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From the Editor

It has been drawn to my attention that the email addresses posted in the Newsletter on the web are vulnerable to the internet pirates that prowl the web in search of addresses that are then sold to spammers. Since spam is becoming a major annoyance in our lives, we could abandon listing email addresses with an abstract, however, communication is an essential aspect of our work, and it would be sad to have to cave in to the cybercriminals. Instead, I will from now on post email addresses as, e.g., 'astronomer *at* star.institute.edu'. Also, I will gradually, as my time permits, update all the archival issues of the Newsletter on our web site in the same manner.

Abstracts of recently accepted papers

A Search for Formaldehyde 6 cm Emission toward Young Stellar Objects. II. H_2CO and H110α Observations

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We report the results of our second survey for Galactic H_2CO maser emission toward young stellar objects. Using the GBT and the VLA in the A configuration we observed 58 star-forming regions and discovered the fifth H_2CO 6 cm maser region in the Galaxy (G23.71-0.20). We have discussed the detection toward G23.71-0.20 in a previous paper. Here we present all the other results from our survey, including detection of H_2CO absorption features toward 48 sources, detection of the H110α recombination line toward 29 sources, detection (including tentative detections) of the carbon recombination line C110α toward 14 sources, subarcsecond angular resolution images of 6 cm continuum emission toward five sources, and observations of the H_2CO masers in IRAS 18566+0408 and NGC 7538. In the case of NGC 7538, we detected the two main H_2CO maser components, and our observations confirm variability of the blueshifted component recently reported by Hoffman et al. The variability of both maser components in NGC 7538 could be caused by a shock wave that reached the redshifted component approximately 14 yr before reaching the blueshifted component. If that were the case, we would expect to detect an increase in the flux density rate of change of the blueshifted component sometime after the year 2009. Our data also support the use of H_2CO/H110α observations as a tool to resolve the kinematic distance ambiguity of massive star-forming regions in the Galaxy.

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Molecular line intensities as measures of cloud masses – II. Conversion factors for specific galaxy types

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We present theoretically established values of the CO-to-H_2 and C-to-H_2 conversion factors that may be used to estimate the gas masses of external galaxies. We consider four distinct galaxy types, represented by M51, NGC 6946, M82 and SMC N27. The physical parameters that best represent the conditions within the molecular clouds in each of the galaxy types are estimated using a χ^2 analysis of several observed atomic fine structure and CO rotational lines. This analysis is explored over a wide range of density, radiation field, extinction and other relevant parameters. Using these estimated physical conditions in methods that we have previously established, CO-to-H_2 conversion factors are then computed for CO transitions up to $J = 9 \rightarrow 8$. For the conventional CO(1–0) transition, the computed conversion factor varies significantly below and above the canonical value for the Milky Way in the four galaxy types considered. Since atomic carbon emission is now frequently used as a probe of external galaxies, we also present, for the first time, the C-to-H_2 conversion factor for this emission in the four galaxy types considered.

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http://arxiv.org/abs/0704.2603

Near-IR CO Overtone Emission in 51 Ophiuchi

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We present high spectral resolution observations of CO overtone ($\Delta v = 2$) emission from hot gas orbiting the Ae star 51 Oph. Using the NIRSPEC instrument on the Keck Telescope we observed various bandheads at high spectral resolving power (R = 25,000). Modeling of the spectra indicates that the radial distribution of excitation temperatures for the vibrational levels is consistent with the gas being in radiative thermal equilibrium except at the inner edge, where low vibrational bands have higher excitation temperatures. Our model fits the emission line width, which has a significant effect on other fitted parameters. We also confirm earlier findings that the emission is caused by hot gas orbiting close to the star in a turbulent disk that is seen close to edge-on. The 10^{-4} $M_\oplus$ of CO gas that is responsible for most of the emission has an average column density of 7.5 $\times 10^{20}$ cm^{-2}.

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Infrared spectroscopy of HCOOH in interstellar ice analogues

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Context: HCOOH is one of the more common species in interstellar ices with abundances of 1–5% with respect to solid H_2O. With the launch of the Spitzer Space Telescope new infrared spectra have become available of interstellar ices in different environments. So far systematic laboratory studies on HCOOH-containing interstellar ice analogues are lacking.

Aims: This study aims at characterizing the HCOOH spectral features in astrophysically relevant ice mixtures in order to interpret astronomical data.

Methods: The ices are grown under high vacuum conditions and spectra are recorded in transmission using a Fourier

transform infrared spectrometer. Pure HCOOH ices deposited at 15 K and 145 K are studied, as well as binary and tertiary mixtures containing H_2O, CO, CO_2 and CH_3OH. The mixture concentrations are varied from 50:50% to ∼10:90% for HCOOH:H_2O. Binary mixtures of HCOOH:X and tertiary mixtures of HCOOH:H_2O:X with X = CO, CO_2, and CH_3OH, are studied for concentrations of ∼10:90% and ∼7:67:26%, respectively.

Results: Pure HCOOH ice spectra show broad bands which split around 120 K due to the conversion of a dimer to a chain-structure. Broad single component bands are found for mixtures with H_2O. Additional spectral components are present in mixtures with CO, CO_2 and CH_3OH. The resulting peak position, full width at half maximum and band strength depend strongly on ice structure, temperature, matrix constituents and the HCOOH concentration. Comparison of the solid HCOOH 5.9, 7.2, and 8.1 μm features with astronomical data toward the low mass source HH 46 and high mass source W 33A shows that spectra of binary mixtures do not reproduce the observed ice features. However, our tertiary mixtures especially with CH_3OH match the astronomical data very well. Thus interstellar HCOOH is most likely present in tertiary or more complex mixtures with H_2O, CH_3OH and potentially also CO or CO_2, providing constraints on its formation.

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TEXES Observations of Pure Rotational H_2 Emission from AB Aurigae

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We present observations of pure rotational molecular hydrogen emission from the Herbig Ae star, AB Aur. Our observations were made using the Texas Echelon Cross Echelle Spectrograph (TEXES) at the NASA Infrared Telescope Facility and the Gemini North Observatory. We searched for H_2 emission in the S(1), S(2), and S(4) lines at high spectral resolution and detected all three. By fitting a simple model for the emission in the three transitions, we derive T = 670 ± 40 K and M = 0.52 ± 0.15 $M_\oplus$ for the emitting gas. On the basis of the 8.5 km s^{-1} FWHM of the S(2) line, assuming the emission comes from the circumstellar disk, and with an inclination estimate of the AB Aur system taken from the literature, we place the location for the emission near 18 AU. Comparison of our derived temperature to a disk structure model suggests that UV and X-ray heating are important in heating the disk atmosphere.

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Unstable magnetohydrodynamical continuous spectrum of accretion disks: A new route to magnetohydrodynamical turbulence in accretion disks

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Context. We present a detailed study of localised magnetohydrodynamical (MHD) instabilities occurring in two-dimensional magnetized accretion disks.

Aims. We model axisymmetric MHD disk tori, and solve the equations governing a two-dimensional magnetized accretion disk equilibrium and linear wave modes about this equilibrium. We show the existence of novel MHD instabilities in these two-dimensional equilibria which do not occur in an accretion disk in the cylindrical limit.

Methods. The disk equilibria are numerically computed by the FINESSE code. The stability of accretion disks is investigated analytically as well as numerically. We use the PHOENIX code to compute all the waves and instabilities accessible to the computed disk equilibrium.

Results. We concentrate on strongly magnetized disks and sub-Keplerian rotation in a large part of the disk. These disk equilibria show that the thermal pressure of the disk can only decrease outwards if there is a strong gravitational potential. Our theoretical stability analysis shows that convective continuum instabilities can only appear if the density contours coincide with the poloidal magnetic flux contours. Our numerical results confirm and complement this theoretical analysis. Furthermore, these results show that the influence of gravity can either be stabilizing or destabilizing on this new kind of MHD instability. In the likely case of a non-constant density, the height of the disk should exceed a threshold before this type of instability can play a role.

Conclusions. This localised MHD instability provides an ideal, linear route to MHD turbulence in strongly magnetized accretion disk tori.

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The brightest stars of the σ Orionis cluster

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Context. The very young σ Orionis cluster ($\sim$ 3 Ma) is a cornerstone in understanding the formation of stars and substellar objects down to planetary masses. However, its stellar population is far from being completely known.

Aims. This study's purpose is to identify and characterise the most massive stars of σ Orionis to complement current and future deep searches for brown dwarfs and planetary-mass objects in the cluster.

Methods. I have cross-correlated the sources in the Tycho and 2MASS catalogues in a region of 30 arcmin radius with its centre in the O-type star σ Ori A. In this area, I studied the membership in the Ori OB 1b association of the brightest stars in the optical using astrometric, X-ray, and both infrared and optical photometric data from public catalogues, and spectroscopic data from the literature.

Results. A list of 26 young stars, four candidate young stars, and 16 probable foreground stars has arisen from the study. Seven young stars probably harbour discs (four are new). There is no mass dependence of the disc frequency in the cluster. I have derived the first mass spectrum for σ Orionis from 1.1 to $24\,M_\odot$ ($\alpha = +2.0^{+0.2}_{-0.1}$; roughly Salpeter-like). I also provide additional proof of the existence of several spatially superimposed stellar populations in the direction of σ Orionis. Finally, the cluster may be closer and older than previously thought.

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Heat Transport in Giant (Exo)planets: A New Perspective

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We explore the possibility that large-scale convection is inhibited over some regions of giant planet interiors, as a consequence of a gradient of composition inherited from either their formation history or particular events like giant impacts or core erosion during their evolution. Under appropriate circumstances, the redistribution of the gradient of molecular weight can lead to double diffusive layered or overstable convection. This leads to much less efficient heat transport and compositional mixing than large-scale adiabatic convection. We show that this process can explain the abnormally large radius of the transit planet HD 209458b and similar objects and may be at play in some giant planets, with short-period planets offering the most favorable conditions. Observational signatures of this transport mechanism are a large radius and a reduced heat flux output compared with uniformly mixed objects. If our suggestion is correct, it bears major consequences on our understanding of giant planet formation, structure and evolution, including possibly our own Jovian planets.

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Clump Lifetimes and the Initial Mass Function

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Recent studies of dense clumps/cores in a number of regions of low-mass star formation have shown that the mass distribution of these clumps closely resembles the initial mass function (IMF) of field stars. One possible interpretation of these observations is that we are witnessing the fragmentation of the clouds into the IMF, and the observed clumps are bound pre-stellar cores. In this paper, we highlight a potential difficulty in this interpretation, namely that clumps of varying mass are likely to have systematically varying lifetimes. This 'timescale' problem can effectively destroy the similarity bewteen the clump and stellar mass functions, such that a stellar-like clump mass function (CMF) results in a much steeper stellar IMF. We also discuss some ways in which this problem may be avoided.

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The Wide Brown Dwarf Binary Oph 1622-2405 and Discovery of a Wide, Low-Mass Binary in Ophiuchus (Oph 1623-2402): A New Class of Young Evaporating Wide Binaries?

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We imaged five objects near the star-forming clouds of Ophiuchus with the Keck Laser Guide Star AO system. We resolved sources 11 (Oph 16222-2405) and 16 (Oph 16233-2402) from Allers and coworkers into binary systems. Source 11 is resolved into a 243 AU binary, the widest known for a very low mass (VLM) binary. The binary nature of source 11 was discovered first by Allers and independently here, during which we obtained the first spatially resolved R $\sim$ 2000 near-infrared (J and K) spectra, mid-IR photometry, and orbital motion estimates. We estimate for 11A and 11B gravities ($\log g > 3.75$), ages (5 ± 2 Myr), luminosities [$\log(L/L_\odot)$ = -2.77 $\pm$ 0.10 and -2.96 $\pm$ 0.10], and temperatures ($T_{eff} = 2375 \pm 175$ K and 2175 ± 175 K). We find self-consistent DUSTY evolutionary model (Chabrier and coworkers) masses of 17^{+4}_{-5} M_J and 14^{+6}_{-5} M_J, for 11A and 11B, respectively. Our masses are higher than those previously reported (1315 M_J and 78 M_J) by Jayawardhana & Ivanov. Hence, we find that the system is unlikely a "planetary mass binary," as do Luhman and coworkers, but it has the second lowest mass and lowest binding energy of any known binary. Oph 11 and Oph 16 belong to a newly recognized population of wide ($\gtrsim$100 AU), young ($<$ 10 Myr), roughly equal mass, VLM stellar and brown dwarf binaries. We deduce that $\sim$6% $\pm$ 3% of young ($<$ 10 Myr) VLM objects are in such wide systems. However, only 0.3% $\pm$ 0.1% of old field VLM objects are found in such wide systems. Thus, young, wide, VLM binary populations may be evaporating, due to stellar encounters in their natal clusters, leading to a field population depleted in wide VLM systems.

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Cavity opening by a giant planet in a protoplanetary disc and effects on planetary migration

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We study the effect of a Jovian planet on the gas distribution of a protoplanetary disc, using a new numerical scheme that allows us to take into consideration the global evolution of the disc, down to an arbitrarily small inner physical radius. We find that Jovian planets do not open cavities in the inner part of the disc (i.e. interior to their orbits) unless (a) the inner physical edge of the disc is close to the planet's location or (b) the planet is much more massive than the disc. In all other cases the planet simply opens a gap in the gas density distribution, whose global profile is essentially unchanged relative to the one that it would have if the planet were absent. We recognize, though, that the dust distribution can be significantly different from the gas distribution and that dust cavities might be opened in some situations, even if the gas is still present in the inner part of the disc.

