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Abstracts of recently accepted papers

Truncated Disks in TW Hya Association Multiple Star Systems

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We present high angular resolution (down to $0.3'' \approx 13$ AU in diameter) Submillimeter Array observations of the 880 μm (340 GHz) thermal continuum emission from circumstellar dust disks in the nearby HD 98800 and Hen 3-600 multiple star systems. In both cases, the dust emission is resolved and localized around one stellar component − the HD 98800 B and Hen 3-600 A spectroscopic binaries − with no evidence for circum-system material. Using two-dimensional Monte Carlo radiative transfer calculations, we compare the SMA visibilities and broadband spectral energy distributions with truncated disk models to empirically locate the inner and outer edges of both disks. The HD 98800 B disk appears to be aligned with the spectroscopic binary orbit, is internally truncated at a radius of 3.5 AU, and extends to only 10-15 AU from the central stars. The Hen 3-600 A disk is slightly larger, with an inner edge at ∼1 AU and an outer radius of 15-25 AU. These inferred disk structures compare favorably with theoretical predictions of their truncation due to tidal interactions with the stellar companions.

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Strong near-infrared emission in the sub-AU disk of the Herbig Ae star HD 163296: evidence of refractory dust?

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We present new long-baseline spectro-interferometric observations of the Herbig Ae star HD 163296 (MWC 275) obtained in the H and K bands with the AMBER instrument at the VLTI. The observations cover a range of spatial resolutions between ∼3 and ∼12 milliarcseconds, with a spectral resolution of ∼30. With a total of 1481 visibilities and 432 closure phases, they represent the most comprehensive (u, v) coverage achieved so far for a young star. The circumstellar material is resolved at the sub-AU spatial scale and closure phase measurements indicate a small but significant deviation from point-symmetry. We discuss the results assuming that the near-infrared excess in HD 163296 is dominated by the emission of a circumstellar disk. A successful fit to the spectral energy distribution, near-infrared visibilities and closure phases is found with a model in which a dominant contribution to the H and K band emission originates in an optically thin, smooth and point-symmetric region extending from about 0.1 to 0.45 AU. At a distance of 0.45 AU from the star, silicates condense, the disk becomes optically thick and develops a puffed-up rim, whose skewed emission can account for the non-zero closure phases. We discuss the source of the inner disk emission and tentatively exclude dense molecular gas as well as optically thin atomic or ionized gas as its possible origin. We propose instead that the smooth inner emission is produced by very refractory grains in a partially cleared region, extending to at least ∼0.5 AU. If so, we may be observing the disk of HD 163296 just before it reaches the transition disk phase. However, we note that the nature of the refractory grains or, in fact, even the possibility of any grain surviving at the very high temperatures we require ($\sim 2100 - 2300$ K at 0.1 AU from the star) is unclear and should be investigated further.

Accepted by Astronomy & Astrophysics

The complex structure of the disk around HD 100546: the inner few astronomical units.

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Disclosing the structure of disks surrounding Herbig AeBe stars is important to expand our understanding of the formation and early evolution of stars and planets. The first astronomical units of these disks in particular, because they are hot, dense, and subject to intense radiation field, hold critical clues to accretion and ejection processes, as well as planet formation in environment different than what prevailed around our own early Sun. We aim at revealing the sub-AU disk structure around the 10 Myr old Herbig Be star HD 100546 and at investigating the origin of its near and mid-infrared excess. We used new AMBER/VLTI observations to resolve the K-band emission and to constrain the location and composition of the hot dust in the innermost circumstellar disk. Combining AMBER observations with photometric and MIDI/VLTI measurements from the litterature, we revisit the disk geometry using a passive disk model based on 3D Monte-Carlo radiative transfer (including full anisotropic scattering). We propose a model that includes a tenuous inner disk made of micron-sized dust grains, a gap, and a massive optically thick outer disk, that successfully reproduces the interferometric data and the SED. We locate the bulk of the K-band emission at ∼0.26 AU. Assuming that this emission originates from silicate dust grains at their sublimation temperature of 1500K, we show that micron-sized grains are required to enable the dust to survive at such a close distance from the star. As a consequence, in our best model, more than 40% of the K-band flux is related to scattering, showing that the direct thermal emission of hot dust is not always sufficient to explain the near-infrared excess. In the massive outer disk, large grains in the mid-plane are responsible for the mm emission while a surface layer of small grains allows the mid and far infrared excesses to be reproduced. Such vertical structure may be an evidence for sedimentation. The interferometric observations are consistent with a disk model that includes a gap until ∼ 13 AU from the star and a total dust mass of ∼0.008 lunar mass ($\sim 6.10^{23}$ g) inside it. These values together with the derived scale height (∼ 2.5 AU) and temperature (∼220 K) at the inner edge of the outer disk (r=13 AU), are consistent with recent CO observations.

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http://arxiv.org/abs/1001.2491

Disk and outflow signatures in Orion-KL: The power of high-resolution thermal infrared spectroscopy

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Context: The Orion-KL region contains the closest examples of high-mass accretion disk candidates. Studying their properties is an essential step in studying high-mass star formation.
Aims: Resolving at high spatial and spectral resolution the molecular line emission in the immediate environment of the exciting sources to infer the physical properties of the associated gas.
Methods: We used the CRIRES high-resolution spectrograph mounted on the VLT to study the ro-vibrational $^{12}CO/^{13}CO$, the Pfund β and H_2 emission between 4.59 and 4.72 μm wavelengths toward the BN object, the disk candidate source n, and a proposed dust density enhancement IRC3.
Results: We detected CO absorption and emission features toward all three targets. Toward the BN object, the data partly confirm the results obtained more than 25 years ago by Scoville et al., however, we also identify several new features. While the blue-shifted absorption is likely due to outflowing gas, toward the BN object we detect CO in emission extending in diameter to ~ 3300 AU with a velocity structure close to the $v_{\rm lsr}$. Although at the observational spectral resolution limit, the ^{13}CO line width of that feature increases with energy levels, consistent with a disk origin. If one attributes the extended CO emission also to a disk origin, its extent is consistent with other massive disk candidates in the literature. For source n, we also find the blue-shifted CO absorption likely from an outflow. However, it also exhibits a narrower range of redshifted CO absorption and adjacent weak CO emission, consistent with infalling motions. We do not spatially resolve the emission for source n. For both sources we conduct a Boltzmann analysis of the ^{13}CO absorption features and find temperatures between 100 and 160 K, and H_2 column densities of the order a few times 10^{23} cm^{-2}. The observational signatures from IRC3 are very different with only weak absorption against a much weaker continuum source. However, the CO emission is extended and shows wedge-like position velocity signatures consistent with jet-entrainment of molecular gas, potentially associated with the Orion-KL outflow system. We also present and discuss the Pfund β and H_2 emission in the region.
Conclusions: This analysis toward the closest high-mass disk candidates outlines the power of high spectral and spatial resolution mid-infrared spectroscopy to study the gas properties close to young massive stars. We will extend qualitatively similar studies to larger samples of high-mass young stellar objects to constrain the physical properties of the dense innermost gas structures in more detail also in a statistical sense.

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http://www.mpia-hd.mpg.de/homes/beuther/papers.html

Clumps in the Outer Disk by Disk Instability: Why They are Initially Gas Giants and the Legacy of Disruption

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We explore the initial conditions for fragments in the extended regions ($r > 50$ AU) of gravitationally unstable disks. We combine analytic estimates for the fragmentation of spiral arms with 3D SPH simulations to show that initial fragment masses are in the gas giant regime. These initial fragments will have substantial angular momentum, and should form disks with radii of a few AU. We show that clumps will survive for multiple orbits before they undergo a second, rapid collapse due to H_2 dissociation and that it is possible to destroy bound clumps by transporting them into the inner disk. The consequences of disrupted clumps for planet formation, dust processing, and disk evolution are discussed. We argue that it is possible to produce Earth-mass cores in the outer disk during the earliest phases of disk evolution.

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A method for reconstructing the variance of a 3D physical field from 2D observations: Application to turbulence in the ISM

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We introduce and test an expression for calculating the variance of a physical field in three dimensions using only information contained in the two-dimensional projection of the field. The method is general but assumes statistical isotropy. To test the method we apply it to numerical simulations of hydrodynamic and magnetohydrodynamic turbulence in molecular clouds, and demonstrate that it can recover the 3D normalised density variance with $\sim 10\%$ accuracy if the assumption of isotropy is valid. We show that the assumption of isotropy breaks down at low sonic Mach number if the turbulence is sub-Alfvénic. Theoretical predictions suggest that the 3D density variance should increase proportionally to the square of the Mach number of the turbulence. Application of our method will allow this prediction to be tested observationally and therefore constrain a large body of analytic models of star formation that rely on it.

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Probing the Protostellar Envelope around L1157: the Dust and Gas Connection

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We present observations of the Class 0 protostar L1157-mm using the Combined Array for Research in Millimeter-wave Astronomy (CARMA) in 3 mm dust continuum and N_2H^+ line emission. In the N_2H^+ line, we detect a large-scale envelope extended over a linear size of ~20,000AU flattened in the direction perpendicular to the outflow. This N_2H^+ feature coincides with the outer envelope seen in the 8 μm extinction by Looney et al. Meanwhile, the dust continuum traces the compact, nearly spherical structure of the inner envelope, where N_2H^+ becomes depleted. This highly flattened N_2H^+ envelope also shows dynamical signatures consistent with gravitational infall in the inner region, but a slow, solid-body rotation at large scales. This flattened structure is not a rotationally supported circumstellar disk; instead, it resembles a prestellar core both morphologically and kinematically, representing the early phase of a Class 0 system. In this paper, we construct a simple model to interpret both the dust continuum and N_2H^+ emission and suggest a possible dynamical scenario for the overall properties of the envelope.

