THE STAR FORMATION NEWSLETTER

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

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The Star Formation Newsletter

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

Newsletter Archive

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List of Contents

Cover Picture

This HST image shows the NGC 2070 cluster in the Tarantula Nebula in the Large Magellanic Cloud. Its total mass is estimated at 450,000 $M_\odot$ The central compact region of the cluster is known as R136 and includes more than 70 massive O and Wolf-Rayet stars within the inner few parsec.

Image courtesy NASA/ESA.

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

Josef Solf

in conversation with Bo Reipurth

Q: *What was your path to Astronomy?*

A: My path to Astronomy was quite unusual. My father was the first one opening my eyes to the marvelous phenomena on the night sky, since he was very well acquainted with astronomy. I remember the night, perhaps I had been about 10, when my father showed me how to find the faint fuzzy spot of the Andromeda galaxy, step by step, within the Andromeda constellation. However, after finishing high-school, rather than following my early scientific inclinations, I decided to become a Jesuit. Over the next decade, I followed the traditional courses including philosophy, theology and other humanities. However, near the final stage of my studies, I decided to return to my early interest in science and, at the mature age of 29, started studying physics at the University of Heidelberg. Six years later in 1969, after I had finished my PhD in Nuclear Physics at the Heidelberg Max-Planck-Institute for Nuclear Physics, I heard that a new Max-Planck-Institute for Astronomy (MPIA) had been funded recently at Heidelberg, too. The projected MPIA should include, beside a new home institute at Heidelberg-Königstuhl, two new modern observatories outside of Germany, one in each hemisphere. Hans Elsässer, already director of the old Landessternwarte, became the designated first director of the MPIA. Then, I saw the unique opportunity to realize the dreams of my youth. After contacting Elsässer, I talked to him about my long-lasting interest in astronomical observations, as well as more recent work done in nuclear physics. At the end of that first conversation, he immediately offered me a position at the new MPIA. Perhaps, he felt that my knowledge of nuclear spectroscopy and computer applications in experimental physics might be useful for optical spectroscopy or computer applications in astronomy, too. My situation at the new MPIA was extremely challenging. I came from an outside field to astronomy joining a rather small team of competent scientists engaged with duties related to building up the facilities required by modern optical astronomy. My own duties included full responsibility for the future spectrographs as well as automation of astronomical instrumentation. During the early 1970s, the Calar Alto, a mountain in southern Spain, had been selected to become the site of the northern-hemisphere observatory of the MPIA, including a 2.2-m and a 3.5-m telescope. My duties were now focused on designing both spectrographs to be installed at the 2.2-m telescope at its Cassegrain as well as Coudé focus. Like all other of my new colleagues, I was still lacking any practical experience in observational spectroscopy. Fortunately, competent help had just arrived from the outside, in George Herbig from the Lick Observatory. Around 1969/1970, he was visiting the Landessternwarte at Heidelberg using its plate archive for his studies of young stars. I took the opportunity to talk to him about my problems of spectrograph design. After answering most of my questions, he invited me to visit Lick Observatory, where he would acquaint me with all "secrets" of high-resolution spectrographs as well as their practical use. I gladly accepted his invitation, and so, in 1971, George took me up to Mt. Hamilton and introduced me to the use of the 120-inch Coudé Spectrograph that he had designed. Back in Heidelberg, I felt better prepared for my duties with respect to our spectrograph projects.

Q: *You have worked extensively on Herbig-Haro objects, at a time when not many people did so. How did that interest develop?*

A: My first interest was stirred in 1974 by Karl-Heinz Böhm from the University of Washington in Seattle, when I attended his talk on HH phenomena during a meeting of German Astronomers. However, at the time it was much too early to consider any astronomical observations on Calar Alto. More than five years later, after the new 2.2-m telescope had become operational, I conducted my first-light observing campaigns to evaluate the performances of both the new Cassegrain spectrograph and the new 2.2-Coudé spectrograph, both of which I had developed. Since low-noise CCD detectors had not yet become available in 1979, I had to use another detector system, recently developed in the technical workshops at MPIA, consisting of a magnetically focused two-stage image-intensifier tube combined with photographic plates for recording the obtained spectrum. Then, being mostly interested in testing the long-slit capabilities of both spectrographs for two-dimensional spectroscopic mapping, I chose as one of the first targets the extended bipolar nebula S106. I succeeded in obtaining many high-quality long-slit emission-line spectrograms of the nebula at various slit positions and position angles. Right from the start, both spectrographs were performing satisfactorily in every respect. The following year, in 1981, when returning from another observing run, I met Karl-Heinz at MPIA during one of his regular visits and showed him a few of my recent high-resolution Coudé spectrograms of emission nebulae. He was much impressed by the performance of the instruments as well as the high quality of the data. However, when I asked him if I could obtain comparable results at Calar Alto on HH-objects, he was initially skeptical, but eventually agreed to join my next observing run. This was the start of our long-lasting cooperation on HH-objects, combining the observational results I would bring in and the theoretical competence Karl-Heinz was providing.

Q: *You collaborated for many years closely with Karl-Heinz Böhm. He died a few years ago, and may not be well known to younger readers. Please tell a bit more about him and about your collaborations.*

A: Karl-Heinz, born in 1923, started his astronomical career with some delay, too. During World War II, he was obliged to serve as the navigation officer on a sub-marine. After finishing high school in 1947, he began to study theoretical astrophysics at the University of Kiel, where he obtained his PhD in 1954, under the supervision of Albrecht Unsöld, then well known for his pioneering work on quantitative spectral analysis of stellar atmospheres. The same year, Karl-Heinz got married to Erika Böhm-Vitense, another young astrophysicist at Kiel. On an exchange fellowship, both spent a year at the University of California, Berkeley, living most of the time at Lick Observatory on Mt. Hamilton. There, in 1954, Karl-Heinz first met George Herbig and was invited by George to a collaboration on Herbig-Haro objects. Karl-Heinz accepted and carried out his first spectrophotometric analysis of HH1 based on three unwidened spectra obtained by George in 1955 with the nebular spectrograph of the Crossley reflector on Mt. Hamilton. Karl-Heinz' results from that early cooperation opened the HH-objects to quantitative study. Back in Germany, Erika and Karl-Heinz, after working at several astrophysical departments, eventually came to Heidelberg. After leaving Germany again in 1968, both became full professors at the Astronomy Department of the University of Washington in Seattle. Nevertheless, Karl-Heinz quite often returned to Germany using his summer vacations from his home University to continue cooperation with colleagues from Germany at Kiel or Heidelberg.

Q: *In the 1980s and 90s you made, together with Böhm and Alex Raga, a number of detailed spectroscopic studies of HH1/HH2, which today stand as the best spectroscopic analysis of these important objects. Please summarize some of your main results.*

A: I can't forget the first night that Karl-Heinz joined my observing session at the 2.2-m Coudé in December 1982. Right after finishing the photographic development of the plate we just had exposed, I showed him our very first spectrogram of HH1, still in the darkroom. He became so enthusiastic about the quality of the high-resolution long-slit spectrogram that he was unable to speak for a while. The harvest of that and a second night was a total of 11 long-slit spectrograms of HH1 as well as most of the brighter components of HH2. All spectrograms were secured in up to 3 different spectral regions, at various slit positions and position angles, either parallel or perpendicular to the direction of outflow. In the ensuing work, Karl-Heinz would take care of the theoretical part in quantitively interpreting and modelling the observed phenomena, while I did all the practical parts including the observation of HH-objects as well as the development of sophisticated data-processing methods for reducing the digitized long-slit spectrograms. During two subsequent Coudé observing sessions carried out in 1983 and 1985, I succeeded in securing many high-resolution long-slit spectrograms of several HH-objects with different degrees of excitation. After digitizing the plates on the PDS microdensitometer at the MPIA, I obtained, for each emission line detected on our spectrograms, the corresponding position-versus-radial-velocity diagram, often called a PV map. PV maps presenting logarithmic isophotic contours of the observed lines have turned out to be of enormous value for analyzing the spatio-kinematic information contained in the complex structure of the line emission. The radial-velocity information of PV maps, combined with their spatial information content, can easily be transformed into useful spatial information along the line-of-sight, thus, allowing a three-dimensional analysis of the physical conditions prevailing in the extended object observed. Specifically, our PV maps from HH1/HH2, HH7/HH11, HH24, HH32, and HH43 have been widely used by Karl-Heinz, Alex Raga, and others (including myself) in the theoretical modelling of the physical conditions prevailing in the objects. By comparing the various PV maps deduced from our observations, Karl-Heinz and his collaborators convincingly demonstrated that the line emission was originating from single bow shocks around clumps of gas moving away from young stellar objects. During the following two years, after the new 3.5-m telescope had become operational on Calar Alto in 1986, I had to conduct again several test-observing campaigns to evaluate the performance of the two new spectrographs I had developed for use at the 3.5-m Cassegrain. The new Echellette-Spectrograph had been optimized to obtain medium-resolution long-slit CCD spectrograms covering the entire spectral range from 0.32 to 1.1 micron. The new Cassegrain Twin Spectrograph was optimized for obtaining medium/high-resolution long-slit CCD spectrograms, simultaneously in both a "blue" and a "red" spectrograph channel. I observed, among other objects, the HH1/HH2 complex, HH43, and outflows from several T-Tauri stars, resulting in high-quality deep long-slit CCD spectrograms from various slit-position angles.

Q: *You and Böhm published, back in 1999, a study of the outflows from T Tauri, which turned out to be surprisingly complex. What were some of your findings?*

A: My interest in the outflow from T Tauri started already in 1985 when I was observing at the 2.2-m Coudé. I took several unwidened spectrograms of T Tauri, with the slit being centered on the star and oriented along various position angles. The resulting spectrograms were not satisfying, since the strong stellar continuum blended almost all contribution from faint forbidden-line emission near the star. Due to the limited storage capacity of the image-intensifier detector system, all attempts to subtract the contribution from the dominating stellar continuum on the spectrograms were unsuccessful within the innermost region of the source. But the regions outside of a central circle of about 1 arcsec radius presented some trace of a rather complex structure of the revolved line emission. These preliminary results encouraged to repeat my high-resolution observations of T Tauri as soon as the detector would be replaced by a CCD detector allowing more efficient data processing. Then in 1992, after a high-efficiency CCD detector became available at the 2.2-m Coudé, I repeated my preliminary observations of T Tauri using the highest spectral and spatial resolution of the 2.2-m Coudé. The new CCD spectrograms were reduced by means of a sophisticated subtraction method for suppressing contributions from the stellar continuum to the line emission, and the resulting spectra showed the amazing improvement enabled by the CCD detector, thus opening the way for sub-arcsecond-scale spectroscopic study of mass outflows near a source. The spatio-kinematic structure of the T Tauri environment is considerably more complex than that of other environments of young stellar sources studied so far, with at least five individual components in the complex emission line structure extending over a wide velocity range, defying an understanding of most of its details. During that same observing session, I also succeeded in obtaining long-slit spectrograms of DG Tau. The resolved spatio-kinematic structure of the mass outflow from DG Tau, although also complex, is more easily interpreted than that detected around T Tauri. Two separate gas components have been identified within the flow, one more compact at low velocity and one more extended at high velocity, with different degrees of excitation. Looking back, I am filled with gratitude for the wonderful and successful collaboration that Karl-Heinz and I had working together over almost two decades.

Q: *You have also done extensive spectroscopic studies of nebulae around evolved stars. Can you summarize the similarities and differences to your studies of outflows from young stars?*

A: From the beginning of using the 2.2-m Coudé, I realized its high potential for observing extended emission line objects due to its long-slit facility. The excellent results from the initial observations of the bipolar nebula S106 suggested extending my high-resolution studies to comprise nebulae associated with young as well as evolved stars. I felt that bipolar morphology was becoming a new paradigm in astronomy. Hence, within my observing programs, I always included a variety of nebular objects around evolved stars, such as proto-planetary nebulae, novae, and symbiotic stars. The methods of observing both types of objects, either young or evolved, have been much the same, and the results obtained were quite similar in many respects, despite some specific differences. To give an example, my study included high-resolution observations of the peculiar V1016 Cyg, known for showing the continuum spectrum of an evolved star together with forbidden emission lines. My first (widened) spectrum of V1016 Cyg clearly revealed that the [NII] lines were split into two distinct components, with a radial-velocity difference of about 50 km/s. The unwidened spectra obtained in subsequent observations, applying various position angles of the slit centered onto the star, and using the highest resolution power of the 2.2-m Coudé, revealed remarkable variations in the distribution of the two spatially and kinematically resolved components of the lines of either [OIII] or [NII]. A detailed analysis of the spatio-kinematic structure of the forbidden lines showed that the line emission was confined within two bipolar lobes, separated by 0.40 arcsecond in space and 51 km/s in radial velocity, centered on the star. Clearly, these data indicated the discovery of a collimated bipolar system of outflows associated with an evolved star. This example, as well as those of many other compact nebulae around evolved stars, reveal an astonishing similarity between outflows from young stars and those from evolved stars. In both cases, either young or old, the center core region is governed basically by the same geometric design, exhibiting an equatorial plane and a bipolar axis. In the case of low-mass young stars, the equatorial plane is defined by an accretion disk due to recent star formation. In the case of close binaries consisting of a hot white dwarf and a mass-losing evolved red giant, the equatorial plane is also defined by an accretion disk, but due to mass exchange from the giant onto the dwarf within the orbital plane of the binary. Thus, paradigmatic bipolarity appears to be a determinant for the physics of mass outflows from stars both young and evolved.

Abstracts of recently accepted papers

Calibrating Column Density Tracers with Gamma-ray Observations of the ρ Ophiuchi Molecular Cloud

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Diffuse gamma-ray emission from interstellar clouds results largely from cosmic ray (CR) proton collisions with ambient gas, regardless of the gas state, temperature, or dust properties of the cloud. The interstellar medium is predominantly transparent to both CRs and gamma-rays, so GeV emission is a unique probe of the total gas column density. The gamma-ray emissivity of a cloud of known column density is then a measure of the impinging CR population and may be used to map the kpc-scale CR distribution in the Galaxy. To this end, we test a number of commonly used column density tracers to evaluate their effectiveness in modeling the GeV emission from the relatively quiescent, nearby ρ Ophiuchi molecular cloud. We confirm that both HI and an appropriate H_2 tracer are required to reproduce the total gas column densities probed by diffuse gamma-ray emisison. We find that the optical depth at 353 GHz (τ_{353}) from Planck reproduces the gamma-ray data best overall based on the test statistic across the entire region of interest, but near infrared stellar extinction also performs very well, with smaller spatial residuals in the densest parts of the cloud.

