THE STAR FORMATION NEWSLETTER

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

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The Star Formation Newsletter

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

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Cover Picture

The southern HII region RCW 32 (Gum 15) is here seen richly detailed in an image from the MPG/ESO 2.2-metre telescope at the La Silla Observatory in Chile. RCW 32 is located in Vela, at a distance of about 1 kpc, and is excited by the B0V star HD 74804 belonging to the 1 myr old cluster Collinder 197.

Image courtesy ESO.

Submitting your abstracts

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

David Soderblom

in conversation with Bo Reipurth

Q: *Your thesis from 1980 focused on rotational velocities and ages of solar-type stars. What led you to this choice?*

A: My advisor, George Herbig, was firmly of the mind that his students should choose their own topic for their thesis. By comparison, there were other professors at the University of California at Santa Cruz who assigned topics, and it is my feeling that they were, on average, less successful because a research career has to be self-defined.

As for my thesis, Andy Skumanich in 1972 published a very short ApJ Letter suggesting that activity and rotation both declined in solar-type stars in a power-law relation. Weber and Davis showed from straightforward considerations that it was possible to derive such a $t^{-1/2}$ relation like the one that Skumanich saw, but what Skumanich showed only went up to the age of the Hyades (600 Myr or so) for rotation, except for the Sun itself, of course. So I set out to use a new very-high resolution ($R \approx 120,000$) spectrograph I had built for the Lick 120-inch coudé to obtain line profiles that could be modeled and analyzed using a Fourier transform method developed by David Gray and Myron Smith.

Because of the high resolution and the use of a coudé auxiliary telescope of 0.6 m diameter, it was slow going in observing stars. I spent a week per month at Lick Observatory on Mount Hamilton for more than two years. But it worked. I estimated stellar ages in a rough way using their lithium abundances, a method I wouldn't use now.

Q: *You got to know your adviser George Herbig very well. Do you have any recollections you want to share?*

A: He was meticulous in his work and very much a virtuoso soloist. Nearly all his papers were single-author, and of the remainder he was nearly always first author, a working style very different from today. It was interesting to read in your book (http://ifa.hawaii.edu/SP1) the recollections of earlier students (1950s and 60s) about working with him at night and a fondness for Gilbert and Sullivan, because in the years I was with him he was always very quiet. We might listen to classical music on the radio (that was the only option, and the night assistant upstairs had to tune it), but that was it.

Q: *In 1991 you published a paper examining the relationship between chromospheric emission and age in late-type dwarfs and its implication for the star formation rate. What were your conclusions?*

A: I had a volume-complete sample of activity in G dwarfs from the Mount Wilson survey of Ca II H and K emission in nearby late-type dwarfs. Using that and the HK strength of the Sun (and its age), it was possible to reconstruct an activity-age relation and it fit the available data very well. That was based on assuming a constant star formation rate. There had been (and continue to be) other papers suggesting surges of one kind or another in the Galactic star formation rate, but they always fail to disprove the null hypothesis, which is the simplest relation, a constant SFR. I also worked with a student to get ages of well-separated binaries in which a fairly massive star (A-type) was with a G dwarf with known activity, as a way of adding in ages older than we had for the nearby clusters.

Q: *In the early 90's you and your collaborators published a very highly cited paper on the evolution of the lithium abundances of solar-type stars in the Pleiades. What accounts for the great interest in this particular paper?*

A: Burt Jones and I got very lucky. There had been reports of significant differences in lithium between some Pleiades K dwarfs of about the same color, and that seemed to contradict what was expected. (As an aside, new observations of lithium in stars *always* seemed to conflict with expectation based on previous samples.) Those Pleiades K dwarfs were faint for pre-Keck telescopes, but Steve Vogt had built the Hamilton spectrograph at the 120-inch coudé, and Burt and I had three nights to see if it was true or not. We were observing in November, which can be very problematic for Mount Hamilton, but the nights were all clear. Even more amazing for that site, we got great seeing. We kept cutting back exposure times because we could easily see our spectra were more than good enough to see star-to-star differences, and over those 3 nights we managed to march through about 100 Pleiads. It was exhilarating to collect so much great quality data. I believe this is still the single largest sample for a single cluster, and it led to the Pleiades being a benchmark sample to compare everything else to, in part because we could detect lithium well into the K stars; for any older sample those stars just have upper limits.

Q: *A simultaneous paper was on the rotation and chromo-*

spheric emission among F,G, and K dwarfs in the Pleiades.

A: That was using the same data, which included Hα and the Ca IRT lines but not H and K. The phenomenology of activity in the Pleiades is fascinating, with Hα especially showing a variety of emission profiles even in G dwarfs. I'm not surprised the lithium paper has been cited a lot, but I thought at the time that this paper on rotation and activity would be the one that got the most attention.

Q: *You have also taken an interest in young moving groups, and published a study of the Ursa Major group with Michel Mayor.*

A: Moving groups of stars are alluring because they offer the potential to study nearby examples of recently-formed stars. But are they all real? Olin Eggen for years promoted the existence of a number of moving groups, including some very old ones that are problematic on basic grounds because of Galactic forces that cause tidal disruption. It has taken some time since his passing for moving groups to take on new prominence, aided significantly by various surveys, especially the astrometric and X-ray ones. The Ursa Major Group was a notable exception at that time because it was possible to clearly identify a group of A stars in the constellation of Ursa Major that formed a nucleus and provided a well-defined age. A central point of our paper was that adding spectroscopic criteria for solar-type stars (activity in particular) led to a sample with tighter kinematics, strongly suggesting the active stars were bona fide members.

Q: *In 1998 you and your collaborators published a paper on the young quadruple system HD 98800. What warranted your attention to this system?*

A: HD 98800 is a quadruple system with three of the stars visible in spectra. It is made up of two spectroscopic pairs (an SB1 and an SB2) with about one-year periods orbiting each other with an ill-determined long-period orbit (>10,000 years). In recent years the SBs have appeared so close on the sky that they cannot be separated at the slit of a ground-based instrument. The spectroscopic orbits provide masses, and that's important because HD 98800 is part of the TW Hya group of pre-main sequence stars with an age of about 10 Myr. Accurate masses are rare for PMS stars, and having three in the same system makes it extraordinary as a test of PMS models. The system is not as T Tauri-like as TW Hya itself (in terms of activity, for instance), but it stands out because one of the spectroscopic pairs has an extremely large infrared excess, much larger than can arise from a disk around a star. My suspicion is that a normal flat disk is being illuminated by the *other* spectroscopic pair because they happen to be near each other right now.

Q: *You have written two major reviews, one in 2010 on the "Ages of Stars" in Annual Reviews, and another in 2014 on "Ages of Young Stars" for Protostars and Planets V. Where do you see the field moving in the future.*

A: I've been interested in ages ever since my thesis. I would describe my scientific interest as the life history of the Sun as told by the stars. That's not possible to do without ages. If we could determine ages both precisely and accurately then we could establish a true comparison sample for the Sun to gain insight into what the possible range of normal variance is. Ages of individual stars also matter enormously for trying to tell the history of our Galaxy. But stars do not reveal their ages easily or in any direct way. There is exactly one object in the Universe for which we have a precise age, and in that case we only know the age of the Sun because we can analyze solar system material in a laboratory. The Sun, like all other stars, tells us nothing directly of its own age.

The fundamental problems with determining ages remain, but it's encouraging to see the field moving forward. Gaia will matter enormously, but so will the major spectroscopic surveys underway or imminent. When it comes down to it, photometry can provide deep insights, but you still need a good spectrum – better yet multiple spectra over time – to understand a star.

Q: *How have you seen the profession of astronomy change over your career?*

A: I made my decision to become an astronomer when I declared my major as astronomy at Berkeley in 1967, just over 50 years ago. At the time it was a much smaller profession, mostly concentrated in a few key observatories and universities. Many, maybe most, publications were single-author. When the nights were cloudy you played pool or looked through the books and journals that were available. You got to meet a lot of other astronomers first hand, over meals in the dining hall, for instance.

Now we work in groups, often very large ones. A range of expertise is often needed for a project, but the general style of work has changed too. You now see groups producing many publications from a single comprehensive dataset. On the whole these are good changes, and the number of astronomers has grown enormously, and with that so has the number of symposia and workshops. The resources available to us, both facilities and funding, have also increased proportionately.

Today is probably the best time ever to be an astronomer, even taking into account the many stresses on us as individuals and a profession. I feel very fortunate to have seen first hand this transition from when photographic plates were still being used (I need never see another again) to detectors and instruments of exceptional capabilities. Each of those improvements enables new science by making it possible to see that which was previously hidden. Many new wonders are just around the corner.

Abstracts of recently accepted papers

Diverse protoplanetary disk morphology produced by a Jupiter-mass planet

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Combining hydrodynamic planet-disk interaction simulations with dust evolution models, we show that protoplanetary disks having a giant planet can reveal diverse morphology in (sub-)millimeter continuum, including a full disk without significant radial structure, a transition disk with an inner cavity, a disk with a single gap and a central continuum peak, and a disk with multiple rings and gaps. Such a diversity originates from (1) the level of viscous transport in the disk which determines the number of gaps a planet can open; (2) the size and spatial distributions of grains determined by the coagulation, fragmentation, and radial drift, which in turn affects the emmisivity of the disk at (sub-)millimeter wavelengths; and (3) the angular resolution used to observe the disk. In particular, our results show that disks having the same underlying gas distribution can have very different grain size/spatial distributions and thus appearance in continuum, depending on the interplay among coagulation, fragmentation, and radial drift. This suggests that proper treatments for the grain growth have to be included in models of protoplanetary disks concerning continuum properties and that complementary molecular line observations are highly desired in addition to continuum observations to reveal the true nature of disks. The fact that a single planet can produce diverse disk morphology emphasizes the need to search for more direct, localized signatures of planets in order to confirm (or dispute) the planetary origin of observed ringed substructures.

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CO destruction in protoplanetary disk midplanes: inside versus outside the CO snow surface

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CO has long been thought to be the best tracer to measure gas masses as it is readily detected at (sub)mm wavelengths in many disks. Inferred gas masses from CO in recent ALMA observations of large samples of disks seem inconsistent with their inferred dust masses. The derived gas-to-dust mass ratios from CO are 1–2 orders of magnitude lower than ∼100 even if photodissociation and freeze-out are included. Herschel measurements of HD line emission imply gas masses in line with gas-to-dust mass ratios of 100. This suggests that at least one additional mechanism is removing gaseous CO. Here we test the suggestion that the bulk of the CO is chemically processed and that the carbon is sequestered into less volatile species such as CO_2, CH_3OH and CH_4 in the dense, shielded midplane regions of the disk. Using our gas-grain chemical code we perform a parameter exploration and follow the CO abundance evolution over a range of conditions representative of shielded disk midplanes. We find that no chemical processing of CO takes place on 1–3 Myr timescales for low cosmic-ray ionisation rates, $< 5 \times 10^{-18}$ s^{-1}. Assuming an ionisation rate of 10^{-17} s^{-1}, more than 90% of the CO is destroyed, but only in the parts of the disk below 30 K. This order of magnitude destruction of CO is robust against the choice of grain-surface reaction rate parameters except for temperatures below

20 K, where there is a strong dependence on the H tunnelling barrier. The low temperatures needed for CO chemical processing indicate that the exact disk temperature structure is important, with warm disks around luminous Herbig stars expected to have little to no CO conversion. For cold disks around T Tauri stars, a large fraction of the emitting CO layer is affected unless the disks are young (<1 Myr). This can lead to inferred gas masses that are up to two orders of magnitude too low.

