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Abstracts of recently accepted papers

Arecibo Observations of Formaldehyde in L1551

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We report observations of the formaldehyde (H_2CO) 6 cm (4.8 GHz) line toward L1551. The observations were conducted with the Arecibo Telescope (beam FWHP$\sim$1') to verify the tentative detection of H_2CO thermal emission reported by Duncan and collaborators in 1987. The H_2CO emission lines were expected to be present with a signal-to-noise ratio of $\geq$10 in our spectra. However, we did not detect H_2CO emission; i.e., our data rule out their tentative detection. The absence of H_2CO emission is also confirmed by the fact that the H_2CO line profiles at the two positions of expected emission are well fitted by a single absorption component (accounting for the hyperfine structure of the line) in one of the positions and by a single absorption line plus a red-wing absorption component in the second position. The Orion BN/KL region remains the only H_2CO 6 cm thermal emitter known. Our observations also demonstrate that the H_2CO 6 cm absorption line traces not only the quiescent molecular cloud but also the kinematics associated with the star formation process in L1551-IRS 5.

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http://www.journals.uchicago.edu/AJ/journal/issues/v132n5/205315/205315.html

High Spectral Resolution Near-IR Observations of ESO-Hα279

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We present high spectral resolution near-IR observations of the stars ESO-Hα279AB located in the Serpens star formation complex. ESO-Hα279A is a known young T Tauri star driving an Herbig-Haro flow while ESO-Hα279B is a nearby (8$''$, 2500AU) extremely red companion. Previous work has suggested that this is not a physically bound system but a chance alignment of young star and background giant. Below, we further investigate the nature of ESO-Hα279B and probe the emission characteristics of ESO-Hα279A. We find that ESO-Hα279B shows many narrow absorption features typical of late-type giant stars and unlike those seen in FU Orionis objects and Herbig-Haro energy sources, the only young stars that exhibit such deep CO absorption. This result confirms that ESO-Hα279B is a background M-type giant view through the molecular cloud hosting ESO-Hα279A and therefore the association of ESO-Hα279AB is fortuitous. For ESO-Hα279A, we find that the Na doublet lines are broadened and self-absorbed and the v=2-0 CO

overtone bandhead is similar in shape to that observed in the young pre-main sequence object SVS 13 in NGC 1333 and not characteristic of a rotating disk velocity dispersion. We consider the origin of the CO emission in relation to current models and suggest that it perhaps is more indicative of creation in a wind or funnel flow rather than in the inner hot regions of a circumstellar disk.

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Deep Near-Infrared Imaging toward the Vela Molecular Ridge C. II. New Protostars and Embedded Clusters in Vela C

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We present new candidates for protostars and embedded clusters detected in our deep near-infrared (J, H, K_S) imaging survey of cloud C of the Vela Molecular Ridge (Vela C). We selected protostar candidates on the basis of positional coincidences with Midcourse Space Experiment (MSX) and/or IRAS sources and the slopes of their spectral energy distributions from 2 to 25μm. For embedded clusters, we selected them on the basis of positional coincidence with MSX and/or IRAS sources and enhancement of stellar number densities. We identified 31 sources as protostar candidates and 5 clusters as embedded clusters; 28 protostar candidates and 3 embedded clusters were newly identified. Most of them are associated with the $C^{18}O$ clumps distributed throughout Vela C. We calculated the bolometric luminosities of the protostar candidates by integrating the observed fluxes from near- to far-infrared, and then estimated the mass range to be from 0.9 to 4.0 $M_\odot$, assuming their ages at the birth line. There is a correlation between the number of members and the K_S magnitude of the brightest star in the embedded clusters.

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Supersonic turbulence, filamentary accretion, and the rapid assembly of massive stars and disks

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We present a detailed computational study of the assembly of protostellar disks and massive stars in molecular clouds with supersonic turbulence. We follow the evolution of large scale filamentary structures in a cluster-forming clump down to protostellar length scales by means of very highly resolved, 3D adaptive mesh refined (AMR) simulations, and show how accretion disks and massive stars form in such environments. We find that an initially elongated cloud core which has a slight spin from oblique shocks collapses first to a filament and later develops a turbulent disk close to the center of the filament. The continued large scale flow that shocks with the filament maintains the high density and pressure within it. Material within the cooling filament undergoes gravitational collapse and the outside-in assembly of a massive protostar. Our simulations show that very high mass accretion rates of up to $10^{-2}\,M_\odot\,yr^{-1}$ and high, supersonic, infall velocities result from such filamentary accretion. Accretion at these rates is higher by an order of magnitude than those found in semi-analytic studies, and can quench the radiation field of a growing massive young star. Our simulations include a comprehensive set of the important chemical and radiative processes such as cooling by molecular line emission, gas-dust interaction, and radiative diffusion in the optical thick regime, as well as H_2 formation and dissociation. Therefore, we are able to probe, for the first time, the relevant physical phenomena on all scales from those characterizing the clump down to protostellar core.

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http://www.ita.uni-heidelberg.de/~banerjee/TurbulentSF.pdf
astro-ph/0609428

Electromagnetic instability of a homogeneous interstellar medium

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The electromagnetic instability of an interstellar medium with an arbitrary velocity distribution is examined over the large scale lengths typical of gas-dust clouds without a significant magnetic field. It is shown that over a moderate time scale (months and years) these instabilities can develop and that the requirement of stability is satisfied by a narrow class of distributions that are close to spherical.

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Infall of gas as the formation mechanism of stars up to 20 times more massive than the Sun

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Theory predicts and observations confirm that low-mass stars (like the Sun) in their early life grow by accreting gas from the surrounding material. But for stars ~ 10 times more massive than the Sun ($\sim 10\ M_\odot$), the powerful stellar radiation is expected to inhibit accretion and thus limit the growth of their mass. Clearly, stars with masses $> 10\ M_\odot$ exist, so there must be a way for them to form. The problem may be solved by non-spherical accretion, which allows some of the stellar photons to escape along the symmetry axis where the density is lower. The recent detection of rotating disks and toroids around very young massive stars has lent support to the idea that high-mass ($\gtrsim 8\ M_\odot$) stars could form in this way. Here we report observations of an ammonia line towards a high-mass star forming region. We conclude from the data that the gas is falling inwards towards a very young star of $\sim 20\ M_\odot$, in line with theoretical predictions of non-spherical accretion.

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http://arxiv.org/abs/astro-ph/0609789

Midplane sedimentation of large solid bodies in turbulent protoplanetary discs

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We study the vertical settling of solid bodies in a turbulent protoplanetary disc. We consider the situation when the coupling to the gas is weak or equivalently when the particle stopping time τ_{st} due to friction with the gas is long compared to the orbital timescale Ω^{-1}. An analytical model, which takes into account the stochastic nature of the sedimentation process using a Fokker-Planck equation for the particle distribution function in phase space, is used to obtain the vertical scale height of the solid layer as a function of the vertical component of the turbulent gas velocity correlation function and the particle stopping time. This is found to be of the same form as the relation obtained for

strongly coupled particles in previous work.

We compare the predictions of this model with results obtained from local shearing box MHD simulations of solid particles embedded in a vertically stratified disc in which there is turbulence driven by the MRI. We find that the ratio of the dust disc thickness to the gas disc thickness satifies $H_d/H = 0.08(\Omega\tau_{st})^{-1/2}$, which is in very good agreement with the analytical model. By discussing the conditions for gravitational instability in the outer regions of protoplanetary discs in which there is a similar level of turbulence, we find that bodies in the size range 50 to 600 metres can aggregate to form Kuiper belt–like objects with characteristic radii ranging from tens to hundreds of kilometres.

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The Water Vapor Abundance in Orion KL Outflows

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We present the detection and modeling of more than 70 far-IR pure rotational lines of water vapor, including the ^{18}O and ^{17}O isotopologues, toward Orion KL. Observations were performed with the Long Wavelength Spectrometer in Fabry-Pérot mode ($\lambda/\Delta\lambda$ 6800-9700) on board the Infrared Space Observatory between $\sim$ 43 and 197μm. The water line profiles evolve from P Cygni-type profiles (even for the $H_2^{18}O$ lines) to pure emission at wavelengths above $\sim$ 100μm. We find that most of the water emission/absorption arises from an extended flow of gas expanding at 25 $\pm$ 5 km s^{-1}. Nonlocal radiative transfer models show that much of the water excitation and line profile formation is driven by the dust continuum emission. The derived beam-averaged water abundance is (2-3) $\times 10^{-5}$. The inferred gas temperature T_k = 80-100 K suggests that (1) water could have been formed in the "plateau" by gas-phase neutral-neutral reactions with activation barriers if the gas was previously heated (e.g., by shocks) to 500 K, and/or (2) H_2O formation in the outflow is dominated by in situ evaporation of grain water-ice mantles, and/or (3) H_2O was formed in the innermost and warmer regions (e.g., the hot core) and was swept up in $\approx$ 1000 yr, the dynamical timescale of the outflow.

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Effective grain surface area in the formation of molecular hydrogen in interstellar clouds

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Aims. In interstellar clouds, molecular hydrogens are formed from atomic hydrogen on grain surfaces. An atomic hydrogen hops around until it finds another one with which it combines. This necessarily implies that the average recombination time, or equivalently, the effective grain surface area depends on the relative numbers of atomic hydrogen influx rate and the number of sites on the grain. Our aim is to discover this dependency.

Methods. We perform a numerical simulation to study the recombination of hydrogen on grain surfaces in a variety of cloud conditions. We use a square lattice (with a periodic boundary condition) of various sizes on two types of grains, namely, amorphous carbon and olivine.

Results. We find that the steady state results of our simulation match very well with those obtained from a simpler analytical considerations provided the "effective" grain surface area is written as $\sim S^{\alpha}$, where S is the actual physical grain area and α is a function of the flux of atomic hydrogen, which is determined from our simulation. We carry out the simulation for various astrophysically relevant accretion rates. For high accretion rates, small grains tend to become partly saturated with H and H_2, and the subsequent accretion will be partly inhibited. For very low accretion rates, the number of sites to be swept before a molecular hydrogen can form is too large compared to the actual number of sites on the grain, implying that α is greater than unity.

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Effective rate coefficients for molecular hydrogen formation in diffuse interstellar clouds

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Aims. A method to determine effective rate coefficients for H_2 formation on grain surfaces is proposed based on the continuous-time, random-walk Monte Carlo simulation.

Methods. Our Monte Carlo simulation is used to calculate the efficiency of molecular hydrogen formation via recombination of H atoms on flat and rough surfaces of olivine and amorphous carbon under a variety of diffuse cloud conditions. The results are then fitted to two types of rate laws to determine effective rate coefficients for use in rate equation treatments. These rate coefficients can be utilized in pure gas-phase models, where the rate of molecular formation is associated with a grain collision rate for H atoms multiplied by an efficiency factor, and in gas-grain models, where the actual diffusion of H atoms on a grain surface is considered.

Results. The effective rate coefficients are tabulated as a function of incoming atomic hydrogen flux and surface temperature, over temperature ranges for which the surfaces show a reasonable efficiency of molecular hydrogen formation. For the flat surfaces studied, corrections to the standard rate treatment do not exceed a factor of three.

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The Bubbling Galactic Disk

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A visual examination of the images from the Galactic Legacy Infrared Mid-Plane Survey Extraordinaire (GLIMPSE) has revealed 322 partial and closed rings that we propose represent partially or fully enclosed three-dimensional bubbles. We argue that the bubbles are primarily formed by hot young stars in massive star formation regions.

We have found an average of about 1.5 bubbles per square degree. About 25% of the bubbles coincide with known radio H II regions, and about 13% enclose known star clusters. It appears that B4-B9 stars (too cool to produce detectable radio H II regions) probably produce about three-quarters of the bubbles in our sample, and the remainder are produced by young O-B3 stars that produce detectable radio H II regions. Some of the bubbles may be the outer edges of H II regions where PAH spectral features are excited and may not be dynamically formed by stellar winds. Only three of the bubbles are identified as known SNRs. No bubbles coincide with known planetary nebulae or W-R stars in the GLIMPSE survey area. The bubbles are small. The distribution of angular diameters peaks between $1'$ and $3'$ with over 98% having angular diameters less than $10'$ and 88% less than $4'$. Almost 90% have shell thicknesses between 0.2 and 0.4 of their outer radii. Bubble shell thickness increases approximately linearly with shell radius. The eccentricities are rather large, peaking between 0.6 and 0.7; about 65% have eccentricities between 0.55 and 0.85.

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Testing the Disk Regulation Paradigm with Spitzer Observations. I. Rotation Periods of Pre-Main-Sequence Stars in the IC 348 Cluster

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We present 105 stellar rotation periods in the young cluster IC 348, 75 of which are new detections, increasing the total number of known periods in this cluster to 143. The period distribution resembles that seen in the heart of the Orion Nebula cluster by Herbst and colleagues. Stars estimated to be less massive than 0.25 $M_\odot$ show a unimodal distribution of fast rotators (P $\sim$ 1-2 days) and a tail of slower rotators, while stars estimated to be more massive than 0.25 $M_\odot$ show a bimodal distribution with peaks at $\sim$ 2 and $\sim$ 8 days. We combine all published rotation periods in IC 348 with Spitzer mid-IR (3.6, 4.5, 5.8, and 8.0μm) photometry, an unprecedentedly efficient and reliable disk indicator, in order to test the disk-braking paradigm. We find no evidence that the tail of slow rotators in low-mass stars or the long-period peak in high-mass stars are preferentially populated by objects with disks as might be expected based on the current disk-braking model. We find some indication that the disk fraction decreases significantly for stars with very short periods (P $\lesssim$ 1.5 days), which is the only feature of our sample that could potentially be interpreted as evidence for disk braking. It has been proposed that the observational signatures of disk braking might be significantly masked by the intrinsic breadth of the initial period distribution. We argue that more rigorous modeling of angular momentum evolution and a quantitative analysis of the observational data are required before the disk-braking model can be regarded as inconsistent with observations.

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Evidence for variable outflows in the young stellar object V645 Cygni

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Aims. As part of the Red MSX Source Survey of Massive Young Stellar Objects (MYSOs) we have conducted multi-wavelength follow up observations of the well-known object V645 Cygni. We present our data on this object, whose near-infrared spectrum is exceptional and place these in context with previous observations

Methods. Our observations of V645 Cyg included near/mid infrared imaging observations, ^{13}CO 2-1 line observations and high signal-to-noise velocity resolved near-infrared spectroscopy.

Results. The spectrum shows P-Cygni hydrogen Brackett emission, consistent with a high velocity stellar wind. A red-shifted emission component to a number of near-IR emission lines was also uncovered. This is associated with a similar component in the Hα line. V645 Cyg is also found to have variable CO first overtone bandhead emission.

Conclusions. The data clearly indicate that the outflow of V645 Cyg is variable. The unidentified feature in a previously published optical spectrum is identified with a receding outflow at 2000 km s^{-1}. The nature of this feature, which is found in hydrogen and helium atomic lines and CO molecular lines remains a puzzle.

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Inside the large globule CB205: YSOs feeding multiple outflows

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Context. The molecular and continuum surveys at NIR and (sub-)mm wavelengths recently performed in the large and distant (≥1 kpc) Bok globules CB3 and CB34 are the framework of the present paper. With this multi-wavelength approach, it is possible to trace the hot jets and cold outflows driven by the (proto-)stars, to investigate how they interact with the surrounding medium, and to assess that in these globules star formation is a continuous process and not a unique event.

Aims. With the present work we continue our survey of a sample of large globules by investigating CB205. The aim is to carefully map the outflow motions and to locate the driving sources. The occurrence of outflows is used to identify the earliest star-forming regions.

Methods. Our analysis has been performed through JCMT observations at (sub)millimeter wavelengths of the continuum (850 and 450 μm) and CO(2-1) and (3-2) line emission.

Results. The continuum maps reveal three Class 0 candidates located in the western region of the globule, without NIR counterparts. The line maps show a complex scenario for the high velocity components with different clumps at different velocities. The outflow activity is concentrated around the Class 0 candidates. On the other hand, the NIR objects are associated with lower velocity outflow clumps.

Conclusions. The present results confirm that for CB205, star formation is propagating through the globule. The western part hosts the latest formation episode with Class 0 candidates feeding multiple outflows. We suggest that the eastern region, which is associated with a NIR cluster, reflects a later evolutionary phase, when the outflow is fading.