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http://arxiv.org/pdf/1611.02265

X-Shooter spectroscopy of young stellar objects - VI - HI line decrements

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Hydrogen recombination emission lines commonly observed in accreting young stellar objects represent a powerful tracer for the gas conditions in the circumstellar structures (accretion columns, and winds or jets). Here we perform a study of the H I decrements and line profiles, from the Balmer and Paschen H I lines detected in the X-Shooter spectra of a homogeneous sample of 36 T Tauri objects in Lupus, the accretion and stellar properties of which were already derived in a previous work. We aim to obtain information on the H I gas physical conditions to delineate a consistent picture of the H I emission mechanisms in pre-main sequence low-mass stars ($M_* < 2M_\odot$). We have empirically classified the sources based on their H I line profiles and decrements. We identified four Balmer decrement types (which we classified as 1, 2, 3, and 4) and three Paschen decrement types (A, B, and C), characterised by different shapes. We first discussed the connection between the decrement types and the source properties and then compared the observed decrements with predictions from recently published local line excitation models. We identify a few groups of sources that display similar H I properties. One third of the objects show lines with narrow symmetric profiles, and present similar Balmer and Paschen decrements (straight decrements, types 2 and A). Lines in these sources are consistent with optically thin emission from gas with hydrogen densities of order 10^9 cm^{-3} and $5\,000 < T < 15\,000$K. These objects are associated with low mass accretion rates. Type 4 (L-shaped) Balmer and type B Paschen decrements are found in conjunction with very wide line profiles and are characteristic of strong accretors, with optically thick emission from high-density gas (log $n_H > 11$ cm^{-3}). Type 1 (curved) Balmer decrements are observed only in three sub-luminous sources viewed edge-on, so we speculate that these are actually type 2 decrements that are reddened because of neglecting a residual amount of extinction in the line emission region. About 20% of the objects present type 3 Balmer decrements (bumpy), which, however, cannot be reproduced with current models.

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Untangling the Near-IR Spectral Features in the Protoplanetary Environment of KH 15D

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We report on Gemini/GNIRS observations of the binary T Tauri system V582 Mon (KH 15D) at three orbital phases. These spectra allow us to untangle five components of the system: the photosphere and magnetosphere of star B, the jet, scattering properties of the ring material, and excess near-IR radiation previously attributed to a possible self-luminous planet. We confirm an early-K subgiant classification for star B and show that the magnetospheric He I emission line is variable, possibly indicating increased mass accretion at certain times. As expected, the H_2 emission features associated with the inner part of the jet show no variation with orbital phase. We show that the reflectance spectrum for the scattered light has a distinctive blue slope and spectral features consistent with scattering and absorption by a mixture of water and methane ice grains in the 1-50 μm size range. This suggests that the methane frost line is closer than ∼5 AU in this system, requiring that the grains be shielded from direct radiation. After correcting for features from the scattered light, jet, magnetosphere, and photosphere, we confirm the presence of leftover near-IR light from an additional source, detectable near minimum brightness. A spectral emission feature matching the model spectrum of a 10 M_J, 1 Myr old planet is found in the excess flux, but other expected features from this model are not seen. Our observations, therefore, tentatively support the picture that a luminous planet is present within the system, although they cannot yet be considered definitive.

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The depletion of water during dispersal of planet-forming disk regions

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We present a new velocity-resolved survey of 2.9 μm spectra of hot H_2O and OH gas emission from protoplanetary disks, obtained with CRIRES at the VLT ($\Delta v \sim 3\,\mathrm{km\,s^{-1}}$). With the addition of archival *Spitzer*-IRS spectra, this is the most comprehensive spectral dataset of water vapor emission from disks ever assembled. We provide line fluxes at 2.9–33 μm that probe from disk radii of ~ 0.05 au out to the region of the water snow line. With a combined dataset for 55 disks, we find a new correlation between H_2O line fluxes and the radius of CO gas emission as measured in velocity-resolved 4.7 μm spectra (R_{co}), which probes molecular gaps in inner disks. We find that H_2O emission disappears from 2.9 μm (hotter water) to 33 μm (colder water) as R_{co} increases and expands out to the snow line radius. These results suggest that the infrared water spectrum is a tracer of inside-out water depletion within the snow line. It also helps clarifying an unsolved discrepancy between water observations and models, by finding that disks around stars of $M_\star > 1.5\ M_\odot$ generally have inner gaps with depleted molecular gas content. We measure radial trends in H_2O, OH, and CO line fluxes that can be used as benchmarks for models to study the chemical composition and evolution of planet-forming disk regions at 0.05–20 au. We propose that JWST spectroscopy of molecular gas may be used as a probe of inner disk gas depletion, complementary to the larger gaps and holes detected by direct imaging and by ALMA.

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On the dynamics of dust during protostellar collapse

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The dynamics of dust and gas can be quite different from each other when the dust is poorly coupled to the gas. In protoplanetary discs, it is well known that this decoupling of the dust and gas can lead to diverse spatial structures and dust-to-gas ratios. In this paper, we study the dynamics of dust and gas during the earlier phase of protostellar collapse, before a protoplanetary disc is formed. We find that for dust grains with sizes <10 μm, the dust is well coupled during the collapse of a rotating, pre-stellar core and there is little variation of the dust-to-gas ratio during the collapse. However, if larger grains are present, they may have trajectories that are very different from the gas during the collapse, leading to mid-plane settling and/or oscillations of the dust grains through the mid-plane. This may produce variations in the dust-to-gas ratio and very different distributions of large and small dust grains at the very earliest stages of star formation, if large grains are present in pre-stellar cores.

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H_2O Masers and Protoplanetary Disk Dynamics in IC 1396 N

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We report H_2O maser line observations of the bright-rimmed globule IC 1396 N using a ground-space interferometer with the 10-m RadioAstron radio telescope as the space-based element. The source was not detected on projected baselines >2.3 Earth diameters, which indicates a lower limit on the maser size of $L > 0.03$ AU and an upper limit on the brightness temperature of 6.25×10^{12} K. Positions and flux densities of maser spots were determined by fringe rate mapping. Multiple low-velocity features from -4.5 km s^{-1} to $+0.7$ km s^{-1} are seen, and two high-velocity features of $V_{\rm LSR} = -9.4$ km s^{-1} and $+4.4$ km s^{-1} are found at projected distances of 157 AU and 70 AU, respectively, from the strongest low-velocity feature at $V_{\rm LSR} \sim 0.3$ km s^{-1}. Maser components from the central part of the spectrum fall into four velocity groups but into three spatial groups. Three spatial groups of low-velocity features detected in the 2014 observations are arranged in a linear structure about 200 AU in length. Two of these groups were not detected in 1996 and possibly are jets which formed between 1996 and 2014. The putative jet seems to have changed direction in 18 years, which we explain by the precession of the jet under the influence of the gravity of material

surrounding the globule. The jet collimation can be provided by a circumstellar protoplanetary disk. There is a straight line orientation in the $V_{\rm LSR}$-Right Ascension diagram between the jet and the maser group at $V_{\rm LSR} \sim 0.3$ km s^{-1}. However, the central group with the same position but at the velocity $V_{\rm LSR} \sim -3.4$ km s^{-1} falls on a straight line between two high-velocity components detected in 2014. Comparison of the low-velocity positions from 2014 and 1996, based on the same diagram, shows that the majority of the masers maintain their positions near the central velocity $V_{\rm LSR} \sim 0.3$ km s^{-1} during the 18 year period.

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Planets Around Low-Mass Stars (PALMS). VI. Discovery of a Remarkably Red Planetary-Mass Companion to the AB Dor Moving Group Candidate 2MASS J22362452+4751425

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We report the discovery of an extremely red planetary-mass companion to 2MASS J22362452+4751425, a ≈0.6 M late-K dwarf likely belonging to the ∼120 Myr AB Doradus moving group. 2M2236+4751 b was identified in multi-epoch NIRC2 adaptive optics imaging at Keck Observatory at a separation of 3.″7, or 230±20 AU in projection at the kinematic distance of 63±5 pc to its host star. Assuming membership in the AB Dor group, as suggested from its kinematics, the inferred mass of 2M2236+4751 b is 11–14 $M_{\rm Jup}$. Follow-up Keck/OSIRIS K-band spectroscopy of the companion reveals strong CO absorption similar to other faint red L dwarfs and lacks signs of methane absorption despite having an effective temperature of ≈900–1200 K. With a $(J-K)_{\rm MKO}$ color of 2.69±0.12 mag, the near-infrared slope of 2M2236+4751 b is redder than all of the HR 8799 planets and instead resembles the ≈23 Myr isolated planetary-mass object PSO J318.5−22, implying that similarly thick photospheric clouds can persist in the atmospheres of giant planets at ages beyond 100 Myr. In near-infrared color-magnitude diagrams, 2M2236+4751 b is located at the tip of the red L dwarf sequence and appears to define the "elbow" of the AB Dor substellar isochrone separating low-gravity L dwarfs from the cooler young T dwarf track. 2M2236+4751 b is the reddest substellar companion to a star and will be a valuable benchmark to study the shared atmospheric properties of young low-mass brown dwarfs and extrasolar giant planets.

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The bound fraction of young star clusters

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The residual gas within newly formed star clusters is expelled through stellar feedback on timescales $\lesssim$1 Myr. The subsequent expansion of the cluster results in an unbinding of a fraction of stars, before the remaining cluster members can re-virialize and form a surviving cluster. We investigate the bound fraction after gas expulsion as a function of initial cluster mass in stars $M_{\rm ecl}$ and gauge the influence of primordial mass segregation, stellar evolution and the tidal field at solar distance. We also assess the impact of the star-formation efficiency $\varepsilon_{\rm SFE}$ and gas expulsion velocity v_g. We perform N-body simulations using Sverre Aarseth's `NBODY7` code, starting with compact clusters in their embedded phase and approximate the gas expulsion by means of an exponentially depleting external gravitational field. We follow the process of re-virialization through detailed monitoring of different Lagrange radii over several Myr, examining initial half-mass radii of 0.1 pc, 0.3 pc and 0.5 pc and $M_{\rm ecl}$ usually ranging from 5×10^3 M$_\odot$ to 5×10^4 M$_\odot$. The strong impact of the relation between the gas expulsion timescale and the crossing time means that clusters with the same initial core density can have very different bound fractions. The adopted $\varepsilon_{\rm SFE} = 0.33$ in the cluster volume results in a distinct sensitivity to v_g over a wide mass range, while a variation of $\varepsilon_{\rm SFE}$ can make the cluster robust to the rapidly decreasing external potential. We confirm that primordial mass segregation leads to a smaller bound fraction, its influence possibly decreasing with mass. Stellar evolution has a higher impact on lower mass clusters, but heating through dynamical friction could expand the cluster to a similar extent. The examined clusters expand well within their tidal radii and would survive gas expulsion even in a strong tidal field.

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Disk-mediated accretion burst in a high-mass young stellar object

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Solar-mass stars form via circumstellar disk accretion (disk-mediated accretion). Recent findings indicate that this process is likely episodic in the form of accretion bursts, possibly caused by disk fragmentation. Although it cannot be ruled out that high-mass young stellar objects (HMYSOs; $M > 8\,\mathrm{M}_\odot$, $L_{bol} > 5{\times}10^3\,\mathrm{L}_\odot$) arise from the coalescence of their low-mass brethren, latest results suggest that they more likely form via disks. Accordingly, disk-mediated accretion bursts should occur. Here we report on the discovery of the first disk-mediated accretion burst from a $\sim$20 M$_\odot$ HMYSO. Our near-infrared images show the brightening of the central source and its outflow cavities. Near-infrared spectroscopy reveals emission lines typical of accretion bursts in low-mass protostars, but orders of magnitude more luminous. Moreover, the energy released and the inferred mass-accretion rate are also orders of magnitude larger. Our results identify disk accretion as the common mechanism of star formation across the entire stellar mass spectrum.

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Analysis of the Kinematic Structure of the Cygnus OB1 association

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The main objective of this study is the characterization of the velocity field in the Cygnus OB1 association using the radial velocity data currently available in the literature. This association is part of a larger star-forming complex located in the direction of the Cygnus region, but whose main subsystems may be distributed at different distances from the sun. We have collected radial velocity data for more than 300 stars in the area of 5 × 5 square degrees centred on the Cygnus OB1 association. We present the results of a kinematic clustering analysis in the subspace of the phase space formed by angular coordinates and radial velocity using two independent methodologies. We have found evidence of structure in the phase space with the detection of two main groups, corresponding to different radial velocity and distance values, belonging to the association, and associated with two main shells defined by the Hα emission. A third grouping well separated from the other two in velocity appears to occupy the whole region associated with what has been called "common shell".

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A Survey of 36 GHz Methanol and 1.7 GHz OH Masers near the Galactic Center I: Data

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Class I methanol masers are collisionally pumped and are generally correlated with outflows in star forming sites in the Galaxy. Using the VLA in its A-array configuration, we present a spectral line survey to identify methanol $J = 4_{-1} \rightarrow 3_0E$ emission at 36.169 GHz. Over 900 pointings were used to cover a region $66' \times 13'$ along the inner Galactic plane. A shallow survey of OH at 1612, 1665, 1667 and 1720 MHz was also carried out over the area covered by our methanol survey. We provide a catalog of 2240 methanol masers with narrow line-widths of $\sim$ 1 km s^{-1}, spatial resolution of $\sim 0.14'' \times 0.05''$ and RMS noise $\sim$ 20 mJy beam^{-1} per channel. Lower limits on the brightness temperature range from 27,000 K to 10,000,000 K showing the emission is of non-thermal origin. We also provide a list of 23 OH (1612), 14 OH (1665), 5 OH (1667) and 5 OH(1720 MHz) masers. The origin of such a large number of methanol masers is not clear. Many methanol masers appear to be associated with infrared dark clouds, though it appears unlikely that these masers trace early phase of star formation in the Galactic center.

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A LOFAR detection of the low mass young star T Tau at 149 MHz

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Radio observations of young stellar objects (YSOs) enable the study of ionised plasma outflows from young protostars via their free–free radiation. Previous studies of the low-mass young system T Tau have used radio observations to model the spectrum and estimate important physical properties of the associated ionised plasma (local electron density, ionised gas content and emission measure). However, without an indication of the low-frequency turnover in the free–free spectrum, these properties remain difficult to constrain. This paper presents the detection of T Tau at 149 MHz with the Low Frequency Array (LOFAR) - the first time a YSO has been observed at such low frequencies. The recovered total flux indicates that the free–free spectrum may be turning over near 149 MHz. The spectral energy distribution is fitted and yields improved constraints on local electron density ($(7.2 \pm 2.1) \times 10^3\,\mathrm{cm}^{-3}$), ionised gas mass ($(1.0 \pm 1.8) \times 10^{-6}\,\mathrm{M}_\odot$) and emission measure ($(1.67 \pm 0.14) \times 10^5\,\mathrm{pc\,cm}^{-6}$).