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http://arxiv.org/pdf/1808.02220

Trapping low-mass planets at the inner edge of the protostellar disc

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The formation of multiple close-in low-mass exoplanets is still a mystery. The challenge is to build a system wherein the outermost planet is beyond 0.2 AU from the star. Here we investigate how the prescription for type I planet migration affects the ability to trap multiple planets in a resonant chain near the inner edge of the protostellar disc. A sharp edge modelled as a hyperbolic tangent function coupled with supersonic corrections to the classical type I migration torques results in the innermost planets being pushed inside the cavity through resonant interaction with farther planets because migration is starward at slightly supersonic eccentricities. Planets below a few Earth masses are generally trapped in a resonant chain with the outermost planet near the disc edge, but long-term stability is not guaranteed. For more massive planets the migration is so fast that the eccentricity of the innermost resonant pair is excited to highly supersonic levels due to decreased damping on the innermost planet as it is pushed inside the cavity; collisions frequently occur and the system consists one or two intermediate-mass planets residing closer to the star than the disc's inner edge. We found a neat pileup of resonant planets outside the disc edge only if the corotation torque does not rapidly diminish at high eccentricity. We call for detailed studies on planet migration near the disc's inner edge, which is still uncertain, and for an improved understanding of eccentricity damping and disc torques in the supersonic regime.

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Mapping deuterated methanol toward L1544: I. Deuterium fraction and comparison with modeling

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The study of deuteration in pre-stellar cores is important to understand the physical and chemical initial conditions in the process of star formation. In particular, observations toward pre-stellar cores of methanol and deuterated methanol, solely formed on the surface of dust grains, may provide useful insights on surface processes at low temperatures. Here we analyze maps of CO, methanol, formaldehyde and their deuterated isotopologues toward a well-known pre-stellar core. This study allows us to test current gas-dust chemical models. Single-dish observations of CH_3OH, CH_2DOH, H_2CO, $H_2{}^{13}CO$, HDCO, D_2CO and $C^{17}O$ toward the prototypical pre-stellar core L1544 were performed at the IRAM 30 m telescope. We analyze their column densities, distributions, and compare these observations with gas-grain chemical models. The maximum deuterium fraction derived for methanol is $[CH_2DOH]/[CH_3OH] \sim 0.08\pm0.02$, while the measured deuterium fractions of formaldehyde at the dust peak are $[HDCO]/[H_2CO] \sim 0.03\pm0.02$, $[D_2CO]/[H_2CO] \sim 0.04\pm0.03$ and $[D_2CO]/[HDCO] \sim 1.2\pm0.3$. Observations differ significantly from the predictions of models, finding discrepancies between a factor of 10 and a factor of 100 in most cases. It is clear though that to efficiently produce methanol on the surface of dust grains, quantum tunneling diffusion of H atoms must be switched on. It also appears

that the currently adopted reactive desorption efficiency of methanol is overestimated and/or that abstraction reactions play an important role. More laboratory work is needed to shed light on the chemistry of methanol, an important precursor of complex organic molecules in space.

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http://arxiv.org/pdf/1808.09871

Planet Formation: An Optimized Population-Synthesis Approach

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The physics of planet formation is investigated using a population synthesis approach. We develop a simple model for planetary growth including pebble and gas accretion, and orbital migration in an evolving protoplanetary disk. The model is run for a population of 2000 stars with a range of disk masses and radii, and initial protoplanet orbits. The resulting planetary distribution is compared with the observed population of extrasolar planets, and the model parameters are improved iteratively using a particle swarm optimization scheme. The characteristics of the final planetary systems are mainly controlled by the pebble isolation mass, which is the mass of a planet that perturbs nearby gas enough to halt the inward flux of drifting pebbles and stop growth. The pebble isolation mass increases with orbital distance so that giant planet cores can only form in the outer disk. Giants migrate inwards, populating a wide range of final orbital distances. The best model fits have large initial protoplanet masses, short pebble drift timescales, low disk viscosities, and short atmospheric cooling times, all of which promote rapid growth. The model successfully reproduces the observed frequency and distribution of giant planets and brown dwarfs. The fit for super Earths is poorer for single-planet systems, but improves steadily when more protoplanets are included. Although the study was designed to match the extrasolar planet distribution, analogs of the Solar System form in 1–2% of systems that contain at least 4 protoplanets.

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http://arxiv.org/pdf/1808.03293

Interactions between Gas Dynamics and Magnetic Fields in the Massive Dense Cores of the DR21 Filament

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We report Submillimeter Array molecular line observations in the 345 GHz band of five massive dense cores, Cyg-N38, Cyg-N43, Cyg-N48, Cyg-N51, and Cyg-N53 in the DR21 filament. The molecular line data reveal several dynamical features of the cores: (1) prominent outflows in all cores seen in the CO and SiO lines, (2) significant velocity gradients in Cyg-N43 and Cyg-N48 seen in the $H^{13}CN$ and $H^{13}CO^+$ lines suggesting 0.1-pc-scale rotational motions, and (3) possible infalls in Cyg-N48 found in the SiO and SO lines. Comparing the molecular line data and our dust polarization data in Ching et al. (2017), we find that the gradients of line-of-sight velocities appear to be randomly oriented relative to the plane-of-sky magnetic fields. Our simulations suggest that this random alignment implies parallel or random alignment between the velocity gradients and magnetic fields in the three dimensional space. The linewidths of $H^{13}CN$

emission are consistently wider than those of $H^{13}CO^+$ emission in the $3''$–$10''$ detectable scales, which can be explained by the existence of ambipolar diffusion with maximum plane-of-the-sky magnetic field strengths of 1.9 mG and 5.1 mG in Cyg-N38 and Cyg-N48, respectively. Our results suggest that the gas dynamics may distort the magnetic fields of the cores of into complex structures and ambipolar diffusion could be important in dissipating the magnetic energies of the cores.

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On the possible common origin of M16 and M17

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It has been suggested that the well-studied giant HII regions M16 and M17 may have had a common origin, being an example of large-scale triggered star formation. While some features of the distribution of the interstellar medium in the region support this interpretation, no definitive detection of an earlier population of massive stars responsible for the triggering has been made thus far. We have carried out observations looking for red supergiants in the area covered by a giant shell seen in HI and CO centered on galactic coordinates $l \sim 14^\circ 5$, $b \sim +1^\circ$ that peaks near the same radial velocity as the bulk of the emission from both giant HII regions, which are located along the shell. Red supergiants have ages in the range expected for the parent association whose most massive members could have triggered the formation of the shell and of the giant HII regions along its rim. We have obtained spectroscopy in the visible of a sample of red stars selected on the basis of their infrared colors, whose magnitudes are consistent with them being red supergiants if they are located at the distance of M16 and M17. Spectroscopy is needed to distinguish red supergiants from AGB stars and RGB stars, which are expected to be abundant along the line of sight. Out of a sample of 37 bright red stars, we identify four red supergiants that confirm the existence of massive stars in the age range between ~ 10 and ~ 30 Myr in the area. At least three of them have Gaia DR2 parallaxes consistent with them being at the same distance as M16 and M17. The evidence of past massive star formation within the area of the gaseous shell lends support to the idea that it was formed by the combined action of stellar winds and ionizing radiation of the precursors of the current red supergiants. These could be the remnants of a richer population, whose most massive members have exploded already as core-collapse supernovae. The expansion of the shell against the surrounding medium, perhaps combined with the overrun of preexisting clouds, is thus a plausible trigger of the formation of a second generation of stars currently responsible for the ionization of M16 and M17.

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http://www.eso.org/~fcomeron/msg_M16M17.pdf

The Effect of Jupiter's Formation on the Distribution of Refractory Elements and Inclusions in Meteorites

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We present a comprehensive evolutionary model of the Sun's protoplanetary disk, constructed to resolve the "CAI storage problem" of meteoritics. We predict the abundances of calcium-rich, aluminum-rich inclusions (CAIs) and refractory lithophile elements under the central assumption that Jupiter's $\sim 30\,M_\oplus$ core formed at about 3 AU at around 0.6 Myr and opened a gap. CAIs were trapped in the pressure maximum beyond Jupiter; carbonaceous chondrites formed there. Inside Jupiter's orbit, CAIs were depleted by aerodynamic drag; ordinary and enstatite chondrites formed there. For 16 chondrites and achondrites, we review meteoritic data on their CAI and refractory abundances and their times of formation, constrained by radiometric dating and thermal models. We predict their formation locations, finding excellent consistency with other location information (water content, asteroid spectra and parent bodies). We predict the size of particle concentrated by turbulence for each chondrite, finding excellent matches to each chondrite's mean chondrule diameter. These consistencies imply meteorite parent bodies assembled quickly from local materials concentrated by turbulence, and usually did not migrate far. We predict CI chondrites are depleted in refractory lithophile elements relative to the Sun, by about 12% (0.06 dex). We constrain the variation of turbulence parameter α in the disk and find a limited role for magnetorotational instability, favoring hydrodynamical instabilities in the outer disk, plus magnetic disk winds in the inner disk. Between 3 and 4 Myr at least, gas persisted outside Jupiter but was depleted inside it, and the solar nebula was a transition disk.

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https://arxiv.org/pdf/1710.03809.pdf

Gas and multi-species dust dynamics in viscous protoplanetary discs: the importance of the dust back-reaction

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We study the dynamics of a viscous protoplanetary disc hosting a population of dust grains with a range of sizes. We compute steady-state solutions, and show that the radial motion of both the gas and the dust can deviate substantially from those for a single-size dust population. Although the aerodynamic drag from the dust on the gas is weaker than in the case where all grains are optimally coupled to the gas, the cumulative "back-reaction" of the dust particles can still alter the gas dynamics significantly. In typical protoplanetary discs, the net effect of the dust back-reaction decreases the gas accretion flow compared to the dust-free (viscous) case, even for dust-to-gas ratios of order 1%. In the outer disc, where dust grains are typically less strongly coupled to the gas and settle towards the midplane, the dust back-reaction can even drive outward gas flow. Moreover, the radial inward drift of large grains is reduced below the gas motion in the inner disc regions, while small dust grains follow the gas dynamics over all the disc extent. The resulting dust and gas dynamics can give rise to observable structures, such as gas and dust cavities. Our results show that the dust back-reaction can play a major role in both the dynamics and observational appearance of protoplanetary discs, and cannot be ignored in models of protoplanetary disc evolution.

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https://arxiv.org/pdf/1806.10148

Spectral Tomography for the Line-of-Sight Structures of the Taurus Molecular Cloud 1

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We clarify the line-of-sight structure of the Taurus Molecular Cloud 1 (TMC-1) on the basis of the CCS($J_N = 4_3 - 3_2$) and HC_3N($J = 5 - 4$) spectral data observed at a very high velocity resolution and sensitivity of $\Delta V \simeq 0.0004$ km s^{-1} (= 61 Hz) and $\Delta T_{\rm mb} \simeq 40$ mK. The data were obtained toward the cyanopolyyne peak with ∼30 hours integration using the Z45 receiver and the PolariS spectrometer installed in the Nobeyama 45m telescope. Analyses of the optically

thin $F = 4 - 4$ and $5 - 5$ hyperfine lines of the HC_3N emission show that the spectra consist of four distinct velocity components with a small line width ($\lesssim$0.1 km s^{-1}) at V_{LSR} =5.727, 5.901, 6.064, and 6.160 km s^{-1}, which we call A, B, C, and D, respectively, in the order of increasing LSR velocities. Utilizing the velocity information of the four velocity components, we further analyzed the optically thicker CCS spectrum and the other hyperfine lines of the HC_3N emission by solving the radiative transfer to investigate how the four velocity components overlap along the line of sight. Results indicate that they are located in the order of A, B, C, and D from far side to near side to the observer, indicating that TMC-1 is shrinking, moving inward as a whole.