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High resolution visible spectroscopy of the jet-driving star Th 28

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Context: We present a study of the extreme T Tauri star Th 28, a young stellar object in the Lupus 3 cloud whose spectrum displays all the variety of signposts associated with early stellar activity. Th 28 is the driving source of a fast jet, and it is thus a very promising target to study the disk-jet connection.

Aims: We try to identify and investigate the different structural components that contribute to the different emission lines in the spectrum of the Th 28 central source.

Methods: We have obtained high resolution visible spectroscopy with the UVES spectrograph at the VLT, using the resolved profiles of both permitted and forbidden lines as tracers of gas with different kinematic and physical properties, complemented with other observations from the literature.

Results: We identify four distinct structural components that contribute to the visible emission-line spectrum of Th 28. The first one, dominating most of the permitted and forbidden lines, is probably associated with the origin of the outflow that produced in the past the Herbig-Haro objects seen to the west of Th 28. The second one is an uncollimated stellar wind characterized by a high excitation and temperature, as shown by the broad profile of the intense [OIII] lines. The third component, traced only by permitted lines, appears as a redshifted tail extending up to radial velocities of +450 km s^{-1}, which we attribute to magnetospheric accretion. From this latter component we obtain a rough estimate of 0.6 $M_\odot$ for the mass of the central object. Using published equivalent widths of the CaII triplet lines we estimate an accretion rate of 2×10^{-8} $M_\odot$ yr^{-1}, comparable to the values inferred for other T Tauri stars of similar mass. The last component, which appears most clearly in the [SII] lines and is hardly seen in any lines other than those of [OI], displays signatures that we interpret as due to rotation, perhaps formed in a disk atmosphere. Following this interpretation, we estimate a disk central hole of 0.5 AU radius.

Conclusions: Even though spatially unresolved, the spectrum of Th 28 is rich in emission lines whose shapes provide important information on the distinct structures were they form. In this way we have been able to identify the existence of a stellar wind, an accretion flow, the basis of a collimated outflow, and possibly a rotating disk atmosphere, obtaining rough estimates of basic parameters of the central source and its environment that should be useful for their further modeling.

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http://www.eso.org/∼fcomeron/th28.pdf

Evolutionary Signatures in the Formation of Low-Mass Protostars. II. Toward Reconciling Models and Observations

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A long-standing problem in low-mass star formation is the "luminosity problem," whereby protostars are underluminous compared to the accretion luminosity expected both from theoretical collapse calculations and arguments based on the minimum accretion rate necessary to form a star within the embedded phase duration. Motivated by this luminosity problem, we present a set of evolutionary models describing the collapse of low-mass, dense cores into protostars. We use as our starting point the evolutionary model following the inside-out collapse of a singular isothermal sphere as presented by Young & Evans (2005). We calculate the radiative transfer of the collapsing core throughout the full duration of the collapse in two dimensions. From the resulting spectral energy distributions, we calculate standard observational signatures (L_{bol}, T_{bol}, L_{bol}/L_{smm}) to directly compare to observations. We incorporate several modifications and additions to the original Young & Evans model in an effort to better match observations with model predictions: (1) we include the opacity from scattering in the radiative transfer, (2) we include a circumstellar disk directly in the two-dimensional radiative transfer, (3) we include a two-dimensional envelope structure, taking into account the effects of rotation, (4) we include mass-loss and the opening of outflow cavities, and (5) we include a simple treatment of episodic mass accretion. We find that scattering, two-dimensional geometry, mass-loss, and outflow cavities all affect the model predictions, as expected, but none resolve the luminosity problem. On the other hand, we find that a cycle of episodic mass accretion similar to that predicted by recent theoretical work can resolve this problem and bring the model predictions into better agreement with observations. Standard assumptions about the interplay between mass accretion and mass loss in our model give star formation efficiencies consistent with recent observations that compare the core mass function (CMF) and stellar initial mass function (IMF). Finally, the combination of outflow cavities and episodic mass accretion reduce the connection between observational Class and physical Stage to the point where neither of the two commonly used observational signatures (T_{bol} and L_{bol}/L_{smm})

can be considered reliable indicators of physical Stage.

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Masers associated with high-mass star formation regions in the Large Magellanic Cloud

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We report the results of a sensitive search for 12.2-GHz methanol maser emission towards a sample of eight high-mass star formation regions in the Large Magellanic Clouds which have been detected in other maser transitions. We detected one source towards the star formation region N105a. This is the first detection of a 12.2-GHz methanol maser outside our Galaxy. We also made near-contemporaneous observations of the 6.7-GHz methanol and 22-GHz water masers towards these sources, resulting in the detection of water maser emission in six new sources, including one associated with the strongest 6.7-GHz maser in the Magellanic Clouds *IRAS*05011-6815. The majority of the maser sources are closely associated with objects identified as likely Young Stellar Objects (YSO) on the basis of *Spitzer Space Telescope* observations. We find that the YSOs associated with masers tend to be more luminous and have redder infrared colours than the sample as a whole. SED modeling of the YSOs shows that the masers are associated with sources of higher central mass, total luminosity and ambient density than the majority of YSOs in the LMC. This is consistent with the well-established relationship between luminous methanol and water masers and young, high-mass objects observed in the Galaxy.

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Ultraviolet-Selected Field and Pre-Main-Sequence Stars Towards Taurus and Upper Scorpius

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We have carried out a Galaxy Evolution Explorer (GALEX) Cycle 1 guest investigator program covering 56 square degrees near the Taurus T association and 12 square degrees along the northern edge of the Upper Scorpius OB association. We combined photometry in the GALEX FUV and NUV bands with data from the Two Micron All Sky Survey to identify candidate young (<100 Myr old) stars as those with an ultraviolet excess relative to older main sequence stars. Follow-up spectroscopy of a partial sample of these candidates suggest 5 new members of Taurus, with 8-20 expected from additional observations, and 5 new members of Upper Scorpius, with 3-6 expected from additional observations. These candidate new members appear to represent a distributed, non-clustered population in either region, although our sample statistics are as of yet too poor to constrain the nature or extent of this population. Rather, our study demonstrates the ability of GALEX observations to identify young stellar populations distributed over a wide area of the sky. We also highlight the necessity of a better understanding of the Galactic ultraviolet source population to support similar investigations. In particular, we report a large population of stars with an ultraviolet excess but no optical indicators of stellar activity or accretion, and briefly argue against several interpretations of these sources.

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Extended High Circular Polarization in the Orion Massive Star Forming Region: Implications for the Origin of Homochirality in the Solar System

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We present a wide-field ($\sim 6' \times 6'$) and deep near-infrared (K_s band: 2.14 μ m) circular polarization image in the Orion nebula, where massive stars and many low-mass stars are forming. Our results reveal that a high circular polarization region is spatially extended ($\sim$ 0.4 pc) around the massive star-forming region, the BN/KL nebula. However, other regions, including the linearly polarized Orion bar, show no significant circular polarization. Most of the low-mass young stars do not show detectable extended structure in either linear or circular polarization, in contrast to the BN/KL nebula. If our solar system formed in a massive star-forming region and was irradiated by net circularly polarized radiation, then enantiomeric excesses could have been induced, through asymmetric photochemistry, in the parent bodies of the meteorites and subsequently delivered to Earth. These could then have played a role in the development of biological homochirality on Earth.

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IR diagnostics of embedded jets: kinematics and physical characteristics of the HH46-47 jet

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We present an analysis of the kinematics and physical properties of the Class I driven jet HH46-47 based on IR medium and low resolution spectroscopy obtained with ISAAC on VLT. Our aim is to study the gas physics as a function of the velocity and distance from the source and to compare the results with similar studies performed on other Class I and classical T Tauri jets as well as with existing models for the jet formation and excitation.

The ratios and luminosities of several important diagnostic lines (e.g. [Fe II] 1.644, 1.600 μm, [P II] 1.189 μm, and H_2 lines) have been used to derive physical parameters such as electron density, H_2 temperature, iron gas-phase abundance and mass flux. [Fe II] 1.644 μm and H_2 2.122 μm position velocity diagrams (PVDs) have been additionally constructed to study the kinematics of both the atomic and molecular gas.

Within 1000-2000 AU from the source the atomic gas presents a wide range of radial velocities, from $\sim$-230 km s^{-1} to $\sim$100 km s^{-1}. Only the gas component at the highest velocity (high velocity component, HVC) survives at large distances. The H_2 shows only a single velocity component at almost zero velocity close to the source while it reaches higer velocities (up to $\sim$95 km s^{-1}) further downstream. Electron densities (n_e) and mass ejection fluxes ($\dot{M}_{jet}$) have been separately measured for the HVC and for the component at lower velocity (LVC) from the [Fe II] lines. n_e increases with decreasing velocities with an average value of $\sim 6000\,\mathrm{cm}^{-3}$ for the LVC and $\sim 4000\,\mathrm{cm}^{-3}$ for the HVC, while the opposite occurs for $\dot{M}_{jet}$ which is $\sim 0.5 - 2 \times 10^{-7}\,\mathrm{M}_{\odot}\mathrm{yr}^{-1}$ and $\sim 0.5 - 3.6 \times 10^{-8}\,\mathrm{M}_{\odot}\mathrm{yr}^{-1}$ for the HVC

and LVC, respectively. The mass flux carried out by the molecular component, measured from the H_2 lines flux, is $\sim 4 \times 10^{-9}\,M_\odot yr^{-1}$. We have estimated that the Fe gas phase abundance is significantly lower than the solar value, with ∼ 88% of iron still depleted onto dust grains in the internal jet region. This fraction decreases to ∼58%, in the external knots.

Many of the derived properties of the HH46-47 jet are common to jets from young stellar objects (YSOs) in different evolutionary states. The derived densities and mass flux values are typical of Class I objects or very active T Tauri stars. However, the spatial extent of the LVC and the velocity dependence of the electron density have been so far observed only in another Class I jet, the HH34 jet, and are not explained by the current models of jet launching.