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WFCAM, Spitzer-IRAC and SCUBA observations of the massive star forming region DR21/W75: I. The collimated molecular jets

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We present wide-field near-infrared images of the DR21/W75 high-mass star forming region, obtained with the Wide Field Camera, WFCAM, on the United Kingdom Infrared Telescope. Broad-band JHK and narrow-band H_2 1-0S(1) images are compared to archival mid-IR images from the Spitzer Space Telescope, and 850 μm dust-continuum maps obtained with the Submillimeter Common User Bolometer Array (SCUBA). Together these data give a complete picture of dynamic star formation across this extensive region, which includes at least four separate star forming sites in various stages of evolution. The H_2 data reveal knots and bow shocks associated with more than 50 individual

flows. Most are well collimated, and at least five qualify as parsec-scale flows. Most appear to be driven by embedded, low-mass protostars. The orientations of the outflows, particularly from the few higher-mass sources in the region (DR21, DR21(OH), W75N and ERO 1), show some degree of order, being preferentially orientated roughly orthogonal to the chain of dusty cores that runs north-south through DR21. Clustering may inhibit disk accretion and therefore the production of outflows; we certainly do not see enhanced outflow activity from clusters of protostars. Finally, although the low-mass protostellar outflows are abundant and widely distributed, the current generation does not provide sufficient momentum and kinetic energy to account for the observed turbulent motions in the DR21/W75 giant molecular clouds. Rather, multiple epochs of outflow activity are required over the million-year timescale for turbulent decay.

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preprints available from: http://www.jach.hawaii.edu/∼cdavis/ (high-res figures) or astroph/0610186 (low-res figures).

Mapping Vela Molecular Ridge Cloud D

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We present the ^{12}CO(1-0) and ^{13}CO(2-1) line maps obtained observing with the SEST a $\sim 1^\circ \times 1^\circ$ region of the Vela Molecular Ridge, Cloud D. This cloud is part of an intermediate-mass star forming region that is relatively close to the Sun. Our observations reveal, over a wide range of spatial scales (from $\sim$ 0.1 to a few parsecs), a variety of dense structures such as arcs, filaments and clumps, that are in many cases associated with far-IR point-like sources, recognized as young stellar objects and embedded star clusters. The velocity field analysis highlights the presence of possible expanding shells, extending over several parsecs, probably related to the star forming activity of the cloud. Furthermore, the analysis of the line shapes in the vicinity of the far-IR sources allowed the detection of 13 molecular outflows. Considering a hierarchical scenario for the gas structure, a cloud decomposition was obtained for both spectral lines by means of the CLUMPFIND algorithm. The CLUMPFIND output has been discussed critically and a method is proposed to reasonably correct the list of the identified clumps. We find that the corresponding mass spectrum shows a spectral index $\alpha \sim 1.3 \div 2.0$ and the derived clump masses are below the corresponding virial masses. The mass-radius and velocity dispersion-radius relationships are also briefly discussed for the recovered clump population.

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The Discovery of Diffuse X-Ray Emission in NGC 2024, One of the Nearest Massive Star-forming Regions

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We analyzed deep 75 ks Chandra ACIS-I data of NGC 2024 with the aim of searching for diffuse X-ray emission in this most nearby (415 pc) of massive star-forming regions. After removing point sources, extended emission was detected in the central circular region with a radius of 0.5 pc, and it is spatially associated with this young massive stellar cluster. Its X-ray spectrum exhibits a very hard continuum (kT > 8 keV) and shows signs of having a He-like Fe Kα line with a 0.57 keV absorption-corrected luminosity of 2×10^{31} ergs s^{-1}. Undetected faint point sources, estimated

from the luminosity function of the detected sources, contribute less than 10% to this emission. Hence, the emission is truly diffuse in nature. Because of the proximity of NGC 2024 and the long exposure, this discovery is one of the strongest pieces of evidence in support of the existence of diffuse X-ray emission in massive star-forming regions.

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Enhanced density and magnetic fields in interstellar OH masers

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Aims. We have observed the 6030 and 6035 MHz transitions of OH in high-mass star-forming regions to obtain magnetic field estimates in both maser emission and absorption.

Methods. Observations were taken with the Effelsberg 100 m telescope.

Results. Our observations are consistent with previous results, although we do detect a new 6030 MHz maser feature near -70 km s^{-1} in the vicinity of W3(OH). In absorption we obtain a possible estimate of -1.1 ± 0.3 mG for the average line-of-sight component of the magnetic field in the absorbing OH gas in K3-50 and submilligauss upper limits for the line-of-sight field strength in DR 21 and W3.

Conclusions. These results indicate that the magnetic field strength in the vicinity of OH masers is higher than that of the surrounding, non-masing material, which in turn suggests that the density of masing OH regions is higher than that of their surroundings.

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Dense and diffuse gas in dynamically active clouds

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We investigate the chemical and observational implications of repetitive transient dense core formation in molecular clouds. We allow a transient density fluctuation to form and disperse over a period of 1 Myr, tracing its chemical evolution. We then allow the same gas immediately to undergo further such formation and dispersion cycles. The chemistry of the dense gas in subsequent cycles is similar to that of the first, and a limit cycle is reached quickly (2 – 3 cycles). Enhancement of hydrocarbon abundances during a specific period of evolution is the strongest indicator of previous dynamical history. The molecular content of the diffuse background gas in the molecular cloud is expected to be strongly enhanced by the core formation and dispersion process. Such enhancement may remain for as long as 0.5 Myr. The frequency of repetitive core formation should strongly determine the level of background molecular enhancement.

We also convolve the emission from a synthesised dark cloud, comprised of ensembles of transient dense cores. We find that the dynamical history of the gas, and therefore the chemical state of the diffuse inter-core medium, may be determined if a sufficient sample of cores is present in an ensemble. Molecular ratios of key hydrocarbons with SO and SO_2 are crucial to this distinction. Only surveys with great enough angular resolution to resolve individual cores, or very small groupings, are expected to show evidence of repetitive dynamical processing. The existence of non-equilibrium chemistry in the diffuse background may have implications for the initial conditions used in chemical models. Observed variations in the chemistries of diffuse and translucent regions may be explained by lines of sight which intersect a number of molecular cloud cores in various stages of evolution.

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The Transition from Atomic to Molecular Hydrogen in Interstellar Clouds: 21cm Signature of the Evolution of Cold Atomic Hydrogen in Dense Clouds

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We have investigated the time scale for formation of molecular clouds by examining the conversion of HI to H_2 using a time–dependent model which includes H_2 photodissociation with rate dependent on dust extinction and self shielding. H_2 formation on dust grains and cosmic ray destruction are also included in one–dimensional model slab clouds which incorporate time–independent density and temperature distributions. We calculate 21cm spectral line profiles seen in absorption against a background provided by general Galactic HI emission, and compare the model spectra with HI Narrow Self–Absorption, or HINSA, profiles absorbed in a number of nearby molecular clouds. The time evolution of the HI and H_2 densities is dramatic, with the atomic hydrogen disappearing in a wave propagating from the central, denser regions which have a shorter H_2 formation time scale, to the edges, where the density is lower and the time scale for H_2 formation longer. The model 21cm spectra are characterized by very strong absorption at early times, when the HI column density through the model clouds is extremely large. Excess emission produced by the warm edges of the cloud when the background temperature is relatively low can be highly confusing in terms of separating the effect of the foreground cloud from variations in the background spectrum. While there are significant variations in the observed HINSA optical depths and fractional abundances of HI, the minimum time for cloud evolution based on the model spectra is set by the requirement that most of the HI in the outer portions of the cloud be removed. The characteristic time that has elapsed since cloud compression and initiation of the HI $\rightarrow$ H_2 conversion is a few $\times$ 10^{14} s, or $\simeq 10^7$ yr. This sets a minimum time for the age of these molecular clouds and thus for star formation that may take place within them.

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Spitzer 24μm Survey of Debris Disks in the Pleiades

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We performed a 24μm 2°× 1° survey of the Pleiades cluster, using the MIPS instrument on Spitzer. Fifty-four members ranging in spectral type from B8 to K6 show 24μm fluxes consistent with bare photospheres. All Be stars show excesses attributed to free-free emission in their gaseous envelopes. Five early-type stars and four solar-type stars show excesses indicative of debris disks. We find a debris disk fraction of 25% for B-A members and 10% for F-K3 ones. These fractions appear intermediate between those for younger clusters and for the older field stars. They indicate a decay with age of the frequency of the dust production events inside the planetary zone, with similar timescales for solar-mass stars as have been found previously for A stars.

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High-Resolution Infrared Imaging of Herschel 36 SE: A Showcase for the Influence of Massive Stars in Cluster Environments

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We present high-resolution infrared imaging of the massive star-forming region around the O star Herschel 36. Special emphasis is given to a compact infrared source at 0.″25 southeast of the star. The infrared source, hereafter Her 36 SE, is extended in the broadband images but features spatially unresolved Brγ line emission. The line-emission source coincides in position with the previous HST detections in Hα and the 2 cm radio continuum emission detected by VLA interferometry. We propose that the infrared source Her 36 SE harbors an early B-type star, deeply embedded in a dusty cloud. The fan shape of the cloud with Her 36 at its apex, however, manifests direct and ongoing destructive influence of the O7 V star on Her 36 SE.

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The Star-forming Region NGC 346 in the Small Magellanic Cloud with Hubble Space Telescope ACS Observations. I. Photometry

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We present a photometric study of the star-forming region NGC 346 and its surrounding field in the Small Magellanic Cloud, using data taken with the Advanced Camera for Surveys (ACS) on board the Hubble Space Telescope (HST). The data set contains both short and long exposures for increased dynamic range, and photometry was performed using the ACS module of the stellar photometry package DOLPHOT. We detected almost 100,000 stars over a magnitude range of V$\sim$11 to V$\sim$28 mag, including all stellar types from the most massive young stars to faint lower main-sequence and premain-sequence stars. We find that this region, which is characterized by a plethora of stellar systems and interesting objects, is an outstanding example of mixed stellar populations. We take into account different features of the color-magnitude diagram of all the detected stars to distinguish the two dominant stellar systems: The stellar association NGC 346 and the old spherical star cluster BS 90. These observations provide a complete stellar sample of a field about $5' \times 5'$ around the most active star-forming region in this galaxy. Considering the importance of these data for various investigations in the area, we provide the full stellar catalog from our photometry. This paper is the first part of an ongoing study to investigate in detail the two dominant stellar systems in the area and their surrounding field.

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HH135/HH136 a luminous H_2 outflow towards a high-mass protostar

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Context. Molecular hydrogen observations towards Herbig-Haro objects provide the possibility of studying physical processes related to star formation.

Aims. Observations towards the luminous IRAS source IRAS 11101-5928 and the associated Herbig-Haro objects HH135/HH136 are obtained to understand whether high-mass stars form via the same physical processes as their low-mass counterparts.

Methods. Near-infrared imaging and spectroscopy are used to infer H_2 excitation characteristics. A theoretical H_2 spectrum is constructed from a thermal ro-vibrational population distribution and compared to the observations.

Results. The observations reveal the presence of a well-collimated, parsec-sized H_2 outflow with a total H_2 luminosity of about 2 $L_\odot$. The bulk of the molecular gas is characterized by a ro-vibrational excitation temperature of 2000 ± 200 K. A small fraction (0.3%) of the molecular gas is very hot, with excitation temperatures around 5500 K. The molecular emission is associated with strong [FeII] emission. The H_2 and [FeII] emission characteristics indicate the presence of fast, dissociative J-shocks at speeds of $v_\mathrm{s} \approx 100$ km s^{-1}. Electron densities of n$_e$ = 3500-4000 cm^{-3} are inferred from the [FeII] line ratios. *Conclusions.* The large H_2 luminosity combined with the very large source luminosity

suggests that the high-mass protostar that powers the HH135/HH136 flow forms via accretion, but with a significantly increased accretion rate compared to that of low-mass protostars.

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Rotationally Modulated X-ray Emission from T Tauri Stars

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We have modelled the rotational modulation of X-ray emission from T Tauri stars assuming that they have isothermal, magnetically confined coronae. By extrapolating surface magnetograms we 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, we calculate X-ray periods and make comparisons with optically determined rotation periods. We find that X-ray periods are typically equal to, or are half of, the optical periods. Further, we 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.

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Correlation between the spatial distribution of the circumstellar disks and the massive stars in the open cluster NGC 6611

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Context: the observations of young stars with circumstellar disks suggest that the disks are dissipated, starting from the inner region, by the radiation of the central star and eventually by the formation of rocky planetesimals, over a time scale of several million years. It was also shown that strong UV radiation emitted by nearby massive stars can heat a circumstellar disk up to some thousand degrees inducing the photoevaporation of the gas. This process strongly reduces the dissipation time scale.

Aims: the aim of this work is to study if there exists a correlation between the spatial distribution of stars with circumstellar disks and the position of massive stars with spectral class earlier than B5, in the open cluster NGC 6611.

Methods: for our purpose, we created a multiband catalog of the cluster, down to V$\sim$23^m, using optical data from a WFI observation at 2.2m of ESO in the BVI bands, the 2MASS public point source catalog and an archival X-ray observation made with CHANDRA/ACIS. We selected the stars with infrared excess (due to the emission of a circumstellar disk) using suitable color indices independent from extinction, and studied their spatial distribution.

Results: we found that the spatial distribution of the stars with K band excess (due to the presence of a circumstellar disk) is anti correlated with that of the massive stars: the disks are more frequent at large distances from these stars. We argue that this is in agreement with the hypothesis that the circumstellar disks are heated by the UV radiation from the massive stars and photoevaporated.

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http://www.astropa.unipa.it/$\sim$mguarce

X-ray accretion signatures in the close CTTS binary V4046 Sgr

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We present *Chandra* HETGS observations of the classical T Tauri star (CTTS) V4046 Sgr. The He-like triplets of O VII, Ne IX, and SiXIII are clearly detected. Similar to the CTTS TW Hya and BP Tau, the forbidden lines of O VII and Ne IX are weak compared to the intercombination line, indicating high plasma densities in the X-ray emitting regions. The SiXIII triplet, however, is within the low-density limit, in agreement with the predictions of the accretion funnel infall model with an additional stellar corona. V4046 Sgr is the first close binary exhibiting these features. Together with previous high-resolution X-ray data on TW Hya and BP Tau, and in contrast to T Tau, now three out of four CTTS show evidence of accretion funnels.

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The structure of the cometary globule CG 12: a high latitude star forming region

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The structure of the high galactic latitude Cometary Globule 12 (CG 12) has been investigated by means of radio molecular line observations. Detailed, high signal to noise ratio maps in $C^{18}O$ (1–0), $C^{18}O$ (2–1) and molecules tracing high density gas, CS (3–2), DCO^+ (2–1) and $H^{13}CO^+$ (1–0), are presented. The $C^{18}O$ line emission is distributed in a 10' long North-South elongated lane with two strong maxima, CG 12-N(orth) and CG 12-S(outh). In CG 12-S the high density tracers delineate a compact core, DCO^+ core, which is offset by 15" from the $C^{18}O$ maximum. The observed strong $C^{18}O$ emission traces the surface of the DCO^+ core or a separate, adjacent cloud component. The driving source of the collimated molecular outflow detected by White (1993) is located in the DCO^+ core. The $C^{18}O$ lines in CG 12-S have low intensity wings possibly caused by the outflow. The emission in high density tracers is weak in CG 12-N and especially the $H^{13}CO^+$, DCO^+ and N_2H^+ lines are +0.5 $\mathrm{km\,s^{-1}}$ offset in velocity with respect to the $C^{18}O$ lines. Evidence is presented that the molecular gas is highly depleted. The observed strong $C^{18}O$ emission towards CG 12-N originates in the envelope of this depleted cloud component or in a separate entity seen in the same line of sight. The $C^{18}O$ lines in CG 12 were analyzed using Positive Matrix Factorization, PMF. The shape and the spatial distribution of the individual PMF factors fitted separately to the $C^{18}O$ (1–0) and (2–1) transitions were consistent with each other. The results indicate a complex velocity and line excitation structure in the cloud. Besides separate cloud velocity components the $C^{18}O$ line shapes and intensities are influenced by excitation temperature variations caused by e.g, the molecular outflow or by molecular depletion. Assuming a distance of 630 pc the size of the CG 12 compact head, 1.1 pc by 1.8 pc, and the $C^{18}O$ mass larger than 100 $M_\odot$ are comparable to those of other nearby low/intermediate mass star formation regions.

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On the Structure of the Orion A Cloud and the Formation of the Orion Nebula Cluster

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We suggest that the Orion A cloud is gravitationally collapsing on large scales, and is producing the Orion Nebula

Cluster due to the focusing effects of gravity acting within a finite cloud geometry. In support of this suggestion, we show how an elliptical rotating sheet of gas with a modest density gradient along the major axis can collapse to produce a structure qualitatively resembling Orion A, with a fan-shaped structure at one end, ridges or filaments along the fan, and a narrow curved filament at the other end reminiscent of the famous integral-shaped filament. The model produces a local concentration of mass within the narrow filament which in principle could form a dense cluster of stars like that of the Orion Nebula. We suggest that global gravitational contraction might be a more common feature of molecular clouds than previously recognized, and that the formation of star clusters is a dynamic process resulting from the focusing effects of gravity acting upon the geometry of finite clouds.

