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Abstracts of recently accepted papers

Self-similar evolutionary solutions of self-gravitating, polytropic β-viscous disks

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Aims. We investigate the β-prescription for viscosity in standard self-gravitating thin disks and predict that in a self-gravitating thin disk the β-model will have a different dynamical behavior compared to the well-known α-prescription.

Methods. We used self-similar methods to solve the integrated equations that govern the dynamical behavior of the thin disk.

Results. We present the results of self-similar solutions of the time evolution of axisymmetric, polytropic, self-gravitating viscous disks around a new-born central object. We apply a β-viscosity prescription derived from rotating shear flow experiments ($\nu = \beta r^2 \Omega$). Using reduced equations in a slow accretion limit, we demonstrate inside-out self-similar solutions after core formation in the center. Some physical quantities for β-disks are determined numerically. We compare our results with α-disks under the same initial conditions. The accretion rate onto the central object for β-disks is grater than for α-disks in the outer regions where β-disks are more efficient. Our results show that the Toomre instability parameter is less than one everywhere on the β-disk which means that in such disks gravitational instabilities can occur, so the β-disk model can be a good candidate for the origin of planetary systems. Our results show that the β-disks will decouple in the outer part of the disk where self-gravity plays an important role, in agreement with theoretical predictions.

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The depletion of NO in pre–protostellar cores

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Understanding the depletion of heavy elements is a fundamental step towards understanding the structure of pre–protostellar cores just prior to collapse. We study the dependence of the NO abundance on position in the pre–protostellar cores L1544 and L183. We observed the 150 GHz and 250 GHz transitions of NO towards L1544 and L183 using the IRAM 30-m telescope. We compare the variation of the NO column density with position in these objects with the H column density derived from dust emission measurements. We find that NO behaves differently from N_2H^+

and appears to be partially depleted in the high density core of L1544. Other oxygen containing compounds are also likely to be depleted in dense–core nuclei. The principal conclusions are that the prestellar core L1544 is likely to be 'carbon rich', the nitrogen chemistry did not reach equilibrium prior to graviational collapse and nitrogen is initially (at densities of the order of 10^4 cm^{-3}) mainly in atomic form. The grain sticking probabilities of atomic C, N, and probably O are significantly smaller than unity

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Dust dynamics during protoplanetary disc clearing

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We consider the dynamics of dust and gas during the clearing of protoplanetary discs. We work within the context of a photoevaporation/viscous model for the evolution of the gas disc, and use a two-fluid model to study the dynamics of dust grains as the gas disc is cleared. Small ($\lesssim$10μm) grains remain well-coupled to the gas, but larger ($\sim$ 1mm) grains are subject to inward migration from large radii ($\sim$ 50AU), suggesting that the time-scale for grain growth in the outer disc is $\sim 10^4$–10^5yr. We describe in detail the observable appearance of discs during clearing, and find that pressure gradients in the gas disc result in a strong enhancement of the local dust-to-gas ratio in a ring near to the inner disc edge. Lastly, we consider a simple model of the disc-planet interaction, and suggest that observations of disc masses and accretion rates provide a straightforward means of discriminating between different models of disc clearing.

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The mass function of dense molecular cores and the origin of the IMF

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Context: Stars form in the cold dense cores of interstellar molecular clouds and the detailed knowledge of the spectrum of masses of such cores is clearly a key for the understanding of the origin of the IMF. To date, observations have presented somewhat contradictory evidence relating to this issue. *Aims*: In this paper we propose to derive the mass function of a complete sample of dense molecular cores in a single cloud employing a robust method that uses uses extinction of background starlight to measure core masses and enables the reliable extension of such measurements to lower masses than previously possible. *Methods*: We use a map of near-infrared extinction in the nearby Pipe dark cloud to identify the population of dense cores in the cloud and measure their masses. *Results*: We identify 159 dense cores and construct the mass function for this population. We present the first robust evidence for a departure from a single power-law form in the mass function of a population of cores and find that this mass function is surprisingly similar in shape to the stellar IMF but scaled to a higher mass by a factor of about 3. This suggests that the distribution of stellar birth masses (IMF) is the direct product of the dense core mass function and a uniform star formation efficiency of 30%±10%, and that the stellar IMF may already be fixed during or before the earliest stages of core evolution. These results are consistent with previous dust continuum studies which suggested that the IMF directly originates from the core mass function. The typical density of $\sim$$10^4$ cm^{-3} measured for the dense cores in this cloud suggests that the mass scale that characterizes the dense core mass function may be the result of a simple process of thermal (Jeans) fragmentation.

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http://arxiv.org/abs/astro-ph/0612126

Magnetocentrifugal Winds in Three Dimensions: A Nonaxisymmetric Steady State

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Outflows can be loaded and accelerated to high speeds along rapidly rotating, open magnetic field lines by centrifugal forces. Whether such magnetocentrifugally driven winds are stable is a long-standing theoretical problem. As a step toward addressing this problem, we perform the first large-scale 3D MHD simulations that extend to a distance $\sim 10^2$ times beyond the launching region, starting from steady 2D (axisymmetric) solutions. In an attempt to drive the wind unstable, we increase the mass loading on one half of the launching surface by a factor of $\sqrt{10}$ and reduce it by the same factor on the other half. The evolution of the perturbed wind is followed numerically. We find no evidence for any rapidly growing instability that could disrupt the wind during the launching and initial phase of propagation, even when the magnetic field of the magnetocentrifugal wind is toroidally dominated all the way to the launching surface. The strongly perturbed wind settles into a new steady state, with a highly asymmetric mass distribution. The distribution of magnetic field strength is, in contrast, much more symmetric. We discuss possible reasons for the apparent stability, including stabilization by an axial poloidal magnetic field, which is required to bend field lines away from the vertical direction and produce a magnetocentrifugal wind in the first place.

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High Resolution Submillimeter Constraints on Circumstellar Disk Structure

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We present a high spatial resolution submillimeter continuum survey of 24 circumstellar disks in the Taurus-Auriga and Ophiuchus-Scorpius star formation regions using the SMA. In the context of a simple model, we use broadband spectral energy distributions and submillimeter visibilities to derive constraints on some basic parameters that describe the structure of these disks. For the typical disk in the sample we infer a radial surface density distribution $\Sigma_r \propto r^{-p}$ with a median $p \approx 0.5$, although consideration of the systematic effects of some of our assumptions suggest that steeper distributions with $p \approx 1$ are more reasonable. The distribution of the outer radii of these disks shows a distinct peak at $R_d \approx 200\,\mathrm{AU}$, with only a few cases where the disk emission is completely unresolved. Based on these disk structure measurements, the mass accretion rates, and the typical spectral and spatial distributions of submillimeter emission, we show that the observations are in good agreement with similarity solutions for steady accretion disks that have a viscosity parameter $\alpha \approx 0.01$. We provide new estimates of the spectral dependence of the disk opacity $\kappa_\nu \propto \nu^\beta$ with a mean $\beta \approx 1.0$, corrected for optically thick emission. This typical value of β is consistent with model predictions for the collisional growth of solids to millimeter size scales in the outer disk. Although direct constraints on planet formation in these disks are not currently available, the extrapolated density distributions inferred here are substantially shallower than those calculated based on the solar system or extrasolar planets and typically used in planet formation models. It is possible that we are substantially underestimating disk densities due to an incomplete submillimeter opacity prescription.

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The XMM-Newton Optical Monitor Survey of the Taurus Molecular Cloud

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The Optical Monitor (OM) on-board XMM-Newton obtained optical/ultraviolet data for the XMM-Newton Extended Survey of the Taurus Molecular Cloud (XEST), simultaneously with the X-ray detectors. With the XEST OM data, we aim to study the optical and ultraviolet properties of TMC members, and to do correlative studies between the X-ray and OM light curves. In particular, we aim to determine whether accretion plays a significant role in the optical/ultraviolet and X-ray emissions. The Neupert effect in stellar flares is also investigated. Coordinates, average count rates and magnitudes were extracted from OM images, together with light curves with low time resolution (a few kiloseconds). For a few sources, OM FAST mode data were also available, and we extracted OM light curves with high time resolution. The OM data were correlated with Two Micron All Sky Survey (2MASS) data and with the XEST catalogue in the X-rays. The XEST OM catalogue contains 2,148 entries of which 1,893 have 2MASS counterparts. However, only 98 entries have X-ray counterparts, of which 51 of them are known TMC members and 12 additional are TMC candidates. The OM data indicate that accreting stars are statistically brighter in the U band than non-accreting stars after correction for extinction, and have U-band excesses, most likely due to accretion. The OM emission of accreting stars is variable, probably due to accretion spots, but it does not correlate with the X-ray light curve, suggesting that accretion does not contribute significantly to the X-ray emission of most accreting stars. In some cases, flares were detected in both X-ray and OM light curves and followed a Neupert effect pattern, in which the optical/ultraviolet emission precedes the X-ray emission of a flare, whereas the X-ray flux is proportional to the integral of the optical flux.

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On the Relative Motions of Dense Cores and Envelopes in Star-Forming Molecular Clouds

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Hydrodynamical simulations of star formation indicate that the motions of protostars through their natal molecular clouds may be crucial in determining the properties of stars through competitive accretion and dynamical interactions. Walsh, Myers & Burton recently investigated whether such motions might be observable in the earliest stages of star formation by measuring the relative shifts of line-centre velocities of low- and high-density tracers of low-mass star-forming cores. They found very small (~ 0.1 km s^{-1}) relative motions. In this paper, we analyse the hydrodynamical simulation of Bate, Bonnell & Bromm and find that it also gives small relative velocities between high-density cores and low-density envelopes, despite the fact that competitive accretion and dynamical interactions occur between protostars in the simulation. Thus, the simulation is consistent with the observations in this respect. However, we also find some differences between the simulation and the observations. Overall, we find that the high-density gas has a higher velocity dispersion than that observed by Walsh et al. We explore this by examining the dependence of the gas velocity dispersion on density and its evolution with time during the simulation. We find that early in the simulation the gas velocity dispersion decreases monotonically with increasing density, while later in the simulation, when the dense cores have formed multiple objects, the velocity dispersion of the high-density gas increases. Thus, the simulation is in best agreement with the observations early on, before many objects have formed in each dense core.

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Investigating the Nature of Variable Class I and Flat Spectrum Protostars Using 2-4 Micron Spectroscopy

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In this study I present new K and L′-band infrared photometry and 2-4μm spectra of ten Class I and flat spectrum stars forming within the Taurus dark cloud complex. Nine sources have H_2 v=0-1 S(1) emission, and some show multiple H_2 emission features in their K-band spectra. Photospheric absorptions characteristic to low mass stars are detected in five of the targets, and these stars were fit with models to determine spectral type, infrared accretion excess veiling (r_K and $r_{L'}$) and dust temperatures, estimates of visual extinction and characteristics of the 3μm water-ice absorption. On average, the models found high extinction values, infrared accretion excess emission with blackbody temperatures in the 900-1050K range, and 3μm absorption profiles best fit by water frozen onto cold grains rather than thermally processed ice. Five techniques were used to estimate the extinction toward the stellar photospheres; most gave vastly different results. Analysis of emission line ratios suggests that the effect of infrared scattered light toward some protostars should not be neglected. For stars that exhibited Brγ in emission, accretion luminosities were estimated using relations between L_{acc} and Brγ luminosity. The young stars in this sample were preferentially chosen as variables, but they do not have the accretion dominated luminosities necessary to put them in their main stage of mass-building. The characteristics of the 2-4μm spectra are placed in the context of existing multi-wavelength data, and five of the stars are more consistent with reddened Class IIs or stars in transition between Class I and II, rather than protostars embedded within massive remnant envelopes.

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astro-ph/0612171, full resolution paper at: http://www.ess.sunysb.edu/tracy/tbeck_mar07_AJ.pdf

The Structure of the Inner HH 34 Jet from Optical Integral Field Spectroscopy

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We present high spatial resolution optical integral field spectroscopy of a collimated Herbig-Haro jet viewed nearly edge-on. Maps of the line emission, velocity centroid, and velocity dispersion were generated for the Hα and [S II] emission features from the inner collimated jet and exciting source region of the HH 34 outflow. The kinematic structure of the jet shows several maxima and minima in both velocity centroid value and velocity dispersion along the jet axis. Perpendicular to the flow direction the velocity decreases outward from the axis to the limb of the jet, but the velocity dispersion increases. Maps of the electron density structure were derived from the line ratio of [S II] 6731/6716 emission. We have found that the jet exhibits a pronounced "striped" pattern in electron density; the high n_e regions are at the leading side of each of the emission knots in the collimated jet, and low n_e regions in the down-flow direction. On average, the measured electron density decreases outward from the inner regions of the jet, but the highest n_e found in the outflow is spatially offset from the nominal position of the exciting star. The results of our high spatial resolution optical integral field spectroscopy show very good agreement with the kinematics and electron density structure predicted by the existing internal working surface models of the HH 34 outflow.

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A kinematic study of the Taurus-Auriga T association

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Aims. This is the first paper in a series dedicated to investigating the kinematic properties of nearby associations of young stellar objects. Here we study the Taurus-Auriga association, with the primary objective of deriving kinematic parallaxes for individual members of this low-mass star-forming region.

Methods. We took advantage of a recently published catalog of proper motions for pre-main sequence stars, which we supplemented with radial velocities from various sources found in the CDS databases. We searched for stars of the Taurus-Auriga region that share the same space velocity, using a modified convergent point method that we tested with extensive Monte Carlo simulations.

Results. Among the sample of 217 Taurus-Auriga stars with known proper motions, we identify 94 pre-main sequence stars that are probable members of the same moving group and several additional candidates whose pre-main sequence evolutionary status needs to be confirmed. We derive individual parallaxes for the 67 moving group members with known radial velocities and give tentative parallaxes for other members based on the average spatial velocity of the group. The Hertzsprung-Russell diagram for the moving group members and a discussion of their masses and ages are presented in a companion paper.