Concerning the migration of the planet, we find that classical type II migration (with speed proportional to the viscosity of the disc) occurs only if the gap opened by the planet is deep and clean. If there is still a significant amount of gas in the gap, the migration of the planet is generally slower than the theoretical type II migration rate. In some situations, migration can be stopped or even reversed. We develop a simple model that reproduces satisfactorily the migration rate observed in the simulations, for a wide range of disc viscosities and planet masses and locations relative to the inner disc edge. Our results are relevant for extrasolar planetary systems, as they explain (a) why some hot Jupiters did not migrate all the way down to their parent stars and (b) why the outermost of a pair of resonant planets is typically the most massive one.

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Collisional Vaporization of Dust and Production of Gas in the β Pictoris Dust Disk

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The need for replenishment of the stable gas observed in the β Pictoris system raises a question about the origin of the gas. Correlations between the gas and the dust distribution suggest that the source is related to the dust. Spectroscopic observations imply that the gas is rotating at Keplerian velocity: this includes also the species that, in absence of braking, would be accelerated away from the star by the radiation pressure. We examine the possibility that the gas originates from collisional vaporization of the dust in the disk and the consequences for the gas velocity distribution and the line profiles of spectral features generated by the gas. A simple model of dust distribution and a model of individual dust-dust collision are used to calculate the gas production rate in the disk. Comparing with the gas column densities derived from observations, the escape times of the atoms from the disk are estimated. For the dust distribution and collision model considered, the vaporization of dust leads to the gas production rates of the order between 0.5×10^{12} and 2×10^{13} g s^{-1} for the grains with the collisional properties close to those of silicate and ice, respectively. We point out the uncertainties in the collision models. We also found that, for the lines of sight bypassing the star, velocity distributions of gas particles released from orbiting bodies can show a peak at Keplerian velocity even in the absence of braking, despite large acceleration by radiation pressure.

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Spitzer Observations of NGC 2362: Primordial Disks at 5 Myr

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We present results from a mid-infrared imaging survey of the ∼5 Myr old cluster NGC 2362 carried out with the Infrared Array Camera (IRAC) on board the Spitzer Space Telescope. The archival mid-infrared data were merged with extant Hα emission data, optical and near-infrared photometry, and moderate-resolution optical spectroscopy to identify the remnant disk-bearing population of the cluster and to estimate the fraction of stars that still retain primordial circumstellar disks. The principal sample of 232 suspected cluster members with masses ranging from ∼10 to 0.3 M$_\odot$ (B2M5 spectral types) was drawn from known Hα emission stars, X-ray-detected stars from a single

100 ks archival Chandra observation, and established lithium-rich stars. A second sample of 153 stars over a similar mass range whose membership status was based on optical photometry alone was also examined. Measured fluxes in the optical and infrared passbands were fitted with synthetic, low-resolution spectra created using the NextGen atmospheric models, permitting the detection of infrared excesses relative to predicted stellar photospheric fluxes. Using the measured slope of the stellar spectral energy distribution through the four IRAC channels to characterize disk emission for the 195 out of 232 activity/lithium-selected stars and the 105 out of 153 photometric membership candidates having complete IRAC photometry, we derive an upper limit for the primordial, optically thick disk fraction of NGC 2362 of $\sim$7% $\pm$ 2%, with another $\sim$12% $\pm$ 3% of suspected members exhibiting infrared excesses indicative of weak or optically thin disk emission. The presence of circumstellar disks among candidate members of NGC 2362 is strongly mass-dependent, such that no stars more massive than $\sim$1.2 $M_\odot$ exhibit significant infrared excess shortward of 8 μm. An upper limit for the fraction of stars hosting primordial, optically thick disks peaks near 10.7% $\pm$ 4% for stars with masses between 1.05 and 0.6 $M_\odot$, but the Spitzer IRAC survey is sensitivity-limited below $\sim$0.3 $M_\odot$. From Hα emission-line strengths, an upper limit for the accretion fraction of the cluster is estimated at $\sim$5%, with most suspected accretors associated with primordial, optically thick disks identified with Spitzer. The presence of primordial disk-bearing stars in NGC 2362, some of which are suspected of still experiencing gaseous accretion, may imply that even within dense cluster environments, sufficient numbers of inner disks survive to ages consistent with core accretion models of giant planet formation to account for the observed frequency of exoplanets within 5 AU of all FGKM-type stars.

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Ionization-induced star formation II. External irradiation of a turbulent molecular cloud

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In this paper, we examine numerically the difference between triggered and revealed star formation. We present smoothed particle hydrodynamic (SPH) simulations of the impact on a turbulent 10^4 $M_\odot$ molecular cloud of irradiation by an external source of ionizing photons. In particular, using a control model, we investigate the triggering of star formation within the cloud. We find that, although feedback has a dramatic effect on the morphology of our model cloud, its impact on star formation is relatively minor. We show that external irradiation has both positive and negative effects, accelerating the formation of some objects, delaying the formation of others and inducing the formation of some that would not otherwise have formed. Overall, the calculation in which feedback is included forms nearly twice as many objects over a period of $\sim$0.5 freefall times ($\sim$2.4 Myr), resulting in a star formation efficiency approximately one-third higher ($\sim$4 per cent as opposed to $\sim$3 per cent at this epoch) as in the control run in which feedback is absent. Unfortunately, there appear to be no observable characteristics which could be used to differentiate objects whose formation was triggered from those which were forming anyway and which were simply revealed by the effects of radiation, although this could be an effect of poor statistics.

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Ice Formation in Radiated Accretion Disks

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Gas to solid phase changes of abundant species in a viscous, irradiated protoplanetary disk are investigated using a new formulation for the freezeout effect. The method is based on a procedure using species-dependent phase diagrams while following the chemical evolution of water and carbon monoxide gas until their partial pressures are sufficient to de-sublimate vapor into ice. It is found that water ice is dominant throughout the nebula while a significant amount of water vapor coexists with the ice in the cooler parts of the inner nebula. Volatile CO molecules de-sublimate only

in the colder outer regions of the nebula near the center plane. Computed column densities for CO gas are compared with similar calculations using an adsorption/desorption model by Aikawa and Herbst and are shown to predict similar distributions.

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Three-body recombination of hydrogen during primordial star formation

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We consider the formation and destruction of H_2 and HD during the gravitational contraction of condensations of the primordial gas, which led to the formation of the first generation of stars (Population III stars). The determination of the populations of the bound rovibrational levels of molecular hydrogen is considered in detail. Initially, the rates per unit volume at which these levels are populated and depopulated are not in equilibrium. As the density increases, equilibrium between the rates of population and depopulation is established first, and then the levels gradually thermalize (i.e. their populations tend towards a Boltzmann distribution at the kinetic temperature of the gas), with the lowest energy levels thermalizing first. Ultimately, both the bound and the continuum states thermalize (i.e. attain a Saha distribution), but this process is not complete until densities $n_H \approx 10^{13}$ cm^{-3} are reached. Using the principle of microscopic reversibility, we derive an expression for the rate coefficient for three-body recombination of hydrogen which is found to differ significantly from the much used expression of Jacobs et al.

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Comparative study of complex N- and O-bearing molecules in hot molecular cores

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We have observed several emission lines of two Nitrogen-bearing (C_2H_5CN and C_2H_3CN) and two Oxygen-bearing (CH_3OCH_3 and $HCOOCH_3$) molecules towards a sample of well-known hot molecular cores (HMCs) in order to check whether the chemical differentiation seen in the Orion-HMC and W3(H_2O) between O- and N-bearing molecules is a general property of HMCs. With the IRAM-30m telescope we have observed 12 HMCs in 21 bands, centered at frequencies from 86250 to 258280 MHz. In six sources, we have detected a number of transitions sufficient to derive their main physical properties. The rotational temperatures obtained from C_2H_5CN, C_2H_3CN and CH_3OCH_3 range from ~ 100 to ~ 150 K in these HMCs. The total column densities of these molecules are of the order of $\sim 10^{15} - 10^{17}$cm^{-2}. Single Gaussian fits performed to unblended lines show a marginal difference in the line peak velocities of the C_2H_5CN and CH_3OCH_3 lines, indicating a possible spatial separation between the region traced by the two molecules. On the other hand, neither the linewidths nor the rotational temperatures and column densities confirm such a result. The average molecular abundances of C_2H_5CN, C_2H_3CN and CH_3OCH_3 are in the range $\sim 10^{-9} - 10^{-10}$, comparable to those seen in the Orion hot core. In other HMCs Bisschop et al. 2007 found comparable values for C_2H_5CN but values ~ 2.5 times larger for CH_3OCH_3. By comparing the abundance ratio of the pair C_2H_5CN/C_2H_3CN with the predictions of theoretical models, we derive that the age of our cores ranges between 3.7 and 5.9×10^4 yrs. The abundances of C_2H_5CN and C_2H_3CN are strongly correlated, as expected from theory which predicts that C_2H_3CN is formed through gas phase reactions involving C_2H_5CN . A correlation is also found between the abundances of C_2H_5CN and CH_3OCH_3, and C_2H_3CN and CH_3OCH_3. In all tracers the fractional abundances increase with the H_2 column density while they are not correlated with the gas temperature. On average, the chemical and physical

differentiation between O- and N-bearing molecules seen in Orion and W3(H_2O) is not revealed by our observations. We believe that this is partly due to the poor angular resolution of our data, which allows us to derive only average values over the sources of the discussed parameters.

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From Ultracompact to Extended H II Regions. II. Cloud Gravity and Stellar Motion

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The dynamical evolution of H II regions with and without stellar motion in dense, structured molecular clouds is studied. Clouds are modeled in hydrostatic equilibrium, with Gaussian central cores and external halos that obey $\rho \propto r^{-2}$ and $\rho \propto r^{-3}$ power laws. Cloud gravity is included as a time-independent, external force. Stellar velocities of 0, 2, 8, and 12 km s^{-1} are considered, permitting stars to move from the central core toward the edge of the cloud. Ultracompact H II regions are seen to evolve into extended H II regions as the stars move toward lower density regions. Our main conclusion is that ultracompact H II regions are pressure-confined entities while they remain embedded within dense cores. The confinement comes from either ram or ambient pressures, or a combination of both. The survival of the ultracompact regions depends on the position of the star with respect to the core center, the stellar lifetime, and the crossing time of the cloud core. Stars with velocities less than the cloud dispersion velocity can produce cometary ultracompact H II regions for 2×10^4 yr or more, in statistical agreement with observations. The sequence ultracompact H II $\rightarrow$ compact H II $\rightarrow$ extended H II shows a variety of structures induced by various instabilities. Some ultracompact H II regions with a core-halo morphology could be explained by self-blocking effects, when stars overtake and ionize leading, piled-up clumps of neutral gas.

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Protostellar clusters in intermediate-mass (IM) star forming regions

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The transition between the low density groups of T Tauri stars and the high density clusters around massive stars occurs in the intermediate-mass (IM) range ($M_{*}\sim$2–8 $M_{\odot}$). High spatial resolution studies of IM young stellar objects (YSO) can provide important clues to understand the clustering in massive star forming regions.

Aims: Our aim is to search for clustering in IM Class 0 protostars. The high spatial resolution and sensitivity provided by the new A configuration of the Plateau de Bure Interferometer (PdBI) allow us to study the clustering in these nearby objects.

Methods: We have imaged three IM Class 0 protostars (Serpens-FIRS 1, IC 1396 N, CB 3) in the continuum at 3.3 and 1.3mm using the PdBI. The sources have been selected with different luminosity to investigate the dependence of

the clustering process on the luminosity of the source.

Results: Only one millimeter (mm) source is detected towards the low luminosity source Serpens–FIRS 1. Towards CB 3 and IC1396 N, we detect two compact sources separated by ∼0.05 pc. The 1.3mm image of IC 1396 N, which provides the highest spatial resolution, reveal that one of these cores is splitted in, at least, three individual sources.

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The penetration of Far-UV radiation into molecular clouds

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Context. FUV radiation strongly affects the physical and chemical state of molecular clouds, from protoplanetary disks to entire galaxies.

Aims. The solution of the FUV radiative transfer equation can be complicated if the most relevant radiative processes such us dust scattering and gas line absorption are included, and have realistic (non-uniform) properties, i.e. if optical properties are depth dependent.

Methods. We have extended the spherical harmonics method to solve for the FUV radiation field in externally or internally illuminated clouds taking into account gas absorption and coherent, nonconservative and anisotropic scattering by dust grains. The new formulation has been implemented in the Meudon PDR code and thus it will be publicly available.

Results. Our formalism allows us to consistently include: (i) varying dust populations and (ii) gas lines in the FUV radiative transfer. The FUV penetration depth rises for increasing dust albedo and anisotropy of the scattered radiation (e.g. when grains grow towards cloud interiors).

