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## *Abstracts of recently accepted papers*

### Molecular Evolution in Collapsing Prestellar Cores III: Contraction of A Bonnor-Ebert Sphere


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The gravitational collapse of a spherical cloud core is investigated by numerical calculations. The initial conditions of the core lie close to the critical Bonnor-Ebert sphere with a central density of $\sim 10^4$ cm$^{-3}$ in one model ($\alpha = 1.1$), while gravity overwhelms pressure in the other ($\alpha = 4.0$), where $\alpha$ is the internal gravity-to-pressure ratio. The $\alpha = 1.1$ model shows reasonable agreement with the observed velocity field in prestellar cores. Molecular distributions in cores are calculated by solving a chemical reaction network that includes both gas-phase and grain-surface reactions. When the central density of the core reaches $10^5$ cm$^{-3}$, carbon-bearing species are significantly depleted in the central region of the $\alpha = 1.1$ model, while the depletion is only marginal in the other model. The two different approaches encompass the observed variations of molecular distributions in different prestellar cores, suggesting that molecular distributions can be probes of contraction or accumulation time scales of cores. The central enhancement of the $NH_3/N_2H^+$ ratio, which is observed in some prestellar cores, can be reproduced under certain conditions by adopting recently measured branching fractions for $N_2H^+$ recombination. Various molecular species, such as $CH_3OH$ and $CO_2$, are produced by grain-surface reactions. The ice composition depends sensitively on the assumed temperature. Multi-deuterated species are included in our most recent gas-grain chemical network. The deuterated isotopomers of $H_3^+$ are useful as probes of the central regions of evolved cores, in which gas-phase species with heavy elements are strongly depleted. At 10 K, our model can reproduce the observed abundance ratio of $ND_3/NH_3$, but underestimates the isotopic ratios of deuterated to normal methanol.



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http://arXiv.org/abs/astro-ph/0410582
http://nova.scitec.kobe-u.ac.jp/~aikawa/paper_list.html


### Submillimeter Array Observations of Disks in the SR 24 Multiple Star System


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We present high-resolution aperture synthesis images from the Submillimeter Array of the 225 GHz (1.3 mm) continuum and $^{12}$CO $J = 2 - 1$ line emission from the disks around components of the hierarchical triple system SR 24, located in the Ophiuchus star-forming region. The most widely separated component, SR 24 S (with a projected semimajor axis $a = 832$ AU), has a circumstellar disk with properties typical of those around single T Tauri stars. The binary SR 24 N ($a = 32$ AU) is undetected in the continuum, but has strong, resolved CO emission which likely originates in a

circumbinary disk with a central gap. The data constrain the total disk mass in the SR 24 N system to be $\leq 10^{-3}\,M_{\odot}$ and indicate that the depletion of CO onto dust grains is not more than 100 times larger than the mean value in the interstellar medium. The SR 24 N disk is unusual in that it is only detected in line emission. It is possible that other low mass disks around binaries and single stars may have been missed in single-dish continuum surveys.

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## $CH_3CN$ Observations toward Southern Massive Star Forming Regions

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In an effort to identify very young sites of massive star formation, we have conducted a survey for hot and dense molecular cores toward a sample of 17 southern sources. The sample consists of sources with IRAS color characteristics of ultra-compact HII regions for which high density molecular material had previously been detected. We observed the J = 5–4, 6–5, 8–7 and 12–11 rotational transitions of $CH_3CN$ and derived rotation temperatures and column densities using the population-diagram technique. We identify four sources with a high temperature molecular component ($T_{rot} > 90$ K) as new candidates for hot molecular cores. We also observed the transitions H35$\alpha$, CS J=3–2 and the continuum in the 3, 2 mm bands toward 17 sources, and the 1.3 mm continuum, H41$\alpha$ and $^{13}$CO J=2–1 transitions toward 10 sources. Eight sources show blue and red wings in the CS J=3–2 line whereas three sources show wings in the $^{13}$CO J=2–1 spectra, suggestive of molecular outflows. Our continuum and recombination line data show that the 91 GHz continuum emission is dominated by free-free emission from ionized regions whereas at 147 GHz emission from dust grains contributes significantly.