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The Planck Cold Clump G108.37−01.06: A Site of Complex Interplay between HII Regions, Young Clusters and Filaments

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The *Planck* Galactic Cold Clumps (PGCCs) are the possible representations of the initial conditions and the very early stages of star formation. With an objective to understand better the star and star cluster formation, we probe the molecular cloud associated with PGCC G108.37−01.06 (hereafter, PG108.3), which can be traced in a velocity range −57 to −51 km s^{-1}. The IPHAS images reveal Hα emission at various locations around PG108.3, and optical spectroscopy of the bright sources in those zones of Hα emission disclose two massive ionizing sources with spectral type O8-O9V and B1V. Using the radio continuum, we estimate ionizing gas parameters and find the dynamical ages of HII regions associated with the massive stars in the range 0.5–0.75 Myr. Based on the stellar surface density map constructed from the deep near-infrared CHFT observations, we find two prominent star clusters in PG108.3; of which, the cluster associated with HII region S148 is moderately massive (∼240 $M_{\odot}$). A careful inspection of JCMT ^{13}CO(3–2) molecular data exhibits that the massive cluster is associated with a number of filamentary structures. Several embedded young stellar objects (YSOs) are also identified in the PG108.3 along the length and junction of filaments. We find the evidence of velocity gradient along the length of the filaments. Along with kinematics of the filaments and the distribution of ionized, molecular gas and YSOs, we suggest that the cluster formation is most likely due to the longitudinal collapse of the most massive filament in PG108.3.

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Formation of cometary O_2 ice and related ice species on grain surfaces in the midplane of the pre-Solar nebula

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The detection of abundant O_2 ice at 1–10% with respect to H_2O ice in the comae of comets 1P/Halley and 67P/Churyumov-Gerasimenko motivated attempts to explain the origin of the high O_2 ice abundance. Recent chemical modelling of the outer, colder regions of a protoplanetary disk midplane has shown production of O_2 ice at the same abundance as that measured in the comet. An updated chemical kinetics code is utilised here to evolve chemistry under pre-Solar nebula midplane conditions. Four different chemical starting conditions, and the effects of various chemical parameters are tested. The parameter space investigation revealed a sweet spot for production of O_2 ice at an abundance matching those in 67P and 1P, and O_3 and H_2O_2 ices abundances matching those in 67P. This means that there is a radial region in the pre-Solar nebula from 120–150 AU, within which O_2 could have been produced in-situ via ice chemistry on grain surfaces. However, it is apparent that there is a high degree of sensitivity of the chemistry to the assumed chemical

parameters (e.g. binding energy, activation barrier width, and quantum tunnelling barrier). Hence, because the more likely scenario starting with a percentage of elemental oxygen locked in O_2 also reproduces the O_2 ice abundance in 67P at early stages, this supports previous suggestions that the cometary O_2 ice could have a primordial origin.

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Protonated CO_2 in massive star-forming clumps

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Interstellar CO_2 is an important reservoir of carbon and oxygen, and one of the major constituents of the icy mantles of dust grains, but it is not observable directly in the cold gas because has no permanent dipole moment. Its protonated form, $HOCO^+$, is believed to be a good proxy for gaseous CO_2. However, it has been detected in only a few star-forming regions so far, so that its interstellar chemistry is not well understood. We present new detections of $HOCO^+$ lines in 11 high-mass star-forming clumps. Our observations increase by more than three times the number of detections in star-forming regions so far. We have derived beam-averaged abundances relative to H_2 in between 0.3 and 3.8×10^{-11}. We have compared these values with the abundances of $H^{13}CO^+$, a possible gas-phase precursor of $HOCO^+$, and CH_3OH, a product of surface chemistry. We have found a positive correlation with $H^{13}CO^+$, while with CH_3OH there is no correlation. We suggest that the gas-phase formation route starting from HCO^+ plays an important role in the formation of $HOCO^+$, perhaps more relevant than protonation of CO_2 (upon evaporation of this latter from icy dust mantles).

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Planetary tidal interactions and the rotational evolution of low-mass stars. The Pleiades' anomaly

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The surface angular velocity evolution of low-mass stars is now globally understood and the main physical mechanisms involved in it are observationally quite constrained. However, while the general behaviour of these mechanisms is grasped, their theoretical description is still under ongoing work. This is the case for instance about the description of the physical process that extract angular momentum from the radiative core, that could be described by several theoretical candidates. Additionally, recent observations showed anomalies in the rotation period distribution of open clusters main sequence early K-type stars that cannot be reproduced by current angular momentum evolution model. In this work, we study the parameter space of star-planet system's configurations to investigate if including the tidal star-planet interaction in angular momentum evolution models could reproduce these rotation period distribution's anomalies. To study this effect, we use a parametric angular momentum evolution model that allows for core-envelope decoupling and angular momentum extraction by magnetized stellar wind that we coupled to an orbital evolution code where we take into account the torque due to the tides raised on the star by the planet. We explore different stellar and planetary configurations (stellar mass from 0.5 to 1.0 $M_\odot$ and planetary mass from 10 $M_\oplus$ to 13 M_{jup}) to study their effect on the planetary orbital and stellar rotational evolution. The stellar angular momentum is the most impacted by the star-planet interaction when the planet is engulfed during the early main sequence phase. Thus, if a close-in Jupiter mass planet is initially located around 50% of the stellar corotation radius, a kink in the rotational

period distribution opens around late and early K-type stars during the early main sequence phase. Tidal star-planet interactions can create a kink in the rotation period distribution of low-mass stars, which could possibly account for unexpected scatter seen in the rotational period distribution of young stellar clusters.

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A high cluster formation efficiency in the Sagittarius B2 complex

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The fraction of stars forming in compact, gravitationally bound clusters (the 'cluster formation efficiency' or CFE) is an important quantity for deriving the spatial clustering of stellar feedback and for tracing star formation using stellar clusters across the Universe. Observations of clusters in nearby galaxies have revealed a strong dependence of the CFE on the local gas density, indicating that more stars form in star clusters when the star formation rate surface density is higher. Previously, it has not been possible to test this relation at very young ages and in clusters with individual stars resolved due to the universally-low densities in the cluster-forming regions in the Local Group. This has even led to the suggestion that the CFE increases with distance from the Sun, which would suggest an observational bias. However, the Central Molecular Zone of the Milky Way hosts clouds with densities that are orders of magnitude higher than anywhere else in the Local Group. We report a measurement of the CFE in the highest-density region in the Galaxy, Sgr B2, based on ALMA observations of high-mass young stellar objects. We find that over a third of the stars (37±7%) in Sgr B2 are forming in bound clusters. This value is consistent with the predictions of environmentally-dependent models for the CFE and is inconsistent with a constant CFE in the Galaxy.

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3D shape of Orion A from Gaia DR2

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We use the Gaia DR2 distances of about 700 mid-infrared selected young stellar objects in the benchmark giant molecular cloud Orion A to infer its 3D shape and orientation. We find that Orion A is not the fairly straight filamentary cloud that we see in (2D) projection, but instead a cometary-like cloud oriented toward the Galactic plane, with two distinct components: a denser and enhanced star-forming (bent) Head, and a lower density and star-formation quieter ∼75 pc long Tail. The true extent of Orion A is not the projected ∼40 pc but ∼90 pc, making it by

far the largest molecular cloud in the local neighborhood. Its aspect ratio (∼30:1) and high column-density fraction (∼45%) make it similar to large-scale Milky Way filaments ("bones"), despite its distance to the galactic mid-plane being an order of magnitude larger than typically found for these structures.

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Morphology of prestellar cores in pressure confined filaments

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Observations of prestellar cores in star-forming filaments show two distinct morphologies. While molecular line measurements often show broad cores, submillimeter continuum observations predominantly display pinched cores compared to the bulk of the filament gas. In order to explain how different morphologies arise, we use the gravitational instability model where prestellar cores form by growing density perturbations. The radial extent at each position is set by the local line-mass. We show that the ratio of core radius to filament radius is determined by the initial line-mass of the filament. Additionally, the core morphology is independent of perturbation length scale and inclination, which makes it an ideal diagnostic for observations. Filaments with a line-mass of less than half its critical value should form broad cores, whereas filaments with more than half its critical line-mass value should form pinched cores. For filaments embedded in a constant background pressure, the dominant perturbation growth times significantly differ for low and high line-mass filaments. Therefore, we predict that only one population of cores is present if all filaments within a region begin with similar initial perturbations.

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Constraining the gap size in the disk around HD 100546 in the mid-infrared

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We refine the gap size measurements of the disk surrounding the Herbig Ae star HD 100546 in the N band. Our new mid-infrared interferometric (MIDI) data have been taken with the UT baselines and span the full range of orientations. The correlated fluxes show a wavy pattern in which the minima separation links to a geometrical structure in the disk. We fit each correlated flux measurement with a spline function, deriving the corresponding spatial scale, while assuming that the pattern arises interferometrically due to the bright emission from the inner disk and the opposing sides of the wall of the outer disk. We then fit an ellipse to the derived separations at their corresponding position angles, thereby using the observations to constrain the disk inclination to $i = 47 \pm 1$ degree and the disk position angle to $PA = 135.0 \pm 2.5$ degree East of North, both of which are consistent with the estimated values in previous studies. We also derive the radius of the ellipse to 15.7±0.8 au. To confirm that the minima separations translate to a geometrical structure in the disk, we model the disk of HD 100546 using a semi-analytical approach taking into account the temperature and optical depth gradients. Using this model, we simultaneously reproduce the level and the minima of the correlated fluxes and constrain the gap size of the disk for each observation. The values obtained

for the projected gap size in different orientations are consistent with the separation found by the geometrical model.

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The dependence of stellar properties on initial cloud density

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We investigate the dependence of stellar properties on the initial mean density of the molecular cloud in which stellar clusters form using radiation hydrodynamical simulations that resolve the opacity limit for fragmentation. We have simulated the formation of three star clusters from the gravitational collapse of molecular clouds whose densities vary by a factor of a hundred. As with previous calculations including radiative feedback, we find that the dependence of the characteristic stellar mass, M_c, on the initial mean density of the cloud, ρ, is weaker than the dependence of the thermal Jeans mass. However, unlike previous calculations, which found no statistically significant variation in the median mass with density, we find a weak dependence approximately of the form $M_c \propto \rho^{-1/5}$. The distributions of properties of multiple systems do not vary significantly between the calculations. We compare our results to the result of observational surveys of star-forming regions, and suggest that the similarities between the properties of our lowest density calculation and the nearby Taurus-Auriga region indicate that the apparent excess of solar-type stars observed may be due to the region's low density.

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Sink particle radiative feedback in smoothed particle hydrodynamics models of star formation

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We present a new method for including radiative feedback from sink particles in smoothed particle hydrodynamics simulations of low-mass star formation, and investigate its effects on the formation of small stellar groups. We find that including radiative feedback from sink particles suppresses fragmentation even further than calculations that only include radiative transfer within the gas. This reduces the star-formation rate following the formation of the initial protostars, leading to fewer objects being produced and a lower total stellar mass. The luminosities of sink particles vary due to changes in the accretion rate driven by the dynamics of the cluster gas, leading to different luminosities for protostars of similar mass. Including feedback from sinks also raises the median stellar mass. The median masses of the groups are higher than typically observed values. This may be due to the lack of dynamical interactions and ejections in small groups of protostars compared to those that occur in richer groups. We also find that the temperature distributions in our calculations are in qualitative agreement with recent observations of protostellar heating in Galactic star-forming regions.