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http://www.astro.lsa.umich.edu/~lhartm/papers.htm

Discovery of large-scale methanol and hydroxyl maser filaments in W3(OH)

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Images of the 6.7-GHz methanol maser emission from W3(OH) made at 50- and 100-mas angular resolution with the Multi-Element Radio-Linked Interferometer Network (MERLIN) are presented. The masers lie across the western face of the ultracompact H II region in extended filaments which may trace large-scale shocks. There is a complex interrelation between the 6.7-GHz methanol masers and hydroxyl (OH) masers at 1.7 and 4.7 GHz. Together the two species trace an extended filamentary structure that stretches at least 3100 au across the face of the ultracompact H II region. The dominant 6.7-GHz methanol emission coincides with the radio continuum peak and is populated by masers with broad spectral lines. The 6.7-GHz methanol emission is elongated at position angle 50° with a strong velocity gradient, and bears many similarities to the methanol maser disc structure reported in NGC 7538. It is surrounded by arcs of ground state OH masers at 1.7 GHz and highly excited OH masers at 13.44 GHz, some of which have the brightest methanol masers at their focus. We suggest that this region hosts the excitation centre for the ultracompact H II region.

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An Equatorial Wind from the Massive Young Stellar Object S140 IRS 1

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The discovery of the second equatorial ionized stellar wind from a massive young stellar object is reported. High-resolution radio continuum maps of S140 IRS 1 reveal a highly elongated source that is perpendicular to the larger scale bipolar molecular outflow. This picture is confirmed by location of a small-scale monopolar near-IR reflection nebula at the base of the blueshifted lobe. A second epoch of observations over a 5 yr baseline show little ordered outward proper motion of clumps as would have been expected for a jet. A third epoch, taken only 50 days after the second, did show significant changes in the radio morphology. These radio properties can all be understood in the context of an equatorial wind driven by radiation pressure from the central star and inner disk acting on the gas in the surface layers of the disk as proposed by Drew et al. This equatorial wind system is briefly compared with the one in S106 IR, and contrasted with other massive young stellar objects that drive ionized jets.

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Dusty Vortices in Protoplanetary Disks

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Global two-dimensional simulations are used to study the coupled evolution of gas and solid particles in a Rossby unstable protoplanetary disk. The initial radial bump in density is unstable to the formation of Rossby waves, which roll up and break into anticyclonic vortices that gradually merge into a large-scale vortical structure persisting for more than 100 rotations. Conditions for the growth of such vortices may naturally appear at the outer edge of the "dead zone" of a protoplanetary disk where gas tends to pile up. We find that solid particles are captured by the vortices and change the evolution: (1) large particles rapidly sink toward the center of the vortices and increase the solid-to-gas ratio by an order of magnitude, (2) solid particles tend to reduce the lifetime of the vortices, and (3) solid particles are effectively confined in the vortices before they are dispersed by the Keplerian shear flow. These results confirm that in a minimum mass solar nebula, persistent vortices could be good places for the formation of the planetesimals or the rocky cores of gas giant planets as soon as particles reach boulder size.

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The cooling of atomic and molecular gas in DR21

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Aims We present an overview of a high-mass star formation region through the major (sub-)mm, and far-infrared cooling lines to gain insight into the physical conditions and the energy budget of the molecular cloud.

Methods We used the KOSMA 3m telescope to map the core ($10' \times 14'$) of the Galactic star forming region DR 21/DR 21 (OH) in the Cygnus X region in the two fine structure lines of atomic carbon (CI $^3\mathrm{P}_1 - ^3\mathrm{P}_0$ and $^3\mathrm{P}_2 - ^3\mathrm{P}_1$) and four mid-$J$ transitions of CO and ^{13}CO, and CS $J = 7-6$. These observations have been combined with FCRAO $J = 1-0$ observations of ^{13}CO and C^{18}O. Five positions, including DR21, DR21 (OH), and DR21 FIR1, were observed with the ISO/LWS grating spectrometer in the OI 63 and 145 μm lines, the CII 158 μm line, and four high-J CO lines. We discuss the intensities and line ratios at these positions and apply Local Thermal Equilibrium (LTE) and non-LTE analysis methods in order to derive physical parameters such as masses, densities and temperatures. The CO line emission has been modeled up to $J = 20$.

Results From non-LTE modeling of the low- to high-J CO lines we identify two gas components, a cold one at temperatures of $\mathrm{T_{kin}} \sim 30 - 40\,\mathrm{K}$, and one with $\mathrm{T_{kin}} \sim 80 - 150\,\mathrm{K}$ at a local clump density of about $\mathrm{n(H_2)} \sim 10^4 - 10^6\,\mathrm{cm^{-3}}$. While the cold quiescent component is massive containing typically more than 94 % of the mass, the warm, dense, and turbulent gas is dominated by mid- and high-J CO line emission and its large line widths.The medium must be clumpy with a volume-filling of a few percent. The CO lines are found to be important for the cooling of the cold molecular gas, e.g. at DR21 (OH). Near the outflow of the UV-heated source DR21, the gas cooling is dominated by line emission of atomic oxygen and of CO. Atomic and ionised carbon play a minor role.

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Habitability of Known Exoplanetary Systems Based on Measured Stellar Properties

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Habitable planets are likely to be broadly Earth-like in composition, mass, and size. Masses are likely to be within a factor of a few of the Earth's mass. Currently, we do not have sufficiently sensitive techniques to detect Earth-mass planets, except in rare circumstances. It is thus necessary to model the known exoplanetary systems. In particular, we need to establish whether Earth-mass planets could be present in the classical habitable zone (HZ) or whether the

giant planets that we know to be present would have gravitationally ejected Earth-mass planets or prevented their formation. We have answered this question by applying computer models to the 152 exoplanetary systems known by 2006 April 18 that are sufficiently well characterized for our analysis. For systems in which there is a giant planet, inside the HZ, which must have arrived there by migration, there are two cases: (1) where the migration of the giant planet across the HZ has not ruled out the existence of Earth-mass planets in the HZ; and (2) where the migration has ruled out existence. For each case, we have determined the proportion of the systems that could contain habitable Earth-mass planets today, and the proportion for which this has been the case for at least the past 1000 Myr (excluding any early heavy bombardment). For case 1 we get 60% and 50%, respectively, and for case 2 we get 7% and 7%, respectively.

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Emission Line Ratios from Variable Velocity Jet Models

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In this paper, we present a grid of axisymmetric numerical simulations of variable ejection velocity jets. In these models we assume that the jets are ejected with a sinusoidally varying ejection velocity and a time-independent ejection density. The grid of models then spans a range of different velocity variability amplitudes and periods. Because the simulations include a treatment of the non-equilibrium ionization state of the gas, we are able to make predictions of the emission in a set of different emission lines. In this way, we obtain predicted emission line ratios for the successive knots along the jets (which correspond to the "internal working surfaces" formed as a result of the ejection velocity variability), which can be compared directly with observations of the chains of knots along HH jets.

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Planet formation around low mass stars: the moving snow line and super-Earths

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We develop a semi-analytic model for planet formation during the pre-main sequence contraction phase of a low mass star. During this evolution, the stellar magnetosphere maintains a fixed ratio between the inner disk radius and the stellar radius. As the star contracts at constant effective temperature, the 'snow line', which separates regions of rocky planet formation from regions of icy planet formation, moves inward. This process enables rapid formation of icy protoplanets that collide and merge into super-Earths before the star reaches the main sequence. The masses and orbits of these super-Earths are consistent with super-Earths detected in recent microlensing experiments.

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Constraints on the nature of dust particles by infrared observations

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The far-infrared (FIR) emissivity of dust is an important parameter characterizing the physical properties of the grains. With the availability of stellar databases and far-infrared data from ISO it is possible to compare the optical and infrared properties of dust, and derive the far-infrared emissivity with respect to the optical extinction. In this paper we present the results of the systematic analysis of the FIR emissivity of interstellar coulds observed with ISOPHOT (the photometer onboard ISO) at least at two infrared wavelengths, one close to $\sim$100μm and one at 200μm. We constructed FIR emission maps, determined dust temperatures, created extinction maps using 2MASS survey data, and calculated far-infrared emissivity for each of these clouds. We present the largest homogeneously reduced database constructed so far for this purpose. During the data analysis special care was taken on possible systematic errors. We find that far-infrared emissivity has a clear dependence on temperature. The emissivity is enhanced by a factor of at most 2 in the low dust temperature regime of $12\,\mathrm{K} \leq \mathrm{T}_d \leq 14\,\mathrm{K}$. This result suggests larger grain sizes in those regions. However, the emissivity increase of at most 2 resticts the possible grain growth processes to ice-mantle formation and coagulation of silicate grains, and excludes the coagulation of carbonaceous particles on the scales of the regions we investigated. In the temperature range $14\,\mathrm{K} \leq \mathrm{T}_d \leq 16\,\mathrm{K}$ a systematic decrease of emissivity is observed with respect to the values of the diffuse interstellar matter. Possible scenarios for this behaviour are discussed in the paper.

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Structure of the inner regions of the circumstellar gas envelopes of young hot stars. I. The isolated Ae Herbig star WW Vul

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Results of simultaneous spectral and photometric monitoring of the Ae Herbig star WW Vul in the neighborhoods of the Hα line and the sodium NaI D resonance doublet are reported. It is shown that the spectral variability of the star is caused mainly by the anisotropic disk wind, whose high velocity component forms in the inner region of the accretion disk. The circumstellar gas in footpoint of the wind shows the variability of the density and velocity, that is in good agreement with the results of modeling of an accretion and outflows around young stars controlled by the stellar and/or disk magnetic field. An analysis of the variability of the parameters of the Hα emission line also showed that the density of the gas in the inner region of the accretion disk varies over a time scale exceeding 10 years.

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Influence of stellar wind on the long-term variability of the Hα emission line. The case of the Herbig Ae-star HD 31648

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The results of high-resolution long-term spectral monitoring in the region of the emission Hα line of the Herbig Ae star HD 31648 are reported. The variability in the observed profile is shown to be caused mainly by a change in the parameters of outflowing circumstellar gas over a time scale of about 3 years.

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Fragmentation of Massive Protostellar Disks

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We examine whether massive-star accretion disks are likely to fragment due to self-gravity. Rapid accretion and high angular momentum push these disks toward fragmentation, whereas viscous heating and the high protostellar luminosity stabilize them. We find that for a broad range of protostar masses and for reasonable accretion times, massive disks larger than ~ 150 AU are prone to fragmentation. We develop an analytical estimate for the angular momentum of accreted material, extending the analysis of Matzner and Levin (2005) to account for strongly turbulent initial conditions. In a core-collapse model, we predict that disks are marginally prone to fragmentation around stars of about four to 15 solar masses – even if we adopt conservative estimates of the disks' radii and tendency to fragment. More massive stars are progressively more likely to fragment, and there is a sharp drop in the stability of disk accretion at the very high accretion rates expected above 110 solar masses. Fragmentation may starve accretion in massive stars, especially above this limit, and is likely to create swarms of small, coplanar companions.

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Multiplicity and Optical Excess across the Substellar Boundary in Taurus

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We present the results of a high-resolution imaging survey of 22 brown dwarfs and very low mass stars in the nearby (~ 145 pc) young ($\sim$ 1-2 Myr) low-density star-forming region Taurus-Auriga. We obtained images with the Advanced Camera for Surveys High Resolution Channel on HST through the F555W (V), F775W (i'), and F850LP (z') filters. This survey confirmed the binarity of [BHS98] MHO 8 (hereafter MHO-Tau-8) and discovered a new candidate binary system, [SS94] V410 X-ray 3 (hereafter V410-Xray3), resulting in a binary fraction of 9^{+10}_{-3}% at separations >4 AU. Both binary systems are tight (<10 AU), and they possess mass ratios of 0.75 and 0.46, respectively. The binary frequency and separations are consistent with low-mass binary properties in the field, but the mass ratio of V410-Xray3 is among the lowest known. We find that the binary frequency is higher for very low mass stars and high-mass brown dwarfs than for lower mass brown dwarfs, implying either a decline in frequency or a shift to smaller separations for the lowest mass binaries. Combining these results with multiplicity statistics for higher mass Taurus members suggests a gradual decline in binary frequency and separation toward low masses. The implication is that the distinct binary properties of very low-mass systems are set during formation and that the formation process is similar to the process that creates higher mass stellar binaries, but occurs on a smaller scale. We combine the survey detection limits with models for planetary-mass objects to show that there are no planets or very low-mass brown dwarfs with mass $>3M_J$ at projected separation >40 AU orbiting any of the Taurus members in our sample, implying that planetary-mass companions at wide separations are rare. Finally, based on fits to the optical and near-infrared spectral energy distributions, we identify several BDs with significant ($\gtrsim 1$ mag) V-band excesses. The excesses appear to be correlated with signatures of accretion and if attributed to accretion luminosity may imply mass accretion rates several orders of magnitude above those inferred from line profile analyses.

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WFCAM, Spitzer-IRAC and SCUBA observations of the massive star forming region DR21/W75: II. Stellar content and star formation

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Wide field near-infrared observations and Spitzer Space Telescope IRAC observations of the DR21/W75 star formation regions are presented. The photometric data are used to analyse the extinction, stellar content and clustering in the entire region by using standard methods. A young stellar population is identified all over the observed field, which is

found to be distributed in embedded clusters that are surrounded by a distributed halo population extending over a larger projected area. The Spitzer/IRAC data are used to compute a spectral index value, α, for each YSO in the field. We use these data to separate pure photospheres from disk excess sources. We find a small fraction of sources with α in excess of 2 to 3 (plus a handful with $\alpha \sim 4$), which is much higher than the values found in the low mass star forming region IC348 ($\alpha \leq 2$). The sources with high values of α spatially coincide with the densest regions of the filaments and also with the sites of massive star formation. Star formation is found to be occuring in long filaments stretching to few parsecs that are fragmented over a scale of $\sim$1 pc. The spatial distribution of young stars are found to be correlated with the filamentary nebulae that are prominently revealed by 8μm and 850μm observations. Five filaments are identified that appear to converge on a center that includes the DR21/DR21(OH) regions. The morphological pattern of filaments and clustering compare well with numerical simulations of star cluster formation by Bate et al. 2003

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high quality pdf at http://www.astro.up.pt/investigacao/ficheiros/178.pdf

Massive Quiescent Cores in Orion. – II. Core Mass Function

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We have surveyed submillimeter continuum emission from relatively quiescent regions in the Orion molecular cloud to determine how the core mass function in a high mass star forming region compares to the stellar initial mass function. Such studies are important for understanding the evolution of cores to stars, and for comparison to formation processes in high and low mass star forming regions. We used the SHARC II camera on the Caltech Submillimeter Observatory telescope to obtain 350 μm data having angular resolution of about 9 arcsec, which corresponds to 0.02 pc at the distance of Orion. Further data processing using a deconvolution routine enhances the resolution to about 3 arcsec. Such high angular resolution allows a rare look into individually resolved dense structures in a massive star forming region.

Our analysis combining dust continuum and spectral line data defines a sample of 51 Orion molecular cores with masses ranging from 0.1 $M_{\odot}$ to 46 $M_{\odot}$ and a mean mass of 9.8 $M_{\odot}$, which is one order of magnitude higher than the value found in typical low mass star forming regions, such as Taurus. The majority of these cores cannot be supported by thermal pressure or turbulence, and are probably supercritical. They are thus likely precursors of protostars.

The core mass function for the Orion quiescent cores can be fitted by a power law with an index equal to -0.85$\pm$0.21. This is significantly flatter than the Salpeter initial mass function and is also flatter than the core mass function found in low and intermediate star forming regions. When compared with other massive star forming regions such as NGC 7538, this slope is flatter than the index derived for samples of cores with masses up to thousands of $M_{\odot}$. Closer inspection, however, indicates slopes in those regions similar to our result if only cores in a similar mass range are considered. Based on the comparison between the mass function of the Orion quiescent cores and those of cores in other regions, we find that the core mass function is flatter in an environment affected by ongoing high mass star formation. Thus, it is likely that environmental processes play a role in shaping the stellar IMF later in the evolution of dense cores and the formation of stars in such regions.

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X-ray and He I 1.0830 μm emission from protostellar jets

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Context. The high energies of protostellar jets, implied by recent observations of X-rays from such flows, came very

much as a surprise. Inferred shock velocities are considerably higher than what was previously known, hence putting even larger energy demands on the driving sources of the jets. The statistics of X-ray emitting jets are still poor, yet a few cases exist which seem to imply a correlation between the presence of He I 1.0830 μm emission and X-ray radiation in a given source.
Aims. This tentative correlation needs confirmation and explanation. If the jet regions of He I 1.0830 μm emission are closely associated with those producing X-rays, high resolution infrared spectroscopy can be used to observationally study the velocity fields in the hot plasma regions of the jets. This would provide the necessary evidence to test and further develop theoretical models of intermediately fast ($> 500 - 1500$ km s^{-1}) interstellar shock waves.
Methods. The HH 154 jet flow from the embedded protostellar binary L 1551 IRS 5 provides a case study, since adequate IR and X-ray spectroscopic data are in existence. The thermal X-ray spectrum is fed into a photoionization code to compute, in particular, the line emission of He I and H I and to account for the observed unusual line intensity ratios.
Results. The advanced model is capable of accounting for most observables, but shows also major weaknesses. It seems not unlikely that these could, in principle, be overcome by a time dependent hydrodynamical calculation with self-consistent cooling. However, such sophisticated model development is decisively beyond the scope of the present work.
Conclusions. Continued X-ray observations, coordinated with simultaneous high resolution infrared spectroscopy, are highly desirable.