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http://www.journals.uchicago.edu/ApJ/future.html

## A New $H_2CO$ 6 cm Maser in IRAS 18566+0408

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We report VLA observations toward IRAS 18566+0408 conducted to determine the nature of the $H_2CO$ 6 cm emission line recently detected by Araya et al. (2004). Our observations clearly show that the $H_2CO$ source is due to maser emission, making IRAS 18566+0408 only the fourth galactic $H_2CO$ 6 cm maser source, out of five known $H_2CO$ emitters. We also report detection of a weak 2 cm continuum source that is coincident with the $H_2CO$ maser. Given the current observational constraints, the maser could be due to the radiative pumping mechanism proposed by Boland & de Jong (1981), however the coincidence of the new $H_2CO$ maser with 22 GHz $H_2O$ masers suggests that shocked molecular gas could also play a role in its excitation.

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## Thermal condensation in a turbulent atomic hydrogen flow

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We present a numerical and analytical study of the thermal fragmentation of a turbulent flow of interstellar hydrogen. We first present the different dynamical processes and the large range of spatial (and temporal) scales that need to be adequately represented in numerical simulations. Next, we present bidimensionnal simulations of turbulent converging flows which induce the dynamical condensation of the warm neutral phase into the cold phase. We then analyse the cold structures and the fraction of unstable gas in each simulation, paying particular attention to the influence of the degree of turbulence. When the flow is very turbulent a large fraction of the gas remains in the thermally unstable domain. This unstable gas forms a filamentary network. We show that the fraction of thermally unstable gas is strongly correlated with the level of turbulence of the flow. We then develop a semi-analytical model to explain the origin of this unstable gas. This simple model is able to reproduce quantitatively the fraction of unstable gas observed in the simulations and its correlation with turbulence. Finally, we stress the fact that even when the flow is very turbulent and in spite of the fact that a large fraction of the gas is maintained dynamically in the thermally unstable domain, the classical picture of a 2-phase medium with stiff thermal fronts and local pressure equilibrium turns out to be still relevant in the vicinity of the cold structures.

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## The Formation and Evolution of Protostellar Disks; 3D AMR Hydro-Simulations of Collapsing, Rotating Bonnor-Ebert-Spheres

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We present a detailed study of the collapse of molecular cloud cores using high resolution 3D adaptive mesh refinement (AMR) numerical simulations. In this first in a series of investigations our initial conditions consists of spherical molecular core obeying the hydrostatic Bonnor-Ebert-Profile with varying degrees of initial rotation. Our simulations cover both the formation of massive disks in which massive stars form as well as low mass disks. We use a customized version of the FLASH code whose AMR technique allows us to follow the formation of a protstellar disk and protostellar core(s) through more than ten orders in density increase while continuously resolving the local Jeans length (i.e. obeying the Truelove criterion). Our numerical simulations also incorporate the energy loss due to molecular line emission in order to obtain a more realistic picture of protostellar core and disk formation. Out initial states model system of mass $168\,M_\odot$ and $2.1\,M_\odot$ that will form high and low mass stars, respectively. We follow many features such as the development complex shock structures, and the possible fragmentation of the disk. We find that slowly rotating cores ($\Omega\,t_{\rm ff} = 0.1$) produce disks in which a strong bar develops but which does not fragment. Faster initial rotation rates ($\Omega\,t_{\rm ff} = 0.2$) result in the formation of a ring which may fragment into two protostellar cores. The size of the rings found in our simulated disks agree with the observations of similar systems.

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## The Origin of the Initial Mass Function and its Dependence on the Mean Jeans Mass in Molecular Clouds

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We investigate the dependence of stellar properties on the mean thermal Jeans mass in molecular clouds. We compare the results from the two largest hydrodynamical simulations of star formation to resolve the fragmentation process down to the opacity limit, the first of which was reported by Bate, Bonnell & Bromm. The initial conditions of the two calculations are identical except for the radii of the clouds, which are chosen so that the mean densities and mean thermal Jeans masses of the clouds differ by factors of nine and three, respectively. We find that the denser cloud, with the lower mean thermal Jeans mass, produces a higher proportion of brown dwarfs and has a lower characteristic (median) mass of the stars and brown dwarfs. This dependence of the initial mass function (IMF) on the density of the cloud may explain the observation that the Taurus star-forming region appears to be deficient in brown dwarfs when compared with the Orion Trapezium cluster. The new calculation also produces wide binaries (separations $> 20$ AU), one of which is a wide binary brown dwarf system. Based on the hydrodynamical calculations, we develop a simple accretion/ejection model for the origin of the IMF. In the model, all stars and brown dwarfs begin with the same mass (set by the opacity limit for fragmentation) and grow in mass until their accretion is terminated stochastically by their ejection from the cloud through dynamically interactions. The model predicts that the main variation of the IMF in different star-forming environments should be in the location of the peak (due to variations in the mean thermal Jeans mass of the cloud) and in the substellar regime. However, the slope of the IMF at high-masses may depend on the dispersion in the accretion rates of protostars.