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http://arxiv.org/abs/0912.2043

The outcome of protoplanetary dust growth: pebbles, boulders, or planetesimals? I. Mapping the zoo of laboratory collision experiments

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The growth processes from protoplanetary dust to planetesimals are not fully understood. Laboratory experiments and theoretical models have shown that collisions among the dust aggregates can lead to sticking, bouncing, and fragmentation. However, no systematic study on the collisional outcome of protoplanetary dust has been performed so far so that a physical model of the dust evolution in protoplanetary disks is still missing. We intend to map the parameter space for the collisional interaction of arbitrarily porous dust aggregates. This parameter space encompasses the dust-aggregate masses, their porosities and the collision velocity. With such a complete mapping of the collisional outcomes of protoplanetary dust aggregates, it will be possible to follow the collisional evolution of dust in a protoplanetary disk environment. We use literature data, perform own laboratory experiments, and apply simple physical models to get a complete picture of the collisional interaction of protoplanetary dust aggregates. In our study, we found four different types of sticking, two types of bouncing, and three types of fragmentation as possible outcomes in collisions among protoplanetary dust aggregates. We distinguish between eight combinations of porosity and mass ratio. For each of these cases, we present a complete collision model for dust-aggregate masses between 10^{-12} and 10^2 g and collision velocities in the range 10^{-4} to 10^4 cm/s for arbitrary porosities. This model comprises the collisional outcome, the mass(es) of the resulting aggregate(s) and their porosities. We present the first complete collision model for protoplanetary dust. This collision model can be used for the determination of the dust-growth rate in protoplanetary disks.

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Nitrogen chemistry and depletion in starless cores

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We investigated the chemistry of nitrogen–containing species, principally isotopomers of CN, HCN, and HNC, in a sample of pre-protostellar cores. We used the IRAM 30 m telescope to measure the emission in rotational and hyperfine transitions of CN, HCN, 13CN, H13CN, HN13C, and HC15N in L 1544, L 183, Oph D, L 1517B, L 310.

The observations were made along axial cuts through the dust emission peak, at a number of regularly–spaced offset positions. The observations were reduced and analyzed to obtain the column densities, using the measurements of the less abundant isotopic variants in order to minimize the consequences of finite optical depths in the lines. The observations were compared with the predictions of a free–fall gravitational collapse model, which incorporates a non-equilibrium treatment of the relevant chemistry. We found that CN, HCN, and HNC remain present in the gas phase at densities well above that at which CO depletes on to grains. The CN:HCN and the HNC:HCN abundance ratios are larger than unity in all the objects of our sample. Furthermore, there is no observational evidence for large variations of these ratios with increasing offset from the dust emission peak and hence with density. Whilst the differential freeze–out of CN and CO can be understood in terms of the current chemistry, the behaviour of the CN:HCN ratio is more difficult to explain. Models suggest that most nitrogen is not in the gas phase but may be locked in ices. Unambiguous conclusions require measurements of the rate coefficients of the key neutral–neutral reactions at low temperatures.

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The Evolution of Density Structure of Starless and Protostellar Cores

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We present a near-infrared extinction study of nine dense cores at evolutionary stages between starless to Class I. Our results show that the density structure of all but one observed cores can be modeled with a single power law $\rho \propto r^p$ between $\sim 0.2R - R$ of the cores. The starless cores in our sample show two different types of density structures, one follows $p \sim -1.0$ and the other follows $p \sim -2.5$, while the protostellar cores all have $p \sim -2.5$. The similarity between the prestellar cores with $p \sim -2.5$ and protostellar cores implies that those prestellar cores could be evolving towards the protostellar stage. The slope of $p \sim -2.5$ is steeper than that of an singular isothermal sphere, which may be interpreted with the evolutionary model of cores with finite mass.

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Dense Gas Tracers in Perseus: Relating the N2H+, NH3, and Dust Continuum Properties of Pre- and Proto-Stellar Cores

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We investigate 35 pre-stellar cores and 36 proto-stellar cores in the Perseus molecular cloud. We find a very tight correlation between the physical parameters describing the N_2H^+ and NH_3 gas. Both the velocity centroids and the line widths of N_2H^+ and NH_3 correlate much better than either species correlates with CO, as expected if the nitrogen-bearing species are probing primarily the dense core gas where the CO has been depleted. We also find a tight correlation in the inferred abundance ratio between N_2H^+ and para-NH_3 across all cores, with N(p-NH_3)/N(N_2H^+)= 22±10. We find a mild correlation between NH_3 (and N_2H^+) column density and the (sub)millimeter dust continuum derived H_2 column density for pre-stellar cores, $N(\text{p-NH}_3)/N(\text{H}_2) \sim 10^{-8}$, but *do not* find a fixed ratio for proto-stellar cores.

The observations suggest that in the Perseus molecular cloud the formation and destruction mechanisms for the two nitrogen-bearing species are similar, regardless of the physical conditions in the dense core gas. While the equivalence

of N_2H^+ and NH_3 as powerful tracers of dense gas is validated, the lack of correspondence between these species and the (sub)millimeter dust continuum observations for proto-stellar cores is disconcerting and presently unexplained.

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The Solar Nebula on Fire: A Solution to the Carbon Deficit in the Inner Solar System

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Despite a surface dominated by carbon-based life, the bulk composition of the Earth is dramatically carbon poor when compared to the material available at formation. Bulk carbon deficiency extends into the asteroid belt representing a fossil record of the conditions under which planets are born. The initial steps of planet formation involve the growth of primitive sub-micron silicate and carbon grains in the Solar Nebula. We present a solution wherein primordial carbon grains are preferentially destroyed by oxygen atoms ignited by heating due to stellar accretion at radii ¡ 5 AU. This solution can account for the bulk carbon deficiency in the Earth and meteorites, the compositional gradient within the asteroid belt, and for growing evidence for similar carbon deficiency in rocks surrounding other stars.

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The Spitzer c2d Survey of Nearby Dense Cores: Jet and Molecular Outflow Associated with a Young Stellar Object in Core A of L1251

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A long infrared jet has been discovered by the *Spitzer* c2d legacy program in core A of L1251. It is associated with a very embedded Class 0 object with an accretion luminosity of about 0.9 $L_\odot$ derived by radiative transfer model fitting to the observed SED. Comparing the observed IRAC colors along the infrared jet with those calculated from a model of an admixture of gas with a power-law temperature distribution indicates that the jet is possibly created by a paraboloidal bow shock propagating into the ambient medium of $n(H_2) = 10^5\ cm^{-3}$. In addition, the variation of the power-law index along the jet suggests that the portion of hot gas decreases with distance from the jet engine. The molecular outflow in this region has been mapped for the first time using CO data. From the calculated outflow momentum flux, a very strong lower limit to the average accretion luminosity is $3.6\,\frac{\sin i}{\cos^3 i}\ L_\odot$, indicative of a decrease in the accretion rate with time.

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Oxygen in dense interstellar gas: The oxygen abundance of the star forming core ρ Oph A

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Context. Oxygen is the third most abundant element in the universe, but its chemistry in the interstellar medium is still not well understood.
Methods. We analysed ISOCAM-CVF spectral image data toward ρ Oph A to derive the temperatures and column densities of H_2 at the locations of ISO-LWS observations of two [O I] ^3P_J lines. The intensity ratios of the (J=1-2) 63 μm to (J=0-1) 145 μm lines largely exceed ten, attesting to these lines being optically thin. This is confirmed by radiative transfer calculations, making these lines suitable for abundance determinations. For that purpose, we calculated line strengths and compared them to the LWS observations.
Results. Excess [O I] emission is observed to be associated with the molecular outflow from VLA 1623. For this region, we determine the physical parameters, T and $N(H_2)$, from the CAM observations, and the gas density, $n(H_2)$, is determined from the flux ratio of the [O I] 63 μm and [O I] 145 μm lines. For the oxygen abundance, our analysis essentially leads to three possibilities: (1) extended low-density gas with standard ISM O-abundance, (2) compact high-density gas with standard ISM O-abundance, and (3) extended high-density gas with reduced oxygen abundance, $[O/H] \sim 2 \times 10^{-5}$.
Conclusions. As option (1) disregards valid [O I] 145 μm data, we do not find it very compelling; instead, we favour option (3), as lower abundances are expected as a result of chemical cloud evolution, but we are not able to dismiss option (2) entirely. Observations at higher angular resolution than offered by the LWS are required to decide between these possibilities.

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$O^{18}O$ and $C^{18}O$ observations of ρ Oph A

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Context. Contrary to theoretical expectation, surprisingly low concentrations of molecular oxygen, O_2, have been found in the interstellar medium. Telluric absorption makes ground based O_2 observations essentially impossible and observations had to be done from space. Millimetre-wave telescopes on space platforms were necessarily small, which resulted in large, several arcminutes wide, beam patterns. Observations of the ($N_J = 1_1 - 1_0$) ground state transition of O_2 with the Odin satellite resulted in a $\gtrsim 5\sigma$ detection toward the dense core ρ Oph A. At the frequency of the line, 119 GHz, the Odin telescope has a beam width of $10'$, larger than the size of the dense core.
Aims. The precise nature of the emitting source and its exact location and extent are therefore unknown. The current investigation is intended to remedy this.
Methods. Although the Earth's atmosphere is entirely opaque to low-lying O_2 transitions, it allows ground based observations of the much rarer $^{16}O^{18}O$ in favourable conditions and at much higher angular resolution with larger telescopes. In addition, ρ Oph A exhibits both multiple radial velocity systems and considerable velocity gradients. Extensive mapping of the region in the proxy $C^{18}O$ ($J = 3 - 2$) line can be expected to help identify the O_2 source on the basis of its line shape and Doppler velocity. Line opacities were determined from observations of optically thin $^{13}C^{18}O$ ($J = 3 - 2$). During several observing periods, two $C^{18}O$ intensity maxima in ρ Oph A were searched for $O^{18}O$ in the ($2_1 - 0_1$) line at 234 GHz with the 12 m APEX telescope. These positions are associated also with peaks in the mm-continuum emission from dust.
Results. Our observations resulted in an upper limit on the integrated $O^{18}O$ intensity of $\int T_A^* dv < 0.01\,\mathrm{K\,km\,s^{-1}}$ (3σ) into the $26''.5$ beam. Together with the $C^{18}O$ data, this leads to a ratio of $N(C^{18}O)/N(O^{18}O) > 16$. Combining Odin's

O_2 with the present $O^{18}O$ observations we infer an O_2 abundance $5 \times 10^{-7} < X(O_2) \lesssim 2.5 \times 10^{-6}$.
Conclusions. Examining the evidence, which is based primarily on observations in lines of $O^{18}O$ and $C^{18}O$, leads us to conclude that the source of observed O_2 emission is most likely confined to the central regions of the ρ Oph A core. In this limited area, implied O_2 abundances could thus be higher than inferred on the basis of Odin observations (5×10^{-8}) by up to two orders of magnitude.