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Magnetic field geometry of the large globule CB 34

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We report the results of optical polarimetric observations of a Bok globule CB34 to study magnetic field structure on large scales (10^5–10^6 AU), which is combined with archival sub-mm observations to characterize the magnetic field structure of CB34 on small scales (10^4–10^5 AU). The optical polarization measurements indicate that the magnetic field in the globule is constrained to a maximum radius of 10^5 AU around the core, out to densities not smaller than 10^4 cm^{-3}. Our study is mainly concentrated on two submillimeter cores C1 and C2 of CB34. The direction of magnetic field of core C2 is found to be nearly perpendicular to the CO outflow direction of the globule. The magnetic field of core C1 is almost aligned with the minor axis of the core which is typical for magnetically dominated star formation models. The mean value of offset between the minor axis of core C2 and the outflow direction is found to be 14° which suggests that the direction of the outflow is almost aligned with the minor axis of core C2. The magnetic field strength in the plane-of-sky for cores C1 and C2 is estimated to be ≈34 μG and ≈70 μG.

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High-Mass Star Formation toward Southern Infrared Bubble S10

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An investigation in radio and infrared wavelengths of two high-mass star-forming regions toward the southern Galactic bubble S10 is presented here. The two regions under study are associated with the broken bubble S10 and Extended Green Object, G345.99-0.02, respectively. Radio continuum emission mapped at 610 and 1280 MHz using the Giant Metrewave Radio Telescope, India, is detected toward both of the regions. These regions are estimated to be ionized by early-B- to late-O-type stars. *Spitzer* GLIMPSE mid-infrared data is used to identify young stellar objects (YSOs) associated with these regions. A Class-I/II-type source, with an estimated mass of 6.2 $M_\odot$, lies $\sim 7''$ from the radio peak. Pixel-wise, modified blackbody fits to the thermal dust emission using *Herschel* far-infrared data is performed to construct dust temperature and column density maps. Eight clumps are detected in the two regions using the 250 μm image. The masses and linear diameter of these range between $\sim$ 300 - 1600 $M_\odot$ and 0.2 – 1.1 pc, respectively, which qualifies them as high-mass star-forming clumps. Modeling of the spectral energy distribution of these clumps indicates the presence of high luminosity, high accretion rate, massive YSOs possibly in the accelerating accretion phase. Furthermore, based on the radio and MIR morphology, the occurrence of a possible bow wave toward the likely ionizing star is explored.

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Globules and pillars in Cygnus X II. Massive star formation in the globule IRAS 20319+3958

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Globules and pillars, impressively revealed by the *Spitzer* and *Herschel* satellites, for example, are pervasive features found in regions of massive star formation. Studying their embedded stellar populations can provide an excellent laboratory to test theories of triggered star formation and the features that it may imprint on the stellar aggregates resulting from it. We studied the globule IRAS 20319+3958 in Cygnus X by means of visible and near-infrared imaging and spectroscopy, complemented with mid-infrared *Spitzer*/IRAC imaging, in order to obtain a census of its stellar content and the nature of its embedded sources. Our observations show that the globule contains an embedded aggregate of about 30 very young ($\lesssim$1 Myr) stellar objects, for which we estimate a total mass of $\sim$ 90 $M_\odot$. The most massive members are three systems containing early B-type stars. Two of them most likely produced very compact HII regions, one of them being still highly embedded and coinciding with a peak seen in emission lines characterising the photon dominated region (PDR). Two of these three systems are resolved binaries, and one of those contains a visible Herbig Be star. An approximate derivation of the mass function of the members of the aggregate gives hints of a slope at high masses shallower than the classical Salpeter slope, and a peak of the mass distribution at a mass higher than that at which the widely adopted log-normal initial mass function peaks. The emission distribution of H_2 and Brγ, tracing the PDR and the ionised gas phase, respectively, suggests that molecular gas is distributed as a shell around the embedded aggregate, filled with centrally-condensed ionised gas. Both, the morphology and the low excitation of the HII region, indicate that the sources of ionisation are the B stars of the embedded aggregate, rather than the external UV field caused by the O stars of Cygnus OB2. The youth of the embedded cluster, combined with the isolation of the globule, suggests that star formation in the globule was triggered by the passage of the ionisation front.

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The hot Jupiter of the magnetically-active weak-line T Tauri star V830 Tau

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We report results of an extended spectropolarimetric and photometric monitoring of the weak-line T Tauri star V830 Tau and its recently-detected newborn close-in giant planet. Our observations, carried out within the MaTYSSE programme, were spread over 91d, and involved the ESPaDOnS and Narval spectropolarimeters linked to the 3.6m Canada-France-Hawaii, the 2m Bernard Lyot and the 8-m Gemini-North Telescopes. Using Zeeman-Doppler Imaging, we characterize the surface brightness distributions, magnetic topologies and surface differential rotation of V830 Tau at the time of our observations, and demonstrate that both distributions evolve with time beyond what is expected from differential rotation. We also report that near the end of our observations, V830 Tau triggered one major flare and two weaker precursors, showing up as enhanced red-shifted emission in multiple spectral activity proxies. With 3 different filtering techniques, we model the radial velocity (RV) activity jitter (of semi-amplitude 1.2 km s^{-1}) that V830 Tau generates, successfully retrieve the 68 m s^{-1} RV planet signal hiding behind the jitter, further confirm the existence of V830 Tau b and better characterize its orbital parameters. We find that the method based on Gaussian-process regression performs best thanks to its higher ability at modelling not only the activity jitter, but also its temporal evolution over the course of our observations, and succeeds at reproducing our RV data down to a rms precision of 35m s^{-1}. Our result provides new observational constraints on scenarios of star / planet formation and demonstrates the scientific potential of large-scale searches for close-in giant planets around T Tauri stars.

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The accretion of migrating giant planets

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Most studies concerning the growth and evolution of massive planets focus either on their accretion or their migration only. In this work we study both processes concurrently to investigate how they might mutually affect each other. We modeled a 2-dimensional disk with a steady accretion flow onto the central star and embed a Jupiter mass planet at 5.2 au. The disk is locally isothermal and viscosity is modeled using a constant α. The planet is held on a fixed orbit for a few hundred orbits to allow the disk to adapt and carve a gap. After this period, the planet is released and free to move according to the gravitational interaction with the gas disk. The mass accretion onto the planet is modeled by removing a fraction of gas from the inner Hill sphere, and the removed mass and momentum can be added to the planet. Our results show that a fast migrating planet is able to accrete more gas than a slower migrating planet. Utilizing a tracer fluid we analyzed the origin of the accreted gas which comes predominantly originating from the inner disk for a fast migrating planet. In case of slower migration the fraction of gas from the outer disk increases. We also found that even for very high accretion rates in some cases gas crosses the planetary gap from the inner to the outer disk. Our simulations show that the crossing of gas changes during the migration process as the migration rate slows down. Therefore classical type II migration where the planet migrates with the viscous drift rate and no gas crosses the gap is no general process but may only occur for special parameters and at a certain time during the orbital evolution of the planet.

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Radio Measurements of the stellar proper motions in the core of the Orion Nebula Cluster

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Using multi–epoch VLA observations, covering a time baseline of 29.1 years, we have measured the proper motions of 88 young stars with compact radio emission in the core of the Orion Nebula Cluster (ONC) and the neighboring BN/KL region. Our work increases the number of young stars with measured proper motion at radio frequencies by a factor of 2.5 and enables us to perform a better statistical analysis of the kinematics of the region than was previously possible. Most stars (79 out of 88) have proper motions consistent with a Gaussian distribution centered on $\overline{\mu_\alpha \cos\delta} = 1.07 \pm 0.09 \quad \mathrm{mas\,yr^{-1}}$, and $\overline{\mu_\delta} = -0.84 \pm 0.16 \quad \mathrm{mas\,yr^{-1}}$, with velocity dispersions of $\sigma_\alpha = 1.08 \pm 0.07 \quad \mathrm{mas\ yr^{-1}}$, $\sigma_\delta = 1.27 \pm 0.15 \quad \mathrm{mas\ yr^{-1}}$. We looked for organized movements of these stars but found no clear indication of radial expansion/contraction or rotation. The remaining nine stars in our sample show peculiar proper motions that differ from the mean proper motions of the ONC by more than $3\,\sigma$. One of these stars, V 1326 Ori, could have been expelled from the Orion Trapezium 7,000 years ago. Two could be related to the multi-stellar disintegration in the BN/KL region, in addition to the previously known sources BN, I and n. The others either have high uncertainties (so their anomalous proper motions are not firmly established) or could be foreground objects.

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A candidate planetary-mass object with a photoevaporating disk in Orion

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In this work, we report the discovery of a candidate planetary-mass object with a photoevaporating protoplanetary disk, Proplyd 133-353, which is near the massive star θ^1 Ori C at the center of the Orion Nebula Cluster (ONC). The object was known to have extended emission pointing away from θ^1 Ori C, indicating ongoing external photoevaporation. Our near-infrared spectroscopic data and the location on the H-R diagram suggests that the central source of Proplyd 133-353 is substellar (∼M9.5), and have a mass probably less than 13 Jupiter mass and an age younger than 0.5 Myr. Proplyd 133-353 shows a similar ratio of X-ray luminosity to stellar luminosity to other young stars in the ONC with a similar stellar luminosity, and has a similar proper motion to the mean one of confirmed ONC members. We propose that Proplyd 133-353 formed in a very low-mass dusty cloud or an evaporating gas globule near θ^1 Ori C as a second-generation of star formation, which can explain both its young age and the presence of its disk.

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CoRoT 223992193: Investigating the variability in a low-mass, pre-main sequence eclipsing binary with evidence of a circumbinary disk

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CoRoT 223992193 is the only known low-mass, pre-main sequence eclipsing binary that shows evidence of a circumbinary disk. The system displays complex photometric and spectroscopic variability over a range of timescales and wavelengths. Using two optical CoRoT runs, and infrared Spitzer 3.6 and 4.5 μm observations (simultaneous with the second CoRoT run), we model the out-of-eclipse light curves. The large scale structure in both CoRoT light curves is consistent with the constructive and destructive interference of starspot signals at two slightly different periods. Using the stellar $v \sin i$'s, we infer different rotation periods: the primary is consistent with synchronisation and the secondary is slightly supersynchronous. Comparison of the raw data to the residuals of our spot model in colour-magnitude space indicates additional contributions consistent with variable dust emission and obscuration. We also identify short-duration flux dips preceding secondary eclipse in all three CoRoT and Spitzer bands. We construct a model of the inner regions of the binary and propose that these dips could be caused by partial occultation of the central binary by the accretion stream onto the primary star. Analysis of 15 VLT/FLAMES Hα profiles reveal an emission profile associated with each star: the majority is consistent with chromospheric emission but higher velocity emission is also seen, which could be due to prominences or accretion-related phenomena. In addition, simultaneous u and r-band observations from CFHT/MEGACam reveal a short-lived u-band excess consistent with either an accretion hot spot or stellar flare. The photometric and spectroscopic variations are complex but are consistent with the picture of two active stars possibly undergoing non-steady, low-level accretion; the system's very high inclination provides a new view of such variability.

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Phase-space structures and stellar populations in the star-forming region NGC 2264

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In this work we analyse the structure of a subspace of the phase space of the star-forming region NGC 2264 using the Spectrum of Kinematic Groupings (SKG). We show that the SKG can be used to process a collection of star data to find substructure at different scales. We have found structure associated with the NGC 2264 region and also with the background area. In the NGC 2264 region, a hierarchical analysis shows substructure compatible with that found in previous specific studies of the area but with an objective, compact methodology that allows us to homogeneously compare the structure of different clusters and star-forming regions. Moreover, this structure is compatible with the different ages of the main NGC 2264 star-forming populations. The structure found in the field can be roughly associated with giant stars far in the background, dynamically decoupled from NGC 2264, which could be related either with the Outer Arm or Monoceros Ring. The results in this paper confirm the relationship between structure in the RV phase-space subspace and different kinds of populations, defined by other variables not necessarily analysed with the SKG, such as age or distance, showing the importance of detecting phase-space substructure in order to trace stellar populations in the broadest sense of the word.

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TYC 8241 2652 1 and the case of the disappearing disk: No smoking gun yet

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TYC 8241 2652 1 is a young star that showed a strong mid-infrared (mid-IR, 8-25 μm) excess in all observations before 2008, which is consistent with a dusty disk. Between 2008 and 2010 the mid-IR luminosity of this system dropped dramatically by at least a factor of 30 suggesting a loss of dust mass of an order of magnitude or more. We aim to constrain possible models including the removal of disk material by stellar activity processes, the presence of a binary companion, or other explanations suggested in the literature. We present new X-ray observations, optical spectroscopy, near-IR interferometry, and mid-IR photometry of this system to constrain its parameters and further explore the cause of the dust mass loss. In X-rays TYC 8241 2652 1 has all the properties expected from a young star: Its luminosity is in the saturation regime and the abundance pattern shows enhancement of O/Fe. The photospheric Hα line is filled with a weak emission feature, indicating chromospheric activity that is consistent with the observed level of coronal emission. Interferometry does not detect a companion and sets upper limits on the companion mass of 0.2, 0.35, 0.1, and 0.05 $M_\odot$ at projected physical separations of 0.1-4 AU,4-5 AU, 5-10 AU, and 10-30 AU, respectively (assuming a distance of 120.9 pc). Our mid-IR measurements, the first of the system since 2012, are consistent with the depleted dust level seen after 2009. The new data confirm that stellar activity is unlikely to destroy the dust in the disk and shows that scenarios, in which either TYC 8241 2652 1 heats the disk of a binary companion or a potential companion heats the disk of TYC 8241 2652 1, are unlikely.

