores must be at least 0.1 $M_\oplus$ at 1 au for migration to be significant; this mass rises to 1 $M_\oplus$ at 5 au. Planet formation models indicate that these cores form on million year timescales. We report here a study of the evolution of 0.1 $M_\oplus$ and 1 $M_\oplus$ cores, migrating from about 2 and 5 au respectively, in million year old photoevaporating discs. In such a disc, a gap opens up at around 2 au after a few million years. The inner region subsequently accrete onto the star on a smaller timescale. We find that, typically, the smallest cores form systems of non-resonant planets beyond 0.5 au with masses up to about 1.5 $M_\oplus$. In low mass discs, the same cores may evolve in situ. More massive cores form systems of a few earth masses planets. They migrate within the inner edge of the disc gap only in the most massive discs. Delivery of material to the inner parts of the disc ceases with opening of the gap. Interestingly, when the heavy cores do not migrate significantly, the type of systems that are produced resembles our solar system. This study suggests that low mm flux transition discs may not form systems of planets on short orbits but may instead harbour earth mass planets in the habitable zone.

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On the energy dissipation rate at the inner edge of circumbinary discs

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We study, by means of numerical simulations and analysis, the details of the accretion process from a disc onto a binary system. We show that energy is dissipated at the edge of a circumbinary disc and this is associated with the tidal torque that maintains the cavity: angular momentum is transferred from the binary to the disc through the action of compressional shocks and viscous friction. These shocks can be viewed as being produced by fluid elements which drift into the cavity and, before being accreted, are accelerated onto trajectories that send them back to impact

the disc. The rate of energy dissipation is approximately equal to the product of potential energy per unit mass at the disc's inner edge and the accretion rate, estimated from the disc parameters just beyond the cavity edge, that would occur without the binary. For very thin discs, the actual accretion rate onto the binary may be significantly less. We calculate the energy emitted by a circumbinary disc taking into account energy dissipation at the inner edge and also irradiation arising there from reprocessing of light from the stars. We find that, for tight PMS binaries, the SED is dominated by emission from the inner edge at wavelengths between 1–4 and 10 μm. This may apply to systems like CoRoT 223992193 and V1481 Ori.

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Planet formation with envelope enrichment: new insights on planetary diversity

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We compute, for the first time, self-consistent models of planet growth including the effect of envelope enrichment. The change of envelope metallicity is assumed to be the result of planetesimal disruption or icy pebble sublimation. We solve internal structure equations taking into account global energy conservation for the envelope to compute in-situ planetary growth. We consider different opacities and equations of state suited for a wide range of metallicities. We find that envelope enrichment speeds up the formation of gas giants. It also explains naturally the formation of low and intermediate mass objects with large fractions of H-He (∼20–30% in mass). High opacity models explain well the metallicity of the giant planets of the solar system, whereas low opacity models are suited for forming small mass objects with thick H-He envelopes and gas giants with sub-solar envelope metallicities. We find good agreement between our models and the estimated water abundance for WASP-43b. For HD 189733b, HD 209458b and WASP-12b we predict fractions of water larger than what is estimated from observations, by at least a factor ~ 2. Envelope enrichment by icy planetesimals is the natural scenario to explain the formation of a large variety of objects, ranging from mini-Neptunes, to gas giants. We predict that the total and envelope metallicity decrease with planetary mass.

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Importance of the H_2 abundance in protoplanetary disk ices for the molecular layer chemical composition

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Protoplanetary disks are the target of many chemical studies (both observational and theoretical) as they contain the building material for planets. Their large vertical and radial gradients in density and temperature make them challenging objects for chemical models. In the outer part of these disks, the large densities and low temperatures provide a particular environment where the binding of species onto the dust grains can be very efficient and can affect the gas-phase chemical composition.
We attempt to quantify to what extent the vertical abundance profiles and the integrated column densities of molecules predicted by a detailed gas-grain code are affected by the treatment of the molecular hydrogen physisorption at the surface of the grains. We performed three different models using the Nautilus gas-grain code. One model uses a H_2 binding energy on the surface of water (440 K) and produces strong sticking of H_2. Another model uses a small binding energy of 23 K (as if there were already a monolayer of H_2), and the sticking of H_2 is almost negligible. Finally,

the remaining model is an intermediate solution known as the encounter desorption mechanism. We show that the efficiency of molecular hydrogen binding (and thus its abundance at the surface of the grains) can have a quantitative effect on the predicted column densities in the gas phase of major species such as CO, CS, CN, and HCN.