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The Physics of Protoplanetesimal Dust Agglomerates. I. Mechanical Properties and Relations to Primitive Bodies in the Solar System

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We present laboratory experiments on the formation of macroscopic dust aggregates. The centimeter-sized highly porous bodies are produced by random ballistic deposition from individual micrometer-sized dust particles. We find packing densities between 0.07 and 0.15 for uncompressed samples, dependent on the shape and size distribution of the constituent dust grains. Impacts into these bodies are simulated by uniaxial compression experiments. We find that the maximum compression, equivalent to the highest protoplanetary impact velocities of ~ 50 m s^{-1}, increases the packing density to 0.20-0.33. Tensile strength measurements with our laboratory samples yield values in the range 200-1100 Pa for slightly compressed samples. We review packing densities and tensile strengths found for primitive solar system bodies, e.g., for comets, primitive meteorites, and meteoroids. We find a consistency between packing densities and tensile strengths of our laboratory samples with those from cometary origin.

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Hot corinos in NGC1333-IRAS4B and IRAS2A

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Context. Complex organic molecules have been detected in massive hot cores for over two decades, and only recently in three hot corinos (the inner regions surrounding Sun-like protostars, where the dust temperature exceeds 100 K). Since hot corinos have sizes of ∼100 AU (i.e., of the order of the extent of the Solar System), it is particularly relevant to understand whether they are common and to identify the formation route(s) of complex organic molecules. Much has yet to be learned on this topic, since even recent models predicted it was not possible to form these molecules in low-mass protostars.
Aims. We aim to enlarge the number of known hot corinos and carry out a first comparative study with hot cores. The ultimate goal is to understand whether complex organic molecules form in the gas phase or on grain surfaces, and what the possible key parameters are.
Methods. We observed millimeter rotational transitions of HCOOH, $HCOOCH_3$, CH_3OCH_3, CH_3CN and C_2H_5CN in a sample of low-mass protostars with the IRAM-30m. Using the rotational diagram method coupled with the information about the sources structure, we calculate the abundances of the observed molecules. To interpret these abundances, we review the proposed formation processes of the above molecules.
Results. We report the detection of $HCOOCH_3$ and/or CH_3CN towards NGC1333-IRAS4B and NGC1333-IRAS2A. We find that abundance ratios of O-bearing molecules to methanol or formaldehyde in hot corinos are comparable and about unity, and are relatively (depending on how the ratios are determined) higher than those in hot cores and in Galactic center clouds.
Conclusions. So far, complex organic molecules were detected in all the hot corinos where they were searched for, suggesting that it is a common phase for low-mass protostars. While some evidence points to grain-surface synthesis (either in the cold or warm-up phase) of these molecules (in particular for HCOOH and $HCOOCH_3$), the present data do not allow us to disregard gas-phase formation. More observational, laboratory, and theoretical studies are required to improve our understanding of hot corinos.

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Magnetospheric accretion-ejection processes in the classical T Tauri star AA Tau

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From a long time series of high resolution (R=115,000) HARPS spectra and simultaneous broad-band photometry, we report new evidence for magnetospheric accretion as well as ejection processes in the nearly edge-on classical T Tauri star AA Tau.

AA Tau's light curve is modulated with a period of 8.22d. The recurrent luminosity dips are due to the periodic occultation of the central star by the magnetically-warped inner disk edge located at about 9 Rstar. Balmer line profiles exhibit a clear rotational modulation of high-velocity redshifted absorption components with a period of 8.22 days as well, with a maximum strength when the main accretion funnel flow passes through the line of sight. At the same time, the luminosity of the system decreases by about 1 mag, indicative of circumstellar absorption of the stellar photosphere by the magnetically-warped, corotating inner disk edge. The photospheric and HeI radial velocities also exhibit periodic variations, and the veiling is modulated by the appearance of the accretion shock at the bottom of the accretion funnel. Diagnostics of hot winds and their temporal behaviour are also presented.

The peculiar geometry of the young AA Tau system (nearly edge-on) allows us to uniquely probe the accretion-ejection region close to the star. We find that most spectral and photometric diagnostics vary as expected from models of magnetically-channelled accretion in young stars, with a large scale magnetosphere tilted by 20 deg. onto the star's spin axis. We also find evidence for time variability of the magnetospheric accretion flow on a timescale of a few rotational periods.

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Binarity as a Key Factor in Protoplanetary Disk Evolution: Spitzer Disk Census of the η Chamaeleontis Cluster

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The formation of planets is directly linked to the evolution of the circumstellar (CS) disk from which they are born. The dissipation timescales of CS disks are therefore of direct astrophysical importance in evaluating the time available for planet formation. We employ Spitzer Space Telescope spectra to complete the CS disk census for the late-type members of the $\simeq$ 8 Myr old η Chamaeleontis star cluster. Of the 15 K- and M-type members, eight show excess emission. We find that the presence of a CS disk is anticorrelated with binarity, with all but one disk associated with single stars. With nine single stars in total, about 80% retain a CS disk. Of the six known or suspected close binaries, the only CS disk is associated with the primary of RECX 9. No circumbinary disks have been detected. We also find that stars with disks are slow rotators with surface values of specific angular momentum j = 2-15 $j_\odot$. All high specific angular momentum systems with j = 20-30 $j_\odot$ are confined to the primary stars of binaries. This provides novel empirical evidence for rotational disk locking and again demonstrates the much shorter disk lifetimes in close binary systems compared to single-star systems. We estimate the characteristic mean disk dissipation timescale to be $\sim$ 5 and $\approx$ 9 Myr for the binary and single-star systems, respectively.

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Warm Gas in the Inner Disks around Young Intermediate Mass Stars

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The characterization of gas in the inner disks around young stars is of particular interest because of its connection to planet formation. In order to study the gas in inner disks, we have obtained high-resolution K-band and M-band spectroscopy of 14 intermediate mass young stars. In sources that have optically thick inner disks, i.e. E(K-L)$\geq$1, our detection rate of the ro-vibrational CO transitions is 100% and the gas is thermally excited. Of the five sources that do not have optically thick inner disks, we only detect the ro-vibrational CO transitions from HD 141569. In this case, we show that the gas is excited by UV fluorescence and that the inner disk is devoid of gas and dust. We discuss the plausibility of the various scenarios for forming this inner hole. Our modeling of the UV fluoresced gas suggests an additional method by which to search for and/or place stringent limits on gas in dust depleted regions in disks around Herbig Ae/Be stars.

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Are isolated planetary-mass objects really isolated? A brown dwarf-exoplanet system candidate in the σ Orionis cluster

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Context. Free-floating planetary-mass objects have masses below the deuterium burning mass limit at about 13 Jupiter masses, and have mostly been found in very young open clusters. Their origin and relationship to stars and brown dwarfs are still a mystery.

Aims. The recent detection by direct imaging of three giant planets at wide separation (50-250 AU) from their primaries has raised the question about the true "isolation" of planetary-mass objects in clusters. Our goal was to test the possibility that some free-floating planetary-mass objects could in fact be part of wide planetary systems.

Methods. We searched in the literature for stellar and brown-dwarf candidates members of the σ Orionis cluster ($\sim$3 Ma, $\sim$360 pc) at small angular separations from published candidate planetary-mass objects. We found one candidate planetary system composed of an X-ray source, SE 70, and a planetary-mass object, S Ori 68, separated by only 4.6 arcsec. In order to assess the cluster membership of the X-ray source, we obtained mid-resolution optical spectroscopy using ISIS on the William Herschel Telescope. We also compiled additional data on the target from available astronomical catalogues.

Results. We have found that SE 70 follows the spectrophotometric sequence of the cluster and displays spectroscopic features of youth, such as lithium in absorption and chromospheric Hα emission. The radial velocity is consistent with cluster membership. Hence, SE 70 is very probably a member of the σ Orionis cluster. The projected physical separation between SE 70 and S Ori 68 is 1700 $\pm$ 300 AU at the distance of the cluster. If a common proper motion is confirmed in the near future, the system would be composed of an M5-6 brown dwarf with an estimated mass of $\sim$45 $M_{\rm Jup}$ and an L5 $\pm$ 2 giant planet with an estimated mass of $\sim$5 $M_{\rm Jup}$. It would be the widest and one of the lowest-mass planetary systems known so far.

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The critical role of disks in the formation of high-mass stars

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Although massive stars (commonly defined as those in excess of $\sim$8 solar masses, or with initial luminosities of $\sim$1,000 times the solar luminosity or more) have an enormous impact on the galactic environment, how they form has been a mystery. The solution probably involves the existence of accretion disks. Rotational motions have been found in the gas surrounding young high-mass stars, which suggests that non-spherical accretion could be the fundamental ingredient of the massive-star formation recipe.

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Planet Formation with Migration

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In the core-accretion model, gas-giant planets form solid cores that then accrete gaseous envelopes. Tidal interactions with disk gas cause a core to undergo inward type I migration in 10^4-10^5 yr. Cores must form faster than this to survive. Giant planets clear a gap in the disk and undergo inward type II migration in $< 10^6$ yr if observed disk accretion rates apply to the disk as a whole. Type II migration times exceed typical disk lifetimes if viscous accretion occurs mainly in the surface layers of disks. Low turbulent viscosities near the midplane may allow planetesimals to form by coagulation of dust grains. The radius r of such planetesimals is unknown. If $r < 0.5$ km, the core formation time is shorter than the type I migration timescale, and cores will survive. Migration is substantial in most cases, leading to a wide range of planetary orbits, consistent with the observed variety of extrasolar systems. When $r \sim 100$m and the midplane $\alpha \sim 3 \times 10^{-5}$, giant planets similar to those in the solar system can form.

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A highly-collimated SiO jet in the HH212 protostellar outflow

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Context In young stars, jets are believed to play a role in removing angular momentum from the circumstellar disk, allowing accretion onto the central star. Recent results suggest that in earlier phases of star formation, SiO might trace the primary jet launched close to the protostar, but further observations are required in order to reveal the properties of this molecular component.
Aims We wish to exploit the combination of high angular and spectral resolution provided by millimetre interferometry to investigate the collimation and kinematics of molecular protostellar jets, and their angular momentum content.
Methods We mapped the inner $40''$ of the HH212 Class 0 outflow in SiO(2–1), SiO(5–4) and continuum using the Plateau de Bure interferometer in its extended configurations. The unprecedented angular resolution (down to $0.34''$) allows accurate comparison with a new, deep H_2 image obtained at the VLT.
Results The SiO emission is confined to a highly-collimated bipolar jet (width $\sim 0.35''$ close to the protostar) along the outflow axis. The jet can be traced down to within 500 AU of the protostar, in a region that is heavily obscured in H_2 images. Where both species are detected, SiO shows the same overall kinematics and structure as H_2, indicating that both molecules are tracing the same material. Transverse cuts reveal no velocity gradient compatible with jet rotation above 1 km s^{-1}, in contrast to previous claims based on H_2 spectra. The central continuum peak is unresolved and close to optically thick, suggesting an edge-on disk with diameter $\leq$ 117 AU.
Conclusions SiO proves to be a powerful tracer of molecular jets in Class 0 sources, in particular of their obscured innermost regions. The very small blue/red overlap in the SiO outflow lobes, despite the nearly edge-on view to HH212, further implies that the high-velocity SiO gas is not tracing a wide-angle wind but is already confined to a flow inside a narrow cone of half-opening angle $<6^\circ$ at $\leq$ 500 AU from the protostar. The broad SiO line widths and the transverse velocity gradients both appear significantly affected by internal bowshocks, and should thus be interpreted with caution.

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http://www.arcetri.astro.it/~codella/codella-hh212-public.pdf

Outflow-driven Cavities: Numerical Simulations of Intermediaries of Protostellar Turbulence

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We investigate the evolution of fossil cavities produced by extinct young stellar object (YSO) jets and wide-angle outflows. Fossil cavities are ellipsoidal or cylindrical shells of swept-up ambient (molecular cloud) material moving at low velocities. The cavities form when the momentum in a YSO jet or wide-angle outflow decays in time, allowing the bow shock or swept-up shell to decelerate to velocities near the turbulent speed in the cloud. It has been suggested in previous studies that cavities provide efficient coupling between the jets/outflows and the cloud and, as such, are the agents by which cloud turbulence can be re-energized. In this paper, we carry forward a series of numerical simulations of jets and outflows whose momentum flux decreases in time. We compare simulations with decaying momentum fluxes to those with constant flux. We show that decaying flux models exhibit deceleration of the outflow head and backfilling via expansion off of the cavity walls. They also have lower density contrast and are longer lived and wider than their continuously driven counterparts. The simulations recover the basic properties of observed fossil cavities. In addition, we provide synthetic observations in terms of position-velocity (PV) diagrams, which demonstrate that fossil cavities form both jets and wide-angle outflows and are characterized by linear "Hubble law" expansion patterns superimposed on "spur" patterns, indicative of the head of a bow shock.

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Orbital evolution and accretion of protoplanets tidally interacting with a gas disk II. Solid surface density evolution with type-I migration

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This paper investigates the surface density evolution of a planetesimal disk due to the effect of type-I migration by carrying out N-body simulation and through analytical method, focusing on terrestrial planet formation. The coagulation and the growth of the planetesimals take place in the abundant gas disk except for a final stage. A protoplanet excites density waves in the gas disk, which causes the torque on the protoplanet. The torque imbalance makes the protoplanet suffer radial migration, which is known as type-I migration. Type-I migration time scale derived by the linear theory may be too short for the terrestrial planets to survive, which is one of the major problems in the planet formation scenario. Although the linear theory assumes a protoplanet being in a gas disk alone, Kominami et al. [Kominami, J., Tanaka, H., Ida, S., 2005. Icarus 167, 231-243] showed that the effect of the interaction with the planetesimal disk and the neighboring protoplanets on type-I migration is negligible. The migration becomes pronounced before the planet's mass reaches the isolation mass, and decreases the solid component in the disk. Runaway protoplanets form again in the planetesimal disk with decreased surface density. In this paper, we present the analytical formulas that describe the evolution of the solid surface density of the disk as a function of gas-to-dust ratio, gas depletion time scale and semimajor axis, which agree well with our results of N-body simulations. In general, significant depletion of solid material is likely to take place in inner regions of disks. This might be responsible for the fact that there is no planet inside Mercury's orbit in our Solar System. Our most important result is that the final surface density of solid components (Σ_d) and mass of surviving planets depend on gas surface density (Σ_g) and its depletion time scale (τ_{dep}) but not on initial Σ_d; they decrease with increase in Σ_g and τ_{dep}. For a fixed gas-to-dust ratio and τ_{dep}, larger initial Σ_d results in smaller final Σ_d and smaller surviving planets, because of larger Σ_g. To retain a specific amount of Σ_d, the efficient disk condition is not an initially large Σ_d but the initial Σ_d as small as the specified final one and a smaller gas-to-dust ratio. To retain Σ_d comparable to that of the minimum mass solar nebula (MMSN), a disk must have the same Σ_d and a gas-to-dust ratio that is smaller than that of MMSN by a factor of $1.3 \times (\tau_{dep}/1\text{Myr})$ at ~ 1 AU. (Equivalently, type-I migration speed is slower than that predicted by the linear theory by the same factor.) The surviving planets are Mars-sized ones in this case; in order to form Earth-sized planets, their eccentricities must be pumped up to start orbit crossing and coagulation among them. At $\sim$5 AU, Σ_d of MMSN is retained under the same condition, but to form a core massive enough to start runaway gas accretion, a gas-to-dust ratio must be smaller than that of MMSN by a factor of $3 \times \tau_{ep}/1\text{Myr}$.

