THE STAR FORMATION NEWSLETTER

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

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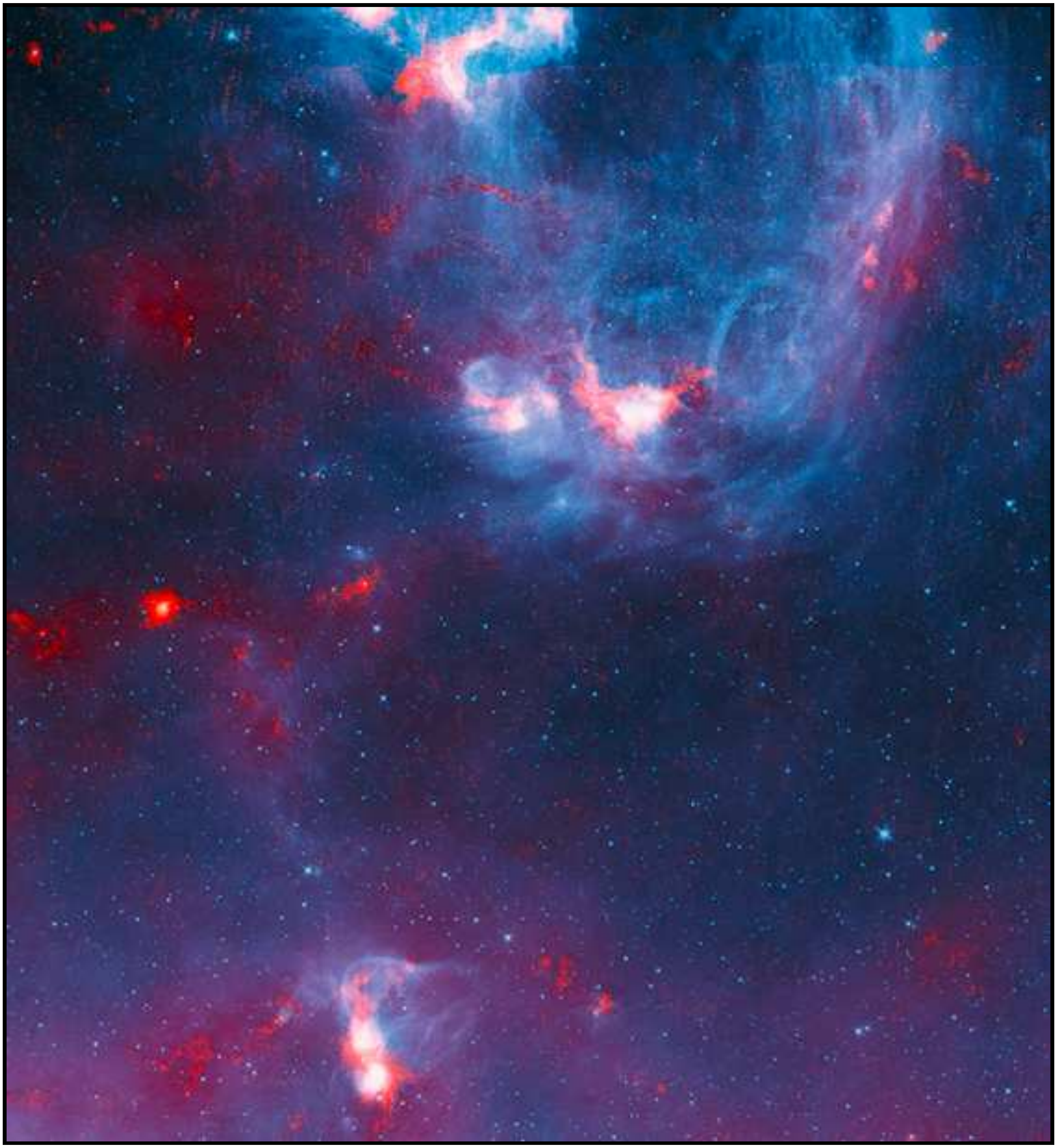

The Star Formation Newsletter

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

Newsletter Archive

www.ifa.hawaii.edu/users/reipurth/newsletter.htm

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Cover Picture

The APEX (Atacama Pathfinder EXperiment) telescope has mapped the entire southern Galactic plane at submillimeter wavelengths in the ATLASGAL (APEX Telescope Large Area Survey of the Galaxy) project. The large ring-like structure in the image is the high-mass star formation region IC 4628 excited by the B-star HDE 322417. The APEX data at 0.87 millimeters are red and the background blue image is from infrared wavelengths by the Spitzer Space Telescope as part of the GLIMPSE survey. The fainter extended red structures come from complementary observations made by ESA's Planck satellite.

Image courtesy the ESO/APEX/ATLASGAL consortium, the NASA/GLIMPSE consortium, and the ESA/Planck consortium

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

Abstracts of recently accepted papers

Characterizing filaments in regions of high-mass star formation: High-resolution submilimeter imaging of the massive star-forming complex NGC 6334 with ArTéMiS

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Context: *Herschel* observations of nearby molecular clouds suggest that interstellar filaments and prestellar cores represent two fundamental steps in the star formation process. The observations support a picture of low-mass star formation according to which filaments of ~ 0.1 pc width form first in the cold interstellar medium, probably as a result of large-scale compression of interstellar matter by supersonic turbulent flows, and then prestellar cores arise from gravitational fragmentation of the densest filaments. Whether this scenario also applies to regions of high-mass star formation is an open question, in part because the resolution of *Herschel* is insufficient to resolve the inner width of filaments in the nearest regions of massive star formation.
Aims: In an effort to characterize the inner width of filaments in high-mass star-forming regions, we imaged the central part of the NGC6334 complex at a resolution higher by a factor of > 3 than *Herschel* at 350 μm.
Methods: We used the large-format bolometer camera ArTéMiS on the APEX telescope and combined the high-resolution ArTéMiS data at 350 μm with *Herschel*/HOBYS data at 70–500 μm to ensure good sensitivity to a broad range of spatial scales. This allowed us to study the structure of the main narrow filament of the complex with a resolution of 8" or < 0.07 pc at $d \sim 1.7$ kpc.
Results: Our study confirms that this filament is a very dense, massive linear structure with a line mass ranging from $\sim 500\, M_\odot$/pc to $\sim 2000\, M_\odot$/pc over nearly 10 pc. It also demonstrates for the first time that its inner width remains as narrow as $W \sim 0.15 \pm 0.05$ pc all along the filament length, within a factor of < 2 of the characteristic 0.1 pc value found with *Herschel* for lower-mass filaments in the Gould Belt.
Conclusions: While it is not completely clear whether the NGC 6334 filament will form massive stars in the future, it is two to three orders of magnitude denser than the majority of filaments observed in Gould Belt clouds, and has a very similar inner width. This points to a common physical mechanism for setting the filament width and suggests that some important structural properties of nearby clouds also hold in high-mass star-forming regions.

Accepted by Astronomy and Astrophysics

http://arxiv.org/pdf/1605.07434

A Comprehensive Dust Model Applied to the Resolved Beta Pictoris Debris Disk from Optical to Radio Wavelengths

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We investigate whether varying the dust composition (described by the optical constants) can solve a persistent problem in debris disk modeling–the inability to fit the thermal emission without over-predicting the scattered light. We model five images of the beta Pictoris disk: two in scattered light from HST/STIS at 0.58 μm and HST/WFC3 at 1.16 μm, and three in thermal emission from Spitzer/MIPS at 24 μm, Herschel/PACS at 70 μm, and ALMA at 870 μm. The WFC3 and MIPS data are published here for the first time. We focus our modeling on the outer part of this disk, consisting of a parent body ring and a halo of small grains. First, we confirm that a model using astronomical silicates cannot simultaneously fit the thermal and scattered light data. Next, we use a simple, generic function for the optical constants to show that varying the dust composition can improve the fit substantially. Finally, we model the dust as a mixture of the most plausible debris constituents: astronomical silicates, water ice, organic refractory material, and vacuum. We achieve a good fit to all datasets with grains composed predominantly of silicates and organics, while ice and vacuum are, at most, present in small amounts. This composition is similar to one derived from previous work on the HR 4796A disk. Our model also fits the thermal SED, scattered light colors, and high-resolution mid-IR data from T-ReCS for this disk. Additionally, we show that sub-blowout grains are a necessary component of the halo.

Accepted by ApJ

http://arxiv.org/pdf/1605.01731

ALMA Observations of Circumstellar Disks in the Upper Scorpius OB Association

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We present ALMA observations of 106 G-, K-, and M-type stars in the Upper Scorpius OB Association hosting circumstellar disks. With these data, we measure the 0.88 mm continuum and ^{12}CO $J = 3-2$ line fluxes of disks around low mass (0.14-1.66 $M_\odot$) stars at an age of 5-11 Myr. Of the 75 primordial disks in the sample, 53 are detected in the dust continuum and 26 in CO. Of the 31 disks classified as debris/evolved transitional disks, 5 are detected in the continuum and none in CO. The lack of CO emission in approximately half of the disks with detected continuum emission can be explained if CO is optically thick but has a compact emitting area (<40 AU), or if the CO is heavily depleted by a factor of at least $\sim$1000 relative to interstellar medium abundances and is optically thin. The continuum measurements are used to estimate the dust mass of the disks. We find a correlation between disk dust mass and stellar host mass consistent with a power-law relation of $M_{dust} \propto M_*^{1.67\pm0.37}$. Disk dust masses in Upper Sco are compared to those measured in the younger Taurus star forming region to constrain the evolution of disk dust mass. We find that the difference in the mean of $\log(M_{dust}/M_*)$ between Taurus and Upper Sco is 0.64 ± 0.09, such that M_{dust}/M_* is lower in Upper Sco by a factor of $\sim$4.5.

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Determining the midplane conditions of circumstellar discs using gas and dust modelling: a study of HD 163296

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The mass of gas in protoplanetary discs is a quantity of great interest for assessing their planet formation potential. Disc gas masses are however traditionally inferred from measured dust masses by applying an assumed standard gas to dust ratio of $g/d = 100$. Furthermore, measuring gas masses based on CO observations has been hindered by the effects of CO freeze-out. Here we present a novel approach to study the midplane gas by combining $C^{18}O$ line modelling, CO snowline observations and the spectral energy distribution (SED) and selectively study the inner tens of au where freeze-out is not relevant. We apply the modelling technique to the disc around the Herbig Ae star HD 163296 with particular focus on the regions within the CO snowline radius, measured to be at 90 au in this disc. Our models yield the mass of $C^{18}O$ in this inner disc region of $M_{C^{18}O}(< 90\,au) \sim 2 \times 10^{-8}\,\mathrm{M}_{\odot}$. We find that most of our models yield a notably low $g/d < 20$, especially in the disc midplane ($g/d < 1$). Our only models with a more ISM-like g/d require $C^{18}O$ to be underabundant with respect to the ISM abundances and a significant depletion of sub-micron grains, which is not supported by scattered light observations. Our technique can be applied to a range of discs and opens up a possibility of measuring gas and dust masses in discs within the CO snowline location without making assumptions about the gas to dust ratio.

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Discovery of a Long-Lived, High Amplitude Dusty Infrared Transient

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We report the detection of an infrared selected transient which has lasted at least 5 years, first identified by a large mid-infrared and optical outburst from a faint X-ray source detected with the Chandra X-ray Observatory. In this paper we rule out several scenarios for the cause of this outburst, including a classical nova, a luminous red nova, AGN flaring, a stellar merger, and intermediate luminosity optical transients, and interpret this transient as the result of a Young Stellar Object (YSO) of at least solar mass accreting material from the remains of the dusty envelope from which it formed, in isolation from either a dense complex of cold gas or massive star formation. This object does not fit neatly into other existing categories of large outbursts of YSOs (FU Orionis types) which may be a result of the object's mass, age, and environment. It is also possible that this object is a new type of transient unrelated to YSOs.

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http://arxiv.org/pdf/1605.05321

CSO and CARMA Observations of L1157. II. Chemical Complexity in the Shocked Outflow

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L1157, a molecular dark cloud with an embedded Class 0 protostar possessing a bipolar outflow, is an excellent source for studying shock chemistry, including grain-surface chemistry prior to shocks, and post-shock, gas-phase processing. The L1157-B1 and B2 positions experienced shocks at an estimated ∼2000 and 4000 years ago, respectively. Prior to these shock events, temperatures were too low for most complex organic molecules to undergo thermal desorption. Thus, the shocks should have liberated these molecules from the ice grain-surfaces en masse, evidenced by prior observations of SiO and multiple grain mantle species commonly associated with shocks. Grain species, such as OCS, CH_3OH, and HNCO, all peak at different positions relative to species that are preferably formed in higher velocity shocks or repeatedly-shocked material, such as SiO and HCN. Here, we present high spatial resolution (∼3″) maps of CH_3OH, HNCO, HCN, and HCO^+ in the southern portion of the outflow containing B1 and B2, as observed with CARMA. The HNCO maps are the first interferometric observations of this species in L1157. The maps show distinct differences in the chemistry within the various shocked regions in L1157B. This is further supported through constraints of the molecular abundances using the non-LTE code RADEX (Van der Tak et al. 2007). We find the east/west chemical differentiation in C2 may be explained by the contrast of the shock's interaction with either cold, pristine material or warm, previously-shocked gas, as seen in enhanced HCN abundances. In addition, the enhancement of the HNCO abundance toward the the older shock, B2, suggests the importance of high-temperature O-chemistry in shocked regions.

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Investigating the origin of hot gas lines in Herbig Ae/Be stars

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We analyze high-resolution UV spectra of a small sample of Herbig Ae/Be stars (HAEBES) in order to explore the origin of the $T \sim 10^5$ K gas in these stars. The C IV 1548,1550 Å line luminosities are compared to non–simultaneous accretion rate estimates for the objects showing C IV emission. We show that the correlation between L_{CIV} and $\dot{M}$ previously established for classical T Tauri stars (CTTSs) seems to extend into the HAEBE mass regime, although the large spread in literature$\dot{M}$ and A_V values makes the actual relationship highly uncertain. With the exception of DX Cha, we find no evidence for hot, optically thick winds in our HAEBE sample. All other objects showing clear doublet emission in C IV can be well described by a two component (i.e., a single component for each doublet member) or four component (i.e., two components for each doublet member) Gaussian emission line fit. The morphologies and peak-flux velocities of these lines suggest they are formed in weak, optically thin stellar winds and not in an accretion flow, as is the case for the hot lines observed in CTTSs. The lack of strong outflow signatures and lack of evidence for line formation in accretion flows is consistent with the conclusion presented in our recent optical and He I 10830 Å studies that the immediate circumstellar environments of HAEBES, in general, are not scaled-up analogs of the immediate environments around CTTSs. The conclusions presented here for hot gas lines around HAEBES should be verified with a larger sample of objects.