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Protostellar Outflows in L1340

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We have searched the L1340 A, B, and C clouds for shocks from protostellar outflows using the H_2 2.122 μm near-IR line as a shock tracer. Substantial outflow activity has been found in each of the three regions of the cloud (L1340 A, L1340 B, & L1340 C). We find 42 distinct shock complexes (16 in L1340 A, 11 in L1340 B, and 15 in L1340 C). We were able to link 17 of those shock complexes in to 12 distinct outflows and identify candidate source stars for each. We examine the properties (A_V, T_{bol}, and L_{bol}) of the source protostars and compare that to the properties of the general population of Class 0/I and flat SED protostars and find that there is an indication, albeit at low statistical significance, that the outflow driving protostars are drawn from a population with lower A_V, higher L_{bol}, and lower T_{bol} than the general population of protostars.

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Terrestrial Planet Formation from an Annulus

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It has been shown that some aspects of the terrestrial planets can be explained, particularly the Earth/Mars mass ratio, when they form from a truncated disk with an outer edge near 1.0 au (Hansen 2009). This has been previously modeled starting from an intermediate stage of growth utilizing pre-formed planetary embryos. We present simulations that were designed to test this idea by following the growth process from km-sized objects located between 0.7 to 1.0 au up to terrestrial planets. The simulations explore initial conditions where the solids in the disk are planetesimals with radii initially between 3 and 300 km, alternately including effects from a dissipating gaseous solar nebula and collisional fragmentation. We use a new Lagrangian code known as LIPAD (Levison et al. 2012), which is a particle-based code that models the fragmentation, accretion and dynamical evolution of a large number of planetesimals, and can model the entire growth process from km-sizes up to planets. A suite of large (Mars mass) planetary embryos is complete in only 1 Myr, containing most of the system mass. A quiescent period then persists for 10–20 Myr characterized by slow diffusion of the orbits and continued accretion of the remaining planetesimals. This is interupted by an instability that leads to embryos crossing orbits and embyro-embryo impacts that eventually produce the final set of planets. While this evolution is different than that found in other works exploring an annulus, the final planetary systems are similar, with roughly the correct number of planets and good Mars-analogs.

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A Census of Large-scale (≥10 pc), Velocity-coherent, Dense Filaments in the Northern Galactic Plane: Automated Identification Using Minimum Spanning Tree

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Large-scale gaseous filaments with lengths up to the order of 100 pc are on the upper end of the filamentary hierarchy of the Galactic interstellar medium (ISM). Their association with respect to the Galactic structure and their role in Galactic star formation are of great interest from both an observational and theoretical point of view. Previous "by-eye" searches, combined together, have started to uncover the Galactic distribution of large filaments, yet inherent bias and small sample size limit conclusive statistical results from being drawn. Here, we present (1) a new, automated method for identifying large-scale velocity-coherent dense filaments, and (2) the first statistics and the Galactic distribution of these filaments. We use a customized minimum spanning tree algorithm to identify filaments by connecting voxels in the position-position-velocity space, using the Bolocam Galactic Plane Survey spectroscopic catalog. In the range of $7.^\circ5 \leq l \leq 194^\circ$, we have identified 54 large-scale filaments and derived mass ($\sim 10^3 - 10^5\ M_\odot$), length (10–276 pc), linear mass density (54–8625 $M_\odot\, pc^{-1}$), aspect ratio, linearity, velocity gradient, temperature, fragmentation, Galactic location, and orientation angle. The filaments concentrate along major spiral arms. They are widely distributed across the Galactic disk, with 50% located within ±20 pc from the Galactic mid-plane and 27% run in the center of spiral arms. An order of 1% of the molecular ISM is confined in large filaments. Massive star formation is more favorable in large filaments compared to elsewhere. This is the first comprehensive catalog of large filaments that can be useful for a quantitative comparison with spiral structures and numerical simulations.