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Ionisation-induced star formation I: The collect and collapse model

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We conduct Smoothed Particle Hydrodynamics simulations of the 'collect and collapse' scenario Elmegreen and Lada, 1977 for star formation triggered by an expanding HII region. We simulate the evolution of a spherical uniform molecular cloud with an ionising source at its centre. The gas in the cloud is self-gravitating, although the cloud is prevented from globally collapsing. We find that the shell driven by the HII region fragments to form numerous self–gravitating objects. We repeat our calculations at four numerical resolutions to ensure that they are converged. We compare our results to the analytical model of Whitworth et al, 1994 and show that our simulations and the predictions of Whitworth et al are in good agreement in the sense that the shell fragments at the time and radius predicted by Whitworth et al, 1994 to within 20% and 25% respectively. Most of the fragments produced in our two highest resolution calculations are approximately half the mass predicted, but this conclusion is robust against both numerical resolution and the presence of random noise (local fluctuations in density of a factor of ~ 2) in the initial gas distribution. We conclude that such noise has little impact on the fragmentation process.

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The young star cluster NGC 2362: low-mass population and initial mass function from a Chandra X-ray observation

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Context. We study the stellar population of the very young cluster NGC 2362, using a deep Chandra ACIS-I X-ray observation. This cluster, only 5 Myr old, has already cleared most of its inter- and circumstellar dust, and with its small and uniform reddening offers a unique opportunity of studying its pre-main-sequence stellar population with minimal disturbance from a dense interstellar medium.

Aims. Our main purposes are to select cluster members down to low masses and to study their properties as a population (spatial properties, initial mass function, and coronal properties).

Methods. We compare existing deep optical photometry and Hα data with new X-ray data. We use combined optical and X-ray criteria to select cluster members.

Results. We detect 387 X-ray sources down to $\log L_{\rm X} = 29.0$ (erg/s), and identify most of them (308) with star-like objects. The majority (88%) of optically identified X-ray sources are found to be very good candidate low-mass pre-main-sequence stars, with minimal field-object contamination. This increases the known cluster census by a substantial amount at low masses, with respect to previous optical/IR studies. The fraction of stars with active accretion is found to be in the range 5-9%. We find a significantly wider spatial distribution for low-mass stars than for massive stars (mass segregation). We find only a small spread around the low-mass cluster sequence in the HR diagram, indicating that star formation lasted only about 1-2 Myr. We have derived the cluster initial mass function, which appears to flatten (on the low-mass side) at higher masses with respect to other very young clusters. The quiescent X-ray emission of low-mass cluster stars is found to be rather strictly correlated with the stellar bolometric luminosity: the small spread in this correlation puts an upper bound on the amplitude of X-ray variability on time scales longer than one day (e.g., activity cycles) in such young coronal sources. We find significant X-ray spectral differences between low-mass stars brighter and fainter than $\log L_{\rm X} \sim 30.3$ (erg/s), respectively, with X-ray brighter stars showing hotter

components ($kT \sim 2$ keV), absent in fainter stars.

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Mid-infrared imaging of the circumstellar dust around three Herbig Ae stars: HD 135344, CQ Tau, and HD 163296

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Aims. Planet formation has been known for many years to be tied to the spatial distribution of gas and dust in disks around young stars. To constrain planet formation models, imaging observations of protoplanetary disks are required.

Methods. Given this, we have undertaken a mid-infrared imaging survey of Herbig Ae stars, which are pre-main sequence stars of intermediate mass still surrounded by a large amount of circumstellar material. The observations were made at a wavelength of 20.5 μm with the CAMIRAS camera mounted at the Cassegrain focus of the Canada France Hawaii Telescope.

Results. We report the observations of three stars, HD 135344, CQ Tau, and HD 163296. The circumstellar material around the three objects is spatially resolved. The extensions feature a disk-like shape. The images provide direct information on two key parameters of the disk: its inclination and its outer radius. The outer radius is found to be quite different from the one deduced from disk models, which is only constrained by fitting the Spectral Energy Distribution of the object. Other parameters of the disk, such as flaring and dust mass have been deduced from fitting both the observed extension and the spectral energy distribution with sophisticated disk models.

Conclusions. Our results show how important imaging data are to tighten constraints on the disk model parameters.

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Searching for massive pre-stellar cores through observations of N_2H^+ and N_2D^+

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Aims. We have measured the deuterium fractionation and the CO depletion factor (ratio between expected and observed CO abundance) in a sample of high-mass protostellar candidates, in order to understand whether the earliest evolutionary stages of high-mass stars have chemical characteristics similar to those of low-mass ones. It has been found that low-mass starless cores on the verge of star formation have large values both of the column density ratio $N(N_2D^+)/N(N_2H^+)$ and of the CO depletion factor.

Methods. With the IRAM-30 m telescope and the JCMT we have observed two rotational lines of N_2H^+ and N_2D^+, the (2-1) line of $C^{17}O$ and DCO^+, and the sub-millimeter continuum towards a sample of 10 high-mass protostellar candidates.

Results. We have detected N_2D^+ emission in 7 of the 10 sources of our sample, and found an average value $N(N_2D^+)/N(N_2H^+) \sim 0.015$. This value is $\sim$3 orders of magnitude larger than the interstellar D/H ratio, indicating the presence of cold and dense gas, in which the physical-chemical conditions are similar to those observed in low-mass pre-stellar cores. The integrated CO depletion factors show that in the majority of the sources the expected CO abundances are larger than the observed values, with a median ratio of 3.2.

Conclusions. In principle, the cold gas that generates the N_2D^+ emission can be the remnant of the massive molecular core in which the high-mass (proto-)star was born, not yet heated up by the central object. If so, our results indicate

that the chemical properties of the clouds in which high-mass stars are born are similar to their low-mass counterparts. Alternatively, this cold gas could be located in one (or more) starless core (cores) near the protostellar object. Due to the poor angular resolution of our data, we cannot distinguish between the two scenarios.

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Molecular line emission in HH54: a coherent view from near to far infrared

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Aims. We present a detailed study of the infrared line emission (1-200 μm) in the Herbig-Haro object HH54. Our database comprises: high- (R $\sim$ 9000) and low- (R $\sim$ 600) resolution spectroscopic data in the near-infrared band (1-2.5 μm); mid-infrared spectrophotometric images (5-12 μm); and, far-IR (45-200 μm, R $\sim$ 200) spectra acquired with the ISO satellite. As a result, we provide the detection of and the absolute fluxes for more than 60 molecular features (mainly from H_2 in the near- and mid-infrared and from H_2O, CO and OH in the far-infrared) and 23 ionic lines.

Methods. The H_2 lines, coming from levels from v = 0 to v = 4 have been interpreted in the context of a state-of-the-art shock code, whose output parameters are adopted as input to a Large Velocity Gradient computation in order to interpret the FIR emission of CO, H2O and OH.

Results. The H_2 emission can be interpreted as originating in either steady-state J-type shocks or in quasi-steady J-type shocks with magnetic precursor. However, our multi-species analysis shows that only a model of a J-type shock with magnetic precursor ($v_{\rm shock}$ = 18 km s^{-1}, $n_{\rm H}$ = 10^4 cm^{-3}, B = 100 μG, age = 400 yr) can account for both the observed H_2 emission and the CO and H_2O lines. Such a model predicts a H_2O abundance of $\sim 7 \times 10^{-5}$, in agreement with estimations from other shock models of outflows associated with low mass protostars. We can exclude the possibility that the observed atomic lines arise in the same shock as the molecular lines, and give arguments in favour of the presence of a further high-velocity, fully dissociative shock component in the region. Finally, in view of the forthcoming spectroscopic facilities on board of the Herschel satellite, we provide predictions for H_2O lines considered to be the most suitable for diagnostic purposes.

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Neon Fine-Structure Line Emission By X-ray Irradiated Protoplanetary Disks

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Using a thermal-chemical model for the generic T-Tauri disk of D'Alessio et al. (1999), we estimate the strength of the fine-structure emission lines of Ne II and Ne III at 12.81 and 15.55 microns that arise from the warm atmosphere of the disk exposed to hard stellar X-rays. The Ne ions are produced by the absorption of keV X-rays from the K shell of neutral Ne, followed by the Auger ejection of several additional electrons. The recombination cascade of the Ne ions is slow because of weak charge transfer with atomic hydrogen in the case of Ne++ and by essentially no charge transfer for Ne+. For a distance of 140 pc, the 12.81 micron line of Ne II has a flux of the order of 1e-14 erg/cm2s, which should be observable with the Spitzer Infrared Spectrometer and suitable ground based instrumentation. The detection of these fine-structure lines would clearly demonstrate the effects of X-rays on the physical and chemical properties of

the disks of young stellar objects and provide a diagnostic of the warm gas in protoplanetary disk atmospheres. They would complement the observed H2 and CO emission by probing vertical heights above the molecular transition layer and larger radial distances that include the location of terrestrial and giant planets.

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Results of the ROTOR-program. I. The long-term photometric variability of classical T Tauri stars

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We present a unique, homogeneous database of photometric measurements for Classical T Tauri stars extending up to 20 years. The database contains more than 21,000 UBVR observations of 72 CTTs. All the data were collected within the framework of the ROTOR-program at Mount Maidanak Observatory (Uzbekistan) and together they constitute the longest homogeneous, accurate record of TTS variability ever assembled. We characterize the long term photometric variations of 49 CTTs with sufficient data to allow a robust statistical analysis and propose an empirical classification scheme.

Several patterns of long term photometric variability are identified. The most common pattern, exhibited by a group of 15 stars which includes T Tau itself, consists of low level variability (ΔV$\leq$0.4mag) with no significant changes occurring from season to season over many years. A related subgroup of 22 stars exhibits a similar stable long term variability pattern, though with larger amplitudes (up to ΔV=1.6 mag). Besides these representative groups, we identify three smaller groups of 3-5 stars each which have distinctive photometric properties.

The long term variability of most CTTs is fairly stable and merely reflects shorter term variability due to cold and hot surface spots. Only a small fraction of CTTs undergo significant brightness changes on the long term (months, years), which probably arise from slowly varying circumstellar extinction.

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Probing the close environment of massive young stars with spectro-astrometry

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Aims. We test the technique of spectro-astrometry as a potential method to investigate the close environment of massive young stars.
Methods. Archival VLT near infrared K band spectra (R=8900) of three massive young stellar objects and one Wolf-Rayet star are examined for spectro-astrometric signatures. The young stellar objects display emission lines such as Brγ CO 2-0 and CO 3-1 that are characteristic of ionised regions and molecular disks respectively. Two of the sample sources also display emission lines such as NIII and MgII that are characteristic of high temperatures.
Results. Most of the emission lines show spectro-astrometric signal at various levels resulting in different positional displacements. The shapes and magnitudes of the positional displacements imply the presence of large disk/envelopes in emission and expanding shells of ionised gas. The results obtained for the source 18006-2422nr766 in particular provide larger estimates ($>$ 300AU) on CO emitting regions indicating that in MYSOs CO may arise from inner regions of extended dense envelopes as well.
Conclusions. The overall results from this study demonstrate the utility of spectro-astrometry as a potential method to constrain the sizes of various physical entities such as disks/envelopes, UCHII regions and/or ionised shells in the close environment of a massive young star.

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X-rays from T Tau: A test case for accreting T Tauri stars

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Context. The generation of X-rays in accreting T Tauri stars (TTS) is thought to be predominantly due to energy dissipation in magnetic fields, but alternative X-ray generation mechanisms have been proposed, such as heating in accretion shocks near the stellar surface, or in shocks forming in jets.
Aims. We test models and trends discussed in the previous literature using X-ray data from the classical TTS T Tau.
Methods. High-resolution spectroscopy from the Reflection Grating Spectrometers on *XMM-Newton* is used to infer electron densities, element abundances, and the thermal structure of the X-ray source. We also discuss the ultraviolet light curve obtained by the Optical Monitor, and complementary ground-based photometry. A high-resolution image from *Chandra* constrains contributions from the two companions of T Tau N.
Results. The X-ray grating spectrum is rich in emission lines, but shows an unusual mixture of features from very hot ($\approx$ 30 MK) and very cool (1–3 MK) plasma, both emitted by similar amounts of emission measure. The cool plasma confirms the picture of a *soft excess* in the form of an enhanced O VII/O VIII Lyα flux ratio, similar to that previously reported for other accreting TTS. Diagnostics from lines formed by this plasma indicate low electron densities ($\lesssim 10^{10}$ cm^{-3}). The Ne/Fe abundance ratio is consistent with a trend in pre-main sequence stars in which this ratio depends on spectral type, but not on accretion.
Conclusions. On the basis of line density diagnostics, we conclude that the density of the cool "soft-excess" plasma is orders of magnitude below that predicted for an accretion shock, assuming previously determined accretion rates of $(3-6)\times 10^{-8} M_{\odot}\mathrm{yr}^{-1}$. We argue that loading of magnetic field lines with infalling material suppresses the heating process in a fraction of the corona. We thus suggest that the X-ray production of T Tau is influenced by the accretion process although the X-rays may not form in the bulk of the accretion footpoints.