Conclusions. Illustrative models of illuminated clouds where only the dust populations are varied confirm earlier predictions for the FUV penetration in diffuse clouds ($A_{\rm V} < 1$). For denser and more embedded sources ($A_{\rm V} > 1$) we show that the FUV radiation field inside the cloud can differ by orders of magnitude depending on the grain properties and growth. Our models reveal significant differences regarding the resulting physical and chemical structures for steep vs. flat extinction curves towards molecular clouds. In particular, we show that the photochemical and thermal gradients can be very different depending on grain growth. Therefore, the assumption of uniform dust properties and averaged extinction curves can be a crude approximation to determine the resulting scattering properties, prevailing chemistry and atomic/molecular abundances in ISM clouds or protoplanetary disks.

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Brown dwarf formation by binary disruption

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Context. The principal mechanism by which brown dwarfs form, and its relation to the formation of higher-mass (i.e. hydrogen-burning) stars, is poorly understood.

Aims. We advocate a new model for the formation of brown dwarfs.

Methods. In this model, brown dwarfs are initially binary companions, formed by gravitational fragmentation of the outer parts ($R \gtrsim 100$ AU) of protostellar discs around low-mass hydrogen-burning stars. Most of these binaries are then gently disrupted by passing stars to create a largely single population of brown dwarfs and low-mass hydrogen-burning

stars.

Results. This idea is consistent with the excess of binaries found in low-density pre-main sequence populations, like that in Taurus, where they should survive longer than in denser clusters.

Conclusions. If brown dwarfs form in this way, as companions to more massive stars, the difficulty of forming very low-mass prestellar cores is avoided. Since the disrupted binaries will tend to be those involving low-mass components and wide orbits, and since disruption will be due to the gentle tides of passing stars (rather than violent N-body interactions in small-N sub-clusters), the liberated brown dwarfs will have velocity dispersions and spatial distributions very similar to higher-mass stars, and they will be able to retain discs, and thereby to sustain accretion and outflows. Thus the problems associated with the ejection and turbulence mechanisms can be avoided. This model implies that most, possibly all, stars and brown dwarfs form in binary or multiple systems.

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High Spatial Resolution Near-Infrared Images of Taurus Protostars

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We analyze near-infrared K- and L-band images of six embedded Class I objects in the Taurus-Auriga molecular cloud. Three of these sources were observed in both bands and three were observed only at L. The L- and K-band images were obtained with the Cryogenic Optical Bench at the KPNO 4 m telescope in the diffraction-limited mode. With the high spatial resolution L-band data, we identify IRAS 04239+2436 as a close pair with a projected separation of 0.29″. We use a radiative transfer code to model the images and derive physical and geometrical parameters for each source. Because the projected positions of the six analyzed sources on the cloud coincide with the densest zones in the complex ($A_V \sim 10$ - 30 mag), we use two models for the optical properties of dust grains in the envelopes: a diffuse ISM model and a grain model with ratio of total to selective extinction $R_V = 4.3$ corresponding to the measured R values in the densest regions of the Taurus molecular cloud. Although the two grain models have different opacities, we can match the observed images with either model by selecting the appropriate envelope infall rate. Thus we cannot distinguish between the two grain models over this narrow wavelength range (K and L bands).

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Why are accreting T Tauri stars observed to be less luminous in X-rays than non-accretors?

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Accreting T Tauri stars are observed to be less luminous in X-rays than non-accretors, an effect that has been detected in various star forming regions. To explain this we have combined, for the first time, a radiative transfer code with an accretion model that considers magnetic fields extrapolated from surface magnetograms obtained from Zeeman-Doppler imaging. Such fields consist of compact magnetic regions close to the stellar surface, with extended field lines interacting with the disc. We study the propagation of coronal X-rays through the magnetosphere and demonstrate that they are strongly absorbed by the dense gas in accretion columns. The reduction in the observed X-ray emission depends on the field geometry, which may explain why accreting T Tauri stars show a larger scatter in their observed X-ray luminosity compared to non-accreting stars.

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Collimation, Proper Motions, and Physical Conditions in the HH 30 Jet from Hubble Space Telescope Slitless Spectroscopy

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We present STIS spectral images of the HH 30 stellar jet taken through a wide slit over two epochs. The jet is unresolved spectrally, so the observations produce emission-line images for each line in the spectrum. This rich data set shows how physical conditions in the jet vary with distance and time, produces precise proper motions of knots within the jet, resolves the jet width close to the star, and gives a spectrum of the reflected light from the disk over a large wavelength range at several positions. We introduce a new method for analyzing a set of line ratios based on minimizing a quadratic form between models and data. The method generates images of the density, temperature, and ionization fraction computed using all the possible line ratios appropriately weighted. In HH 30, the density declines with distance from the source in a manner consistent with an expanding flow and is larger by a factor of 2 along the axis of the jet than it is at the periphery. Ionization in the jet ranges from $\sim 5\%$ to 40%, and high-ionization/excitation knots form at about 100 AU from the star and propagate outward with the flow. These high-excitation knots are not accompanied by corresponding increases in the density, so if formed by velocity variations the knots must have a strong internal magnetic pressure to smooth out density increases while lengthening recombination times.

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Dissipative structures of diffuse molecular gas II: The translucent environment of a dense core

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This paper belongs to a series of four, dedicated to the analysis of the dynamical, thermal and chemical properties of translucent molecular gas, with the perspective of characterizing the processes driving the dissipation of supersonic turbulence, an anticipated prerequisite of dense core formation. We analyze the small scale morphology and velocity structure of the parsec-scale environment of a low mass dense core ($1\,M_\odot$). Our work is based on large maps made with the IRAM-30m telescope in the two lowest rotational transitions of ^{12}CO and ^{13}CO with high angular ($20''$ or 0.015 pc at 115 GHz) and spectral ($0.055\,\mathrm{km\,s^{-1}}$) resolutions. The field is translucent, hence providing strong constraints on the column density and physical conditions in the gas. More than one third of the field mass (6.5 $M_\odot$) lies in an elongated tail of dense and cold gas, possibly extending beyond the edge of the map and connected to the core in space and velocity. This core tail is highly turbulent and sub-structured into narrow filaments of aspect ratio up to 20. These are pure velocity structures with velocity shears in the range $2-10\,\mathrm{km\,s^{-1}\,pc^{-1}}$. Another third of the mass, according to the weak extinction of the field, lies in more dilute molecular and atomic gas. Its molecular fraction, largely traced by optically thick ^{12}CO lines, is even more turbulent than the dense core tail. The gas emitting in the broad wings of the ^{12}CO lines is organized into a conspicuous network of narrow criss-crossed filaments, whose pattern at the parsec scale is seen for the first time. The gas there is optically thin in the ^{12}CO$(1-0)$ line ($\tau_{12} < 0.2$), warmer than 25 K and more dilute than 1000 cm^{-3}. These optically thin ^{12}CO-filaments, though contributing to about 10% of the mass of the environment, have a CO cooling rate a few times larger than that of the whole field on average. Whether dense or dilute, all the filamentary structures in the field (with transverse sizes $0.015-0.03$ pc), are preferentially oriented along the direction of the magnetic fields, as measured a few parsecs away. Using the Chandrasekhar-Fermi method, we estimate the intensity of the magnetic fields intensity in the dilute molecular gas to be $B_{pos} = 15\ \mu$G. We infer that the turbulent motions in the dilute gas are in the trans-Alfvénic range. The 1 $M_\odot$ dense core is surrounded by a translucent and highly turbulent environment whose gas dynamics are not super-Alfvénic. The low mass dense core is not isolated but still connected to a massive reservoir of dense gas. Filaments of optically thin ^{12}CO are found to radiate more efficiently in the CO lines than the whole field on average. These are the structures that we tentatively identify with the locus of intermittent dissipation of turbulence, and for which there is no observational evidence that they are shocks.

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An Inner Hole in the Disk around TW Hydrae Resolved in 7 Millimeter Dust Emission

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We present Very Large Array observations at 7 millimeters wavelength that resolve the dust emission structure in the disk around the young star TW Hydrae at the scale of the ∼4 AU (∼0.16") radius inner hole inferred from spectral energy distribution modeling. These high resolution data confirm directly the presence of an inner hole in the dust disk and reveal a high brightness ring that we associate with the directly illuminated inner edge of the disk. The clearing of the inner disk plausibly results from the dynamical effects of a giant planet in formation. In an appendix, we develop an analytical framework for the interpretation of visibility curves from power-law disk models with inner holes.

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A Survey of Dense Cores in the Orion A Cloud

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We have carried out an $H^{13}CO^+(J = 1-0)$ core survey in a large area of $1^\circ.5 \times 0^\circ.5$, covering the whole region of the Orion A molecular cloud, using the Nobeyama 45 m radio telescope with the 25-BEam Array Receiver System (BEARS). This survey is unique in that a large area (~ 48 pc^2) of the cloud was covered with a high spatial resolution of $21''$ (0.05 pc) and with deep integration ($1\sigma \sim 0.1$ K in T_A^*), resulting in a core mass detection of 1.6 $M_\odot$. The morphology of the $H^{13}CO^+(J = 1-0)$ emission is very similar to that of bf the 850 μm continuum emission. We identified 236 dense cores from our data with the clumpfind algorithm. The cores are close to virial equilibrium, independent of whether they are thermal or turbulent. We predict an IMF from the core mass function considering binary formation and confusion along the line-of-sight, and found that this IMF agrees well with the Orion Nebula Cluster IMF for a star-formation efficiency of ~ 40 %. Therefore, we suggest that the IMF is determined at the time of the dense core formation. Furthermore, we discovered three cores with large velocity widths, significantly wider than those of the other cores, only toward the M42 H II region, suggesting that the energy input from the H II region increases the velocity width. Since the three cores can produce the most massive stars owing to their large mass accretion rates, massive star formation in the next generation in the Orion A cloud is likely to be caused by nearby stellar activity.

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Star Formation at Very Low Metallicity. II: On the Insignificance of Metal-Line Cooling During the Early Stages of Gravitational Collapse

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We study the influence of low levels of metal enrichment on the cooling and collapse of ionized gas in small protogalactic halos using three-dimensional, smoothed particle hydrodynamics simulations. Our initial conditions represent protogalaxies forming within a fossil H II region, a previously ionized H II region which has not yet had time to cool and recombine. Prior to cosmological reionization, such regions should be relatively common, since the characteristic lifetimes of the likely ionizing sources are significantly shorter than a Hubble time. We show that in these regions, H_2 is the dominant and most effective coolant, and that it is the amount of H_2 formed that determines whether or not the gas can collapse and form stars.

At the low metallicities ($Z < 10^{-3}\,Z_\odot$) thought to be associated with the transition from Population III to early Population II star formation, metal-line cooling has an almost negligible effect on the evolution of low-density gas, altering the density and temperature evolution of the gas by less than 1% compared to the metal-free case at densities below $1\,\mathrm{cm}^{-3}$ and temperatures above 2000 K. Although there is evidence that metal-line cooling becomes more effective at higher density, we find no significant differences in behaviour from the metal-free case at any density below our sink particle creation threshold at $n = 500\,\mathrm{cm}^{-3}$. Increasing the metallicity also increases the importance of metal-line cooling, but it does not significantly affect the dynamical evolution of the low-density gas until $Z \sim 0.1\,Z_\odot$. This result holds regardless of whether or not an ultraviolet background is present.

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A Photoevaporating Rotating Disk in the Cepheus A HW2 Star Cluster.

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We present VLA and PdBI subarcsecond images ($\sim$0.15″-0.6″) of the radiocontinuum emission at 7 mm and of the SO_2 $J = 19_{2,18} \rightarrow 18_{3,15}$ and $J = 27_{8,20} \rightarrow 28_{7,21}$ lines toward the Cepheus A HW2 region. The SO_2 images reveal the presence of a hot core internally heated by an intermediate mass protostar, and a circumstellar rotating disk around the HW2 radio jet with size 600 AU×100 AU and mass of $\sim 1\,M_\odot$. Keplerian rotation for the disk velocity gradient of $\sim 5\,\mathrm{km\,s^{-1}}$ requires a $9\,M_\odot$ central star, which cannot explain the total luminosity observed in the region. This may indicate that the disk does not rotate with a Keplerian law due to the extreme youth of this object. Our high sensitivity radiocontinuum image at 7 mm shows in addition to the ionized jet, an extended emission to the west (and marginally to the south) of the HW2 jet, filling the south-west cavity of the HW2 disk. From the morphology and location of this free-free continuum emission at centimeter and millimeter wavelengths (spectral index of $\sim$0.4-1.5), we propose that the disk is photoevaporating due to the UV radiation from the central star. All this indicates that the Cepheus A HW2 region harbors a cluster of massive stars. Disk accretion seems to be the most plausible way to form massive stars in moderate density/luminosity clusters.

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The Magnetic Fields of Classical T Tauri Stars

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We report new magnetic field measurements for 14 classical T Tauri stars (CTTSs). We combine these data with one previous field determination in order to compare our observed field strengths with the field strengths predicted by magnetospheric accretion models. We use literature data on the stellar mass, radius, rotation period, and disk accretion rate to predict the field strength that should be present on each of our stars according to these magnetospheric accretion models. We show that our measured field values do not correlate with the field strengths predicted by simple magnetospheric accretion theory. We also use our field strength measurements and literature X-ray luminosity data to test a recent relationship expressing X-ray luminosity as a function of surface magnetic flux derived from various solar feature and main sequence star measurements. We find that the T Tauri stars we have observed have weaker than expected X-ray emission by over an order of magnitude on average using this relationship. We suggest the cause for this is actually a result of the very strong fields on these stars which decreases the efficiency with which gas motions in the photosphere can tangle magnetic flux tubes in the corona.