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The JCMT Gould Belt Survey: Evidence for Dust Grain Evolution in Perseus Star-forming Clumps

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The dust emissivity spectral index, β, is a critical parameter for deriving the mass and temperature of star-forming structures, and consequently their gravitational stability. The β value is dependent on various dust grain properties, such as size, porosity, and surface composition, and is expected to vary as dust grains evolve. Here we present β, dust temperature, and optical depth maps of the star-forming clumps in the Perseus Molecular Cloud determined from fitting SEDs to combined *Herschel* and JCMT observations in the 160 μm, 250 μm, 350 μm, 500 μm, and 850μm bands. Most of the derived β, and dust temperature values fall within the ranges of 1.0 - 2.7 and 8 - 20 K, respectively. In Perseus, we find the β distribution differs significantly from clump to clump, indicative of grain growth. Furthermore, we also see significant, localized β variations within individual clumps and find low β regions correlate with local temperature peaks, hinting at the possible origins of low β grains. Throughout Perseus, we also see indications of heating from B stars and embedded protostars, as well evidence of outflows shaping the local landscape.

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Appearance of Dusty Filaments at Different Viewing Angles

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Context: In the last years, there have been many studies on the omnipresence and structures of filaments in star-forming regions, as well as their role in the process of star formation. Those filaments are normally identified as elongated fibres across the plane of the sky. But how would we detect filaments that are inclined?
Aims: We aim to learn more about whether, and how, total column density or dust temperature change with respect to the line of sight. Such variations would enable observers to use dust observations to identify and study filaments at any inclination and gain more insight on the distribution and orientations of filaments within the Galactic plane.
Methods: As a first step, we perform numerical calculations on simple cylindrical models to evaluate the influence of filament geometry on the average flux density. After that, we apply our three-dimensional Monte Carlo dust radiative transfer code on two models of star-forming regions and derive maps of effective total column density and dust temperature at different viewing angles.
Results: We see only slight changes of average flux density for all cylinders we study. For our more complex models, we find that the effective dust temperature is not sensitive to viewing angle, while the total column density is strongly influenced, with differences exceeding an order of magnitude. The variations are not injective with the viewing angle and depend on the structure of the object.
Conclusions: We conclude that there is no single quantity in our analysis that can uniquely trace the inclination and three-dimensional structure of a filament based on dust observations alone. However, observing wide variations in total column density at a given effective dust temperature is indicative of inclined filaments.

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Hubble imaging of V1331 Cygni: proper motion study of its circumstellar structures

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Aims: The young star V1331 Cyg received previous attention because it is surrounded by an optical, arc-like reflection nebula. V1331 Cyg is commonly considered to be a candidate for an object that has undergone an FU-Ori (FUOR) outbreak in the past. This in turn could lead to a time-varying appearance of the dusty arcs that may be revealed by multi-epoch imaging. In particular, a radial colour analysis of the dust arcs can then be attempted to check whether the radial grain size distribution was modified by a previous FUOR wind.
Methods: Second-epoch imaging of V1331 Cyg was obtained by us in 2009 using the Hubble Space Telescope (HST). By comparing this to archival HST data from 2000, we studied the time evolution of the circumstellar nebulae. After a point spread function subtraction using model point spread functions, we used customised routines to perform a proper motion analysis. The nebula expansion was derived by deconvolving and correlating the two-epoch radial brightness profiles. Additional data from other facilities – TLS, UKIDSS, Spitzer, and Herschel – were also incorporated to improve our understanding of the star in terms of environment, viewing angle, bipolar outflow length, and the FUOR phenomenon.
Results: The outer dust arc is found to be expanding at $\approx 14.8 \pm 3.6$ km s^{-1} on average. The expansion velocity for the inner ring is less consistent, between 0.8 km s^{-1} and 3.0 km s^{-1}. The derived radial colour profiles do not indicate a spatial separation of the dust grain sizes. The Herschel 160 μm images show for the first time thermal emission from dust probably residing in the outer arc. By viewing V1331 Cyg almost pole-on, the length of the bipolar outflow exceeds previous estimates by far.
Conclusions: The outer arc expansion timescale is consistent with the implantation time of the CO torus, which supports the hypothesis of an outburst that occurred a few thousand years ago. The azimuthal colour variation of the outer arc is probably due to changes of the scattering angle, imposed by a tilt or helical geometry of the dust configuration.

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Interferometric mapping of magnetic fields: The ALMA view of the massive star forming clump W43-MM1

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Here we present the first results from ALMA observations of 1 mm polarized dust emission towards the W43-MM1 high mass star forming clump. We have detected a highly fragmented filament with source masses ranging from 14 $M_\odot$ to 312 $M_\odot$, where the largest fragment, source A, is believed to be one of the most massive in our Galaxy.

We found a smooth, ordered, and detailed polarization pattern throughout the filament which we used to derived magnetic field morphologies and strengths for 12 out of the 15 fragments detected ranging from 0.2 to 9 mG. The dynamical equilibrium of each fragment was evaluated finding that all the fragments are in a super-critical state which is consistent with previously detected infalling motions towards W43-MM1. Moreover, there are indications suggesting that the field is being dragged by gravity as the whole filament is collapsing.

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http://arxiv.org/pdf/1605.08037

The ALMA-PILS survey: First detections of deuterated formamide and deuterated isocyanic acid in the interstellar medium

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Formamide (NH_2CHO) has previously been detected in several star-forming regions and is thought to be a precursor for different prebiotic molecules. Its formation mechanism is still debated, however. Observations of formamide, related species, and their isopotologues may provide useful clues to the chemical pathways leading to their formation. The Protostellar Interferometric Line Survey (PILS) represents an unbiased, high angular resolution and sensitivity spectral survey of the low-mass protostellar binary IRAS 16293–2422 with the Atacama Large Millimeter/submillimeter Array (ALMA). For the first time, we detect the three singly deuterated forms of NH_2CHO (NH_2CDO, cis- and trans-NHDCHO), as well as DNCO towards the component B of this binary source. The images reveal that the different isotopologues are all present in the same region. Based on observations of the ^{13}C isotopologues of formamide and a standard $^{12}C/^{13}C$ ratio, the deuterium fractionation is found to be similar for the three different forms with a value of about 2%. The DNCO/HNCO ratio is also comparable to the D/H ratio of formamide ($\sim$1%). These results are in agreement with the hypothesis that NH_2CHO and HNCO are chemically related through grain-surface formation.

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A Neptune-sized transiting planet closely orbiting a 5-10 million year old star

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Theories of the formation and early evolution of planetary systems postulate that planets are born in circumstellar disks, and undergo radial migration during and after dissipation of the dust and gas disk from which they formed. The highly precise ages of meteorites indicate that planetesimals – the building blocks of planets – are produced within the first million years of a star's life.
A prominent question is: how early can we find fully formed planets like those frequently detected on short orbital periods around mature stars? Some theories suggest the *in situ* formation of planets close to their host stars is unlikely and the existence of such planets is evidence for large scale migration. Other theories posit that planet assembly at small orbital separations may be common. Here we report a newly born, transiting planet orbiting its star every 5.4 days. The planet size is approximately 1.5 times Neptune, and its mass is less than 3.6 times Jupiter (at 99.7% confidence, with true mass likely to be within a factor of several of Neptune). The 5–10 million year old star has a tenuous dust disk extending in to about 2 times the Earth-Sun separation, in addition to the large planet located at less than 1/20 the Earth-Sun separation.
The existence of this young planet, located in a region of recently completed star formation, provides new evidence regarding planet formation and migration timescales.

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Star formation activity in the neighbourhood of W-R 1503-160L star in the mid-infrared bubble N46

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In order to investigate star formation (SF) processes in extreme environments, we have carried out a multi-wavelength analysis of the mid-infrared bubble N46, which hosts a WN7 Wolf-Rayet (W-R) star. We have used ^{13}CO line data to trace an expanding shell surrounding the W-R star containing about five condensations within the molecular cloud associated with the bubble. The W-R star is associated with a powerful stellar wind having a mechanical luminosity of $\sim 4 \times 10^{37}$ ergs s^{-1}. A deviation of the H-band starlight mean polarization angles around the bubble has also been traced, indicating the impact of stellar wind on the surroundings. The *Herschel* temperature map shows a temperature range of ∼18–24 K toward the five molecular condensations. The photometric analysis reveals that these condensations are associated with the identified clusters of young stellar objects, revealing ongoing SF process. The densest among these five condensations (peak $N(H_2) \sim 9.2 \times 10^{22}$ cm^{-2} and $A_V \sim 98$ mag) is associated with a 6.7 GHz methanol maser, an infrared dark cloud, and the CO outflow, tracing active massive SF within it. At least five compact radio sources (crss) are physically linked with the edges of the bubble and each of them is consistent with the radio spectral class of a B0V–B0.5V type star. The ages of the individual infrared counterparts of three crss (∼1–2 Myr) and a typical age of WN7 W-R star (∼4 Myr) indicate that the SF activities around the bubble are influenced by the feedback of the W-R star.

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The bimodal initial mass function in the Orion nebula cloud

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Due to its youth, proximity and richness the Orion Nebula Cloud (ONC) is an ideal testbed to obtain a comprehensive view on the Initial Mass Function (IMF) down to the planetary mass regime. Using the HAWK-I camera at the VLT, we have obtained an unprecedented deep and wide near-infrared JHK mosaic of the ONC (90% completeness at $K \sim 19.0$ mag, $22' \times 28'$). Applying the most recent isochrones and accounting for the contamination of background stars and galaxies, we find that ONC's IMF is bimodal with distinct peaks at about 0.25 and 0.025 $M_\odot$ separated by a pronounced dip at the hydrogen burning limit (0.08 $M_\odot$), with a depth of about a factor 2–3 below the log-normal distribution. Apart from ∼920 low-mass stars ($M < 1.4\,M_\odot$) the IMF contains ∼760 brown dwarf (BD) candidates and ∼160 isolated planetary mass object (IPMO) candidates with $M > 0.005\,M_\odot$, hence about ten times more substellar candidates than known before. The substellar IMF peak at 0.025 $M_\odot$ could be caused by BDs and IPMOs which have been ejected from multiple systems during the early star-formation process or from circumstellar disks.

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High-Precision Radio and Infrared Astrometry of LSPM J1314+1320AB - II: Testing Pre–Main-Sequence Models at the Lithium Depletion Boundary with Dynamical Masses

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We present novel tests of pre–main-sequence models based on individual dynamical masses for the M7 binary LSPM J1314+1320AB. Joint analysis of Keck adaptive optics astrometric monitoring along with Very Long Baseline Array radio data from a companion paper yield component masses of $92.8 \pm 0.6\,M_{\rm Jup}$ ($0.0885 \pm 0.0006\,M_\odot$) and $91.7 \pm 1.0\,M_{\rm Jup}$ ($0.0875 \pm 0.0010\,M_\odot$) and a parallactic distance of 17.249 ± 0.013 pc. We find component luminosities consistent with the system being coeval at 80.8 ± 2.5 Myr, according to BHAC15 evolutionary models. The presence of lithium is consistent with model predictions, marking the first test of the theoretical lithium depletion boundary using ultracool dwarfs of known mass. However, we find the evolutionary model-derived average effective temperature (2950 ± 5 K) is 180 K hotter than given by a spectral type–$T_{\rm eff}$ relation based on BT-Settl models (2770 ± 100 K). We suggest that the dominant source of this discrepancy is model radii being too small by ≈13%. In a test mimicking the typical application of models by observers, we derive masses on the H-R diagram using luminosity and BT-Settl temperature. The estimated masses are lower by 46^{+16}_{-19}% (2.0σ) than we measure dynamically and would imply that this is a system of $\approx 50\,M_{\rm Jup}$ brown dwarfs, highlighting the large systematic errors possible in H-R diagram properties. This is first time masses have been measured for ultracool (≥M6) dwarfs displaying spectral signatures of low gravity. Based on features in the infrared, LSPM J1314+1320AB appears higher gravity than typical Pleiades and AB Dor members, opposite the expectation given its younger age. The components of LSPM J1314+1320AB are now the nearest, lowest mass pre–main-sequence stars with direct mass measurements.

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Inferring the Evolutionary Stages of the internal structures of NGC7538S and IRS1 from Chemistry

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Context: Radiative feedback of young (proto)stars, and gas dynamics including gravitational collapse and outflows of high-mass star-forming regions (HMSFRs), may leave footprints to the gas density and temperature distributions, the velocity profile, and the chemical abundances.
Aims: To unambiguously diagnose the detailed physical mechanisms and the evolutionary status of HMSFRs.
Methods: We have performed 0.4" ($\sim$ 1000 AU) resolution observations at 1.37 mm towards two HMSFRs: NGC 7538 S and IRS1, using the Plateau de Bure Interferometer (PdBI). The observations covered abundant molecular lines, including tracers of gas column density, hot molecular cores, shocks, and complex organic molecules. This paper presents a joint analysis of the 1.37 mm continuum emission and the line intensity of 15 molecular species (including 22 isotopologues). Assuming local thermal equilibrium (LTE), we derived molecular column densities and molecular abundances for each internal gas substructure which is spatially resolved. These derived quantities are compared with a suite of 1-D gas-grain models.
Results: NGC 7538 S is resolved into at least three dense gas condensations. Despite the comparable continuum intensity of these condensations, their differing molecular line emission is suggestive of an overall chemical evolutionary trend from the northeast to the southeast. Line emission from MM1 is consistent with a chemically evolved hot molecular core (HMC), whereas MM3 remains a prestellar candidate which only exhibits emission of lower-excitation lines. The condensation MM2, spatially located in between MM1 and MM3, shows an intermediate chemical evolutionary status. Since these three condensations are embedded within the same parent gas core, their differing chemical properties are the most likely due to the different warm-up histories, rather than the different dynamic timescales. Despite remaining spatially unresolved, in IRS1 we detect abundant complex organic molecules (e.g. NH_2CHO, CH_3OH, $HCOOCH_3$, CH_3OCH_3), indicating that IRS1 is the most chemically evolved HMC presented here. We observe a continuum that is dominated by absorption features with at least three strong emission lines, potentially from CH_3OH. The CH_3OH lines which are purely in emission have higher excitation than the ones showing purely absorption. Potential reasons for that difference are discussed.
Conclusions: This is the first comprehensive comparison of observations of the two high-mass cores NGC 7538 S and IRS1 and a chemical model. We have found that different chemical evolutionary stages can coexist in the same natal gas core. Our achievement illustrates the strength of chemical analysis for understanding HMSFRs.