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http://www.issibern.ch/teams/Taurus/papers.html OR http://www.astro.phys.ethz.ch/papers/guedel/guedel_p_nf.html

Sub-arcsecond Near-Infrared Images of Massive Star Formation Region NGC 6334 V

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We present high spatial resolution (0.3") polarimetric images in the H and K bands and direct images in the L' and M' bands of the NGC 6334 V infrared nebulae. The images show complex structures including the multi-shells and various knots in the nebulae. The appearances and colors of the eastern and western nebulae differ considerably. Our polarization images also show differences between the illuminating sources of the nebulae: the eastern nebula is illuminated by a deeply embedded mid-infrared source, KDJ 4, and the western nebula by our newly detected near-infrared source, WN-A1. The degree of polarization of the nebulae is very large, up to 70% at K and 60% at H, which is consistent with a single scattering of near-infrared radiation from each source at the walls of the mass outflows.

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ftp://optik3.mtk.nao.ac.jp/pub/hashmtjn/NGC6334V.pdf

Near-Infrared Polarization Images of The Orion Molecular Cloud 1 South Region

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We present the polarization images in the J, H, & Ks bands of the Orion Molecular Cloud 1 South region. The polarization images clearly show at least six infrared reflection nebulae (IRNe) which are barely seen or invisible in the intensity images. Our polarization vector images also identify the illuminating sources of the nebulae: IRN 1 & 2, IRN 3, 4, & 5, and IRN 6 are illuminated by three IR sources, Source 144-351, Source 145-356, and Source 136-355, respectively. Moreover, our polarization images suggest the candidate driving sources of the optical Herbig-Haro objects for the first time; HH529, a pair of HH202 and HH528 or HH 203/204, HH 530 and HH269 are originated from Source 144-351, Source 145-356, and Source 136-355, respectively.

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ftp://optik3.mtk.nao.ac.jp/pub/hashmtjn/Omc1s.pdf

Cloud dispersal in turbulent flows

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Cold clouds embedded in warm media are very common objects in astrophysics. Their disruption time-scale depends strongly on the dynamical configuration. We discuss the evolution of an initially homogeneous cold cloud embedded in warm turbulent gas. Within a couple of dynamical time-scales, the filling factor of the cold gas within the original cloud radius drops below 50 per cent. Turbulent diffusivities estimated from the time evolution of radial filling factor profiles are not constant with time. Cold and warm gas are bodily transported by turbulence and mixed. This is only mildly indicated by column density maps. The radiation field within the cloud, however, increases by several orders of magnitudes due to the mixing, with possible consequences for cloud chemistry and evolution within a few dynamical time-scales.

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Looking into the cradle: new mid-IR observations of multiple proto-stars

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We present high spatial resolution mid-infrared observations of three proto-stellar systems, namely SSV63, L1551NE and L1551–IRS5, obtained with VISIR at the VLT. All of them are suspected binary or multiple systems, but prone to ambiguities in the literature. The aim of this work is to study their multiplicity. For the SSV63 system, we report the discovery of a new Class I companion, $\sim$ 2.6”NW of SSV63E, which was never seen in previous near-IR and radio continuum studies. The companion to SSV63W, which was detected at near-IR wavelengths, is also present in the mid-IR regime. The geometrical arrangement of sources in the SSV63 system strongly supports the view of hierarchical

fragmentation of cloud cores. In the case of L1551NE, we have confirmed the presence of a companion at 0.5NW from the central star, as previously reported by Reipurth et al. (2002). Finally, we have not detected any companion to L1551–IRS5. However, we find signs of extended emission around the target. In total, we have detected three binaries. The SEDs of the primaries are consistent with their Class I/flat-spectrum classification. For the secondaries, ancillary data are required to derive their evolutionary status.

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Low-Mass X-Ray Binaries with Pre-Main Sequence Companions

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In this Letter we examine the idea that a subset of short-period black hole low-mass X-ray binaries could be powered by mass transfer from premain-sequence donors. As the star contracts toward the main sequence, the strong magnetic fields operate the magnetic braking, which dissipates the orbital angular momentum, driving the binary to contact. We show that the periods and apparent donor spectral classes of the X-ray binaries with a premain-sequence donor agree better with the available observations of black hole X-ray binaries than those of binaries with a main-sequence donor. This mechanism also explains, without the need for additional hypotheses, the roughly primordial abundance of Li detected in donor companions of black hole X-ray candidates in our Galaxy.

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Improved age constraints for the AB Dor quadruple system - The binary nature of AB Dor B

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We present resolved NACO photometry of the close binary AB Dor B in H- and Ks-band. AB Dor B is itself known to be a wide binary companion to AB Dor A, which in turn has a very low-mass close companion named AB Dor C. These four known components make up the young and dynamically interesting system AB Dor, which will likely become a benchmark system for calibrating theoretical pre-main sequence evolutionary mass tracks for low-mass stars. However, for this purpose the actual age has to be known, and this subject has been a matter of discussion in the recent scientific literature. We compare our resolved photometry of AB Dor Ba and Bb with theoretical and empirical isochrones in order to constrain the age of the system. This leads to an age estimate of about 50 to 100 Myr. We discuss the implications of such an age range for the case of AB Dor C, and compare with other results in the literature.

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Hydrodynamic turbulence cannot transport angular momentum effectively in astrophysical disks

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The most efficient energy sources known in the Universe are accretion disks. Those around black holes convert 5-40 per cent of rest-mass energy to radiation. Like water circling a drain, inflowing mass must lose angular momentum, presumably by vigorous turbulence in disks, which are essentially inviscid. The origin of the turbulence is unclear. Hot disks of electrically conducting plasma can become turbulent by way of the linear magnetorotational instability. Cool disks, such as the planet-forming disks of protostars, may be too poorly ionized for the magnetorotational instability to occur, and therefore essentially unmagnetized and linearly stable. Nonlinear hydrodynamic instability often occurs in linearly stable flows (for example, pipe flows) at sufficiently large Reynolds numbers. Although planet-forming disks have extreme Reynolds numbers, keplerian rotation enhances their linear hydrodynamic stability, so the question of whether they can be turbulent and thereby transport angular momentum effectively is controversial. Here we report a laboratory experiment, demonstrating that non-magnetic quasi-keplerian flows at Reynolds numbers up to millions are essentially steady. Scaled to accretion disks, rates of angular momentum transport lie far below astrophysical requirements. By ruling out purely hydrodynamic turbulence, our results indirectly support the magnetorotational instability as the likely cause of turbulence, even in cool disks.

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Long-term infrared variability of the UX Ori-type star SV Cep

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We investigate the long-term optical-infrared variability of SV Cep, and explain it in the context of an existing UX Ori (UXOR) model. A 25-month monitoring programme was completed with the Infrared Space Observatory in the 3.3–100 μm wavelength range. Following a careful data reduction, the infrared light curves were correlated with the variations of SV Cep in the V-band. A remarkable correlation was found between the optical and the far-infrared light curves. In the mid-infrared regime the amplitude of variations is lower, with a hint for a weak anti-correlation with the optical changes. In order to interpret the observations, we modelled the spectral energy distribution of SV Cep assuming a self-shadowed disc with a puffed-up inner rim, using a 2-dimensional radiative transfer code. We found that modifying the height of the inner rim, the wavelength-dependence of the long-term optical-infrared variations is well reproduced, except the mid-infrared domain. The origin of variation of the rim height might be fluctuation in the accretion rate in the outer disc. In order to model the mid-infrared behaviour we tested to add an optically thin envelope to the system, but this model failed to explain the far-infrared variability. Infrared variability is a powerful tool to discriminate between models of the circumstellar environment. The proposed mechanism of variable rim height may not be restricted to UXOR stars, but might be a general characteristic of intermediate-mass young stars.

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Oscillations of Starless Cores

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If the split, asymmetric molecular spectral line profiles that are seen in many starless cores are interpreted as indicative of global collapse or expansion of the core, then one possible implication is that most starless cores have short lifetimes, on the order of the collapse or sound crossing timescale. An alternative interpretation of the line profiles, as indicative of perturbations on an underlying equilibrium structure, leads to the opposite implication, that many cores have long lifetimes. While evidence suggests that some cores are collapsing on a free-fall timescale, we show that observations of some other starless cores can be reproduced by a model of nonradial oscillations about the equilibrium configuration of a pressure-bounded, thermally-supported sphere (Bonnor-Ebert sphere). We model the oscillations as linear perturbations following a standard analysis developed for stellar pulsations and compare the column densities and molecular spectral line profiles predicted from a particular model to observations of the Bok globule B68.

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A brown dwarf desert for intermediate mass stars in Sco OB2?

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We present JHK_S observations of 22 intermediate-mass stars in the Scorpius-Centaurus OB association, obtained with the NAOS/CONICA system at the ESO Very Large Telescope. This survey was performed to determine the status of (sub)stellar candidate companions of Sco OB2 member stars of spectral type A and late-B. The distinction between companions and background stars is made on the basis of a comparison to isochrones and additional statistical arguments. We are sensitive to companions with an angular separation of $0.1'' - 11''$ ($13 - 1430$ AU) and the detection limit is $K_S = 17$ mag. We detect 62 stellar components of which 18 turn out to be physical companions, 11 candidate companions, and 33 background stars. Three of the 18 confirmed companions were previously undocumented as such. The companion masses are in the range $0.03\ \mathrm{M}_\odot \leq M \leq 1.19\ \mathrm{M}_\odot$, corresponding to mass ratios $0.06 \leq q \leq 0.55$. We include in our sample a subset of 9 targets with multi-color ADONIS observations from Kouwenhoven et al. (2005). In the ADONIS survey secondaries with $K_S < 12$ mag were classified as companions; those with $K_S > 12$ mag as background stars. The multi-color analysis in this paper demonstrates that the simple $K_S = 12$ mag criterion correctly classifies the secondaries in $\sim 80\%$ of the cases. We reanalyse the total sample (i.e. NAOS/CONICA and ADONIS) and conclude that of the 176 secondaries, 25 are physical companions, 55 are candidate companions, and 96 are background stars. Although we are sensitive (and complete) to brown dwarf companions as faint as $K_S = 14$ mag in the semi-major axis range $130 - 520$ AU, we detect only one, corresponding to a brown dwarf companion fraction of $0.5 \pm 0.5\%$ ($M \gtrsim 30\ \mathrm{M_J}$). However, the number of brown dwarfs is consistent with an extrapolation of the (stellar) companion mass distribution into the brown dwarf regime. This indicates that the physical mechanism for the formation of brown dwarf companions around intermediate mass stars is similar to that of stellar companions, and that the embryo ejection mechanism does not need to be invoked in order to explain the small number of brown dwarf companions among intermediate mass stars in the Sco OB2 association.

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On the time dependence of differential rotation in young late-type stars

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A model for the angular momentum transfer within the convection zone of a rapidly rotating star is introduced and applied to the analysis of recent observations of temporal fluctuations of the differential rotation on the young late-type stars AB Doradus (AB Dor) and LQ Hydrae (LQ Hya). Under the hypothesis that the mean magnetic field produced by the stellar dynamo rules the angular momentum exchanges and that the angular velocity depends only on the distance s from the rotation axis and the time, the minimum azimuthal Maxwell stress $\mid B_s B_\phi \mid$, averaged over the convection zone, is found to range from $\sim$0.04 to $\sim$0.14 T^2. If the poloidal mean magnetic field B_s is of the order of 0.01 T, as indicated by the Zeeman-Doppler imaging maps of those stars, then the azimuthal mean field B_ϕ can reach an intensity of several teslas, which significantly exceeds equipartition with the turbulent kinetic energy. Such strong fields can account also for the orbital period modulation observed in cataclysmic variables and RS Canum Venaticorum systems with a main-sequence secondary component. Moreover, the model allows us to compute the kinetic energy dissipation rate during the maintenance of the differential rotation. Only in the case of the largest surface shear observed on LQ Hya may the dissipated power exceed the stellar luminosity, but the lack of a sufficient statistic on the occurrence of such episodes of large shear does not allow us to estimate their impact on the energy budget of the convection zone.

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Studying Turbulence Using Doppler-broadened Lines: Velocity Coordinate Spectrum

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We discuss a new technique for studying astrophysical turbulence that utilizes the statistics of Doppler-broadened spectral lines. The technique relates the power velocity coordinate spectrum (VCS), i.e., the spectrum of fluctuations measured along the velocity axis in position-position-velocity data cubes available from observations, to the underlying power spectra of the velocity/density fluctuations. Unlike the standard spatial spectra, which are a function of angular wavenumber, the VCS is a function of the velocity wavenumber $k_v \sim 1/v$. We show that absorption affects the VCS to a higher degree for small k_v and obtain the criteria for disregarding the absorption effects for turbulence studies at large k_v. We consider the retrieval of turbulence spectra from observations for high and low spatial resolution observations and find that the VCS allows one to study turbulence even when the emitting turbulent volume is not spatially resolved. This opens interesting prospects for using the technique for extragalactic research. We show that, while thermal broadening interferes with the turbulence studies using the VCS, it is possible to separate thermal and nonthermal contributions. This allows a new way of determining the temperature of the interstellar gas using emission and absorption spectral lines.

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The Excitation of SO in Cold Molecular Clouds: TMC-1

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We have performed calculations on the excitation of SO using the accurate collisional rate coefficients at low temperatures for the system SO-He recently published by Lique et al. Compared with the results of Green, the new excitation rates show significant differences for transitions involving the low energy levels. We present a set of radiative transfer models for different cloud geometries and physical conditions, using the new rate coefficients for SO, and show that they provide a more correct diagnostic of the physical conditions of cold dark clouds. We have applied these results to observations of mapping results in TMC-1 done in the $2_3 - 1_2$, $3_4 - 2_3$, and $2_2 - 1_1$ transitions (using the IRAM 30 m telescope) and the $0_1 - 1_0$ transition (using the 100 m Effelsberg radio telescope). The intensity maxima for all these lines is found around the so-called ammonia peak. The structure of TMC-1 is well represented by a cylindric filament with several cores [$T_K = 8$ K, $n(H_2) \sim 3 \times 10^4$ cm^{-3}] surrounded by an envelope [$T_K = 10$ K, $n(H_2) \sim (6-8) \times 10^3$ cm^{-3}] showing a complex velocity structure. The abundance of SO in TMC-1 is nearly constant along the filament, X(SO) $\simeq 10^{-8}$, except at the ammonia peak, where a higher SO abundance, X(SO) $\simeq 2.5 \times 10^{-8}$, is required.