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H I 21 cm Emission as a Tracer of Gas During the Evolution from Protoplanetary to Debris Disks

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We present radiative transfer models for the H I 21 cm emission from circumstellar disks and use them to convert observed upper limits on the H I 21 cm flux to limits on the total disk gas mass. We also present fresh upper limits for the H I 21 cm emission of the disks around HD 135344, LkCa 15, and HD 163296, obtained with the Giant Meterwave Radio Telescope. Our observations and models span a range of disk types, from young protoplanetary disks to old debris disks. The models self-consistently calculate the gas chemistry (H/H_2 balance) and the thermal structure of UV irradiated disks. Atomic hydrogen production is dominated by UV irradiation in transition phase objects as well as debris disks, but for very young disks, H I production by stellar X-rays is important. This irradiation produces H I 21 cm at the surface of the disks. In massive protoplanetary disks, UV produced H I constitutes less than 0.5% of the total disk mass, while X-rays clearly dominate the chemistry and thus the H I production. In debris disks, hydrogen is mainly molecular, since the high dust-to-gas mass ratio leads to warmer disks. The 21 cm flux cannot be detected with currently available radio telescopes in such disks. The strongest 21 cm fluxes are predicted for transition phase disks at distances of 100 pc. The expected H I fluxes in such disks are close to current detection limits. A telescope with about ∼10% the area of the SKA will be able to detect the H I 21 cm emission from such disks, while the full SKA will provide resolved images. Such observations will probe the kinematics of disks, as well as the effects of irradiation and evaporation at their surface layer.

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The outburst of the eruptive young star OO Serpentis between 1995 and 2006

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Aims. OO Serpentis is a deeply embedded pre-main sequence star in the Serpens NW star-forming region. The star

went into outburst in 1995 and gradually faded afterwards. In many respects its eruption resembled the well-known FU Orionis-type (FUor) or EX Lupi-type (EXor) outbursts. Since very few such events have ever been documented at infrared wavelengths, our aim is to study the temporal evolution of OO Ser in the infrared.
Methods. OO Ser was monitored with the *Infrared Space Observatory* in the $3.6 - 100\,\mu$m wavelength range, starting 4 months after peak brightness and covering a period of 20 months. Eight years later, in 2004-2006 we again observed OO Ser at 2.2 and $12\,\mu$m from the ground and complemented this dataset with archival Spitzer obsevations also from 2004. We analysed these data with special attention to source confusion and constructed light curves at 10 different wavelengths as well as spectral energy distributions.
Results. The outburst caused brightening in the whole infrared regime. According to the infrared light curves, OO Ser started a wavelength-independent fading after the peak brightness. Later the flux decay became slower but stayed practically wavelength-independent. The fading is still ongoing, and current fading rates indicate that OO Ser will not return to quiescent state before 2011. The outburst timescale of OO Ser seems to be shorter than that of FUors, but longer than that of EXors.
Conclusion. The outburst timescale and the moderate luminosity suggest that OO Ser is different from both FUors and EXors, and shows some similarities to the recently erupted young star V1647 Ori. Based on its SED and bolometric temperature, OO Ser seems to be an early class I object, with an age of $< 10^5$ yr. As proposed by outburst models, the object is probably surrounded by an accretion disc and a dense envelope. This picture is also supported by the wavelength-independence of the fading. Due to the shorter outburst timescales, models developed for FUors can only work for OO Ser if the viscosity parameter in the circumstellar disc, α, is set to an order of magnitude higher value than usual for FUors.

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UV spectrum of FU Ori and the "compromise" model of FUORs

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We analysed UV (2300-3100 Å) spectrum of a young star FU Ori, observed with Hubble Space Telescope. The longward part of the spectrum reminds that of supergiant with $T_{ef} \simeq 5000 - 6000$ K, but radiation from regions with $T_{ef} \simeq 9000$ K dominates at wavelengths shortward 2600 Å. We discuss possibility to explain these features of the spectrum as well as profile of Al II] 2669.2 emission line and results of X-ray observations in the frame of advective accretion disk model, geometrical thickness of which, starting from distance $r \sim 10^{12}$ cm increases inward. The innermost regions of the disk has cone-like shape such as we observe only some part of its back side. The model is a some kind of compromise between models of thin accretion disk and supergiant: in fact it is an accretion model but its observational manifestation is similar to G0-supergiant. A numerous disk wind's absorption lines are superimposed on the spectrum of accretion disk. The outflowing gas is cold ($T \simeq 5000$) K and dense ($\log N_e \simeq 11$). The number of wind's lines increases with decreasing wavelength, resulting in strong decreasing of observed intensity of disk's radiation at the blue part of the spectrum. Due to this reason maximum value of disk's temperature, derived from low resolution IUE spectra, was underestimated previously.

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Molecular Line Emission from Massive Protostellar Disks: Predictions for ALMA and the EVLA

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We compute the molecular line emission of massive protostellar disks by solving the equation of radiative transfer through the cores and disks produced by the recent radiation-hydrodynamic simulations of Krumholz, Klein, & McKee. We find that in several representative lines the disks show brightness temperatures of hundreds of Kelvin over velocity channels ~ 10 km s^{-1} wide, extending over regions hundreds of AU in size. We process the computed intensities to model the performance of next-generation radio and submillimeter telescopes. Our calculations show that observations using facilities such as the EVLA and ALMA should be able to detect massive protostellar disks and measure their rotation curves, at least in the nearest massive star-forming regions. They should also detect significant sub-structure and non-axisymmetry in the disks, and in some cases may be able to detect star-disk velocity offsets of a few km s^{-1}, both of which are the result of strong gravitational instability in massive disks. We use our simulations to explore the strengths and weaknesses of different observational techniques, and we also discuss how observations of massive protostellar disks may be used to distinguish between alternative models of massive star formation.

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Mass Transfer in Close, Rapidly Accreting Protobinaries: An Origin for Massive Twins?

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Rapidly accreting massive protostars undergo a phase of deuterium shell burning during pre-main sequence evolution that causes them to swell to tenths of an AU in radius. During this phase, those with close binary companions will overflow their Roche lobes and begin transferring mass. Since massive stars frequently have companions at distances well under 1 AU, this process may affect the early evolution of a substantial fraction of massive stars. We use a simple protostellar evolution model to determine the range in accretion rates, mass ratios, and orbital separations for which mass transfer will occur, and we compute approximately the stability and final outcome of the transfer process. We discuss how mass transfer affects the demographics of massive binaries, and show that it provides a natural explanation for the heretofore unexplained population of massive "twins", high mass binaries with mass ratios very close to unity.

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Velocity Distribution of Collapsing Starless Cores, L694-2 and L1197

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In an attempt to understand the dynamics of collapsing starless cores, we have conducted a detailed investigation of the velocity fields of two collapsing cores, L694-2 and L1197, with high spatial resolution HCN J = 10 maps and Monte Carlo radiative transfer calculation. It is found that infall motion is most active in the middle and outer layers outside the central flat region of the density profile, while both the central and outermost parts of the cores are static or exhibit slower motion. The objects' peak velocities are 0.28 km s^{-1} for L694-2 and 0.20 km s^{-1} for L1197, which could not be found in simple models. These velocity fields are roughly consistent with the gravitational collapse models of the isothermal core; however, the velocity gradients inside the peak velocity position are steeper than those of the models. Our results also show that the density distributions are $\sim$ r$^{-2.5}$ and $\sim$ r$^{-1.5}$ in the outer part for L694-2 and L1197, respectively. HCN abundance relative to H_2 is spatially almost constant in L694-2, with a value of 7×10^{-9}, while for L1197 it shows a slight inward increase from 1.7 to 3.5×10^{-9}.

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ISO far-infrared observations of the high-latitude cloud L1642: II. Correlated variations of far-infrared emissivity and temperature of "classical large" dust particles

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Aims. Our aim is to compare the infrared properties of big, "classical" dust grains with visual extinction in the cloud L1642 . In particular, we study the differences in grain emissivity between diffuse and dense regions in the cloud.

Methods. The far-infrared properties of dust are based on large-scale 100 μm and 200 μm maps. Extinction through the cloud was derived by using the star count method in the B- and I-bands, and colour excess method in the J, H, and K_s bands. Radiative transfer calculations were used to study the effects of increasing absorption cross-section on the far-infrared emission and dust temperature.

Results. Dust emissivity, measured by the ratio of far-infrared optical depth to visual extinction, τ(far-IR)/A_V, increases with decreasing dust temperature in L1642 . There is about a two-fold increase in emissivity over the dust temperature range of 19 K-14 K. Radiative transfer calculations show that, in order to explain the observed decrease of dust temperature towards the centre of L1642 , an increase of absorption cross-section of dust at far-IR is necessary. This temperature decrease cannot be explained solely by the attenuation of interstellar radiation field. Increased absorption cross-section also manifests itself as an increased emissivity. We find that, due to temperature effects, the apparent value of optical depth τ_{app}(far-IR), derived from 100 μm and 200 μm intensities, is always lower than the true optical depth.

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The Ionization Fraction of Barnard 68: Implications for Star and Planet Formation

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We present a detailed study of the ionization fraction of the Barnard 68 pre-stellar core, using millimeter $H^{13}CO^+$ and DCO^+ lines observations. These observations are compared to the predictions of a radiative transfer model coupled to a chemical network that includes depletion on grains and gas phase deuterium fractionation. Together with previous observations and modelling of CO and isotopologues, our $H^{13}CO^+$ and DCO^+ observations and modelling allow to place constraints on the metal abundance and the cosmic ionization rate. The $H^{13}CO^+$ emission is well reproduced for metals abundances lower than 3×10^{-9} and a standard cosmic ray ionization rate. However, the observations are also consistent with a complete depletion of metals, *i.e.* with cosmic rays as the only source of ionization at visual extinctions greater than a few A_v. The DCO^+ emission is found to be dependent of the ortho to para H_2 ratio, and indicates a ratio of $\sim 10^{-2}$. The derived ionization fraction is about 5×10^{-9} with respect to H nuclei, which is about an order of magnitude lower than the one observed in the L1544 core. The corresponding ambipolar diffusion timescale is found to be an order of magnitude larger than the free fall timescale at the center of the core. The inferred metal abundance suggests that magnetically inactive regions (*dead zones*) are present in protostellar disks.

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Planetary Migration to Large Radii

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There is evidence for the existence of massive planets at orbital radii of several hundred AU from their parent stars where the timescale for planet formation by core accretion is longer than the disc lifetime. These planets could have formed close to their star and then migrated outwards. We consider how the transfer of angular momentum by viscous disc interactions from a massive inner planet could cause significant outward migration of a smaller outer planet. We find that it is in principle possible for planets to migrate to large radii. We note, however, a number of effects which may render the process somewhat problematic.

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Planets in binary systems: is the present configuration indicative of the formation process?

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Aims. The present dynamical configuration of planets in binary star systems may not reflect their formation process since the binary orbit may have changed in the past after the planet formation process was completed. An observed binary system may have been part of a former hierarchical triple that became unstable after the planets completed their growth around the primary star. Alternatively, in a dense stellar environment even a single stellar encounter between the star pair and a singleton may singificantly alter the binary orbit. In both cases the planets we observe at present would have formed when the dynamical environment was different from the presently observed one.

Methods. We have numerically integrated the trajectories of the stars (binary plus singleton) and of test planets to investigate the abovementioned mechanisms. The orbits of the planets have been computed to test the survival of a planetary system around the primary during the chaotic phase of the stars.

Results. Our simulations show that the circumstellar environment during planetary formation around the primary was gravitationally less perturbed when the binary was part of a hierarchical triple because the binary was necessarely wider and, possibly, less eccentric. This circumstance has consequences for the planetary system in terms of orbital spacing, eccentricity, and mass of the individual planets. Even in the case of a single stellar encounter the present appearance of a planetary system in a binary may significantly differ from what it had while planet formation was ongoing. However, while in the case of instability of a triple the trend is always towards a tighter and more eccentric binary system, when a single stellar encounter affects the system the orbit of the binary can become wider and be circularized.

Conclusions. Modelling the formation of a planetary system around a binary is a potentially complex task and an effort has to be made to look into its present dynamics for traces of a possible chaotic past.