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K-band integral field spectroscopy and optical spectroscopy of massive young stellar objects in the Small Magellanic Cloud

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We present K-band integral field spectroscopic observations towards 17 massive young stellar objects (YSOs) in the low metallicity Small Magellanic Cloud (SMC) and two YSO candidates in the compact H II regions N81 and N88 A (also in the SMC). These sources, originally identified using *Spitzer* photometry and/or spectroscopy, have been resolved into 29 K-band continuum sources. By comparing Brγ emission luminosities with those presented for a Galactic sample of massive YSOs, we find tentative evidence for increased accretion rates in the SMC. Around half of our targets exhibit emission line (Brγ, He I and H_2) morphologies which extend significantly beyond the continuum source and we have mapped both the emission morphologies and the radial velocity fields. This analysis also reveals evidence for the existence of ionized low density regions in the centre outflows from massive YSOs. Additionally we present an analysis of optical spectra towards a similar sample of massive YSOs in the SMC, revealing that the optical emission is photo-excited and originates near the outer edges of molecular clouds, and is therefore consistent with a high mean-free path of UV photons in the interstellar medium (ISM) of the SMC. Finally, we discuss the sample of YSOs in an evolutionary context incorporating the results of previous infrared and radio observations, as well as the near-infrared and optical observations presented in this work. Our spectroscopic analysis in both the K-band and the

optical regimes, combined with previously obtained infrared and radio data, exposes differences between properties of massive YSOs in our own Galaxy and the SMC, including tracers of accretion, discs and YSO–ISM interactions.

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The JCMT and Herschel Gould Belt Surveys: A comparison of SCUBA-2 and Herschel data of dense cores in the Taurus dark cloud L1495

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We present a comparison of SCUBA-2 850-μm and *Herschel* 70–500-μm observations of the L1495 filament in the Taurus Molecular Cloud with the goal of characterising the SCUBA-2 Gould Belt Survey (GBS) data set. We identify and characterise starless cores in three data sets: SCUBA-2 850-μm, *Herschel* 250-μm, and *Herschel* 250-μm spatially filtered to mimic the SCUBA-2 data. SCUBA-2 detects only the highest-surface-brightness sources, principally detecting protostellar sources and starless cores embedded in filaments, while *Herschel* is sensitive to most of the cloud structure, including extended low-surface-brightness emission. *Herschel* detects considerably more sources than SCUBA-2 even after spatial filtering. We investigate which properties of a starless core detected by *Herschel* determine its detectability by SCUBA-2, and find that they are the core's temperature and column density (for given dust properties). For similar-temperature cores, such as those seen in L1495, the surface brightnesses of the cores are determined by their column densities, with the highest-column-density cores being detected by SCUBA-2. For roughly spherical geometries, column density corresponds to volume density, and so SCUBA-2 selects the densest cores from a population at a given temperature. This selection effect, which we quantify as a function of distance, makes SCUBA-2 ideal for identifying those cores in *Herschel* catalogues that are closest to forming stars. Our results can now be used by anyone wishing to use the SCUBA-2 GBS data set.

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How to design a planetary system for different scattering outcomes: giant impact sweet spot, maximising exocomets, scattered disks

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This paper considers the dynamics of scattering of planetesimals or planetary embryos by a planet on a circumstellar orbit. We classify six regions in the planet's mass versus semimajor axis parameter space according to the dominant outcome for scattered objects: ejected, accreted, remaining, escaping, Oort Cloud, depleted Oort Cloud. We use these outcomes to consider which planetary system architectures maximise the observability of specific signatures, given that signatures should be detected first around systems with optimal architectures (if such systems exist in nature). Giant impact debris is most readily detectable for $0.1 - 10M_\oplus$ planets at 1-5 au, depending on detection method and spectral type. While A stars have putative giant impact debris at $4 - 6$ au consistent with this sweet spot, that of FGK stars is typically $\ll 1$ au contrary to expectations; an absence of $1 - 3$ au giant impact debris could indicate a low frequency of terrestrial planets there. Three principles maximise cometary influx from exo-Kuiper belts: a chain of closely separated planets interior to the belt, none of which is a Jupiter-like ejector; planet masses not increasing strongly with distance (for a net inward torque on comets); ongoing replenishment of comets, possibly by embedded low-mass planets. A high Oort Cloud comet influx requires no ejector and architectures that maximise the Oort Cloud population. Cold debris disks are usually considered classical Kuiper belt analogues. Here we consider the possibility of detecting scattered disk analogues, which could be betrayed by a broad radial profile and lack of small grains, as well as spherical 100-1000 au mini-Oort Clouds. Some implications for escaping planets around young stars, detached planets akin to Sedna, and the formation of super-Earths, are also discussed.