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Spiral-driven accretion in protoplanetary discs - III tri-dimensional simulations

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Understanding how accretion proceeds in proto-planetary discs and more generally their dynamics is a crucial issue for explaining the conditions in which planets form. The role that accretion of gas from the surrounding molecular cloud onto the disc may have on its structure needs to be quantified. We perform tri-dimensional simulations using the Cartesian AMR code RAMSES of an accretion disc subject to infalling material. For the aspect ratio of $H/R \approx 0.15$ and disk mass $M_{\rm d} \approx 10^{-2}\ M_\odot$ used in our study, we find that for typical accretion rates on the order of a few 10^{-7} $M_\odot$ yr^{-1}, values of the α parameter as high as a few 10^{-3} are inferred. The mass that is accreted in the inner part of the disc is typically at least 50% of the total mass that has been accreted onto the disc. Our results suggest that external accretion of gas at moderate values, onto circumstellar discs may trigger prominent spiral arms, reminiscent of recent observations made with various instruments, and lead to significant transport through the disc. If confirmed from observational studies, such accretion may therefore influence disc evolution.

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Gravitational instability of filamentary molecular clouds, including ambipolar diffusion

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The gravitational instability of a filamentary molecular cloud in non-ideal magnetohydrodynamics is investigated. The filament is assumed to be in hydrostatic equilibrium. We add the effect of ambipolar diffusion to the filament which is threaded by an initial uniform axial magnetic field along its axis. We write down the fluid equations in cylindrical coordinates and perform linear perturbation analysis. We integrate the resultant differential equations and then derive the numerical dispersion relation. We find that, a more efficient ambipolar diffusion leads to an enhancement of the growth of the most unstable mode, and to increase of the fragmentation scale of the filament.

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FU Orionis outbursts, preferential recondensation of water ice, and the formation of giant planets

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Ices, including water ice, prefer to recondense onto pre-existing nuclei rather than spontaneously forming grains from

a cloud of vapor. Interestingly, different potential recondensation nuclei have very different propensities to actually nucleate water ice at the temperatures associated with freeze-out in protoplanetary discs. Therefore, if a region in a disc is warmed and then recooled, water vapor should not be expected to refreeze evenly onto all available grains. Instead it will preferentially recondense onto the most favorable grains. When the recooling is slow enough, only the most favorable grains will nucleate ice, allowing them to recondense thick ice mantles. We quantify the conditions for preferential recondensation to rapidly create pebble-sized grains in protoplanetary discs and show that FU Orionis type outbursts have the appropriate cooling rates to drive pebble creation in a band about 5 astronomical units wide outside of the quiescent frost line from approximately Jupiter's orbit to Saturn's (about 4 to 10 au). Those pebbles could be of the appropriate size to proceed to planetesimal formation via the Streaming Instability, or to contribute to the growth of planetesimals through pebble accretion. We suggest that this phenomenon contributed to the formation of the gas giants in our own Solar System.

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Long-term photometric behavior of the PMS stars V977 Cep and V982 Cep in the vicinity of NGC 7129

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Long-term $BVRI$ photometric light curves of the pre-main sequence stars V977 Cep and V982 Cep during the period from 2000 October to 2016 August are presented. The stars are located in the vicinity of the reflection nebula NGC 7129. Our photometric data shows that both stars exhibit strong photometric variability in all optical passbands, which is typical for Classical T Tauri stars. Using our observational data we defined the reasons for the observed brightness variations. In the case of V977 Cep we registered previously unknown periodicity in its light curve.

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The low-mass population in the young cluster Stock 8: Stellar properties and Initial Mass Function

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The evolution of H II regions/supershells can trigger a new generation of stars/clusters at their peripheries, with environmental conditions that may affect the initial mass function, disk evolution and star formation efficiency. In this paper we study the stellar content and star formation processes in the young cluster Stock 8, which itself is thought to be formed during the expansion of a supershell. We present deep optical photometry along with JHK and 3.6, 4.5 μm photometry from UKIDSS and *Spitzer*-IRAC. We use multi-color criteria to identify the candidate young stellar objects in the region. Using evolutionary models, we obtain a median log(age) of ∼6.5 (∼3.0 Myr) with an observed age spread of ∼0.25 dex for the cluster. Monte Carlo simulations of the population of Stock 8, based on estimates for the photometric uncertainty, differential reddening, binarity, and variability, indicate that these uncertainties introduce an age spread of ∼0.15 dex. The intrinsic age spread in the cluster is ∼0.2 dex. The fraction of young stellar objects surrounded by disk is ∼35%. The K-band luminosity function of Stock 8 is similar to that of the Trapezium cluster. The IMF of Stock 8 has a Salpeter-like slope at $> 0.5\ M_\odot$ and the IMF flattens and peaks at $\sim 0.4\ M_\odot$, below which declines into the substellar regime. Although Stock 8 is surrounded by several massive stars, there seems to be no

severe environmental effect in the form of IMF due to the proximity of massive stars around the cluster.

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Submillimeter polarization observation of the protoplanetary disk around HD 142527

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We present the polarization observations toward the circumstellar disk around HD 142527 by using Atacama Large Millimeter/submillimeter Array (ALMA) at the frequency of 343 GHz. The beam size is $0.51arcsec \times 0.44arcsec$, which corresponds to the spatial resolution of $\sim 71 \times 62$ AU. The polarized intensity displays a ring-like structure with a peak located on the east side with a polarization fraction of $P = 3.26 \pm 0.02$ %, which is different from the peak of the continuum emission from the northeast region. The polarized intensity is significantly weaker at the peak of the continuum where $P = 0.220 \pm 0.010$ %. The polarization vectors are in the radial direction in the main ring of the polarized intensity, while there are two regions outside at the northwest and northeast areas where the vectors are in the azimuthal direction. If the polarization vectors represent the magnetic field morphology, the polarization vectors indicate the toroidal magnetic field configuration on the main ring and the poloidal fields outside. On the other hand, the flip of the polarization vectors is predicted by the self-scattering of thermal dust emission due to the change of the direction of thermal radiation flux. Therefore, we conclude that self-scattering of thermal dust emission plays a major role in producing polarization at millimeter wavelengths in this protoplanetary disk. Also, this puts a constraint on the maximum grain size to be approximately 150 μm if we assume compact spherical dust grains.

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Filamentary flow and magnetic geometry in evolving cluster-forming molecular cloud clumps

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We present an analysis of the relationship between the orientation of magnetic fields and filaments that form in 3D magnetohydrodynamic simulations of cluster-forming, turbulent molecular cloud clumps. We examine simulated cloud clumps with size scales of $L \sim$ 2–4 pc and densities of $n \sim$ 400–1000 cm^{-3} with Alfven Mach numbers near unity. We

simulated two cloud clumps of different masses, one in virial equilibrium, the other strongly gravitationally bound, but with the same initial turbulent velocity field and similar mass-to-flux ratio. We apply various techniques to analyze the filamentary and magnetic structure of the resulting cloud, including the DisPerSE filament-finding algorithm in 3D. The largest structure that forms is a 1–2 parsec-long filament, with smaller connecting sub-filaments. We find that our simulated clouds, wherein magnetic forces and turbulence are comparable, coherent orientation of the magnetic field depends on the virial parameter. Subvirial clumps undergo strong gravitational collapse and magnetic field lines are dragged with the accretion flow. We see evidence of filament-aligned flow and accretion flow onto the filament in the subvirial cloud. Magnetic fields oriented more parallel in the subvirial cloud and more perpendicular in the denser, marginally bound cloud. Radiative feedback from a 16 $M_\odot$ forming in a cluster in one of our simulations ultimately results in the destruction of the main filament, the formation of an HII region, and the sweeping up of magnetic fields within an expanding shell at the edges of the HII region.

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A Hunt for Massive Starless Cores

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We carry out an ALMA N_2D^+(3-2) and 1.3 mm continuum survey towards 32 high mass surface density regions in seven Infrared Dark Clouds with the aim of finding massive starless cores, which may be the initial conditions for the formation of massive stars. Cores showing strong N_2D^+(3-2) emission are expected to be highly deuterated and indicative of early, potentially pre-stellar stages of star formation. We also present maps of these regions in ancillary line tracers, including $C^{18}O$(2-1), DCN(3-2) and DCO^+(3-2). Over 100 N_2D^+ cores are identified with our newly developed core-finding algorithm based on connected structures in position-velocity space. The most massive core has $\sim 70\ M_\odot$ (potentially $\sim 170\ M_\odot$) and so may be representative of the initial conditions or early stages of massive star formation. The existence and dynamical properties of such cores constrain massive star formation theories. We measure the line widths and thus velocity dispersion of six of the cores with strongest N_2D^+(3-2) line emission, finding results that are generally consistent with virial equilibrium of pressure confined cores.

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Highly variable young massive stars in ATLASGAL clumps

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High-amplitude variability in Young Stellar Objects (YSOs) is usually associated with episodic accretion events. It has not been observed so far in massive YSOs. Here, the high-amplitude variable star sample of ContrerasPeña et al.(2016) has been used to search for highly-variable(ΔK$\geq$1 mag) sources coinciding with dense clumps mapped using the 850μm continuum emission by the ATLASGAL survey. 18 variable sources are centred on the sub-mm clump peaks, and coincide (<1 arcsec) with a 24μm point or compact (<10 arcsec) source. 13 of these 18 sources can be fit by YSO models. The 13 variable YSOs(VYSO) have luminosities of $\sim$10^3 L$_\odot$, an average mass of 8 M$_\odot$and a range of ages up to 10^6 yr. 11 of these 13 VYSOs are located in the midst of infrared dark clouds. 9 of the 13 sources have ΔK>2 mag, significantly higher compared to the mean variability of the entire VVV sample. The light curves of these objects sampled between 2010-2015 display rising, declining, or quasi-periodic behaviour but no clear periodicity. Light-curve analysis using Plavchan method show that the most prominent phased signals have periods of a few hundred days. The nature and time-scale of variations found in 6.7 Ghz methanol maser emission (MME) in massive stars are similar to that of the VYSO light curves. We argue that the origin of the observed variability is episodic accretion. We suggest that the timescale of a few hundred days may represent the frequency at which a spiralling disk feeds dense gas to the young massive star.

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Structure of Herbig AeBe disks at the milliarcsecond scale A statistical survey in the H band using PIONIER-VLTI

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Context. It is now generally accepted that the near-infrared excess of Herbig AeBe stars originates in the dust of a circumstellar disk.
Aims. The aims of this article are to infer the radial and vertical structure of these disks at scales of order one au, and the properties of the dust grains.
Methods. The program objects (51 in total) were observed with the H-band (1.6 μm) PIONIER/VLTI interferometer. The largest baselines allowed us to resolve (at least partially) structures of a few tenths of an au at typical distances of a few hundred parsecs. Dedicated UBVRIJHK photometric measurements were also obtained. Spectral and 2D geometrical parameters are extracted via fits of a few simple models: ellipsoids and broadened rings with azimuthal modulation. Model bias is mitigated by parallel fits of physical disk models. Sample statistics were evaluated against similar statistics for the physical disk models to infer properties of the sample objects as a group.
Results. We find that dust at the inner rim of the disk has a sublimation temperature $T_{\rm sub} \approx 1800$ K. A ring morphology is confirmed for approximately half the resolved objects; these rings are wide $\delta r/r \geq 0.5$. A wide ring favors a rim that, on the star-facing side, looks more like a knife edge than a doughnut. The data are also compatible with a the combination of a narrow ring and an inner disk of unspecified nature inside the dust sublimation radius. The disk inner part has a thickness $z/r \approx 0.2$, flaring to $z/r \approx 0.5$ in the outer part. We confirm the known luminosity-radius

relation; a simple physical model is consistent with both the mean luminosity-radius relation and the ring relative width; however, a significant spread around the mean relation is present. In some of the objects we find a halo component, fully resolved at the shortest interferometer spacing, that is related to the HAeBe class.

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Synthetic Observations of Magnetic Fields in Protostellar Cores

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The role of magnetic fields in the early stages of star formation is not well constrained. In order to discriminate between different star formation models, we analyze 3D magnetohydrodynamic simulations of low-mass cores and explore the correlation between magnetic field orientation and outflow orientation over time. We produce synthetic observations of dust polarization at resolutions comparable to millimeter-wave dust polarization maps observed by CARMA and compare these with 2D visualizations of projected magnetic field and column density. Cumulative distribution functions of the projected angle between the magnetic field and outflow show different degrees of alignment in simulations with differing mass-to-flux ratios. The distribution function for the less magnetized core agrees with observations finding random alignment between outflow and field orientations, while the more magnetized core exhibits stronger alignment. We find that fractional polarization increases when the system is viewed such that the magnetic field is close to the plane of the sky, and the values of fractional polarization are consistent with observational measurements. The simulation outflow, which reflects the underlying angular momentum of the accreted gas, changes direction significantly over the first ∼0.1 Myr of evolution. This movement could lead to the observed random alignment between outflows and the magnetic fields in protostellar cores.

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Externally heated protostellar cores in the Ophiuchus star-forming region

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We present APEX 218 GHz observations of molecular emission in a complete sample of embedded protostars in the Ophiuchus star-forming region. To study the physical properties of the cores, we calculate H_2CO and c-C_3H_2 rotational temperatures, both of which are good tracers of the kinetic temperature of the molecular gas. We find that the H_2CO temperatures range between 16 K and 124 K, with the highest H_2CO temperatures toward the *hot corino* source IRAS 16293-2422 (69–124 K) and the sources in the ρ Oph A cloud (23–49 K) located close to the luminous Herbig Be star S 1, which externally irradiates the ρ Oph A cores. On the other hand, the c-C_3H_2 rotational temperature is consistently low (7–17 K) in all sources. Our results indicate that the c-C_3H_2 emission is primarily tracing more shielded parts of the envelope whereas the H_2CO emission (at the angular scale of the APEX beam; 3600 au in Ophiuchus) mainly traces the outer irradiated envelopes, apart from in IRAS 16293-2422, where the *hot corino* emission dominates. In some sources, a secondary velocity component is also seen, possibly tracing the molecular outflow.

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On the origin of C_4H and CH_3OH in protostellar envelopes

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The formation pathways of different types of organic molecules in protostellar envelopes and other regions of star formation are subjects of intense current interest. We here present observations of C_4H and CH_3OH, tracing two distinct groups of interstellar organic molecules, toward 16 protostars in the Ophiuchus and Corona Australis molecular clouds. Together with observations in the literature, we present C_4H and CH_3OH data from single-dish observations of 40 embedded protostars. We find no correlation between the C_4H and CH_3OH column densities in this large sample. Based on this lack of correlation, a difference in line profiles between C_4H and CH_3OH, and previous interferometric observations of similar sources, we propose that the emission from these two molecules is spatially separated, with the CH_3OH tracing gas that has been transiently heated to high ($\sim$ 70–100 K) temperatures, and the C_4H tracing the cooler large-scale envelope where CH_4 molecules have been liberated from ices. These results provide insight in the differentiation between *hot corino* and *warm carbon-chain chemistry* in embedded protostars.