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The ALMA-PILS survey: Isotopic composition of oxygen-containing complex organic molecules toward IRAS 16293–2422B

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One of the important questions of astrochemistry is how complex organic molecules, including potential pre-biotic species, are formed in the envelopes around embedded protostars. The abundances of minor isotopologues of a molecule, in particular the D- and ^{13}C-bearing variants, are sensitive to the densities, temperatures, and time-scales characteristic of the environment in which they form, and can therefore provide important constraints on the formation routes and conditions of individual species. The aim of this paper is to systematically survey the deuteration and the ^{13}C content of a variety of oxygen-bearing complex organic molecules on Solar System scales toward the 'B component' of the protostellar binary IRAS 16293–2422. We have used the data from an unbiased molecular line survey of the protostellar binary IRAS 16293−2422 between 329 and 363 GHz from the Atacama Large Millimeter/submillimeter Array (ALMA). The data probe scales of 60 AU (diameter) where most of the organic molecules are expected to have sublimated off dust grains and be present in the gas-phase. The deuterated and ^{13}C-isotopic species of ketene, acetaldehyde, and formic acid, as well as deuterated ethanol, are detected unambiguously for the first time in the interstellar medium. These species are analysed together with the ^{13}C isotopic species of ethanol, dimethyl ether and methyl formate along with mono-deuterated methanol, dimethyl ether and methyl formate. The complex organic molecules can be divided into two groups with one group, the simpler species, showing a D/H ratio of $\approx 2\%$ and the other, the more complex species, D/H ratios of 4–8%. This division may reflect the formation time of each species in the ices before or during warm-up/infall of material through the protostellar envelope. No significant differences are seen in the deuteration of different functional groups for individual species, possibly a result of the short time-scale for infall through the innermost warm regions where exchange reactions between different species may be taking place. The species show differences in excitation temperatures between 125 K and 300 K. This likely reflects the binding energies of the individual species, in good agreement to what has previously been found for high-mass sources. For dimethyl ether the ^{12}C/^{13}C ratio is found to be lower by up to a factor of two compared to typical ISM values similar to what has previously been inferred for glycolaldehyde. Tentative identifications suggest that the same may apply for ^{13}C isotopologues of methyl formate and ethanol. If confirmed, this may be a clue to their formation at the late prestellar or early protostellar phases with an enhancement of the available ^{13}C relative to ^{12}C related to small differences in binding energies for CO isotopologues or the impact of FUV irradiation by the central protostar. The results point to the importance of ice surface chemistry for the formation of these complex organic molecules at different stages in the evolution of embedded protostars and demonstrate the use of accurate isotope measurements for understanding the history of individual species.

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Distortion of Magnetic Fields in a Starless Core IV: Magnetic Field Scaling on Density and Mass-to-flux Ratio Distribution in FeSt 1-457

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In the present study, the magnetic field scaling on density, $|B| \propto \rho^{\kappa}$, was revealed in a single starless core for the first time. The κ index of 0.78 ± 0.10 was obtained toward the starless dense core FeSt 1-457 based on the analysis of the radial distribution of the polarization angle dispersion of background stars measured at the near-infrared wavelengths. The result prefers $\kappa = 2/3$ for the case of isotropic contraction, and the difference of the observed value from $\kappa = 1/2$ is 2.8 sigma. The distribution of the ratio of mass to magnetic flux was evaluated. FeSt 1-457 was found to be magnetically supercritical near the center ($\lambda \approx 2$), whereas nearly critical or slightly subcritical at the core boundary ($\lambda \approx 0.98$). Ambipolar-diffusion-regulated star formation models for the case of moderate magnetic field strength may explain the physical status of FeSt 1-457. The mass-to-flux ratio distribution for typical dense cores (critical Bonnor–Ebert sphere with central $\lambda = 2$ and $\kappa = 1/2$–$2/3$) was calculated and found to be magnetically critical/subcritical at the core edge, which indicates that typical dense cores are embedded in and evolve from magnetically critical/subcritical diffuse surrounding medium.

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The JCMT Gould Belt Survey: SCUBA-2 Data-Reduction Methods and Gaussian Source Recovery Analysis

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The JCMT Gould Belt Survey was one of the first Legacy Surveys with the James Clerk Maxwell Telescope in Hawaii, mapping 47 square degrees of nearby ($<$ 500 pc) molecular clouds in both dust continuum emission at 850 μm and 450 μm, as well as a more-limited area in lines of various CO isotopologues. While molecular clouds and the material that forms stars have structures on many size scales, their larger-scale structures are difficult to observe reliably in the submillimetre regime using ground-based facilities. In this paper, we quantify the extent to which three subsequent data-reduction methods employed by the JCMT GBS accurately recover emission structures of various size scales, in particular, dense cores which are the focus of many GBS science goals. With our current best data-reduction procedure, we expect to recover 100% of structures with Gaussian sigma sizes of $\leq 30''$ and intensity peaks of at least five times the local noise for isolated peaks of emission. The measured sizes and peak fluxes of these compact structures are reliable (within 15% of the input values), but source recovery and reliability both decrease significantly for larger emission structures and for fainter peaks. Additional factors such as source crowding have not been tested in our analysis. The most recent JCMT GBS data release includes pointing corrections, and we demonstrate that these tend to decrease the sizes and increase the peak intensities of compact sources in our dataset, mostly at a low level (several percent), but occasionally with notable improvement.

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Zooming in to Massive Star Birth

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We present high resolution (0.2", 1000 AU) 1.3 mm *ALMA* observations of massive infrared dark cloud clump, G028.37+00.07-C1, thought to harbor the early stages of massive star formation. Using N_2D^+(3-2) we resolve the previously identified C1-S core, separating the bulk of its emission from two nearby protostellar sources. C1-S is thus identified as a massive ($\sim 50 M_\odot$), compact ($\sim$ 0.1pc diameter) starless core, e.g., with no signs of outflow activity. Being highly deuterated, this is a promising candidate for a pre-stellar core on the verge of collapse. An analysis of its dynamical state indicates a sub-virial velocity dispersion compared to a trans-Alfvénic turbulent core model. However, virial equilibrium could be achieved with sub-Alfvénic conditions involving $\sim$ 2mG magnetic field strengths.

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Dust segregation in Hall-dominated turbulent protoplanetary disks

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Imaging of dust continuum emitted from disks around nearby protostars reveals diverse substructure. In recent years, theoretical efforts have been intensified to investigate in how far the intrinsic dynamics of protoplanetary disks (PPDs) can lead to such features. Turbulence in the realm of non-ideal magnetohydrodynamics (MHD) is one candidate for explaining the generation of zonal flows which can lead to local dust enhancements. Adopting a radially-varying cylindrical disk model, and considering combinations of vertical and azimuthal initial net flux, we perform 3D non-ideal MHD simulations aimed at studying self-organization induced by the Hall effect in turbulent PPDs. To this end, new modules have been incorporated into the Nirvana-iii and fargo3d codes. We moreover include dust grains, treated in the fluid approximation, in order to study their evolution subject to the emerging zonal flows. In the regime of a dominant Hall effect, we robustly obtain large-scale organized concentrations in the vertical magnetic field that remain stable for hundreds of orbits. For disks with vertical initial net flux alone, we confirm the presence of zonal flows and vortices that introduce regions of super-Keplerian gas flow. Including a moderately strong net-azimuthal magnetic flux can significantly alter the dynamics, partially preventing the self-organization of zonal flows. For plasma beta-parameters < 50, large-scale near-axisymmetric structures develop in the vertical magnetic flux. In all cases, we demonstrate that the emerging features are capable of accumulating dust grains for a range of Stokes numbers.

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Transport of CO in Protoplanetary Disks: Consequences of Pebble Formation, Settling, and Radial Drift

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Current models of (exo)planet formation often rely on a large influx of so-called 'pebbles' from the outer disk into the planet formation region. In this paper, we investigate how the formation of pebbles in the cold outer regions of protoplanetary disks and their subsequent migration to the inner disk can alter the gas-phase CO distribution both interior and exterior to the midplane CO snowline. By simulating the resulting CO abundances in the midplane as well as the warm surface layer, we identify observable signatures of large-scale pebble formation and migration that can be used as 'smoking guns' for these important processes. Specifically, we find that after 1 Myr, the formation and settling of icy pebbles results in the removal of up to 80% of the CO vapor in the warm ($T > 22$ K) disk layers outside the CO snowline, while the radial migration of pebbles results in the generation of a plume of CO vapor interior the snowline, increasing the CO abundance by a factor $\sim 2-6$ depending on the strength of the turbulence and the sizes of the individual pebbles. The absence of this plume of CO vapor in young nearby disks could indicate efficient conversion of CO into a more refractory species, or a reduction in the radial mass flux of pebbles by, for example, disk inhomogeneities or early planetesimal formation.

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Revisiting the pre-main-sequence evolution of stars II. Consequences of planet formation on stellar surface composition

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We want to investigate how planet formation is imprinted on stellar surface composition using up-to-date stellar evolution models. We simulate the evolution of pre-main-sequence stars as a function of the efficiency of heat injection during accretion, the deuterium mass fraction, and the stellar mass. For simplicity, we assume that planet formation leads to the late accretion of zero-metallicity gas, diluting the surface stellar composition as a function of the mass of the stellar outer convective zone. We adopt $150M_\oplus(M_\star/M_\odot)(Z/Z_\odot)$ as an uncertain but plausible estimate of the mass of heavy elements that is not accreted by stars with giant planets, including our Sun. By combining our stellar evolution models to these estimates, we evaluate the consequences of planet formation on stellar surface composition. We show that after the first $\sim$0.1 Myr, the evolution of the convective zone follows classical evolutionary tracks within a factor of two in age. We find that planet formation should lead to a scatter in stellar surface composition that is larger for high-mass stars than for low-mass stars. We predict a spread in [Fe/H] of approximately 0.02 dex for stars with $T_{\rm eff} \sim 5500$ K, marginally compatible with differences in metallicities observed in some binary stars with planets. Stars with $T_{\rm eff} \geq 7000$ K may show much larger [Fe/H] deficits, by 0.6 dex or more, compatible with the existence of refractory-poor λ Boo stars. We also find that planet formation may explain the lack of refractory elements seen in the Sun as compared to solar twins, but only if the ice-to-rock ratio in the solar-system planets is less than $\approx$0.4 and planet formation began less than $\approx$1.3 Myr after the beginning of the formation of the Sun.

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Multiplicity of disc-bearing stars in Upper Scorpius and Upper Centaurus-Lupus

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We present observations of disc-bearing stars in Upper Scorpius (US) and Upper Centaurus-Lupus (UCL) with moderate resolution spectroscopy in order to determine the influence of multiplicity on disc persistence after $\sim 5-20$ Myr. Discs were identified using infra-red (IR) excess from the Wide-field Infra-red Survey Explorer (WISE) survey. Our survey consists of 55 US members and 28 UCL members, using spatial and kinematic information to assign a probability of membership. Spectra are gathered from the ANU 2.3m telescope using the Wide Field Spectrograph (WiFeS) to detect radial velocity variations that indicate the presence of a companion. We identify 2 double-lined spectroscopic binaries, both of which have strong IR excess. We find the binary fraction of disc bearing stars in US and UCL for periods up to 20 years to be $0.06^{+0.07}_{-0.02}$ and $0.13^{+0.06}_{-0.03}$ respectively. Based on the multiplicity of field stars, we obtain an expected binary fraction of $\sim 0.12^{+0.02}_{-0.01}$. The determined binary fractions for disc-bearing stars does not vary significantly from the field, suggesting that the overall lifetime of discs may not differ between single and binary star systems.

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A large-scale survey of CO and its isotopologues toward the Rosette molecular cloud

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Using the PMO-13.7m millimeter telescope at Delingha in China, we have conducted a large-scale simultaneous survey of ^{12}CO, ^{13}CO, and $C^{18}O$ J=1-0 emission toward the Rosette molecular cloud (RMC) region with a sky coverage of 3.5×2.5 deg^2. The majority of the emission in the region comes from the RMC complex with velocities lying in the range from -2 km s^{-1} to 20.5 km s^{-1}. Beyond this velocity range, 73 molecular clumps are identified with kinematic distances from 2.4 kpc to 11 kpc. Based on the spatial and velocity distribution, nine individual clouds, C1-C9, have been identified for the RMC complex. It appears that the C3 cloud is different from other clouds in the RMC complex in view of its characteristic velocity, excitation temperature, and velocity dispersion. Most of the young stellar clusters in the region are located in positions of both high column density and high excitation temperature. Seven new molecular filaments are discovered in the RMC complex. Evidence for cloud-cloud collision is found in the region of young stellar clusters REFL9 and PouF, showing that these young stellar clusters probably result from a cloud-cloud collision. The abundance ratios of ^{13}CO to $C^{18}O$ in the region have a mean value of 13.7 which is 2.5 times larger than the solar system value, showing that UV photons from the nearby OB clusters have strong influence on the chemistry of clouds in the RMC complex.