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Paper and animations available at http://www.astro.ex.ac.uk/people/mbate

## Near-arcsecond resolution observations of the hot corino of the solar type protostar IRAS 16293–2422

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Complex organic molecules have previously been discovered in solar type protostars, raising the questions of where and how they form in the envelope. Possible formation mechanisms include grain mantle evaporation, interaction of the outflow with its surroundings or the impact of UV/X-rays inside the cavities. In this Letter we present the first interferometric observations of two complex molecules, $CH_3CN$ and $HCOOCH_3$, towards the solar type protostar IRAS 16293–2422. The images show that the emission originates from two compact regions centered on the two components of the binary system. We discuss how these results favor the grain mantle evaporation scenario and we investigate the implications of these observations for the chemical composition and physical and dynamical state of the two components.

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## The CIDA Variability Survey of Orion OB1. I: the low-mass population of Ori OB 1a and 1b

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We present results of a large scale, multi-epoch optical survey of the Ori OB1 association, carried out with the QuEST camera at the Venezuela National Astronomical Observatory. We identify for the first time the widely spread low-mass, young population in the Orion OB1a and OB1b sub-associations. Candidate members were picked up by their variability in the $V$-band and position in color-magnitude diagrams. We obtained spectra to confirm membership. In a region spanning $\sim 68\mathrm{deg}^2$ we found 197 new young stars; of these, 56 are located in the Ori OB1a subassociation and 142 in Ori OB1b. The spatial distribution of the the low mass young stars is spatially coincident with that of the high mass members, but suggests a much sharper edge to the association. Comparison with the spatial extent of molecular gas and extinction maps indicates that the subassociation Ori 1b is concentrated within a ring-like structure of radius $\sim 2^\circ$($\sim$ 15 pc at 440 pc), centered roughly on the star $\epsilon$ Ori in the Orion belt. The ring is apparent in $^{13}$CO and corresponds to a region with an extinction $A_V \geq 1$. The stars exhibiting strong H$\alpha$ emission, an indicator of active accretion, are found along this ring, while the center is populated with weak H$\alpha$ emitting stars. In contrast, Ori OB1a is located in a region devoid of gas and dust. We identify a grouping of stars within a $\sim 3\,\mathrm{deg}^2$ area located in 1a, roughly clustered around the B2 star 25 Ori. The Herbig Ae/Be star V346 Ori is also associated with this grouping, which could be an older analog of $\sigma$ Ori. Using using several sets of evolutionary tracks we find an age of 7 - 10 Myr for Ori 1a and of $\sim 4-6$ Myr for Ori OB1b, consistent with previous estimates from OB stars. Indicators such as the equivalent width of H$\alpha$ and near-IR excesses show that the number of accreting low-mass stars decreases sharply between Ori 1b and Ori 1a. These results indicate that while a substantial fraction of accreting disks remain at ages $\sim 5$ Myr, inner disks are essentially dissipated by 10 Myr.

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## On the Surface Heating of Synchronously-Spinning Short-Period Jovian Planets

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We consider the atmospheric flow on short-period extra-solar planets through two-dimensional numerical simulations of hydrodynamics with radiation transfer. The observed low eccentricity of these planets indicates that tidal dissipation within them has been effective in circularizing their orbits and synchronizing their spins. Consequently, one side of these planets (the day side) is always exposed to the irradiation from the host star, whereas the other (the night side) is always in shadow. The temperature of the day side is determined by the equilibrium which the planetary atmosphere establishes with the stellar radiation. For planets around solar-type stars with periods less than 7 days, the flux of stellar irradiation exceeds that released from their Kelvin-Helmholtz contraction by several orders of magnitude. A fraction of the thermal energy deposited on the day side is advected to the night side by a current. We show that the radiation transfer and the night-side temperature distribution in a planet's atmosphere are sensitive functions of its opacity. If the atmosphere contains grains with an abundance and size distribution comparable to that of the interstellar medium, only shallow heating occurs on the day side, whereas the heat flux carried by the circulation does not effectively heat the night side, which cools well below the day side. The temperature difference affects the spectroscopic signature of these planets. However, the temperature difference decreases as the abundance of grains in the atmosphere is reduced. This effect occurs because if the grains are depleted, the stellar radiative flux penetrates more deeply into the atmosphere on the day side, and the higher-density atmospheric circulation carries a larger flux of heat over to the night side. A simple analytic model of the dissipation of the circulation flow and associated kinetic heating is also considered. This heating effect occurs mostly near the photosphere, not deep enough to significantly affect the size of planets. The depth of the energy deposition increases as the abundance of grains is reduced. Finally, we show that the surface irradiation suppresses convection near the photospheric region on the day side. But, in some cases, depending on the opacity, convection zones are present near the surface on the night side. This structural modification may influence the response and dissipation of tidal disturbances and alter the circularization and synchronization time scales.