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The [Ne III] Jet of DG Tau and Its Ionization Scenarios

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Forbidden neon emission from jets of low-mass young stars can be used to probe the underlying high-energy processes in these systems. We analyze spectra of the jet of DG Tau obtained with the Very Large Telescope/X-Shooter spectrograph in 2010. [Ne III] λ3869 is clearly detected in the innermost $3''$ microjet and the outer knot located at $\sim 6''.5$. The velocity structure of the inner microjet can be decomposed into the low-velocity component (LVC) at ~ -70 km s^{-1} and the high-velocity component (HVC) at ~ -180 km s^{-1}. Based on the observed [Ne III] flux and its spatial extent, we suggest the origins of the [Ne III] emission regions and their relation with known X-ray sources along the jet. The flares from the hard X-ray source close to the star may be the main ionization source of the innermost microjet. The fainter soft X-ray source at $0''.2$ from the star may provide sufficient heating to help to sustain the ionization fraction against the recombination in the flow. The outer knot may be reionized by shocks faster than 100 km s^{-1} such that [Ne III] emission reappears and that the soft X-ray emission at $5''.5$ is produced. Velocity decomposition of the archival *Hubble Space Telescope* spectra obtained in 1999 shows that the HVC had been faster, with a velocity centroid of ~ -260 km s^{-1}. Such a decrease in velocity may potentially be explained by the expansion of the stellar magnetosphere, changing the truncation radius and thus the launching speed of the jet. The energy released by magnetic reconnections during relaxation of the transition can heat the gas up to several tens of megakelvin and provide the explanation for on-source keV X-ray flares that ionize the neon microjet.

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The ALMA-PILS survey: First detections of ethylene oxide, acetone and propanal toward the low-mass protostar IRAS 16293-2422

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Context. One of the open questions in astrochemistry is how complex organic and prebiotic molecules are formed. The unsurpassed sensitivity of the Atacama Large Millimeter/submillimeter Array (ALMA) takes the quest for discovering molecules in the warm and dense gas surrounding young stars to the next level. *Aims.* Our aim is to start the process of compiling an inventory of oxygen-bearing complex organic molecules toward the solar-type Class 0 protostellar binary IRAS 16293-2422 from an unbiased spectral survey with ALMA, Protostellar Interferometric Line Survey (PILS). Here we focus on the new detections of ethylene oxide (c-C_2H_4O), acetone (CH_3COCH_3), and propanal (C_2H_5CHO). *Methods.* With ALMA, we surveyed the spectral range from 329 to 363 GHz at 0.5” (60 AU diameter) resolution. Using a simple model for the molecular emission in local thermodynamical equilibrium, the excitation temperatures and column densities of each species were constrained. *Results.* We successfully detect propanal (44 lines), ethylene oxide (20 lines) and acetone (186 lines) toward one component of the protostellar binary, IRAS16293B. The high resolution maps demonstrate that the emission for all investigated species originates from the compact central region close to the protostar. This, along with a derived common excitation temperature of Tex $\sim$ 125 K, is consistent with a coexistence of these molecules in the same gas. *Conclusions.* The observations mark the first detections of acetone, propanal and ethylene oxide toward a low-mass protostar. The relative abundance ratios of the two sets of isomers, a CH_3COCH_3/C_2H_5CHO ratio of 8 and a CH_3CHO/c-C_2H_4O ratio of 12, are comparable to previous observations toward high-mass protostars. The majority of observed abundance ratios from these results as well as those measured toward high-mass protostars are up to an order of magnitude above the predictions from chemical models. This may reflect either missing reactions or uncertain rates in the chemical networks. The physical conditions, such as temperatures or densities, used in the models, may not be applicable to solar-type protostars either.

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Kinematics of a young low-mass star forming core: Understanding the evolutionary state of the First Core Candidate L1451-mm

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We use 3mm multi-line and continuum CARMA observations towards the first hydrostatic core (FHSC) candidate L1451-mm to characterize the envelope kinematics at 1000 AU scales and investigate its evolutionary state. We detect evidence of infall and rotation in the $NH_2D(1_{1,1}\text{-}1_{0,1})$, N_2H^+(1-0) and HCN(1-0) molecular lines. We compare the

position velocity diagram of the $NH_2D(1_{1,1}$-$1_{0,1})$ line with a simple kinematic model and find that it is consistent with an envelope that is both infalling and rotating while conserving angular momentum around a central mass of about 0.06 $M_\odot$. The N_2H^+(1-0) LTE mass of the envelope along with the inferred infall velocity leads to a mass infall rate of approximately 6×10^{-6} $M_\odot$ yr^{-1}, implying a young age of 10^4 years for this FHSC candidate. Assuming that the accretion onto the central object is the same as the infall rate we obtain that the minimum source size is 1.5-5 AU consistent with the size expected for a first core. We do not see any evidence of outflow motions or signs of outflow-envelope interaction at scales $\gtrsim$ 2000 AU. This is consistent with previous observations that revealed a very compact outflow ($\lesssim$ 500 AU). We conclude that L1451-mm is indeed at a very early stage of evolution, either a first core or an extremely young Class 0 protostar. Our results provide strong evidence that L1451-mm is the best candidate for being a bonafide first core.

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Photophoretic Levitation and Trapping of Dust in the Inner Regions of Protoplanetary Disks

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In protoplanetary disks, the differential gravity-driven settling of dust grains with respect to gas and with respect to grains of varying sizes determines the observability of grains, and sets the conditions for grain growth and eventually planet formation. In this work we explore the effect of photophoresis on the settling of large dust grains in the inner regions of actively accreting protoplanetary disks. Photophoretic forces on dust grains result from the collision of gas molecules with differentially heated grains. We undertake one dimensional dust settling calculations to determine the equilibrium vertical distribution of dust grains in each column of the disk. In the process we introduce a new treatment of the photophoresis force which is consistent at all optical depths with the representation of the radiative intensity field in a two-stream radiative transfer approximation. The levitation of large dust grains creates a photophoretic dust trap several scale heights above the mid-plane in the inner regions of the disk where the dissipation of accretion energy is significant. We find that differential settling of dust grains is radically altered in these regions of the disk, with large dust grains trapped in a layer below the stellar irradiation surface in where the dust to gas mass ratio can be enhanced by a factor of a hundred for the relevant particles. The photophoretic trapping effect has a strong dependence on particle size and porosity.

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Physical properties of molecular clouds for the entire Milky Way disk

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This study presents a catalog of 8107 molecular clouds that covers the entire Galactic plane and includes 98% of the ^{12}CO emission observed within $b \pm 5°$. The catalog was produced using a hierarchical cluster identification method applied to the result of a Gaussian decomposition of the Dame et al. data. The total H_2 mass in the catalog is $1.2 \times 10^9\,M_\odot$, in agreement with previous estimates. We find that 30% of the sight lines intersect only a single cloud, with another 25% intersecting only two clouds. The most probable cloud size is $R \sim 30\,$pc. We find that $M \propto R^{2.2\pm0.2}$,

with no correlation between the cloud surface density, Σ, and R. In contrast with the general idea, we find a rather large range of values of Σ, from 2 to 300 $M_\odot$ pc^{-2}, and a systematic decrease with increasing Galactic radius, $R_{\rm gal}$. The cloud velocity dispersion and the normalization $\sigma_0 = \sigma_v/R^{1/2}$ both decrease systematically with $R_{\rm gal}$. When studied over the whole Galactic disk, there is a large dispersion in the line width-size relation, and a significantly better correlation between σ_v and ΣR. The normalization of this correlation is constant to better than a factor of two for $R_{\rm gal} < 20$ kpc. This relation is used to disentangle the ambiguity between near and far kinematic distances. We report a strong variation of the turbulent energy injection rate. In the outer Galaxy it may be maintained by accretion through the disk and/or onto the clouds, but neither source can drive the 100 times higher cloud-averaged injection rate in the inner Galaxy.

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Herschel / HIFI spectral line survey of the Orion Bar - Temperature and density differentiation near the PDR surface

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Photon dominated regions (PDRs) are interfaces between the mainly ionized and mainly molecular material around young massive stars. Analysis of the physical and chemical structure of such regions traces the impact of far-ultraviolet radiation of young massive stars on their environment.
We present results on the physical and chemical structure of the prototypical high UV-illumination edge-on Orion Bar PDR from an unbiased spectral line survey with a wide spectral coverage which includes lines of many important gas coolants such as [CII], [CI], and CO and other key molecules such as H_2CO, H_2O, HCN, HCO^+, and SO.
A spectral scan from 480-1250 GHz and 1410-1910 GHz at 1.1 MHz resolution was obtained by the HIFI instrument on board the *Herschel* Space Observatory. We obtained physical parameters for the observed molecules. For molecules with multiple transitions we used rotational diagrams to obtain excitation temperatures and column densities. For species with a single detected transition we used an optically thin LTE approximation. In the case of species with available collisional rates, we also performed a non-LTE analysis to obtain kinetic temperatures, H_2 volume densities, and column densities.
About 120 lines corresponding to 29 molecules (including isotopologues) have been detected in the *Herschel*/HIFI line survey, including 11 transitions of CO, 7 transitions of ^{13}CO, 6 transitions of C^{18}O, 10 transitions of H_2CO, and 6 transitions of H_2O. The rotational temperatures are in the range between $\sim$22 and $\sim$146 K and the column densities are in the range between 1.8×10^{12} cm^{-2} and 4.5×10^{17} cm^{-2}. For species with at least three detected transitions and available collisional excitation rates we derived a best fit kinetic temperature and H_2 volume density. Most species trace kinetic temperatures in the range between 100 and 150 K and H_2 volume densities in the range between 10^5 and 10^6 cm^{-3}. The species with temperatures and / or densities outside this range include the H_2CO transitions tracing a very high temperature (315 K) and density (1.4×10^6 cm^{-3}) component and SO corresponding to the lowest temperature (56 K) measured as a part of this line survey.
The observed lines/species reveal a range of physical conditions (gas density /temperature) involving structures at high density / high pressure, making the traditional clump/interclump picture of the Orion Bar obsolete.

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The Gould's Belt Distances Survey (GOBELINS) I. Trigonometric parallax distances and depth of the Ophiuchus complex

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We present the first results of the *Gould's Belt Distances Survey (GOBELINS)*, a project aimed at measuring the proper motion and trigonometric parallax of a large sample of young stars in nearby regions using multi-epoch Very Long Baseline Array (VLBA) radio observations. Enough VLBA detections have now been obtained for 16 stellar systems in Ophiuchus to derive their parallax and proper motion. This leads to distance determinations for individual stars with an accuracy of 0.3 to a few percent. In addition, the orbits of 6 multiple systems were modelled by combining absolute positions with VLBA (and in some cases, near infrared) angular separations. Twelve stellar systems are located in the dark cloud Lynds 1688; the individual distances for this sample are highly consistent with one another, and yield a mean parallax for Lynds 1688 of $\varpi = 7.28 \pm 0.06$ mas, corresponding to a distance $d = 137.3 \pm 1.2$ pc. This represents an accuracy better than 1%. Three systems for which astrometric elements could be measured are located in the eastern streamer (Lynds 1689) and yield an estimate of $\varpi = 6.79 \pm 0.16$ mas, corresponding to a distance $d = 147.3 \pm 3.4$ pc. This suggests that the eastern streamer is located about 10 pc farther than the core, but this conclusion needs to be confirmed by observations (currently being collected) of additional sources in the eastern streamer. From the measured proper motions, we estimate the one-dimensional velocity dispersion in Lynds 1688 to be 2.8±1.8 and 3.0±2.0 km s^{-1}, in R.A. and DEC., respectively; these are larger than, but still consistent within 1σ, with those found in other studies.

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A closer look at the "characteristic" width of molecular cloud filaments

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Filaments in Herschel molecular cloud images are found to exhibit a "characteristic width". This finding is in tension with spatial power spectra of the data, which show no indication of this characteristic scale. We demonstrate that this discrepancy is a result of the methodology adopted for measuring filament widths. First, we perform the previously used analysis technique on artificial scale-free data, and obtain a peaked width distribution of filament-like structures. Next, we repeat the analysis on three Herschel maps and reproduce the narrow distribution of widths found in previous

studies − when considering the average width of each filament. However, the distribution of widths measured at all points along a filament spine is broader than the distribution of mean filament widths, indicating that the narrow spread (interpreted as a "characteristic" width) results from averaging. Furthermore, the width is found to vary significantly from one end of a filament to the other. Therefore, the previously identified peak at 0.1 pc cannot be understood as representing the typical width of filaments. We find an alternative explanation by modelling the observed width distribution as a truncated power-law distribution, sampled with uncertainties. The position of the peak is connected to the lower truncation scale and is likely set by the choice of parameters used in measuring filament widths. We conclude that a "characteristic" width of filaments is not supported by the available data.

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Using CO line ratios to trace the physical properties of molecular clouds

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The carbon monoxide (CO) rotational transition lines are the most common tracers of molecular gas within giant molecular clouds (MCs). We study the ratio ($R_{2-1/1-0}$) between CO's first two emission lines and examine what information it provides about the physical properties of the cloud. To study $R_{2-1/1-0}$ we perform smooth particle hydrodynamic simulations with time dependent chemistry (using GADGET-2), along with post-process radiative transfer calculations on an adaptive grid (using RADMC-3D) to create synthetic emission maps of a MC. $R_{2-1/1-0}$ has a bimodal distribution that is a consequence of the excitation properties of each line, given that $J = 1$ reaches local thermal equilibrium (LTE) while $J = 2$ is still sub-thermally excited in the considered clouds. The bimodality of $R_{2-1/1-0}$ serves as a tracer of the physical properties of different regions of the cloud and it helps constrain local temperatures, densities and opacities. Additionally this bimodal structure shows an important portion of the CO emission comes from diffuse regions of the cloud, suggesting that the commonly used conversion factor of $R_{2-1/1-0} \sim 0.7$ between both lines may need to be studied further.