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http://arxiv.org/pdf/1610.00714

Stacking Spectra in Protoplanetary Disks: Detecting Intensity Profiles from Hidden Molecular Lines in HD 163296

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We introduce a new stacking method in Keplerian disks that (1) enhances signal-to-noise ratios (S/N) of detected molecular lines and (2) that makes visible otherwise undetectable weak lines. Our technique takes advantage of the Keplerian rotational velocity pattern. It aligns spectra according to their different centroid velocities at their different positions in a disk and stacks them. After aligning, the signals are accumulated in a narrower velocity range as compared to the original line width without alignment. Moreover, originally correlated noise becomes de-correlated. Stacked and aligned spectra, thus, have a higher S/N. We apply our method to ALMA archival data of DCN (3–2), DCO^+ (3–2), N_2D^+ (3–2), and H_2CO ($3_{0,3}$–$2_{0,2}$), ($3_{2,2}$–$2_{2,1}$), and ($3_{2,1}$–$2_{2,0}$) in the protoplanetary disk around HD 163296. As a result, (1) the S/N of the originally detected DCN (3–2), DCO^+ (3–2), and H_2CO ($3_{0,3}$–$2_{0,2}$) and N_2D^+ (3–2) lines are boosted by a factor of $\gtrsim$4–5 at their spectral peaks, implying one order of magnitude shorter integration times to reach the original S/N; and (2) the previously undetectable spectra of the H_2CO ($3_{2,2}$–$2_{2,1}$) and ($3_{2,1}$–$2_{2,0}$) lines are materialized at more than 3σ. These dramatically enhanced S/N allow us to measure intensity distributions in all lines with high significance. The principle of our method can not only be applied to Keplerian disks but also to any systems with ordered kinematic patterns.

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http://arxiv.org/pdf/1610.01780

Interaction between the Supernova Remnant HB 3 and the Nearby Star-Forming Region W3

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We performed millimeter observations in CO lines toward the supernova remnant (SNR) HB 3. Substantial molecular gas around -45 km s^{-1} is detected in the conjunction region between the SNR HB 3 and the nearby W3 complex. This molecular gas is distributed along the radio continuum shell of the remnant. Furthermore, the shocked molecular gas indicated by line wing broadening features is also distributed along the radio shell and inside it. By both morphological correspondence and dynamical evidence, we confirm that the SNR HB 3 is interacting with the -45 km s^{-1} molecular cloud (MC), in essence, with the nearby H II region/MC complex W3. The red-shifted line wing broadening features indicate that the remnant is located at the nearside of the MC. With this association, we could place the remnant at the same distance as the W3/W4 complex, which is 1.95 ± 0.04 kpc. The spatial distribution of aggregated young stellar object candidates (YSOc) shows a correlation to the shocked molecular strip associated with the remnant. We also find a binary clump of CO at ($l = 132.^{\circ}94$, $b = 1.^{\circ}12$) around -51.5 km s^{-1} inside the projected extent of the remnant, and it is associated with significant mid-infrared (mid-IR) emission. The binary system also has a tail structure resembling the tidal tails of interacting galaxies. According to the analysis of CO emission lines, the larger clump in this binary system is about stable, and the smaller clump is significantly disturbed.

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Shock-driven Accretion in Circumplanetary Disks: Observables and Satellite Formation

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Circumplanetary disks (CPDs) control the growth of planets, supply material for satellites to form, and provide observational signatures of young forming planets. We have carried out two dimensional hydrodynamical simulations with radiative cooling to study CPDs, and suggested a new mechanism to drive the disk accretion. Two spiral shocks are present in CPDs, excited by the central star. We find that spiral shocks can at least contribute to, if not dominate the angular momentum transport and energy dissipation in CPDs. Meanwhile, dissipation and heating by spiral shocks have a positive feedback on shock-driven accretion itself. As the disk is heated up by spiral shocks, the shocks become more open, leading to more efficient angular momentum transport. This shock driven accretion is, on the other hand, unsteady on a timescale of months/years due to production and destruction of vortices in disks. After being averaged over time, a quasi-steady accretion is reached from the planet's Hill radius all the way to the planet surface, and the disk α-coefficient characterizing angular momentum transport due to spiral shocks is $\sim$0.001–0.02. The disk surface density ranges from 10 to 1000 g cm^{-2} in our simulations, which is at least 3 orders of magnitude smaller than the "minimum mass sub-nebula" model used to study satellite formation; instead it is more consistent with the "gas-starved" satellite formation model. Finally, we calculate the millimeter flux emitted by CPDs at ALMA and EVLA wavelength bands and predict the flux for several recently discovered CPD candidates, which suggests that ALMA is capable of discovering these accreting CPDs.