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The formation of peptide-like molecules on interstellar dust grains

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Molecules with an amide functional group resemble peptide bonds, the molecular bridges that connect amino acids, and may thus be relevant in processes that lead to the formation of life. In this study, the solid state formation of some of the smallest amides is investigated in the laboratory. To this end, CH_4:HNCO ice mixtures at 20 K are irradiated with far-UV photons, where the radiation is used as a tool to produce the radicals required for the formation of the amides. Products are identified and investigated with infrared spectroscopy and temperature programmed desorption mass spectrometry.
The laboratory data show that NH_2CHO, CH_3NCO, $NH_2C(O)NH_2$, $CH_3C(O)NH_2$ and CH_3NH_2 can simultaneously be formed. The NH_2CO radical is found to be key in the formation of larger amides. In parallel, ALMA observations towards the low-mass protostar IRAS 16293−2422B are analysed in search of CH_3NHCHO (N-methylformamide) and $CH_3C(O)NH_2$ (acetamide). $CH_3C(O)NH_2$ is tentatively detected towards IRAS 16293−2422B at an abundance comparable with those found towards high-mass sources. The combined laboratory and observational data indicates that NH_2CHO and $CH_3C(O)NH_2$ are chemically linked and form in the ice mantles of interstellar dust grains. A solid-state reaction network for the formation of these amides is proposed.

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A Submillimeter Burst of S255IR SMA1 - The Rise And Fall Of Its Luminosity

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Temporal photometric variations at near infrared to submillimeter wavelengths have been found in low-mass young stellar objects. These phenomena are generally interpreted as accretion events of star-disk systems with varying accretion rates. There is growing evidence suggesting that similar luminosity flaring also occurs in high-mass star/cluster-forming regions. We report in this Letter the rise and fall of the 900 μm continuum emission and the newly found 349.1 GHz methanol maser emission in the massive star forming region S255IR SMA1 observed with the Submillimeter Array and the Atacama Large Millimeter/submillimeter Array. The level of flux variation at a factor of $\sim$2 at the submillimeter band and the relatively short 2-year duration of this burst suggest that the event is probably similar to those milder and more frequent minor bursts seen in 3D numerical simulations.

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The HH30 edge-on T Tauri star
A rotating and precessing monopolar outflow scrutinized by ALMA

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The disk-outflow connection is thought to play a key role in extracting excess angular momentum from a forming protostar. We present ALMA $0''.25$ angular resolution observations — in the dust continuum at 1.33 mm and of the molecular line transitions of ^{12}CO(2–1) and ^{13}CO(2–1) — of the circumstellar disk and outflow around the T Tauri star HH30, a rare and beautiful example of a pre-main sequence star exhibiting a flared edge-on disk, an optical jet, and a CO molecular outflow.
The 1.3 mm continuum emission shows a remarkable elongated morphology along PA$= 31.2° \pm 0.1°$ that has a constant brightness out to a radius of $r = 75$ au. The emission is marginally resolved in the transverse direction, implying an intrinsic vertical width $\leq$24 au and an inclination to the line-of-sight $i \geq 84.8°$. The monopolar outflow, detected in ^{12}CO, arises from the north-eastern face of the disk from a disk radius $r \leq 22$ au and extends up to $5''$ (or 700 au) above the disk plane.
We derive a lower limit to the total mass of the CO cavity/outflow of $1.7 \times 10^{-5}\ M_\odot$. The CO cavity morphology is that of a hollow cone with semi-opening angle $\sim$35°. The derived kinematics are consistent with gas flowing along the conical surface with a constant velocity of 9.3$\pm$0.7 km/s. We detect small rotation signatures ($V_\phi \times \sin i \in [0.1; 0.5]$ km s^{-1}) in the same sense as the underlying circumstellar disk. From these rotation signatures we infer an average specific angular momentum of the outflow of 38$\pm$15 au km s^{-1} at altitudes $z < 250$ au. We also report the detection of small amplitude wiggling (1.2°) of the CO axis around an average inclination to the line of sight of $i = 91°$.
The derived morphology and kinematics of the CO cavity are compatible with expectations from a slow disk wind, originating either through photo-evaporation or magneto-centrifugal processes.

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Multiple rings in the transitional disk of GM Aurigae revealed by VLA and ALMA

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Our understanding of protoplanetary disks is rapidly departing from the classical view of a smooth, axisymmetric disk. This is in part thanks to the high angular resolution that (sub)mm observations can provide. Here we present the combined results of ALMA (0.9 mm) and VLA (7 mm) dust continuum observations toward the protoplanetary disk around the solar analogue GM Aur. Both images clearly resolve the $\sim$35 au inner cavity. The ALMA observations also reveal a fainter disk that extends up to $\sim$ 250 au. We model our observations using two approaches: an analytical fit to the observed deprojected visibilities, and a physical disk model that fits the SED as well as the VLA and ALMA observations. Despite not being evident in the deconvolved images, the VLA and ALMA visibilities can only be fitted with two bright rings of radii $\sim$40 and $\sim$80 au. Our physical model indicates that this morphology is the result of an accumulation or trapping of large dust grains, probably due to the presence of two pressure bumps in the disk. Even though alternative mechanisms cannot be discarded, the multiple rings suggest that forming planets may have cleared at least two gaps in the disk. Finally, our analysis suggests that the inner cavity might display different sizes at 0.9 mm and 7 mm. This discrepancy could be caused by the presence of free-free emission close to the star at 7 mm, or by a more compact accumulation of the large dust grains at the edge of the cavity.

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Pyroclastic Blowout: Dust Survival in Isolated versus Clustered Supernovae

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Following the current debate on the fate of SN-condensed dust grains, here we explore by means of three-dimensional hydrodynamical simulations the interaction of dusty supernova remnants (SNRs) with the shocked winds of neighboring massive stars within young massive stellar clusters (SSCs). As a comparison, we have also explored the evolution of supernova remnants in the diffuse ISM with constant density. Since the hydrodynamics of SNRs is intimately related to the properties of their immediate environment, the lifecycle of dust grains in SNRs within SSCs is radically different from that in the diffuse ISM. Moreover, off-centered SNRs evolving in the steep density gradient established due to a star cluster wind experience a blowout phase: shell fragmentation due to protruding Rayleigh-Taylor instabilities and the venting of SN ejecta. Our main finding is that clustered SN explosions will cause a net increase in the amount of dust in the surroundings of young massive stellar clusters. Our analysis considers the multiple dust processing resulting from the passage of the SN reverse shock, including its reflection at the SNR's center, the injection of shocked stellar winds within the respective remnant's volume and the effect of secondary forward shocks produced in sequential SN explosions. In the simulations, we have on-the-fly calculated the rates of thermal sputtering and dust-induced radiative cooling provided an initial distribution of grain sizes and dust content. Fast-moving elongated dusty SN ejecta resemble mushroom clouds violently ascending in a stratified atmosphere after volcanic super-eruptions, where the pyroclasts carried by the clouds are wind-driven and eventually accumulate into the vast surroundings.

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First Results of an ALMA Band 10 Spectral Line Survey of NGC 6334I: Detections of Glycolaldehyde ($HC(O)CH_2OH$) and a New Compact Bipolar Outflow in HDO and CS

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We present the first results of a pilot program to conduct an ALMA Band 10 spectral line survey of the high-mass star-forming region NGC 6334I. The observations were taken in exceptional weather conditions (0.19 mm precipitable water) with typical system temperatures $T_{\rm sys}$ <950 K at ∼890 GHz. A bright, bipolar north-south outflow is seen in HDO and CS emission, driven by the embedded massive protostar MM1B. This has allowed, for the first time, a direct comparison of the thermal water in this outflow to the location of water maser emission from prior 22 GHz VLA observations. The maser locations are shown to correspond to the sites along the outflow cavity walls where high velocity gas impacts the surrounding material. We also compare our new observations to prior *Herschel* HIFI spectral line survey data of this field, detecting an order of magnitude more spectral lines (695 vs 65) in the ALMA data. We focus on the strong detections of the complex organic molecule glycolaldehyde ($HC(O)CH_2OH$) in the ALMA data that is not detected in the heavily beam-diluted HIFI spectra. Finally, we stress the need for dedicated THz laboratory spectroscopy to support and exploit future high-frequency molecular line observations with ALMA.

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A global correlation linking young stars, clouds, and galaxies. Towards a unified view of star formation.

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Context: The star formation rate (SFR) linearly correlates with the amount of dense gas mass (M_{dg}) involved in the formation of stars both for distant galaxies and clouds in our Galaxy. Similarly, the mass accretion rate ($\dot{M}_{\rm acc}$) and the disk mass (M_{disk}) of young, Class II stars are also linearly correlated.
Aims: We aim to explore the conditions under which the previous relations could be unified.
Methods: Observational values of SFR, M_{dg}, $\dot{M}_{\rm acc}$, and M_{disk} for a representative sample of galaxies, star forming clouds, and young stars have been compiled from the literature. Data were plotted together in order to analyze how the rate of gas transformed into stars and the mass of dense gas directly involved in this transformation relate to each other over vastly different physical systems.
Results: A statistically significant correlation is found spanning $\sim$ 16 orders of magnitude in each axis, but with large scatter. This probably represents one of the widest ranges of any empirical correlation known, encompassing galaxies that are several kiloparsec in size, parsec-size star-forming clouds within our Galaxy, down to young, pre-main sequence stars with astronomical unit-size protoplanetary disks. Assuming that this global correlation has an underlying physical reason, we propose a bottom-up hypothesis suggesting that a relation between $\dot{M}_{\rm acc}$ and the total circumstellar mass surrounding Class 0/I sources (M_{cs}; disk+envelope) drives the correlation in clouds that host protostars and galaxies that host clouds. This hypothesis is consistent with the fact that the SFRs derived for clouds over a timescale of 2 Myr can be roughly recovered from the sum of instantaneous accretion rates of the protostars embedded within them, implying that galactic SFRs averaged over $\sim$ 10-100 Myr should be constant over this period too. Moreover, the sum of the circumstellar masses directly participating in the formation of the protostellar population in a cloud likely represents a non-negligible fraction of the dense gas mass within the cloud.
Conclusions: If the fraction of gas directly participating in the formation of stars is $\sim$ 1-35% of the dense gas mass associated with star-forming clouds and galaxies, then the global correlation for all scales has a near unity slope and an intercept consistent with the (proto-)stellar accretion timescale, $M_{cs}/\dot{M}_{\rm acc}$. Therefore, an additional critical test of our hypothesis is that the $\dot{M}_{\rm acc}$-M_{disk} correlation for Class II stars should also be observed between $\dot{M}_{\rm acc}$ and M_{cs} for Class 0/I sources with similar slope and intercept.

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Protostellar classification using supervised machine learning algorithms

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Classification of young stellar objects (YSOs) into different evolutionary stages helps us to understand the formation process of new stars and planetary systems. Such classification has traditionally been based on spectral energy distribution (SED) analysis. An alternative approach is provided by supervised machine learning algorithms, which can be trained to classify large samples of YSOs much faster than via SED analysis. We attempt to classify a sample of Orion YSOs (the parent sample size is 330) into different classes, where each source has already been classified using multiwavelength SED analysis. We used eight different learning algorithms to classify the target YSOs, namely a decision tree, random forest, gradient boosting machine (GBM), logistic regression, naïve Bayes classifier, *k*-nearest neighbour classifier, support vector machine, and neural network. The classifiers were trained and tested by using a 10-fold cross-validation procedure. As the learning features, we employed ten different continuum flux densities spanning from the near-infrared to submillimetre wavebands (3.6 - 870 μm). With a classification accuracy of 82% (with respect to the SED-based classes), a GBM algorithm was found to exhibit the best performance. The lowest accuracy of 47% was obtained with a nave Bayes classifier. Our analysis suggests that the inclusion of the 3.6 μm

and 24 μm flux densities is useful to maximise the YSO classification accuracy. Although machine learning has the potential to provide a rapid and fairly reliable way to classify YSOs, an SED analysis is still needed to derive the physical properties of the sources (e.g. dust temperature and mass), and to create the labelled training data. The machine learning classification accuracies can be improved with respect to the present results by using larger data sets, more detailed missing value imputation, and advanced ensemble methods (e.g. extreme gradient boosting). Overall, the application of machine learning is expected to be very useful in the era of big astronomical data, for example to quickly assemble interesting target source samples for follow-up studies.