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The hybrid disks: a search and study to better understand evolution of disks

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The increased sensitivity of millimeter-wave facilities now makes possible the detection of low amounts of gas in debris disks. Some of the gas-rich debris disks harbour peculiar properties, with possible pristine gas and secondary generated dust. The origin of the gas in these hybrid disks is strongly debated and the current sample is too sparse to understand this phenomenon. More detections are necessary to increase the statistics on this population. Lying at the final stages of evolution of proto-planetary disks and at the beginning of the debris disk phase, these objects could bring new insight on the processes involved in the making of planetary systems. We have carried out a deep survey of the CO J=2→1 and CO J=3→2 lines with the APEX and IRAM radiotelescopes in young debris disks, selected after hybrid disks properties. The survey is complemented with a bibliographic study of the ratio between the emission of the gas and the continuum (S_{CO}/F_{cont}) in CTTS, Herbig Ae, WTTS, hybrid and debris disks. Our sub-mm survey comprises 25 stars, including 17 new targets, and we increase the sensitivity limit by a factor 2 on eight sources compared to previous similar studies. We report $4\,\sigma$ tentative detection of a double-peaked CO J=2→1 line around HD 23642, an eclipsing binary located in the Pleiades. We also reveal a correlation between the emission of the CO gas and the dust continuum from CTTS, Herbig Ae and few debris disks. The observed trend of the gas to dust *flux ratio* suggests a concurrent dissipation of the dust and gas component. Hybrid disks systematically lie above this trend, suggesting that these systems may witness a transient phase, when the dust has evolved more rapidly than the gas, with a flux ratio S_{CO}/F_{cont} enhanced by a factor 10 to 100 compared to standard (proto-)planetary disks.

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The SILCC project — IV. Impact of dissociating and ionising radiation on the interstellar medium and Hα emission as a tracer of the star formation rate

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We present three-dimensional radiation-hydrodynamical simulations of the impact of stellar winds, photoelectric heating, photodissociating and photoionising radiation, and supernovae on the chemical composition and star formation in a stratified disc model. This is followed with a sink-based model for star clusters with populations of individual massive stars. Stellar winds and ionising radiation regulate the star formation rate at a factor of ~ 10 below the simulation with only supernova feedback due to their immediate impact on the ambient interstellar medium after star formation. Ionising radiation (with winds and supernovae) significantly reduces the ambient densities for most supernova explosions to $\rho < 10^{-25}\,\mathrm{g\,cm^{-3}}$, compared to $10^{-23}\mathrm{g\,cm^{-3}}$ for the model with only winds and supernovae. Radiation from massive stars reduces the amount of molecular hydrogen and increases the neutral hydrogen mass and volume filling fraction. Only this model results in a molecular gas depletion time scale of 2 Gyr and shows the best agreement with observations. In the radiative models, the Hα emission is dominated by radiative recombination as opposed to collisional excitation (the dominant emission in non-radiative models), which only contributes $\sim$ 1–10 % to the total Hα emission. Individual massive stars ($M \geq 30\,\mathrm{M_\odot}$) with short lifetimes are responsible for significant fluctuations in the Hα luminosities. The corresponding inferred star formation rates can underestimate the true instantaneous star formation rate by factors of ~ 10.

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The anatomy of the Orion B Giant Molecular Cloud: A local template for studies of nearby galaxies

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We aim to develop the Orion B Giant Molecular Cloud (GMC) as a local template for interpreting extra-galactic molecular line observations. We use the wide-band receiver at the IRAM-30m to spatially and spectrally resolve the Orion B GMC. The observations cover almost 1 square degree at 26″ resolution with a bandwidth of 32 GHz from 84 to 116 GHz in only two tunings. Among the mapped spectral lines are the ^{12}CO, ^{13}CO, $C^{18}O$, $C^{17}O$, HCN, HNC, ^{12}CN, C_2H, HCO^+, N_2H^+ (1–0), and ^{12}CS, ^{32}SO, SiO, c-C_3H_2, CH_3OH (2–1) transitions. We introduce the molecular anatomy of the Orion B GMC, including relations between line intensities and gas column density or far-UV radiation fields, and correlations between selected line and line ratios. We also obtain a dust-traced gas mass that is less than about one third the CO-traced mass, using the standard $X_{\rm CO}$ conversion factor. The presence of overluminous CO can be traced back to the dependence of the CO intensity on UV illumination. In fact, while most lines show some dependence on the UV radiation field, CN and C_2H are the most sensitive. Moreover dense cloud cores are almost exclusively traced by N_2H^+. Other traditional high density tracers, such as HCN (1–0), are also easily detected in extended translucent regions at a typical density of about 500 H_2 cm^{-3}. In general, we find no straightforward relation between line critical density and the fraction of the line luminosity coming from dense gas regions. Our initial findings demonstrate that the relations between line (ratio) intensities and environment in GMCs are more complicated than often assumed. Sensitivity (i.e., the molecular column density), excitation, and above all chemistry contribute to the observed line intensity distributions. They must be considered together when developing the next generation of extra-galactic molecular line diagnostics of mass, density, temperature and radiation field.

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Long-term variability of T Tauri stars using WASP

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We present a reference study of the long-term optical variability of young stars using data from the WASP project. Our primary sample is a group of well-studied classical T Tauri stars (CTTS), mostly in Taurus-Auriga. WASP lightcurves cover timescales up to 7 years and typically contain 10000-30000 datapoints. We quantify the variability as function of timescale using the time-dependent standard deviation 'pooled sigma'. We find that the overwhelming majority of CTTS has low-level variability with $\sigma < 0.3$ mag dominated by timescales of a few weeks, consistent with rotational modulation. Thus, for most young stars monitoring over a month is sufficient to constrain the total amount of variability over timescales up to a decade. The fraction of stars with strong optical variability ($\sigma > 0.3$ mag) is 21% in our sample and 21% in an unbiased control sample. An even smaller fraction (13% in our sample, 6% in the control) show evidence for an increase in variability amplitude as a function of timescale from weeks to months or years. The presence of long-term variability correlates with the spectral slope at 3-5 mum, which is an indicator of inner disk geometry, and with the U-B band slope, which is an accretion diagnostics. This shows that the long-term variations in CTTS are predominantly driven by processes in the inner disk and in the accretion zone. Four of the stars with long-term variations show periods of 20-60 d, significantly longer than the rotation periods and stable over months to years. One possible explanation are cyclic changes in the interaction between the disk and the stellar magnetic field.

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The Proper Motions of the Double Radio Source n in the Orion BN/KL Region

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We have extended the time baseline for observations of the proper motions of radio sources in the Orion BN/KL region from 14.7 to 22.5 years. We present improved determinations for the sources BN and I. In addition, we address the proper motions of the double radio source n, that have been questioned in the literature. We confirm that all three sources are moving away at transverse velocities of tens of km s^{-1} from a region in-between them, where they were located about 500 years ago. Source n exhibits a new component that we interpret as due to a one-sided ejection of free-free emitting plasma that took place after 2006.36. We used the highly accurate relative proper motions between sources BN and I to determine that their closest separation took place in the year 1475±6, when they were within ∼100 AU or less from each other in the plane of the sky.

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Initial mass function of planetesimals formed by the streaming instability

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The streaming instability is a mechanism to concentrate solid particles into overdense filaments that undergo gravitational collapse and form planetesimals. However, it remains unclear how the initial mass function of these planetesimals depends on the box dimensions of numerical simulations. To resolve this, we perform simulations of planetesimal formation with the largest box dimensions to date, allowing planetesimals to form simultaneously in multiple filaments that can only emerge within such large simulation boxes. In our simulations, planetesimals with sizes between 80 km and several hundred kilometers form. We find that a power law with a rather shallow exponential cutoff at the high-mass end represents the cumulative birth mass function better than an integrated power law. The steepness of the exponential cutoff is largely independent of box dimensions and resolution, while the exponent of the power law is not constrained at the resolutions we employ. Moreover, we find that the characteristic mass scale of the exponential cutoff correlates with the mass budget in each filament. Together with previous studies of high-resolution simulations with small box domains, our results therefore imply that the cumulative birth mass function of planetesimals is consistent with an exponentially tapered power law with a power-law exponent of approximately −1.6 and a steepness of the exponential cutoff in the range of 0.3–0.4.

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Astrochemical Properties of Planck Cold Clumps

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We observed thirteen Planck cold clumps with the James Clerk Maxwell Telescope/SCUBA-2 and with the Nobeyama 45 m radio telescope. The N_2H^+ distribution obtained with the Nobeyama telescope is quite similar to SCUBA-2 dust distribution. The 82 GHz HC_3N, 82 GHz CCS, and 94 GHz CCS emission are often distributed differently with respect to the N_2H^+ emission. The CCS emission, which is known to be abundant in starless molecular cloud cores,

is often very clumpy in the observed targets. We made deep single-pointing observations in DNC, $HN^{13}C$, N_2D^+, cyclic-C_3H_2 toward nine clumps. The detection rate of N_2D^+ is 50%. Furthermore, we observed the NH_3 emission toward 15 Planck cold clumps to estimate the kinetic temperature, and confirmed that most of targets are cold ($\lesssim 20$ K). In two of the starless clumps observe, the CCS emission is distributed as it surrounds the N_2H^+ core (chemically evolved gas), which resembles the case of L1544, a prestellar core showing collapse. In addition, we detected both DNC and N_2D^+. These two clumps are most likely on the verge of star formation. We introduce the Chemical Evolution Factor (CEF) for starless cores to describe the chemical evolutionary stage, and analyze the observed Planck cold clumps.

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Multi-Epoch Detections of Water Ice Absorption in Edge-on Disks around Herbig Ae Stars: PDS 144N and PDS 453

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We report the multi-epoch detections of the water ice in 2.8–4.2 μm spectra of two Herbig Ae stars, PDS 144N (A2 IVe) and PDS 453 (F2 Ve), which have an edge-on circumstellar disk. The detected water ice absorption is found to originate from their protoplanetary disks. The spectra show a relatively shallow absorption of water ice around 3.1 μm for both objects. The optical depths of the water ice absorption are $\sim$0.1 and $\sim$0.2 for PDS 144N and PDS 453, respectively. Compared to the water ice previously detected in low-mass young stellar objects with an edge-on disk with a similar inclination angle, these optical depths are significantly lower. It suggests that stronger UV radiation from the central stars effectively decreases the water ice abundance around the Herbig Ae stars through photodesorption. The water ice absorption in PDS 453 shows a possible variation of the feature among the six observing epochs. This variation could be due to a change of absorption materials passing through our line-of-sight to the central star.

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Robustness of N_2H^+ as tracer of the CO snowline

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Snowlines in protoplanetary disks play an important role in planet formation and composition. Since the CO snowline is difficult to observe directly with CO emission, its location has been inferred in several disks from spatially resolved ALMA observations of DCO^+ and N_2H^+. N_2H^+ is considered to be a good tracer of the CO snowline based on astrochemical considerations predicting an anti-correlation between N_2H^+ and gas-phase CO. In this work, the robustness of N_2H^+ as a tracer of the CO snowline is investigated. A simple chemical network is used in combination with the radiative transfer code LIME to model the N_2H^+ distribution and corresponding emission in the disk around TW Hya. The assumed CO and N_2 abundances, corresponding binding energies, cosmic ray ionization rate, and degree of large-grain settling are varied to determine the effects on the N_2H^+ emission and its relation to the CO snowline. For the adopted physical structure of the TW Hya disk and molecular binding energies for pure ices, the balance between freeze-out and thermal desorption predicts a CO snowline at 19 AU, corresponding to a CO midplane freeze-out temperature of 20 K. A model with a total, i.e. gas plus ice, CO abundance of 3×10^{-6} with respect to H_2 fits the position of the emission peak observed by Qi et al. 2013 for the TW Hya disk. However, the relationship

between N_2H^+ and the CO snowline is more complicated than generally assumed: for the investigated parameters, the N_2H^+ column density peaks at least 5 AU outside the CO snowline. Moreover, the N_2H^+ emission can peak much further out, as far as ∼50 AU beyond the snowline. Hence, chemical modeling, as done here, is necessary to derive a CO snowline location from N_2H^+ observations.

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Radio and infrared study of the star forming region IRAS 20286+4105

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A multi-wavelength investigation of the star forming complex IRAS 20286+4105, located in the Cygnus-X region, is presented here. Near-infrared K-band data is used to revisit the cluster / stellar group identified in previous studies. The radio continuum observations, at 610 and 1280 MHz show the presence of a HII region possibly powered by a star of spectral type B0 – B0.5. The cometary morphology of the ionized region is explained by invoking the bow-shock model where the likely association with a nearby supernova remnant is also explored. A compact radio knot with non-thermal spectral index is detected towards the centre of the cloud. Mid-infrared data from the *Spitzer* Legacy Survey of the Cygnus-X region show the presence of six Class I YSOs inside the cloud. Thermal dust emission in this complex is modelled using *Herschel* far-infrared data to generate dust temperature and column density maps. *Herschel* images also show the presence of two clumps in this region, the masses of which are estimated to be $\sim 175\,M_\odot$ and $30\,M_\odot$. The mass-radius relation and the surface density of the clumps do not qualify them as massive star forming sites. An overall picture of a runaway star ionizing the cloud and a triggered population of intermediate-mass, Class I sources located toward the cloud centre emerges from this multiwavelength study. Variation in the dust emissivity spectral index is shown to exist in this region and is seen to have an inverse relation with the dust temperature.

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Investigating the rotational evolution of very low-mass stars and brown dwarfs in young clusters using Monte Carlo simulations

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Very low-mass (VLM) stars and brown dwarfs (BDs) present a different rotational behaviour from their solar mass counterparts. We investigate the rotational evolution of young VLM stars and BDs using Monte Carlo simulations under the hypothesis of disk locking and stellar angular momentum conservation. We built a set of objects with masses ranging from 0.01 $M_\odot$ to 0.4 $M_\odot$ and considered models with single- and double-peaked initial period distributions with and without disk locking. An object is considered to be diskless when its mass accretion rate is below a given threshold. Models with initial single-peaked period distributions reproduce the observations well given that BDs rotate faster than VLM stars. We observe a correlation between rotational period and mass when we relax the disk locking hypothesis, but with a shallower slope compared to some observational results. The angular momentum evolution of diskless stars is flatter than it is for stars with a disk which occurs because the moment of inertia of objects less massive than 0.2 $M_\odot$ remains pratically constant for a time scale that increases with decreasing stellar mass. Comparing our results with the available observational data we see that disk locking is not as important in the low-mass regime and that the rotational behaviour of VLM stars and BDs is different from what is seen in their solar mass counterparts.