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Rotational excitation of CO in a cool, mixed atomic and molecular hydrogen gas

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Context. Rate constants for rotational excitation of CO by atomic hydrogen have recently been recalculated and found to be much larger than was previously believed, larger even than for excitation by H_2.

Aims. To clarify the effect upon CO rotational excitation of an admixture of atomic hydrogen in diffuse molecule-bearing gas.

Methods. The equations of statistical equilibrium in the CO rotation ladder are solved under a variety of conditions typical of CO-bearing gas in the diffuse ISM.

Results. Atomic hydrogen, if present, substantiantially increases the brightness and excitation temperatures of the CO rotational transitions, and increases the J=2-1/J=1-0, J=3-2/J=2-1, etc. line brightness ratios. A modest admixture of atomic hydrogen mimics a pure H_2-gas of substantially higher ambient thermal pressure.

Conclusions. Rotational excitation of CO by atomic hydrogen is important if even a few percent of the hydrogen is in atomic form.

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The role of the energy equation in the fragmentation of protostellar discs during stellar encounters

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In this paper, we use high-resolution smoothed particle hydrodynamics (SPH) simulations to investigate the response of a marginally stable self-gravitating protostellar disc to a close parabolic encounter with a companion discless star. Our main aim is to test whether close brown dwarfs or massive planets can form out of the fragmentation of such discs. We follow the thermal evolution of the disc by including the effects of heating due to compression and shocks and a

simple prescription for cooling and find results that contrast with previous isothermal simulations. In the present case we find that fragmentation is inhibited by the interaction, due to the strong effect of tidal heating, which results in a strong stabilization of the disc. A similar behaviour was also previously observed in other simulations involving discs in binary systems. As in the case of isolated discs, it appears that the condition for fragmentation ultimately depends on the cooling rate.

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http://arxiv.org/abs/astro-ph/0610201, higher quality figures at: http://www.astro.le.ac.uk/~gl53/Lodatoetal06/

Discovery of a Young Substellar Companion in Chamaeleon

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During an imaging survey of the Chamaeleon I star-forming region with the Advanced Camera for Surveys aboard the Hubble Space Telescope, we have discovered a candidate substellar companion to the young low-mass star CHXR 73 ($\tau \sim 2$ Myr, M ~ 0.35 $M_\odot$). We measure a projected separation of $1.''30 \pm 0.''03$ for the companion, CHXR 73 B, which corresponds to 210 AU at the distance of the cluster. A near-infrared spectrum of this source obtained with the Cornell Massachusetts Slit Spectrograph at the Magellan II telescope exhibits strong steam absorption that confirms its late-type nature ($\gtrsim$ M9.5). In addition, the gravity-sensitive shapes of the H- and K-band continua demonstrate that CHXR 73 B is a young, premain-sequence object, rather than a field star. The probability that CHXR 73 A and B are unrelated members of Chamaeleon I is ~ 0.001. We estimate the masses of CHXR 73 B and other known substellar companions in young clusters with a method that is consistent with the dynamical measurements of the eclipsing binary brown dwarf 2M 0535-0546, which consists of a comparison of the bolometric luminosities of the companions to the values predicted by the evolutionary models of Chabrier et al. and Burrows et al. We arrive at mass estimates of 0.003-0.004, 0.024 ± 0.012, $0.011^{+0.01}_{-0.003}$, and $0.012^{+0.008}_{-0.005}$ $M_\odot$ for 2M 1207-3932 B, GQ Lup B, DH Tau B, and CHXR 73 B, respectively. Thus, DH Tau B and CHXR 73 B appear to be the least massive companions to stars outside the solar system that have been detected in direct images, and may have masses that are within the range observed for extrasolar planetary companions (M $\lesssim 0.015$ $M_\odot$). However, because these two objects (as well as 2M 1207-3932 B) probably did not form within circumstellar disks around their primaries, we suggest that they should be viewed as brown dwarf companions rather than planets.

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Evolution of emission line activity in intermediate mass young stars

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We present optical spectra of 45 intermediate mass Herbig Ae/Be stars. Together with the multi-epoch spectroscopic and photometric data compiled for a large sample of these stars and ages estimated for individual stars by using pre-main sequence evolutionary tracks, we have studied the evolution of emission line activity in them. We find that, on average, the Hα emission line strength decreases with increasing stellar age in HAeBe stars, indicating that the accretion activity gradually declines during the PMS phase. This would hint at a relatively long-lived (a few Myr) process being responsible for the cessation of accretion in Herbig Ae/Be stars. We also find that the accretion activity in these stars drops substantially by ~ 3 Myr. This is comparable to the timescale in which most intermediate mass stars are thought to lose their inner disks, suggesting that inner disks in intermediate mass stars are dissipated rapidly

after the accretion activity has fallen below a certain level. We, further find a relatively tight correlation between strength of the emission line and near-infrared excess due to inner disks in HAeBe stars, indicating that the disks around Herbig Ae/Be stars cannot be entirely passive. We suggest that this correlation can be understood within the frame work of the puffed-up inner rim disk models if the radiation from the accretion shock is also responsible for the disk heating.

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Non-local diffusion and the chemical structure of molecular clouds

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We present an application of a non-local turbulent transport model (currently being used to model transport in magnetically confined laboratory plasmas) to the study of the chemical structure of a molecular cloud. We consider a 'toy model' chemistry with a single molecular species which is adsorbed/desorbed from grain surfaces. With this idealized chemistry, we are able to find analytic solutions to both the 'classical' turbulent diffusion model as well as to the non-local transport model. For the turbulent diffusion model, we find that for the turbulent transport to be important one needs a mixing length comparable to the size of the cloud. On the other hand, with the non-local transport model we find that the chemistry is already strongly affected by the turbulent transport for mixing lengths two orders of magnitude smaller than the cloud size. This model then has the desirable property of being able to mix material over long distances (compared with the size of a molecular cloud) without requiring an inordinately large characteristic size for the turbulent eddies.

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First High-Contrast Science with an Integral Field Spectrograph: the Sub-Stellar Companion to GQ Lup

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We present commissioning data from the OSIRIS integral field spectrograph (IFS) on the Keck II 10 m telescope that demonstrate the utility of adaptive optics IFS spectroscopy in studying faint close-in sub-stellar companions in the haloes of bright stars. Our $R{\approx}2000$ J- and H-band spectra of the sub-stellar companion to the 1–10 Myr-old GQ Lup complement existing K-band spectra and photometry, and improve on the original estimate of its spectral type. We find that GQ Lup B is somewhat hotter (M6–L0) than reported in the discovery paper by Neuhäuser and collaborators (M9–L4), mainly due to the surface-gravity sensitivity of the K-band spectral classification indices used by the discoverers. Spectroscopic features characteristic of low surface gravity objects, such as lack of alkali absorption and a triangular H-band continuum, are indeed prominent in our spectrum of GQ Lup B. The peculiar shape of the H-band continuum and the difference between the two spectral type estimates is well explained in the context of the diminishing strength of H_2 collision induced absorption with decreasing surface gravity, as recently proposed for young ultra-cool dwarfs by Kirkpatrick and collaborators. Using our updated spectroscopic classification of GQ Lup B and a re-evaluation of the age and heliocentric distance of the primary, we perform a comparative analysis of the available sub-stellar evolutionary models to estimate the mass of the companion. We find that the mass of GQ Lup B is 0.010–0.040 $M_{\odot}$. Hence, it is unlikely to be a wide-orbit counterpart to the known radial-velocity extrasolar planets, whose masses are ≤ 0.015 $M_{\odot}$. Instead, GQ Lup A/B is probably a member of a growing family of very low mass ratio

widely separated binaries discovered through high-contrast imaging.

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Star formation triggered by SN explosions: an application to the stellar association of Beta-Pictoris

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In the present study, considering the physical conditions that are relevant in interactions between supernova remnants (SNRs) and dense molecular clouds for triggering star formation we have built a diagram of SNR radius versus cloud density in which the constraints above delineate a shaded zone where star formation is allowed. We have also performed fully 3-D radiatively cooling numerical simulations of the impact between SNRs and clouds under different initial conditions in order to follow the initial steps of these interactions. We determine the conditions that may lead either to cloud collapse and star formation or to complete cloud destruction and find that the numerical results are consistent with those of the SNR-cloud density diagram. Finally, we have applied the results above to the $\beta-$Pictoris stellar association which is composed of low mass Post-T Tauri stars with an age of 11 Myr. It has been recently suggested that its formation could have been triggered by the shock wave produced by a SN explosion localized at a distance of about 62 pc that may have occurred either in the Lower Centaurus Crux (LCC) or in the Upper Centaurus Lupus (UCL) which are both nearby older subgroups of that association (Ortega and co-workers). Using the results of the analysis above we have shown that the suggested origin for the young association at the proposed distance is plausible only for a very restricted range of initial conditions for the parent molecular cloud, i.e., a cloud with a radius of the order of 10 pc, a density of the order of $10-20$ cm^{-3}, and a temperature of the order of $10-100$ K.

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A Cold Nearby Cloud inside the Local Bubble

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The high-latitude Galactic H I cloud toward the extragalactic radio source 3C 225 is characterized by very narrow 21 cm emission and absorption indicative of a very low H I spin temperature of about 20 K. Through high-resolution optical spectroscopy, we report the detection of strong, very narrow Na I absorption corresponding to this cloud toward a number of nearby stars. Assuming that the turbulent H I and Na I motions are similar, we derive a cloud temperature of 20^{+6}_{-8} K (in complete agreement with the 21 cm results) and a line-of-sight turbulent velocity of 0.37 ± 0.08 km s^{-1} from a comparison of the H I and Na I absorption line widths. We also place a firm upper limit of 45 pc on the distance of the cloud, which situates it well inside the Local Bubble in this direction and makes it the nearest known cold diffuse cloud discovered to date.

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The Formation and Evolution of Solar Systems: Placing Our Solar System in Context with Spitzer

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We provide an overview of the Spitzer Legacy Program "Formation and Evolution of Planetary Systems" (FEPS) which was proposed in 2000, begun in 2001, and executed aboard the Spitzer Space Telescope between 2003 and 2006. This program exploits the sensitivity of Spitzer to carry out mid-infrared spectrophotometric observations of solar-type stars. With a sample of ∼328 stars ranging in age from ∼3 Myr to ∼3 Gyr, we trace the evolution of circumstellar gas and dust from primordial planet-building stages in young circumstellar disks through to older collisionally generated debris disks. When completed, our program will help define the time scales over which terrestrial and gas giant planets are built, constrain the frequency of planetesimal collisions as a function of time, and establish the diversity of mature planetary architectures.

In addition to the observational program, we have coordinated a concomitant theoretical effort aimed at understanding the dynamics of circumstellar dust with and without the effects of embedded planets, dust spectral energy distributions, and atomic and molecular gas line emission. Together with the observations, these efforts will provide astronomical context for understanding whether our Solar System – and its habitable planet – is a common or a rare circumstance. Additional information about the FEPS project can be found on the team website: http://feps.as.arizona.edu/

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http://gould.as.arizona.edu/∼mmeyer/mmeyer

The Planetary Mass Companion 2MASS1207-3932 B: Temperature, Mass and Evidence for an Edge-On Disk

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We present J–band imaging and $H+K$–band low-resolution spectroscopy of the 2MASS1207-3932AB system, obtained with the VLT NIR-AO instrument (NACO). Our J-band astrometry is consistent with AB being a co-moving system, in agreement with the recent results of Chauvin et al. (2005). For the putative planetary mass secondary, we find $J = 20.0 \pm 0.2$ mag. The shapes of the HK spectra for both components imply low gravity, as expected for this young (5–10 Myr-old) system, as well as a dusty atmosphere for the secondary. Comparisons to the latest synthetic spectra yield $T_{eff-A} \approx 2550 \pm 150$K, and $T_{eff-B} \approx 1600 \pm 100$K. These temperatures are consistent with the late-M and mid-to-late L spectral types derived earlier for 2M1207A and B respectively. For these T_{eff}, and an age of 5–10 Myrs,

the latest theoretical evolutionary tracks imply $M_A \approx 24\pm6$ M_{Jup} and $M_B \approx 8\pm2$ M_{Jup}. Independent comparisons of the theoretical tracks to the observed colors, spanning $\sim I$ to L' (including recent HST photometry), also yield the same mass and temperature estimates. Our mass for the primary agrees with other recent analyses; however, our secondary mass, while still in the planetary regime, is 2–3 times larger than claimed previously. The roots of this discrepancy can be traced directly to the luminosities: while the absolute photometry and M_{bol} of the primary are in excellent agreement with theoretical predictions (especially with the recently derived $d = 53\pm6$ pc for the system), the secondary appears $\sim 2.5\pm0.5$ mag *fainter* than expected in all photometric bands from I to L' as well as in M_{bol}. This anomalous under-luminosity accounts for the much lower secondary mass (and temperature) derived in earlier studies. We argue that this effect is highly unlikely to result from: *(i)* a large overestimation of our secondary T_{eff}; *(ii)* serious overestimation of luminosities by the theoretical evolutionary models; *(iii)* very large distance/age variations between the two components; or *(iv)* faintness in the secondary due to formation via core-accretion. These conclusions are bolstered by the absence of any luminosity problems with the primary in our analysis. Similarly, we find no luminosity discrepancies in the recently discovered sub-stellar companion AB Pic B, which is also young (age ~30 Myr) and comparable in spectral classification (~L-type) and temperature (~1700K) to 2M1207B. We therefore suggest grey extinction in 2M1207B, due to occlusion by an edge-on circum-secondary disk. This scenario is consistent with the observed properties of edge-on disks around T Tauri stars, and with the known presence of a high-inclination evolved disk around the primary. Finally, the system's implied mass ratio of ~0.3 suggests a binary-like formation scenario.

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Spitzer Observations of HH 54 and HH 7-11: Mapping the H_2 Ortho-to-Para Ratio in Shocked Molecular Gas

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We report the results of spectroscopic mapping observations carried out toward the Herbig-Haro objects HH 7-11 and HH 54 over the 5.2-37μm region using the Infrared Spectrograph on the Spitzer Space Telescope. These observations have led to the detection and mapping of the S(0)-S(7) pure rotational lines of molecular hydrogen, together with emissions in fine-structure transitions of Ne^+, Si^+, S, and Fe^+. The H_2 rotational emissions indicate the presence of warm gas with a mixture of temperatures in the range 400-1200 K – consistent with the expected temperature behind nondissociative shocks of velocity $\sim$ 10-20 km s^{-1} while the fine-structure emissions originate in faster shocks of velocity $\sim$ 35-90 km s^{-1} that are dissociative and ionizing. The H_2 ortho-to-para ratio is quite variable, typically falling substantially below the equilibrium value of 3 attained at the measured gas temperatures. The nonequilibrium ortho-to-para ratios are characteristic of temperatures as low as $\sim$ 50 K, and are a remnant of an earlier epoch, before the gas temperature was elevated by the passage of a shock. Correlations between the gas temperature and H_2 ortho-to-para ratio show that ortho-to-para ratios <0.8 are attained only at gas temperatures below $\sim$ 900 K; this behavior is consistent with theoretical models in which the conversion of para- to ortho-H_2 behind the shock is driven by reactive collisions with atomic hydrogen, a process that possesses a substantial activation energy barrier ($E_A/k \sim$ 4000 K) and is therefore very inefficient at low temperature. The lowest observed ortho-to-para ratios of only $\sim$ 0.25 suggest that the shocks in HH 54 and HH 7 are propagating into cold clouds of temperature $\lesssim$ 50 K in which the H_2 ortho-to-para ratio is close to equilibrium.