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Outflow detection in a 70 μm dark high-mass core

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We present observations towards a high-mass ($> 40\,M_\odot$), low luminosity ($< 10\,L_\odot$) 70 μm dark molecular core G 28.34 S-A at 3.4 mm, using the IRAM 30 m telescope and the NOEMA interferometer. We report the detection of SiO $J = 2 \rightarrow 1$ line emission, which is spatially resolved in this source at a linear resolution of $\sim$0.1 pc, while the

3.4 mm continuum image does not resolve any internal sub-structures. The SiO emission exhibits two W-E oriented lobes centring on the continuum peak. Corresponding to the red-shifted and blue-shifted gas with velocities up to $40\,\mathrm{km\,s^{-1}}$ relative to the quiescent cloud, these lobes clearly indicate the presence of a strong bipolar outflow from this $70\,\mu$m dark core, a source previously considered as one of the best candidates of "starless" core. Our SiO detection is consistent with ALMA archival data of SiO $J = 5 \rightarrow 4$, whose high-velocity blue-shifted gas reveals a more compact lobe spatially closer to the dust center. This outflow indicates that the central source may be in an early evolutionary stage of forming a high-mass protostar. We also find that the low-velocity components (in the range of $\mathrm{V_{lsr}}{}^{+3}_{-5}\,\mathrm{km\,s^{-1}}$) have an extended, NW-SE oriented distribution. Discussing the possible accretion scenarios of the outflow-powering young stellar object, we argue that the molecular line emission and the molecular outflows may provide a better indication of the accretion history when forming young stellar object, than that from a snapshot observations of the present bolometric luminosity. This is particularly significant for the cases of episodic accretion, which may occur during the collapse of the parent molecular core.

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The abundance discrepancy factor and t^2 in nebulae: are non-thermal electrons the culprits?

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Photoionization produces supra-thermal electrons, electrons with much more energy than is found in a thermalized gas at electron temperatures characteristic of nebulae. The presence of these high energy electrons may solve the long-standing t^2/ADF puzzle, the observations that abundances obtained from recombination and collisionally excited lines do not agree, and that different temperature indicators give different results, if they survive long enough to affect diagnostic emission lines. The presence of these non-Maxwellian distribution electrons are usually designated by the term kappa. Here we use well established methods to show that the distance over which heating rates change are much longer than the distance supra thermal electrons can travel, and that the timescale to thermalize these electrons are much shorter than the heating or cooling timescales. These estimates establish that supra thermal electrons will have disappeared into the Maxwellian velocity distribution long before they affect the collisionally excited forbidden and recombination lines that are used for deriving abundances relative to hydrogen. The electron velocity distribution in nebulae should be closely thermal.

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Ionization fraction and the enhanced sulfur chemistry in Barnard 1

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Barnard B1b has revealed as one of the most interesting globules from the chemical and dynamical point of view. It presents a rich molecular chemistry characterized by large abundances of deuterated and complex molecules. Furthermore, it hosts an extremely young Class 0 object and one candidate to First Hydrostatic Core (FHSC). Our aim was to determine the cosmic ray ionization rate and the depletion factors in this extremely young star forming region. We carried out a spectral survey towards Barnard 1b as part of the IRAM Large program ASAI using the IRAM 30-m telescope at Pico Veleta (Spain). This provided a very complete inventory of neutral and ionic C-, N- and S- bearing species with, up to our knowledge, the first secure detections of the deuterated ions DCS^+ and $DOCO^+$. We used a state-of-the-art pseudo-time-dependent gas-phase chemical model to determine the value of the cosmic ray ionization rate and the depletion factors. The observational data were well fitted with ζ_{H_2} between 3×10^{-17} s^{-1} and 10^{-16} s^{-1}. Elemental depletions were estimated to be ∼10 for C and O, ∼1 for N and ∼25 for S. Barnard B1b presents similar depletions of C and O than those measured in pre-stellar cores. The depletion of sulfur is higher than that of C and O but not as extreme as in cold cores. In fact, it is similar to the values found in some bipolar outflows, hot cores and photon-dominated regions. Several scenarios are discussed to account for these peculiar abundances. We propose that it is the consequence of the initial conditions (important outflows and enhanced UV fields in the surroundings) and a rapid collapse (∼0.1 Myr) that permits to maintain most S- and N-bearing species in gas phase to great optical depths. The interaction of the compact outflow associated with B1b-S with the surrounding material could enhance the abundances of S-bearing molecules, as well.

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Magnetic fields in early protostellar disk formation

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We consider formation of accretion disks from a realistically turbulent molecular gas using 3D MHD simulations. In particular, we analyze the effect of the fast turbulent reconnection described by the Lazarian & Vishniac (1999) model for the removal of magnetic flux from a disk. With our numerical simulations we demonstrate how the fast reconnection enables protostellar disk formation resolving the so-called "magnetic braking catastrophe". In particular, we provide a detailed study of the dynamics of a 0.5 $M_\odot$ protostar and the formation of its disk for up to several thousands years. We measure the evolution of the mass, angular momentum, magnetic field, and turbulence around the star. We consider effects of two processes that strongly affect the magnetic transfer of angular momentum, both of which are based on turbulent reconnection: the first, "reconnection diffusion", removes the magnetic flux from the disk, the other involves the change of the magnetic field's topology, but does not change the absolute value of the magnetic flux through the disk. We demonstrate that for the first mechanism, turbulence causes a magnetic flux transport outward from the inner disk to the ambient medium, thus decreasing the coupling of the disk to the ambient material. A similar effect is achieved through the change of the magnetic field's topology from a split monopole configuration to a dipole configuration. We explore how both mechanisms prevent the catastrophic loss of disk angular momentum and compare both above turbulent reconnection mechanisms with alternative mechanisms from the literature.

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Testing the Binary Trigger Hypothesis in FUors

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We present observations of three FU Orionis objects (hereafter, FUors) with nonredundant aperture-mask interferometry (NRM) at 1.59 μm and 2.12 μm that probe for binary companions on the scale of the protoplanetary disk that feeds their accretion outbursts. We do not identify any companions to V1515 Cyg or HBC 722, but we do resolve a close binary companion to V1057 Cyg that is at the diffraction limit ($\rho = 58.3 \pm 1.4$ mas or 30 ± 5 AU) and currently much fainter than the outbursting star ($\Delta K' = 3.34 \pm 0.10$ mag). Given the flux excess of the outbursting star, we estimate that the mass of the companion ($M \sim 0.25 M_\odot$) is similar to or slightly below that of the FUor itself, and therefore it resembles a typical T Tauri binary system. Our observations only achieve contrast limits of $\Delta K' \sim 4$ mag, and hence we are only sensitive to companions that were near or above the pre-outburst luminosity of the FUors. It remains plausible that FUor outbursts could be tied to the presence of a close binary companion. However, we argue from the system geometry and mass reservoir considerations that these outbursts are not directly tied to the orbital period (i.e., occurring at periastron passage), but instead must only occur infrequently.

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A Protostellar Jet Emanating from a Hypercompact HII Region

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We present radio continuum observations of the high-mass young stellar object (HMYSO) G345.4938+01.4677 made using the Australia Telescope Compact Array (ATCA) at 5, 9, 17, and 19 GHz. These observations provide definite evidence that the outer and inner pairs of radio lobes consist of shock ionized material being excited by an underlying collimated and fast protostellar jet emanating from a hypercompact HII region. By comparing with images taken 6 yr earlier at 5 and 9 GHz using the same telescope, we assess the proper motions of the radio sources. The outer West and East lobes exhibit proper motions of 64 ± 12 and 48 ± 13 milliarcsec yr^{-1}, indicating velocities projected in the plane of the sky and receding from G345.4938+01.4677 of 520 and 390 km s^{-1}, respectively. The internal radio lobes also display proper motion signals consistently receding from the HMYSO, with magnitudes of 17 ± 11 and 35 ± 10 milliarcsec yr^{-1} for the inner West and East lobes, respectively. The morphology of the outer West lobe is that of a detached bow shock. At 17 and 19 GHz, the outer East lobe displays an arcuate morphology also suggesting a bow shock. These results show that disk accretion and jet acceleration — possibly occurring in a very similar way compared with low-mass protostars — is taking place in G345.4938+01.4677 despite the presence of ionizing radiation and the associated hypercompact HII region.

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A Possible Solution for the M/L-[Fe/H] Relation of Globular Clusters in M31: A metallicity and density dependent top-heavy IMF

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The observed mass-to-light (M/L) ratios of a large sample of GCs in M31 show an inverse trend with metallicity compared to what is expected from Simple Stellar Population (SSP) models with an invariant canonical stellar IMF, in the sense that the observed M/L ratios decrease with increasing metallicity. We show that incorporating the effect of dynamical evolution the SSP models with a canonical IMF can not explain the decreasing M/L ratios with increasing metallicity for the M31 GCs. The recently derived top-heavy IMF as a function of metallicity and embedded cluster density is proposed to explain the lower than expected M/L ratios of metal-rich GCs. We find that the SSP models with a top-heavy IMF, retaining a metallicity- **and cluster mass-**dependent fraction of the remnants within the clusters, and taking standard dynamical evolution into account can successfully explain the observed $M/L - [Fe/H]$ relation of M31 GCs. Thus we propose that the kinematical data of GCs can be used to constrain the top-heaviness of the IMF in GCs.

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IRAS 16253−2429: the First Proto-Brown Dwarf Binary Candidate Identified through Dynamics of Jets

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The formation mechanism of brown dwarfs (BDs) is one of the long-standing problems in star formation because the typical Jeans mass in molecular clouds is too large to form these substellar objects. To answer this question, it is crucial to study a BD at the embedded phase. IRAS 16253−2429 is classified as a very low luminosity object (VeLLO) with internal luminosity 0.1 $L_\odot$. VeLLOs are believed to be very low-mass protostars or even proto-BDs. We observed the jet/outflow driven by IRAS 16253−2429 in CO (2–1), (6–5), and (7–6) using the IRAM 30 m and APEX telescopes and the SMA in order to study its dynamical features and physical properties. Our SMA map reveals two protostellar jets, indicating the existence of a proto-binary system as implied by the precessing jet detected in H_2 emission. We detect a wiggling pattern in the position-velocity diagrams along the jet axes, which is likely due to the binary orbital motion. Based on this, we derive the current mass of the binary as ∼0.032 $M_\odot$. Given the low envelope mass, IRAS 16253−2429 will form a binary that probably consist of one or two BDs. Furthermore, we found that the outflow force as well as the mass accretion rate are very low based on the multi-transition CO observations, which suggests that the final masses of the binary components are at the stellar/substellar boundary. Since IRAS 16253 is located in an isolated environment, we suggest that BDs can form through fragmentation and collapse like low-mass stars.

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A Candidate Young Massive Planet in Orbit around the Classical T Tauri Star CI Tau

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The ∼2 Myr old classical T Tauri star CI Tau shows periodic variability in its radial velocity (RV) variations measured at infrared (IR) and optical wavelengths. We find that these observations are consistent with a massive planet in a ∼ 9-day period orbit. These results are based on 71 IR RV measurements of this system obtained over 5 years, and on 26 optical RV measurements obtained over 9 years. CI Tau was also observed photometrically in the optical on 34 nights over ∼one month in 2012. The optical RV data alone are inadequate to identify an orbital period, likely the result of star spot and activity induced noise for this relatively small dataset. The infrared RV measurements reveal significant periodicity at ∼9 days. In addition, the full set of optical and IR RV measurements taken together phase coherently and with equal amplitudes to the ∼9 day period. Periodic radial velocity signals can in principle be produced by cool spots, hot spots, and reflection of the stellar spectrum off the inner disk, in addition to resulting from a planetary companion. We have considered each of these and find the planet hypothesis most consistent with the data. The radial velocity amplitude yields an $M \sin i$ of ~ 8.1 M_{Jup}; in conjunction with a 1.3 mm continuum emission measurement of the circumstellar disk inclination from the literature, we find a planet mass of ~ 11.3 M_{Jup}, assuming alignment of the planetary orbit with the disk.

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Volatile carbon locking and release in protoplanetary disks. A study of TW Hya and HD 100546

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The composition of planetary solids and gases is largely rooted in the processing of volatile elements in protoplanetary disks. To shed light on the key processes, we carry out a comparative analysis of the gas-phase carbon abundance in two systems with a similar age and disk mass, but different central stars: HD 100546 and TW Hya. We combine our recent detections of C^0 in these disks with observations of other carbon reservoirs (CO, C^+, C_2H) and gas mass and warm gas tracers (HD, O^0), as well as spatially resolved ALMA observations and the spectral energy distribution. The disks are modelled with the DALI 2D physical-chemical code. Stellar abundances for HD 100546 are derived from archival spectra. Upper limits on HD emission from HD 100546 place an upper limit on the total disk mass of $\leq 0.1\,M_{\odot}$. The gas-phase carbon abundance in the atmosphere of this warm Herbig disk is at most moderately depleted compared to the interstellar medium, with $[\mathrm{C}]/[\mathrm{H}]_{\mathrm{gas}} = (0.1 - 1.5) \times 10^{-4}$. HD 100546 itself is a λ Boötis star, with solar abundances of C and O but a strong depletion of rock-forming elements. In the gas of the T Tauri disk TW Hya, both C and O are strongly underabundant, with $[\mathrm{C}]/[\mathrm{H}]_{\mathrm{gas}} = (0.2 - 5.0) \times 10^{-6}$ and C/O>1. We discuss evidence that the gas-phase C and O abundances are high in the warm inner regions of both disks. Our analytical model, including vertical mixing and a grain size distribution, reproduces the observed $[\mathrm{C}]/[\mathrm{H}]_{\mathrm{gas}}$ in the outer disk of TW Hya and allows to make predictions for other systems.

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The rotation period distributions of 4–10 Myr T Tauri stars in Orion OB1: New constraints on pre-main-sequence angular momentum evolution

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Most existing studies of the angular momentum evolution of young stellar populations have focused on the youngest ($\lesssim$ 1–3 Myr) T Tauri stars. In contrast, the angular momentum distributions of older T Tauri stars ($\sim$4–10 Myr) have been less studied, even though they hold key insight to understanding stellar angular momentum evolution at a time when protoplanetary disks have largely dissipated and when models therefore predict changes in the rotational evolution that can in principle be tested. We present a study of photometric variability among 1,974 confirmed T Tauri members of various sub-regions of the Orion OB1 association, and with ages spanning 4–10 Myr, using optical time-series from three different surveys. For 564 of the stars ($\sim$32% of the weak-lined T Tauri stars and $\sim$13% of the classical T Tauri stars in our sample) we detect statistically significant periodic variations which we attribute to the stellar rotation periods, making this one of the largest samples of T Tauri star rotation periods yet published. We observe a clear change in the overall rotation period distributions over the age range 4–10 Myr, with the progressively older sub-populations exhibiting systematically faster rotation. This result is consistent with angular momentum evolution model predictions of an important qualitative change in the stellar rotation periods starting at $\sim$5 Myr, an age range for which very few observational constraints were previously available.