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Saving Planetary Systems: Dead Zones and Planetary Migration

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The tidal interaction between a disk and a planet leading to a planet's migration is widely believed to be the mechanism that explains the variety of orbital radii of extrasolar planets. A long-standing question is what stops the migration before planets plunge into their central stars. We propose a new, simple mechanism to significantly slow down planet migration and test it using a hybrid numerical integrator to simulate disk-planet interaction. Key to this scenario are the low-viscosity regions in protostellar disks known as dead zones. Low viscosity affects planetary migration in two ways. First, it allows a smaller mass planet to open a gap, and hence trade the faster type I migration (pre-gap-opening migration) for the slower type II migration (post-gap-opening migration). Second, low viscosity slows down type II migration itself, because type II migration varies directly with viscosity. We present numerical simulations of planetary migration in disks using a hybrid symplectic integrator-gas dynamics code. Assuming that the disk viscosity parameter inside the dead zone is $\alpha = 10^{-4}$ to 10^{-5}, we find that, when a low-mass planet (110 $M_\oplus$) migrates from outside the dead zone, it is stopped by mass accumulation inside the dead zone. When a low-mass planet migrates from inside the dead zone, it opens a gap, slowing its migration. A massive planet like Jupiter, in contrast, opens a gap and slows down inside the dead zone, independent of its initial orbital radius. The final orbital radius of a Jupiter-mass planet depends on the dead zone's viscosity. For the range of α-values noted above, this can vary from 7 AU to an orbital radius of 0.1 AU, which is characteristic of the hot Jupiters.

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Fragmentation of Gravitationally Unstable Gaseous Protoplanetary Disks with Radiative Transfer

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We report on the results of the first 3D SPH simulations of gravitationally unstable protoplanetary disks with radiative transfer. We adopt a flux-limited diffusion scheme justified by the high opacity of most of the disk. The optically thin surface of the disk cools as a blackbody. We find that gravitationally bound clumps with masses close to a Jupiter mass can arise. Fragmentation appears to be driven by vertical convective-like motions capable of transporting the heat from the disk midplane to its surface on a timescale of only about 40 years at 10 AU. A larger or smaller cooling efficiency of the disk at the optically thin surface can promote or stifle fragmentation by affecting the vertical temperature profile, which determines whether convection can happen or not, and by regulating accretion from optically thin regions toward overdense regions. We also find that the chances of fragmentation increase for a higher mean molecular weight, μ, since compressional heating is reduced. Only disks with masses >0.12 $M_\odot$ and with $\mu \geq 2.4$, as expected for gas with a metallicity comparable to solar or higher, can fragment.

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On the difference between Herbig Ae and Herbig Be stars

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We present linear spectropolarimetric data for eight Herbig Be and four Herbig Ae stars at Hα, Hβ and Hγ. Changes in the linear polarization are detected across all Balmer lines for a large fraction of the observed objects, confirming that the small-scale regions surrounding these objects are flattened (i.e. disc-like). Furthermore, all objects with detections show similar characteristics at the three spectral lines, despite differences in transition probability and optical depth going from Hα to Hγ. A large fraction of early Herbig Be stars (B0 - B3) observed show line-depolarization effects. However, the early Herbig Ae stars (A0 - A2), observed for comparison, show intrinsic line-polarization signatures. Our data suggest that the popular magnetic accretion scenario for T Tauri objects may be extended to Herbig Ae stars, but that it may not be extended to early Herbig Be stars, for which the available data are consistent with disc accretion.

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Herbig-Haro jets in 3D: the HL/XZ Tau region

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Jets and outflows from young stellar objects (YSOs) can be identified and traced through the distribution and structure of shocked emission-line features. To understand the formation of these regions requires kinematic data at high spectral resolution and with full spatial coverage.

In this work, we investigate the environment of HL/XZ Tau, which contains a compact and very active nest of YSOs. We explore the kinematic properties of the close association of jets in this region and study the interaction of jets with the ambient medium, as well as the outflows with each other.

We present scanning Fabry-Perót interferometry of the HL/XZ Tau region in Hα and [SII] 6716Å emission. We also measure the proper motions of the knots in the outflows, as derived from images obtained in 1997 and 2001, to achieve the full 3D kinematic picture.

Radial velocities of the HL Tau jet indicate a fast spine of low excitation surrounded by a slower sheared sheath of higher excitation. Proper motions range from $200-220$ km s^{-1} in the HL Tau jet and are aligned within 10 degrees of the jet spine. In combination, the proper motions and radial velocities indicate that three outflows in this region may be interacting with each other. Evidence of an outflow associated with LkHα 358 is found, and we suggest it is a source of Herbig-Haro (HH) knots that lie to the southeast of HL Tau and HH 265.

We conclude that the southern lobe of the XZ Tau wind disrupts the eastern lobe of the collimated outflow from LkHα 358. The jet emerging from HL Tau is deflected by the northern lobe of the wind from XZ Tau. We propose several probable explanations for the unusual structure of the HL Tau jet. It is plausible that the shocks in the jet spine are maintained by the ram pressure of a low-density crosswind from XZ Tau. The crosswind interacts to form a sheath of entrained gas.

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On the Flaring of Jet-sustaining Accretion Disks

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Jet systems with two unequal components interact with their parent accretion disks through the asymmetric removal of linear momentum from the star-disk system. We show that as a result of this interaction, the disk's state of least energy is not made up of orbits that lie in a plane containing the star's equator, as in a disk without jets. The disk's profile has the shape of a sombrero, curved in the direction of acceleration. For this novel state of minimum energy, we derive the temperature profile of thin disks. The flaring geometry caused by the sombrero profile increases the disk temperature, especially in its outer regions. The jet-induced acceleration disturbs the vertical equilibrium of the disk, leading to mass loss in the form of a secondary wind emanating from the upper face of the disk. The jets' time variability causes the disk to radially expand or contract, depending on whether the induced acceleration increases or decreases. It also excites vertical motion and eccentric distortions in the disk and affects the sombrero profile's curvature. These perturbations lead to the heating of the disk through its viscous stresses as it tries to settle into the varying state of minimum energy. The jet-disk interaction studied here will help us to estimate the duration of the jet episode in star-disk systems and may explain the origin of the recently observed one-sided molecular outflow of the HH 30 disk-jet system.

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Observations of spatial and velocity structure in the Orion molecular cloud

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Observations are reported of H_2 IR emission in the S(1) v=1-0 line at 2.121 μm in the Orion Molecular Cloud, OMC1, using the GriF instrument on the Canada-France-Hawaii Telescope. GriF uses a combination of adaptive optics and Fabry-Perot interferometry, yielding a spatial resolution of $0.15''$ to $0.18''$ and velocity discrimination as high as 1 km s^{-1}. 193 bright H_2 emission regions can be identified in OMC1. The general characteristics of these features are described in terms of radial velocities, brightness and spatial displacement of maxima of velocity and brightness, the latter to yield the orientation of flows in the plane of the sky. Strong spatial correlation between velocity and bright H_2 emission is found and serves to identify many features as shocks. Important results are: (i) velocities of the excited gas illustrate the presence of a zone to the south of BN-IRc2 and Peak 1, and the west of Peak 2, where there is a powerful blue-shifted outflow with an average velocity of -18 km s^{-1}. This is shown to be the NIR counterpart of an outflow previously identified in the radio, originating from either source I or source n. (ii) There is a band of weak radial velocity features (<5 km s^{-1}) in Peak 1. (iii) A small proportion of the flows may represent sites of low mass star formation and one region shows evidence of multiple flows which may indicate multiple low mass star formation within OMC1.

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Photodesorption of CO ice

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At the high densities and low temperatures found in star forming regions, all molecules other than H_2 should stick on dust grains on timescales shorter than the cloud lifetimes. Yet these clouds are detected in the millimeter lines of gaseous CO. At these temperatures, thermal desorption is negligible and hence a non-thermal desorption mechanism is necessary to maintain molecules in the gas phase. Here, the first laboratory study of the photodesorption of pure CO ice under ultra high vacuum is presented, which gives a desorption rate of 3×10^{-3} CO molecules per UV (7–10.5 eV) photon at 15 K. This rate is factors of 10^2-10^5 larger than previously estimated and is comparable to estimates of other non-thermal desorption rates. The experiments constrains the mechanism to a single photon desorption process of ice surface molecules. The measured efficiency of this process shows that the role of CO photodesorption in preventing total removal of molecules in the gas has been underestimated.

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Accretion of terrestrial planets from oligarchs in a turbulent disk

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We have investigated the final accretion stage of terrestrial planets from Mars-mass protoplanets that formed through oligarchic growth in a disk comparable to the minimum mass solar nebula (MMSN), through N-body simulation including random torques exerted by disk turbulence due to Magneto-Rotational Instability. For the torques, we used the semi-analytical formula developed by Laughlin et al. [Laughlin, G., Steinacker, A., Adams, F.C., 2004. Astrophys. J. 608, 489496]. The damping of orbital eccentricities (in all runs) and type-I migration (in some runs) due to the tidal interactions with disk gas is also included. Without any effect of disk gas, Earth-mass planets are formed in terrestrial planet regions in a disk comparable to MMSN but with too large orbital eccentricities to be consistent with the present eccentricities of Earth and Venus in our Solar System. With the eccentricity damping caused by the tidal interaction with a remnant gas disk, Earth-mass planets with eccentricities consistent with those of Earth and Venus are formed in a limited range of disk gas surface density ($\sim 10^4$ times MMSN). However, in this case, on average, too many ($\gtrsim 6$) planets remain in terrestrial planet regions, because the damping leads to isolation between the planets. We have carried out a series of N-body simulations including the random torques with different disk surface density and strength of turbulence. We found that the orbital eccentricities pumped up by the turbulent torques and associated random walks in semimajor axes tend to delay isolation of planets, resulting in more coagulation of planets. The eccentricities are still damped after planets become isolated. As a result, the number of final planets decreases with increase in strength of the turbulence, while Earth-mass planets with small eccentricities are still formed. In the case of relatively strong turbulence, the number of final planets are 45 at 0.52 AU, which is more consistent with Solar System, for relatively wide range of disk gas surface density ($\sim 10^4$ - 10^2 times MMSN).

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Two regimes of Turbulent Fragmentation and the stellar IMF from Primordial to Present Day Star Formation

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The Padoan and Nordlund model of the stellar initial mass function (IMF) is derived from low order statistics of supersonic turbulence, neglecting gravity (e.g. gravitational fragmentation, accretion and merging). In this work the predictions of that model are tested using the largest numerical experiments of supersonic hydrodynamic (HD) and magneto-hydrodynamic (MHD) turbulence to date ($\sim 1000^3$ computational zones) and three different codes (Enzo, Zeus and the Stagger Code). The model predicts a power law distribution for large masses, related to the turbulence energy power spectrum slope, and the shock jump conditions. This power law mass distribution is confirmed by the numerical experiments. The model also predicts a sharp difference between the HD and MHD regimes, which is recovered in the experiments as well, implying that the magnetic field, even below energy equipartition on the large scale, is a crucial component of the process of turbulent fragmentation. These results suggest that the stellar IMF of primordial stars may differ from that in later epochs of star formation, due to differences in both gas temperature and magnetic field strength. In particular, we find that the IMF of primordial stars born in turbulent clouds may be narrowly peaked around a mass of order 10 $M_\odot$, as long as the column density of such clouds is not much in excess of 10^{22} cm^{-2}.

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Probing the structure of protoplanetary disks: a comparative study of DM Tau, LkCa 15, and MWC 480

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Context. The physical structure of proto-planetary disks is not yet well constrained by current observations. Millimeter interferometry is an essential tool to investigate young disks.

Aims. We study the vertical and radial temperature distribution in a few well-known disks from an observational perspective. The surface density distribution of CO and HCO^+ and the scale-height are also investigated.

Methods. We report CO observations at sub-arcsecond resolution with the IRAM array of the disks surrounding MWC 480, LkCa 15, and DM Tau, and simultaneous measurements of HCO^+ $J = 1 \rightarrow 0$. To derive the disk properties, we fit a standard disk model in which all parameters are power laws of the distance to the star to the data. Possible biases associated with the method are detailed and explained. We compare the properties of the observed disks with similar objects.

Results. We find evidence for a vertical temperature gradient in the disks of MWC 480 and DM Tau , as in AB Aur , but not in LkCa 15 . The disk temperatures increase with stellar effective temperature. Except for AB Aur , the bulk of the CO gas is at temperatures smaller than 17 K, below the condensation temperature on grains. We find the scale height of the CO distribution to be larger (by 50%) than the expected hydrostatic scale height. The total amount of CO and the isotopologue ratio depends globally on the star. The more UV luminous objects appear to have more CO, but there is no simple dependency. The $[^{13}CO]/[HCO^+]$ ratio is $\sim$600, with substantial variations between sources, and with radius. The temperature behavior is consistent with expectations, but published chemical models have difficulty reproducing the observed CO quantities. Changes in the slope of the surface density distribution of CO, compared to the continuum emission, suggest a more complex surface density distribution than is usually assumed in models. Vertical mixing seems an important chemical agent, as does photo-dissociation by the ambient UV radiation at the disk's outer edge.

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On the stratified dust distribution of the GG Tau circumbinary ring

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Aims. Our objective is to study the vertical dust distribution in the circumbinary ring of the binary system GG Tau and to search for evidence of stratification, one of the first steps expected to occur during planet formation.

Methods. We present a simultaneous analysis of four scattered light images spanning a range of wavelength from 800 nm to 3800 nm and compare them with (i) a parametric prescription for the vertical dust stratification, and (ii) with the results of SPH bi-fluid hydrodynamic calculations.

Results. The parametric prescription and hydrodynamical calculations of stratification both reproduce the observed brightness profiles well. These models also provide a correct match for the observed star/ring integrated flux ratio. Another solution with a well-mixed, but "exotic", dust size distribution also matches the brightness profile ratios but fails to match the star/ring flux ratio. These results give support to the presence of vertical stratification of the dust in the ring of GG Tau and further predict the presence of a radial stratification also.