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Protoplanetary Disk Sizes and Angular Momentum Transport

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In young circumstellar disks, accretion–the inspiral of disk material onto the central star–is important for both the buildup of stellar masses and the outcome of planet formation. Although the existence of accretion is well documented, understanding the angular momentum transport mechanism that enables disk accretion has proven to be an enduring challenge. The leading theory to date, the magnetorotational instability, which redistributes angular momentum within the disk, is increasingly questioned, and magnetothermal disk winds, which remove angular momentum from the disk, have emerged as an alternative theoretical solution. Here we investigate whether measurements of disk radii can provide useful insights into which, if either, of these mechanisms drive disk accretion, by searching for evidence of viscous spreading in gaseous disks, a potential signature of “in disk” angular momentum transport. We find that the large sizes of most Class II (T Tauri) gas disks compared to those of their earlier evolutionary counterparts, Class I gas disks, are consistent with expectations for viscous spreading in the Class II phase. There is, however, a large spread in the sizes of Class II gas disks at any age, including a population of very small Class II gas disks. Their small sizes may result from processes such as photoevaporation, disk winds, or truncation by orbiting low mass companions.

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Warping a protoplanetary disc with a planet on an inclined orbit

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Recent observations of several protoplanetary discs have found evidence of departures from flat, circular motion in the inner regions of the disc. One possible explanation for these observations is a disc warp, which could be induced by a planet on a misaligned orbit. We present three-dimensional numerical simulations of the tidal interaction between a protoplanetary disc and a misaligned planet. For low planet masses we show that our simulations accurately model the evolution of inclined planet orbit (up to moderate inclinations). For a planet massive enough to carve a gap, the disc is separated into two components and the gas interior and exterior to the planet orbit evolve separately, forming an inner and outer disc. Due to the inclination of the planet, a warp develops across the planet orbit such that there is a relative tilt and twist between these discs. We show that when other parameters are held constant, the relative inclination that develops between the inner and outer disc depends on the outer radius of the total disc modelled. For a given disc mass, our results suggest that the observational relevance of the warp depends more strongly on the mass of the planet rather than the inclination of the orbit.

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The Gould's Belt Distances Survey (GOBELINS). V. Distances and Kinematics of the Perseus molecular cloud

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We derive the distance and structure of the Perseus molecular cloud by combining trigonometric parallaxes from Very Long Baseline Array (VLBA) observations, taken as part of the GOBELINS survey, and Gaia Data Release 2. Based on our VLBA astrometry, we obtain a distance of 321±10 pc for IC 348. This is fully consistent with the mean distance of 320±26 measured by Gaia. The VLBA observations toward NGC 1333 are insufficient to claim a successful distance measurement to this cluster. Gaia parallaxes, on the other hand, yield a mean distance of 293±22 pc. Hence, the distance along the line of sight between the eastern and western edges of the cloud is ∼30 pc, which is significantly smaller than previously inferred. We use Gaia proper motions and published radial velocities to derive the spatial velocities of a selected sample of stars. The average velocity vectors with respect to the LSR are ($\bar{u}$, $\bar{v}$, $\bar{w}$) = (−6.1±1.6, 6.8±1.1, −0.9±1.2) and (−6.4±1.0, 2.1±1.4, −2.4±1.0) km/s for IC 348 and NGC 1333, respectively. Finally, our analysis of the kinematics of the stars has shown that there is no clear evidence of expansion, contraction, or rotational motions within the clusters.

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First Observations of the Magnetic Field inside the Pillars of Creation: Results from the BISTRO Survey

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We present the first high-resolution, submillimeter-wavelength polarimetric observations of and thus direct observations of the magnetic field morphology within the dense gas of the Pillars of Creation in M16. These 850 μm observations, taken as part of the B-Fields in Star-forming Region Observations Survey (BISTRO) using the POL-2 polarimeter on the Submillimeter Common-User Bolometer Array 2 (SCUBA-2) camera on the James Clerk Maxwell Telescope (JCMT), show that the magnetic field runs along the length of the Pillars, perpendicular to and decoupled from the field in the surrounding photoionized cloud. Using the Chandrasekhar-Fermi method we estimate a plane-of-sky magnetic field strength of 170 – 320 μG in the Pillars, consistent with their having been formed through the compression of gas with initially weak magnetization. The observed magnetic field strength and morphology suggests that the magnetic field may be slowing the Pillars' evolution into cometary globules. We thus hypothesize that the evolution and lifetime of the Pillars may be strongly influenced by the strength of the coupling of their magnetic field to that of their parent photoionized cloud – i.e., that the Pillars' longevity results from magnetic support.

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Studies of Turbulence Dissipation in Taurus Molecular Cloud with Core Velocity Dispersion

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Turbulence dissipation is an important process affecting the energy balance in molecular clouds, the birth place of stars. Previously, the rate of turbulence dissipation is often estimated with semi-analytic formulae from simulation. Recently we developed a data analysis technique called core-velocity-dispersion (CVD), which, for the first time, provides direct measurements of the turbulence dissipation rate in Taurus, a star forming cloud. The thus measured dissipation rate of $(0.45 \pm 0.05) \times 10^{33}$ erg s^{-1} is similar to those from dimensional analysis and also consistent with the previous energy injection rate based on molecular outflows and bubbles.

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Diffuse interstellar bands in the HII region M17: Insights into their relation with the total-to-selective visual extinction R_V

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Diffuse interstellar bands (DIBs) are broad absorption features measured in sightlines probing the diffuse interstellar medium. Although large carbon-bearing molecules have been proposed as the carriers producing DIBs, their identity remains unknown. The sight line to the young massive star-forming region M17 shows anomalous extinction in the sense that the total-to-selective extinction parameter differs significantly from the average Galactic value and may reach values $R_V > 4$. Given the high R_V values, we investigate whether the DIBs in sight lines towards young OB stars in M17 show a peculiar behaviour. We measure the properties of the most prominent DIBs in M17 and study these as a function of $E(B-V)$ and R_V. The DIB strengths in M17 concur with the observed relations between DIB equivalent width and reddening $E(B-V)$ in Galactic sight lines. For several DIBs we discover a linear relation between

the normalised DIB strength EW/A_V and ${R_V}^{-1}$. These trends suggest two groups: (i) a group of ten moderately strong DIBs that show a sensitivity to changes in R_V that is modest and proportional to DIB strength, and (ii) a group of four very strong DIBs that react sensitively and to a similar degree to changes in R_V, but in a way that does not appear to depend on DIB strength. The DIB behaviour as a function of reddening is not peculiar in sight lines to M17. Also, we do not detect anomalous DIB profiles as seen in Her 36. DIBs are stronger, per unit visual extinction, in sight lines characterised by a smaller value of R_V (large fraction of small dust particles). New relations between extinction normalised DIB strengths, EW/A_V, and R_V support the idea that DIB carriers and interstellar dust are connected. Given the distinct behaviour of two groups of DIBs, different types of carriers do not necessarily relate to the dust grains in a similar way.

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Long-lived protoplanetary disks in multiple systems: the VLA view of HD 98800

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The conditions and evolution of protoplanetary disks in multiple systems can be considerably different from those around single stars, which may have important consequences for planet formation. We present Very Large Array (VLA) 8.8 mm (34 GHz) and 5 cm (6 GHz) observations of the quadruple system HD 98800, which consists of two spectroscopic binary systems (Aa-Ab, Ba-Bb). The Ba-Bb pair is surrounded by a circumbinary disk, usually assumed to be a debris disk given its ∼10 Myr age and lack of near infrared excess. The VLA 8.8 mm observations resolve the disk size (5–5.5 au) and its inner cavity (≈3 au) for the first time, making it one of the smallest disks known. Its small size, large fractional luminosity, and millimeter spectral index consistent with blackbody emission support the idea that HD 98800 B is a massive, optically thick ring which may still retain significant amounts of gas. The disk detection at 5 cm is compatible with free-free emission from photoionized material. The diskless HD 98800 A component is also detected, showing partial polarization at 5 cm compatible with non-thermal chromospheric activity. We propose that tidal torques from Ba-Bb and A-B have stopped the viscous evolution of the inner and outer disk radii, and the disk is evolving via mass loss through photoevaporative winds. This scenario can explain the properties and longevity of HD 98800 B as well as the lack of a disk around HD 98800 A, suggesting that planet formation could have more time to proceed in multiple systems than around single stars in certain system configurations.

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The double population of Chamaeleon I detected by Gaia DR2

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Context. Chamaeleon I represents an ideal laboratory to study the cluster formation in a low-mass environment. Recently, two sub clusters spatially located in the northern and southern parts of Chamaeleon I were found with different ages and radial velocities.
Aims. In this letter we report new insights into the structural properties, age, and distance of Chamaeleon I based on the astrometric parameters from Gaia data-release 2 (DR2).
Methods. We identified 140 sources with a reliable counterpart in the Gaia DR2 archive. We determined the median distance of the cluster using Gaia parallaxes and fitted the distribution of parallaxes and proper motions assuming the presence of two clusters. We derived the probability of each single source of belonging to the northern or southern sub-clusters, and compared the HR diagram of the most probable members to pre-main sequences isochrones.
Results. The median distance of Chamaeleon I is ∼190 pc. This is about 20 pc larger than the value commonly adopted in the literature. From a Kolmogorov-Smirnov test of the parallaxes and proper-motion distributions we conclude that

the northern and southern clusters do not belong to the same parent population. The northern population has a distance $d_N = 192.7 \pm 0.4$ pc, while the southern one $d_S = 186.5 \pm 0.7$ pc. The two sub-clusters appear coeval, at variance with literature results, and most of the sources are younger than 3 Myr. The northern cluster is more elongated and extends towards the southern direction partially overlapping with the more compact cluster located in the south. A hint of a relative rotation between the two sub-clusters is also found.

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Streaming Instability of Multiple Particle Species in Protoplanetary Disks

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The radial drift and diffusion of dust particles in protoplanetary disks affect both the opacity and temperature of such disks as well as the location and timing of planetesimal formation. In this paper, we present results of numerical simulations of particle-gas dynamics in protoplanetary disks that include dust grains with various size distributions. We consider three scenarios in terms of particle size ranges, one where the Stokes number $\tau_s = 10^{-1}$–10^0, one where $\tau_s = 10^{-4}$–10^{-1} and finally one where $\tau_s = 10^{-3}$–10^0. Moreover, we consider both discrete and continuous distributions in particle size. In accordance with previous works we find in our multi-species simulations that different particle sizes interact via the gas and as a result their dynamics changes compared to the single-species case. The larger species trigger the streaming instability and create turbulence that drives the diffusion of the solid materials. We measure the radial equilibrium velocity of the system and find that the radial drift velocity of the large particles is reduced in the multi-species simulations and that the small particle species move on average outwards. We also vary the steepness of the size distribution, such that the exponent of the solid number density distribution, $dN/da \propto a^{-q}$, is either $q = 3$ or $q = 4$. We measure the scale height of the particles and observe that small grains are stirred up well above the sedimented midplane layer where the large particles reside. Our measured diffusion and drift parameters can be used in coagulation models for planet formation as well as to understand relative mixing of the components of primitive meteorites (matrix, chondrules and CAIs) prior to inclusion in their parent bodies.

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The VLA Nascent Disk and Multiplicity Survey of Perseus Protostars (VANDAM). V. 18 Candidate Disks around Class 0 and I Protostars in the Perseus Molecular Cloud

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We present the full disk-fit results VANDAM survey of all Class 0 and I protostars in the Perseus molecular cloud.