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Dense Molecular Cores Being Externally Heated

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We present results of our study on eight dense cores, previously classified as starless, using infrared (3-160 μm) imaging observations with *AKARI* telescope and molecular line (HCN and N_2H^+) mapping observations with *KVN* telescope. Combining our results with the archival IR to mm continuum data, we examined the starless nature of these eight cores. Two of the eight cores are found to harbor faint protostars having luminosity of $\sim 0.3 - 4.4$ $L_\odot$. The other six cores are found to remain as starless and probably are in a dynamically transitional state. The temperature maps produced using multi-wavelength images show an enhancement of about 3-6 K towards the outer boundary of these cores, suggesting that they are most likely being heated externally by nearby stars and/or interstellar radiation fields. Large virial parameters and an over-dominance of red asymmetric line profiles over the cores may indicate that the cores are set into either an expansion or an oscillatory motion, probably due to the external heating. Most of the

starless cores show coreshine effect due to the scattering of light by the micron-size dust grains. This may imply that the age of the cores is of the order of $\sim 10^5$ years, being consistent with the timescale required for the cores to evolve into an oscillatory stage due to the external perturbation. Our observational results support the idea that the external feedback from nearby stars and/or interstellar radiation fields may play an important role in the dynamical evolution of the cores.

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Molecular Emission in Dense Massive Clumps from the Star-Forming Regions S231-S235

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The article deals with observations of star-forming regions S231-S235 in 'quasi-thermal' lines of ammonia (NH_3), cyanoacetylene (HC_3N) and maser lines of methanol (CH_3OH) and water vapor (H_2O). S231-S235 regions is situated in the giant molecular cloud G174+2.5. We selected all massive molecular clumps in G174+2.5 using archive CO data. For the each clump we determined mass, size and CO column density. After that we performed observations of these clumps. We report about first detections of NH_3 and HC_3N lines toward the molecular clumps WB89 673 and WB89 668. This means that high-density gas is present there. Physical parameters of molecular gas in the clumps were estimated using the data on ammonia emission. We found that the gas temperature and the hydrogen number density are in the ranges 16-30 K and $2.8\text{-}7.2\times10^3$ cm^{-3}, respectively. The shock-tracing line of CH_3OH molecule at 36.2 GHz is newly detected toward WB89 673.

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Angular momentum loss in the envelope-disk transition region of HH 111 protostellar system: evidence for magnetic braking?

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HH 111 is a Class I protostellar system at a distance of $\sim$400 pc, with the central source VLA 1 associated with a rotating disk deeply embedded in a flattened envelope. Here we present the observations of this system at $\sim 0''.6$ (240 AU) resolution in C18O (J=2–1) and 230 GHz continuum obtained with Atacama Large Millimeter/Submillimeter Array, and in SO obtained with Submillimeter Array. The observations show for the first time how a Keplerian rotating disk can be formed inside a flattened envelope. The flattened envelope is detected in $C^{18}O$, extending out to $\gtrsim$2400 AU from the VLA 1 source. It has a differential rotation, with the outer part ($\gtrsim$2000 AU) better described by a rotation that has constant specific angular momentum and the innermost part ($\lesssim$160 AU) by a Keplerian rotation. The rotationally supported disk is therefore relatively compact in this system, which is consistent with the dust continuum observations. Most interestingly, if the flow is in steady state, there is a substantial drop in specific angular momentum in the envelope-disk transition region from 2000 AU to 160 AU, by a factor of $\sim$3. Such a decrease is not expected outside a disk formed from simple hydrodynamic core collapse, but can happen naturally if the core is significantly magnetized, because magnetic fields can be trapped in the transition region outside the disk by the ram pressure of the protostellar accretion flow, which can lead to efficient magnetic braking. In addition, SO shock emission is detected around the outer radius of the disk and could trace an accretion shock around the disk.

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Physical characteristics of bright Class I methanol masers

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Class I methanol masers are thought to be tracers of interstellar shock waves. However, they have received relatively little attention mostly as a consequence of their low luminosities compared to other maser transitions. This situation has changed recently and Class I methanol masers are now routinely used as signposts of outflow activity especially in high extinction regions. The recent detection of polarisation in Class I lines now makes it possible to obtain direct observational information about magnetic fields in interstellar shocks. We make use of newly calculated collisional rate coefficients for methanol to investigate the excitation of Class I methanol masers and to reconcile the observed Class I methanol maser properties with model results. We performed large velocity gradient calculations with a plane-parallel slab geometry appropriate for shocks to compute the pump and loss rates which regulate the interactions of the different maser systems with the maser reservoir. We study the dependence of the pump rate coefficient, the maser loss rate, and the inversion efficiency of the pumping scheme of several Class I masers on the physics of the emitting gas. We predict inversion in all transitions where maser emission is observed. Bright Class I methanol masers are mainly high-temperature ($> 100\,$K) high-density ($n(\mathrm{H_2}) \sim 10^7 - 10^8\,\mathrm{cm}^{-3}$) structures with methanol maser emission measures, ξ, corresponding to high methanol abundances close to the limits set by collisional quenching. Our model predictions reproduce reasonably well most of the observed properties of Class I methanol masers. Class I masers in the 25 GHz series are the most sensitive to the density of the medium and mase at higher densities than other lines. Moreover, even at high density and high methanol abundances, their luminosity is predicted to be lower than that of the 44 GHz and 36 GHz masers. Our model predictions also reflect the observational result that the 44 GHz line is almost always stronger than the 36 GHz maser. By comparison between observed isotropic photon luminosities and our model predictions, we infer maser beam solid angles of roughly 10^{-3} steradian.

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Protostars at Low Extinction in Orion A

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In the list of young stellar objects compiled by Megeath et al. (2012) for the Orion A molecular cloud, only 44 out of 1208 sources found projected onto low extinction (A_k<0.8 mag) gas are identified as protostars. These objects are puzzling because protostars are not typically expected to be associated with extended low extinction material. Here, we use high resolution extinction maps generated from Herschel data, optical/infrared and Spitzer Space Telescope photometry and spectroscopy of the low extinction protostellar candidate sources to determine if they are likely true protostellar sources or contaminants. Out of 44 candidate objects, we determine that 10 sources are likely protostars, with the rest being more evolved young stellar objects (18), galaxies (4), false detections of nebulosity and cloud edges (9), or real sources for which more data are required to ascertain their nature (3). We find none of the confirmed protostars to be associated with recognizable dense cores and we briefly discuss possible origins for these orphaned objects.

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ATLASGAL A Galaxy-wide sample of dense filamentary structures

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Context: Filamentary structures are ubiquitous in the interstellar medium. Investigating their connection to the large-scale structure of the Galaxy and their role in star formation is leading to a paradigm shift in our understanding of star formation.
Aims: We study the properties of filamentary structures from the ATLASGAL survey, which is the largest and most sensitive systematic ground-based survey of the inner Galactic plane at submillimeter wavelengths.
Method: We use the Disperse algorithm to identify spatially coherent structures located across the inner-Galaxy ($300^\circ < \ell < 60^\circ$ and $|b| < 1.5$). As a result we produce a catalogue of $\sim$1800 structures; these were then independently classified by the five lead authors into one of the following types: marginally resolved, elongated structures, filaments, network of filaments and complexes. This resulted in the identification of 517 filamentary structures. We determine their physical properties and investigate their overall Galactic distribution.
Results: We find that almost 70% of the total 870 μm flux associated with these structures resides in filaments and networks of filaments and we estimate that they are likely to be associated with a similar fraction of the mass. Correlating these structures with tracers of massive star formation we also find that a similar fraction of the massive star forming clumps are associated with filaments and networks of filaments, which highlights the importance of these types of structures to star formation in the Galaxy. We have determined distances, masses and physical sizes for 241 of the filamentary structures. We find a median distance of 3.8 kpc, a mean mass of a few $10^3\,M_\odot$, a mean length of $\sim$6 pc and a mass-to-length ratio of $(M/L) \sim$200-2000 $M_\odot\,pc^{-1}$. We also find that these filamentary structures are tightly correlated with the spiral arms in longitude and velocity, and that their semi-major axis is preferentially aligned parallel to the Galactic mid-plane and therefore with the direction of large-scale Galactic magnetic field. We find many examples where the dense filaments identified in ATLASGAL are associated with larger scale filamentary structures ($\sim$100 pc), and argue that this is likely to be common, and as such these may indicate a connection between large-scale Galactic dynamics and star formation.
Conclusions: We have produced a large and Galaxy-wide catalogue of dense filamentary structures that are representative of a particular size and mass range not previously well studied in the literature. Analyses of the properties and distribution of these filaments reveals that they are correlated with the spiral arms and make a significant contribution to star formation in the Galaxy. Massive star formation is ongoing within $\sim$20% of the filaments and is strongly correlated with the filaments with the largest mass-to-length ratios. The luminosity of the embedded sources has a similar distribution to the Galactic-wide samples of young massive stars and can therefore be considered to be representative.

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The intrinsic abundance ratio and X-factor of CO isotopologues in L1551 shielded from FUV photodissociation

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We investigate the intrinsic abundance ratio of ^{13}CO to $C^{18}O$ and the X-factor in L 1551 using the Nobeyama Radio Observatory (NRO) 45 m telescope. L 1551 is chosen because it is relatively isolated in the Taurus molecular cloud shielded from FUV photons, providing an ideal environment for studying the target properties. Our observations cover ∼40 arcmin×40 arcmin with resolution ∼30 arcsec, which are the maps with highest spatial dynamical range to date. We derive the $X_{^{13}\mathrm{CO}}/X_{\mathrm{C}^{18}\mathrm{O}}$ value on the sub-parsec scales in the range of ∼3–27 with a mean value of 8.0±2.8. Comparing to the visual extinction map derived from the *Herschel* observations, we found that the abundance ratio reaches its maximum at low A_{V} (i.e., $A_{\mathrm{V}} \sim$ 1–4 mag), and decreases to the typical solar system value of 5.5 inside L 1551 MC. The high $X_{^{13}\mathrm{CO}}/X_{\mathrm{C}^{18}\mathrm{O}}$ value at the boundary of the cloud is most likely due to the selective FUV photodissociation of $C^{18}O$. This is in contrast with Orion-A where its internal OB stars keep the abundance ratio at a high level greater than ∼10. In addition, we explore the variation of the X-factor, because it is an uncertain but widely used quantity in extragalactic studies. We found that X-factor $\propto N_{\mathrm{H}_2}^{1.0}$ which is consistent with previous simulations. Excluding the high density region, the average X-factor is similar to the Milky Way average value.

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Star Formation and Feedback: A Molecular Outflow-Prestellar Core Interaction in L1689N

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We present Herschel, ALMA Compact Array (ACA), and Caltech Submillimeter Observatory (CSO) observations of the prestellar core in L1689N, which has been suggested to be interacting with a molecular outflow driven by the nearby solar type protostar IRAS 16293−2422. This source is characterized by some of the highest deuteration levels seen in the interstellar medium. The change in the NH_2D line velocity and width across the core provides clear evidence of an interaction with the outflow, traced by the high-velocity water emission. Quiescent, cold gas, characterized by narrow line widths is seen in the NE part of the core, while broader, more disturbed line profiles are seen in the W/SW part. Strong N_2D^+ and ND_3 emission is detected with the ACA, extending S/SW from the peak of the single-dish NH_2D emission. The ACA data also reveal the presence a compact dust continuum source, with a mean size of ∼1100 au, a central density of (1–2) × 10^7 cm^{-3}, and a mass of 0.20–0.4 $M_\odot$. The dust emission peak is displaced ∼5″ to the south with respect to the N_2D^+ and ND_3 emission, as well as the single-dish dust continuum peak, suggesting that the northern, quiescent part of the core is characterized by spatially extended continuum emission, which is resolved out by the interferometer. We see no clear evidence of fragmentation in this quiescent part of the core, which could lead to a second generation of star formation, although a weak dust continuum source is detected in this region in the

ACA data.

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A Census of Young Stars and Brown Dwarfs in IC 348 and NGC 1333

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We have obtained optical and near-infrared spectra of candidate members of the star-forming clusters IC 348 and NGC 1333. We classify 100 and 42 candidates as new members of the clusters, respectively, which brings the total numbers of known members to 478 and 203. We also have performed spectroscopy on a large majority of the previously known members of NGC 1333 in order to provide spectral classifications that are measured with the same scheme that has been applied to IC 348 in previous studies. The new census of members is nearly complete for $K_s < 16.8$ at $A_J < 1.5$ in IC 348 and for $K_s < 16.2$ at $A_J < 3$ in NGC 1333, which correspond to masses of $\gtrsim$0.01 $M_\odot$ for ages of 3 Myr according to theoretical evolutionary models. The faintest known members extend below these completeness limits and appear to have masses of $\sim$0.005 $M_\odot$. In extinction-limited samples of cluster members, NGC 1333 exhibits a higher abundance of objects at lower masses than IC 348. It would be surprising if the initial mass functions of these clusters differ significantly given their similar stellar densities and formation environments. Instead, it is possible that average extinctions are lower for less massive members of star-forming clusters, in which case extinction-limited samples could be biased in favor of low-mass objects in the more heavily embedded clusters like NGC 1333. In the H-R diagram, the median sequences of IC 348 and NGC 1333 coincide with each other for the adopted distances of 300 and 235 pc, which would suggest that they have similar ages. However, NGC 1333 is widely believed to be younger than IC 348 based on its higher abundance of disks and protostars and its greater obscuration. Errors in the adopted distances may be responsible for this discrepancy.

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HII Region Ionization of the Interstellar Medium: A Case Study of NGC 7538

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Using data from the Green Bank Telescope, we analyze the radio continuum (free-free) and radio recombination line (RRL) emission of the compact H II region NGC 7538 (Sharpless 158). We detect extended radio continuum and hydrogen RRL emission beyond the photodissociation region (PDR) toward the north and east, but a sharp decrease in emission toward the south and west. This indicates that a non-uniform PDR morphology is affecting the amount of radiation "leaking" through the PDR. The strongest carbon RRL emission is found in the western PDR that appears to be dense. We compute a leaking fraction $f_R = 15 \pm 5\,\%$ of the radio continuum emission measured in the plane of the sky which represents a lower limit when accounting for the three-dimensional geometry of the region. We detect an average $^4He^+/H^+$ abundance ratio by number of 0.088 ± 0.003 inside the H II region and a decrease in this ratio with increasing distance from the region beyond the PDR. Using *Herschel Space Observatory* data, we show that small dust temperature enhancements to the north and east of NGC 7538 coincide with extended radio emission, but that the dust temperature enhancements are mostly contained within a second PDR to the east. Unlike the giant H II

region W43, the radiation leaking from NGC 7538 seems to only affect the local ambient medium. This suggests that giant H II regions may have a large effect in maintaining the ionization of the interstellar medium.

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Evidence for a correlation between mass accretion rates onto young stars and the mass of their protoplanetary disks

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A relation between the mass accretion rate onto the central young star and the mass of the surrounding protoplanetary disk has long been theoretically predicted and observationally sought. For the first time, we have accurately and homogeneously determined the photospheric parameters, the mass accretion rate, and the disk mass for an essentially complete sample of young stars with disks in the Lupus clouds. Our work combines the results of surveys conducted with VLT/X-Shooter and ALMA. With this dataset we are able to test a basic prediction of viscous accretion theory, the existence of a linear relation between the mass accretion rate onto the central star and the total disk mass. We find a correlation between the mass accretion rate and the disk dust mass, with a ratio that is roughly consistent with the expected viscous timescale when assuming an ISM gas-to-dust ratio. This confirms that mass accretion rates are related to the properties of the outer disk. We find no correlation between mass accretion rates and the disk mass measured by CO isotopologues emission lines, possibly due to the small number of measured disk gas masses. This suggests that the mm-sized dust mass better traces the total disk mass and that masses derived from CO may be underestimated, at least in some cases.