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A Multiwavelength Study of M17: The Spectral Energy Distribution and PAH Emission Morphology of a Massive Star Formation Region

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We combine diffuse emission photometry from GLIMPSE and several other Galactic plane surveys covering near-IR through radio wavelengths to synthesize a global spectral energy distribution (SED) for the M17 complex. By balancing the integrated flux in the SED with the total bolometric luminosity of all known O and early B stars in the ionizing cluster, we estimate a distance to M17 of $1.6^{+0.3}_{-0.1}$ kpc. At this distance, the observed total flux in the SED corresponds to a luminosity of $2.4 \pm 0.3 \times 10^6$ $L_\odot$. We find that the SED from the H II region peaks at shorter wavelengths and has a qualitatively different shape than the SED from the photodissociation region (PDR). We find that polycyclic aromatic hydrocarbons (PAHs) are destroyed over a short distance or edge at the boundary of the H II region. We demonstrate that this PAH destruction edge can be located easily using GLIMPSE band-ratio images and confirm this using Spitzer IRS spectra. We investigate the relative roles of extreme ultraviolet (EUV) and X-ray photons in the destruction of PAHs, concluding that X-rays are not an important PAH destruction mechanism in M17 or, by extension, in any other Galactic H II region. Our results support the hypothesis that PAHs are destroyed by EUV photons within H II regions. PAHs dominate the mid-IR emission in the neutral PDR beyond the ionized gas.

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Diffusive low optical depth particle discs truncated by planets

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Two-dimensional particle discs in proximity to a planet are numerically integrated to determine when a planet in a circular orbit can truncate a particle disc. Collisions are treated by giving each particle a series of velocity perturbations during the integration. We estimate the mass of a planet required to truncate a particle disc as a function of collision rate, related to the disc optical depth, and velocity perturbation size, related to the disc velocity dispersion. We find that for particle discs in the regime estimated for debris discs, a Neptune mass planet is sufficiently massive to truncate the disc. If both the velocity dispersion and the disc optical depth are low (dispersion less than approximately 0.02 in units of circular motion, and optical depth less than 10^{-4}) then an Earth mass planet suffices. We find that the disc is smooth and axisymmetric unless the velocity perturbation is small and the planet mass is of the order of or greater than a Neptune mass in which case azimuthal structure is seen near prominent mean motion resonances.

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Terrestrial Planet Formation around Individual Stars within Binary Star Systems

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We calculate herein the late stages of terrestrial planet accumulation around a solar-type star that has a binary companion with semimajor axis larger than the terrestrial planet region. We perform more than 100 simulations to survey binary parameter space and to account for sensitive dependence on initial conditions in these dynamical systems. As expected, sufficiently wide binaries leave the planet formation process largely unaffected. As a rough approximation, binary stars with periastron $q_B > 10$ AU have a minimal effect on terrestrial planet formation within $\sim$2 AU of the primary, whereas binary stars with $q_B \lesssim 5$ AU restrict terrestrial planet formation to within $\sim$1 AU

of the primary star. Given the observed distribution of binary orbital elements for solar-type primaries, we estimate that about 40% - 50% of the binary population is wide enough to allow terrestrial planet formation to take place unimpeded. The large number of simulations allows us to determine the distribution of resultsthe distribution of plausible terrestrial planet systemsfor effectively equivalent starting conditions. We present (rough) distributions for the number of planets, their masses, and their orbital elements.

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Characterizing the Disk around the TW Hydrae Association Brown Dwarf 2MASSW J1207334-393254

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We present detailed modeling of the disk around the TW Hydrae Association (TWA) brown dwarf 2MASSW J1207334-393254 (2M1207), using Spitzer observations from 3.6 to 24 μm. The spectral energy distribution (SED) does not show a high amount of flaring. We have obtained a good fit using a flat disk of mass between 10^{-4} and 10^{-6} $M_\odot$, $\dot{M} \lesssim 10^{-11}$ $M_\odot$ yr^{-1}, and a large inclination angle between 60° and 70°. We have used three different grain models to fit the 10 μm Si emission feature, and have found the results to be consistent with ISM-like dust. In comparison with other TWA members, this suggests lesser dust processing for 2M1207, which could be explained by mechanisms such as aggregate fragmentation and/or turbulent mixing. We have found a good fit using an inner disk radius equal to the dust sublimation radius, which indicates the absence of an inner hole in the disk. This suggests the presence of a small K - L excess, similar to the observed K - [3.6] excess.

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The Infrared Extinction Law at Extreme Depth in a Dark Cloud Core

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We combined sensitive near-infrared data obtained with ground-based imagers on the ESO NTT and VLT telescopes with space mid-infrared data acquired with the IRAC imager on the Spitzer Space Telescope to calculate the extinction law A_λ/A_{K_S} as a function of λ between 1.25 and 7.76 μm to an unprecedented depth in Barnard 59, a star forming, dense core located in the Pipe Nebula. The ratios A_λ/A_{K_S} were calculated from the slopes of the distributions of sources in color-color diagrams $\lambda - K_S$ vs. $H - K_S$. The distributions in the color-color diagrams are fit well with single slopes to extinction levels of $A_{K_S} \approx 7$ ($A_V \approx 59$ mag). Consequently, there appears to be no significant variation of the extinction law with depth through the B59 line of sight. However, when slopes are translated into the relative extinction coefficients A_λ/A_{K_S}, we find an extinction law which departs from the simple extrapolation of the near-infrared power law extinction curve, and agrees more closely with a dust extinction model for a cloud with a total to selective absorption $R_V = 5.5$ and a grain size distribution favoring larger grains than those in the diffuse ISM. Thus, the difference we observe could be possibly due to the effect of grain growth in denser regions. Finally, the slopes in our diagrams are somewhat less steep than those from the study of Indebetouw et al. (2005) for clouds with lower column densities, and this indicates that the extinction law between 3 and 8 μm might vary slightly as a function of environment.

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Methyl Formate in the NGC 2264 IRS 1 Region

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Millimeter-wave spectral lines of $HCOOCH_3$ are observed toward a massive star-forming region, NGC 2264 IRS 1, with the Nobeyama 45 m radio telescope and Nobeyama Millimeter Array. The $HCOOCH_3$ emission is not detected toward the dense core around IRS 1, which is the brightest IR source. However, it is definitively detected toward MMS 3, which is thought to contain a high-mass equivalent of a Class 0 protostar. The column density and the fractional abundance of $HCOOCH_3$ in MMS 3 are found to be (430) $\times 10^{15}$ cm^{-2} and (0.75.3) $\times 10^{-8}$, respectively, assuming that the range of the excitation temperature is from 50 to 250 K. The fractional abundance is lower by an order of magnitude than that in the compact ridge of Orion KL. On the other hand, the upper limit to the fractional abundance toward IRS 1 is significantly lower than the abundance toward MMS 3. Since MMS 3 is less evolved than IRS 1, this result would indicate that $HCOOCH_3$ preferentially exists in the younger stage of protostellar evolution, as in the case of low-mass star forming regions. The distribution of $HCOOCH_3$ is found to be slightly offset from the dust continuum peak of MMS 3 by 13″. This situation is similar to that found in the compact ridge of Orion KL, which would provide us with an important clue in exploring its peculiar chemistry.

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Absolute Proper Motions of H_2O Masers Away from the Galactic Plane Measured with VERA in the "Superbubble" Region NGC 281

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We report on absolute proper-motion measurements of an H_2O maser source in the NGC 281 West molecular cloud, which is located ∼320 pc above the Galactic plane and is associated with an HI loop extending from the Galactic plane. We have conducted multi-epoch phase-referencing observations of the maser source with VERA (VLBI Exploration of Radio Astrometry) over a monitoring period of 6 months since May 2006. We find that the H_2O maser features in NGC 281 West are systematically moving toward the southwest and further away from the Galactic plane with a vertical velocity of $\sim 20-30$ km s^{-1} at its estimated distance of $2.2-3.5$ kpc. Our new results provide the most direct evidence that the gas in the NGC 281 region on the HI loop was blown out from the Galactic plane, most likely in a superbubble driven by multiple or sequential supernova explosions in the Galactic plane.

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Formation of OB Associations in Galaxies

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We consider the formation of OB associations from two perspectives: (a) the fractional gas consumption in star formation, ϵ, per dynamical time scale $t_{\rm dyn}$ in a galaxy, and (b) the origin of the so-called Kennicutt-Schmidt law that the rate of star formation per unit area is proportional to a power, α, of the surface density in H I and H_2 gas when certain thresholds are crossed. The empirical findings that $\epsilon \approx 10^{-2}$ and $\alpha \approx 1.4$ or 1.5 have simple explanations if the rate of star formation is magnetically regulated. An empirical test of the ideas resides in an analysis of why giant OB associations are "strung out like pearls along the arms" of spiral galaxies.

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Mean-Field Magnetohydrodynamics of Accretion Disks

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We consider the accretion process in a disk with magnetic fields that are dragged in from the interstellar medium by gravitational collapse. Two diffusive processes are at work in the system: (1) "viscous" torques exerted by turbulent and magnetic stresses, and (2) "resistive" redistribution of mass with respect to the magnetic flux arising from the imperfect conduction of current. In steady state, self-consistency between the two rates of drift requires that a relationship exists between the coefficients of turbulent viscosity and turbulent resistivity. Ignoring any interactions with a stellar magnetosphere, we solve the steady-state equations for a magnetized disk under the gravitational attraction of a mass point and threaded by an amount of magnetic flux consistent with calculations of magnetized gravitational collapse in star formation. Our model mean-field equations have an exact analytical solution that corresponds to magnetically diluted Keplerian rotation about the central mass point. The solution yields the strength of the magnetic field and the surface density as functions of radial position in the disk and their connection with the departure from pure Keplerian rotation in representative cases. We compare the predictions of the theory with the available observations concerning T Tauri stars, FU Orionis stars, and low- and high-mass protostars. Finally, we speculate on the physical causes for high and low states of the accretion disks that surround young stellar objects. One of the more important results of this study is the physical derivation of analytic expressions for the turbulent viscosity and turbulent resistivity.

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The Transition from the First Stars to the Second Stars in the Early Universe

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We observe a sharp transition from a singular, high-mass mode of star formation to a low-massdominated mode, in numerical simulations, at a metallicity of 10^{-3} $Z_\odot$. We incorporate a new method for including the radiative cooling from metals into adaptive mesh refinement hydrodynamic simulations. Our results illustrate how metals, produced by the first stars, led to a transition from the high-mass star formation mode of Population III stars to the low-mass mode that dominates today. We ran hydrodynamic simulations with cosmological initial conditions in the standard

ΛCDM model, with metallicities, from zero to 10^{-2} $Z_\odot$, beginning at redshift z = 99. The simulations were run until a dense core forms at the center of a 5×10^5 $M_\odot$ dark matter halo, at $z \sim 18$. Analysis of the central 1 $M_\odot$ core reveals that the two simulations with the lowest metallicities, Z = 0 and 10^{-4} $Z_\odot$, contain one clump with 99% of the mass, while the two with metallicities Z = 10^{-3} and 10^{-2} $Z_\odot$ each contain two clumps that share most of the mass. The Z = 10^{-3} $Z_\odot$ simulation also produced two low-mass protostellar objects with masses between 10^{-2} and 10^{-1} $M_\odot$. Gas with $Z \geq 10^{-3}$ $Z_\odot$ is able to cool to the temperature of the cosmic microwave background (CMB), which sets a lower limit to the minimum fragmentation mass. This suggests that the second-generation stars produced a spectrum of lower mass stars but were still more massive, on average, than stars formed in the local universe.

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Probing Inward Motions in Starless Cores Using The HCN J = 1-0 Hyperfine Transitions : A Pointing Survey Toward Central Regions

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We have carried out a survey toward the central regions of 85 starless cores in HCN J = 1-0 to study inward motions in the cores. Sixty-four cores were detected with HCN lines. The infall asymmetry in the HCN spectra is found to be more prevalent, and more prominent than in any other previously used infall tracers such as CS J = 2-1, DCO+ J = 2-1, and N2H+ J = 1-0. We found close relation between the intensities of the HCN and N2H+ lines. This implies that the HCN is not much depleted in the central regions of the cores. In some cores, the HCN spectra show different sign of asymmetry from other molecular lines. A few cores show various signs of asymmetry in individual HCN hyperfine lines. The distribution of the velocity shift dV of the HCN profiles with respect to the systemic velocity of the optically thin tracer is found to be more shifted toward bluer side than those of other infall tracers, indicating that the HCN traces inward motions more frequently. The dV distribution of each HCN hyperfine line for all sources is similar. Moreover the dV values obtained from different HCN hyperfine lines for each source are nearly similar. These may mean that most of starless cores are in similar kinematic states across the layers of the cores. We identify 17 infall candidates using all available indicators such as the velocity shift dV and the blue to red peak intensity ratio of double peaked profiles for HCN J = 1-0, CS J = 2-1, J = 3-2, DCO+ J = 2-1, and N2H+ J = 1-0. Four of them, L63, L492, L694-2, and L1197 are found to show higher blue to red ratio in the HCN hyperfine line along the lower opacity, suggesting that infall speed becomes higher toward the center.