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A Wide-field Narrow-band Optical Survey of the Braid Nebula Star Formation Region in Cygnus OB7

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We study the population of Herbig-Haro flows and jets in an area of Cygnus OB7 designated the Braid Nebula star formation region. This complex forms part of the L 1003 dark cloud, and hosts two FU Orionis (FUor) -like objects as well as several other active young stars. To trace outflow activity and relate both known, and newly discovered, flows to young star hosts we intercompare new, deep, narrow-band Hα and [S II] optical images taken on the Subaru 8-meter Telescope on Mauna Kea, Hawaii. Our images show that there is considerable outflow and jet activity in this region suggesting the presence of an extensive young star population. We confirm that both of the FUor-like objects drive extensive Herbig-Haro flows and document further members of the flows in both objects. The L 1003 star formation complex is a highly kinematically active region with young stars in several different stages of evolution. We trace collimated outflows from numerous young stars although the origin of some HH objects remains elusive.

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Discovery of a Faint Companion to Alcor Using MMT/AO 5 μm Imaging

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We report the detection of a faint stellar companion to the famous nearby A5V star Alcor (80 UMa). The companion has M-band ($\lambda = 4.8\,\mu$m) magnitude 8.8 and projected separation 1".11 (28 AU) from Alcor. The companion is most likely a low-mass (~0.3 $M_\odot$) active star which is responsible for Alcor's X-ray emission detected by ROSAT ($L_X \simeq 10^{28.3}$ erg/s). Alcor is a nuclear member of the Ursa Major star cluster (UMa; d $\simeq$ 25 pc, age $\simeq$ 0.5 Gyr), and has been occasionally mentioned as a possible distant (709") companion of the stellar quadruple Mizar (ζ UMa). Comparing the revised Hipparcos proper motion for Alcor with the mean motion for other UMa nuclear members shows that Alcor has a peculiar velocity of 1.1 km/s, which is comparable to the predicted velocity amplitude induced by the newly-discovered companion (~1 km/s). Using a precise dynamical parallax for Mizar and the revised Hipparcos parallax for Alcor, we find that Mizar and Alcor are physically separated by 0.36 ± 0.19 pc (74 ± 39 kAU; minimum

18 kAU), and their velocity vectors are marginally consistent (χ^2 probability 6%). Given their close proximity and concordant motions we suggest that the Mizar quadruple and the Alcor binary be together considered the 2nd closest stellar sextuplet. The addition of Mizar-Alcor to the census of stellar multiples with six or more components effectively doubles the local density of such systems within the local volume (d < 40 pc).

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Physical Properties of Dense Cores in the ρ Ophiuchi Main Cloud and A Significant Role of External Pressures in Clustered Star Formation

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Using the archive data of the $H^{13}CO^+$ ($J = 1-0$) line emission taken with the Nobeyama 45 m radio telescope with a spatial resolution of ~ 0.01pc, we have identified 68 dense cores in the central dense region of the ρ Ophiuchi main cloud. The $H^{13}CO^+$ data also indicates that the fractional abundance of $H^{13}CO^+$ relative to H_2 is roughly inversely proportional to the square root of the H_2 column density with a mean of 1.72×10^{-11}. The mean radius, FWHM line width, and LTE mass of the identified cores are estimated to be 0.045 ± 0.011 pc, 0.49 ± 0.14 km s^{-1}, and 3.4 ± 3.6 $M_\odot$, respectively. The majority of the identified cores have subsonic internal motions. The virial ratio, the ratio of the virial mass to the LTE mass, tends to decrease with increasing the LTE mass and about 60 percent of the cores have virial ratios smaller than 2, indicating that these cores are not transient structures but self-gravitating. The detailed virial analysis suggests that the surface pressure often dominates over the self-gravity and thus plays a crucial role in regulating core formation and evolution. By comparing the ρ Oph cores with those in the Orion A molecular cloud observed with the same telescope, we found that the statistical properties of the core physical quantities are similar between the two clouds if the effect of the different spatial resolutions is corrected. The line widths of the ρ Oph cores appear to be nearly independent of the core radii over the range of $0.01 - 0.1$ pc and deviate upwards from the Heyer & Brunt relation. This may be evidence that turbulent motions are driven by protostellar outflows in the cluster environment.

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Toward understanding the formation of multiple systems – A pilot IRAM-PdBI survey of Class 0 objects

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The formation process of binary stars and multiple systems is poorly understood. The multiplicity rate of Class II pre-main-sequence stars and Class I protostars is well documented and known to be high ($\sim$ 30% to 50% between $\sim$100 and 4000 AU). However, optical / near-infrared observations of Class I/Class II YSOs barely constrain the pristine properties of multiple systems, since dynamical evolution can quickly alter these properties during the protostellar phase.
Here, we seek to determine the typical outcome of protostellar collapse and to constrain models of binary formation by core fragmentation during collapse, using high-resolution millimeter continuum imaging of very young (Class 0)

protostars observed at the beginning of the main accretion phase.
We carried out a pilot high-resolution study of 5 Class 0 objects, including 3 Taurus sources and 2 Perseus sources, using the most extended (A) configuration of the IRAM Plateau de Bure Interferometer (PdBI) at 1.3 mm. Our PdBI observations have a typical HPBW resolution $\sim 0.3''-0.5''$ and rms continuum sensitivity $\sim 0.1-1$ mJy/beam, which allow us to probe the multiplicity of Class 0 protostars down to separations $a \sim 50$ AU and circumstellar mass ratios $q \sim 0.07$.
We detected all 5 primary Class 0 sources in the 1.3 mm dust continuum. A single component associated with the primary Class 0 object was detected in the case of the three Taurus sources, while robust evidence of secondary components was found toward the two Perseus sources: L1448-C and NGC1333-IR2A. We show that the secondary 1.3 mm continuum component detected $\sim$ 600 AU south-east of L1448-C, at a position angle close to that of the CO(2–1) jet axis traced by our data, is an outflow feature directly associated with the powerful jet driven by L1448-C. The secondary 1.3 mm continuum component detected $\sim$ 1900 AU south-east of NGC1333-IR2A may either be a genuine protostellar companion or trace the edge of an outflow cavity. Therefore, our PdBI observations revealed only wide ($>$ 1500 AU) protobinary systems and/or outflow-generated features.
When combined with previous millimeter interferometric observations of Class 0 protostars, our pilot PdBI study tentatively suggests that the binary fraction in the $\sim 75-1000$ AU range increases from the Class 0 to the Class I stage. It also seems to argue against purely hydrodynamic models of binary star formation. We briefly discuss possible alternative scenarios to reconcile the low multiplicity rate of Class 0 protostars on small scales with the higher binary fraction observed at later (e.g. Class I) evolutionary stages.

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Direct Imaging of Bridged Twin Protoplanetary Disks in a Young Multiple Star

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Studies of the structure and evolution of protoplanetary disks are important for understanding star and planet formation. Here, we present the direct image of an interacting binary protoplanetary system. Both circumprimary and circumsecondary disks are resolved in the near-infrared. There is a bridge of infrared emission connecting the two disks and a long spiral arm extending from the circumprimary disk. Numerical simulations show that the bridge corresponds to gas flow and a shock wave caused by the collision of gas rotating around the primary and secondary stars. Fresh material streams along the spiral arm, consistent with the theoretical scenarios where gas is replenished from a circummultiple reservoir.

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On the evolution of a star cluster and its multiple stellar systems following gas dispersal

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We investigate the evolution, following gas dispersal, of a star cluster produced from a hydrodynamical calculation of the collapse and fragmentation of a turbulent molecular cloud. We find that when the gas, initially comprising $\approx 60\%$ of the mass, is removed, the system settles into a bound cluster containing $\approx 30-40\%$ of the stellar mass surrounding by an expanding halo of ejected stars. The bound cluster expands from an initial radius of < 0.05 pc to $1-2$ pc over $\approx 4-10$ Myr, depending on how quickly the gas is removed, implying that stellar clusters may begin with far higher stellar densities than usually assumed. With rapid gas dispersal the most massive stars are found to be mass segregated for the first ~ 1 Myr of evolution, but classical mass segregation only develops for cases with long gas removal timescales. Eventually, many of the most massive stars are expelled from the bound cluster. Despite the high initial stellar density and the extensive dynamical evolution of the system, we find that the stellar multiplicity is almost constant during the 10 Myr of evolution. This is because the primordial multiple systems are formed in a clustered environment and, thus, by their nature are already resistant to further evolution. The majority of multiple system evolution is confined to the decay of high-order systems (particularly quadruple systems) and the formation of a significant population of very wide (10^4-10^5 AU) multiple systems in the expanding halo. This formation mechanism for wide binaries potentially solves the problem of how most stars apparently form in clusters and yet a substantial population of wide binaries exist in the field. We also find that many of these wide binaries and the binaries produced by the decay of high-order multiple systems have unequal mass components, potentially solving the problem that hydrodynamical simulations of star formation are found to under-produce unequal-mass solar-type binaries.