Accepted by ApJ

http://arxiv.org/pdf/1609.09250

Dissertation Abstracts

Activity of T Tauri type stars and objects similar to them

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Ph.D. degree awarded: June 2016

The main purpose of the dissertation is, on the basis of long-term light curves, to classify the variability of 28 PMS stars and to draw conclusions about the physical mechanisms initiating the observed changes in their brightness. 22 of the investigated stars are located in the dense molecular cloud L935, known as 'Gulf of Mexico' (NGC 7000/IC 5070), and 6 stars are located in the vicinity of the reflection nebula NGC 7129.

The multicolour photometric observations that we present were performed from 1993 to 2015 with the 2-m RCC, the 50/70-cm Schmidt and the 60-cm Cassegrain telescopes of the Rozhen NAO (Bulgaria) and the 1.3-m RC telescope of the Skinakas Observatory (Greece). All frames were taken through a standard Johnson–Cousins set of filters.

The studied stars were classified as follows:

• V752 Cyg, V1539 Cyg, V1716 Cyg, FHO 26, FHO 29, LkHα 186, LkHα 187, LkHα 191, [KW97] 53-17, [KW97] 53-22, [KW97] 53-23, V391 Cep, NGC 7129 S V2 and 2MASS J21403576+6635000 show characteristics for classical T Tauri stars; • V1538 Cyg, V1929 Cyg, [KW97] 53-20 and NGC 7129 S V1 are probably weak-line T Tauri stars; • LkHα 189 and [KW97] 53-11 show characteristics for both type T Tauri stars and spectral observations are needed for their exact classification; • V350 Cep shows indications for EXor and/or FUor-type variability; • V521 Cyg, FHO 27, FHO 28 and NGC 7129 S V3 show characteristics for UXor-type variability; • V1957 Cyg, V2051 Cyg and [KW97] 53-36 likely are evolved PMS stars or post-T Tauri stars.

Periodicity was discovered for 3 of the investigated stars. V1716 Cyg indicates a 4.15-day period, V1929 Cyg indicates a 0.43-day period and LkHα 189 indicates a 2.45-day period.

https://zenodo.org/record/60675

New Jobs

Postdoctoral position on star- and planet formation and astrochemistry with JWST-MIRI

A 3 year postdoctoral position is available within the Molecular Astrophysics group located at Leiden Observatory led by prof. dr. E.F. van Dishoeck associated with guaranteed and open time programs of JWST-MIRI on protostars and protoplanetary disks. The candidate will be involved in the planning of JWST observations, testing of data reduction software, analysis of initial science verification data, writing of open time JWST proposals, and exploitation of the first JWST science data.

The postdoc will be part of a larger international team studying the physical structure of protostars and their outflows, as well as the chemical evolution from collapsing cores to protoplanetary disks and exoplanets. The postdoc is expected to co-supervise PhD or MSc students. The position should start no later than October 1, 2017.

Candidates with an observational background in star formation or protoplanetary disks and with expertise in infrared spectroscopy are encouraged to apply.

Leiden Observatory carries out observational, interpretative and theoretical research in the fields of the star and planet formation, astrochemistry, laboratory astrophysics, galactic structure, the formation, dynamics and evolution of (high-redshift) galaxies and their nuclei, and cosmology. Leiden is a charming town, located close to a major international airport.

Applications should include a curriculum vitae, publication list, and a brief statement of research experience and interests, and arrange for at least three letters of reference to be uploaded at

http://jobs.strw.leidenuniv.nl/2016/dishoeckPDMIRI

Review of applications will start on November 15 2016.

Postdoctoral fellowship in star- and planet formation, astrochemistry

A 3-year postdoctoral fellowship is available within the Molecular Astrophysics group located at Leiden Observatory led by prof. dr. E.F. van Dishoeck. The postdoc will be part of an international team studying the physical and chemical evolution from collapsing cores to planet-forming disks and exoplanets centered around ALMA and (guaranteed time) JWST data.