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A Surprising Reversal of Temperatures in the Brown-Dwarf Eclipsing Binary 2MASS J05352184-0546085

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The newly discovered brown-dwarf eclipsing binary 2MASS J05352184–0546085 provides a unique laboratory for testing the predictions of theoretical models of brown-dwarf formation and evolution. The finding that the lower-mass brown dwarf in this system is hotter than its higher-mass companion represents a challenge to brown-dwarf evolutionary models, none of which predict this behavior. Here we present updated determinations of the basic physical properties of 2M0535–05, bolstering the surprising reversal of temperatures with mass in this system. We compare these measurements with widely used brown-dwarf evolutionary tracks, and find that the temperature reversal can be explained by some models if the components of 2M0535–05 are mildly non-coeval, possibly consistent with dynamical simulations of brown-dwarf formation. Alternatively, a strong magnetic field on the higher-mass brown dwarf might explain its anomalously low surface temperature, consistent with emerging evidence that convection is suppressed in magnetically active, low-mass stars. Finally, we discuss future observational and theoretical work needed to further characterize and understand this benchmark system.

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Discovery of a Molecular Outflow in the Haro 6-10 Star-forming Region

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We present high-sensitivity ^{12}CO and ^{13}CO $J = 1 \rightarrow 0$ molecular line maps covering the full extent of the parsec scale Haro 6-10 Herbig-Haro (HH) flow. We report the discovery of a molecular CO outflow along the axis of parsec-scale HH flow. Previous molecular studies missed the identification of the outflow probably due to their smaller mapping area and the confusing spectral features present toward the object. Our detailed molecular line study of the full 1.6 pc extent of the optical flow shows evidence for both blueshifted and redshifted gas set in motion by Haro 6-10 activity. The molecular outflow is centered at Haro 6-10, with redshifted gas being clumpy and directed toward the northeast, while blueshifted gas is in the southwest direction. The molecular gas terminates well within the cloud, short of the most distant HH objects of the optical flow. Contamination from an unrelated cloud along the same line of sight prevents a thorough study of the blueshifted outflow lobe and the mass distribution at the lowest velocities in both lobes. The cloud core in which Haro 6-10 is embedded is filamentary and flattened in the east-west direction. The total cloud mass is calculated from ^{13}CO $J = 1 \rightarrow 0$ to be ~ 200 M$_\odot$. The lower limit of the mass associated with the outflow is ~ 0.25 M$_\odot$.

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Photodissociation Feedback of Population III Stars onto Neighboring Prestellar Cores

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We investigate the star formation process in the primordial environment in the presence of radiative feedback from other Population III stars that formed earlier. In this paper, we focus our attention on the effects of photodissociative radiation, leading toward a full understanding of the radiative feedback effects. We perform three-dimensional radiation hydrodynamics simulations on this issue, as well as analytic estimates, paying special attention to the self-shielding effect and the dynamics of the star-forming cloud. As a result, we find that the ignition timing of the source star is crucial. If the ignition is later than the epoch when the central density of the collapsing cloud exceeds $\sim 10^3$ 10^4 cm^{-3}, the collapse cannot be reversed, even if the source star is located at $\lesssim$100 pc. The uncertainty of the critical density comes from the variety of initial conditions of the collapsing cloud. We also find the analytic criterion for a cloud to collapse with a given central density, temperature, and Lyman-Wernerband flux that irradiates the cloud. Although we focus on the radiation from neighboring stars, this result can also be applied to the effects of the diffuse Lyman-Werner (LW) radiation field that is expected to be built up prior to the reionization of the universe. We find that self-gravitating clouds can easily self-shield from diffuse LW radiation and continue their collapse for densities larger than $\sim 10^3$ cm^{-3}.

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The shapes of molecular cloud cores in Orion

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We investigate the intrinsic shapes of starless cores in the Orion GMC, using the prestellar core sample of Nutter & Ward-Thompson (2007), which is based on submillimeter SCUBA data. We employ a maximum-likelihood method to reconstruct the intrinsic distribution of ellipsoid axial ratios from observations of the axial ratios of projected plane-of-the-sky core ellipses. We find that, independently of the details of the assumed functional form of the distribution, there is a strong preference for oblate cores of finite thickness. Cores with varying finite degrees of triaxiality are a better fit than purely axisymmetric cores although cores close to axisymmetry are not excluded by the data. The incidence of prolate starless cores in Orion is found to be very infrequent. We also test the consistency of the observed data with a uniform distribution of intrinsic shapes, where oblate and prolate cores of all degrees of triaxiality occur with equal probability. Such a distribution is excluded at the 0.1% level. These findings have important implications for theories of core formation within molecular clouds.

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A tale of two cores: triggered massive star formation in the bright-rimmed cloud SFO75

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Context. Bright-rimmed clouds (BRCs) are isolated molecular clouds located on the edges of evolved HII regions. Star formation within the BRCs may have been triggered through the propagation of photoionisation-induced shocks driven by the expansion of the HII region.
Aims. The main focus of this paper is to investigate the current level of star formation within one of these clouds and evaluate to what extent, if any, star formation may have been triggered.
Methods. We present a detailed multi-wavelength study of the BRC SFO 75, including 1.3 cm and 1.2 mm continuum, and ^{13}CO and ammonia spectral line observations. To build up a comprehensive picture of the local environment we complement our observations with archival data from the 2MASS, GLIMPSE and IRAS surveys.
Results. The ^{13}CO and 1.2 mm emission reveals the presence of a dense core located behind the bright rim of the cloud which is approximately coincident with that of the IRAS point source. From an analysis of the IRAS and 1.2 mm fluxes we derive a dust temperature of ~ 30 K, a luminosity of $L_{\rm bol} = 1.6 \times 10^4$ L$_\odot$ and estimate the core mass to be $\sim$570 M$_\odot$. The higher resolution ammonia observations resolve the 1.2 mm core into two distinct cores, one directly behind the cloud's rim (Core A) and the second located slightly farther back (Core B). These have masses of 8–15 M$_\odot$ and 3.5–7 M$_\odot$ for Core A and Core B respectively, which are significantly larger than their virial masses. Comparing the morphology of Core A with that of the photon-dominated region and ionised boundary layer leaves little doubt that it is being strongly affected by the ionisation front. 2MASS and GLIMPSE archive data, which reveal a small cluster of three deeply embedded ($A_{\rm v} \sim 20$ mag) high- and intermediate-mass young stellar objects towards Core A, leads us to conclude that the star formation found in this core has been triggered. In stark contrast, Core B appears to have a much simpler, almost spherical, morphology. No stars are found towards Core B. We find evidence supporting the presence of shocked gas within the surface layers of the cloud which appears to extend to midway between the two ammonia cores.
Conclusions. The scenario that emerges from our analysis is one where the two ammonia cores pre-date the arrival of

the ionisation front. Since its arrival the over-pressure of the ionised gas at the surface of the cloud has driven shocks into the surface layers of the cloud. The propagation of these shocks through Core A have triggered the formation of a small cluster of massive stars, however, the shock front has not yet propagated deeply enough into the cloud to have affected the evolution of Core B.

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High-Resolution Imaging of the Dust Disk around 49 Ceti

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Subarcsecond scale Keck images of the young A1 V star, 49 Ceti, resolve emission at $\lambda = 12.5$ and 17.9 μm from a disk with long axis at position angle (P.A.) $125° \pm 10°$ and inclination $\phi = 60° \pm 15°$. At 17.9 μm, the emission is brighter and more extended toward the northwest (NW) than the southeast (SE). Modeling of the mid-infrared images combined with flux densities from the literature indicate that the bulk of the mid-infrared emission comes from very small grains ($a \sim 0.1$ μm) confined between 30 and 60 AU from the star. This population of dust grains contributes negligibly to the significant excess observed in the spectral energy distribution. Most of the nonphotospheric energy is radiated at longer wavelengths by an outer disk of larger grains ($a \sim 15$ μm), inner radius $\sim$60 AU, and outer radius $\sim$900 AU. Global properties of the 49 Cet disk show more affinity with the β Pic and HR 4796A disks than with other debris disks. This may be because they are all very young ($t < 20$ Myr), adding strength to the argument that they are transitional objects between Herbig Ae and "Vega-like" A stars with more tenuous circumstellar disks.

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Comparison of ^{13}CO line and far-infrared continuum emission as a diagnostic of dust and molecular gas physical conditions - II. The simulations: testing the method

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The reliability of modelling the far-infrared continuum to ^{13}CO $J = 1 \rightarrow 0$ spectral line ratios applied to the Orion clouds (see previous paper in the series) on the scales of several parsecs (i.e. $\sim$7 pc) is tested by applying the models to simulated data. The two-component models are found to give the dustgas temperature difference, ΔT, to within 1 or 2 K. However, other parameters like the column density per velocity interval and the gas density can be wrong by an order of magnitude or more. In particular, the density can be systematically underestimated by an order of magnitude or more. The overall mass of the clouds is estimated correctly to within a few per cent.

These results may permit us to reliably constrain estimates of the Orion clouds' physical parameters, based on the real observations of the far-infrared continuum and ^{13}CO $J = 1 \rightarrow 0$ spectral line. Nevertheless, other systematics must be treated first. These include the effects of background/foreground subtraction, effects of the H i component of the interstellar medium, and others. These will be discussed in a future paper.

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Comparison of ^{13}CO line and far-infrared continuum emission as a diagnostic of dust and molecular gas physical conditions - III. Systematic effects and scientific implications

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Far-infrared (far-IR) continuum data from the COBE/DIRBE instrument were combined with Nagoya 4-m ^{13}CO J = 1 → 0 spectral line data to infer the multiparsec-scale physical conditions in the Orion A and B molecular clouds, using 140 μm/240 μm dust colour temperatures and the 240 μm/^{13}CO J = 1 → 0 intensity ratios. In theory, the ratio of far-IR, submillimetre, or millimetre continuum to that of a ^{13}CO (or C^{18}O) rotational line can place reliable upper limits on the temperature of the dust and molecular gas on multiparsec scales; on such scales, both the line and continuum emission are optically thin, resulting in a continuum-to-line ratio that suffers no loss of temperature sensitivity in the high-temperature limit as occurs for ratios of CO rotational lines or ratios of continuum emission in different wavelength bands.

Two-component models fit the Orion data best, where one has a fixed temperature and the other has a spatially varying temperature. The inferred physical conditions are consistent with those determined from previously observed maps of ^{12}CO J = 1 → 0 and J = 2 → 1 that cover the entire Orion A and B molecular clouds. The models require that the dustgas temperature difference is 0 ± 2 K. If this surprising result is confirmed with independent studies and applies to much of the Galactic interstellar medium (ISM), except in unusual regions such as the Galactic Centre, then there are a number of implications. These include dustgas thermal coupling that is commonly factors of 510 stronger than previously believed, Galactic-scale molecular gas temperatures closer to 20 K than to 10 K, an improved explanation for the N(H_2)/I(CO) conversion factor (a full discussion of this is deferred to a later paper), and ruling out at least one dust grain alignment mechanism. The simplest interpretation of the models suggests that about 4050 per cent of the Orion clouds are in the form of cold (i.e. ∼310 K) dust and gas, although alternative explanations are not ruled out. These alternatives include the contribution to the 240-μm continuum by dust associated with atomic hydrogen and reduced ^{13}CO abundance towards the clouds' edges. Even considering these alternatives, it is still likely that cold material with temperatures of ∼710 K still exists. If this cold gas and dust are common in the Galaxy, then mass estimates of the Galactic ISM must be revised upwards by up to 60 per cent.

The feasibility of submillimetre or millimetre continuum to ^{13}CO line ratios constraining estimates of dust and molecular gas temperatures was tested. The model fits allowed the simulation of the necessary millimetre-continuum and ^{13}CO J = 1 → 0 maps used in the test. In certain 'hot spots' that have continuum-to-line ratios above some threshold value the millimetre continuum to ^{13}CO ratio can estimate the dust temperature to within a factor of 2 over large ranges of physical conditions. Nevertheless, supplemental observations of the ^{13}CO J = 2 → 1 line or of shorter wavelength continuum are advisable in placing lower limits on the estimated temperature. Even without such supplemental observations, this test shows that the continuum-to-line ratio places reliable upper limits on the temperature.

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Young Stellar Groups around Herbig Ae/Be Stars: A Low-Mass YSO Census

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We present near-IR and mid-IR observations of eight embedded young stellar groups around Herbig Ae/Be stars (HAEBEs) using archived Spitzer IRAC data and 2MASS data. These young stellar groups are nearby (≤ 1 kpc) and still embedded within their molecular clouds. In order to identify the young stellar objects in our sample, we use the color-color diagram of J - [3.6] versus K_s - [4.5]. The Spitzer images of our sample show that the groups around HAEBEs, spectral types earlier than B8, are usually associated with bright infrared nebulosity. Within this, there are normally 1050 young stars distributed close to the HAEBEs (<1 pc). Not only are there young stars around the HAEBEs, there are also young stellar populations throughout the whole cloud, some of which are distributed and some of which are clumped. The groups around the HAEBEs are substructures of the large young population within the molecular cloud. The sizes of groups are also comparable with those substructures seen in massive clusters. Young stars in groups around HAEBEs have generally larger SED slopes compared to those outside, which suggests that the young stars in groups are probably younger than the distributed systems. This might imply that there is usually a higher and more continuous star-forming rate in groups, that the formation of groups initiates later, or that low-mass stars in groups form slower than those outside. Finally, there is no obvious trend between the SED slopes and the distance to the HAEBEs for those young stars within the groups. This suggests that the clustering of young stars dominates over the effect of massive stars on the low-mass young stars at the scale of our study.