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Zodiacal Exoplanets in Time (ZEIT) III: A Neptune-sized planet orbiting a pre-main-sequence star in the Upper Scorpius OB Association

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We confirm and characterize a close-in ($P_{\rm orb}$ = 5.425 days), super-Neptune sized ($5.04^{+0.34}_{-0.37}\,R_{earth}$) planet transiting K2-33 (2MASS J16101473-1919095), a late-type (M3) pre-main sequence (11 Myr-old) star in the Upper Scorpius subgroup of the Scorpius-Centaurus OB association. The host star has the kinematics of a member of the Upper Scorpius OB association, and its spectrum contains lithium absorption, an unambiguous sign of youth (< 20 Myr) in late-type dwarfs. We combine photometry from K2 and the ground-based MEarth project to refine the planet's properties and constrain the host star's density. We determine K2-33's bolometric flux and effective temperature from moderate resolution spectra. By utilizing isochrones that include the effects of magnetic fields, we derive a precise radius (6-7%) and mass (16%) for the host star, and a stellar age consistent with the established value for Upper Scorpius. Follow-up high-resolution imaging and Doppler spectroscopy confirm that the transiting object is not a stellar companion or a background eclipsing binary blended with the target. The shape of the transit, the constancy of the transit depth and periodicity over 1.5 years, and the independence with wavelength rules out stellar variability, or a dust cloud or debris disk partially occulting the star as the source of the signal; we conclude it must instead be planetary in origin. The existence of K2-33b suggests close-in planets can form in situ or migrate within ∼ 10 Myr, e.g., via interactions with a disk, and that long-timescale dynamical migration such as by Lidov-Kozai or planet-planet scattering is not responsible for all short-period planets.

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Chemical solver to compute molecule and grain abundances and non-ideal MHD resistivities in prestellar core-collapse calculations

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We develop a detailed chemical network relevant to calculate the conditions that are characteristic of prestellar core collapse. We solve the system of time-dependent differential equations to calculate the equilibrium abundances of molecules and dust grains, with a size distribution given by size-bins for these latter. These abundances are used to compute the different non-ideal magneto-hydrodynamics resistivities (ambipolar, Ohmic and Hall), needed to carry out simulations of protostellar collapse. For the first time in this context, we take into account the evaporation of the grains, the thermal ionisation of Potassium, Sodium and Hydrogen at high temperature, and the thermionic emission of grains in the chemical network, and we explore the impact of various cosmic ray ionisation rates. All these processes significantly affect the non-ideal magneto-hydrodynamics resistivities, which will modify the dynamics of the collapse. Ambipolar diffusion and Hall effect dominate at low densities, up to $n_H = 10^{12}$ cm^{-3} , after which Ohmic diffusion takes over. We find that the time-scale needed to reach chemical equilibrium is always shorter than the typical dynamical (free fall) one. This allows us to build a large, multi-dimensional multi-species equilibrium abundance table over a large temperature, density and ionisation rate ranges. This table, which we make accessible to the community, is used during first and second prestellar core collapse calculations to compute the non-ideal magneto-hydrodynamics resistivities, yielding a consistent dynamical-chemical description of this process.

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Exocometary gas in the HD 181327 debris ring

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An increasing number of observations have shown that gaseous debris discs are not an exception. However, until now we only knew of cases around A stars. Here we present the first detection of ^{12}CO (2–1) disc emission around an F star, HD 181327, obtained with ALMA observations at 1.3 mm. The continuum and CO emission are resolved into an axisymmetric disc with ring-like morphology. Using a Markov chain Monte Carlo method coupled with radiative transfer calculations we study the dust and CO mass distribution. We find the dust is distributed in a ring with a radius of 86.0±0.4 AU and a radial width of 23.2±1.0 AU. At this frequency the ring radius is smaller than in the optical, revealing grain size segregation expected due to radiation pressure. We also report on the detection of low level continuum emission beyond the main ring out to ∼200 AU. We model the CO emission in the non-LTE regime and we find that the CO is co-located with the dust, with a total CO gas mass ranging between 1.2×10^{-6} $M_{\oplus}$ and 2.9×10^{-6} $M_{\oplus}$, depending on the gas kinetic temperature and collisional partners densities. The CO densities and location suggest a secondary origin, i.e. released from icy planetesimals in the ring. We derive a CO+CO_2 cometary composition that is consistent with Solar system comets. Due to the low gas densities it is unlikely that the gas is shaping the dust distribution.

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Embedded star clusters as sources of high-energy cosmic rays: Modelling and constraints

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Massive stars are mainly found in stellar associations. These massive star clusters occur in the heart of giant molecular clouds. The strong stellar wind activity in these objects generates large bubbles and induces collective effects that could accelerate particles up to high energy and produce gamma rays. The best way to input an acceleration origin to the stellar wind interaction in massive stellar cluster is to observe young massive star clusters in which no supernova explosion has occurred yet.

This work aims to constrain the part of stellar wind mechanical energy that is converted into energetic particles using the sensitivity of the ongoing Fermi/LAT instrument. This work further provides detailed predictions of expected gamma-ray fluxes in the view of the on-set of the next generation of imaging atmospheric Cherenkov telescopes.
A one-zone model where energetic particles are accelerated by repeated interactions with strong supersonic shocks occurring in massive star clusters was developed. The particle escape from the star cluster and subsequent interaction with the surrounding dense material and magnetic fields of the HII region was computed. We applied this model to a selection of eight embedded star clusters constricted by existing observations. We evaluated the gamma-ray signal from each object, combining both leptonic and hadronic contributions. We searched for these emissions in the Fermi/LAT observations in the energy range from 3 to 300 GeV and compared them to the sensitivity of the Cherenkov Telescope Array.
No significant gamma-ray emission from these star clusters has been found. Less than 10% of stellar wind luminosities are supplied to the relativistic particles. Some clusters even show acceleration efficiency of less than 1%. The CTA would be able to detect gamma-ray emission from several clusters in the case of an acceleration efficiency of close to 1%.

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Protoplanetary disks in the hostile environment of Carina

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We report the first direct imaging of protoplanetary disks in the star-forming region of Carina, the most distant, massive cluster in which disks have been imaged. Using the Atacama Large Millimeter/sub-millimeter Array (ALMA), disks are observed around two young stellar objects (YSOs) that are embedded inside evaporating gaseous globules and exhibit jet activity. The disks have an average size of 120 AU and total masses of 30 and 50 $M_{\rm Jup}$. Given the measured masses, the minimum timescale required for planet formation (∼1–2 Myr) and the average age of the Carina population (∼1–4 Myr), it is plausible that young planets are present or their formation is currently ongoing in these disks. The non-detection of millimeter emission above the 4σ threshold (∼7 $M_{\rm Jup}$) in the core of the massive cluster Trumpler 14, an area containing previously identified proplyd candidates, suggest evidence for rapid photo-evaporative disk destruction in the cluster's harsh radiation field. This would prevent the formation of giant gas planets in disks located in the cores of Carina's dense sub-clusters, whereas the majority of YSO disks in the wider Carina region remain unaffected by external photo-evaporation.

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Determining protoplanetary disk gas masses from CO isotopologues line observations

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Despite intensive studies of protoplanetary disks, there is still no reliable way to determine their total (gast+dust) mass and their surface density distribution, quantities that are crucial for describing both the structure and the evolution of disks up to the formation of planets.
The goal of this work is to use less abundant CO isotopologues, such as ^{13}CO, C^{18}O and C^{17}O, whose detection is routine for ALMA, to infer the gas mass of disks. Isotope-selective effects need to be taken into account in the analysis,

because they can significantly modify CO isotopologues line intensities.
CO isotope-selective photodissociation has been implemented in the physical-chemical code DALI (Dust And LInes) and more than 800 disk models have been run for a range of disk and stellar parameters. Dust and gas temperature structures have been computed self-consistently, together with a chemical calculation of the main atomic and molecular species. Both disk structure and stellar parameters have been investigated by varying the parameters in the grid of models. Total fluxes have been ray-traced for different CO isotopologues and for various low $J-$ transitions for different inclinations.
A combination of ^{13}CO and C^{18}O total intensities allows inference of the total disk mass, although with non-negligible uncertainties. These can be overcome by employing spatially resolved observations, i.e. the disk's radial extent and inclination. Comparison with parametric models by Williams & Best (2014) shows differences at the factor of a few level, especially for extremely low and high disk masses. Finally, total line intensities for different CO isotopologue and for various low-J transitions are provided and are fitted to simple formulae. The effects of a lower gas-phase carbon abundance and different gas-to-dust ratios are investigated as well, and comparison with other tracers is made.
Disk masses can be determined within a factor of a few by comparing CO isotopologue lines observations with the simulated line fluxes provided in this paper, modulo the uncertainties in the volatile elemental abundances.

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A study of the wiggle morphology of HH 211 through numerical simulations

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Recent high-resolution high-sensitivity observations of protostellar jets have shown many to possess deviations to their trajectories. HH 211 is one such example where sub-mm observations with the SMA have revealed a clear reflection-symmetric wiggle. The most likely explanation is that the HH 211 jet source could be moving as part of a protobinary system. Here we test this assumption by simulating HH 211 through 3D hydrodynamic jet propagation simulations using the PLUTO code with a molecular chemistry and cooling module, and initial conditions based on an analytical model derived from SMA observations. Our results show the reflection-symmetric wiggle can be recreated through the assumption of a jet source perturbed by binary motion at its base, and that a regular sinusoidal velocity variation in the jet beam can be close to matching the observed knot pattern. However, a more complex model with either additional heating from the protostar, or a shorter period velocity pulsation may be required to account for enhanced emission near the source, and weaker knot emission downstream. Position velocity diagrams along the pulsed jet beam show a complex structure with detectable signatures of knots and show caution must be exercised when interpreting radial velocity profiles through observations. Finally, we make predictions for future HH 211 observations with ALMA.

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Dynamics of Circumstellar Disks III: The case of GG Tau A

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We present 2-dimensional hydrodynamic simulations using the Smoothed Particle Hydrodynamic (SPH) code, VINE, to model a self-gravitating binary system similar to the GG Tau A system. We simulate systems configured with semi-major axes of either $a = 62$ AU ('wide') or $a = 32$ AU ('close'), and with eccentricity of either $e = 0$ or $e = 0.3$. Strong spiral structures are generated with large material streams extending inwards. A small fraction accretes onto the circumstellar disks, with most returning to the torus. Structures also propagate outwards, generating net outwards mass flow and eventually losing coherence at large distances. The torus becomes significantly eccentric in shape. Accretion onto the stars occurs at a rate of a few $\times 10^{-8} M_\odot$/yr implying disk lifetimes shorter than $\sim 10^4$ yr, without replenishment. Only wide configurations retain disks by virtue of robust accretion. In eccentric configurations, accretion is episodic, occurs preferentially onto the secondary at rates peaked near binary periapse. We conclude that the GG Tau A torus is strongly self gravitating and that a major contribution to its thermal energy is shock dissipation. We interpret its observed features as manifestations of spiral structures and the low density material surrounding it as an excretion disk created by outward mass flux. We interpret GG Tau A as a coplanar system with an eccentric torus, and account for its supposed mutual inclination as due to degeneracy between the interpretation of inclination and eccentricity. Although the disks persist for long enough to permit planet formation, the environment remains unfavorable due to high temperatures. We conclude that the GG Tau A system is in an eccentric, $a \sim 62$ AU orbit.

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Episodic High Velocity Outflows from V899 Mon: A Constraint On The Outflow Mechanisms

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We report the detection of large variations in the outflow wind velocity from a young eruptive star, V899 Mon during its ongoing high accretion outburst phase. Such large variations in the outflow velocity (from -722 km s^{-1} to -425 km s^{-1}) have never been reported previously in this family of objects. Our continuous monitoring of this source shows that the multi-component, clumpy, and episodic high velocity outflows are stable in the time scale of a few days, and vary over the time scale of a few weeks to months. We detect significant decoupling in the instantaneous outflow strength to accretion rate. From the comparison of various possible outflow mechanisms in magnetospheric accretion of young stellar objects, we conclude magnetically driven polar winds to be the most consistent mechanism for the outflows seen in V899 Mon. The large scale fluctuations in outflow over the short period makes V899 Mon the most ideal source to constrain various magnetohydrodynamics (MHD) simulations of magnetospheric accretion.

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Supernova Driving. III. Synthetic Molecular Cloud Observations

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We present a comparison of molecular clouds (MCs) from a simulation of supernova-driven interstellar medium (ISM) turbulence with real MCs from the Outer Galaxy Survey. The radiative transfer calculations to compute synthetic CO spectra are carried out assuming the CO relative abundance depends only on gas density, according to four different models. Synthetic MCs are selected above a threshold brightness temperature value, $T_{\rm B,min} = 1.4$ K, of the $J = 1-0$ ^{12}CO line, generating 16 synthetic catalogs (four different spatial resolutions and four CO abundance models), each containing up to several thousands MCs. The comparison with the observations focuses on the mass and size distributions and on the velocity-size and mass-size Larson relations. The mass and size distributions are found to be consistent with the observations, with no significant variations with spatial resolution or chemical model, except in the case of the unrealistic model with constant CO abundance. The velocity-size relation is slightly too steep for some of the models, while the mass-size relation is a bit too shallow for all models only at a spatial resolution $dx \approx 1$ pc. The normalizations of the Larson relations show a clear dependence on spatial resolution, for both the synthetic

and the real MCs. The comparison of the velocity-size normalization suggests that the SN rate in the Perseus arm is approximately 70% or less of the rate adopted in the simulation. Overall, the realistic properties of the synthetic clouds confirm that supernova-driven turbulence can explain the origin and dynamics of MCs.

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Supernova Driving. II. Compressive Ratio in Molecular-Cloud Turbulence

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The compressibility of molecular cloud (MC) turbulence plays a crucial role in star formation models, because it controls the amplitude and distribution of density fluctuations. The relation between the compressive ratio (the ratio of powers in compressive and solenoidal motions) and the statistics of turbulence has been previously studied systematically only in idealized simulations with random external forces. In this work, we analyze a simulation of large-scale turbulence (250 pc) driven by supernova (SN) explosions that has been shown to yield realistic MC properties. We demonstrate that SN driving results in MC turbulence with a broad lognormal distribution of the compressive ratio, with a mean value ≈ 0.3, lower than the equilibrium value of ≈ 0.5 found in the inertial range of isothermal simulations with random solenoidal driving. We also find that the compressibility of the turbulence is not noticeably affected by gravity, nor are the mean cloud radial (expansion or contraction) and solid-body rotation velocities. Furthermore, the clouds follow a general relation between the rms density and the rms Mach number similar to that of supersonic isothermal turbulence, though with a large scatter, and their average gas density PDF is described well by a lognormal distribution, with the addition of a high-density power-law tail when self-gravity is included.