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Warm SiO gas in molecular bullets associated with protostellar outflows

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In this paper we present the first SiO multiline analysis (from J=2-1 to J=11-10) of the molecular bullets along the outflows of the Class 0 sources L1448-mm and L1157-mm, obtained through observations with IRAM and JCMT. This analysis has been performed to investigate the physical properties of different types of bullets, in order to explore their excitation conditions and put constraints on their formation and evolution. For this purpose we have computed the main physical parameters (n_{H_2}, T_{kin}, N_{SiO}) in each bullet and compared them with other tracers of warm and dense gas and with models for the SiO excitation in shocks. We find that the bullets close to L1448–mm, associated with high velocity gas, have higher excitation conditions (n_{H_2} ~10^6 cm^{-3}, $T > 500$ K) with respect to the L1157 bullets (n_{H_2} ~1–5×10^5 cm^{-3}, $T \sim 100 - 300$ K). In both the sources, there is a clear evidence of the presence of velocity components having different excitation conditions, with the denser and/or warmer gas associated with the gas at the higher speed. In L1448 the bulk of the emission is due to the high-excitation and high velocity gas, while in L1157 most of the emission comes from the low excitation gas at ambient velocity. The observed velocity-averaged line ratios are well reproduced by shocks with speeds v_s larger than ~30 km s^{-1} and densities $\sim 10^5 - 10^6$ cm^{-3}. Plane-parallel shock models, however, fail to predict all the observed line profiles and in particular the very similar profiles shown by both low and high excitation lines. The overall observations support the idea that the L1157 clumps are shock interaction events older than the L1448 bullets close to the driving source. In the latter objects, the velocity structure and the variations of physical parameters with the velocity resemble very closely those found in optical/IR jets near the protostar, suggesting that similar launching and excitation mechanisms are also at the origin of collimated jets seen at millimetre wavelengths.

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http://www.mporzio.astro.it/~bruni/publ.html

Halting Type I planet migration in non-isothermal disks

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Aims: We investigate the effect of including a proper energy balance on the interaction of a low-mass planet with a protoplanetary disk. Methods: We use a three-dimensional version of the RODEO method to perform hydrodynamical simulations including the energy equation. Radiation is included in the flux-limited diffusion approach. Results: The sign of the torque depends sensitively on the ability of the disk to radiate away the energy generated in the immediate surroundings of the planet. In the case of high opacity, corresponding to the dense inner regions of protoplanetary disks, migration is directed *outward*, instead of the usual inward migration that was found in locally isothermal disks. For low values of the opacity we recover inward migration, and we show that torques originating in the coorbital region are responsible for the change in migration direction.

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Gravitational Instabilities induced by Cluster Environment? - The encounter-induced angular momentum transfer in discs

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Aim: The aim of this work is to understand to what extend gravitational interactions between the stars in high-density young stellar clusters, like the Orion Nebula Cluster (ONC), cha nge the angular momentum in their protoplanetary discs.

Method: Two types of simulations were combined — N-body simulations of the dynamics of the stars in the ONC,

and angular momentum loss results from sim ulations of star-disc encounters.

Results: It is shown that in a star-disc encounter the angular momentum loss is usually larger than the mass loss, so that the disc remnant has a lower specific angular momentum. Assum ing an age of 1-2 Myr for the ONC, the disc angular momentum in the higher density region of t he Trapezium is reduced by 15-20% on average. Encounters therefore play an important part in the angula r momentum transport in these central regions but are not the dominant process. More importantly, even in the outer cluster regions the angular momentum loss is on average 3-5%. Here it is shown that a 3-5% loss in angular momentum might be enough to trigge r gravitational instabilities even in low-mass discs - a possible prerequisite for the formation of planetary systems.

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A highly abnormal massive star mass function in the Orion Nebula cluster and the dynamical decay of trapezia systems

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The ONC appears to be unusual on two grounds: The observed constellation of the OB-stars of the entire Orion Nebula cluster and its Trapezium at its centre implies a time-scale problem given the age of the Trapezium, and an IMF problem for the whole OB-star population in the ONC. Given the estimated crossing time of the Trapezium, it ought to have totally dynamically decayed by now. Furthermore, by combining the lower limit of the ONC mass with a standard IMF it emerges that the ONC should have formed at least about 40 stars heavier than 5 $M_\odot$ while only ten are observed. Using N-body experiments we (i) confirm the expected instability of the trapezium and (ii) show that beginning with a compact OB-star configuration of about 40 stars the number of observed OB stars after 1 Myr within 1 pc radius and a compact trapezium configuration can both be reproduced. These two empirical constraints thus support our estimate of 40 initial OB stars in the cluster. Interestingly a more-evolved version of the ONC resembles the Upper Scorpius OB association. The N-body experiments are performed with the new C-code CATENA by integrating the equations of motion using the chain-multiple-regularization method. In addition we present a new numerical formulation of the initial mass function.

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Detecting a rotation in the Epsilon Eridani debris disc

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The evidence for a rotation of the Epsilon Eridani debris disc is examined. Data at 850-μm wavelength were previously obtained using the Submillimetre Common User Bolometer Array (SCUBA) over periods of 1997-1998 and 2000-2002. By χ^2 fitting after shift and rotation operations, images from these two epochs were compared to recover proper motion and orbital motion of the disc. The same procedures were then performed on simulated images to estimate the accuracy of the results.

Minima in the χ^2 plots indicate a motion of the disc of approximately 0.6 arcsec per year in the direction of the star's proper motion. This underestimates the true value of 1 arcsec per year, implying that some of the structure in the disc region is not associated with Epsilon Eridani, originating instead from background galaxies. From the χ^2 fitting for orbital motion, a counterclockwise rotation rate of $\sim 2.^\circ 75$ per year is deduced. Comparisons with simulated data in which the disc is not rotating show that noise and background galaxies result in approximately Gaussian fluctuations with a standard deviation of $\pm 1.^\circ 5$ per year. Thus, counterclockwise rotation of disc features is supported at approximately a 2σ level, after a 4-yr time difference. This rate is faster than the Keplerian rate of $0.^\circ 65$ per year

for features at ≈ 65 au from the star, suggesting their motion is tracking a planet inside the dust ring.

Future observations with SCUBA-2 can rule out no rotation of the Epsilon Eridani dust clumps with $\sim 4\sigma$ confidence. Assuming a rate of about $2.^{\circ}75$ per year, the rotation of the features after a 10-yr period could be shown to be $\geq 1^{\circ}$ per year at the 3σ level.

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VLT/Flames observations of the star forming region NGC 6530

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Mechanisms regulating the evolution of pre-main sequence stars can be understood by studying stellar properties such as rotation, disk accretion, internal mixing and binarity. To investigate such properties, we studied a sample of 332 candidate members of the massive and populous star forming region NGC 6530.
We want to select cluster members by using different membership criteria, to study the properties of pre-main sequence stars with or without circumstellar disks.
We use intermediate resolution spectra including the Li I 6707.8 Å line to derive radial and rotational velocities, binarity and to measure the Equivalent Width of the lithium line; these results are combined with X-ray data to study the cluster membership. Optical-IR data and Hα spectra, these latter available for a subsample of our targets, are used to classify CTTS and WTTS and to compare the properties of stars with and without disks.
We find a total of 237 certain members including 53 binaries. The rotational velocity distributions of stars with IR excesses are statistically different from that of stars without IR excesses, while the fraction of binaries with disks is significantly smaller than that of single stars. Stars with evidence for accretion show circumstellar disks; youth of cluster members is confirmed by the lithium abundance consistent with the initial content.
As indicated by the disk-locking picture, stars with disks have in general rotational velocities lower than stars without disks. Binaries in NGC 6530 seem have undergone a significant disk evolution.

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http://www.astropa.unipa.it/Library/preprint.html

Coronagraphic imaging of three weak-line T Tauri stars: evidence of planetary formation around PDS 70

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Context. High angular resolution imaging of nearby pre-main sequence stars with ages between 1 and 30 Myr can give valuable information on planet formation mechanisms. This range of ages is thought to correspond to the dissipation of the optically thick dust disks surrounding young stars and to the end of the planet formation.

Aims. This paper presents new observations of three weak-line T Tauri Stars (WTTS) of intermediate ages ranging from 7 to 16 Myr. It aims at increasing the knowledge and sample of circumstellar disks around "old" WTTS.

Methods. We observed three stars with the VLT's NAOS-CONICA adaptive optics system in coronagraphic mode. The four-quadrant phase mask coronagraph was used to improve the dynamic range (by a factor of $\sim$100) while preserving the high angular resolution (inner working angle of $0.''15$).

Results. One object of our sample (PDS 70), a K5 star, exhibits a brown dwarf companion and a disk in scattered light with a surface brightness power law of $r^{-2.8}$, extending from a distance of 14 to 140 AU (assuming a stellar distance of 140 pc) and an integrated luminosity of 16.7 mJy in the K_s-band. The mass of the companion can be estimated to

be within a range between 27 and 50 Jupiter masses with an effective temperature of 2750 ± 100 K. This object also shows a resolved outflow stretching up to ~550 AU.

Conclusions. This newly detected circumstellar disk shows strong similarities with the disk around TW Hya, and adds to the observed population of "old" TTS surrounded by circumstellar material. Moreover, three clues of planetary formation are brought to light by this study.

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Atomic Carbon in the AFGL 333 Cloud

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We have mapped the W3 giant molecular cloud in the C^0 $^3P_1$-$^3P_0$ ([C I] 492 GHz) and ^{12}CO J = 3-2 emission lines with the Mount Fuji Submillimeter-wave Telescope. The [C I] distribution is extended over the molecular cloud, having peaks at three star forming clouds, W3 Main, W3(OH), and AFGL 333. The [C I] emission is found to be strong in the AFGL 333 cloud, where the ^{12}CO J = 3-2 emission is relatively weak. In order to characterize the physical and chemical states of the AFGL 333 cloud, we have also observed the CO J = 1-0 isotopomer lines and the CCS and N_2H^+ lines with the Nobeyama Radio Observatory 45 m Telescope. The [C^0]/[CO] and [CCS]/[N_2H^+] abundance ratios are found to be higher in the AFGL 333 cloud than in the W3(OH) cloud, suggesting that the AFGL 333 cloud is younger than the W3(OH) cloud. In the AFGL 333 cloud we have found two massive cores without any sign of active star formation. They are highly gravitationally bound and are regarded as good candidates for a massive prestellar core.

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Discovery of an 86 AU Radius Debris Ring around HD 181327

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HST NICMOS PSF-subtracted coronagraphic observations of HD 181327 have revealed the presence of a ringlike disk of circumstellar debris seen in 1.1μm light scattered by the disk grains, surrounded by a diffuse outer region of lower surface brightness. The annular disk appears to be inclined by $31.^\circ 7 \pm 1.^\circ 6$ from face-on, with the disk major-axis P.A. at $107^\circ \pm 2^\circ$. The total 1.1μm flux density of the light scattered by the disk (at $1.''2 < r < 5.''0$) of 9.6 ± 0.8 mJy is $0.17\% \pm 0.015\%$ of the starlight. Seventy percent of the light from the scattering grains appears to be confined in a 36 AU wide annulus centered on the peak of the radial surface brightness (SB) profile 86.3 ± 3.9 AU from the star, well beyond the characteristic radius of thermal emission estimated from IRAS and Spitzer flux densities, assuming blackbody grains ($\approx$ 22 AU). The 1.1μm light scattered by the ring (1) appears bilaterally symmetric, (2) exhibits directionally preferential scattering well represented by a Henyey-Greenstein scattering phase function with g_{HG} = 0.30 ± 0.03, and (3) has a median SB (over all azimuth angles) at the 86.3 AU radius of peak SB of 1.00 ± 0.07 mJy arcsec^{-2}. No photocentric offset is seen in the ring relative to the position of the central star. A low SB diffuse halo is seen in the NICMOS image to a distance of $\sim 4''$. Deeper 0.6μm Hubble Space Telescope (HST) ACS PSF-subtracted coronagraphic observations reveal a faint (V $\approx$ 21.5 mag arcsec^{-2}) outer nebulosity at $4'' < r < 9''$, asymmetrically brighter to the north of the star. We discuss models of the disk and properties of its grains, from which we infer a maximum vertical scale height of 48 AU at the 87.6 AU radius of maximum surface density, and a total maximum

dust mass of collisionally replenished grains with minimum grain sizes of $\approx 1\mu$m of $\approx 4M_{Moon}$.

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X-ray Variability in the Young Massive Triple θ^2 Ori A

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Massive stars rarely show intrinsic X-ray variability. The only O-stars credited to be intrinsically variable are θ^1 Ori C due to effects from magnetic confinement of its wind, and θ^2 Ori A suspected of similar activity. Early *Chandra* observations have shown that the most massive star system in the Orion Trapezium Cluster, θ^2 Ori A, shows rapid variability on time scales of hours. We determine X-ray fluxes from observations with *Chandra* and find that the star shows very strong variability over the last 5 years. We observed a second large outburst of the X-ray source in November 2004 with the high resolution transmission grating spectrometer on-board *Chandra* and compare the emissivity and line properties in states of low and high flux. In the low state X-ray emissivities indicate temperatures well above 25 MK. In the high state we find an extended emissivity distribution with high emissivities in the range from 3 MK to over 100 MK. The outburst event in stellar terms is one of the most powerful ever observed and the most energetic one in the ONC with a lower total energy limit of 1.5×10^{37} ergs. The line diagnostics show that under the assumption that the He-like ons are photoexcited the line emitting regions in the low states are as close as within $1-2$ stellar radii from the O-star's photosphere, whereas the hard states suggest a distance of $3-5$ stellar radii. We discuss the results in the context of stellar flares, magnetic confinement, and binary interactions. By matching the dates of all observations with the orbital phases of the spectroscopy binary orbit we find that the two outbursts are very close to the periastron passage of the stars. We argue that the high X-ray states are possibly the result of reconnection events from magnetic interactions of the primary and secondary stars of the spectroscopic binary. Effects from wind collisions seem unlikely for this system. The low state emissivity and R-ratios strengthen the predicament that the X-ray emission is enhanced by magnetic confinement of the primary wind. We also detect Fe fluorescence indicative of the existence of substantial amounts of neutral Fe in the vicinity of the X-ray emission.

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A complete ^{12}CO 2–1 map of M51 with HERA: I. Radial averages of CO, HI, and radio continuum

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The mechanisms governing the star formation rate in spiral galaxies are not yet clear. The nearby, almost face-on, and interacting galaxy M51 offers an excellent opportunity to study at high spatial resolutions the local star formation laws.

In this first paper, we investigate the correlation of H_2, HI, and total gas surface densities with the star forming activity, derived from the radio continuum (RC), along radial averages out to radii of 12 kpc.

We have created a complete map of M51 in ^{12}CO 2–1 at a resolution of 450 kpc using HERA at the IRAM-30m telescope. These data are combined with maps of HI and the radio-continuum at 20 cm wavelength. The latter is used to estimate the star formation rate (SFR), thus allowing to study the star formation efficiency and the local Schmidt law $\Sigma_{\rm SFR} \propto \Sigma^n_{\rm gas}$. The velocity dispersion from CO is used to study the critical surface density and the gravitational stability of the disk.

The total mass of molecular material derived from the integrated ^{12}CO 2–1 intensities is $2\,10^9\,{\rm M}_\odot$. The 3σ detection limit corresponds to a mass of $1.7\,10^5\,{\rm M}_\odot$. The global star formation rate is $2.56\,{\rm M}_\odot\,{\rm yr}^{-1}$ and the global gas depletion

time is 0.8 Gyr. HI and RC emission are found to peak on the concave, downstream side of the outer south-western CO arm, outside the corotation radius. The total gas surface density $\Sigma_{\rm gas}$ drops by a factor of ~ 20 from $70\,{\rm M}_\odot\,{\rm pc}^{-2}$ at the center to $3\,{\rm M}_\odot\,{\rm pc}^{-2}$ in the outskirts at radii of 12 kpc. The fraction of atomic gas gradually increases with radius. The ratio of HI over H_2 surface densities, $\Sigma_{\rm HI}/\Sigma_{\rm H2}$, increases from ~ 0.1 near the center to ~ 20 in the outskirts without following a simple power-law. $\Sigma_{\rm HI}$ starts to exceed $\Sigma_{\rm H2}$ at a radius of ~ 4 kpc. The star formation rate per unit area drops from $\sim 400\,{\rm M}_\odot\,{\rm pc}^{-2}\,{\rm Gyr}^{-1}$ in the starburst center to $\sim 2\,{\rm M}_\odot\,{\rm pc}^{-2}\,{\rm Gyr}^{-1}$ in the outskirts. The gas depletion time varies between 0.1 Gyr in the center and 1 Gyr in the outskirts, and is shorter than in other non-interacting normal galaxies. Neither the HI surface densities nor the H_2 surface densities show a simple power-law dependence on the star formation rate per unit area. In contrast, $\Sigma_{\rm gas}$ and $\Sigma_{\rm SFR}$ are well characterized by a local Schmidt law with a power-law index of $n = 1.4 \pm 0.6$. The index equals the global Schmidt law derived from disk-averaged values of $\Sigma_{\rm gas}$ and $\Sigma_{\rm SFR}$ of large samples of normal and starburst galaxies.

The critical gas velocity dispersions needed to stabilize the gas against gravitational collapse in the differentially rotating disk of M51 using the Toomre criterion, vary with radius between 1.7 and 6.8 kms^{-1}. Observed radially averaged dispersions derived from the CO data vary between 28 kms^{-1} in the center and $\sim$8 kms^{-1} at radii of 7 to 9 kpc. They exceed the critical dispersions by factors $Q_{\rm gas}$ of 1 to 5. We speculate that the gravitational potential of stars leads to a critically stable disk.