We have 18 new protostellar disk candidates around Class 0 and I sources, which are well described by a simple, parametrized disk model fit to the 8 mm VLA dust-continuum observations. 33% of Class 0 protostars and just 11% of Class I protostars have candidate disks, while 78% of Class 0 and I protostars do not have signs of disks within our 12 AU disk diameter resolution limit, indicating that at 8 mm most disks in the Class 0 and I phases are <10 AU in radius. These small radii may be a result of surface brightness sensitivity limits. Modeled 8 mm radii are similar to the radii of known Class 0 disks with detected Keplerian rotation. Since our 8 mm data trace a population of larger dust grains which radially drift towards the protostar and are lower limits on true disk sizes, large disks at early times do not seem to be particularly rare. We find statistical evidence that Class 0 and I disks are likely drawn from the same distribution, meaning disk properties may be defined early in the Class 0 phase and do not undergo large changes through the Class I phase. By combining our candidate disk properties with previous polarization observations, we find a qualitative indication that misalignment between inferred envelope-scale magnetic fields and outflows may indicate disks on smaller scales in Class 0 sources.

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The mass of the young planet Pictoris b through the astrometric motion of its host star

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The young massive Jupiters discovered with high-contrast imaging provide a unique opportunity to study the formation and early evolution of gas giant planets. A key question is to what extent gravitational energy from accreted gas contributes to the internal energy of a newly formed planet. This has led to a range of formation scenarios from 'cold' to 'hot' start models. For a planet of a given mass, these initial conditions govern its subsequent evolution in luminosity and radius. Except for upper limits from radial velocity studies, disk modelling, and dynamical instability arguments, no mass measurements of young planets are yet available to distinguish between these different models. Here we report on the detection of the astrometric motion of Beta Pictoris, the 21 Myr-old host star of an archetypical directly-imaged gas giant planet, around the system's centre of mass. Subtracting the highly accurate Hipparcos-Gaia proper motion from the internal 3-yr Hipparcos astrometric data reveals the reflex motion of the star, giving a model-independent planet mass of $M = 11 \pm 2\ M_{\rm Jup}$. This is consistent with scenarios in which the planet is formed in a high-entropy state as assumed by hot start models. The ongoing data collection by Gaia will in the near future lead to mass measurements of other young gas giants and form a great asset to further constrain early evolution scenarios.

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Structure Formation in a Young Protoplanetary Disk by a Magnetic Disk Wind

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Structure formation in young protoplanetary disks is investigated using a one-dimensional model including the formation and the evolution of disks. Recent observations with ALMA found that a ring-hole structure may be formed in young protoplanetary disks, even when the disk is embedded in the envelope. We present a one-dimensional model for the formation of a protoplanetary disk from a molecular cloud core and its subsequent long-term evolution within a single framework. Such long-term evolution has not been explored by numerical simulations due to the limitation of computational power. In our model, we calculate the time evolution of the surface density of the gas and the dust with the wind mass loss and the radial drift of the dust in the disk. We find that the MHD disk wind is a viable mechanism for the formation of ring-hole structure in young disks. We perform a parameter study of our model and derive condition of the formation of ring-hole structures within 6×10^5 years after the start of the collapse of the

molecular cloud core. The final outcome of the disk shows five types of morphology and this can be understood by comparing the timescale of the viscous diffusion, the mass loss by MHD disk wind and the radial drift of the dust. We discuss the implication of the model for the WL 17 system, which is suspected to be an embedded, yet transitional, disk.

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Possible Counter Rotation between the Disk and Protostellar Envelope around the Class I Protostar IRAS 04169+2702

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We present results from our SMA observations and data analyses of the SMA archival data of the Class I protostar IRAS 04169+2702. The high-resolution (0.5") ^{13}CO (3–2) image cube shows a compact (r =< 100 au) structure with a northwest (blue) to southeast (red) velocity gradient, centered on the 0.9-mm dust-continuum emission. The direction of the velocity gradient is orthogonal to the axis of the molecular outflow as seen in the SMA ^{12}CO (2–1) data. A similar gas component is seen in the SO (6_5–5_4) line. On the other hand, the C^{18}O (2–1) emission traces a more extended (r =400 au) component with the opposite, northwest (red) to southeast (blue) velocity gradient. Such opposite velocity gradients in the different molecular lines are also confirmed from direct fitting to the visibility data. We have constructed models of a forward-rotating and counter-rotating Keplerian disk and a protostellar envelope, including the SMA imaging simulations. The counter-rotating model could better reproduce the observed velocity channel maps, although we could not obtain statistically significant fitting results. The derived model parameters are; Keplerian radius of 200 au, central stellar mass of 0.1 M_{solar}, and envelope rotational and infalling velocities of 0.20 km s^{-1} and 0.16 km s^{-1}, respectively. One possible interpretation for these results is the effect of the magnetic field in the process of disk formation around protostars, *i.e.*, Hall effect.

Accepted by ApJ

http://arxiv.org/pdf/1808.06039

Temperature, Mass and Turbulence: A Spatially Resolved Multi-Band Non-LTE Analysis of CS in TW Hya

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Observations of multiple rotational transitions from a single molecule allow for unparalleled constraints on the physical conditions of the emitting region. We present an analysis of CS in TW Hya using the J=7–6, 5–4 and 3–2 transitions imaged at $\sim 0\farcs5$ spatial resolution, resulting in a temperature and column density profile of the CS emission region extending out to 230 au, far beyond previous measurements. In addition, the 15 kHz resolution of the observations and the ability to directly estimate the temperature of the CS emitting gas, allow for one of the most sensitive searches for turbulent broadening in a disk to date. Limits of $v_{\rm turb} \lesssim 0.1 c_{\rm s}$ can be placed across the entire radius of the disk.

We are able to place strict limits of the local H_2 density due to the collisional excitations of the observed transitions. From these we find that a minimum disk mass of $3 \times 10^{-4}\ M_\odot$ is required to be consistent with the CS excitation conditions and can uniquely constrain the gas surface density profile in the outer disk.

Accepted by ApJ

http://arxiv.org/pdf/1808.01768

Yes, multi-periodic dwarfs in Upper Scorpius are binaries

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We found that multi-periodic low-mass stars discovered by Kepler K2 in the Upper Scorpius association are close binaries with typical separations of the order of 10 au and large mass ratios. These stars were surveyed by speckle interferometry at the SOAR telescope with spatial resolution of 0.″04. Out of 129 observed targets, we resolved 70 pairs (including 16 previously known ones and three new triple systems). The distribution of projected separations of binaries with primary stars less massive than the Sun corresponds to a log-normal with median of 11.6 au and logarithmic dispersion of 0.60 dex, similar to M dwarfs in the field. Future orbits of newly discovered binaries will provide accurate measurements of masses to calibrate pre-main sequence evolutionary tracks; a tentative orbit of one previously known binary is determined here.

Accepted by AJ

http://arxiv.org/pdf/1808.02544

Methanol and its relation to the water snowline in the disk around the young outbursting star V883 Ori

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We report the detection of methanol in the disk around the young outbursting star V883 Ori with the Atacama Large Millimeter/submillimeter Array (ALMA). Four transitions are observed with upper level energies ranging between 115 and 459 K. The emission is spatially resolved with the 0.″14 beam and follows the Keplerian rotation previously observed for $C^{18}O$. Using a rotational diagram analysis, we find a disk-averaged column density of $\sim 10^{17}$ cm^{-2} and a rotational temperature of ∼90–100 K, suggesting that the methanol has thermally desorbed from the dust grains. We derive outer radii between 120 and 140 AU for the different transitions, compared to the 360 AU outer radius for $C^{18}O$. Depending on the exact physical structure of the disk, the methanol emission could originate in the surface layers beyond the water snowline. Alternatively, the bulk of the methanol emission originates inside the water snowline, which can then be as far out as ∼100 AU, instead of 42 AU as was previously inferred from the continuum opacity. In addition, these results show that outbursting young stars like V883 Ori are good sources to study the ice composition of planet forming material through thermally desorbed complex molecules, which have proven to be hard to observe in more evolved protoplanetary disks.

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http://arxiv.org/pdf/1808.08258

Discovery of two embedded massive YSOs and an outflow in IRAS 18144−1723

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Massive stars are rarely seen to form in isolation. It has been proposed that association with companions or clusters in the formative stages is vital to their mass accumulation. In this paper we study IRAS 18144−1723, a massive young stellar object (YSO) which had been perceived in early studies as a single source. In the CO(3–2) line, we detect an outflow aligned well with the outflow seen in H_2 in this region. We show that there are at least two YSOs here, and that the outflow is most likely to be from a deeply embedded source detected in our infrared imaging. Using multi-wavelength observations, we study the outflow and the embedded source and derive their properties. We conclude that IRAS 18144 hosts an isolated cloud, in which at least two massive YSOs are being born. From our sub-mm observations, we derive the mass of the cloud and the core hosting the YSOs.

Accepted by MNRAS

http://arxiv.org/pdf/1808.00230

Gaia DR2 study of Herbig Ae/Be stars

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We use Gaia Data Release 2 (DR2) to place 252 Herbig Ae/Be stars in the HR diagram and investigate their characteristics and properties. For all known Herbig Ae/Be stars with parallaxes in Gaia DR2, we collected their atmospheric parameters and photometric and extinction values from the literature. To these data we added near- and mid-infrared photometry, collected Hα equivalent widths and line profiles, and their binarity status. In addition, we developed a photometric variability indicator from Gaia's DR2 information. We provide masses, ages, luminosities, distances, variabilities and infrared excesses homogeneously derived for the most complete sample of Herbig Ae/Be stars to date. We find that high mass stars have a much smaller infrared excess and have much lower optical variabilities compared to lower mass stars, with the break at around 7 $M_{\odot}$. Hα emission is generally correlated with infrared excess, with the correlation being stronger for infrared emission at wavelengths tracing the hot dust closest to the star. The variability indicator as developed by us shows that $\sim$25% of all Herbig Ae/Be stars are strongly variable. We observe that the strongly variable objects display doubly peaked Hα line profiles, indicating an edge-on disk. The fraction of strongly variable Herbig Ae stars is close to that found for A-type UX Ori stars. It had been suggested that this variability is in most cases due to asymmetric dusty disk structures seen edge-on. The observation here is in strong support of this hypothesis. Finally, the difference in dust properties occurs at 7 $M_{\odot}$, while various properties traced at UV/optical wavelengths differ at 3 $M_{\odot}$. The latter has been linked to different accretion mechanisms at work whereas the differing infrared properties and variabilities are related to different (dust-)disk dispersal mechanisms.

Accepted by A&A

http://arxiv.org/pdf/1808.00476

Selective Aggregation Experiments on Planetesimal Formation and Mercury-Like Planets

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Much of a planet's composition could be determined right at the onset of formation. Laboratory experiments can constrain these early steps. This includes static tensile strength measurements or collisions carried out under Earth's gravity and on various microgravity platforms. Among the variety of extrasolar planets which eventually form are (Exo)-Mercury, terrestrial planets with high density. If they form in inner protoplanetary disks, high temperature experiments are mandatory but they are still rare. Beyond the initial process of hit-and-stick collisions, some additional selective processing might be needed to explain Mercury. In analogy to icy worlds, such planets might, e.g., form in environments which are enriched in iron. This requires methods to separate iron and silicate at early stages. Photophoresis might be one viable way. Mercury and Mercury-like planets might also form due to the ferromagnetic properties of iron and mechanisms like magnetic aggregation in disk magnetic fields might become important. This review highlights some of the mechanisms with the potential to trigger Mercury formation.

Accepted by Geosciences: Detection and Characterization of Extrasolar Planets

http://arxiv.org/pdf/1808.10246

On estimating angular momenta of infalling protostellar cores from observations

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We use numerical simulations of molecular cloud formation in the colliding flow scenario to investigate the reliability of observational estimates of the angular momenta of early-state, low-mass protostellar cores. We show that, with suitable corrections for projection factors, molecular line observations of velocity gradients in NH3 can be used to provide reasonable estimates of core angular momenta within a factor of two to three, with a few large underestimates due to unfavorable viewing angles. Our results differ from previous investigations which suggested that observations might overestimate true angular momenta by as much as an order of magnitude; the difference is probably due to the much smoother velocity field on small scales in our simulations, which result from allowing turbulence to decay and gravitational infall to dominate. The results emphasize the importance of understanding the nature of 'turbulent' velocities, with implications for the formation of protostellar disks during core collapse.