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Dust and Gas environment of the young embedded cluster IRAS 18511+0146

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Context. Since massive and intermediate mass stars form in clusters, a comparative investigation of the environments of the young embedded cluster members can reveal significant information about the conditions under which stars form and evolve.
Aims. IRAS 18511+0146 is a young embedded (proto)cluster located at 3.5 kpc surrounding what appears to be an intermediate mass protostar. In this paper, we investigate the nature of cluster members (two of which are believed to be the most massive and luminous) using imaging and spectroscopy in the near and mid-infrared. In particular, we examine the three brightest mid-infrared objects and two among these are believed to be most massive ones driving the luminosity of this region.
Methods. Near-infrared spectroscopy of nine objects (bright in K bands) towards IRAS 18511+0146 has been carried out. Several cluster members have also been investigated in the mid-infrared using spectroscopic and imaging with VISIR on the VLT. Far-infrared images from the *Herschel* Hi-GAL survey have been used to construct the column density and temperature maps of the region.
Results. The brightest point-like object associated with IRAS 18511+0146 is referred to as S7 in the present work (designated UGPS J185337.88+015030.5 in the UKIRT Galactic Plane survey). S7 is likely the most luminous object in the cluster as it is bright at all wavelengths ranging from the near-infrared to millimetre. Seven of the nine objects show rising spectral energy distributions (SED) in the near-infrared, with four objects showing Br-γ emission. Three members: S7, S10 (also UGPS J185338.37+015015.3) and S11 (also UGPS J185338.72+015013.5) are bright in mid-infrared with diffuse emission being detected in the vicinity of S11 in PAH bands. Silicate absorption is detected towards these three objects, with an absorption maximum between 9.6 and 9.7 μm, large optical depths $(1.8 - 3.2)$, and profile widths of $1.6 - 2.1$ μm. The silicate profiles of S7 and S10 are similar, in contrast to S11 (which has the largest width and optical depth). The cold dust emission peaks at S7, with temperature at 26 K and column density $N(H_2) \sim 7 \times 10^{22}$ cm^{-2}. The bolometric luminosity of IRAS 18511 region is $L \sim 1.8 \times 10^4$ $L_\odot$. S7 is the main contributor to the bolometric luminosity, with L (S7) $\geq 10^4$ $L_\odot$.
Conclusions. S7 is a high mass protostellar object with ionised stellar winds, evident from the correlation between radio and bolometric luminosity as well as the asymmetric Br-γ profile. The differences in silicate profiles of S7 and S11 could be due to different radiation environment as we believe the former to be more massive and in an earlier phase than the latter.

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On the nature of very low luminosity objects (VeLLOs)

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The nature of very low luminosity objects with the internal luminosity $L_{\rm obj} \leq 0.1$ $L_\odot$ is investigated by means of numerical modeling coupling the core collapse simulations with the stellar evolution calculations. The gravitational collapse of a large sample of model cores in the mass range $0.1 - 2.0$ $M_\odot$ is investigated. We start our numerical simulations from the pre-stellar phase and terminate them at the end of the embedded phase when 90% of the initial core mass has accreted onto the forming protostar plus disk system. The disk formation and evolution is studied using numerical hydrodynamics simulations, while the formation and evolution of the central star is calculated using a stellar evolution code. Three scenarios for mass accretion from the disk onto the star are considered: hybrid accretion in which a fraction of accreted energy absorbed by the protostar depends on the accretion rate, hot accretion wherein a fraction of accreted energy is constant, and cold accretion wherein all accretion energy is radiated away. Our conclusions on the nature of VeLLOs depend crucially on the character of protostellar accretion. In the hybrid accretion scenario, most VeLLOs (90.6%) are expected to be the first hydrostatic cores (FHSCs) and only a small fraction (9.4%) are true protostars. In the hot accretion scenario, all VeLLOs are FHSCs because of too high photospheric luminosity of protostars. In the cold accretion scenario, on the contrary, the majority of VeLLOs belong to the Class I phase of stellar evolution. The reason is that the stellar photospheric luminosity, which sets the floor for the total internal luminosity of a young star, is lower in cold accretion, thus enabling more VeLLOs in the protostellar stage. VeLLOs are rather rare objects occupying 7%–11% of the total duration of the embedded phase and their masses do not exceed 0.3 $M_{\odot}$. When compared with observations of Dunham et al. (2008, 2014) inferring a fraction of VeLLOs in the protostellar stage $\sim$ 6.25%, we find that cold accretion provides a much better fit to observations than hybrid accretion (5.7% for cold accretion vs. 0.7% for hybrid accretion). Both accretion scenarios predict more VeLLOs in the Class I phase than in the Class 0 phase, in contrast to observations. Finally, when accretion variability with episodic bursts is artificially filtered out from our numerically derived accretion rates, the fraction of VeLLOs in the protostellar stage drops significantly, suggesting a causal link between the two phenomena.

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Gas Kinematics in the HII regions G351.69-1.15 and G351.63-1.25

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We probe the structure and kinematics of two neighbouring H II regions identified as cometary and bipolar, using radio recombination lines (RRL). The H172α RRLs from these H II regions: G351.69–1.15 and G351.63–1.25, are mapped using GMRT, India. We also detect carbon RRLs C172α towards both these regions. The hydrogen RRLs display the effects of pressure and dynamical broadening in the line profiles, with the dynamical broadening ($\sim$ 15 km/s) playing a major role in the observed profile of G351.69–1.15. We investigate the kinematics of molecular gas species towards this H II region from the MALT90 pilot survey. The molecular gas is mostly distributed towards the north and north-west of the cometary head. The molecular line profiles indicate signatures of turbulence and outflow in this region. The ionized gas at the cometary tail is blue shifted by $\sim$8 km/s with respect to the ambient molecular cloud, consistent with the earlier proposed champagne flow scenario. The relative velocity of $\sim$5 km/s between the northern and southern lobes of the bipolar H II region G351.63–1.25 is consistent with the premise that the bipolar morphology is a result of the expanding ionized lobes within a flat molecular cloud.

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The SHARDDS survey: first resolved image of the HD114082 debris disk in Lower Centaurus Crux with SPHERE

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We present the first resolved image of the debris disk around the 16±8 Myr old star, HD 114082. The observation was made in the H-band using the SPHERE instrument. The star is at a distance of 92±6 pc in the Lower Centaurus Crux association. Using a Markov Chain Monte Carlo analysis, we determined that the debris is likely in the form of a dust ring with an inner edge of $27.7^{+2.8}_{-3.5}$ au, position angle $-74^{\circ}{}^{+0.5}_{-1.5}$, and an inclination with respect to the line of sight of $6.7^{\circ}{}^{+3.8}_{-0.4}$. The disk imaged in scattered light has a surface density declining with radius like $\sim$r^{-4}, steeper than expected for grain blowout by radiation pressure. We find only marginal evidence (2σ) of eccentricity, and rule out planets more massive than 1.0 $M_{\rm jup}$ orbiting within 1 au of the ring's inner edge, since such a planet would have disrupted the disk. The disk has roughly the same fractional disk luminosity ($L_{\rm disk}/L_* = 3.3 \times 10^{-3}$) as HR4796A and β Pictoris, however it was not detected by previous instrument facilities most likely because of its small angular size (radius $\sim 0.''4$), low albedo ($\sim$0.2) and low scattering efficiency far from the star due to high scattering anisotropy. With the arrival of extreme adaptive optics systems like SPHERE and GPI, the morphology of smaller, fainter and more distant debris disks are being revealed, providing clues to planet-disk interactions in young protoplanetary systems.

Accepted by A&A

http://arxiv.org/pdf/1611.05866

Planetesimal collisions as a chondrule forming event

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Chondritic meteorites contain unique spherical materials named chondrules: sub-mm sized silicate grains once melted in a high temperature condition in the solar nebula. We numerically explore one of chondrule forming processes, planetesimal collisions. Previous studies found that impact jetting via protoplanet-planetesimal collisions make chondrules with an amount of 1% of impactors' mass, when impact velocity exceeds 2.5 km s^{-1}. Based on the mineralogical data of chondrules, undifferentiated planetesimals would be more suitable for chondrule-forming collisions than potentially differentiated protoplanets. We examine planetesimal-planetesimal collisions using a shock physics code and find two things: one is that planetesimal-planetesimal collisions produce the nearly same amount of chondrules as protoplanet-planetesimal collisions ($\sim$1%). The other is that the amount of produced chondrules becomes larger as the impact velocity increases when two planetesimals collide with each other. We also find that progenitors of chondrules can be ejected from deeper regions of large targets (planetesimals or protoplanets) than small impactors (planetesimals). The composition of targets is therefore important to fully account for the mineralogical data of currently sampled chondrules.

Accepted by ApJ

http://arxiv.org/pdf/1611.05511

GMC Collisions as Triggers of Star Formation. II. 3D Turbulent, Magnetized Simulations

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We investigate giant molecular cloud (GMCs) collisions and their ability to induce gravitational instability and thus star formation. This mechanism may be a major driver of star formation activity in galactic disks. We carry out a series of three dimensional, magnetohydrodynamics (MHD), adaptive mesh refinement (AMR) simulations to study how cloud collisions trigger formation of dense filaments and clumps. Heating and cooling functions are implemented based on photo-dissociation region (PDR) models that span the atomic to molecular transition and can return detailed diagnostic information. The clouds are initialized with supersonic turbulence and a range of magnetic field strengths and orientations. Collisions at various velocities and impact parameters are investigated. Comparing and contrasting colliding and non-colliding cases, we characterize morphologies of dense gas, magnetic field structure, cloud kinematic signatures, and cloud dynamics. We present key observational diagnostics of cloud collisions, especially: relative orientations between magnetic fields and density structures, like filaments; ^{13}CO(J=2-1), ^{13}CO(J=3-2), and ^{12}CO(J=8-7) integrated intensity maps and spectra; and cloud virial parameters. We compare these results to observed Galactic clouds.

Accepted by ApJ

https://arxiv.org/pdf/1606.01320

Signs of Early-Stage Disk Growth Revealed with ALMA

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We present ALMA 1.3 mm continuum, ^{12}CO, C^{18}O, and SO data for the Class 0 protostars, Lupus 3 MMS, IRAS 15398−3559, and IRAS 16253−2429 at resolutions of ∼100 AU. By measuring a rotational profile in C^{18}O, a 100 AU Keplerian disk around a 0.3 $M_\odot$ protostar is observed in Lupus 3 MMS. No 100 AU Keplerian disks are observed in IRAS 15398−3559 and IRAS 16253−2429. Nevertheless, embedded compact (<30 AU) continuum components are detected. The C^{18}O emission in IRAS 15398−3559 shows signatures of infall with a constant angular momentum. IRAS 16253−2429 exhibits signatures of infall and rotation, but its rotational profile is unresolved. By fitting the C^{18}O data with our kinematic models, the protostellar masses and the disk radii are inferred to be 0.01 $M_\odot$ and 20 AU in IRAS 15398−3559, and 0.03 $M_\odot$ and 6 AU in IRAS 16253−2429. By comparing the specific angular momentum profiles from 10,000 to 100 AU in 8 Class 0 and I protostars, we find that the evolution of envelope rotation can be described with conventional inside-out collapse models. In comparison with a sample of 18 protostars with known disk radii, our results reveal signs of disk growth, with the disk radius increasing as ${M_*}^{0.8\pm0.14}$ or $t^{1.09\pm0.37}$ in the Class 0 stage, where M_* is the protostellar mass and t is the age. The disk growth rate slows down in the Class I stage. Besides, we find a hint that the mass accretion rate declines as $t^{-0.26\pm0.04}$ from the Class 0 to I stages.

Accepted by ApJ

https://arxiv.org/pdf/1611.08416v1.pdf

Chemistry in a forming protoplanetary disk: main accretion phase

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We investigate the chemistry in a radiation-hydrodynamics model of star-forming core which evolves from a cold (~ 10 K) prestellar core to the main accretion phase in $\sim 10^5$ yr. A rotationally-supported gravitationally unstable disk is formed around a protostar. We extract the temporal variation of physical parameters in $\sim 1.5 \times 10^3$ SPH particles which end up in the disk, and perform post-processing calculations of the gas-grain chemistry adopting a three-phase model. Inside the disk, the SPH particles migrate both inward and outward. Since a significant fraction of volatiles such as CO can be trapped in the water-dominant ice in the three-phase model, the ice mantle composition depends not only on the current position in the disk but also on whether the dust grain has ever experienced higher temperatures than the water sublimation temperature. Stable molecules such as H_2O, CH_4, NH_3 and CH_3OH are already abundant at the onset of gravitational collapse and simply sublimated as the fluid parcels migrate inside the water snow line. On the other hand, various molecules such as carbon chains and complex organic molecules (COMs) are formed in the disk. COMs abundance sensitively depends on the outcomes of photodissociation and diffusion rates of photofragments in bulk ice mantle. As for S-bearing species, H_2S ice is abundant in the collapse phase. In the warm regions in the disk, H_2S is sublimated to be destroyed, while SO, H_2CS, OCS and SO_2 become abundant.

Accepted by ApJ

https://arxiv.org/pdf/1611.03587

The ALMA Early Science view of FUor/EXor objects. I. Through the looking-glass of V2775 Ori

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As part of an ALMA survey to study the origin of episodic accretion in young eruptive variables, we have observed the circumstellar environment of the star V2775 Ori. This object is a very young, pre-main sequence object which displays a large amplitude outburst characteristic of the FUor class. We present Cycle-2 band 6 observations of V2775 Ori with a continuum and CO (2–1) isotopologue resolution of $0\farcs25$ (103 au). We report the detection of a marginally resolved circumstellar disc in the ALMA continuum with an integrated flux of 106 ± 2 mJy, characteristic radius of $\sim$30 au, inclination of $14.0^{+7.8}_{-14.5}$ deg, and is oriented nearly face-on with respect to the plane of the sky.

The ^{12}CO emission is separated into distinct blue and red-shifted regions that appear to be rings or shells of expanding material from quasi-episodic outbursts. The system is oriented in such a way that the disc is seen through the outflow remnant of V2775 Ori, which has an axis along our line-of-sight. The ^{13}CO emission displays similar structure to that of the ^{12}CO, while the $C^{18}O$ line emission is very weak. We calculated the expansion velocities of the low- and medium-density material with respect to the disc to be of -2.85 km s^{-1} (blue), 4.4 km s^{-1} (red) and -1.35 and 1.15 km s^{-1} (for blue and red) and we derived the mass, momentum and kinetic energy of the expanding gas. The

outflow has an hourglass shape where the cavities are not seen. We interpret the shapes that the gas traces as cavities excavated by an ancient outflow. We report a detection of line emission from the circumstellar disc and derive a lower limit of the gas mass of 3 $M_{\rm jup}$.

Accepted by MNRAS

http://arxiv.org/pdf/1611.00765

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.