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CO observations towards bright-rimmed clouds

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Bright-rimmed clouds (BRCs) appear to be sites of triggered star formation induced through the propagation of shocks initiated by the expansion of nearby HII regions. Our main aim is to establish support for observations of star-forming activity within a sample of BRCs. A secondary aim is to establish a plausible link between such star formation and observed external influences. We have conducted CO (J = 2-1) observations using the James Clerk Maxwell Telescope to probe the environments of a sample of star-forming BRCs associated with embedded protostellar cores. Local thermodynamic equilibrium analysis allows the determination of the physical properties of these protostars and investigation of the structure and kinematic motions within the molecular gas. Using a combination of archival radio and mid-infrared data, and submillimeter observations, we have refined the Sugitani, Fukui and Ogura (SFO) catalogue, excluding 18 BRCs that do not show any evidence of photoionization induced collapse. Of the remaining 26 clouds that are being photoionized, we find 20 that are associated with embedded protostars. These 20 clouds are excellent candidates with which to further investigate the radiatively driven implosion mode of triggered star formation. Comparing the physical parameters of the triggered and untriggered samples, we find that the surface temperatures of the potentially triggered clouds are significantly higher (by around 10 K) than those in which triggering is considered unlikely. The higher surface temperatures found towards the sample of potentially triggered clouds are consistent with the hypothesis that these clouds are being externally heated through their exposure to the HII region.

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Full 2D radiative transfer modelling of transitional disk LkCa 15

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Context. With the legacy of Spitzer and current advances in (sub)mm astronomy, a large number of so-called 'transitional' disks has been identified which are believed to contain gaps or have developped large inner holes, some filled with dust. This may indicate that complex geometries may be a key feature in disk evolution that has to be understood and modeled correctly. The disk around LkCa 15 is such a disk, with a large gap ranging from ∼5 - 50 AU, as identified by Espaillat et al. (2007) using 1+1D radiative transfer modelling. To fit the SED, they propose 2 possible scenarios for the inner (<5 AU) disk - optically thick or optically thin - and one scenario for the outer disk.
Aims. We use the gapped disk of LkCa 15 as a showcase to illustrate the importance of 2D radiative transfer in transitional disks, by showing how the vertical dust distribution in dust-filled inner holes determines not only the radial optical depth but also the outer disk geometry.
Methods. We use MCMax, a 2D radiative transfer code with a self-consistent vertical density and temperature structure, to model the SED of LkCa 15.
*Results*We identify two possible geometries for the inner *and* outer disk, that are both different from those in Espaillat et al. (2007). An inner disk in hydrostatic equilibrium reprocesses enough starlight to fit the near infrared flux, but also casts a shadow on the inner rim of the outer disk. This requires the outer disk scale height to be large enough to rise out of the shadow. An optically thin inner disk does not cast such a shadow, and the SED can be fitted with a smaller outer disk scale height. For the dust in the inner regions to become optically thin however, the scale height would have to be so much larger than its hydrostatic equilibrium value that it effectively becomes a dust shell. It is currently unclear if a physical mechanism exists which could provide for such a configuration.
Conclusions. We find that the radial optical depth of dust within the inner hole of LkCa 15 is controlled by its vertical distribution. If it turns optically thick, the outer disk scale height must be increased to raise the outer disk out of the inner disk's shadow.

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Planetesimal collisions in binary systems

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We study the collisional evolution of km-sized planetesimals in tight binary star systems to investigate whether accretion towards protoplanets can proceed despite the strong gravitational perturbations from the secondary star. The orbits of planetesimals are numerically integrated in two dimensions under the influence of the two stars and gas drag. The masses and orbits of the planetesimals are allowed to evolve due to collisions with other planetesimals and accretion of collisional debris. In addition, the mass in debris can evolve due to planetesimal-planetesimal collisions and the creation of new planetesimals. We show that it is possible in principle for km-sized planetesimals to grow by two orders of magnitude in size if the efficiency of planetesimal formation is relatively low. We discuss the limitations of our two-dimensional approach.

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H II regions: Witnesses to massive star formation

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We describe the first three-dimensional simulation of the gravitational collapse of a massive, rotating molecular cloud that includes heating by both non-ionizing and ionizing radiation. These models were performed with the FLASH code, incorporating a hybrid, long characteristic, ray tracing technique. We find that as the first protostars gain sufficient mass to ionize the accretion flow, their H II regions are initially gravitationally trapped, but soon begin to rapidly fluctuate between trapped and extended states, in agreement with observations. Over time, the same ultracompact H II region can expand anisotropically, contract again, and take on any of the observed morphological classes. In their extended phases, expanding H II regions drive bipolar neutral outflows characteristic of high-mass star formation. The total lifetime of H II regions is given by the global accretion timescale, rather than their short internal sound-crossing time. This explains the observed number statistics. The pressure of the hot, ionized gas does not terminate accretion. Instead the final stellar mass is set by fragmentation-induced starvation. Local gravitational instabilities in the accretion flow lead to the build-up of a small cluster of stars, all with relatively high masses due to heating from accretion radiation. These companions subsequently compete with the initial high-mass star for the same common gas reservoir and limit its mass growth. This is contrary to the classical competitive accretion model, where the massive stars are never hindered in growth by the low-mass stars in the cluster. Our findings show that the most significant differences between the formation of low-mass and high-mass stars are all explained as the result of rapid accretion within a dense, gravitationally unstable, ionized flow.

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Planet-planet scattering in planetesimal disks II: Predictions for outer extrasolar planetary systems

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We develop an idealized dynamical model to predict the typical properties of outer extrasolar planetary systems, at radii comparable to the Jupiter to Neptune region of the Solar System. The model is based upon the hypothesis that dynamical evolution in outer planetary systems is controlled by a combination of planet-planet scattering and planetary interactions with an exterior disk of small bodies ("planetesimals"). Our results are based on 5,000 long duration N-body simulations that follow the evolution of three planets from a few to 10 AU, together with a planetesimal disk containing 50 $M_\oplus$ from 10-20 AU. For large planet masses ($M > M_{\rm Sat}$) the model recovers the observed eccentricity distribution of extrasolar planets. For lower mass planets the range of outcomes in models with disks is far greater than is seen in isolated planet-planet scattering. Common outcomes include strong scattering among massive planets, sudden jumps in eccentricity due to resonance crossings driven by divergent migration, and re-circularization of scattered low-mass planets in the outer disk. We present distributions of the eccentricity and inclination that result, and discuss how they vary with planet mass and initial system architecture. In agreement with other studies, we find that the currently observed eccentricity distribution (derived primarily from planets at $a < 3$ AU) is consistent with isolated planet-planet scattering. We explain the observed mass dependence – which is in the opposite sense from that predicted by the simplest scattering models – as a consequence of strong correlations between planet masses in the same system. At somewhat larger radii initial planetary mass correlations and disk effects can yield similar modest changes to the eccentricity distribution. Nonetheless, *strong* damping of eccentricity for low mass planets at large radii appears to be a secure signature of the dynamical influence of disks. Radial velocity measurements capable of detecting planets with $K \approx 5$ m s^{-1} and periods in excess of 10 years will provide constraints on this regime. Finally, we present an

analysis of the predicted separation of planets in two planet systems, and of the population of planets in mean motion resonances (MMRs). We show that, if there are systems with ∼Jupiter-mass planets that avoid close encounters, the planetesimal disk acts as a damping mechanism and populates mean motion resonances (MMRs) at a very high rate (50-80%). In many cases, resonant chains (in particular the 4:2:1 Laplace resonance) are set up among all three planets. We expect such resonant chains to be common among massive planets in outer planetary systems.

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The Multiple Pre-Main Sequence System HBC 515 in L1622

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The bright pre-main sequence star HBC 515 (HD 288313) located in the L1622 cometary cloud in Orion has been studied extensively with optical/infrared imaging and ultraviolet/optical/infrared spectroscopy. The spectra indicate that HBC 515 is a weakline T Tauri star of spectral type K2V. Adaptive optics imaging in the K-band reveals that HBC 515 is a binary with two equally bright components separated by 0.5″. A very faint third component is found 5″ to the northwest. Spitzer IRAC and MIPS observations show that at mid-infrared wavelengths this third source dominates the system, suggesting that it is a protostar still embedded in the nascent cloud of HBC 515. The close association of a weakline T Tauri star with a newborn protostar in a multiple system is noteworthy. Two nearby T Tauri stars are likely associated with the HBC 515 multiple system, and the dynamical evolution of the complex that would lead to such a configuration is considered.

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The present-day star formation rate of the Milky-Way determined from *Spitzer* detected young stellar objects

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We present initial results from a population synthesis model aimed at determining the star formation rate of the Milky-Way. We find that a total star formation rate of 0.68 to 1.45 $M_\odot$/yr is able to reproduce the observed number of young stellar objects in the *Spitzer*/IRAC GLIMPSE survey of the Galactic plane, assuming simple prescriptions for the 3D Galactic distributions of YSOs and interstellar dust, and using model SEDs to predict the brightness and color of the synthetic YSOs at different wavelengths. This is the first Galaxy-wide measurement derived from pre-main-sequence objects themselves, rather than global observables such as the total radio continuum, Hα, or FIR flux. The value obtained is slightly lower than, but generally consistent with previously determined values. We will extend this method in the future to fit the brightness, color, and angular distribution of YSOs, and simultaneously make use of multiple surveys, to place constraints on the input assumptions, and reduce uncertainties in the star formation rate estimate. Ultimately, this will be one of the most accurate methods for determining the Galactic star formation rate, as it makes use of stars of all masses (limited only by sensitivity) rather than solely massive stars or indirect tracers of massive stars.