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Mass determination for T Tauri stars from JHK Photometry

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We present a method that uses disk models to determine stellar masses for Pre-Main sequence T Tauri stars from JHK photometry. We find that the infrared excess produced by the disk behaves in a similar way to the extinction vector when plotted on color-color and color-magnitude diagrams, but that it is linearly independent. Employing these vectors as a basis of a vector space we carry out a coordinate transformation that allows us to find the mass of a central star for a given age. To test this Principal Vectors (PV) method we compare the mass values (M_{PV}) obtained for 14 T Tauri objects in the Taurus-Auriga region with mass values known by dynamical methods. Further on, we

analyzed 4 systems with multiple components (GG Tau, FO Tau, FS Tau, and V733 Tau) and determined the mass for each component of the system. We analyzed the effect of using different evolutionary models and other parameter values.

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Self-similar shocks in polytropic gas flows around star-forming regions

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Self-similar shock solutions in spherically symmetric polytropic gas flows are constructed and analysed in contexts of protostar formation processes. Among other possible solutions, we model a similarity shock across the sonic critical curve with an inner free-fall core collapse and a simultaneous outer expansion of the extended envelope; the separation or stagnation surface between these two flow zones travels outwards in a self-similar manner at a variable speed. One readily obtains accretion shock solutions. Semicomplete self-similar solutions across the sonic critical curve either once or twice without shocks can also be constructed. Features of star formation clouds of our polytropic model include the mass density scaling in the outer flow zone $\rho \propto r^{-2/(2-\Gamma)}$, the temperature scalings of the inner flow zone $T \propto r^{-3(\Gamma-1)/2}$ and of the outer flow zone $T \propto r^{-2(\Gamma-1)/(2-\Gamma)}$ and the variable central mass accretion rate, $\dot{M} = k^{3/2}t^{(3-3\gamma)}m_0/G$ where γ is the polytropic index, k is a constant, m_0 is the core mass and G is the gravitational constant. Spectral line profiles characteristic of the 'envelope expansion with core collapse' shock solutions are expected. Random magnetic field permeated in a partially ionized cloud can be incorporated into this theoretical polytropic model framework. We discuss briefly our results in context of the oft-observed starless B335 cloud system as an example.

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Planetesimals in the Presence of Giant Planet Migration

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We present N-body simulations illustrating how giant planet migration can significantly affect the conditions for the formation of interior terrestrial planets. A giant planet migrating through a swarm of planetesimals will scatter many of them onto very eccentric and inclined orbits, preventing them from playing any further role in additional planet formation. The magnitude of this excitation is strongly dependent on the mass and migration rate of the giant planet. We found that if planet migration occurs for low-mass planets (one-tenth of the mass of Jupiter) or proceeds very rapidly (10^{-3} AU yr^{-1}), planetesimal swarms can dynamically cool via gas drag, collisions, and dynamical friction after the giant passes through. Other simulations produce a population of planetesimals on orbits with very high eccentricity and inclination, which may persist and become a signature of a previous migration event. In some cases further growth of terrestrial planets is possible, leading to our prediction of terrestrial planets existing on orbits outside of some hot Jupiters.

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Rotational periods of solar-mass young stars in Orion

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The evolution of the angular momentum in young low-mass stars is still a debated issue. The stars presented here were discovered as X-ray sources in the ROSAT All-Sky Survey (RASS) of the Orion complex and subsequently optically identified thanks to both low and high resolution spectroscopy.

The determination of the rotational periods in young low-mass stars of different age is fundamental for the understanding of the angular momentum evolution.

We performed a photometric monitoring program on a sample of 40 solar-mass young stars in the Orion star-forming region, almost all previously identified as weak T Tauri stars (WTTS) candidates. Photometric B and V data were collected from 1999 to 2006 at Catania Astrophysical Observatory (OAC). Data were also acquired in December 1998 at Calar Alto Observatory (CA) and in 1999, 2000, and 2003 at San Pedro Martir (SPM). From the observed rotational modulation, induced by starspots, we derived the rotation periods, using both the Lomb-Scargle periodogram and the CLEAN deconvolution algorithms.

In total, we were able to determine the rotation periods for 39 stars, spanning from about 0.5 to 13 days, showing a rather flat distribution with a peak around 1-2 days. Though some of these stars were found to be spectroscopic binaries, only the systems with shorter orbital periods and circular orbits turned out to be synchronized. In the other cases, the rotational period is shorter than the period of pseudo-synchronization at periastron.

The new data provide further evidence for the spin up of solar-mass stars predicted by models of angular momentum evolution of pre-main sequence (PMS) stars.

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On the Migration of Protogiant Solid Cores

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The increase of computational resources has recently allowed high-resolution, three-dimensional calculations of planets embedded in gaseous protoplanetary disks. They provide estimates of the planet migration timescale that can be compared to analytical predictions. While these predictions can result in extremely short migration timescales for cores of a few Earth masses, recent numerical calculations have given an unexpected outcome: the torque acting on planets with masses between 5 and 20 $M_\oplus$ is considerably smaller than the analytic, linear estimate. These findings motivated the present work, which investigates existence and origin of this discrepancy or "offset", as we shall call it, by means of two- and three-dimensional numerical calculations. We show that the offset is indeed physical and arises from the co-orbital corotation torque, since (1) it scales with the disk vortensity gradient, (2) its asymptotic value depends on the disk viscosity, (3) it is associated to an excess of the horseshoe zone width. We show that the offset corresponds to the onset of nonlinearities of the flow around the planet, which alter the streamline topology as the planet mass increases: at low mass the flow nonlinearities are confined to the planet's Bondi sphere, whereas at larger mass the streamlines display a classical picture reminiscent of the restricted three-body problem, with a

prograde circumplanetary disk inside a "Roche lobe". This behavior is of particular importance for the subcritical solid cores ($M \lesssim 15\ M_\oplus$) in thin ($H/r \lesssim 0.06$) protoplanetary disks. Their migration could be significantly slowed down, or reversed, in disks with shallow surface density profiles.

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A Survey of the SO $J_K = 1_0 - 0_1$ Transition toward Massive Star-forming Regions

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We present the most extensive survey to date of the SO ground state transition $J_K = 1_0 - 0_1$ (30 GHz). We observed 49 regions of massive star formation with the Max-Planck-Institut für Radioastronomie (MPIfR) 100 m telescope. In addition, the SO $J_K = 4_3 - 3_2$ transition was observed with the IRAM 30 m telescope toward a subsample of seven sources. Emission in the SO $J_K = 1_0 - 0_1$ transition most likely arises from the parsec-scale molecular clumps surrounding ultracompact H II regions. In general, the SO $J_K = 1_0 - 0_1$ line has a Gaussian shape and appears to be optically thin. We derive SO column densities between 0.58×10^{14} and 12×10^{14} cm^{-2} and SO abundances in the range $0.18 \times 10^{-9} - 4.4 \times 10^{-9}$. Our observations show that the SO ground state transition is an effective tool to study massive star-forming clumps, and the data presented in this paper provide a useful supplement for future multitransition SO studies.

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Empirical isochrones and relative ages for young stars, and the radiative-convective gap.

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We have selected pre-main-sequence stars in 12 groups of notional ages ranging from 1 Myr to 35 Myrs, using heterogeneous membership criteria. Using these members we have constructed empirical isochrones in V, V-I colour magnitude diagrams (CMDs). This allows us to identify clearly the gap between the radiative main sequence and the convective pre-main-sequence (the R-C gap). We follow the evolution of this gap with age and show that it can be a useful age indicator for groups less than 15 Myrs old. We also observe a reduction in absolute spreads about the sequences with age. Finally the empirical isochrones allow us to place the groups in order of age, independently of theory. The youngest groups can be collated into three sets of similar ages. The youngest set is the ONC, NGC6530 and IC5146 (nominally 1 Myrs); next Cep OB3b, NGC2362, Lambda Ori and NGC2264 (nominally 3 Myrs); and finally Sigma Ori and IC348 (nominally 4-5 Myrs). This suggests Cep OB3b is younger than previously thought, and IC348 older. For IC348 the stellar rotation rate distribution and fraction of stars with discs imply a younger age than we derive. We suggest this is because of the absence of O-stars in this cluster, whose winds and/or ionising radiation may be an important factor in the removal of discs in other clusters.

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Laboratory and Astronomical Identification of the Negative Molecular Ion C_6H^-

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The negative molecular ion C_6H^- has been detected in the radio band in the laboratory and has been identified in the molecular envelope of IRC +10216 and in the dense molecular cloud TMC-1. The spectroscopic constants derived from laboratory measurements of 17 rotational lines between 8 and 187 GHz are identical to those derived from the astronomical data, establishing unambiguously that C_6H^- is the carrier of the series of lines with rotational constant 1377 MHz first observed by K. Kawaguchi et al. in IRC +10216. The column density of C_6H^- toward both sources is 1% - 5% that of neutral C_6H. These surprisingly high abundances for a negative ion imply that if other molecular anions are similarly abundant with respect to their neutral counterparts, they may be detectable both in the laboratory at high resolution and in interstellar molecular clouds.

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Magnetically Dominated Strands of Cold Hydrogen in the Riegel-Crutcher Cloud

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We present new high-resolution (100″) neutral hydrogen (H I) self-absorption images of the Riegel-Crutcher cloud obtained with the Australia Telescope Compact Array and the Parkes Radio Telescope. The Riegel-Crutcher cloud lies in the direction of the Galactic center at a distance of 125 ± 25 pc. Our observations resolve the very large, nearby sheet of cold hydrogen into a spectacular network of dozens of hairlike filaments. Individual filaments are remarkably elongated, being up to 17 pc long with widths of less than 0.1 pc. The strands are reasonably cold, with spin temperatures of 40 K and in many places appearing to have optical depths larger than 1. Comparing the H I images with observations of stellar polarization, we show that the filaments are very well aligned with the ambient magnetic field. We argue that the structure of the cloud has been determined by its magnetic field. In order for the cloud to be magnetically dominated the magnetic field strength must be $> 30\mu$G.

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Two-component magnetohydrodynamical outflows around young stellar objects - Interplay between stellar magnetospheric winds and disc-driven jets

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Context. We present the first-ever simulations of non-ideal magnetohydrodynamical (MHD) stellar magnetospheric winds coupled with disc-driven jets where the resistive and viscous accretion disc is self-consistently described.

Aims. These innovative MHD simulations are devoted to the study of the interplay between a stellar wind (having different ejection mass rates) and an MHD disc-driven jet embedding the stellar wind.

Methods. The transmagnetosonic, collimated MHD outflows are investigated numerically using the VAC code. We first investigate the various angular momentum transports occurring in the magneto-viscous accretion disc. We then analyze the modifications induced by the interaction between the two components of the outflow.

Results. Our simulations show that the inner outflow is accelerated from the central object's hot corona thanks to both the thermal pressure and the Lorentz force. In our framework, the thermal acceleration is sustained by the heating produced by the dissipated magnetic energy due to the turbulence. Conversely, the outflow launched from the

resistive accretion disc is mainly accelerated by the magneto-centrifugal force.

Conclusions. The simulations show that the MHD disc-driven outflow extracts angular momentum more efficiently than do viscous effects in near-equipartition, thin-magnetized discs where turbulence is fully developed. We also show that, when a dense inner stellar wind occurs, the resulting disc-driven jet has a different structure, namely a magnetic structure where poloidal magnetic field lines are more inclined because of the pressure caused by the stellar wind. This modification leads to both an enhanced mass-ejection rate in the disc-driven jet and a larger radial extension that is in better agreement with the observations, besides being more consistent.

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Are Debris Disks and Massive Planets Correlated?

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Using data from the *Spitzer Space Telescope* Legacy Science Program "Formation and Evolution of Planetary Systems" (FEPS), we have searched for debris disks around 9 FGK stars (2–10 Gyr), known from radial velocity (RV) studies to have one or more massive planets. Only one of the sources, HD 38529, has excess emission above the stellar photosphere; at 70 μm the signal-to-noise ratio in the excess is 4.7 while at $\lambda < 30$ μm there is no evidence of excess. The remaining sources show no excesses at any *Spitzer* wavelengths. Applying survival tests to the FEPS sample and the results for the FGK survey published in Bryden et al. (2006), we do not find a significant correlation between the frequency and properties of debris disks and the presence of close-in planets. We discuss possible reasons for the lack of a correlation.

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The role of Fischer-Tropsch catalysis in Jovian subnebular chemistry

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We examine the production of methane via Fischer-Tropsch catalysis in an evolving turbulent model of the Jovian subnebula and its implications for the composition of satellitesimals produced in situ. We show that there is a catalytically-active region in the Jovian subnebula from 65 Jupiter radii that moves inwards with time. The pressure range in this region is about 10^{-4} to 10^{-3} bar and implies that, if transport processes and the cooling of the subnebula

are not considered, CO and CO_2 are entirely converted into CH_4 via Fischer-Tropsch catalysis in about 10^1-10^2 and 10^3-10^4 years, respectively. On the other hand, the comparison of the chemical conversion times with the viscous timescale of the subdisk in the catalytically-active region implies that only CO can be fully converted into CH_4, the conversion of CO_2 thus being restricted to a limited production of CH_4. Moreover, the time required by the Jovian subnebula to cool down from the optimal temperature for Fischer-Tropsch catalysis to the condensation temperature of ices is at least two orders of magnitude higher than the viscous timescale. This implies that any CH_4 produced in the catalytically-active zone will be accreted onto Jupiter long before being incorporated into the forming ices. We then conclude that in an evolving turbulent subnebula, even if Fischer-Tropsch catalysis is active, it has no influence on the composition of the forming satellitesimals that will ultimately take part in the formation of regular icy satellites, in opposition to what has been expected from stationary models.

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Growing Hydrodynamic Modes in Keplerian Accretion Disks during Secondary Perturbations: Elliptical Vortex Effects

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The origin of hydrodynamic turbulence, and in particular of an anomalously enhanced angular momentum transport, in accretion disks is still an unsolved problem. This is especially important for cold disk systems that are practically neutral in charge, since the turbulence in those systems cannot be of magnetohydrodynamic origin. While the flow must exhibit some instability and then turbulence in support of the transfer of mass inward and angular momentum outward, according to the linear perturbation theory, in the absence of magnetohydrodynamic effects, it should always be stable. We demonstrate that the three-dimensional secondary disturbance to the primarily perturbed disk, consisting of elliptical vortices, gives significantly large hydrodynamic growth in such a system and hence may suggest a transition to an ultimately turbulent state. This result is essentially applicable to accretion disks around quiescent cataclysmic variables, in protoplanetary and star-forming disks, and the outer region of disks in active galactic nuclei, where the gas is significantly colder, and thus the magnetic Reynolds number is smaller than 10^4.