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http://hera.ph1.uni-koeln.de/~kramer/docs/m51/p_m51.pdf

A Unified Model for Bipolar Outflows from Young Stars

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We develop a unified model for molecular outflows in star formation. The model incorporates essential features expected of the primary wind, which is thought to be driven magnetocentrifugally from close to the central stellar object, and the ambient core material shaped by anisotropic magnetic support. The primary wind is modeled as a toroidally magnetized fast outflow moving radially away from the origin, with an angle-dependent density distribution: a dense axial jet surrounded by a more tenuous wide-angle wind, as expected in the X-wind model. If dynamically significant magnetic fields are present, the star-forming core will settle faster along the field lines than across, forming a toroid-like structure. We approximate the structure with a singular isothermal toroid whose density distribution can be obtained analytically. The interaction of the laterally stratified wind and the ambient toroid is followed using the Zeus2D magnetohydrodynamics (MHD) code. We find that the lobes produced by the interaction resemble many systematics observed in molecular outflows from very young stars, ranging from Class 0 to I sources. In particular, both the dense axial jet and the wide-angle wind participate in the wind-ambient interaction. In our model, the jet- and wind-driven pictures of molecular outflows are unified. We discuss the observational implications of the unified picture, including the possibility of detecting the primary jet/wind directly.

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Random flows and diagnostics of turbulence in the high latitude cirrus

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Aims. We present an analysis of the exceptionally turbulent velocity field in the high Galactic latitude cirrus cloud MBM 3. As in the other translucent clouds in our study (MBM 16 and MBM 40), there is no evidence for internal star formation. However, the large scale velocity variation in this cloud is more pronounced.

Methods. We have mapped the cloud in ^{12}CO and ^{13}CO (1-0) at high spatial (0.03 pc) and velocity (0.06 km s^{-1}) resolution. We constructed several velocity probability density functions (PDFs), estimated the turbulent transfer rate, and analyzed the linewidths as a function of the size of randomly chosen regions within the cloud.

Results. We find strong shear flows throughout the cloud that can easily power the turbulent motions. The wings of the PDFs are well approximated by a lorentzian distribution. Such distributions, related to Levy processes that are well known to be produced by correlated processes, are an unambiguous diagnostic of the turbulent intermittency.

Conclusions. We find that the linewidth-size relation frequently used to indicate the role of turbulence in molecular clouds is not an unambiguous signature of its presence.

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Can a chondrule precursor survive a shock wave?

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In a shock-wave heating model, a chondrule is formed due to frictional heating between its precursor and gas. If the tensile stress inside the precursor derived from the gas dynamic pressure, is greater than the tensile strength of the precursor, the precursor is broken into smaller pieces. The yield (onset of plastic deformation) and breaking (onset of fracturing) strengths of the precursor when sintering is taken into account was calculated. The timescale of sintering is estimated. The model in Sirono & Greenberg (2000, Icarus 145, 230), in which a grain aggregate is assumed to comprise chains of spherical grains of uniform size was used. The critical packing fraction above which an aggregate can survive a shock wave is obtained. If the degree of sintering is low, the breaking strength of the aggregate decreases due to sintering. When sintering has sufficiently occurred, the aggregate can avoid breaking up. Sintering can proceed upstream of the shock wave before the passage of the shock wave.

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A Distributed Population of Low Mass Pre-Main Sequence Stars near the Taurus Molecular Clouds

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We present a drift scan survey covering a $\sim 5^o \times 50^o$ region toward the Southern portion of the Taurus-Auriga molecular cloud. Data taken in the B, R, I filters with the Quest-2 camera on the Palomar 48-inch telescope were combined with 2MASS near-infrared photometry to select candidate young stars. Follow-up optical spectroscopy of 190 candidates led to identification of 42 new low mass pre-main sequence stars with spectral types M4-M8, of which approximately half exhibit surface gravity signatures similar to known Taurus stars while the other half exhibit surface gravity signatures similar to members of the somewhat older Upper Sco, TW Hya and Beta Pic associations. The pre-main sequence stars are spread over $\sim 35^o$, and many are located well outside of previously explored regions. From assessment of the spatial and proper motion distributions, we argue that the new pre-main sequence stars identified far from the clouds cannot have originated from the vicinity of the 1–2 Myr-old subclusters which contain the bulk of the identified Taurus members, but instead represent a newly-identified area of recent star-formation near the clouds.

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Gas-Phase CO_2 Emission toward Cepheus A East: The Result of Shock Activity?

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We report the first detection of gas-phase CO_2 emission in the star-forming region Cepheus A East, obtained by spectral line mapping of the ν_2 bending mode at 14.98μm with the Infrared Spectrograph on board the Spitzer Space Telescope. The gaseous CO_2 emission covers a region about $35'' \times 25''$ in extent and results from radiative pumping by 15μm continuum photons emanating predominantly from the HW2 protostellar region. The gaseous CO_2 exhibits a temperature distribution ranging from 50 to 200 K. A correlation between the gas-phase CO_2 distribution and that of H_2 S(2), a tracer of shock activity, indicates that the CO_2 molecules originate in a cool postshock gas component associated with the outflow powered by HW2. The presence of CO_2 ice absorption features at 15.20μm toward this region and the lack of correlation between the IR continuum emission and the CO_2 gas emission distribution further suggest that the gaseous CO_2 molecules are mainly sputtered off grain mantles (by the passage of slow nondissociative shocks with velocities of 15-30 km s^{-1}) rather than sublimated through grain heating.

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A Keck HIRES Doppler Search for Planets Orbiting Metal-Poor Dwarfs. I. Testing Giant Planet Formation and Migration Scenarios

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We describe a high-precision Doppler search for giant planets orbiting a well-defined sample of metal-poor dwarfs in the field. This experiment constitutes a fundamental test of theoretical predictions, which will help discriminate between proposed giant planet formation and migration models. We present details of the survey, as well as an overall assessment of the quality of our measurements, making use of the results for stars that show no significant velocity variation.

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Periodic radial velocity variations in RU Lup

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Context. RU Lup is a Classical T Tauri star with unusually strong emission lines, which has been interpreted as manifestations of accretion. Recently, evidence has accumulated that this star might have a variable radial velocity.
Aims. We intended to investigate in more detail the possible variability in radial velocity using a set of 68 high-

resolution spectra taken at the VLT (UVES), the AAT (UCLES) and the CTIO (echelle).
Methods. Using standard cross-correlation techniques, we determined the radial velocity of RU Lup. We analysed these results with Phase-dispersion minimization and the Lomb-Scargle periodogram and searched for possible periodicities in the obtained radial velocities. We also analysed changes in the absorption line shapes and the photometric variability of RU Lup.
Results. Our analysis indicated that RU Lup exhibits variations in radial velocity with a periodicity of 3.71 days and an amplitude of 2.17 km s^{-1}. These variations can be explained by the presence of large spots, or groups of spots, on the surface of RU Lup. We also considered a low-mass companion and stellar pulsations as alternative sources for these variations but found these to be unlikely.

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Entrainment Mechanisms for Outflows in the L1551 Star-forming Region

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We present high sensitivity ^{12}CO and ^{13}CO J = 1-0 maps covering the full extent of the parsec-scale L1551 molecular outflow, including the redshifted east-west (EW) flow. We also present ^{12}CO J = 3-2 data obtained over a good fraction of the L1551 outflow. We compare the molecular data to wide-field, narrowband optical emission in Hα. While there are multiple outflows in the L1551 cloud, the main outflow is oriented at 50° position angle and appears to be driven by an embedded source(s) in the central IRS 5 region. The J = 3-2 data indicate that there may be molecular emission associated with the L1551 NE jet, within the redshifted lobe of the main outflow. We have also better defined the EW flow and believe we have identified its blueshifted counterpart. We speculate that the origin of the EW outflow lies near HH 102. Velocity-dependent opacity correction is used to estimate the mass and energy of the outflow. The resulting mass spectral indices from our analysis are systematically lower (less steep) than the power-law indices obtained toward other outflows in several recent studies that use a similar opacity correction method. We show that systematic errors and biases in the mass analysis procedures could result in errors in the determination of the power-law indices. The mass spectral indices, the morphological appearance of the position-velocity plots, and integrated intensity maps of molecular data, compared with the optical, suggest that jet-driven bow shock entrainment is the best explanation for the driving mechanism of outflows in L1551. The kinetic energy of the outflows is found to be comparable to the binding energy of the cloud and sufficient to maintain the turbulence in the L1551 cloud.

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Secondary Star Formation in a Population III Object

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We explore the possibility of subsequent star formation after a first star forms in a Population III object, by focusing on the radiation-hydrodynamic (RHD) feedback caused by ionizing photons, as well as H_2-dissociating photons. For this purpose, we perform three-dimensional RHD simulations in which the radiative transfer of ionizing photons and H_2-dissociating photons from a first star is self-consistently coupled with hydrodynamics based on a smoothed particle hydrodynamics method. It is shown that density peaks above a threshold density can keep collapsing, owing to the shielding of H_2-dissociating radiation by an H_2 shell formed ahead of a D-type ionization front. But, below the threshold density an M-type ionization front with a shock propagates, and density peaks are radiation-hydrodynamically evaporated by the shock. The threshold density depends on the distance from the source star and is $\approx 10^2$ cm^{-3} for a source distance of 30 pc. Taking into consideration that the extent of a Population III object is $\approx$ 100 pc and the density peaks within it have densities of 10^2 - 10^4 cm^{-3}, it is concluded that secondary star formation is possible in

the broad regions of a Population III object.

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Near-Infrared Polarization Images of the Orion Nebula

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Wide-field ($\sim 8' \times 8'$) and deep near-infrared (JHK$_s$ bands) polarization images of the Orion Nebula are presented. These data revealed various circumstellar structures as infrared reflection nebulae (IRNe) around young stellar objects (YSOs), both massive and low-mass. We found the IRN around both IRc2 and BN to be very extensive, suggesting that there might be two extended (>0.7 pc) bipolar/monopolar IRNe in these sources. We discovered at least 13 smaller scale ($\sim$ 0.01 - 0.1 pc) IRNe around less massive YSOs, including the famous source θ^2 Ori C. We also suggest the presence of many unresolved (<690 AU) systems around low-mass YSOs and young brown dwarfs showing possible intrinsic polarizations. Wide-field infrared polarimetry is thus demonstrated to be a powerful technique in revealing IRNe and hence potential disk/outflow systems among high-mass to substellar YSOs.

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A radio continuum and neutral hydrogen counterpart to the IRAS Vela shell

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Aims. We look for radio-continuum and atomic neutral hydrogen (HI) counterparts of the IRAS Vela shell (IVS).

Methods. Neutral hydrogen (HI) and 1410 MHz radio continuum surveys carried out with the Instituto Argentino de Radioastronomía (IAR) dishes are the main databases used in this investigation.

Results. A good morphological correlation was found between arc-shaped structures at radio wavelengths and in the 100 μm IR emission. This correlation is observed at velocities of the HI between -17.5 and -2.1 km s^{-1}, in agreement with the velocities of the molecular gas detected in the region. The radial distribution of the different components is consistent with the presence of an expanding shell that is being ionized from inside. Assuming a distance of 400 pc, the amount of ionized and atomic gas associated with the IVS is 2.3×10^4 and 6.8×10^4 solar masses, respectively. The origin of the expansion of the IVS could not be identified.

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Nuclear spin conversion of formaldehyde in protostar environments induced by non reactive collisions

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Context. Formaldehyde is an important diagnostic of the physical conditions in star forming regions. The temperature of formation is determined by measuring the relative abundance of para-H_2CO and ortho-H_2CO. The key hypothesis for this determination is that the ortho-para interconversion is strictly forbidden once the molecule is formed. However H_2CO nuclear spin conversion mechanisms do exist in a gas phase either involving reactive or non-reactive collisions. This last process is governed by internal properties of the molecule, such as the mixing of energetically closed ortho-para level pairs, which are coupled through magnetic intramolecular interactions. This mixing is interrupted by a collision that makes the molecule leave the mixed state and puts it in a pure state, ortho or para, with a non zero probability for both isomeric forms.

Aims. This model allows us to estimate the spin conversion induced by non reactive collisions in different conditions encountered in the interstellar medium.

Methods. We calculated the ortho-para conversion rate in H_2CO for different temperatures and H_2 abundances.

Results. It is shown that the characteristic conversion time is always much longer than the H_2CO lifetime.

Conclusions. Consequently, the conversion probability is zero in gas-phase protostar environments for these non reactive collisions.

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The RMS Survey: Radio observations of candidate massive YSOs in the southern hemisphere

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Context: The Red MSX Source (RMS) survey is a multi-wavelength programme of follow-up observations designed to distinguish between genuine massive young stellar objects (MYSOs) and other embedded or dusty objects, such as ultra compact (UC) HII regions, evolved stars and planetary nebulae (PNe). We have identified nearly 2000 MYSOs candidates by comparing the colours of MSX and 2MASS point sources to those of known MYSOs.
Aims: There are several other types of embedded or dust enshrouded objects that have similar colours as MYSOs and contaminate our sample. Two sources of contamination are from UCHII regions and PNe, both of which can be identified from the radio emission emitted by their ionised nebulae.
Method: In order to identify UCHII regions and PNe that contaminate our sample we have conducted high resolution radio continuum observations at 3.6 and 6 cm of all southern MYSOs candidates ($235^{o} < l < 350^{o}$) using the Australia Telescope Compact Array (ATCA). These observations have a spatial resolution of $\sim$1–2$''$ and typical image rms noise values of $\sim$0.3 mJy − sensitive enough to detect a HII region powered by B0.5 star at the far side of the Galaxy.
Results: Of the 826 RMS sources observed we found 199 to be associated with radio emission, $\sim$25% of the sample. The Galactic distribution, morphologies and spectral indices of the radio sources associated with the RMS sources are consistent with these sources being UCHII regions. Importantly, the 627 RMS sources for which no radio emission was detected are still potential MYSOs. In addition to the 802 RMS fields observed we present observations of a further 190 fields. These observations were made towards MSX sources that passed cuts in earlier versions of the survey, but were later excluded.

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Infrared study of the Southern Galactic star forming region associated with IRAS 14416-5937

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Aims: We have carried out an infrared study of the southern Galactic massive star forming region associated with IRAS 14416-5937.
Methods: This star forming region has been mapped simultaneously in two far infrared bands at $\sim$ 150 & 210 μm using the TIFR 1-m balloon borne telescope with $\sim 1'$ angular resolution. We have used 2MASS JHK$_s$ as well as Spitzer-GLIMPSE data of this region to study the stellar populations of the embedded young cluster. This region comprises of two sources, designated as A & B and separated by $\sim$ 2 pc. The spectrum of a region located close to the source A obtained using the Long Wavelength Spectrometer (LWS) on-board the Infrared Space Observatory (ISO), is presented. Emission from warm dust and from Unidentified Infrared Bands (UIBs) is estimated using the mid-infrared data of the MSX survey.
Results: The spatial distributions of (1) the temperature of cool dust and (2) optical depth at 200 μm have been obtained taking advantage of the similar beams in both the TIFR bands. A number of atomicfine structure lines have been detected in the ISO-LWS spectrum, which have been used to estimate the electron density and the effective temperature of the ionising radiation in this region. From the near and mid infrared images, we identify a dust lane due north-west of source A. The dust lane is populated by Class I type sources. Class II type sources are found further along the dust lane as well as below it. Self consistent radiative transfer models of the two sources (A and B) are in good agreement with the observed spectral energy distributions.
Conclusions: The spatial distribution of young stellar objects in and around the dust lane suggests that active star formation is taking place along the dust lane and is possibly triggered by the expanding HII regions of A and B.

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The BM Ori system. IV. A new component of the system

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Cross correlations between observed and synthetic spectra are used to discover yet another satellite of BM Ori with the following characteristics: effective temperature T_{eff} = 4000 K, radius R = 16$R_\odot$, mass M = 1.8$M_\odot$, spectral type K7 III, absolute bolometric stellar magnitude $M_b = + 4^m.0$, axial rotation velocity V sin$i$ = 85 km/s, and relative luminosity 0.005 near the V band.

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A Large Scale Survey of NGC 1333

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We observed the clustered star forming complex NGC 1333 with the BIMA and FCRAO telescopes in the transitions HCO^+(1–0) and N_2H^+(1–0) over an $11' \times 11'$ area with resolution $\sim 10''$ (0.015 pc). The N_2H^+ emission follows very closely the submillimeter dust continuum emission, while HCO^+ emission appears more spatially extended and also

traces outflows. We have identified 93 N_2H^+ cores using the CLUMPFIND algorithm, and we derive N_2H^+ core masses between 0.05 and 2.5 $M_\odot$, with uncertainties of a factor of a few, dominated by the adopted N_2H^+ abundance. From a comparison with virial masses, we argue that most of these N_2H^+ cores are likely to be bound, even at the lowest masses, suggesting that the cores do not trace transient structures, and implies the entire mass distribution consists of objects that can potentially form stars. We find that the mass distribution of N_2H^+ cores resembles the field star IMF, which suggests that the IMF is locked in at the pre-stellar stage of evolution. We find that the N_2H^+ cores associated with stars identified from Spitzer infrared images have a flat mass distribution. This might be because lower mass cores lose a larger fraction of their mass when forming a star. Even in this clustered environment, we find no evidence for ballistic motions of the cores relative to their lower density surroundings traced by isotopic CO emission, though this conclusion must remain tentative until the surroundings are observed at the same high resolution as the N_2H^+.