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The Mass Distributions of Starless and Protostellar Cores in Gould Belt Clouds

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Using data from the SCUBA Legacy Catalogue (850 μm) and *Spitzer Space Telescope* (3.6 - 70 μm), we explore dense cores in the Ophiuchus, Taurus, Perseus, Serpens, and Orion molecular clouds. We develop a new method to discriminate submillimeter cores found by SCUBA as starless or protostellar, using point source photometry from Spitzer wide field surveys. First, we identify infrared sources with red colors associated with embedded young stellar objects (YSOs). Second, we compare the positions of these YSO-candidates to our submillimeter cores. With these identifications, we construct new, self-consistent starless and protostellar core mass functions (CMFs) for the five clouds. We find best fit slopes to the high-mass end of the CMFs of -1.26 ± 0.20, -1.22 ± 0.06, -0.95 ± 0.20, and -1.67 ± 0.72 for Ophiuchus, Taurus, Perseus, and Orion, respectively. Broadly, these slopes are each consistent with the -1.35 power-law slope of the Salpeter initial mass function (IMF) at higher masses, but suggest some differences. We examine a variety of trends between these CMF shapes and their parent cloud properties, potentially finding a correlation between the high-mass slope and core temperature. We also find a trend between core mass and effective size, but we are very limited by sensitivity. We make similar comparisons between core mass and size with visual extinction (for $A_V \geq 3$) and find no obvious trends. We also predict the numbers and mass distributions of cores that future surveys with SCUBA-2 may detect in each of these clouds.

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Accretion in Evolved and Transitional Disks in Cep OB2: Looking for the Origin of the Inner Holes

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We present accretion rates for a large number of solar-type stars in the Cep OB2 region, based on U band observations. Our study comprises 95 members of the ~4 Myr-old cluster Tr 37 (including 20 "transition" objects; TO), as well as the only CTTS in the ~12 Myr-old cluster NGC 7160. The stars show different disk morphologies, with the majority of them having evolved and flattened disks. The typical accretion rates are about one order of magnitude lower than in regions aged 1-2 Myr, and we find no strong correlation between disk morphology and accretion rates. Although half of the TO are not accreting, the median accretion rates of normal CTTS and accreting "transition" disks are similar ($\sim 3\times10^{-9}$ and 2×10^{-9} $M_\odot$ yr^{-1}, respectively). Comparison with other regions suggests that the TO observed at different ages do not necessarily represent the same type of objects, which is consistent with the fact that the different processes that can lead to reduced IR excess/inner disk clearing (e.g., binarity, dust coagulation/settling,

photoevaporation, giant planet formation) do not operate on the same timescales. Accreting TO in Tr 37 are probably suffering strong dust coagulation/settling. Regarding the equally large number of non-accreting TO in the region, other processes, like photoevaporation, the presence of stellar/substellar companions, and/or giant planet formation may account for their "transitional" SEDs and negligible accretion rates.

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http://www.mpia.de/homes/sicilia/aurora_publications.html

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The destruction and survival of polycyclic aromatic hydrocarbons in the disks of T Tauri stars

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In Spitzer observations of Tauri stars and their disks, features of polycyclic aromatic hydrocarbons (PAHs) are detected in less than 10% of the objects, although the stellar photosphere is sufficiently hot to excite PAHs. To explain the deficiency, we discuss PAH destruction by photons, assuming that the star has beside its photospheric emission also a far ultraviolet (FUV), an extreme ultraviolet (EUV) and an X–ray component with a fractional luminosity of 1%, 0.1% and 0.025%, respectively. We consider as a PAH destruction process unimolecular dissociation and present a simplified scheme to estimate the location from the star at which the molecules become photo-stable. We find that soft photons with energies below $\sim 20\,\mathrm{eV}$ dissociate PAHs only up to short distances from the star ($r < 1\,\mathrm{AU}$); whereas dissociation by hard photons (EUV and X–ray) is so efficient that it would destroy all PAHs (from regions in the disk where they could be excited). As a possible path for PAH–survival we suggest turbulent motions in the disk. They can replenish or remove PAHs from the reach of hard photons. For standard disk models, where the surface density changes like r^{-1} and the mid plane temperature like $r^{-0.5}$, the critical vertical velocity for PAH survival is proportional to $r^{-3/4}$ and equals $\sim 5\,\mathrm{m/s}$ at $10\,\mathrm{AU}$, which is in the range of expected velocities in the surface layer. The uncertainty in the parameters is large enough to explain both detection and non-detection of PAHs. Our approximate treatment also takes into account the presence of gas which is ionized at the top of the disk and neutral at lower levels.

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The nature of the recent extreme outburst of the Herbig Be/FU Ori bina ry Z CMa

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Z CMa is a binary system which consists of two young stars: a Herbig AeBe component Z CMa NW embedded in a dust cocoon and a less massive component Z CMa SE, which is classified as a FU Orionis type star. Associated to the binary system is a giant parsec-size jet. Past spectropolarimetric observations showed that the position angle of the linear optical polarization is perpendicular to the jet axis, indicating that the visual light escapes the cocoon via cavities aligned with the jet axis and is then scattered back into the line of sight of the observer. Recently the system showed the largest outburst reported during the almost 90 years of available observations.

We present new spectrophotometric and spectropolarimetric data obtained in 2008 during the recent outburst phase. The data obtained in the visual spectral range at medium spectral resolution were used to study the geometry of the system from the linear polarization spectra as well as its magnetic field from the circular polarization spectra.

During the recent outburst we detected that the Z CMa system is polarized by 2.6% in the continuum and emission line spectrum, with a position angle still perpendicular to the jet. From the high level of polarization we concluded that the outburst is associated with the dust-embedded Herbig AeBe NW component. The deep absorption components of the Balmer lines in the velocity frame which extend from zero velocity and reach a wind velocity of $\sim$700 km s^{-1}, together with the absence of a red-shifted broad emission at similar velocities, indicate a bi-polar wind. We did not detect a significant mean longitudinal magnetic field during the outburst, but in the data obtained in 2004 we detected the possible presence of a rather strong magnetic field of the order of $\sim$1 kG. However, we critically review the applied method of magnetic field measurements in the presence of a strong stellar wind. The main result of our studies is that the bolometric luminosity of Z CMa remained surprisingly constant during the recent outburst. We conclude that either the geometry of the cavity through which the light escapes from the cocoon has opened a new path or that the screen of dust, which reflects the light toward the observer became more efficient, causing the observed increase of the visual brightness by about 2.5 magnitudes.

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A Test of Star Formation Laws in Disk Galaxies

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We use observations of the radial profiles of the mass surface density of total, Σ_g, and molecular, $\Sigma_{\rm H2}$, gas, rotation velocity and star formation rate surface density, $\Sigma_{\rm sfr}$, of the molecular dominated regions of 12 disk galaxies from Leroy et al. to test several star formation laws: a "Kennicutt-Schmidt power law", $\Sigma_{\rm sfr} = A_g \Sigma_{g,2}^{1.5}$; a "Constant molecular law", $\Sigma_{\rm sfr} = A_{\rm H2}\Sigma_{\rm H2,2}$; the "Turbulence-regulated laws" of Krumholz & McKee (KM) and Krumholz, McKee & Tumlinson (KMT), a "Gas-Ω law", $\Sigma_{\rm sfr} = B_\Omega \Sigma_g \Omega$; and a shear-driven "GMC collisions law", $\Sigma_{\rm sfr} = B_{\rm CC}\Sigma_g \Omega(1-0.7\beta)$, where $\beta \equiv d \ln v_{\rm circ}/d \ln r$. We find the constant molecular law, KMT turbulence law and GMC collision law are the most accurate, with an rms error of a factor of 1.5 if the normalization constants are allowed to vary between galaxies. Of these three laws, the GMC collision law does not require a change in physics to account for the full range of star formation activity seen from normal galaxies to circumnuclear starbursts. A single global GMC collision law with $B_{\rm CC} = 8.0 \times 10^{-3}$, i.e. a gas consumption time of 20 orbital times for $\beta = 0$, yields an rms error of a factor of 1.8.

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http://www.astro.ufl.edu/~jt/preprints/ms_disk_SFRs.pdf

Eccentricity pumping of a planet on an inclined orbit by a disc

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In this paper, we show that the eccentricity of a planet on an inclined orbit with respect to a disc can be pumped up to high values by the gravitational potential of the disc, even when the orbit of the planet crosses the disc plane. This process is an extension of the Kozai effect. If the orbit of the planet is well inside the disc inner cavity, the process is formally identical to the classical Kozai effect. If the planet's orbit crosses the disc but most of the disc mass is beyond the orbit, the eccentricity of the planet grows when the initial angle between the orbit and the disc is larger than some critical value which may be significantly smaller than the classical value of 39 degrees. Both the eccentricity and the inclination angle then vary periodically with time. When the period of the oscillations of the eccentricity is smaller than the disc lifetime, the planet may be left on an eccentric orbit as the disc dissipates.

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A *Spitzer Space Telescope* far-infrared spectral atlas of compact sources in the Magellanic Clouds. II. The Small Magellanic Cloud

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We present far-infrared spectra, λ=52–93 μm, obtained with the *Spitzer Space Telescope* in the Spectral Energy Distribution mode of its MIPS instrument, of a selection of luminous compact far-infrared sources in the Small Magellanic Cloud. These comprise nine Young Stellar Objects (YSOs), the compact H II region N 81 and a similar object within N 84, and two red supergiants (RSGs). We use the spectra to constrain the presence and temperature of cool dust and the excitation conditions within the neutral and ionized gas, in the circumstellar environments and interfaces with the surrounding interstellar medium. We compare these results with those obtained in the LMC. The spectra of the sources in N 81 (of which we also show the ISO-LWS spectrum between 50–170 μm) and N 84 both display strong [O I] λ63-μm and [O III] λ88-μm fine-structure line emission. We attribute these lines to strong shocks and photo-ionized gas, respectively, in a "champagne flow" scenario. The nitrogen content of these two H II regions is very low, definitely $N(\mathrm{N})/N(\mathrm{O}) < 0.04$ but possibly as low as $N(\mathrm{N})/N(\mathrm{O}) < 0.01$. Overall, the oxygen lines and dust continuum are weaker in star-forming objects in the SMC than in the LMC. We attribute this to the lower metallicity of the SMC compared to that of the LMC. Whilst the dust mass differs in proportion to metallicity, the oxygen mass differs less; both observations can be reconciled with higher densities inside star-forming cloud cores in the SMC than in the LMC. The dust in the YSOs in the SMC is warmer (37–51 K) than in comparable objects in the LMC (32–44 K). We attribute this to the reduced shielding and reduced cooling at the low metallicity of the SMC. On the other hand, the *efficiency* of the photo-electric effect to heat the gas is found to be indistinguishable to that measured in the same manner in the LMC, $\approx$ 0.1–0.3%. This may result from higher cloud-core densities, or smaller grains, in the SMC. The dust associated with the two RSGs in our SMC sample is cool, and we argue that it is swept-up interstellar dust, or formed (or grew) within the bow-shock, rather than dust produced in these metal-poor RSGs themselves. Strong emission from crystalline water ice is detected in at least one YSO. The spectra constitute a valuable resource for the planning and interpretation of observations with the *Herschel Space Observatory* and the *Stratospheric Observatory For Infrared Astronomy* (SOFIA).