The postdoc is expected to co-supervise PhD or MSc students and is encouraged to also pursue a personal research program. The position can start anytime in 2017.

Candidates with an observational and/or modeling background in astrochemistry, star formation, circumstellar disks, submillimeter/infrared spectroscopy, or planet formation are encouraged to apply.

Leiden Observatory carries out observational, interpretative and theoretical research in the fields of the star and planet formation, astrochemistry, laboratory astrophysics, galactic structure, the formation, dynamics and evolution of (high-redshift) galaxies and their nuclei, and cosmology. Leiden is a charming town, located close to a major international airport.

Applications should include a curriculum vitae, publication list, and a brief statement of research experience and interests, and arrange for at least three letters of reference to be uploaded at:

http://jobs.strw.leidenuniv.nl/2016/dishoeckPD

Review of applications will start on November 15 2016.

2 years Post-Doctoral Position in protostellar discs/accretion discs dynamics at the University of Milano (Italy)

The Department of Physics at the University of Milano (Italy) is seeking candidates for a 2 year post-doctoral position in protostellar disc/accretion disc dynamics, to start in early 2017.

The successful candidate will carry out research in at least one of the following areas: (a) theoretical modeling of gas and dust dynamics in protostellar discs, with applications to high resolution imaging of discs through, e.g. ALMA and extreme adaptive optics instruments, and to planet formation; (b) theoretical modeling of accretion discs around black holes, including black hole binaries, tidal disruption events and general relativistic effects.

Applicants should have a PhD in physics, astronomy or related subject by the time of the appointment. We encourage applications from candidates with strong expertise in numerical fluid dynamics.

The appointment is for 2 years with an income tax free gross salary of 21000 Euro per year (plus 7200 Euro per year of mobility allowance for candidates who are not residents in Italy), corresponding to a net monthly salary of approximately 1500 Euro (2100 Euro for non-Italian residents).

The official call for applications can be found at the following web page:

http://www.unimi.it/ricerca/assegni_ricerca/1260.htm

The deadline is the 15th of November 2016.

Informal expressions of interest (including a one-page statement of research interests, CV and list of publications) and enquiries can be addressed to: giuseppe.lodato@unimi.it

Included Benefits: Benefits include retirement benefit, access to national health care system, mobility allowance for non-Italian residents

Postdoctoral Research Positions in Astrochemistry

The Harvard-Smithsonian Center for Astrophysics invites applications for up to three postdoctoral research positions to work with Professor Karin Öberg in laboratory, theoretical and/or observational astrochemistry. The Öberg astrochemistry group explores the origins of chemical complexity in space and, how chemistry affects star and planet formation, including the bulk and organic compositions of young planets. The successful applicants will lead and participate in laboratory, theoretical and/or observational projects in line with this mission. They will work with Professor Öberg to develop new programs, support existing ones, and mentor graduate and undergraduate students. Applicants with previous experience in astrochemistry and related research are encouraged to apply.

Resources include a newly built astrochemistry laboratory with two existing ice experiments, and a third to be designed in 2017, the Odyssey and ITC (Institute for Theory and Computation) computer clusters, as well as access to data from multiple ALMA and SMA observational programs.

The positions are for two years, renewable for a third year upon mutual agreement. The nominal starting date will be September 1, 2017, but an earlier or later start is negotiable depending on the applicant's availability. Candidates must have a Ph.D. in astronomy, physics, chemistry, or equivalent, by the date of appointment. Applicants should submit a cover letter, CV, list of publications, and a statement explaining research interests and qualifications, and arrange for three letters of recommendation to be sent directly. All materials and inquiries should be sent by email to christine.benoit@cfa.harvard.edu.

Applications that are complete by January 1, 2017 will receive full consideration. The CfA hosts a strong research program in astronomy/astrophysics/astrochemistry and provides a stimulating environment. Harvard University is an Equal Opportunity / Affirmative Action Employer. Women and members of minority groups are especially welcome to apply.

Post-doctoral Position in Exoplanet Research at ETH Zurich

The Institute for Astronomy, ETH Zurich, Star and Planet Formation Research Group invites applications for a new post-doctoral fellowship to work with Dr. Sascha P. Quanz on extra-solar planets. Research in our group covers several areas including the direct detection and characterization of extra-solar planets, the structure and evolution of circumstellar disks, and the formation of planets in those disks.