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A general model for the identification of specific PAHs in the far-IR

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Context. In the framework of the interstellar PAH hypothesis, far-IR skeletal bands are expected to be a fingerprint of single species in this class.

Aims. A detailed model of the photo-physics of interstellar PAHs is required for such single-molecule identification of their far-IR features in the presently available Infrared Space Observatory data and in those of the forthcoming Herschel Space Observatory mission.

Methods. We modelled the detailed photophysics of a vast sample of species in different radiation fields, using a compendium of Monte-Carlo techniques and quantum-chemical calculations. This enabled us to validate the use of purely theoretical data and assess the expected accuracy and reliability of the resulting synthetic far-IR emission spectra.

Results. We produce positions and intensities of the expected far-IR features that ought to be emitted by each species

in the sample in the considered radiation fields. A composite emission spectrum for our sample is computed for one of the most favourable sources for detection, namely the Red Rectangle nebula. The resulting spectrum is compared with the estimated dust emission in the same source to assess the dependence of detectability on key molecular parameters.

Conclusions. Identifying specific PAHs from their far-IR features is going to be a difficult feat in general; still, it may well be possible under favourable conditions.

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Detection of the 205μm [N II] Line from the Carina Nebula

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We report the first detection of the 205μm $^3P_1 \rightarrow ^3P_0$ [N II] line from a ground-based observatory using a direct detection spectrometer. The line was detected from the Carina star formation region using the South Pole Imaging Fabry-Perot Interferometer (SPIFI) on the Antarctic Submillimeter Telescope and Remote Observatory (AST/RO) at the South Pole. The [N II] 205μm line strength indicates a low-density (n $\sim$ 32 cm^{-3}) ionized medium, similar to the low-density ionized halo previously reported in its [O III] 52 and 88μm line emission. When compared with the Infrared Space Observatory [C II] observations of this region, we find that 27% of the [C II] line emission arises from this low-density ionized gas, but the large majority (73%) of the observed [C II] line emission arises from the neutral interstellar medium. This result supports and underpins prior conclusions that most of the observed [C II] 158μm line emission from Galactic and extragalactic sources arises from the warm, dense photodissociated surfaces of molecular clouds. The detection of the [N II] line demonstrates the utility of Antarctic sites for THz spectroscopy.

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ISO-ChaI 192: A new embedded eruptive variable in the Chamaeleon I dark cloud

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We report the detection of an increase of about 2 magnitudes in the 2.2 μm brightness of ISO-ChaI 192, a Class I low-mass stellar object thought to be responsible of driving a bipolar CO outflow in the Chamaeleon I cloud. This substantial brightness change has taken place during a period of about 3 yr, from March 1996 to April 1999. An elongated infrared reflection nebula of size $\sim$ 530 AU is seen originating from the star in the direction of the CO bipolar outflow. The historic infrared properties of this young stellar object are examined in order to substantiate the hypothesis that this object is an FU-Ori or EX Lup type system. Combining our new ground-based near- and mid-infrared photometry with *Spitzer*/IRAC and MIPS broad-band fluxes supplemented by published recent spectrophotometry, the spectral energy distribution (SED) of this source was constructed. We explored the plausibility of a "standard" configuration of infalling envelope+disk+central source for this object by fitting a two-dimensional radiative transfer code that includes the contributions of each of these components.

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A general catalogue of 6.7GHz methanol masers II: statistical analysis

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Context: Methanol masers at 6.7GHz are recognised markers of high-mass star formation regions. The study of their distribution in the Galaxy gives important insights into the star formation activity of the Milky Way. We present a statistical analysis on the General Catalogue of 6.7GHz methanol masers in the Galaxy with the aim of extracting global properties of the masers. Aims: We provide constraints on the luminosity function of 6.7GHz methanol masers and on their total number in the Galaxy. Methods: We model the spatial distribution of the masers in the Milky Way by using their distribution in galactocentric distance which is unambiguous once a rotation curve for the Galaxy is assumed. This is the starting point for determining the luminosity function of the masers. Results: The luminosity function of 6.7GHz methanol masers is modelled as a power-law with sharp cutoffs and having an index lying between -1.5 and -2. We also predict the number of detections of methanol masers assuming different sensitivity limits in the observations.

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Resolving the inner dust disks surrounding LkCa 15 and MWC 480 at mm wavelengths

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Aims : We constrain the dust distribution and its properties (temperature, emissivity) in inner proto-planetary disks.
Methods : We performed sub-arcsecond high-sensitivity interferometric observations of the thermal dust emission at 1.4 mm and 2.8 mm in the disks surrounding LkCa 15 and MWC 480, with the new 750 m baselines of the IRAM PdBI array. This provides a linear resolution of $\sim$ 60 AU at the distance of Taurus.
Results : We report the existence of a cavity of $\sim$ 50 AU radius in the inner disk of LkCa 15. Whereas LkCa 15 emission is optically thin, the optically thick core of MWC 480 is resolved at 1.4 mm with a radius of $\sim$ 35 AU, constraining the dust temperature. In MWC 480, the dust emission is coming from a colder layer than the CO emission, most likely the disk mid-plane.
Conclusions : These observations provide direct evidence of an inner cavity around LkCa 15. Such a cavity most probably results from the tidal disturbance created by a low-mass companion or large planet at $\sim$ 30 AU from the star. These results suggest that planetary system formation is already at work in LkCa 15. They also indicate that the classical steady-state viscous disk model is too simplistic a description of the inner 50 AU of "proto-planetary" disks and that the disk evolution is coupled to the planet formation process. The MWC 480 results indicate that a proper estimate of the dust temperature and size of the optically thick core are essential for determining the dust emissivity index β.

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Monte Carlo radiative transfer in protoplanetary disks

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Aims. We present a new continuum 3D radiative transfer code, MCFOST, based on a Monte-Carlo method. MCFOST can be used to calculate (i) monochromatic images in scattered light and/or thermal emission; (ii) polarisation maps; (iii) interferometric visibilities; (iv) spectral energy distributions; and (v) dust temperature distributions of

protoplanetary disks.

Methods. Several improvements to the standard Monte Carlo method are implemented in MCFOST to increase efficiency and reduce convergence time, including wavelength distribution adjustments, mean intensity calculations, and an adaptive sampling of the radiation field. The reliability and efficiency of the code are tested against a previously-defined benchmark, using a 2D disk configuration. No significant difference (no more than 10% and usually much less) is found between the temperatures and SEDs calculated by MCFOST and by other codes included in the benchmark.

Results. A study of the lowest disk mass detectable by Spitzer, around young stars, is presented and the colours of "representative" parametric disks compared to recent IRAC and MIPS Spitzer colours of solar-like young stars located in nearby star-forming regions.

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Deeply embedded objects and shocked molecular hydrogen: The environment of the FU Orionis stars RNO 1B/1C

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We present Spitzer IRAC and IRS observations of the dark cloud L1287. The mid-infrared (MIR) IRAC images show deeply embedded infrared sources in the vicinity of the FU Orionis objects RNO 1B and RNO 1C suggesting their association with a small young stellar cluster. For the first time we resolve the MIR point source associated with IRAS 00338+6312 which is a deeply embedded intermediate-mass protostar driving a known molecular outflow. The IRAC colors of all objects are consistent with young stars ranging from deeply embedded Class 0/I sources to Class II objects, part of which appear to be locally reddened. The two IRS spectra show strong absorption bands by ices and dust particles, confirming that the circumstellar environment around RNO 1B/1C has a high optical depth. Additional hydrogen emission lines from pure rotational transitions are superimposed on the spectra. Given the outflow direction, we attribute these emission lines to shocked gas in the molecular outflow powered by IRAS 00338+6312. The derived shock temperatures are in agreement with high velocity C-type shocks.

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Dust filtration at gap edges: implications for the spectral energy distributions of discs with embedded planets

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The spectral energy distributions (SEDs) of some T Tauri stars display a deficit of near-infrared flux that could be a consequence of an embedded Jupiter-mass planet partially clearing an inner hole in the circumstellar disc. Here, we use two-dimensional numerical simulations of the planet-disc interaction, in concert with simple models for the dust dynamics, to quantify how a planet influences the dust at different radii within the disc. We show that pressure gradients at the outer edge of the gap cleared by the planet act as a filter - letting particles smaller than a critical size through to the inner disc while holding back larger particles in the outer disc. The critical particle size depends on the disc properties, but is typically of the order of 10μm. This filtration process will lead to discontinuous grain populations across the planet's orbital radius, with small grains in the inner disc and an outer population of larger grains. We show that this type of dust population is qualitatively consistent with SED modelling of systems that have optically thin inner holes in their circumstellar discs. This process can also produce a very large gas-to-dust ratio in the inner disc, potentially explaining those systems with optically thin inner cavities that still have relatively high accretion rates.

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Radio Continuum Sources Associated with AB Aur

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We present high angular resolution, high-sensitivity Very Large Array observations at 3.6 cm of the Herbig Ae star AB Aur. This star is of interest since its circumstellar disk exhibits characteristics that have been attributed to the presence of an undetected low mass companion or giant gas planet. Our image confirms the continuum emission known to exist in association with the star, and detects a faint protuberance that extends about $0\farcs3$ to its SE. Previous theoretical considerations and observational results are consistent with the presence of a companion to AB Aur with the separation and position angle derived from our radio data. We also determine the proper motion of AB Aur by comparing our new observations with data taken about 17 years ago and find values consistent with those found by Hipparcos.

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Compact Centimeter and Millimeter Sources in NGC 6334 I(N): OB Stars in the Making?

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We present sensitive, high angular resolution 1.3 cm and 7 mm observations of the massive core NGC 6334 I(N), a region known to be undergoing massive star formation. At 1.3 cm we detect three sources, of which two had been previously detected at centimeter or millimeter wavelengths. At 7 mm we detect four sources. We suggest that three of these sources are subcomponents of the millimeter source SMA 1, that at these wavelengths is the dominant source in the region. The fourth 7 mm source appears to be associated with the relatively isolated source SMA 6. In all four 7 mm sources, the continuum emission is arising from structures of dimensions in the order of 1000 AU for which we estimate masses of order a few solar masses. We interpret these 7 mm sources as massive circumstellar disks that, however, surround stars or compact small stellar groups that at present have masses comparable to those of the disks but that may be accreting on their way to become massive stars.

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Methanol and Other Molecular Tracers of Outflows and Dense Gas in the Molecular Cloud G345.01+1.79

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The results of SEST millimeter observations of the molecular cloud G345.01+1.79 are presented. Spectra of CH_3OH, SO_2, SiO, HCO^+, $C^{18}O$, $C^{33}S$, $C^{34}S$, HCN and DCN lines have been obtained. Mapping of the cloud in CH_3OH, SiO and $C^{34}S$ lines indicates that the maximum of integrated intensity in the SiO and $C^{34}S$ lines and in low-excitation CH_3OH transitions coincide with the northern group of methanol masers, while the corresponding maximum for high-excitation CH_3OH transitions coincides with the southern methanol-maser group. The physical parameters are estimated from the quasi-thermal CH_3OH lines under the large-velocity-gradient approximation and their distribution in the sky derived. The density and temperature are higher toward the southern group of methanol maser then in the northern group. This may indicate that star formation is in an earlier stage of evolution in the nothern than toward the southern group. A maser component can be distinguished in 14 (of 71) CH_3OH lines. We have detected for the first time weak, probably maser, emission in the CH_3OH lines at 148.11, 231.28, 165.05, 165.06 and 165.07 GHz. A blue wing is clearly visible in the CH_3OH, SiO, $C^{18}O$ and SO_2 lines. The emission in this wing is probably associated with a compact source whose velocity is characteristic of the CH_3OH maser emission in the southern group of masers.

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Angular momentum transport in protostellar discs

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Angular momentum transport in protostellar discs can take place either radially, through turbulence induced by the magnetorotational instability (MRI), or vertically, through the torque exerted by a large-scale magnetic field that threads the disc. Using semi-analytic and numerical results, we construct a model of steady-state discs that includes vertical transport by a centrifugally driven wind as well as MRI-induced turbulence. We present approximate criteria for the occurrence of either one of these mechanisms in an ambipolar diffusion-dominated disc. We derive "strong field" solutions in which the angular momentum transport is purely vertical and "weak field" solutions that are the stratified-disc analogues of the previously studied MRI channel modes; the latter are transformed into accretion solutions with predominantly radial angular-momentum transport when we implement a turbulent-stress prescription based on published results of numerical simulations. We also analyze "intermediate field strength" solutions in which both modes of transport operate at the same radial location; we conclude, however, that significant spatial overlap of these two mechanisms is unlikely to occur in practice. To further advance this study, we have developed a general scheme that incorporates also the Hall and Ohm conductivity regimes in discs with a realistic ionization structure.

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http://xxx.lanl.gov/abs/astro-ph/0611359 http://www.mso.anu.edu.au/ raquel/

Three-dimensional Compressible Hydrodynamic Simulations of Vortices in Disks

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We carry out three-dimensional, high-resolution (up to $1024^2 \times 256$) hydrodynamic simulations of the evolution of vortices in vertically unstratified Keplerian disks using the shearing sheet approximation. The transient amplification of incompressible, linear amplitude leading waves (which has been proposed as a possible route to nonlinear hydrodynamic turbulence in disks) is used as one test of our algorithms; our methods accurately capture the predicted amplification, converge at second order, and are free from aliasing. Waves that are expected to reach nonlinear amplitude at peak amplification become unstable to Kelvin-Helmholtz modes when $\mid W_{max} \mid \gtrsim \omega$ (where W_{max} is the local maximum of vorticity and ω the angular velocity). We study the evolution of a power-law distribution of vorticity consistent with Kolmogorov turbulence; in two dimensions long-lived vortices emerge and decay slowly, similar to previous studies. In three dimensions, however, vortices are unstable to bending modes, leading to rapid decay. Only vortices with a length-to-width ratio smaller than 1 survive; in three dimensions the residual kinetic energy and shear stress is at least 1 order of magnitude smaller than in two dimensions. No evidence for sustained hydrodynamic turbulence

and transport is observed in three dimensions. Instead, at late times the residual transport is determined by the amplitude of slowly decaying, large-scale vortices (with horizontal extent comparable to the scale height of the disk), with additional contributions from nearly incompressible inertial waves possible. Evaluating the role that large-scale vortices play in astrophysical accretion disks will require understanding the mechanisms that generate and destroy them.