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Consequences of tidal interaction between disks and orbiting protoplanets for the evolution of multi-planet systems with architecture resembling that of Kepler 444

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We study orbital evolution of multi-planet systems with masses in the terrestrial planet regime induced through tidal interaction with a protoplanetary disk assuming that this is the dominant mechanism for producing orbital migration and circularization. We develop a simple analytic model for a system that maintains consecutive pairs in resonance while undergoing orbital circularization and migration. Migration times for each planet may be estimated once planet masses, circularization times and the migration time for the innermost planet are given. We applied it to a model system with the current architecture of Kepler 444 interacting with a protoplanetary disk, the evolution time for the system as a whole being comparable to current protoplanetary disk lifetimes.
In addition we performed numerical simulations with input data obtained from this model. These indicate that although the analytic model is inexact, relatively small corrections to estimated migration rates yield systems for which period ratios vary by a minimal extent. Because of relatively large deviations from exact resonance in the observed system of up to 2%, the migration times obtained in this way indicate only weak convergent migration such that a system for which the planets did not interact would contract by only $\sim 1\%$ although undergoing significant inward migration as a whole. We performed additional simulations to investigate how the system could undergo significant convergent migration before reaching its final state. These indicate migration times have to be significantly

shorter and resonances significantly closer. Relative migration rates would then have to decrease allowing period ratios to increase to become more distant from resonances as the system approached its final state in the inner regions of the protoplanetary disk.

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Towards detecting methanol emission in low-mass protoplanetary discs with ALMA: The role of non-LTE excitation.

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The understanding of organic content of protoplanetary discs is one of the main goals of the planet formation studies. As an attempt to guide the observational searches for weak lines of complex species in discs, we modelled the (sub-)millimetre spectrum of gaseous methanol (CH_3OH), one of the simplest organic molecules, in the representative T Tauri system. We used 1+1D disc physical model coupled to the gas-grain ALCHEMIC chemical model with and without 2D-turbulent mixing. The computed CH_3OH abundances along with the CH_3OH scheme of energy levels of ground and excited torsional states were used to produce model spectra obtained with the non-local thermodynamic equilibrium (non-LTE) 3D line radiative transfer code LIME. We found that the modelled non-LTE intensities of the CH_3OH lines can be lower by factor of > 10–100 than those calculated under assumption of LTE. Though population inversion occurs in the model calculations for many (sub-)millimetre transitions, it does not lead to the strong maser amplification and noticeably high line intensities. We identify the strongest CH_3OH (sub-)millimetre lines that could be searched for with the Atacama Large Millimeter Array (ALMA) in nearby discs. The two best candidates are the CH_3OH $5_0 - 4_0$ A^+ (241.791 GHz) and $5_{-1} - 4_{-1}$ E (241.767 GHz) lines, which could possibly be detected with the $\sim 5\sigma$ signal-to-noise ratio after ~ 3 hours of integration with the full ALMA array.

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The Star-formation History and Accretion-Disk Fraction Among the K-Type Members of the Scorpius-Centaurus OB Association

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We present results of a spectroscopic survey for new K- and M-type members of Scorpius-Centaurus (Sco-Cen), the nearest OB Association (∼100–200 pc). Using an X-ray, proper motion and color-magnitude selected sample, we obtained spectra for 361 stars, for which we report spectral classifications and Li and Hα equivalent widths. We identified 156 new members of Sco-Cen, and recovered 51 previously published members. We have combined these with previously known members to form a sample of 493 solar-mass (∼0.7–1.3 $M_\odot$) members of Sco-Cen. We investigated the star-formation history of this sample, and re-assessed the ages of the massive main-sequence turn-off and the G-type members in all three subgroups. We performed a census for circumstellar disks in our sample using WISE infrared data and find a protoplanetary disk fraction for K-type stars of $4.4^{+1.6}_{-0.9}$% for Upper Centaurus-Lupus and Lower Centaurus-Crux at ∼16 Myr and $9.0^{+4.0}_{-2.2}$% for Upper Scorpius at ∼10 Myr. These data are consistent with a protoplanetary disk e-folding timescale of ∼4–5 Myr for ∼1 Msun stars, twice that previously quoted (Mamajek 2009), but consistent with the Bell et al. revised age scale of young clusters. Finally, we construct an age map of Scorpius-Centaurus which clearly reveals substructure consisting of concentrations of younger and older stars. We find evidence for strong age gradients within all three subgroups. None of the subgroups are consistent with being simple,

coeval populations which formed in single bursts, but likely represents a multitude of smaller star formation episodes of hundreds to tens of stars each.

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Discovery of concentric broken rings at sub-arcsec separations in the HD 141569A gas-rich, debris disk with VLT/SPHERE

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Transition disks correspond to a short stage between the young protoplanetary phase and older debris phase. Along this evolutionary sequence, the gas component disappears leaving room for a dust-dominated environment where already-formed planets signpost their gravitational perturbations. We endeavor to study the very inner region of the well-known and complex debris, but still gas-rich disk, around HD 141569A using the exquisite high-contrast capability of SPHERE at the VLT. Recent near-infrared (IR) images suggest a relatively depleted cavity within ∼200 au, while former mid-IR data indicate the presence of dust at separations shorter than ∼100 au. We obtained multi-wavelength images in the near-IR in J, H2, H3 and Ks bands with the IRDIS camera and a 0.95–1.35 μm spectral data cube with the IFS. Data were acquired in pupil-tracking mode, thus allowing for angular differential imaging. We discovered several new structures inside 1″, of which the most prominent is a bright ring with sharp edges (semi-major axis: 0.″4) featuring a strong north-south brightness asymmetry. Other faint structures are also detected from 0.″4 to 1″ in the form of concentric ringlets and at least one spiral arm. Finally, the VISIR data at 8.6 μm suggests the presence of an additional dust population closer in. Besides, we do not detect companions more massive than 1–3 mass of Jupiter.

The performance of SPHERE allows us to resolve the extended dust component, which was previously detected at thermal and visible wavelengths, into very complex patterns with strong asymmetries ; the nature of these asymmetries remains to be understood. Scenarios involving shepherding by planets or dust-gas interactions will have to be tested against these observations.

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The first stars of the Rho Ophiuchi Dark Cloud. XMM-Newton view of Rho Oph and its neighbors

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Star formation in molecular clouds can be triggered by the dynamical action of winds from massive stars. Furthermore, X-ray and UV fluxes from massive stars can influence the life time of surrounding circumstellar disks. We present the results of a 53 ks XMM-Newton observation centered on the ρ Ophiuchi A+B binary system. ρ Ophiiuchi lies in the center of a ring of dust, likely formed by the action of its winds. This region is different from the dense core of the cloud (L1688 Core F) where star formation is at work. X-rays are detected from ρ Ophiuchi as well as a group of surrounding X-ray sources. We detected 89 X-ray sources, 47 of them have at least one counterpart in 2MASS + All-WISE catalogs. Based on IR and X-ray properties, we can distinguish between young stellar objects (YSOs) belonging to the cloud and background objects. Among the cloud members, we detect 3 debris disk objects and 22 disk-less / Class III young stars. We show that these stars have ages in $5 - 10$ Myr, and are significantly older than the YSOs in L1688. We speculate that they are the result of an early burst of star formation in the cloud. An X-ray energy of $\geq 5 \times 10^{44}$ ergs has been injected into the surrounding medium during the past 5 Myr, we discuss the effects of such energy budget in relation to the cloud properties and dynamics.

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Mid-J CO shock tracing observations of infrared dark clouds II Low-J CO constraints on excitation, depletion, and kinematics

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Infrared dark clouds are kinematically complex molecular structures in the interstellar medium that can host sites of massive star formation. We present 4 square arcminute maps of the 12CO, 13CO, and C18O J = 3 to 2 lines from selected locations within the C and F (G028.37+00.07 and G034.43+00.24) infrared dark clouds (IRDCs), as well as single pointing observations of the 13CO and C18O J = 2 to 1 lines towards three cores within these clouds. We derive CO gas temperatures throughout the maps and find that CO is significantly frozen out within these IRDCs. We find that the CO depletion tends to be the highest near column density peaks, with maximum depletion factors between 5 and 9 in IRDC F and between 16 and 31 in IRDC C. We also detect multiple velocity components and complex kinematic structure in both IRDCs. Therefore, the kinematics of IRDCs seem to point to dynamically evolving structures yielding dense cores with considerable depletion factors.

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A search for ionized jets towards massive young stellar objects

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Radio continuum observations using the Australia telescope compact array at 5.5, 9.0, 17.0 and 22.8 GHz have detected free-free emission associated with 45 of 49 massive young stellar objects and HII regions. Of these, 26 sources are classified as ionized jets (12 of which are candidates), 2 as ambiguous jets or disc winds, 1 as a disc-wind, 14 as HII regions and 2 were unable to be categorised. Classification as ionized jets is based upon morphology, radio flux and spectral index, in conjunction with previous observational results at other wavelengths. Radio-luminosity and momentum are found to scale with bolometric luminosity in the same way as low-mass jets, indicating a common mechanism for jet production across all masses. In 13 of the jets, we see associated non-thermal/optically-thin lobes resulting from shocks either internal to the jet and/or at working surfaces. Ten jets display non-thermal (synchrotron emission) spectra in their lobes, with an average spectral index of -0.55 consistent with Fermi acceleration in shocks. This shows that magnetic fields are present, in agreement with models of jet formation incorporating magnetic fields. Since the production of collimated radio jets is associated with accretion processes, the results presented in this paper support the picture of disc-mediated accretion for the formation of massive stars with an upper-limit on the jet phase lasting approximately 6.5×10^4 yr. Typical mass loss rates in the jet are found to be 1.4×10^{-5} $M_\odot$ yr^{-1} with associated momentum rates of the order $(1-2) \times 10^{-2}$ $M_\odot$ km s^{-1} yr^{-1}.

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Discs in misaligned binary systems

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We perform SPH simulations to study precession and changes in alignment between the circumprimary disc and the binary orbit in misaligned binary systems. We find that the precession process can be described by the rigid-disc

approximation, where the disc is considered as a rigid body interacting with the binary companion only gravitationally. Precession also causes change in alignment between the rotational axis of the disc and the spin axis of the primary star. This type of alignment is of great important for explaining the origin of spin-orbit misaligned planetary systems. However, we find that the rigid-disc approximation fails to describe changes in alignment between the disc and the binary orbit. This is because the alignment process is a consequence of interactions that involve the fluidity of the disc, such as the tidal interaction and the encounter interaction. Furthermore, simulation results show that there are not only alignment processes, which bring the components towards alignment, but also anti-alignment processes, which tend to misalign the components. The alignment process dominates in systems with misalignment angle near 90°, while the anti-alignment process dominates in systems with the misalignment angle near 0° or 180°. This means that highly misaligned systems will become more aligned but slightly misaligned systems will become more misaligned.

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First detections of the key prebiotic molecule PO in star-forming regions

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Phosphorus is a crucial element in biochemistry, especially the P−O bond, which is key for the formation of the backbone of the deoxyribonucleic acid. So far, PO has only been detected towards the envelope of evolved stars, and never towards star-forming regions. We report the first detection of PO towards two massive star-forming regions, W51 e1/e2 and W3(OH), using data from the IRAM 30m telescope. PN has also been detected towards the two regions. The abundance ratio PO/PN is 1.8 and 3 for W51 and W3(OH), respectively. Our chemical model indicates that the two molecules are chemically related and are formed via gas-phase ion-molecule and neutral-neutral reactions during the cold collapse. The molecules freeze out onto grains at the end of the collapse and desorb during the warm-up phase once the temperature reaches ∼35 K. Similar abundances of the two species are expected during a period of 5×10^4 yr at the early stages of the warm-up phase, when the temperature is in the range 35−90 K. The observed molecular abundances of 10^{-10} are predicted by the model if a relatively high initial abundance of 5×10^{-9} of depleted phosphorus is assumed.

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The Radio Jet Associated with the Multiple V380 Ori System

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The giant Herbig-Haro object 222 extends over ∼6′ in the plane of the sky, with a bow shock morphology. The identification of its exciting source has remained uncertain over the years. A non-thermal radio source located at the core of the shock structure was proposed to be the exciting source. However, Very Large Array studies showed that the radio source has a clear morphology of radio galaxy and a lack of flux variations or proper motions, favoring an extragalactic origin. Recently, an optical-IR study proposed that this giant HH object is driven by the multiple stellar system V380 Ori, located about 23′ to the SE of HH 222. The exciting sources of HH systems are usually detected as weak free-free emitters at centimeter wavelengths. Here we report the detection of an elongated radio source associated with the Herbig Be star or with its close infrared companion in the multiple V380 Ori system. This radio source has the characteristics of a thermal radio jet and is aligned with the direction of the giant outflow defined by HH 222 and its suggested counterpart to the SE, HH 1041. We propose that this radio jet traces the origin of the large scale HH outflow. Assuming that the jet arises from the Herbig Be star, the radio luminosity is a few times smaller than the value expected from the radio-bolometric correlation for radio jets, confirming that this is a more evolved object than those used to establish the correlation.

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Direct Imaging discovery of a second planet candidate around the possibly transiting planet host CVSO 30

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We surveyed the 25 Ori association for direct-imaging companions. This association has an age of only few million years. Among other targets, we observed CVSO 30, which has recently been identified as the first T Tauri star found to host a transiting planet candidate. We report on photometric and spectroscopic high-contrast observations with the Very Large Telescope, the Keck telescopes, and the Calar Alto observatory. They reveal a directly imaged planet candidate close to the young M3 star CVSO 30. The JHK-band photometry of the newly identified candidate is at better than 1 sigma consistent with late-type giants, early-T and early-M dwarfs, and free-floating planets. Other hypotheses such as galaxies can be excluded at more than 3.5 σ. A lucky imaging z' photometric detection limit z'= 20.5 mag excludes early-M dwarfs and results in less than 10 M_{Jup} for CVSO 30 c if bound. We present spectroscopic observations of the wide companion that imply that the only remaining explanation for the object is that it is the first very young (< 10 Myr) L-T-type planet bound to a star, meaning that it appears bluer than expected as a result of a decreasing cloud opacity at low effective temperatures. Only a planetary spectral model is consistent with the spectroscopy, and we deduce a best-fit mass of 4 - 5 Jupiter masses (total range 0.6 - 10.2 Jupiter masses). This means that CVSO 30 is the first system in which both a close-in and a wide planet candidate are found to have a common host star. The orbits of the two possible planets could not be more different: they have orbital periods of 10.76 hours and about 27000 years. The two orbits may have formed during a mutual catastrophic event of planet-planet scattering.