The new position will mainly be in support of currently ongoing large imaging surveys at the Very Large Telescope as well as for the development of new image processing and data analysis algorithms to maximise the scientific return of these surveys.

Salary and duration of the appointment will be commensurate with experience. Starting salary begins at CHF 86'300, with an initial appointment of 2+1 years (depending on performance). Successful applicants will have the opportunity to work with students at all levels. Switzerland is a member of ESO and ESA, and the successful applicant will have full access to their facilities. The Institute for Astronomy maintains access to a range of high performance computing options, including stand-alone machines, large clusters, and the resources of the Swiss National Supercomputing Center (CSCS). Interested applicants will also be welcome to explore research opportunities in the Astronomical Instrumentation Laboratory. Our group is also involved in the Swiss National Centre for Competence in Research (NCCR) "PlanetS" Project, an interdisciplinary and inter-institutional research program focussed on the origin, evolution, and characterization of planets inside and outside the Solar System. For more information see: http://nccr-planets.ch.

Applications should consist of a CV and brief descriptions of past/proposed research (combined length not to exceed 6 pages). A separate publication list should be attached. Materials should be sent electronically in a single pdf file. This file, as well as three letters of reference (sent directly by the referees), should be sent to eth-astro-star-planet@phys.ethz.ch. Review of applications will begin December 1, 2016 and will continue until the position is filled. The starting date for the position can be as early as (early) spring 2017, but later dates are also possible.

The ETH Zurich will provide benefits for maternity leave, retirement, and accident insurance.
Weblink: https://www.ethz.ch/en/the-eth-zurich/working-teaching-and-research.html

2017 Exploration Fellowship in Earth and Space Science at Arizona State University

The School of Earth and Space Exploration (SESE) at Arizona State University invites applications for a Postdoctoral Research Associate who will serve as an Exploration Fellow. The mission of the postdoctoral Fellowship is to foster SESEs interdisciplinary research program by attracting and supporting outstanding early-career scientists and engineers to pursue independent research in collaboration with SESE faculty. Research areas within SESE encompass theoretical and observational astrophysics, astrobiology, cosmology, earth and planetary science, instrumentation and systems engineering, and science education. Anticipated start date for the position is July 2017. The expected duration of the Fellowship is three years. Incoming Fellows will receive an annual stipend of $61,000 with health benefits, plus $9,000 per year in discretionary research funds. A relocation allowance will be provided.

Interested candidates should contact two current faculty members in SESE to discuss potential collaborative research topics and determine whether they would agree to serve as mentors. When a topic of mutual interest between the applicant and potential faculty mentors is identified, the applicant should submit a research proposal that includes: (1) a cover letter identifying the proposed research topic and the names of the two faculty mentors, (2) a current CV, (3) a research proposal not longer than five pages, and (4) two papers exemplifying the applicants research. Applicants should arrange for three letters of reference to be submitted separately. Preference will be given to proposals that include interdisciplinary research spanning multiple research areas within SESE.

Minimum Qualifications: Ph.D. by the time of appointment, but received no earlier than 2012, in a field relevant to Earth and Space exploration, including (but not limited to) astrophysics, biology, chemistry, engineering, geology, physics, and planetary science. Applicants who received their Ph.D. prior to 2012 will not be considered.

Desired Qualifications: (1) research proposal that demonstrates relevance, interdisciplinary merit, and/or potential impact of the proposed research activities to the overarching big picture research questions in the field and to the mission of SESE, (2) a record of prior achievement and experience demonstrating the potential to accomplish proposed research objectives, and (3) evidence of strong verbal and written communication skills.

More information about the Exploration Fellowship can be found at: http://sese.asu.edu/exploration-fellowship

Arizona State University is a VEVRAA Federal Contractor and an Equal Opportunity/Affirmative Action Employer. All qualified applicants will be considered without regard to race, color, sex, religion, national origin, disability, protected veteran status, or any other basis protected by law. https://www.asu.edu/aad/manuals/acd/acd401.html https://www.asu.edu/titleIX/

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.