Accepted by MNRAS

https://arxiv.org/pdf/1808.04802

Abstracts of recently accepted major reviews

Debris Disks: Structure, Composition, and Variability

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Debris disks are tenuous, dust-dominated disks commonly observed around stars over a wide range of ages. Those around main sequence stars are analogous to the Solar Systems Kuiper Belt and zodiacal light. The dust in debris disks is believed to be continuously regenerated, originating primarily with collisions of planetesimals. Observations of debris disks provide insight into the evolution of planetary systems; and the composition of dust, comets, and planetesimals outside the Solar System; as well as placing constraints on the orbital architecture and potentially the masses of exoplanets that are not otherwise detectable. This review highlights recent advances in multi-wavelength, high-resolution scattered light and thermal imaging that have revealed a complex and intricate diversity of structures in debris disks and discusses how modeling methods are evolving with the breadth and depth of the available observations. Two rapidly advancing subfields highlighted in this review include observations of atomic and molecular gas around main sequence stars and variations in emission from debris disks on very short (days to years) timescales, providing evidence of non-steady-state collisional evolution particularly in young debris disks.

Accepted by Annual Reviews of Astronomy and Astrophysics

https://arxiv.org/pdf/1802.04313

Moving ... ??

If you move or your e-mail address changes, please send the editor your new address. If the Newsletter bounces back from an address for three consecutive months, the address is deleted from the mailing list.

New Jobs

Post-doctoral research position at University of Tübingen: Time-variability of accretion, outflows and star-disk interaction in Young Stellar Objects

The Institute for Astronomy & Astrophysics of the University of Tübingen (IAAT) has an opening for a post-doctoral researcher to work on optical/IR photometric and spectroscopic monitoring data of benchmark pre-main sequence stars with the aim to study the effects of system geometry and the dynamics of accretion/outflows along disk evolution and across stellar mass. The data were obtained at ESO telescopes on La Silla and Paranal and span time-scales crucial for the dynamics in the environment of Young Stellar Objects (hours to years).

The project is embedded in a research group led by JProf. B. Stelzer with focus on multi-wavelength observations of the formation and evolution of low-mass stars and brown dwarfs. The successful candidate will be involved in international collaborations and is expected to regularly publish the results in refereed journals.

The applicant must have a PhD or equivalent degree in physics or astrophysics. Expertise with photometric and/or spectroscopic data analysis is essential and a background in star formation studies is desirable.

The position is funded by DFG (German Science Foundation) for up to 2.5 years (30 months). Salary will be according to 100% (full-time) E13 of the TV-L of the German public services. The application is expected to consist of a CV (including personal data, formation, skills and expertises), copies of university degrees and a brief (2 page) statement of previous research experiences and motivation. The candidate should arrange for two letters of recommendation to be sent directly to Prof. B. Stelzer. The **deadline for applications is Sep 28, 2018** with possible starting date around the end of this year (i.e. as soon as the amministrative procedure allows).

The University of Tübingen is committed to increasing the percentage of women in research and teaching and thus encourages women with adequate qualifications to apply. In case of equal qualification preference will be given to applicants with disabilities.

Employment takes place via the Central Administration of the University.

Contact for application and further information:
Beate Stelzer (stelzer@astro.uni-tuebingen.de)

Postdoctoral Position in Star Formation Studies

Applications are invited for a two-year postdoctoral position in star formation studies at The University of Western Ontario. The successful applicant will work with Prof. Shantanu Basu, and experience with computational simulations of present-day star formation or first stars in the universe is preferred.

The applications will be assessed based on the synergy of possible research, and the selected application will also be nominated for a CITA National Fellowship to be held at Western. To apply, please send a cover letter, a cv including a publication list, and a brief description of research experience and interests, to basu@uwo.ca. The application deadline is 31 October 2018.

A description of ongoing research projects in the group and a list of recent publications can be obtained from `http://physics.uwo.ca/~basu/`.

PhD Position in Astrochemistry, Star and Planet Formation

A **full-time, 4-year PhD position in astrochemistry, star and planet formation** is open at the Center for Space and Habitability (CSH), Universitat Bern. Brutto salary of 47 000 - 50 000CHF per year (as set by the SNSF). A full package of social benefits is included. **Starting date**: between **November 1st, 2018** and **April 30th, 2019**.

Under the guidance of Dr. Maria Drozdovskaya, a PhD research project is available, which aims to understand the chemical processes that link the different stages of star and planet formation, and that determine the composition of forming cometary and planetary embryos. The insights gained during this project will enhance our understanding of the early history of our Solar System. The work is funded by a Swiss National Science Foundation (SNSF) Ambizione grant (PI: Drozdovskaya) entitled "The Planetary Cookbook: Chemical Composition of Volatiles and Refractories from Star-Forming Regions to Comets and Planetesimals".

Primary features of the project include theoretical physicochemical modelling work; possibility of working with observational data from, e.g., ALMA, JWST; active participation in the scientific life of the CSH; exposure to the largest group of planetary scientists in the world via associate membership in the NCCR PlanetS; sufficient funds for participation in national and international conferences, and collaborator visits.

Must-haves of candidates are a Master-level degree (or analog) in quantitative science or engineering (e.g., astronomy, physics, chemistry, mathematics, computer science or a related field) by the starting date; and competence in spoken and written English.

Nice-to-haves of candidates are programming experience, and exposure to at least basic astronomy. However, applications from students in other fields of quantitative science or engineering that are interested in learning astronomy are very welcomed.

Work-life balance is important; and the Canton of Bern offers 5 weeks of vacation per year (excluding national and cantonal holidays). The CSH is dedicated to equal opportunities, geographical and gender balance, and inclusivity.

Applicants should send all application materials in **one PDF file** to maria.drozdovskaya'at'csh.unibe.ch by the deadline of **November 1st, 2018**. Note that applications are considered on a **rolling basis**, implying that the position may be filled earlier or that late applications may also receive partial consideration. A complete application consists of: cover letter (max. 1 page); curriculum vitae (CV); personal statement detailing, but not limited to: past research experience and the skills obtained, reasons for pursuing a 4-year PhD in general and this research project in specific, aspirations for the future (max. 2 pages); a full list and transcripts (grades) of all university-level courses (Bachelor- and Master-level) and a translated version, if not in English, German, French, Russian or Dutch (notarized translation is not needed); up-to-date contact information of two references that may be contacted for a reference letter.

Postdoctoral position in infrared interferometry of planet forming disks

Applications are invited for a postdoctoral position at Leiden Observatory to pursue infrared interferometric studies of planet forming disks using the newly commissioned MATISSE instrument on VLTI.

The successful candidate will work under supervision of Michiel Hogerheijde, join the MATISSE Guaranteed Time program, and interact with the extensive group of researchers studying planet forming disks at Leiden Observatory. Collaborative projects with scientists at the University of Amsterdam are also foreseen.

Leiden Observatory is the oldest university astronomy department in the world and the largest astronomy department in the Netherlands. Leiden is a charming university town with an international flair, located near Amsterdam.

The successful candidate will have a PhD in physics or astronomy by the starting date. Research experience in the field of planet forming disks and the use of (infrared) interferometry is desired.

The appointment is for a period of three years and comes with full benefits and a competitive salary. The anticipated start date of the appointment is January 1 2019 or soon thereafter.

Applications should be submitted electronically at http://jobs.strw.leidenuniv.nl/2018/HogerheijdePD and should include a curriculum vitae, publication list, a brief statement of research experience and interests, and arrange for at least two letters of reference to be uploaded. Review of applications will start on October 15 2018.

Summary of Upcoming Meetings

Take a Closer Look - The Innermost Region of Protoplanetary Discs and its Connection to the Origin of Planets
15 - 19 October 2018, ESO Headquarters, Garching, Germany
http://www.eso.org/sci/publications/announcements/sciann17072.html

Planet Formation and Evolution
27 February - 1 March, Rostock, Germany
http://pfe2019.stat.physik.uni-rostock.de

Exploring the Infrared Universe: The Promise of SPICA
20 - 23 May 2019, Crete, Greece
http://www.spica2019.org

Zooming in on Star Formation - A tribute to Åke Nordlund
9 - 14 June 2019, Nafplio, Greece
http://www.nbia.dk/nbia-zoomstarform-2019

From Stars to Planets II: Connecting our Understanding of Star and Planet Formation
17 - 20 June 2019, Gothenburg, Sweden
http://cosmicorigins.space/fstpii

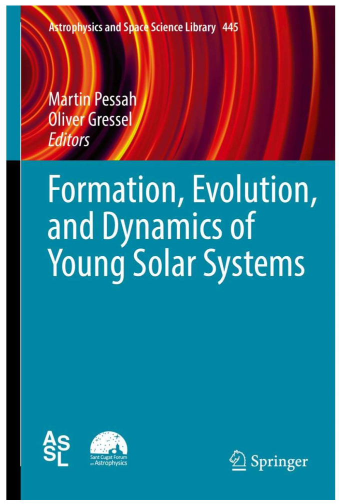
Abstract submission deadline

The deadline for submitting abstracts and other submissions is the first day of the month.

New Books

Formation, Evolution, and Dynamics of Young Solar Systems

Edited by Martin Pessah and Oliver Gressel



The discovery in recent years of thousands of exoplanets has been a major impetus for planetary science, and has placed new observational constraints on planet formation models. Coupled with the emergence of powerful new instruments and observational facilities like ALMA, our understanding of how disks form, evolve, and lead to planetary systems has developed at a dizzying speed. Even specialists can be forgiven for not being able to follow all aspects of this dynamic field. This new book provides a detailed and comprehensive overview of physical processes behind all the new data and the exciting discoveries of recent years. Among the topics covered are the properties and evolution of the gas and dust components of disks, the relation between disk studies and analysis of chondrules, the role of pebble accretion in the formation of planetesimals, and the dynamical effect of newborn planets on disk structure. The 12 chapters are written by leading experts in their individual fields, and together offer an authoritative account of the state of our current understanding of how disks evolve into planets.

The following lists the chapters and subsections of the book:

1. The Determination of Protoplanetary Disk Masses
Edwin A. Bergin and Jonathan P. Williams
1.1 Introduction
1.2 The Determination of Dust Masses
1.3 The Determination of Gas Masses
1.4 Reconciliation?
1.5 Conclusion and Future Prospects

2. The ALMA Revolution: Gas and Dust in Transitional Disks
Nienke van der Marel
2.1 Introduction
2.2 Dust Observations
2.3 Gas Observations
2.4 Large Surveys

9. Observational Signatures of Planet Formation in Recent Resolved Observations of Protoplanetary Disks
Ruobing Dong, Zhaohuan Zhu, and Jeffrey Fung
9.1 Introduction
9.2 General Modeling Scheme and Numerical Methods
9.3 Gaps
9.4 Spiral Arms 9.5 Large Scale Disk Asymmetry
9.6 Summary and Discussion

10. Super-Earths: Atmospheric Accretion, Thermal Evolution and Envelope Loss
Sivan Ginzburg, Niraj K. Inamdar, and Hilke E. Schlichting
10.1 Introduction
10.2 Gas Accretion
10.3 Atmosphere Heating
10.4 Evaporation
10.5 Late Evolution
10.6 Diversity of the Super-Earth Population and Giant Impacts
10.7 Summary

11. Constraints from Planets in Binaries
Kaitlin M. Kratter
11.1 Introduction
11.2 Binary Formation Models
11.3 Constraints on Planets in Binaries from Formation Models
11.4 Binary Planet Dynamics
11.5 Triple System Case Studies
11.6 Discussion

12. Planet Population Synthesis via Pebble Accretion
Bertram Bitsch and Anders Johansen
12.1 Introduction
12.2 Disc Evolution
12.3 Planet Growth Mechanisms
12.4 Planet Migration
12.5 Population Synthesis
12.6 Summary

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