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A Possible Stellar metallic Enhancement in Post-T Tauri Stars by a Planetesimal Bombardment

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The photospheres of stars hosting planets have larger metallicity than stars lacking planets. This could be the result of a metallic star contamination produced by the bombarding of hydrogen deficient solid bodies. In the present work we study the possibility of an earlier metal enrichment of the photospheres by means of impacting planetesimals during the first 20-30Myr. Here we explore this contamination process by simulating the interactions of an inward migrating planet with a disc of planetesimal interior to its orbit. The results show the percentage of planetesimals that fall on the star. We identified the dependence of the planet's eccentricity (e_p) and time scale of migration (τ) on the rate of infalling planetesimals. For very fast migrations ($\tau = 10^2$yr and $\tau = 10^3$yr) there is no capture in mean motion resonances, independently of the value of e_p. Then, due to the planet's migration the planetesimals suffer close approaches with the planet and more than 80% of them are ejected from the system. For slow migrations ($\tau = 10^5$yr and $\tau = 10^6$yr) the percentage of collisions with the planet decrease with the increase of the planet's eccentricity. For $e_p = 0$ and $e_p = 0.1$ most of the planetesimals were captured in the 2:1 resonance and more than 65% of them collided with the star. Whereas migration of a Jupiter mass planet to very short pericentric distances requires unrealistic high disc masses, these requirements are much smaller for smaller migrating planets. Our simulations for a slowly migrating 0.1 M_{Jupiter} planet, even demanding a possible primitive disc three times more massive than a primitive solar nebula, produces maximum [Fe/H] enrichments of the order of 0.18 dex. These calculations open possibilities to explain hot Jupiters exoplanets metallicities.

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Abstracts of recently accepted major reviews

Recent Developments in Maser Theory

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This review covers selected developments in maser theory since the previous meeting, “Cosmic Masers: From Proto-Stars to Black Holes” (Migenes & Reid 2002). Topics included are time variability of fundamental constants, pumping of OH megamasers and indicators for differentiating disks from bi-directional outflows.

Accepted by IAU symposium 242, “Astrophysical Masers and their Environments”

http://arxiv.org/abs/0704.2620

T Tauri Stars: Mass Accretion and X-ray Emission

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Ph.D dissertation directed by: Dr Moira Jardine

Ph.D degree awarded: April 2007

I develop the first magnetospheric accretion model to take account of the observed complexity of T Tauri magnetic fields, and the influence of stellar coronae. It is now accepted that accretion onto classical T Tauri stars is controlled by the stellar magnetosphere, yet to date the majority of accretion models have assumed that the stellar magnetic field is dipolar. By considering a simple steady state accretion model with both dipolar and complex magnetic fields I find a correlation between mass accretion rate and stellar mass of the form $\dot{M} \propto M_*^\alpha$, with my results consistent within observed scatter. For any particular stellar mass there can be several orders of magnitude difference in the mass accretion rate, with accretion filling factors of a few percent. I demonstrate that the field geometry has a significant effect in controlling the location and distribution of hot spots, formed on the stellar surface from the high velocity impact of accreting material. I find that hot spots are often at mid to low latitudes, in contrast to what is expected for accretion to dipolar fields, and that particularly for higher mass stars, accreting material is predominantly carried by open field lines. Material accreting onto stars with fields that have a realistic degree of complexity does so with a distribution of in-fall speeds.

I have also modelled the rotational modulation of X-ray emission from T Tauri stars assuming that they have isothermal, magnetically confined coronae. By extrapolating from surface magnetograms I find that T Tauri coronae are compact and clumpy, such that rotational modulation arises from X-ray emitting regions being eclipsed as the star rotates. Emitting regions are close to the stellar surface and inhomogeneously distributed about the star. However some regions of the stellar surface, which contain wind bearing open field lines, are dark in X-rays. From simulated X-ray light curves, obtained using stellar parameters from the Chandra Orion Ultradeep Project, I calculate X-ray periods and make comparisons with optically determined rotation periods. I find that X-ray periods are typically equal to, or are half of, the optical periods. Further, I find that X-ray periods are dependent upon the stellar inclination, but that the ratio of X-ray to optical period is independent of stellar mass and radius.

I also present some results that show that the largest flares detected on T Tauri stars may occur inside extended magnetic structures arising from the reconnection of open field lines within the disc. I am currently working to establish whether such large field line loops can remain closed for a long enough time to fill with plasma before being torn open by the differential rotation between the star and the disc. Finally I discuss the current limitations of the model and suggest future developments and new avenues of research.

Postdoctoral Position in Star Formation-Smithsonian Astrophysical Observatory

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Applications are invited for the position of postdoctoral fellow at the Smithsonian Astrophysical Observatory (SAO) for a recent recipient of a Ph. D. degree, with expertise and interests in observational and analytical studies of star formation. The applicant should have experience with observations of star-forming regions in the X-ray and/or infrared and/or in continuum emission at centimeter, millimeter, or submillimeter wavelengths; should have a record of publications or achievements which have advanced our knowledge of star formation; and should be interested in pursuing a program of observations and analysis, with emphasis on physical conditions and processes in star-forming regions. Candidates also should have demonstrated strong scientific interest in working in this field.

The successful applicant will participate in the analysis and interpretation of XMM data acquired in the region of the Orion A cloud, with supporting data from the Spitzer Space telescope, and archival Chandra data from ANCHORS. The successful applicant may also obtain, reduce, and analyze supporting ground-based observations using facilities such as the SMA and the MMT.

The position is for two years, with extension to a third year possible, contingent on performance and funding. Interested candidates should submit a curriculum vita, a bibliography and a statement of research interests and plans, and should arrange for three letters of recommendation to be sent as soon as possible for full consideration. All materials should be sent to Dr. S. Wolk at the above address or by e-mail before 1 August 2007. However, earlier is preferred. The SAO is an AAE/EEO employer committed to diversity in our workplace.

Postdoctoral Research Associates Studying Disks Around Young Stars

Applications are invited for two 5-year postdoctoral research positions at the UK Astronomy Technology Centre (UK ATC), to join an active group studying disks around stars and their relationship to planetary systems, starting in July 2007.

For post 1, the successful candidate will take a leading role in the detailed planning and data analysis of an Open Time Key Project using the Herschel Space Observatory to study debris disks around nearby stars, to analyse and publish results from the imaging of debris disks from Guaranteed Herschel time, and to use new facilities such as SCUBA-2 on the James Clerk Maxwell Telescope and other telescopes/instruments to further advance our understanding of debris disks and their relationship to planetary systems.

For post 2, the successful candidate will develop models of spectral line emission from disks around young stars to compare with existing and future observations. Such models are likely to incorporate disk dynamics, chemistry, and radiative transfer, with the aim of making testable predictions for instruments operating at wavelengths from the sub-millimetre (such as ALMA), far-infrared (eg Herschel) through to the near-infrared (eg CRIRES on the VLT). He/she is also likely to participate in and influence related observational campaigns.

The UK ATC is co-sited with the University of Edinburgh's Institute for Astronomy, and the two PDRAs will be working closely with a group of astronomers working in the field of debris and planetary disks at both the UK ATC and the University. For more information and an application form please go to http://www.roe.ac.uk/ukatc/people/employment.html, call our recruitment line on (+44) 131 668 8268, or email us at atcrecruitment *at* roe.ac.uk. The closing date is 1st June 2007.

Post-doctoral Position on Herschel Observations of Star and Planet Formation

The Institute of Astronomy of ETH Zurich has contributed hardware and software to ESA's Herschel Space Observatory to be launched in late 2008. A new postdoctoral research position is available as part of our preparation for the data evaluation. The successful candidate will work with the group of Prof. Arnold Benz and international collaborators on observational studies of star formation regions and protoplanetary disks. He or she is expected to participate in Herschel garanteed and open time proposals and to conduct independent ground-based observations. Experience in high-resolution infrared or radio/sub-mm spectroscopy including line data analysis and/or chemical modeling of young stellar systems is highly desirable. Experience in radiative transfer modeling in the far-IR/submm wavelength range is considered an asset.

Candidates must obtain a Ph.D. in Astronomy or Physics prior to the starting date. The appointment is for two years and will be renewable for a third year pending budgetary approval. Salaries will be approximately CHF 77,000 - 90,000 (about Euro 46,000 - 55,000), depending on experience.

Applicants should send a CV, a list of publications, a brief description of past and proposed research (maximum 3 pages each), and should arrange for three letters of recommendation to be sent to Prof. Dr. Arnold Benz, Institute of Astronomy, ETH, CH-8092 Zurich, Switzerland. Applications may be submitted electronically to benz *at* astro.phys.ethz.ch. Consideration of completed applications will begin July 1, 2007 and will continue until a suitable candidate is identified.

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.

Protoplanetary Dust - the Cosmochemical and Astrochemical Perspectives

A special session on protoplanetary dust at the 70th Annual Meeting of the Meteoritical Society [Tucson, Arizona, Aug 13-17, 2007].

In the frame of the MetSoc07 meeting we invite contributions to a special session that focuses on the overlap between the astronomical and meteoritical studies of protoplanetary dust in the context of planet formation. The talks will highlight the key stages of the evolution of planetary material from the pre-Solar dust and the interstellar medium through the protostellar collapse to the formation of rocky and giant planets. The session aims to establish links between the astronomical observations of dusty disks around young stars and the cosmochemistry studies of meteorites and cometary dust from the young Solar System. Special emphasis will be given to recent results from the Spitzer Space Telescope and the Stardust mission.

Session Chairs:

Daniel Apai (Steward Observatory, University of Arizona)
Dante Lauretta (Lunar and Planetary Laboratory, University of Arizona)

Special Session Home Page: **http://dusty.as.arizona.edu/pDust/**

Massive Star Formation: Observations Confront Theory

3rd conference announcement and reminder

September 10th to 14th 2007 in Heidelberg/Germany.

The registration is open (accessible from above WWW-address), and the early registration deadline is extended to 15th of June 2007. All talk requests received until then will be considered by the SOC. Later registrations can always present posters.

The conference fees are:

250 Euro: Early registration (before May 31, includes reception, proceedings and coffee breaks)
300 Euro: Late registration (includes reception, proceedings and coffee breaks)
25 Euro: Conference dinner (optional)
15 Euro: Boat trip on the Neckar (optional, Friday, afternoon, price may slightly change depending on the demand).

For accommodation, rooms in several hotels of different class and style have been reserved. You can head directly to the booking from our web-page.

Topics:

1. The earliest stages of high-mass star formation: Initial conditions and early collapse
2. Properties and evolution of massive protostars
3. Clustered massive star formation
4. Feedback (outflows, turbulence, dust and gas bubbles, ionization)
5. Massive Star Formation in a Galactic Context
6. Extragalactic star formation
7. Future perspectives for observational, theoretical and modeling tools

For more information and details, please go to **http://www.mpia.de/MSF07/**

4th JETSET School: "From models to observations and experiments"
25-29 June 2007, Azores, Portugal
http://www.astro.up.pt/jets-4/

Testing models for jet launching and collimation requires a high degree of interdisciplinary and sophistication. Indeed, closing the circle between pure MHD, thermo-chemical evolution, high angular resolution spectro-imaging and laboratory experiments is not trivial. This school aims at bridging these gaps by providing a series of 3h-4h lectures bridging the foundations of the discipline. In parallel, some space is reserved to short contributed talks addressing front-line research in the field.

1. *Lab experiments (Rob Coker, LLNL)*
   Scaling the physics. The scaling laws and relevance of MHD equations from the lab to young stars and AGN jets. What can and cannot be scaled. Experimental diagnostics.
2. *Output from MHD models (Nektarios Vlahakis, Athens)*
   The output of several classes of MHD models (analytical and numerical) in terms of velocity, density, and morphology, in relation to the magnetic field distribution and associated currents.
3. *MHD heating (Eric Priest, Edinburgh, TBC)*
   MHD heating of in the solar context: Alfven wave dissipation, MHD turbulence, reconnexion. Lessons learned and applicability of ideas to jets are discussed.
4. *Thermo-chemical evolution (David Flower, Durham)*
   The evolution of coupled atomic and chemical networks of gas in a flow. Processes, time-scales, effects of central source radiation. Molecular line cooling, shocks and ambipolar diffusion.
5. *Observational predictions (Alex Raga, UNAM)*
   Statistical equilibrium solutions. Emissivities (radio, optical, Xrays) and radiative transfer corrections. Construction of synthetic maps, spectra, PV diagrams including observational bias (e.g. convolution). Heating/cooling of atomic gas in jets (including atomic shocks).
6. *Inversion of observations (Catherine Dougados, LAOG)*
   Deriving physical quantities from line ratios and kinematics, including bias on projection and convolution.

31st May is the deadline for early registration and submission of abstracts for contributed talks.