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Effect of multilayer ice chemistry on gas-phase deuteration in starless cores

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Context: Astrochemical models commonly used to study the deuterium chemistry in starless cores consider a two-phase approach in which the ice on the dust grains is assumed to be entirely reactive. Recent experimental studies suggest that cold interstellar ices are mostly inert, and a multilayer model distinguishing the chemical processes at the surface and in the ice bulk would be more appropriate.
Aims: We investigate whether the multilayer model can be as successful as the bulk model in reproducing the observed abundances of various deuterated gas-phase species toward starless cores.
Methods: We calculated abundances for various deuterated species as functions of time using a pseudo-time-dependent chemical model adopting fixed physical conditions. We also estimated abundance gradients in starless cores by adopting a modified Bonnor-Ebert sphere as a core model. In the multilayer ice scenario, we consider desorption from one or several monolayers on the surface.
Results: We find that the multilayer model predicts abundances of DCO^+ and N_2D^+ that are about an order of magnitude lower than observed; the difference is caused by the trapping of CO and N_2 within the grain mantle. As a result of the mantle trapping, deuteration efficiency in the gas phase increases and we find stronger deuterium fractionation in ammonia than has been observed. Another distinguishing feature of the multilayer model is that D_3^+ becomes the main deuterated ion at high density. The bulk ice model is generally easily reconciled with observations.
Conclusions: Our results underline that more theoretical and experimental work is needed to understand the composition and morphology of interstellar ices, and the desorption processes that can act on them. With the current constraints, the bulk ice model appears to reproduce the observations more accurately than the multilayer ice model. According to our results, the abundance ratio of H_2D^+ to N_2D^+ is higher than 100 in the multilayer model, while only a few $\times$ 10 in the bulk model, and so observations of this ratio could provide information on the ice morphology in starless cores. Observations of the abundance of D_3^+ compared to H_2D^+ and D_2H^+, although challenging, would provide additional constraints for the models.

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Circumplanetary disk or circumplanetary envelope?

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We present three-dimensional simulations with nested meshes of the dynamics of the gas around a Jupiter mass planet with the JUPITER and FARGOCA codes. We implemented a radiative transfer module into the JUPITER code to account for realistic heating and cooling of the gas. We focus on the circumplanetary gas flow, determining its characteristics at very high resolution (80% of Jupiter's diameter). In our nominal simulation where the temperature evolves freely by the radiative module and reaches 13000 K at the planet, a circumplanetary envelope was formed filling the entire Roche-lobe. Because of our equation of state is simplified and probably overestimates the temperature, we also performed simulations with limited maximal temperatures in the planet region (1000 K, 1500 K, and 2000 K). In these fixed temperature cases circumplanetary disks (CPDs) were formed. This suggests that the capability to form a circumplanetary disk is not simply linked to the mass of the planet and its ability to open a gap. Instead, the gas temperature at the planet's location, which depends on its accretion history, plays also fundamental role. The CPDs in the simulations are hot and cooling very slowly, they have very steep temperature and density profiles, and are strongly sub-Keplerian. Moreover, the CPDs are fed by a strong vertical influx, which shocks on the CPD surfaces creating a hot and luminous shock-front. In contrast, the pressure supported circumplanetary envelope is characterized by internal convection and almost stalled rotation.

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Dust and gas density evolution at a radial pressure bump in protoplanetary disks

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We investigate the simultaneous evolution of dust and gas density profiles at a radial pressure bump located in a protoplanetary disk. If dust particles are treated as test particles, a radial pressure bump traps dust particles that drift radially inward. As the dust particles become more concentrated at the gas pressure bump, however, the drag force from dust to gas (back-reaction), which is ignored in a test-particle approach, deforms the pressure bump. We find that the pressure bump is completely deformed by the back-reaction when the dust-to-gas mass ratio reaches ~ 1 for a slower bump restoration. The direct gravitational instability of dust particles is inhibited by the bump destruction. In the dust-enriched region, the radial pressure support becomes $\sim 10 - 100$ times lower than the global value set initially. Although the pressure bump is a favorable place for streaming instability (SI), the flattened pressure gradient inhibits SI from forming large particle clumps corresponding to $100 - 1000$ km sized bodies, which has been previously proposed. If SI occurs there, the dust clumps formed would be $10 - 100$ times smaller, that is, of about $1 - 100$ km.

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Effect of planet ingestion on low-mass stars evolution: the case of 2MASS J08095427−4721419 star in the Gamma Velorum cluster

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We analysed the effects of planet ingestion on the characteristics of a pre-MS star similar to the Gamma Velorum cluster member 2MASS J08095427−4721419 (#52). We discussed the effects of changing the age t_0 at which the accretion episode occurs, the mass of the ingested planet and its chemical composition. We showed that the mass of the ingested planet required to explain the current $[Fe/H]^{\#52}$ increases by decreasing the age t_0 and/or by decreasing the Iron content of the accreted matter.

We compared the predictions of a simplified accretion method – where only the variation of the surface chemical composition is considered – with that of a full accretion model that properly accounts for the modification of the stellar structure. We showed that the two approaches result in different convective envelope extension which can vary up to 10 percent. We discussed the impact of the planet ingestion on a stellar model in the colour-magnitude diagram, showing that a maximum shift of about 0.06 dex in the colour and 0.07 dex in magnitude are expected and that such variations persist even much later the accretion episode. We also analysed the systematic bias in the stellar mass and age inferred by using a grid of standard non accreting models to recover the characteristics of an accreting star. We found that standard non accreting models can safely be adopted for mass estimate, as the bias is $\lesssim$6 percent, while much more caution should be used for age estimate where the differences can reach about 60 percent.

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A comparison between grid and particle methods on the small-scale dynamo in magnetised supersonic turbulence

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We perform a comparison between the smoothed particle magnetohydrodynamics (SPMHD) code, Phantom, and the Eulerian grid-based code, Flash, on the small-scale turbulent dynamo in driven, Mach 10 turbulence. We show, for the first time, that the exponential growth and saturation of an initially weak magnetic field via the small-scale dynamo can be successfully reproduced with SPMHD. The two codes agree on the behaviour of the magnetic energy spectra, the saturation level of magnetic energy, and the distribution of magnetic field strengths during the growth and saturation phases. The main difference is that the dynamo growth rate, and its dependence on resolution, differs between the codes, caused by differences in the numerical dissipation and shock capturing schemes leading to differences in the effective Prandtl number in Phantom and Flash.

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Orion's Veil: Magnetic field strengths and other properties of a PDR in front of the Trapezium Cluster

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We present an analysis of physical conditions in the Orion Veil, a largely atomic PDR that lies just in front (about 2 pc) of the Trapezium stars. We have obtained 21 cm HI and 18 cm OH VLA Zeeman effect data. These data yield images of the line-of-sight magnetic field strength Blos in atomic and molecular regions of the Veil. We find $B_{\rm los}$ is typically -50 to -75 μG in the atomic gas across much of the Veil (25$''$ resolution); $B_{\rm los}$ is -350 μG at one position in the molecular gas (40$''$ resolution). The Veil has two principal HI velocity components. Magnetic and kinematical data suggest a close connection between these components. They may represent gas on either side of a shock wave preceding a weak-D ionization front. Magnetic fields in the Veil HI components are 3–5 times stronger than they are elsewhere in the ISM where N(H) and n(H) are comparable. The HI components are magnetically subcritical (magnetically dominated), like the CNM, although they are about 1 dex denser. Strong fields in the Veil HI components may have resulted from low turbulence conditions in the diffuse gas that gave rise to OMC-1. Strong fields may also be related to magnetostatic equilibrium that has developed in the Veil since star formation. We consider the location of the Orion-S molecular core, proposing a location behind the main Orion H^+ region.

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Three-dimensional distribution of hydrogen fluoride gas toward NGC 6334 I and I(N)

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Context. The HF molecule has been proposed as a sensitive tracer of diffuse interstellar gas, while at higher densities its abundance could be influenced heavily by freeze-out onto dust grains.
Aims. We investigate the spatial distribution of a collection of absorbing gas clouds, some associated with the dense, massive star-forming core NGC 6334 I, and others with diffuse foreground clouds elsewhere along the line of sight. For the former category, we aim to study the dynamical properties of the clouds in order to assess their potential to feed the accreting protostellar cores.
Methods. We use far-infrared spectral imaging from the *Herschel* SPIRE iFTS to construct a map of HF absorption at 243 μm in a $6' \times 3.5'$ region surrounding NGC 6334 I and I(N).
Results. The combination of new, spatially fully sampled, but spectrally unresolved mapping with a previous, single-pointing, spectrally resolved HF signature yields a three-dimensional picture of absorbing gas clouds in the direction of NGC 6334. Toward core I, the HF equivalent width matches that of the spectrally resolved observation. At angular separations $>\sim$20" from core I, the HF absorption becomes weaker, consistent with three of the seven components being associated with this dense star-forming envelope. Of the remaining four components, two disappear beyond $\sim 1'$ distance from the NGC 6334 filament, suggesting that these clouds are spatially associated with the star-forming complex. Our data also implies a lack of gas phase HF in the envelope of core I(N). Using a simple description of adsorption onto and desorption from dust grain surfaces, we show that the overall lower temperature of the envelope of source I(N) is consistent with freeze-out of HF, while it remains in the gas phase in source I.
Conclusions. We use the HF molecule as a tracer of column density in diffuse gas ($n_{\rm H} \approx 10^2$–10^3 cm^{-3}), and find that it may uniquely trace a relatively low density portion of the gas reservoir available for star formation that otherwise escapes detection. At higher densities prevailing in protostellar envelopes ($>10^4$ cm^{-3}), we find evidence of HF depletion from the gas phase under sufficiently cold conditions.

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High spatial resolution optical imaging of the multiple T Tauri system LkHα 262/LkHα 263

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We report high spatial resolution i$'$ band imaging of the multiple T Tauri system LkHα 262/LkHα 263 obtained during the first commissioning period of the Adaptive Optics Lucky Imager (AOLI) at the 4.2 m William Herschel Telescope, using its Lucky Imaging mode. AOLI images have provided photometry for each of the two components LkHα 263 A and B ($0\farcs41$ separation) and marginal evidence for an unresolved binary or a disc in LkHα 262. The AOLI data combined with previously available and newly obtained optical and infrared imaging show that the three components of LkHα 263 are co-moving, that there is orbital motion in the AB pair, and, remarkably, that LkHα 262-263 is a common proper motion system with less than 1 mas yr^{-1} relative motion. We argue that this is a likely five-component

gravitationally bounded system. According to BT-settl models the mass of each of the five components is close to $0.4\ M_\odot$ and the age is in the range 1–2 Myr. The presence of discs in some of the components offers an interesting opportunity to investigate the formation and evolution of discs in the early stages of multiple very low-mass systems. In particular, we provide tentative evidence that the disc in 263C could be coplanar with the orbit of 263AB.

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A ram-pressure threshold for star formation

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In turbulent fragmentation, star formation occurs in condensations created by converging flows. The condensations must be sufficiently massive, dense and cool to be gravitationally unstable, so that they start to contract; *and* they must then radiate away thermal energy fast enough for self-gravity to remain dominant, so that they continue to contract. For the metallicities and temperatures in local star forming clouds, this second requirement is only met robustly when the gas couples thermally to the dust, because this delivers the capacity to radiate across the full bandwidth of the continuum, rather than just in a few discrete spectral lines. This translates into a threshold for vigorous star formation, which can be written as a minimum ram-pressure $P_{\rm CRIT} \sim 4\times10^{-11}$dyne. $P_{\rm CRIT}$ is independent of temperature, and corresponds to flows with molecular hydrogen number-density $n_{\rm H_2.FLOW}$ and velocity $v_{\rm FLOW}$ satisfying $n_{\rm H_2.FLOW}v^2_{\rm FLOW} \gtrsim 800\,{\rm cm}^{-3}({\rm km/s})^2$. This in turn corresponds to a minimum molecular hydrogen column-density for vigorous star formation, $N_{\rm H_2.CRIT} \sim 4\times10^{21}{\rm cm}^{-2}$ ($\Sigma_{\rm CRIT} \sim 100\,{\rm M}_\odot{\rm pc}^{-2}$), and a minimum visual extinction $A_{\rm V,CRIT} \sim 9\,$mag. The characteristic diameter and line-density for a star-forming filament when this threshold is just exceeded – a *sweet spot* for local star formation regions – are $2R_{\rm FIL} \sim 0.1$pc and $\mu_{\rm FIL} \sim 13{\rm M}_\odot{\rm pc}^{-2}$. The characteristic diameter and mass for a prestellar core condensing out of such a filament are $2R_{\rm CORE} \sim 0.1$pc, and $M_{\rm CORE} \sim 1\,{\rm M}_\odot$. We also show that fragmentation of a shock-compressed layer is likely to commence while the convergent flows creating the layer are still ongoing, and we stress that, under this circumstance, the phenomenology and characteristic scales for fragmentation of the layer are fundamentally different from those derived traditionally for pre-existing layers.

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A theoretical perspective on the formation and fragmentation of protostellar discs

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We discuss the factors influencing the formation and gravitational fragmentation of protostellar discs. We start with a review of how observations of prestellar cores can be analysed statistically to yield plausible initial conditions for simulations of their subsequent collapse. Simulations based on these initial conditions show that, despite the low levels of turbulence in prestellar cores, they deliver primary protostars and associated discs which are routinely subject to stochastic impulsive perturbations; consequently misalignment of the spins and orbits of protostars are common. Also, the simulations produce protostars that collectively have a mass function and binary statistics matching those observed in nearby star formation regions, but only if a significant fraction of the turbulent energy in the core is solenoidal, and accretion onto the primary protostar is episodic with a duty cycle $\gtrsim 3000\,$yr. Under this circumstance a core typically spawns between 4 and 5 protostars, with high efficiency, and the lower-mass protostars are mainly formed by disc fragmentation. The requirement that a proto-fragment in a disc lose thermal energy on a dynamical timescale dictates that **there is a sweet spot for** disc fragmentation at radii $70\,{\rm AU} \lesssim R \lesssim 100\,{\rm AU}$ and temperatures $10\,{\rm K} \lesssim T \lesssim 20\,{\rm K}$, and this might explain the Brown Dwarf Desert.

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Cygnus OB2 DANCe: A high precision proper motion study of the Cygnus OB2 association

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We present a high-precision proper motion study of 873 X-ray and spectroscopically selected stars in the massive OB association Cygnus OB2 as part of the DANCe project. These were calculated from images spanning a 15 year baseline and have typical precisions < 1 mas/yr. We calculate the velocity dispersion in the two axes to be $\sigma_\alpha(c) = 13.0^{+0.8}_{-0.7}$ and $\sigma_\delta(c) = 9.1^{+0.5}_{-0.5}$ km s^{-1}, using a 2-component, 2-dimensional model that takes into account the uncertainties on the measurements. This gives a 3-dimensional velocity dispersion of $\sigma_{3D} = 17.8 \pm 0.6$ km s^{-1} implying a virial mass significantly larger than the observed stellar mass, confirming that the association is gravitationally unbound. The association appears to be dynamically unevolved, as evidenced by considerable kinematic substructure, non-isotropic velocity dispersions and a lack of energy equipartition. The proper motions show no evidence for a global expansion pattern, with approximately the same amount of kinetic energy in expansion as there is in contraction, which argues against the association being an expanded star cluster disrupted by process such as residual gas expulsion or tidal heating. The kinematic substructures, which appear to be close to virial equilibrium and have typical masses of 40–400 M$_\odot$, also do not appear to have been affected by the expulsion of the residual gas. We conclude that Cyg OB2 was most likely born highly substructured and globally unbound, with the individual subgroups born in (or close to) virial equilibrium, and that the OB association has not experienced significant dynamical evolution since then.