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The Characterization and Galactic Distribution of Infrared Dark Clouds

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Using ^{13}CO J = 1 → 0 molecular line emission from the Boston University-Five College Radio Astronomy Observatory Galactic Ring Survey (BU-FCRAO GRS), we have established kinematic distances to 313 infrared dark clouds (IRDCs) by matching the morphology of the molecular line emission in distinct velocity channels to their mid-infrared extinction. The Galactic distribution of IRDCs shows an enhancement toward the Galaxy's most massive and active star-forming structure, the so-called 5 kpc ring. IRDCs have typical sizes of ∼5 pc, peak column densities of $\sim 10^{22}$ cm^{-2}, LTE masses of $\sim 5 \times 10^3$ M$_\odot$, and volume-averaged H$_2$ densities of $\sim 2 \times 10^3$ cm^{-3}. The similarity of these properties to those of molecular clumps associated with active star formation suggests that IRDCs represent the densest clumps within giant molecular clouds where clusters may eventually form.

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HST NICMOS Imaging of the Planetary-mass Companion to the Young Brown Dwarf 2MASSW J1207334-393254

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Multiband (0.9-1.6μm) images of the TW Hydrae association (TWA) brown dwarf 2MASSW J1207334-393254 (also known as 2M 1207) and its candidate planetary-mass companion (2M 1207b) were obtained on 2004 August 28 and 2005 April 26 with HST NICMOS. The images from these two epochs unequivocally confirm the two objects as a common proper motion pair (16.0 σ confidence). A new measurement of the proper motion of 2M 1207 implies a distance to the system of 59 ± 7 pc and a projected separation of 46 ± 5 AU. The NICMOS and previously published VLT photometry of 2M 1207b, extending overall from 0.9 to 3.8μm, are fully consistent with an object of a few Jupiter masses at the canonical age of a TWA member (∼8 Myr) based on evolutionary models of young giant planets. These observations provide information on the physical nature of 2M 1207b and unambiguously establish that the first direct image of a planetary-mass companion in orbit around a self-luminous body, other than our Sun, has been secured.

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What is a Planet?

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A planet is an end product of disk accretion around a primary star or substar. I quantify this definition by the degree to which a body dominates the other masses that share its orbital zone. Theoretical and observational measures of dynamical dominance reveal gaps of 45 orders of magnitude separating the eight planets of our solar system from the populations of asteroids and comets. The proposed definition dispenses with upper and lower mass limits for a planet. It reflects the tendency of disk evolution in a mature system to produce a small number of relatively large bodies (planets) in nonintersecting or resonant orbits, which prevents collisions between them.

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First Doppler images of the very young K2-dwarf PW Andromedae = HD 1405

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Aims. We present the first Doppler images of the single pre-main-sequence star PW And. Its position in the HR-diagram suggests it to be in the rapid-braking phase just prior to arrival on the ZAMS.

Methods. Images are obtained from seven individual spectral lines as well as from 5-nm wide chunks of spectrum that invert a total of 58 line profiles simultaneously.

Results. Cool spots with temperature differences with respect to the stellar photosphere of up to 1200 K are detected. Spot occurrence is mostly within an equatorial band up to ±40° of the stellar equator and thus contradicts magnetic-flux tube emergence models based on young K-star properties that predict an emerging latitude in two distinct bands of +45-55°. This confirms previous suggestions that current magnetic-flux tube models predict emergence latitudes too low for G-dwarfs and too high for K-dwarfs, which may be caused by the fact that the G-dwarf models heavily rely on comparisons with the Sun. We also redetermine the absolute parameters of PW And in the light of a missing Hipparcos parallax and revise its age to be more near 20 Myr, in agreement with its logarithmic lithium abundance of 2.87 ± 0.05. A precise rotational period of $1^d.76159 \pm 0.00006$ was found from our photometric data in 2004.

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X-ray Emission from T Tauri Stars and the Role of Accretion: Inferences from the XMM-Newton Extended Survey of the Taurus Molecular Cloud

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T Tau stars display different X-ray properties depending on whether they are accreting (classical T Tau stars; CTTS) or not (weak-line T Tau stars; WTTS). X-ray properties may provide insight into the accretion process between disk and stellar surface. We use data from the *XMM-Newton Extended Survey of the Taurus Molecular Cloud* (XEST) to study differences in X-ray properties between CTTS and WTTS. We perform correlation and regression analysis between X-ray parameters and stellar properties. We confirm the existence of a X-ray luminosity (L_X) vs. mass (M) relation, $L_X \propto M^{1.69\pm0.11}$, but this relation is a consequence of X-ray saturation and a mass vs. bolometric luminosity (L_*) relation for the TTS with an average age of 2.4 Myr. X-ray saturation indicates $L_X = \mathrm{const}L_*$, although the constant is different for the two subsamples: $\mathrm{const} = 10^{-3.73\pm0.05}$ for CTTS and $\mathrm{const} = 10^{-3.39\pm0.06}$ for WTTS. Given a similar L_* distribution of both samples, the X-ray luminosity function also reflects a real X-ray deficiency in CTTS, by a factor of ≈ 2 compared to WTTS. The average electron temperatures $T_{\rm av}$ are correlated with $L_{\rm X}$ in WTTS but not in CTTS; CTTS sources are on average hotter than WTTS sources. At best marginal dependencies are found between X-ray properties and mass accretion rates or age. The most fundamental properties are the two saturation laws, indicating suppressed $L_{\rm X}$ for CTTS. We speculate that some of the accreting material in CTTS is cooling active regions to temperatures that may not significantly emit in the X-ray band, and if they do, high-resolution spectroscopy may be required to identify lines formed in such plasma, while CCD cameras do not detect these components. The similarity of the $L_{\rm X}$ vs. $T_{\rm av}$ dependencies in WTTS and main-sequence stars as well as their similar X-ray saturation laws suggests similar physical processes for the hot plasma, i.e., heating and radiation of a magnetic corona.

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http://www.issibern.ch/teams/Taurus/papers.html

On the hydrodynamics of the matter reinserted within superstellar clusters

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We present semi-analytical and numerical models, accounting for the impact of radiative cooling on the hydrodynamics of the matter reinserted as strong stellar winds and supernovae within the volume occupied by young, massive and compact superstellar clusters. First of all we corroborate the location of the threshold line in the mechanical energy input rate vs the cluster size plane, found by Silich et al. (2004). Such a line separates clusters able to drive a quasi-adiabatic or a strongly radiative wind from clusters in which catastrophic cooling occurs within the star cluster volume. Then we show that the latter, clusters above the threshold line, undergo a bimodal behavior in which the central densest zones cool rapidly and accumulate the injected matter to eventually feed further generations of star formation, while the outer zones are still able to drive a stationary wind. The results are presented into a series of universal dimensionless diagrams from which one can infer: the size of the two zones, the fraction of the deposited mass that goes into each of them and the luminosity of the resultant winds, for clusters of all sizes and energy input rates, regardless the assumed adiabatic terminal speed ($v_{A\infty}$).

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Debris disks in main sequence binary systems

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We observed 69 A3-F8 main sequence binary star systems using the Multiband Imaging Photometer for *Spitzer* onboard the *Spitzer* Space Telescope. We find emission significantly in excess of predicted photospheric flux levels for 9^{+4}_{-3}% and 40^{+7}_{-6}% of these systems at 24 and 70 microns, respectively. Twenty two systems total have excess emission, including four systems that show excess emission at both wavelengths. A very large fraction (nearly 60%) of observed binary systems with small (<3 AU) separations have excess thermal emission.We interpret the observed infrared excesses as

thermal emission from dust produced by collisions in planetesimal belts. The incidence of debris disks around main sequence A3-F8 binaries is marginally higher than that for single old AFGK stars. Whatever combination of nature (birth conditions of binary systems) and nurture (interactions between the two stars) drives the evolution of debris disks in binary systems, it is clear that planetesimal formation is not inhibited to any great degree.

We model these dust disks through fitting the spectral energy distributions and derive typical dust temperatures in the range 100–200 K and typical fractional luminosities around 10^{-5}, with both parameters similar to other *Spitzer*-discovered debris disks. Our calculated dust temperatures suggest that about half the excesses we observe are derived from circumbinary planetesimal belts and around one third of the excesses clearly suggest circumstellar material. Three systems with excesses have dust in dynamically unstable regions, and we discuss possible scenarios for the origin of this short-lived dust.

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Hard X-Rays from Ultracompact H II Regions in W49A

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We report the Chandra detection of hard X-ray emission from the Welch ring in W49A, an organized structure of ultracompact (UC) H II regions containing a dozen nascent early-type stars. Two UC H II regions are associated with hard X-ray emission in a deep Advanced CCD Imaging Spectrometer (ACIS) image exposed for ∼96.7 ks. One of the two X-ray sources has no near-infrared counterpart and is extended by $\sim 5''$, or ∼0.3 pc, at a distance of ∼11.4 kpc, which is spatially aligned with the cometary radio continuum emission associated with the UC H II region. The X-ray spectrum of the emission, when fit with a thermal model, indicates a heavily absorbed plasma with extinction of $\sim 5 \times 10^{23}$ cm^{-2}, temperature ∼7 keV, and X-ray luminosity in the 3.0-8.0 keV band of $\sim 3 \times 10^{33}$ ergs s^{-1}. Both the luminosity and the size of the emission resemble the extended hard emission found in UC H II regions in Sagittarius B2, yet they are smaller by an order of magnitude than the emission found in massive star clusters such as NGC 3603. Three possibilities are discussed for the cause of the hard extended emission in the Welch ring: an ensemble of unresolved point sources, shocked interacting winds of the young O stars, and a wind-blown bubble interacting with ambient cold matter.

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Chemical sensitivity to the ratio of the cosmic-ray ionization rates of He and H_2 in dense clouds

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Aims. To determine whether or not gas-phase chemical models with homogeneous and time-independent physical conditions explain the many observed molecular abundances in astrophysical sources, it is crucial to estimate the uncertainties in the calculated abundances and compare them with the observed abundances and their uncertainties. Non linear amplification of the error and bifurcation may limit the applicability of chemical models. Here we study such effects on dense cloud chemistry.

Methods. Using a previously studied approach to uncertainties based on the representation of rate coefficient errors

as log normal distributions, we attempted to apply our approach using as input a variety of different elemental abundances from those studied previously. In this approach, all rate coefficients are varied randomly within their log normal (Gaussian) distribution, and the time-dependent chemistry calculated anew many times so as to obtain good statistics for the uncertainties in the calculated abundances.

Results. Starting with so-called "high-metal" elemental abundances, we found bimodal rather than Gaussian like distributions for the abundances of many species and traced these strange distributions to an extreme sensitivity of the system to changes in the ratio of the cosmic ray ionization rate $\zeta_{\rm He}$ for He and that for molecular hydrogen $\zeta_{\rm H_2}$. The sensitivity can be so extreme as to cause a region of bistability, which was subsequently found to be more extensive for another choice of elemental abundances. To the best of our knowledge, the bistable solutions found in this way are the same as found previously by other authors, but it is best to think of the ratio $\zeta_{\rm He}/\zeta_{\rm H_2}$ as a control parameter perpendicular to the "standard" control parameter $\zeta/n_{\rm H}$.

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The detection of the (J, K) = (18, 18) line of NH_3

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Aims. A study of the metastable $(J, K) = (18, 18)$ line of ammonia (NH_3) is presented aiming at better defining the physical properties of molecular gas in extreme environments.

Methods. The spectra were collected with the Effelsberg 100-m telescope and are analyzed in combination with other data using a rotation diagram (Boltzmann plot).

Results. The first astronomical detection of the metastable (J,K) = (18, 18) line of NH_3 is reported. This is the NH_3 line with by far the highest energy, 3130 K above the ground state, detected in interstellar space. It is observed in absorption toward the galactic center star forming region Sgr B2. There is a clear detection toward Sgr B2 (M) and a likely one toward Sgr B2 (N). An upper limit for emission is determined for Orion KL. If we combine the (18, 18) line results from Sgr B2 (M) with the previously measured (12, 12) absorption line, we find a rotation temperature, $T_{\rm rot}$, of >1300 K for the absorbing cloud. This is at least a factor of two higher than previously derived values from less highly excited ammonia lines. $T_{\rm rot}$ gives a lower limit to the kinetic temperature. There is a hot low density gas component in the envelope of Sgr B2. It is possible that the (18, 18) line arises in this region. The radial velocity of the low density, hot envelope is the same as that of the dense hot cores, so the (18, 18) line could also arise in the dense hot cores where non-metastable (J>K) absorption lines from energy levels of up to ∼1350 K above the ground state have been observed. A discussion of scenarios is presented.

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Measurement of the Spin-Orbit Alignment in the Exoplanetary System HD 189733

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We present spectroscopy of a transit of the exoplanet HD 189733b. By modeling the Rossiter-McLaughlin effect (the anomalous Doppler shift due to the partial eclipse of the rotating stellar surface), we find the angle between the sky projections of the stellar spin axis and orbit normal to be $\lambda = -1^\circ.4 \pm 1^\circ.1$. This is the third case of a "hot Jupiter" for which λ has been measured. In all three cases λ is small, ruling out random orientations with 99.96% confidence, and suggesting that the inward migration of hot Jupiters generally preserves spin-orbit alignment.

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Benzene formation in the inner regions of protostellar disks

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Benzene (c-C_6H_6) formation in the inner 3 AU of a protostellar disk can be efficient, resulting in high abundances of benzene in the midplane region. The formation mechanism is different to that found in interstellar clouds and in protoplanetary nebulae, and proceeds mainly through the reaction between allene (C_3H_4) and its ion. This has implications for PAH formation, in that some fraction of PAHs seen in the solar system could be native rather than inherited from the interstellar medium.