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http://astro.phys.unsw.edu.au/∼awalsh/ngc1333.ps.gz

Methanol in the L1551 Circumbinary Torus

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We report observations of gaseous methanol in an edge-on torus surrounding the young stellar object L1551 IRS5. The peaks in the torus are separated by $\sim$ 10,000 AU from L1551 IRS5, and contain $\sim$ 0.03 M_{earth} of cold CH_3OH. We infer that the CH_3OH abundance increases in the outer part of the torus, probably as a result of methanol evaporation from dust grain surfaces heated by the shock luminosity associated with the shocks associated with the jets of an externally located x-ray source. Any methanol released in such a cold environment will rapidly freeze again, spreading CH_3OH throughout the circumbinary torus to nascent dust grains, planitesimals, and primitive bodies. These observations probe the initial chemical conditions of matter infalling onto the disk.

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http://arxiv.org/abs/astro-ph/0609661
http://physics.open.ac.uk/∼gjwhite/L1551methanol.ps
http://physics.open.ac.uk/∼gjwhite/L1551methanol.pdf

The minimum mass for star formation and the origin of binary brown dwarfs

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Context: The minimum mass for star formation is a critical parameter with profound astrophysical, cosmological and anthropic consequences.
Aims: Our first aim is to calculate the minimum mass for *Primary Fragmentation* in a variety of potential star-formation scenarios, i.e. (a) hierarchical fragmentation of a 3-D medium; (b) one-shot, 2-D fragmentation of a shock-compressed layer; (c) fragmentation of a circumstellar disc. By Primary Fragmentation we mean fragmentation facilitated by efficient radiative cooling. Our second aim is to evaluate the role of H_2 dissociation in facilitating

Secondary Fragmentation and thereby producing close, low-mass binaries.
Methods: We use power-law fits to the constitutive physics, a one-zone model for condensing fragments, and the diffusion approximation for radiative transport in the optically thick limit, in order to formulate simple analytic estimates.
Results: (**i**) For contemporary, local star formation, the minimum mass for Primary Fragmentation is in the range 0.001 to 0.004 $M_\odot$, irrespective of the star-formation scenario considered. This result is remarkable since, both the condition for gravitational instability, and the radiation transport regime operating in a minimum-mass fragment, are different in the different scenarios. (**ii**) Circumstellar discs are only able to radiate fast enough to undergo Primary Fragmentation in their cool outer parts ($R \gtrsim 100$ AU). Therefore brown dwarfs should have difficulty forming by Primary Fragmentation at $R \lesssim 30$ AU, explaining the Brown Dwarf Desert. Conversely, Primary Fragmentation at $R \gtrsim 100$ AU could be the source of brown dwarfs in wide orbits about Sun-like stars, and could explain why massive discs extending beyond this radius are rarely seen. (**iii**) H_2 dissociation can lead to collapse and Secondary Fragmentation, thereby converting primary fragments into close, low-mass binaries, with semi-major axes $a \sim 5\,\mathrm{AU}\,(m_{\mathrm{SYSTEM}}/0.1\,M_\odot)$, in good agreement with observation; in this circumstance, the minimum mass for Primary Fragmentation becomes a minimum *system* mass, rather than a minimum *stellar* mass. (**iv**) Any primary fragment can undergo Secondary Fragmentation, producing a close low-mass binary, provided only that the primary fragment is spinning. Secondary Fragmentation is therefore most likely in primary fragments formed in the outer parts of circumstellar discs (since such fragments inevitably spin), and this could explain why a brown dwarf in a wide orbit about a Sun-like star has a greater likelihood of having a brown-dwarf companion than a brown dwarf in the field – as seems to be observed. Moreover, we show that binary brown dwarfs formed in this way can sometimes be ejected into the field without breaking up.

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Synthesis Imaging of Dense Molecular Gas in the N113 H II Region of the Large Magellanic Cloud

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We present aperture synthesis imaging of dense molecular gas in the Large Magellanic Cloud, taken with the prototype millimeter receivers of the Australia Telescope Compact Array (ATCA). Our observations of the N113 H II region reveal a condensation with a size of $\sim 6''$ (1.5 pc) FWHM, detected strongly in the 1-0 lines of HCO^+, HCN, and HNC, and weakly in C_2H. Comparison of the ATCA observations with single-dish maps from the Mopra Telescope and sensitive spectra from the Swedish-ESO Submillimetre Telescope indicates that the condensation is a massive clump of 10^4 $M_\odot$ within a larger $\sim 10^5$ M_{odot} molecular cloud. The clump is centered adjacent to a compact, obscured H II region that is part of a linear structure of radio continuum sources extending across the molecular cloud. We suggest that the clump represents a possible site for triggered star formation. Examining the integrated line intensities as a function of interferometer baseline length, we find evidence for decreasing HCO^+/HCN and HCN/HNC ratios on longer baselines. These trends are consistent with a significant component of the HCO^+ emission arising in an extended clump envelope and a lower HCN/HNC abundance ratio in dense cores.

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Transience of hot dust around sun-like stars

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There is currently debate over whether the dust content of planetary systems is stochastically regenerated or originates in planetesimal belts evolving in quasi-steady state. In this paper a simple model for the steady state evolution of debris disks due to collisions is developed and confronted with the properties of the emerging population of 8 sun-like stars that have hot dust at < 10 AU. The model shows that there is a maximum possible disk mass at a given age, since more massive primordial disks process their mass faster. The corresponding maximum dust luminosity is $f_{\rm max} = 0.16 \times 10^{-3} r^{7/3} t_{\rm age}^{-1}$, where r is disk radius in AU and $t_{\rm age}$ is system age in Myr. The majority (5/8) of the hot disks exceed this limit by a factor $\gg 1000$ and so cannot be the products of massive asteroid belts, rather the following systems must be undergoing transient events characterized by an unusually high dust content near the star: η Corvi, HD69830, HD72905, BD+20307 and HD128400. It is also shown that the hot dust cannot originate in a recent collision in an asteroid belt, since there is also a maximum rate at which collisions of sufficient magnitude to reproduce a given dust luminosity can occur in a disk of a given age. For the 5 transient disks, there is at best a 1:10^5 chance of witnessing such an event compared with 2% of stars showing this phenomenon. Further it is shown that the planetesimal belt feeding the dust in these systems must be located further from the star than the dust, typically at $\gg 2$ AU. Other notable properties of the 5 hot dust systems are: two also have a planetesimal belt at > 10 AU (η Corvi and HD72905); one has 3 Neptune mass planets at < 1 AU (HD69830); all but one exhibit strong silicate features in the mid-IR. We consider the most likely origin for the dust in these systems to be a dynamical instability which scattered planetesimals inwards from a more distant planetesimal belt in an event akin to the Late Heavy Bombardment in our own system, the dust being released from such planetesimals in collisions and possibly also sublimation. Further detailed study of the planet, planetesimal and dust populations in these rare objects has the potential to uncover the chaotic evolutionary history of these systems and to shed light on the history of the solar system.

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Star-Disk Coupling by a Time-varying Magnetic Field

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Observations suggest that stars lose appreciable angular momentum prior to reaching the main sequence. Two principal spin-down mechanisms have been proposed. One is removal of angular momentum by magnetized winds or jets; the other is transfer of angular momentum from the star to its accretion disk through the effects of magnetic fields. In the latter case, spin evolution occurs due to both mass accretion along field lines and torques resulting from coupling of the stellar magnetic field to the disk. In this paper we study the latter torques in the context of a magnetic field varying in time. We find that magnetic variability reduces the efficiency with which the field can wind up, somewhat widening the region of magnetic coupling. Nonetheless, the steady state result–that magnetic torques can be applied only within a thin annulus around the corotation radius–is little changed for what we believe to be realistic physical conditions. These results are generally applicable to disk accretion onto magnetized bodies.

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Pulsating pre-main sequence stars in IC 4996 and NGC 6530

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Context. Asteroseismology of pulsating pre-main sequence (PMS) stars has the potential of testing the validity of current models of PMS structure and evolution. As a first step, a sufficiently large sample of pulsating PMS stars has to be established, which allows to select candidates optimally suited for a detailed asteroseismological analysis based on photometry from space or ground based network data.

Aims. A search for pulsating PMS members in the young open clusters IC 4996 and NGC 6530 has been performed to improve the sample of known PMS pulsators. As both clusters are younger than 10 million years, all members with spectral types later than A0 have not reached the zero-age main sequence yet. Hence, IC 4996 and NGC 6530 are most suitable to search for PMS pulsation among their A- and F-type cluster stars.

Methods. CCD time series photometry in Johnson B and V filters has been obtained for IC 4996 and NGC 6530. The resulting light curves for 113 stars in IC 4996 and 194 stars in NGC 6530 have been subject to detailed frequency analyses.

Results. 2 δ Scuti-like PMS stars have been discovered in IC 4996 and 6 in NGC 6530. For another PMS star in each cluster, pulsation can only be suspected. According to the computed pulsation constants, the newly detected PMS stars seem to prefer to pulsate in a similar fashion to the classical δ Scuti stars, and with higher overtone modes.

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Chemical Evolution of Ice and Gas from Molecular Clouds to Protostars

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Ph.D dissertation directed by: Neal Evans and John Lacy

Ph.D degree awarded: August 2006

We present observations toward stars behind molecular clouds (background stars) and toward massive protostars in order to study the chemical evolution in molecular clouds before and during star formation. Infrared absorption spectroscopy with the *Spitzer Space Telescope* toward background stars shows that complex ices exist toward lines of sight not associated with star formation. In addition to solid H_2O, CO, and CO_2, we find evidence for HCOOH and a tentative identification of NH_4^+. We also find that the 6.0 μm H_2O band changes when mixed with CO_2 in high concentrations. These results give the initial composition of solid material prior to star formation.

Once the star formation process ensues, the icy grain mantles sublimate due to heating from the protostar. We present gas-phase, infrared absorption spectroscopy using TEXES, a high-resolution spectrograph, toward the massive protostars NGC 7538 IRS 1 and AFGL 2591. While we only detect two molecules (C_2H_2 and HCN) toward AFGL 2591, NGC 7538 IRS 1 shows a very rich mid-infrared spectrum with absorption from seven molecules (C_2H_2, HCN, CH_3, HNCO, NH_3, CH_4, and CS). We present the first infrared detection of interstellar HNCO as well as the first detection of CH_3 in dense gas. Sublimation of icy mantles can explain the observed enhancement of molecules formed on grains such as CH_4, NH_3, and HNCO. Other species such as C_2H_2 are also enhanced though its formation is less certain. It is possible that C_2H_2 also forms on grains though no evidence of solid C_2H_2 has been found to date. Daughter molecules such as CH_3 are also found in high abundance toward NGC 7538 IRS 1. The gas observations presented in this work could be tracing material in a disk or material that, at some point in time, was part of a circumstellar disk. By combining observations of gas and ice compositions, we can begin to understand the chemical evolution from quiescent molecular clouds to protostars.

http://www.claudiaknez.org/Thesis

The primordial binary population in the association Sco OB2

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Ph.D dissertation directed by: Lex Kaper, Anthony Brown, Simon Portegies Zwart, and Ed van den Heuvel

Ph.D degree awarded: September 2006

Observations over the last decade have indicated that a large fraction of the stars are part of a binary or multiple system. For our understanding of star formation it is therefore of crucial importance to characterise the outcome of the star forming process in terms of binary parameters. In this thesis we aim to recover the primordial binary population, which is defined as *the population of binaries as established just after the gas has been removed from the forming system, i.e., when the stars can no longer accrete gas from their surroundings*. OB associations are the prime targets for finding the primordial binary population. Due to their youth (5–50 Myr) and low stellar density (< 0.1 M$_\odot$ pc^{-3}), the effects of stellar evolution and dynamical interactions have only modestly effected the binary population since the moment of gas expulsion.

In this thesis we study the nearest (118–145 pc) young (5–20 Myr) association Sco OB2. We first recover the *current* binary population in Sco OB2 using a literature study, and extend the dataset with two (ADONIS and NAOS-CONICA) adaptive optics binarity surveys. By modeling the selection effects of visual, eclipsing, spectroscopic, and astrometric binary surveys in the available dataset, and comparing the simulated observations of model associations to the real observations, we recover the current binary population of Sco OB2.

Our results indicate that simulated observations of models with a binary fraction of 100% are most consistent with the observations ($> 70\%$ at the 3σ confidence level). The observed mass ratio distribution among binaries with primary spectral type A and B is consistent with an intrinsic distribution $f_q(q) \propto q^{-0.4\pm0.2}$, while random pairing between binary components is excluded. The semi-major axis distribution has the form $f_a(a) \propto a^{-1.0\pm0.15}$, while the log-normal period distribution of Duquennoy & Mayor (1991) is inconsistent with the observations. The observed eccentricity distribution, although poorly constrained by observations, is consistent with a flat distribution.

Our study further indicates a very small brown dwarf companion frequency, as well as a small substellar-to-stellar companion frequency among A and B type stars. These properties, often referred to as the *brown dwarf desert*, are a natural result of the mass ratio distribution in Sco OB2. If star formation results in a mass ratio distribution of the above form, the embryo ejection scenario is not necessary to explain the small number of brown dwarf companions. Our results suggest that brown dwarfs form like stars, and that the brown dwarf desert can be ascribed to an excess of planetary companions, rather than by a lack of brown dwarf companions.

Due to the youth and low stellar density of Sco OB2, one expects that stellar and dynamical evolution have only mildly affected its binary population since the moment of gas removal. The current binary population of Sco OB2 is thus very similar to its primordial binary population. The major result presented in this thesis, i.e. that practically all intermediate mass stars have formed in a binary or multiple system, provides fundamental information to our understanding of the star forming process.

http://dare.uva.nl/en/record/195643 (a printed version of the thesis is available on request)

Gas Evolution and Energization by Supernovae in Regions of Intense Star Formation

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Ph.D dissertation directed by: Elisabete M. de Gouveia Dal Pino

Ph.D degree awarded: October 2006

In this work, galactic environments characterized by a high star formation rate (SBs) and by a strongly energized gas due to supernova (SN) explosions are investigated. In order to understand the gas evolution from the smallest (few parsec) to the largest scales (several kpc), analytical and numerical models have been developed. First, we have studied the interactions between clouds (with radius $r \sim 0.1$ pc) and SN shock fronts in the interstellar medium (ISM), performing three-dimensional chemo-hydrodynamical simulations. The results have shown that due to radiative cooling, the interactions produce elongated, cold filamentary clouds, instead of causing their complete destruction by Rayleigh-Taylor and Kelvin-Helmholtz instabilities. The simulations have also revealed a substantial mass loss from the clouds to the diffuse ISM only when a photoionizing flux from the hot stars is present. These results, together with a detailed study of the clouds loss rate by photoevaporation, thermal evaporation and drag by the interstellar gas, were employed in the construction of a semi-analytical model which was able to qualitatively trace the thermalisation history of the ISM in a SB region with a typical size of few 100 pc, and to determine the heating efficiency (HE) of the SNe, i.e., the fraction of the SNe energy which is not radiated away. Low HE values (~ 0) mean that most of the SN energy is radiated away, while high HE values (~ 1) mean that most of the SN energy is stored into the gas. We have found that HE has a time-dependent trend that is sensitive mainly to the initial total gas mass of the SB region, and remains very small during the first 16 Myr of the SB activity (with a lifetime ~ 30 Myr). After this time, the gas temperature increases to 10^6 K in ~ 0.5 Myr. This efficient gas heating may cause its complete removal from the system and also favour a rapid dispersion of the stars that formed during the star burst. In fact, we have shown that a high rate of SN explosions may lead to a premature death of evolving young stellar clusters, particularly in SB and interacting galaxies, and this dispersion can explain the increase in the amount of field stars in these galaxies. Through an analytical study accompanied by fully 3-D chemo-hydrodynamical numerical simulations we have also shown that shock interactions between supernova remnants (SNRs) and giant molecular clouds (GMCs) may enhance the star formation rate under some circumstances, creating favourable conditions for the shocked gas to become gravitationally unstable. In particular, we have built a diagram of the SNR radius versus the clouds density in which the physical conditions of the impact constrain a shaded zone where star formation is allowed. Finally, we have studied the gas evolution after being energized by SNe explosions, when it expands into a superbubble and is ejected outside the galactic disk. Depending on the amount of energy that is injected by the SNe, the gas may become a galactic wind or simply generate a galactic fountain. In a galactic fountain, the ejected gas is re-captured by the gravitational potential, and falls back onto the galactic disk. We have investigated the formation of galactic fountains with the help of 3-D hydrodynamical adiabatic numerical simulations, where we have built a computational domain with similar characteristics to those of our Galaxy and exploded a number of SNe within a stellar cluster in the disk, outside the nuclear region. These calculations, though preliminary, have shown that the presence of the galactic rotation may inhibit the gas ejection to high latitudes. Also, the gas flux generated during these events may favour the development of turbulence and the spread of the metals which were originally concentrated in the SB region where the SNe exploded. The results obtained in this work have revealed a possible hierarchy of the physical processes in the evolution of the galactic gas, with the characteristic phenomena of the small scales ($\sim$ pc) driving the phenomena of the larger scales ($\sim$ 100 pc$-$kpc). Further and more detailed studies on the formation of superbubbles, winds, galactic fountains and turbulence, taking into account the effects of radiative cooling, magnetic fields, and even higher numerical resolutions are still needed.

http://www.teses.usp.br

Growing and Moving Planets in Disks

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Ph.D dissertation directed by: Vincent Icke and Garrelt Mellema

Ph.D degree awarded: September 2006

The interaction of a planet with the protoplanetary disk from which it formed is an important process in planet formation theory, because it determines the final shape of the planetary system in terms of masses and orbits. In this thesis, we explore the nature of the intimate relationship between planet and disk by means of numerical hydrodynamical simulations.