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Disk Polarization From Both Emission and Scattering of Magnetically Aligned Grains: The Case of NGC 1333 IRAS4A1

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Dust polarization in millimeter (and centimeter) has been mapped in disks around an increasing number of young stellar objects. It is usually thought to come from emission by magnetically aligned (non-spherical) grains, but can also be produced by dust scattering. We present a semi-analytic theory of disk polarization that includes both the direction emission and scattering, with an emphasis on their relative importance and how they are affected by the disk inclination. For face-on disks, both emission and scattering tend to produce polarization in the radial direction, making them difficult to distinguish, although the scattering-induced polarization can switch to the azimuthal direction if the incident radiation is beamed strongly enough in the radial direction in the disk plane. Disk inclination affects the polarizations from emission and scattering differently, especially on the major axis where, in the edge-on limit, the former vanishes while the latter reaches a polarization fraction as large as 1/3. The polarizations from the two competing mechanisms tend to cancel each other on the major axis, producing two low polarization holes (one on each side of the center) under certain conditions. We find tantalizing evidence for at least one such hole in NGC1333

IRAS4A1, whose polarization observed at 8 mm on the 100 AU scale is indicative of a pattern dominated by scattering close to the center and by direction emission in the outer region. If true, it would imply not only that a magnetic field exists on the disk scale, but that it is strong enough to align large, possibly mm-sized, grains.

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Molecular line study of massive star forming regions from the RMS survey

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In this paper we selected a sample of massive star forming regions from the Red MSX Source (RMS) survey, to study star formation activities (mainly outflow and inflow signatures). We focused on three molecular lines from the Millimeter Astronomy Legacy Team Survey at 90 GHz (MALT90): HCO^+ (1–0), $H^{13}CO^+$ (1–0) and SiO (2–1). According to previous observations, our sources could be divided into two groups: nine massive young stellar object (MYSO) candidates (radio-quiet) and ten HII regions (having spherical or unresolved radio emissions). Outflow activities were found in eleven sources while only three show inflow signatures in all. The high outflow detection rate means outflows are common in massive star forming regions. The inflow detection rate was relatively low. We suggest this was due to beam dilution of the telescope. All the three inflow candidates have outflow(s). The outward radiation and thermal pressure from the central massive star(s) do not seem to strong enough to halt accretion in G345.0034−00.2240. Our simple model of G318.9480−00.1969 shows it has an infall velocity of about 1.8 km s^{-1} . The spectral energy distribution (SED) analysis agrees our sources are massive and intermediate-massive star formation regions.

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New Jobs

Postdoc position on the first stellar clusters

The theory group in the Astronomy Department at the Universidad de Concepción (Chile) invites applications for a postdoc position on **"The formation and evolution of the first stellar clusters"**. The position is initially restricted to two years, with potential opportunities for extension. The objective of the project is to carry out numerical simulations exploring the formation of the first stellar clusters after metal enrichment.

The theory group in Concepción is the largest theoretical astrophysics group in Chile, consisting of Prof. M. Fellhauer and Prof. D. Schleicher, as well as two postdoctoral researchers and more than 10 students, and includes projects on hydrodynamical, stellar dynamical and magneto-hydrodynamical modeling. More information on the activities of the theory group can be found on our website (http://www.astro-udec.cl/theory-group/index.html). The project will be carried out in collaboration with the star formation group of Prof. Robi Banerjee at Hamburg Observatory.

Applicants for the position should hold a PhD in astronomy or a related field and have experience in computational modeling, preferably in the context of the first stars and galaxies. Interested candidates should send a cover letter stating their research interests, a CV including a list of publications and a 3-page research statement as a single pdf file to Prof. Dominik Schleicher (dschleicher@udec.cl), and arrange for three letters of recommendations. The selection of candidates starts on July 1, with potential starting dates from September 2016. Applications will be accepted until the position is filled.

Contact:
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Star formation with Gaia

PhD position at the University of Vienna

Gaia is an ambitious ESA mission to chart a three-dimensional map of our Galaxy, with a first data release towards the end of the Summer of 2016. Gaia will provide unprecedented positional and radial velocity measurements with the accuracies needed to produce a stereoscopic and kinematic census of about one billion stars in our Galaxy. To capitalize on the University of Vienna involvement in this mission we are looking for a PhD candidate to work of star formation topics with Gaia. The candidate will work in particular on the characterization of the recently discovered Blue Streams (Bouy & Alves 2015), their origin, and implications for local and global star formation. We are looking for a highly motivated PhD student with a good knowledge of data analysis, statistics, and data visualization (preferably with open source tools, e.g., Python, R) and familiarity with astronomical research.

The Observatory of the University of Vienna offers a stimulating research environment with a large staff working in various areas of astrophysics. The department is involved in major observatories of ESO and ESA such as the ELT and Gaia. The city of Vienna has been ranked first for six consecutive years in Mercer's Quality of Living Survey.

Review of applications starts on July 30th, 2016, and will continue until the position is filled. Applications should be sent to Prof. João Alves (joao.alves@univie.ac.at) with 1) a CV that includes a brief description of past research, and 2) the names of two researchers that could be contacted to provide a recommendation letter.

Postdoctoral Position in Exo-Planetary Science - York University

Applications are invited for a postdoctoral position at York University in Toronto. The successful candidate will work with Professor Ray Jayawardhana and his collaborators on observational and analytical studies of extra-solar planets and related topics such as planet formation and sub-stellar objects. Photometric and spectroscopic characterization of extra-solar planets is of particular interest. Prof. Jayawardhana's research group currently includes two postdocs and two graduate students. Group members use data from VLT, Subaru, Gemini, Keck, CFHT, Kepler, and other major observatories, and are also involved in science planning for the NIRISS instrument on JWST and the SPIRou instrument for CFHT. The successful candidate will also have the opportunity to collaborate with Professor John Moores at York, and with other members of the Technologies for Exo-Planetary Science (TEPS) program, funded by NSERC at $1.65 million, at institutions across Canada and abroad. The position is for two years, with extension to a third year possible, and comes with a competitive salary and funds for research expenses. Start date is flexible, ideally between August-November 2016.

Applicants should send their curriculum vitae, a description of research interests and plans and a list of publications, and should arrange for three letters of recommendation to be sent directly to Marlene Caplan (marlene@yorku.ca). All materials should be submitted electronically. Applications are accepted until the position is filled, and those received before July 1, 2016 will receive full consideration. Early expressions of interest and inquiries are welcome, and should be made to rayjay@yorku.ca.

Post-doctoral positions in protoplanetary discs and planet formation

The Theoretical Astrophysics Group at the University of Leicester invites applications for one or more post-doctoral Research Associate positions. These positions are 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 applicants 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 positions are available from 1st July 2016, but the starting date is flexible. The salary scale is £32,600–£37,768, depending on experience. The successful applicants 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`. Informal enquiries should be directed to Dr Richard Alexander (`richard.alexander@leicester.ac.uk`). All applications received by June 30th 2016 will be given full consideration.

Summer School "The HR diagram in radio - stellar physics at long wavelengths"

Sept 26-30, 2016, Arcachon, France

The french Programme National de Physique Stellaire organizes the 2016 Evry Schatzman School entitled: "The HR diagram in radio - stellar physics at long wavelengths". The school program also covers circumstellar radio emission (jets, disks, AGB winds and envelopes), and will introduce the participants to the use of modern ground radio observatories NOEMA, ALMA and SKA.

The School will take place in the Teich Bird Reserve (on the Atlantic coast next to Arcachon and Bordeaux, France). All lectures will be given in English, at a level geared to Ph.D. students and young researchers.

There are no registration fees. Lodging and meal expenses are 300 euros in total for the School duration. Financial support is available, and can be applied for when you pre-register.

Registration is open up to 31 May 2016, on the dedicated Web site where all scientific and practical information are given. http://ees2016.sciencesconf.org/

Lectures:
• the HR diagram in radio: observational techniques and emission processes: 2 x 1h30 (Eric Josselin)
• activity, binarity, and magnetism as seen in the radio : 2 x 1h30 (Wouter Vlemmings)
• Solar type stars: chromospheric and coronal radio emission, magnetospheres: 2 x 1h30 (Sven Wedemeyer)
• Star formation and protostars in the radio range:
- Disks : 2h (Anne Dutrey)
- Jets : 2h (Frederic Gueth)
• Winds and mass-loss in the radio range:
- Hot stars : 2h (Jean-Claude Bouret)
- Cold stars : 2h (Sofia Ramstedt)

Seminars and tutorials:
- presentation of ALMA and NOEMA : 1h30 (Sebastien Maret)
- presentation of SKA : 1h30 (Stephane Corbel)
- Preparation and reduction of radio observations : 2 x 2h (Fabrice Herpin & Stephane Guilloteau)

It will possible to present e-posters which will be communicated to participants on an USB key. Posters will be discussed during the school.

Should you have any question, please contact Eric Josselin (eric.josselin(at)umontpellier.fr) or Yveline Lebreton (Yveline.Lebreton(at)obspm.fr).

The SOC (E. Josselin, Y. Lebreton, F. Herpin, S. Cabrit)

631. WE-Heraeus-Seminar: Stellar aggregates over mass and spatial scales

URL: https://astro.uni-bonn.de/conferences/aggregates2016/index.html

Date: December 5 - 9, 2016

Venue: Physikzentrum Bad Honnef, Germany

No registration fee. Full-board costs of all participants at the Physics Center will be covered. Participation is limited to maximum 80 (including the invited speakers). Registration opens in June.

The Local Truth: Star-Formation and Feedback in the SOFIA Era
Celebrating 50 Years of Airborne Astronomy
October 17-20, 2016
Asilomar Conference Grounds, Pacific Grove, CA, USA

This conference will focus on the current understanding of star-formation and the impact of feedback processes in Galactic molecular clouds and nearby galaxies. High angular resolution and high spectral resolution observations in the mid- and far-infrared, as provided by SOFIA, are critical for a detailed understanding of the key physical processes involved. Such "local truth" is necessary for correctly interpreting observations of star formation tracers in distant galaxies.

An array of topics covered during the meeting will include the Theory of Star Formation and Feedback; the Chemistry and Conditions of the Interstellar Medium and Molecular Clouds; the Galactic Center, Magellanic Clouds, and External Galaxies; Facilities and Instrumentation; the History of Airborne Astronomy; and more.

Confirmed Invited Speakers

- John Bally (Univ. of Colorado)
- Eric Becklin (SOFIA)
- Edith Falgarone (ENS, Paris)
- Uma Gorti (SETI/NASA Ames))
- Ralf Klessen (Univ. of Heidelberg)
- Charlie Lada (Harvard-Smithsonian, CFA)
- Karl Menten (MPIfR, Bonn)
- Mark Morris (UCLA)
- David Neufeld (Johns Hopkins Univ.)
- Gordon Stacey (Cornell Univ.)
- Jonathan Tan (Univ. of Florida)
- Xander Tielens (Leiden Univ.)
- Michael Werner (JPL)

Conference Venue: The Local Truth conference will be held at the beautiful Asilomar Conference Grounds in Pacific Grove, CA, near Monterey. Information about Asilomar is available at www.visitasilomar.com.

Conference Registration: Conference Registration is done through the USRA Meeting Portal. The registration fee is a flat $200 to be paid via credit card at the time of registration.

The deadline for registration is August 31, 2016 at 11:59 CDT (GMT - 5 hrs). Registration will not be available on-site, so please register now!

Abstract Submission: Abstract Submission is done through the USRA Meeting Portal. Abstracts will be accepted through October 7, 2016 at 11:59 CDT (GMT - 5 hrs). Attendees are invited to submit multiple abstracts, if desired, but we request that only one oral presentation be requested.

http://www.sofia.usra.edu/Asilomar2016

E-mail contact: starformation2016@sofia.usra.edu

Summary of Upcoming Meetings

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

EPoS 2016 The Early Phase of Star Formation - Progress after 10 years of EPoS
26 June - 1 July 2016, Ringberg Castle, Germany
http://www.mpia.de/homes/stein/EPoS/2016/2016.php

New Directions in Planet Formation
11 - 15 July 2016 Leiden, The Netherlands
https://www.lorentzcenter.nl/lc/web/2016/799/info.php3?wsid=799&venue=Oort

The role of feedback in the formation and evolution of star clusters
18 - 22 July 2016 Sexten, Italy
http://www.sexten-cfa.eu/en/conferences/2016/details/72-the-role-of-feedback-in-the-formation-and-evolution-

Binary Stars
24 - 30 July 2016, Cambridge, UK
http://www.ast.cam.ac.uk/meetings/2016/binary.stars.cambridge.2016

Star Formation in Different Environments
25 - 29 July 2016, Quy Nhon, Viet Nam
http://sfde16.0x1115.org/

First Stars V
1 - 5 August 2016 Heidelberg, Germany
http://www.lsw.uni-heidelberg.de/FirstStarsV

Star Clusters: from Infancy to Teenagehood
8 - 12 August 2016, Heidelberg, Germany
http://wwwstaff.ari.uni-heidelberg.de/infant_clusters_2016/

CLOUDY: Emission Lines in Astrophysics
8 - 12 August 2016, Mexico City, Mexico
https://sites.google.com/a/astro.unam.mx/cloudy2016/

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

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

Heating and Cooling Processes in the ISM
7 -9 September 2016 Cologne, Germany
https://www.astro.uni-koeln.de/hac2016

Linking Exoplanet and Disk Compositions
12 - 14 September, 2016 Baltimore, USA
http://www.stsci.edu/~banzatti/images/workshop.pdf

Interstellar shocks: models, observations & experiments
14-16 September 2016, Torun, Poland
http://shocks2016.faj.org.pl

Half a Decade of ALMA: Cosmic Dawns Transformed 20 - 23 September 2016 Indian Wells, USA
http://www.cvent.com/events/half-a-decade-of-alma-cosmic-dawns-transformed/event-summary-12c52aba23024057862

VIALACTEA2016: The Milky Way as a Star Formation Engine
26 - 30 September 2016, Rome, Italy
http://vialactea2016.iaps.inaf.it

The ISM-SPP Olympian School of Astrophysics 2016
3 - 7 October 2016, Mt. Olympus, Greece
http://school2016.olympiancfa.org/

The Local Truth: Galactic Star-formation and Feed-back in the SOFIA Era - Celebrating 50 years of airborne astronomy
16 - 20 October 2016, Pacific Grove, USA
http://www.sofia.usra.edu/Science/workshops/SOFIA_Conference_2016

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

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