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A near IR imaging survey of high and intermediate-mass young stellar outflow candidates

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We have carried out a near-infrared imaging survey of luminous young stellar outflow candidates using the United Kingdom Infrared Telescope. Observations were obtained in the broad band K (2.2 μm) and through narrow band filters at the wavelengths of H_2 v =1–0 S(1) (2.1218 μm) and Brγ (2.166 μm) lines. Fifty regions were imaged with a field of view of 2.2×2.2 arcmin^2. Several young embedded clusters are unveiled in our near-infrared images. 76% of the objects exhibit H_2 emission and 50% or more of the objects exhibit aligned H_2 emission features suggesting collimated outflows, many of which are new detections. These observations suggest that disk accretion is probably the leading mechanism in the formation of stars, at least up to late O spectral types. The young stellar objects responsible for many of these outflows are positively identified in our images based on their locations with respect to the outflow lobes, 2MASS colours and association with MSX, IRAS, millimetre and radio sources. The close association of molecular outflows detected in CO with the H_2 emission features produced by shock excitation by jets from the young stellar

objects suggests that the outflows from these objects are jet-driven. Towards strong radio emitting sources, H_2 jets were either not detected or were weak when detected, implying that most of the accretion happens in the pre-UCHII phase; accretion and outflows are probably weak when the YSO has advanced to its UCHII stage.

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Mopra line survey mapping of NGC 6334 I and I(N) at 3 mm

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A $5' \times 5'$ region encompassing NGC 6334 I and I(N) has been mapped at a wavelength of 3 mm (from 83.5 to 115.5 GHz) with the Mopra telescope at an angular resolution between $33''$ and $36''$. This investigation has made use of the recently installed 3 mm MMIC receiver and the Mopra Spectrometer (MOPS) with broadband capabilities permitting total coverage of the entire frequency range with just five different observations. In total, the spatial distribution of nineteen different molecules, ions and radicals, along with additional selected isotopologues have been studied. Whilst most species trace the sites of star formation, CH_3CN appears to be most closely associated with NGC 6334 I and I(N). Both CN and C_2H appear to be widespread, tracing gas that is not associated with active star formation. Both N_2H^+ and HC_3N closely resemble dust continuum emission, showing they are reliable tracers of dense material, as well as the youngest stages of high mass star formation. Hot ($E_u/k >$100 K) thermal CH_3OH emission is preferentially found towards NGC 6334 I, contrasting with I(N), where only cold ($E_u/k <$22 K) thermal CH_3OH emission is found.

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A Test of Pre–Main-Sequence Li Depletion Models

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Despite the extensive study of lithium depletion during pre–main-sequence contraction, studies of individual stars show discrepancies between ages determined from the HR diagram and ages determined from lithium depletion (Song et al. 2002, White & Hillenbrand 2005) indicating open questions in the pre–main-sequence evolutionary models. To further test these models, we present high resolution spectra for members of the β Pictoris Moving Group (BPMG), which is young and nearby. We measure equivalent widths of the 6707.8Å Li I line in these stars and use them to determine lithium abundances. We combine the lithium abundance with the predictions of pre–main-sequence evolutionary models in order to calculate a lithium depletion age for each star. We compare this age to the age predicted by the HR diagram of the same model. We find that the evolutionary models under-predict the amount of lithium depletion for the BPMG given its nominal HR diagram age of $\sim$12 Myr (Zuckerman et al. 2001), particularly for the mid-M stars, which have no observable Li I line. This results in systematically older ages calculated from lithium depletion isochrones than from the HR diagram. We suggest that this discrepancy may be related to the discrepancy between measured M-dwarf radii and the smaller radii predicted by evolutionary models.

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High-Velocity Jets and Slowly Rotating Envelope in B335

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We have performed detailed imaging and analyses of SMA observations in 230 GHz continuum, ^{12}CO (2–1), ^{13}CO (2–1), and C^{18}O (2–1) emission toward B335, an isolated and nearby ($\sim$ 150 pc) Bok globule with an embedded Class 0 source ($L_{\rm bol} \sim 1.5\ L_\odot$). We report the first discover of high-velocity ($V_{\rm propagation} \sim 160$ km s^{-1}) ^{12}CO (2–1) jets with a size of $\sim$ 900 AU $\times$ 1500 AU along the E-W direction in B335. The estimated mass-loss rate ($\sim 2.3 \times 10^{-7}\ M_\odot$ yr^{-1}) and the momentum flux ($\sim 3.7 \times 10^{-5}\ M_\odot$ yr^{-1} km s^{-1}) of the ^{12}CO jets in B335 are one order of magnitude lower than those of other ^{12}CO jets in more luminous sources such as HH 211 ($L_{\rm bol} \sim 3.6\ L_\odot$) and HH 212 ($L_{\rm bol} \sim 14\ L_\odot$). The weaker jet activity in B335 could be due to the lower active accretion onto the central protostar. The C^{18}O emission shows a compact ($\sim$ 1500 AU) condensation associated with the central protostar, and it likely traces the protostellar envelope around B335, as in the case of the 230 GHz continuum emission. The envelope exhibits a velocity gradient from the east (blueshifted) to west (redshifted) that can be interpreted as an infalling motion. The estimated central stellar mass, the mass infalling rate, and the accretion luminosity are 0.04 $M_\odot$, $6.9 \times 10^{-6}\ M_\odot$ yr^{-1}, and 2.1 $L_\odot$, respectively. On the other hand, there is no clear velocity gradient perpendicular to the outflow axis in the C^{18}O envelope, suggesting little envelope rotation on a hundred-AU scale. The upper limits of the rotational velocity and specific angular momentum were estimated to be 0.04 km s^{-1} and 7.0×10^{-5} km s^{-1} pc at a radius of 370 AU, respectively. The specific angular momentum and the inferred Keplerian radius ($\sim$ 6 AU) in B335 are 1 - 2 orders of magnitude smaller than those in other more-evolved sources. Possible scenarios to explain the lower specific angular momentum in B335 are discussed.

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The outcome of protoplanetary dust growth: pebbles, boulders, or planetesimals? II. Introducing the bouncing barrier

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The sticking of micron sized dust particles due to surface forces in circumstellar disks is the first stage in the production of asteroids and planets. The key ingredients that drive this process are the relative velocity between the dust particles in this environment and the complex physics of dust aggregate collisions. Here we present the results of a collision model, which is based on laboratory experiments of these aggregates. We investigate the maximum aggregate size and mass that can be reached by coagulation in protoplanetary disks. We model the growth of dust aggregates at 1 AU at the midplane at three different gas densities. We find that the evolution of the dust does not follow the previously assumed growth-fragmentation cycles. Catastrophic fragmentation hardly occurs in the three disk models. Furthermore we see long lived, quasi-steady states in the distribution function of the aggregates due to bouncing. We explore how the mass and the porosity change upon varying the turbulence parameter and by varying the critical mass ratio of dust particles. Particles reach Stokes numbers of roughly 10^{-4} during the simulations. The particle growth is stopped by bouncing rather than fragmentation in these models. The final Stokes number of the aggregates is rather insensitive to the variations of the gas density and the strength of turbulence. The maximum mass of the particles is limited to approximately 1 gram (chondrule-sized particles). Planetesimal formation can proceed via the turbulent concentration of these aerodynamically size-sorted chondrule-sized particles.

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The physical properties of extrasolar planets

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Tremendous progress in the science of extrasolar planets has been achieved since the discovery of a Jupiter orbiting the nearby Sun-like star 51 Pegasi in 1995. Theoretical models have now reached enough maturity to predict the characteristic properties of these new worlds, mass, radius, atmospheric signatures, and can be confronted with available observations. We review our current knowledge of the physical properties of exoplanets, internal structure and composition, atmospheric signatures, including expected biosignatures for exo-Earth planets, evolution, and the impact of tidal interaction and stellar irradiation on these properties for the short-period planets. We discuss the most recent theoretical achievements in the field and the still pending questions. We critically analyse the different solutions suggested to explain abnormally large radii of a significant fraction of transiting exoplanets. Special attention is devoted to the recently discovered transiting objects in the overlapping mass range between massive planets and low-mass brown dwarfs, stressing the ambiguous nature of these bodies, and we discuss the possible observable diagnostics to identify these two distinct populations. We also review our present understanding of planet formation and critically examine the different suggested formation mechanisms. We expect the present review to provide the basic theoretical background to capture the essential of the physics of exoplanet formation, structure and evolution, and the related observable signatures.