For this thesis, we have developed a new numerical method (RODEO, a ROe solver for Disk Embedded Objects). It derives from a general relativistic method, and it inherits some interesting features from general relativistic hydrodynamics. For example, gravity, which is merely a geometrical effect in general relativity, fits in very naturally in the method. Also, because of the covariant formulation, the method can handle arbitrary spatial coordinates, in two and in three dimensions. It can operate in two-fluid mode, which was used to treat a disk consisting of gas and dust. There is also a particle module for simulating larger dust boulders. Radiative transfer is included in the flux-limited diffusion approach.

We start by investigating one side of the relationship between planet and disk, namely how the disk is influenced by the presence of a planet. It is well known that massive planets (comparable to Jupiter) open up deep gaps in the disk. These gaps are very interesting, also from an observational point of view. It is therefore very important to find out which planets open up gaps and which do not. We show that while it takes a Jupiter-mass planet to open up a gap in the *gas* disk, it takes only a planet of a twenty times lower mass to open up a gap in the mm-size dust distribution. These dust particles emit at mm-wavelengths, and these dust gaps may therefore be observed with future mm-telescopes like ALMA.

On the other side of the relationship we find that the planet's growth and movement are severely affected by interaction with the disk. Deep gaps opened up by high-mass planets prevent them from reaching masses higher than approximately five times Jupiter's mass. The dust gaps in turn prevent dust accretion onto high-mass planets. This has severe implications on the final composition of the planet.

Inward migration of planets is now widely accepted as the mechanism to form Hot Jupiters. There is a time scale problem, however: migration theory predicts that essentially all low-mass planets should fall into the central star before their formation process is completed. This theory makes several important assumptions about the disk; for example, there are no magnetic fields. It has also been common practise in the study of planet-disk interaction to work with an isothermal equation of state: the temperature remains constant during the simulations. We explore the effects of releasing this assumption by means of radiation-hydrodynamical simulations of embedded low-mass planets. We find that when the disk can not cool efficiently through radiation, inward migration stops or is even reversed. Only in regions of low opacity does the usual inward migration take place. Therefore, the dense inner regions of protoplanetary disks can act as a safety net for migrating low-mass planets.

It is advantageous not to have the planet moving through the computational grid, because this introduces unwanted diffusion. Therefore one usually works in a rotating coordinate frame, which rotates with the angular velocity of the planet. When the planet is allowed to migrate radially, however, it again starts to move through the grid. We have used the ability of the method to handle arbitrary spatial coordinates to simulate eccentric and migrating planets while keeping the planet at a fixed loacation on the grid. We show that especially at low eccentricities this new coordinate frame gives more reliable results.

Finally, we have looked at dust-gas interaction in transitional disks that have lost most of their gas. When the dust-to-gas ratio approaches unity, streaming instabilities develop. We investigate the formation of planetary gaps in this regime, which is important for observations of these disks. We show that the combined effect of dust-gas interaction, radiation pressure and a perturbing planet can account for much of the structure seen in the transitional disk HD 141569.

New Jobs

Submillimeter Array Postdoctoral Fellowships 2007 Smithsonian Astrophysical Observatory

The Submillimeter Array, a collaborative project of the Smithsonian Astrophysical Observatory and the Academia Sinica Institute of Astronomy and Astrophysics (Taiwan), is a radio-interferometer located at an altitude of 4,000 m near the summit of Mauna Kea, Hawaii. It consists of eight six-meter diameter antennas configurable to achieve sub-arcsecond resolution and is in routine operation in two low-frequency atmospheric windows centered at 220 and 300 GHz, and a high frequency window at 650 GHz. The SMA is now being equipped with receivers that will extend the low frequency coverage up to 430 GHz and enable enhanced polarization capability throughout the 330-350 GHz frequency range. For more information about the SMA, see http://sma-www.cfa.harvard.edu

Applications are invited for two SMA postdoctoral fellowships beginning in the fall of 2007. Fellowships are for a period of two years, with the possibility of a one-year extension. These positions are aimed chiefly at research in submillimeter astronomy, and the successful candidates are expected to propose and participate in science observations with the SMA. The current major areas of study include: the formation, kinematics, and chemistry of protostellar disks and outflows, AGN's, energetics of normal and luminous galaxies, and solar system studies. It is expected that both positions will be based at the Harvard Smithsonian Center for Astrophysics in Cambridge. However, candidates with a desire to be located at the SMA facility at the University of Hawaii, Hilo, are also encouraged to apply.

Applicants must have a recent Ph.D. in astronomy or a related field. Practical experience in millimeter or submillimeter wavelength astronomy, radio interferometry, instrumentation, or experience in any applicable branch of astrophysical theory is desirable. Questions should be directed to David Wilner, dwilner@cfa.harvard.edu. Applications, including a curriculum vita, statement of research interest, and three letters of recommendation should be sent to Jennifer Barnett before 15 December 2006 for full consideration. Note that applicants for other CfA fellowships are not automatically forwarded to the SMA Fellowship Selection Committee. AAE/EOE.

Submission Address for Resumes/CVs:
Jennifer Barnett
SMA Postdoctoral Fellowship
Smithsonian Astrophysical Observatory
60 Garden Street, MS 42
Cambridge, MA 02138
USA
E-mail: jbarnett@cfa.harvard.edu

Postdoctoral research position in star and/or planet formation

Applications are invited for a postdoctoral research position at the University of Geneva (Geneva Observatory and its affiliated Integral Science Data Centre) to start as soon as possible.

The successful candidate will be member of a new research group led by Prof. Marc Audard in the field of star formation. The group will work on a project to study physical processes in disks around young stars through multi-wavelength observations and/or theoretical modeling. In particular, research efforts focus on understanding high-energy processes in young stars and their impact on the circumstellar disk and on planet formation.

Applicants with an observational (infrared, millimeter, or X-rays) or theoretical background in star and/or planet formation are particularly encouraged to apply. The successful candidate is expected to collaborate with the group but will also be encouraged to pursue independent research.

The appointment will be for two years, with possible extensions up to four years, contingent on funding and performance. Funds for research expenses are available as well.

Candidates should send a curriculum vitae, a publication list, a description of research interests and plans. They should also arrange for three letters of recommendation to be sent by e-mail (preferred; Marc.Audard@obs.unige.ch) or directly to Prof. Marc Audard, ISDC/Geneva Observatory, Ch. d'Ecogia 16, 1290 Versoix, Switzerland (Tel: +41 22 379 2166). Applications will be accepted until the position is filled.

From Stars to Planets - Connecting our Understanding of Star and Planet Formation (2nd Announcement)

University of Florida, Gainesville Wed. 11th - Sat. 14th April 2007

Recent advances in the observations of extra-solar planets and protoplanetary disks have been dramatic. However, theories to explain the properties of these planetary systems remain in their infancy. At the same time, star formation research has seen significant progress, particularly in the recognition of the importance of clustered star formation, in the measurement of the lifetimes of circumstellar disks in such clustered regions, and in the determination of the initial mass function down to sub-stellar mass scales.

This conference aims to bring together researchers from the star and planet formation communities to help them better understand the recent observational advances in each of these fields and make connections between the physical mechanisms responsible for star and planet formation. We expect the discussions to help motivate future observational tests of theoretical ideas.

The conference will be held at the University of Florida, located in Gainesville, within 2 hours drive of Orlando, Tampa, Jacksonville, St. Augustine, and the Atlantic and Gulf Coasts. The weather in April is dry, sunny and warm.

Confirmed participants include: Fred Adams, John Bally, Matthew Bate, Ted Bergin, Alan Boss, Eugene Chiang, Stanley Dermott, Neal Evans, Eric Feigelson, Eric Ford, Adam Frank, Charles Gammie, Jian Ge, Bo Gustafson, Karl Haisch, Lynne Hillenbrand, David Hollenbach, Ray Jayawardhana, Mark Krumholz, Charles Lada, Elizabeth Lada, Doug Lin, Mike Liu, Kevin Luhman, Eduardo Martin, Chris Matzner, Lucio Mayer, Michael Meyer, Amaya Moro-Martin, August Muench, Phil Myers, Ralph Pudritz, Roman Rafikov, Frank Shu, Keivan Stassun, Jonathan Tan, Charles Telesco, Ewine van Dishoeck, Jonathan Williams, Mark Wyatt, Andrew Youdin and Hans Zinnecker.

If you are interested in attending the conference please visit the website

http://conference.astro.ufl.edu/STARSTOPLANETS/

review the scientific program and submit your proposed title and abstract by December 1st 2006. These will be reviewed by the SOC as the basis for selection of participants, whose total number is limited to 120.

Best regards,

The SOC

Elizabeth Lada (co-chair, UF), Jonathan Tan (co-chair, UF), Fred Adams (Michigan), Stanley Dermott (UF), Eric B. Ford (Berkeley/CfA/UF), Jian Ge (UF), Lynne Hillenbrand (Caltech), Doug Lin (UCSC), Charles Telesco (UF), Jonathan Williams (Hawaii), Andrew Youdin (Princeton/CITA).

First Announcement

JETSET School and Workshop no. 3

Numerical MHD and Instabilities: Visualization Techniques and Virtual Reality

Turin, Italy, 8-13 January 2007

Scientific Aims: The third school and workshop in the framework of the Marie-Curie Research Training Network JETSET is organised by the Turin node. The main topic of the school is "Numerical MHD and Instabilities", with a special session dedicated to visualization techniques and virtual reality. The first JETSET school (Villard-de-Lans, France, January 2006) was dedicated to jet theories and models whereas the second school (Marciana Marina, Elba, Italy, September 2006) had high angular resolution observations as the topic. High angular resolution observations now provide information on the region close to the YSO and thus a great challenge is posed to the numerical models to reproduce such observations through high resolution simulations. The comparison between observational data and simulation results will test the theories and give us a better understanding of the jet propagation and acceleration mechanisms.

We aim to provide an insight to the field of numerical methods, starting with the fundamentals. Hence we offer an excellent opportunity to participants not working in this field to learn the basics. The school will be an overview of the numerical treatment of the MHD equations, i.e. the methods used, the physics taken into account, and the approximations introduced by the numerical models. The non-ideal effects, now available in a number of numerical codes due to more sophisticated algorithms and increased computer power availability, will also be discussed. Moreover, the school intends to review the capabilities and robustness of the "competing" algorithms of the numerical codes devised for astrophysical problems. Thus informing the users about their possible uses and limitations. In summary we will embrace the spirit of the JETSET schools, that is to facilitate the exchange of information between observers, theoreticians and simulation software developers.

Scientific Organizing Committee: S. Massaglia, G. Bodo, S. Cabrit, C. Dougados, T. Downes A. Ferrari, T. Lery, T. Ray, P. Rossi, E. Trussoni, K. Tsinganos

Local Organizing Committee: P. Rossi, S. Massaglia, T. Matsakos, A. Mignone, O. Tesileanu

For a preliminary program and further details, see **http://jetset2007.ph.unito.it**

Structure Formation in the Universe: Galaxies, Stars, Planets

Chamonix, France 27 May - 1 June 2007

This is the **second announcement** of the conference *"Structure formation in the universe"*, to be held in Chamonix, France from 27 May through 1 June 2007. The aim of the conference is to bring together researchers working in the fields of planet, star and galaxy formation in order to share their expertise and to address common physical and numerical issues in the understanding of structure formation in astrophysics.

The **registration**, with the possibility to submit a poster presentation, is **now open**, with the hotel reservation. Chamonix is a very touristic location so booking as early as possibly is recommended. All information of the conference website.

Scientific rationale, final program and list of speakers on: **http://chamonix2007.ens-lyon.fr/**

Organizer and contact: **G. Chabrier (ENS-Lyon; chabrier@ens-lyon.fr)**

New Books

The Birth of Stars and Planets

by John Bally and Bo Reipurth

This book was motivated by a desire to provide access for a wider audience to the amazing developments we have seen in recent years in the fields of star and planet formation, the early solar system, and meteoritics. Written in a non-technical language, the book allows the layman to follow the complex processes that underlie the birth of stars and planets. The book is heavily illustrated, with many full page color photos, in an effort to express also the aesthetic side of research in early stellar evolution.

The book contains the following chapters:

Part I - Stars and Clusters

1. Our Cosmic Backyard
The big questions - Stars: beacons and building blocks - A 14-billion-year-old expanding Universe

2. Looking Up at the Night Sky
The golden age of astronomy - Telescopes - Opening the spectrum - Space - Instruments and computers

3. The Dark Clouds of the Milky Way
Dark clouds and the structure of our Milky Way galaxy - Molecular clouds - Cores, dust, and chemistry - Dark clouds: cradles of stars

4. Infant Stars
The cold Universe: far-infrared and sub-millimeter observations - The search for newborn stars - Protostars and spinning disks - Observations of protostars - The initial mass function - Energy sources of protostars

5. Companions in Birth: Binary Stars
Binary stars - Young binaries and multiples - The birth of binaries - Disintegration of multiple stellar systems - Competition in small stellar systems

6. Outflows from Young Stars
The objects of Herbig and Haro - Jets from newborn stars - Churning dark clouds - Properties of outflows - The ins and outs of young stars

7. Towards Adulthood
Properties of young stars - Circumstellar disks - Eruptions - Farewell to disks - Adolescence: spots, flares, and X-rays - Herbig Ae/Be stars

8. The Social Life of Stars: Stellar Groups
Associations: a loose brotherhood of stars - Into the void - The birth of clusters: ties that bind - Super star clusters and globular clusters - The life and death of a cluster

9. Chaos in the Nest: The Brief Lives of Massive Stars
Massive stars: live fast, die young - Hot bubbles, silverlined clouds and elephant trunks - An overview of the Orion region - When star death triggers star birth - A history of star birth in Orion - Orion blows a bubble - The ejected runaway stars - Giant star-forming regions

Part II - Planetary Systems

10. Solar Systems in the Making
Knowing our own backyard: the Solar System - Ice, dust, rocks, and planetesimals - The birth of planets - Moons and rings everywhere - Pluto and the Kuiper Belt - Pristine material: comets and the Oort cloud - The zodiacal light and debris disks around other stars

11. Messengers from the Past
Finding meteorites in cold and hot deserts - Types of meteorites - Meteorites as interplanetary flotsam - Parent bodies and left-over planetesimals - Bull's-eyes and near misses

12. Hazards to Planet Formation
Young stars and disks in Orion - Evaporating disks - Clusters and collisions - Supernovae and disks - Can planetary systems form in proplyds? - Towards a variety of planetary systems

13. Planets around Other Stars
The quest for other worlds - Giant planets and wobbling stars - Planets in silhouette - Gravity's lens - The odd pulsar planets - Extrasolar gas giants and their host stars - Future telescopes in space and the quest for exo-planets

Part III - The Cosmic Context

14. Cosmic Cycles
Light, winds, explosions - Evolution and death of low to intermediate mass stars - Evolution and death of massive stars - Supernova remnants, superbubbles, massive shells, and giant rings - Formation of molecular clouds: a new beginning - The Gould's Belt: a fossil record of formation - From the ashes of the old: new clouds, new stars

15. Star Formation in Galaxies
Giant islands in the sky: the galaxies - Star formation in spiral galaxies - The center of our Milky Way - Colliding galaxies: star formation in the extreme - Nuclear starbursts: the power of giant black holes - Extragalactic jets: analogs of protostellar jets?

16. The First Stars and Galaxies
The cosmic microwave background - The first clouds - The first stars - The formation and evolution of galaxies

17. Astrobiology, Origins, and SETI
Astrobiology and the origins of life - The light of life - Messages from the deep? - Finale

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