Abstracts of recently accepted major reviews

The gas disk: Evolution and chemistry

Christian Rab[1], Carla Baldovin-Saavedra[1], Odysseas Dionatos[1], Eduard Vorobyov[1,2], Manuel Güdel[1]

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Protoplanetary disks are the birthplaces of planetary systems. The evolution of the star-disk system and the disk chemical composition determines the initial conditions for planet formation. Therefore a comprehensive understanding of the main physical and chemical processes in disks is crucial for our understanding of planet formation. We give an overview of the early evolution of disks, discuss the importance of the stellar high-energy radiation for disk evolution and describe the general thermal and chemical structure of disks. Finally we provide an overview of observational tracers of the gas component and disk winds.

Accepted by Space Science Reviews (″The Disk in Relation to the Formation of Planets and their Proto-atmospheres″)

http://arxiv.org/pdf/1611.09658

A "Rosetta Stone" for protoplanetary disks: The synergy of multi-wavelength observations

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The recent progress in instrumentation and telescope development has brought us different ways to observe protoplanetary disks, including interferometers, space missions, adaptive optics, polarimetry, and time- and spectrally-resolved data. While the new facilities have changed the way we can tackle the existing open problems in disk structure and evolution, there is a substantial lack of interconnection between different observing techniques and their user communities. Here, we explore the complementarity of some of the state-of-the-art observing techniques, and how they can be brought together in a collective effort to understand how disks evolve and disperse at the time of planet formation. This paper was born at the ″Protoplanetary Discussions″ meeting in Edinburgh, 2016. Its goal is to clarify where multi-wavelength observations of disks converge in unveiling disk structure and evolution, and where they diverge and challenge our current understanding. We discuss caveats that should be considered when linking results from different observations, or when drawing conclusions based on limited datasets (in terms of wavelength or sample). We focus on disk properties that are currently being revolutionized by multi-wavelength observations. Specifically: the inner disk radius, holes and gaps and their link to large-scale disk structures, the disk mass, and the accretion rate. We discuss how the links between them, as well as the apparent contradictions, can help us to disentangle the disk physics and to learn about disk evolution.

Accepted by PASA

https://arxiv.org/pdf/1611.01798

New Jobs

Postdoctoral position in star/planet formation and exoplanets

The University of Vienna announces availability of a 4-year postdoctoral position in the field of star and planet formation and/or exoplanetary research. We seek an excellent candidate developing research in any of the areas of planet formation, protoplanetary disks, or exoplanetary atmospheres, focusing on theoretical/numerical modeling or observations also aiming at JWST in the future. The position is part of the Star and Planet Formation group of Prof. Manuel Güdel that hosts a large national research program on planet formation and exoplanetary habitability (http://path.univie.ac.at) offering many opportunities for participation and collaboration. The candidate will be expected to carry out his/her independent research programs, but is strongly encouraged to also engage in collaborations within the group.

The candidate will have access to observatories of ESO and ESA; for numerical work, the Vienna Scientific Cluster will be accessible. There are many opportunities to interact within ongoing or planned instrument projects (PLATO, CHEOPS, Athena, ESO E-ELT, etc). Funds are made available to support travel expenses and conference participation. A modest level of teaching is expected. The position should be filled at the earliest possible date but no earlier than 1 March 2017. Duration of employment: 4 years.

Applications include a motivation letter addressed to Prof. M. Güdel, a CV, a publication list, a summary of past research (max. 2 pages), and an outline of the proposed research program for the duration of the employment (max. 4 pages). These documents must be submitted electronically as a PDF file to university's Job Center, http://jobcenter.univie.ac.at/en/applications/, referring to Job code 7143. Review starts 1 February 2017. Applicants should arrange for three letters of reference sent by the referees directly to manuel.guedel@univie.ac.at.

Post-doctoral position in protoplanetary discs and planet formation

The Theoretical Astrophysics Group at the University of Leicester invites applications for a post-doctoral Research Associate. This position is funded by a European Research Council (ERC) grant awarded to Dr Richard Alexander, and will initially be for a period of three years, with the possibility of extension depending on progress and funding considerations. The project ("BuildingPlanS") will use large suites of numerical simulations to link the architectures of observed exoplanet systems to their formation in protoplanetary discs.

The successful applicant will be expected to carry out independent and collaborative research for this project, and will also have opportunities to collaborate more widely within the Theoretical Astrophysics Group (whose existing research programme includes star and planet formation, AGN physics, accretion discs, galactic dynamics & dark matter). We are therefore particularly interested in candidates with expertise in protoplanetary discs, planet formation and migration, or numerical hydrodynamics, but all applicants with a strong background in theoretical astrophysics are encouraged to apply.

Applicants must have a PhD in astrophysics (or a related discipline), or expect to be awarded a PhD before taking up the position. The position is available from 1st July 2017, but the starting date is flexible. The salary scale is £32,958–£38,138, depending on experience. The successful applicant will have access to substantial expenses for relocation, travel and computing equipment, as well as extensive access to high-performance computing facilities.

Applications should be submitted electronically, via `http://www2.le.ac.uk/offices/jobs` (reference SEN00796). Informal enquiries should be directed to Dr Richard Alexander (`richard.alexander@leicester.ac.uk`). All applications received by January 16th 2017, will be given full consideration.

Meetings

Francesco's Legacy: Star Formation in Space and Time

June 5–9 2017

Istituto degli Innocenti, Firenze (ITALY)

http://www.arcetri.astro.it/sfst2017/

"The complex of processes known as star formation must have occurred innumerable times in the remote past. The Big Bang, after all, did not produce a Universe full of stars but of diffuse gas. How gas turns into stars is the subject of this book. Anyone wishing to study the problem is aided immediately by the fact that star formation is also occurring now, and in regions close enough that the transformation can be examined in some detail."

These opening lines of the textbook "The Formation of Stars" by Steve Stahler and Francesco Palla (Wiley 2004) convey the vast extent, in both space and time, of star formation. This conference is dedicated to the memory of Francesco Palla (1954-2016), a leading figure in the field of star formation and a person of rare qualities. As a scientist, Francesco left behind a broad and profound legacy in studies of the interstellar medium, young stellar cluster, and protostellar evolution now and in the primordial Universe. The goal of this conference is to gather observational and theoretical experts in the various aspects of the star formation process addressed by Francesco in his career, to outline the advances in these studies and the prospects for future developments.

Today, high-resolution observations, theoretical modelling and state-of-the-art numerical simulations make it possible to analyze in detail the physical aspects of star formation over many spatial scales, both in the present-day Universe and in the distant past.

Observations of star formation in nearby galaxies are revealing how the different environments affect star formation, while high-sensitivity surveys of nearby molecular clouds have uncovered the filamentary structure of the dense interstellar medium. At the same time, space- and ground-based surveys allow a superb characterization of the young stellar cluster population. Moreover, asteroseismology is offering a unique window to constrain the intrinsic parameters and structure of young stars as well as to date young stellar clusters. The characteristics of the first stars formed at the end of the Dark Ages of the Universe are now constrained by direct observations of the composition of second-generation low-mass stars, offering, for the first time, an opportunity to test models of the chemical and thermal conditions within the primordial gas. This conference aims at presenting a broad perspective on the process of star formation in our Galaxy, in nearby galaxies, and in the early Universe.

The following topics will be covered:

- The evolution of molecular clouds Lifetime, structure and dynamics of molecular clouds, fragmentation, magnetic fields and turbulence, star formation efficiency, stellar feedback.
- Protostellar and pre-main sequence evolution Ages of PMS stars, brown dwarfs, Herbig Ae-Be stars, stellar pulsations and asteroseismology, PMS evolutionary models, protoplanetary disks.
- Young stellar clusters The formation of stellar clusters in the Milky Way and nearby galaxies, chemical content, ages and age dispersions, high-mass star formation.
- The first stars Primordial chemistry, cooling and fragmentation, primordial star formation and the IMF, stellar archeology.

SOC: Riccardo Cesaroni (Arcetri), Edvige Corbelli (Arcetri), Daniele Galli (Arcetri), Susana Lizano (UNAM), Andre Maeder (Geneva Observatory), Marcella Marconi (Capodimonte), Gary Melnick (CfA), Antonella Natta (DIAS), Kazuyuki Omukai (Tohoku), Sofia Randich (Arcetri), Steve Stahler (Berkeley) (co-Chair), Leonardo Testi (ESO-Arcetri), Hans Zinnecker (SOFIA) (co-Chair)

Stellar Magnetism: Challenges, Connections, and Prospects. 14th Potsdam Thinkshop

The scientific programme will highlight the most recent observational and theoretical work in the field including, but not limited to, the following topics:

- the origin of stellar magnetic fields
- magnetic field geometry and evolution in pre-main-sequence stars
- magnetic fields, rotation, and differential rotation on the main sequence
- the role of small-scale magnetic fields in stellar atmospheres
- global dynamos, activity cycles, and the rotation-activity-age relation in solar-type stars
- magnetic fields in massive stars and magnetically-confined winds
- magnetic star/planet and disk/planet interaction
- magnetism in the late stages of stellar evolution
- future perspectives in theory and observational facilities

Registration and abstract submission will be opened on the 5th of January 2017.

https://thinkshop.aip.de/14/

Spectroscopy with SOFIA: new results & future opportunities (SOFIA2017)

Schloss Ringberg, Tegernsee, Germany, March 5-8, 2017

Continuing on the success of the 2015 Ringberg meeting on spectroscopy with SOFIA at which about 70 participants discussed SOFIA results ranging from nearby star formation to the interstellar medium in nearby galaxies, SOFIA2017 aims at presenting new science results and looking into future science opportunities for the next years enabled by new instrumentation.

Several instruments on SOFIA allow unique spectroscopic studies of the physics and chemistry of the interstellar medium: GREAT covers with high spectral resolution selected FIR-windows between 1.2 and 4.7 THz (63-250 μm), which includes the major cooling lines from [CII] and [OI] of the interstellar medium, the latter even with arrays of 14 and 7 pixels, respectively. An extension to cover the 500–600 GHz frequency range is currently being built. In larger fields, these lines can be probed with the FIFI-LS integral field spectrometer (50–200 μm) at lower spectral resolution, while EXES covers even shorter wavelengths (from 4.5 to 28.3 μm), again with high spectral resolution, including the important H2 rotational transitions. The forthcoming third generation instrument HIRMES will cover 25–120 μm continuously with resolution of 10000–100000. Finally, FORCAST and FLITECAM allow low-resolution grism spectroscopy, including PAHs.

Given the rapid progress in instrument development, resulting in continuous upgrades and extensions of the existing detectors, as well as new science projects, it is timely to discuss new results from SOFIA and to look into science opportunities for the coming years, particularly in the area of FIR spectroscopy.

The conference venue, Ringberg Castle, will provide a unique setting for in-depth discussions on current and future unique science with SOFIA. In particular, sessions on new scientific results, on synergies with other observatories, and on new instruments enabling new science are envisioned. Even if you have no SOFIA-related results yourself, we invite you to attend so you can see and find out for yourself what SOFIA can do for you. We specifically encourage the attendance of graduate and PhD students, and will reserve a number of slots for them.

Updates on the registration and submission of abstracts will be given on the workshop website:

https://events.mpifr-bonn.mpg.de/indico/event/16/

Multi-Scale Star Formation

April 3-7, 2017 Morelia, Michoacán, México

http://www.crya.unam.mx/multi-scaleSF17/

Our understanding of the physical and chemical processes that culminate in the formation of stars and stellar clusters in the Universe has undergone great progress in recent years, both from observations and from theory and simulations. One of the main realizations is that the star-formation process involves a continuous gas flow from galactic (kpc) scales down to stellar (AU) scales. However, there is still a lack of exchange from the different communities performing research in this topic at different characteristic scales.

Given the need to cross-link processes over this wide range of scales, this conference aims at bringing together experts that work in all the relevant scales related to star formation, with the hope that researchers working in a given scale range will bring in their point of view to workers at other scales, improving our understanding of star formation as a broader theme. To achieve this, each session will contain contributed talks from different scales, although preserving an underlying scheme. The invited talks will seek to relate a specific topic to the broader context. There will also be time allocated for two or three one-hour discussion sessions to exchange ideas on the relation of a specific scale to the others.

The conference will be held at the University Cultural Center (Centro Cultural Universitario) of the "Universidad Michoacana de San Nicols de Hidalgo" (UMSNH). This is a beautiful colonial-style building with an auditorium for 300 people and several smaller meeting rooms, located at the heart of downtown Morelia, within 2 blocks of the Cathedral, and within walking-distance from several hotels. For more information, click on the following link:

http://www.mexicoescultura.com/recinto/55277/en

The city of Morelia is the capital of the state of Michoacn in central Mxico. Before the spanish colonization, the area was inhabited by the purpecha and the matlatzinca cultures, but no major cities were founded in the valley during this time. The spanish founded a settlement here in 1541 with the name of Valladolid. After the mexican war of independence, the city was renamed Morelia in honor of Jos Mara Morelos, one of the main leaders of the war. Morelia is currently a beautiful colonial city, with an ordinance that no building should be taller than its cathedral's towers, to preserve its majestic dominance over the landscape. Morelia was declared a UNESCO World Heritage Site in 1991.

SOC: Gustavo Bruzual, Paola Caselli, Francoise Combes, Bruce Elmegreen, Neal Evans, Lee Hartmann, Melvin Hoare, Susana Lizano, Mordecai Mac Low, Frederique Motte, Casiana Munoz Tunon, Luis Felipe Rodriguez, Meg Urry, Enrique Vazquez-Semadeni (chair), Qizhou Zhang.

Early registration: January 20, 2017

Short Announcements

Report on the SOFIA Conference at Asilomar, October 17-20, 2016

"*The Local Truth: Star Formation and Feedback in the SOFIA Era*" was held at the Asilomar Conference Grounds in California during October 17-20, 2016. About 100 astronomers from all around the world attended the conference. Many new SOFIA results on a wide range of topics related to star formation and the interstellar medium were presented and discussed at the conference and we look forward to reading publications of those results. Additionally, there were evening talks on the history of airborne astronomy and on synergies of SOFIA with other facilities. The meeting was highly productive and the organizers appreciate the positive feedback from the participants.

There will be no Conference Proceedings for the meeting; instead the presentations are posted on our website and will continue to be added as they are submitted. Please check the website at: https://www.sofia.usra.edu/conference/local-truth-star-formation-and-feedback-sofia-era-celebrating-50-years-airborne-5

Summary of Upcoming Meetings

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

Multi-Scale Star Formation
3 - 7 April 2017, Morelia, Mexico
http://www.irya.unam.mx/multi-scaleSF17/

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

Francesco's Legacy: Star Formation in Space and Time
6 - 9 June 2017, Firenze, Italy
http://www.arcetri.astro.it/sfst2017/

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/