Meetings

ACCRETION, DIFFERENTIATION AND EARLY EVOLUTION OF THE TERRESTRIAL PLANETS

Nice, May 29 to June 3, 2017

This workshop will be a follow up to the one that we organized in Nice in May 2014. We expect around 120 participants, including a significant number of students and young scientists. The topics to be discussed include, but are not limited to:

1) Chemistry of small bodies in the early solar system and their relation to meteorites 2) Early dynamos in small bodies 3) Dynamical models of terrestrial planet formation and evolution of the Earth-Moon angular momentum 4) Moon formation models 5) Core-mantle differentiation 6) Delivery of volatile elements, including water 7) Nature and timing of the "late veneer" 8) Consequences of impacts 9) Geodynamics in early terrestrial planets including the onset of the geodynamo, mantle convection and plate tectonics. 10) Geophysics of extra-solar Earths and super-Earths

The workshop will be held at Le Saint Paul Hotel which is located on the sea front close to downtown Nice - see http://lesaintpaul-hotel.fr/. Participants will arrive on Monday May 29, 2014 and depart on Saturday June 3, so that scientific sessions (talks and posters) will be scheduled over a period of 4 days. The aim is, of course, to have lots of productive discussions!

Limited funding will be available, mainly to provide support, when necessary, for young scientists.

We have invited a number of scientists who have made major contributions to a range of scientific disciplines within the overall theme of the workshop. The following have confirmed that they will attend: C. Alexander, H. Becker, M. Bizarro, J. Day, C. Dorn, L. Elkins-Tanton, L. Hallis, J. Hernlund, M. Hirschmann, T. Kruijer, S. Labrosse, S. Lock, S. Marchi, B. Marty, S. Mojzsis, S. Mukhopadhyay, M. Nakajima, F. Nimmo, J. O?Rourke, S. Raymond, J. Siebert, A.Shahar, P. Tackley, T. Gerya, N. Tosi, J. Wade, B. Weiss, B. Wood, H. Palme.

The total number of participants is limited to 120. Scientists who wish to attend the workshop (including invited speakers) should complete an application form (https://www-n.oca.eu/morby/Accrete.html) and return it to dave.rubie@uni-bayreuth.de as soon as possible. Upon being accepted as a participant, a registration fee of 100 Euros must be paid in order to confirm registration..

Abstract deadline is 28th February 2017.

Accommodation is available at Le Saint Paul Hotel with rooms costing 115 euros/night (sea view) or 95 euros/night (garden view). Each room is a double room and they have 40 rooms total (in the case of sharing, the cost per person is 50% of the above figures). Alternatively, participants can book accommodation in nearby hotels.

With best regards

Dave Rubie and Alessandro Morbidelli

Emails: dave.rubie@uni-bayreuth.de and morby@oca.eu

Summary of Upcoming Meetings

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

Disks, Dynamos, and Data: Confronting MHD Accretion Theory with Observations
6 - 10 February 2017, Santa Barbara, USA
https://www.kitp.ucsb.edu/activities/disks-c17

The Physics of the ISM - 6 years of ISM-SPP 1573: what have we learned?
13 - 17 February 2017, Cologne, Germany
https://hera.ph1.uni-koeln.de/~ism2017/

Star Formation from Cores to Clusters
6 - 9 March 2017, Santiago, Chile
http://www.eso.org/sci/meetings/2017/star-formation2017.html

Astrochemistry VII - Through the Cosmos from Galaxies to Planets
20 - 24 March 2017, Puerto Varas, Chile
http://newt.phys.unsw.edu.au/IAUS332/

Formation and Dynamical Evolution of Exoplanets
26 - 31 March 2017, Aspen, USA
http://ciera.northwestern.edu/Aspen2017.php

Protoplanetary Disks and Planet Formation and Evolution
29 May - 23 June 2017, Garching bei München, Germany
http://www.munich-iapp.de/scientific-programme/programmes-2017/protoplanetary-disks/

Accretion, Differentiation and Early Evolution of Terrestrial Planets
29 May - 3 June 2017, Nice, France
https://www-n.oca.eu/morby/Accrete.html

Gordon Research Seminar Origins of Solar Systems
17 - 18 June 2017, South Hadley, USA
https://www.grc.org/programs.aspx?id=17506

Gordon Research Conference Origins of Solar Systems: Making a Habitable Planet
18 - 23 June 2017, South Hadley, USA
https://www.grc.org/programs.aspx?id=12346

Planet Formation and Evolution 2017
25 - 27 September 2017, Jena, Germany
http://www.astro.uni-jena.de/~pfe2017

Cool Stars 20: Cambridge Workshop on Cool Stars, Stellar Systems and the Sun
29 July - 3 August 2018, Cambridge/Boston, USA
http://www.coolstars20.com

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