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SHARC-II Mapping of Spitzer c2d Small Clouds and Cores

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We present the results of a submillimeter survey of 53 low-mass dense cores with the Submillimeter High Angular Resolution Camera II (SHARC-II). The survey is a follow-up project to the *Spitzer* Legacy Program "From Molecular Cores to Planet-Forming Disks", with the purpose being to create a complete data set of nearby low-mass dense cores from the infrared to the millimeter. We present maps of 52 cores at 350 μm and three cores at 450 μm, two of which were observed at both wavelengths. Of these 52 cores, 41 were detected by SHARC-II: 32 contained one submillimeter source while 9 contained multiple sources. For each submillimeter source detected, we report various source properties including source position, fluxes in various apertures, size, aspect ratio, and position angle. For the 12 cores that were not detected we present upper limits. The sources detected by SHARC-II have, on average, smaller sizes at the 2σ contours than those derived from longer-wavelength bolometer observations. We conclude that this is not caused by a failure to integrate long enough to detect the full extent of the core; instead it arises primarily from the fact that the observations presented in this survey are insensitive to smoothly varying extended emission. We find that SHARC-II observations of low-mass cores are much better suited to distinguishing between starless and protostellar cores than observations at longer wavelengths. Very Low Luminosity Objects, a new class of objects being discovered by the *Spitzer Space Telescope* in cores previously classified as starless, look very similar at 350 μm to other cores with more luminous protostars.

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http://peggysue.as.utexas.edu/SIRTF/

Multiple Jets from the High-Mass (Proto)stellar Cluster AFGL5142

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We present studies of a massive protocluster AFGL5142 in the J=2-1 transition of the CO isotopologues, SO, CH_3OH and CH_3CN lines, as well as continuum at 225 GHz and 8.4 GHz. The 225 GHz continuum emission reveals three prominent peaks MM-1, MM-2 and MM-3 with estimated circumstellar material of 3, 3, and 2 $M_\odot$, respectively. MM-1 and MM-2 are associated with strong CH_3CN emission with temperatures of 90 ± 20 and 250 ± 40 K, respectively, while both MM-1 and MM-3 are associated with faint continuum emission at 8.4 GHz. The heating implied by the temperature indicates that MM-1 and MM-2 cores contain embedded massive young stars. Additional dust continuum peaks MM-4 and MM-5 appear to be associated with H_2O masers. With many continuum sources at cm and mm wavelengths, and those already identified in the infrared, this region is forming a cluster of stars.

A total of 22 lines from 9 molecules are detected. The line strength varies remarkably in the region. The strong SO emission is found both in molecular outflows and cloud cores. CH_3OH emission, on the contrary, is much weaker in molecular outflows, and is detected toward hot cores MM-1 and MM-2 only, but is absent in less massive and perhaps less evolved cores MM-3, MM-4 and MM-5. The modeling of the CH_3CN spectra yields an abundance relative to H_2 of 1×10^{-8} and 4×10^{-8} for the MM-1 and MM-2 cores, respectively. With similar core mass, the higher temperature and CH_3CN abundance in the MM-2 core suggest that it might be at a more evolved stage than the MM-1 core.

The CO and SO emission reveals at least three molecular outflows originating from the center of the dust core. The outflows are well collimated, with terminal velocities up to 50 km s^{-1} from the cloud velocity. Outflow A coincides with the SiO jet identified previously by Hunter et al. (1999). The maximum velocity of both the CO and SiO outflow increases with the distance from the driving source. Since jet-like outflows and disk-mediated accretion process are physically connected, the well collimated outflows indicate that even in this cluster environment, accretion is responsible for the formation of individual stars in the cluster.

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The Impact of High-Energy Radiation on the Chemistry of Star-Forming Regions

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Young stars are deeply embedded in their natal molecular cloud. The youngest objects are surrounded by large amounts of dust and gas that completely absorb all radiation from the protostar at wavelengths shorter than optical. As a consequence, these objects can only be studied at infrared and (sub)millimeter wavelengths – the reign of dust and molecules. To trace the central high-energy radiation from UV to X-rays in those sources, their molecular environment has to be studied. First, the influence of a central far ultraviolet (FUV) source on the chemistry in the surrounding spherically symmetric envelope is studied for the isolated massive star-forming region AFGL 2591. A code was developed based on a previously published chemical model that solves for the time and depth-dependent molecular abundances. It is found that enhanced FUV fluxes lead to abundant radicals and ions in the inner few hundred AU of the envelope. Comparison between observations and models is improved with moderate FUV fluxes at the inner edge of the envelope.

The chemical reaction network is then extended to allow the impact of X-rays from the central source on the protostellar envelope. The chemistry in the envelope of AFGL 2591 is studied for different X-ray fluxes. In contrast to FUV, X-rays can enhance certain species in the envelope out to distances of a few thousand AU from the central source. The X-ray models improve the fits to observations in comparison to the FUV models.

The water abundance in star-forming environments under the influence of X-rays and FUV fields is studied in detail. It is found that X-rays destroy water on (relatively) short timescales in regions with gas temperatures of ¡ 300 K. At higher temperatures, water can persist with high abundances even for high X-ray fluxes. Central FUV fields were found to have negligible influence, unless the photons can escape through cavities and irradiate regions at larger distances from the source.

Observations of molecular lines in two high-mass objects and nine low-mass sources are presented. The observations were carried out using the James Clerk Maxwell Telescope on Mauna Kea, Hawaii. The observed ions and radicals are found to trace X-ray and FUV fluxes from the central source. The observations towards the high-mass objects were best interpreted by a FUV field irradiating the outflow walls, suggesting that the high-mass objects have low opacity outflows that allow the FUV photons to escape the central region. X-rays are predicted to be more effective than FUV fields in the low-mass objects.

New Jobs

Astrobiology Postdoctoral Fellow (Young Variable Stars)

University of Hawaii - Institute for Astronomy

The Institute for Astronomy (IfA) invites applications for a postdoctoral fellow with interests in young variable stars to work with the University of Hawaii's NASA Astrobiology Institute lead team (see http://www.ifa.hawaii.edu/UHNAI/). The UH lead team maintains an innovative and multi-disciplinary research environment linking astronomical, biological, microbiological, chemical, and geological sciences to investigate the origin, history, distribution and role of water as it relates to life in the universe. The program centers around interactions with an interdisciplinary group of postdoctoral fellows. We have a particular need for an individual interested in the study of variability of young stars and circumstellar disks, to be performed within the VYSOS (Variable Young Stellar Objects Survey) project led by Dr. Bo Reipurth. VYSOS uses two new robotic 16 inch telescopes, one located at the Mauna Loa Observatory in Hawaii, the other at Cerro Armazones in Chile. Both telescopes will be devoted to continuous monitoring of regions of recent star formation all along the Galactic plane, starting early 2007. The observations are automatically reduced and calibrated using advanced software packages that result in major data bases and catalogs, which are consulted using efficient algorithms.

Minimum qualifications include a Ph.D. in astronomy or a related field, a record of research in stellar astronomy as demonstrated by publications, good computer and software skills, and expertise in astronomical data processing and handling of large databases. Additional desirable qualifications: Experience with image analysis, software for automated data reduction, algorithms to find variable objects, time series analysis, and/or scheduling software. Education and public outreach is an integral part of the Astrobiology program and experience with or interest in E/PO will be considered positively in an application.

The successful candidate will join the VYSOS team and will focus on research using the VYSOS data. He/she will also have access to the unequaled astronomical observing facilities of the Mauna Kea and Haleakala observatories. The candidate is encouraged to work collaboratively with other fellows and co-investigators in an interdisciplinary environment and is expected to participate in the group activities (e.g. seminars, meetings, discussion groups etc). The appointment is for 2 years assuming satisfactory progress and availability of funds. Fellows will receive a stipend of approximately US$4400 per month, a small relocation allowance and basic research costs.

Please address application materials including a complete application form (http://www.ifa.hawaii.edu/UHNAI/ application.html), which includes a CV, publication list, and a list of three professional references to Michele Tom, Personnel Officer, Institute for Astronomy, 2680 Woodlawn Drive, Honolulu, HI 96822. The letters of recommendation SHOULD BE sent SEPARATELY to this same address. Further details about the VYSOS project may be obtained from Dr. Bo Reipurth by email (reipurth@ifa.hawaii.edu). Questions about the UH Astrobiology lead team's program may be directed to Dr. K. J. Meech (meech@ifa.hawaii.edu). Applications will be reviewed beginning February 1, 2007 and the position kept open until filled. The position is available immediately. The University of Hawaii is an EEO/AA employer and encourages applications from women and minorities.

Moving ... ??

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

Postdoctoral Position in Numerical Simulations of Star and/or Planet Formation

Astrophysics Group, University of Exeter

We are looking for a postdoctoral researcher in the fields of star or planet formation, to work with Professor Matthew Bate in the Astrophysics Group. The Groups work focuses on both theoretical and observational star and planet formation. Our research was rated excellent in the last UK Research Assessment Exercise. Exeter is also the coordinating node of the new EC-funded Marie Curie Research Training Network, CONSTELLATION, on the Origin of the Initial Mass Function, a consortium of 12 institutions across Europe.

You will have an appropriate first degree and a PhD (or equivalent). You should also have a strong record of publication in astrophysical hydrodynamical, magnetohydrodynamical and/or radiative transfer numerical simulations. You will be expected to make use of UK supercomputer facilities, including the UK Astrophysical Fluids Facility (UKAFF) and the supercomputer Exeter plans to purchase in 2007.

The position is a fixed-term, three-year appointment with a starting salary up to £29,716 pa on scale £21,467 to £34,448 pa (depending on level of appointment) 36.5 hours per week.

The closing date for receipt of applications is 15 January, 2007.

Informal enquiries can be made by e-mailing mbate@astro.ex.ac.uk. An application form is available on request, and applicants should send this, along with a description of their current research and future plans (3 pages), a brief curriculum vitae including the names and contact details of three references, and a list of refereed publications to Professor Matthew Bate, School of Physics, University of Exeter, EX4 4QL, United Kingdom. Electronic submissions may be made to the above email address.

Equal Opportunities Employer

Postdoctoral position in the ALMA Regional Center node

A postdoctoral position will be available starting mid 2007 within the framework of the Dutch node of the European ALMA Regional Center (ARC). The appointment is for an initial period of two years with a possible extension with one additional year. The ARC node will offer support for general ALMA users as well as expert advise in high-frequency observing and wide-field / high dynamic range imaging, and provide infrastructure for science analysis. In addition to carrying out a personal research program, the postdoc is expected to aid in the ARC tasks and specifically to assist with the commissioning of the ALMA antennas and software. The postdoc wil be required to spend several periods of up to 3 months in Chile, working at the high Chajnantor site. Interest and ability to work at high altitude is required. Candidates with an in-depth background in millimeter or radio interferometry and with an interest in submillimeter observations of star formation or other areas of astronomy are encouraged to apply.

Applicants should send a curriculum vitae, publication list, and a statement of research interests, and arrange for three letters of recommendation to be sent to Dr. M.R. Hogerheijde by e-mail (preferred) or regular mail to Leiden Observatory, PO Box 9513, 2300 RA, Leiden, The Netherlands. The closing date for applications and all letters of recommendation is 15 January 2007. For further inquiries, contact Dr. M.R. Hogerheijde or see http://www.strw.leidenuniv.nl/~alma/arc.

Postdoctoral position in star and planet formation

As part of a research program on the structure and evolution of protoplanetary disks, a postdoctoral research position is available for two years at Leiden Observatory, starting mid-2007.

The successful applicant will work with Dr. Michiel Hogerheijde and a group of several graduate and undergraduate students on studying millimeter and (far) infrared observations of protoplanetary disks as well as associated modeling of disk chemistry, hydrodynamics, and radiative transfer. In addition to time spent on her/his own research and collaborative research with other group members, specific tasks of the successful applicant include further development of available software tools to model the disk structure, chemistry, and radiative transfer.

Current or future instruments that our group uses include the James Clerk Maxwell Telescope, the (enhanced) SubMillimeter Array, the Atacama Pathfinder EXperiment, the Spitzer Space Telescope, and the Herschel Space Observatory. Our group interacts closely with the molecular astrophysics and laboratory astrophysics group of Prof. Dr. Ewine van Dishoeck, and is part of the Observatory of Leiden University. For more information see http://www.strw.leidenuniv.nl/∼michiel

Applications should include a curriculum vitae with a list of publications, a brief description of past research experience, and a brief statement of research the candidate is interested in carrying out. The applicant should also arrange for three letters of reference to be sent directly to the submission address. Deadline for application and receipt of letters of reference is 15 January 2007.

Submission address: michiel@strw.leidenuniv.nl (preferred) or Leiden Observatory, att. Dr. M. Hogerheijde, PO Box 9513, 2300 RA, Leiden, The Netherlands.

Meetings

2007 Gordon Conference on Origins of Solar Systems

The 2007 Gordon Research Conference on Origins of Solar Systems will be held at Mt. Holyoke College in South Hadley, MA on 8-13 July 2007. This unique interdisciplinary meeting includes astronomers and astrophysicists interested in star and planet formation, planetary scientists and meteoriticists interested in the early history of the Solar System, and plasma and life scientists. This meeting is much broader than most conferences and many fruitful research collaborations have been initiated at Gordon conferences, encouraged by the relaxed pace of the meeting.

If you would like to attend a meeting which is not packed solid with talks, but has a limited number of overview talks; if you would enjoy spending extended time reading posters (or would like to have plenty of time for people to look at your poster and even speak with you); and if you might like participating in evening beverage sessions with colleagues from a wide variety of backgrounds, this is the meeting for you.

The preliminary scientific program includes the following topics: Stardust and dust in protoplanetary disks; radioisotopes and solar system chronology; evolution of protoplanetary disks (observations); debris disks; disk physics and planet formation; exoplanet results from lensing and transits; chemistry in protoplanetary disks; and chondrule formation. Another topic may be included in the final program. The list of invited speakers and session moderators includes Yuri Aikawa, David Bennett, Ted Bergin, Martin Bizzarro, Alan Boss, Fred Ciesla, Harold Connolly, Marianna Cosarinsky, Suzan Edwards, Elise Furlan, Charles Gammie, Lynne Hillenbrand, Rhian Jones, Scott Kenyon, Zoe Leinhardt, Mike Meyer, Amaya Moro-Martin, Scott Sandford, Sara Seager, Dan Watson, Ed Young, and Mike Zolensky. The Chair and Vice-Chair of the 2007 Origins of Solar Systems conference are Lee Hartmann (Michigan) and Sara Russell (Natural History Museum, London). Please contact us (lhartm@umich.edu, sara.russell@nhm.ac.uk) with any questions or suggestions. Information on registering, travel, accommodations, etc. will be available at http://www.grc.org/programs/2007/origins.htm, probably in February.