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http://stacks.iop.org/0034-4885/73/016901

http://arxiv.org/abs/1001.3577

A Universal Stellar Initial Mass Function? A Critical Look at Variations

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Few topics in astronomy initiate such vigorous discussion as whether or not the initial mass function (IMF) of stars is universal, or instead sensitive to the initial conditions of star formation. The distinction is of critical importance: the IMF influences most of the observable properties of stellar populations and galaxies, and detecting variations in the IMF could provide deep insights into the process by which stars form. In this review, we take a critical look at the case for IMF variations, with a view towards whether other explanations are sufficient given the evidence. Studies of the field, local young clusters and associations, and old globular clusters suggest that the vast majority were drawn from a "universal" IMF: a power-law of Salpeter index ($\Gamma = 1.35$) above a few solar masses, and a log normal or shallower power-law ($\Gamma \sim 0 - 0.25$) between a few tenths and a few solar masses (ignoring the effects of unresolved binaries). The shape and universality of the IMF at the stellar-substellar boundary is still under investigation and uncertainties remain large, but most observations are consistent with a IMF that declines ($\Gamma < -0.5$) well below the hydrogen burning limit. Observations of resolved stellar populations and the integrated properties of most galaxies are also consistent with a "universal IMF", suggesting no gross variations in the IMF over much of cosmic time. There are indications of "non-standard" IMFs in specific local and extragalactic environments, which clearly warrant further study. Nonetheless, there is no clear evidence that the IMF varies strongly and systematically as a function of initial conditions after the first few generations of stars.

Accepted by Annual Reviews of Astronomy and Astrophysics

http://xxx.lanl.gov/abs/1001.2965

FUors and Early Stellar Evolution

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Victor Ambartsumian was among the first researchers who recognized the importance and uniqueness of FUors, the term he coined for the rare outburst sources of the FU Orionis type. A wealth of observational data and concomitant theoretical work has advanced our understanding of FUors in the intervening almost 40 years. These results are summarized in this brief review, with special emphasis on observations related to the binarity of FUors. It is argued that at least some FUors represent the transitions of young binaries from a wide to a close system, and are thus signposts of the formation of a spectroscopic binary. The EXor phenomenon is also discussed, together with a variety of other eruptive events. Finally, we discuss in some detail recent observations of V1647 Ori, the latest eruption to have been witnessed in a star forming region.

Accepted for publication in the Victor Ambartsumian Centennial Volume "Evolution of Cosmic Objects through their Physical Activity", eds. Hayk Harutyunyan, Areg Mickaelian, and Yervant Terzian

http://www.ifa.hawaii.edu/publications/preprints/09preprints/Reipurth_09-217-rev.pdf

The Star Formation Newsletter is a vehicle for fast distribution of information of interest for astronomers working on star 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).

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The Star Formation Newsletter is available on the World Wide Web at http://www.ifa.hawaii.edu/users/reipurth/newsletter.htm.

Ionization Feedback in Massive Star Formation

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Ph.D dissertation directed by: Ralf Klessen

Ph.D degree awarded: December 2009

Understanding the origin of high-mass stars is central to modern astrophysics. We shed light on this problem using novel radiation-hydrodynamic simulations that consistently follow the gravitational collapse of a massive molecular cloud, the subsequent build-up and fragmentation of the accretion disk surrounding the nascent star, and, for the first time, the interaction between its intense UV radiation field and the infalling material. We show that ionization feedback can neither stop protostellar mass growth nor suppress fragmentation. We present a consistent picture of the formation and evolution of H II regions that explains the observed morphology, time variability, and ages of ultracompact H II regions, solving the long-standing lifetime problem.

http://www.ub.uni-heidelberg.de/archiv/10220/

Postdoctoral Positions in Galactic Radio and (Sub)millimeter Astronomy
MAX-PLANCK-INSTITUT FÜR RADIOASTRONOMIE

(review date moved to March 1st)

For the major project "A Global View of Star Formation in the Milky Way (GLOSTAR)" financed by an Advanced Investigator Grant of the European Research Council (ERC), the Max-Planck-Institut für Radioastronomie (MPIfR) in Bonn, Germany, at this point is seeking up to three highly qualified postdoctoral researchers with solid experience in interferometry, in particular very long baseline interferometry (VLBI) and/or cm-to-submm interferometry of star forming regions.

The successful applicants will work with Prof. Karl M. Menten's group and international collaborators on GLOSTAR using a powerful multi-pronged approach:

1) Using VLBI observations of maser sources GLOSTAR will measure distances by trigonometric parallax to most of the dominant star forming regions in the Galaxy, which will reveal its spiral structure as well as faithfully represent the luminosity and masses of its constituents.

2) Very sensitive observations of the Galactic plane with the newly Expanded Very Large Array are planned to find masers and hyper- and ultracompact HII regions, pinpointing the very centers of the earliest star-forming activity. Furthermore, follow-up observations of pre-star cluster clumps found in the APEX ATLASGAL submillimeter dust continuum survey are foreseen in ALMA early science.

3) Observations of infrared emission from more developed massive star clusters coupled with classic spectro-photometric methods applied at IR wavelengths will yield distances that can be properly calibrated with the trigonometric parallaxes.

All together, GLOSTAR aims at building a unique dataset with true legacy value for a global perspective on star formation in our Galaxy.

The MPIfR offers a vibrant research environment with a strong expertise in star formation and interferometry. It is the leading radioastronomical institute in Germany, operates the 100-m radio telescope at Effelsberg, which is a key element of the European VLBI Network, holds a 50% share of the observing time with the APEX telescope in Chile and offers access to the IRAM instruments.

Salaries are paid at German civil service rates according to TvÖD 14 (gross annual pre-tax income including health insurance contributions and social security currently in the range 40.000 EUR to 50.000 EUR, depending on experience).

Applicants must have a PhD in astronomy, astrophysics, or a closely related field. Interested candidates should send application materials including curriculum vitae, list of publications, a two-page summary of relevant experience and plans, and the names of three professional referees who have been asked by the applicant to be willing to submit letters of recommendation by email to kmenten *at* mpifr-bonn.mpg.de. Initial review of applicants will begin on March 1, 2010; however, applications will be accepted until the position is filled. The earliest starting date is May 1, 2010.

Max-Planck-Institut für Radioastronomie
Prof. Karl M. Menten
Auf dem Hügel 69
D-53121 Bonn, Germany

E-Mail submission: kmenten *at* mpifr-bonn.mpg.de

The Max Planck Society is an equal opportunity employer. Applications from women, disabled people and minority groups are particularly welcome. The MPIfR supports its employees in their search for suitable child care.

Included Benefits: Health insurance contributions and social security payments are included in the salary.

Postdoctoral and PhD positions in star formation and young stellar environments
Department of Astronomy
University of Vienna (Austria)

The Department of Astronomy of the University of Vienna announces job openings in the new research group in star formation and young stellar environments led by Professor Manuel Guedel. Research of the group will concentrate on physical processes in the environments of young stars, specifically addressing observations and modeling of circumstellar disks, but also extending to planetary systems.

Candidates interested in these topics are invited to apply at either the postdoctoral or graduate student level. Research may be oriented toward theory, numerical simulations, or observations, emphasizing the use of major present and future observatories such as, for example, Herschel (present involvement in the open-time key project DIGIT and the guaranteed-time project HEXOS), IRAM, ALMA, EVLA, VLT, or JWST (for which Prof. Guedel acts as a Co-PI of the Mid-Infrared Instrument). Initial appointments are for 4 years, with a possibility of extension. Participation in teaching activities at a modest level is expected.

The Department of Astronomy is undergoing a major new development with the establishment of three new chairs in astrophysics, additional to an existing chair. A large staff in various areas of astrophysics offers a stimulating research environment. The institute provides access to an in-house PC cluster for numerical simulations; access to a supercomputer is also available. Extended collaborations in stellar and planetary research are being established with the Space Research Institute and the University in Graz, and institutions abroad. Austria is a member state of both ESA and ESO, offering access to their first-class facilities. The department is presently supporting or considering initiatives toward participation in future observatories of ESA/JAXA/NASA (Spica, Plato, Euclid, JWST) and ESO (VLT instrumentation, E-ELT).

Review of applications starts February 15, 2010 and will continue until the positions are filled. Applications should be sent electronically and should include a CV/publication list and a brief description of past research and plans for future research projects (postdocs) resp. documentation of previous studies and experience (grad students). Three letters of reference should be sent directly by referees familiar with the candidate's skills.

E-mail submission address: manuel.guedel *at* univie.ac.at (CC to guedel@astro.phys.ethz.ch)

Further information can be obtained by e-mailing to the above address.

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.

Herschel

and

The Formation of Stars and Planetary Systems

2010 September 6 − 9

Chalmers University of Technology & Onsala Space Observatory

Göteborg, Sweden

The goal of this conference is to bring together researchers from the infrared and star formation communities to share recent research results, contrast them with earlier insights gained from ground-based and space-based observatories, and help guide our theoretical understanding of physical and chemical processes in regions of star and planet formation. The meeting comes at a time when the early, exciting results from the Herschel Key Programs will become available. The scientific themes of the meeting include:

1. **The characteristics of dust and gas in prestellar cores**
2. **The characteristics of dust and gas around protostars**
3. **From protoplanetary disks to debris disks**
4. **The organic inventory of regions of star and planet formation**

The format for the workshop would allow for invited reviews and contributed talks in approximately equal number. In addition, there will be poster sessions. Total attendance will be limited to 150 participants.

The **Scientific Organizing Committee** includes:

Chair: A. Tielens, Leiden Observatory
Co-chair: R. Liseau, Onsala Space Observatory
J. H. Black, Onsala Space Observatory
M. Griffin, Cardiff University
E. Herbst, Ohio State University
Th. Henning, MPI-A, Heidelberg
M. Meyer, ETH, Zrich
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G. Pilbratt, ESTEC
A. Poglitsch, MPIfEP Garching
A. Sargent, Caltech
M. Tafalla, Observ. Astron. Nacional, Madrid
R. Waters, University of Amsterdam

The **Local Organizing Committee** includes René Liseau (chair), Camilla Andersson, Carina Persson, Kay Justtanont, Michael Olberg, Per Bjerkeli et al.

E-mail contact: herschel2010 *at* chalmers.se
http://www.chalmers.se/herschel