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## Disk evolution in the Ori OB1 association

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We analyze multi-band photometry of a subsample of low mass stars in the associations Ori OB1a and 1b discovered during the CIDA Orion Variability Survey, which have ages of 7 - 10 Myr and 3 - 5 Myr, respectively. We obtained $UBVR_cI_c$ photometry at Mt Hopkins for 6 Classical T Tauri stars (CTTS) and 26 Weak T Tauri stars (WTTS) in Ori OB1a, and for 21 CTTS and 2 WTTS in Ori OB1b. We also obtained $L$ band photometry for 14 CTTS at Mt. Hopkins, and 10$\mu$m and 18$\mu$m photometry with OSCIR at Gemini for 6 CTTS; of these, all 6 were detected at 10$\mu$m while only one was detected at 18$\mu$m. We estimate mass accretion rates from the excess luminosity at $U$, and find that they are consistent with determinations for a number of other associations, with or without high mass star formation. The observed decrease of mass accretion rate with age is qualitatively consistent with predictions of viscous evolution of accretion disks, although other factors can also play a role in slowing accretion rates. We compare the excesses over photospheric fluxes in $H-K$, and $K-L$, and $K-N$ with the younger sample of Taurus and find an overall decrease of disk emission from Taurus to Ori OB1b to Ori OB1a. This decrease implies that significant grain growth and settling towards the midplane has taken place in the inner disks of Ori OB1. We compare the SED of the star detected at both 10$\mu$m and 18$\mu$m with disk models for similar stellar and accretion parameters. We find that the low $\leq$ 18$\mu$m fluxes of this Ori OB1b star cannot be due to the smaller disk radius expected from viscous evolution in the presence of the FUV radiation fields from the OB stars in the association. Instead, we find that the disk of this star is essentially a flat disk, with little if any flaring, indicating a a significant degree of dust settling towards the midplane, as expected from dust evolution in protoplanetary disks.

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http://www.cida.ve/∼briceno/publications/

## Evolution of Cold Circumstellar Dust Around Solar-Type Stars

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We present submillimeter (CSO 350$\mu$m) and millimeter (SEST 1.2 mm, OVRO 3 mm) photometry for 125 solar-type stars from the FEPS *Spitzer* Legacy program that have masses between ∼0.5 and 2.0 $M_\odot$ and ages from ∼3 Myr to 3 Gyr. Continuum emission was detected toward four stars with a signal to noise ratio $\geq$ 3: the classical T Tauri stars RX J1842.9−3532, RX J1852.3−3700, and PDS 66 with SEST, and the debris disk system HD 107146 with OVRO. RX J1842.9−3532 and RX J1852.3−3700 are located in projection nearby the R CrA molecular cloud with estimated ages of ∼10 Myr (Neuhäuser et. al. 2000), while PDS 66 is a probable member of the ∼ 20 Myr old Lower Centaurus-Crux subgroup of the Scorpius-Centaurus OB association (Mamajek et al. 2004). The continuum emission toward these three sources is unresolved at the 24″ SEST resolution and likely originates from circumstellar accretion disks, each with estimated dust masses of ∼5×10$^{-5}$ $M_\odot$. Analysis of the visibility data toward HD 107146 (age ∼80-200 Myr) indicates that the 3 mm continuum emission is centered on the star within the astrometric uncertainties

and resolved with a gaussian-fit FWHM size of $(6.5'' \pm 1.4'') \times (4.2'' \pm 1.3'')$, or 185 AU×120 AU. The results from our continuum survey are combined with published observations to quantify the evolution of dust mass with time by comparing the mass distributions for samples with different stellar ages. The frequency distribution of circumstellar dust masses around solar-type stars in the Taurus molecular cloud (age $\sim$ 2 Myr) is distinguished from that around 3-10 Myr and 10-30 Myr old stars at a significance level of $\sim 1.5\sigma$ and $\sim 3\sigma$ respectively. These results suggest a decrease in the mass of dust contained in small dust grains and/or changes in the grain properties by stellar ages of 10-30 Myr, consistent with previous conclusions. Further observations are needed to determine if the evolution in the amount of cold dust occurs on even shorter time scales.

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## The 90-110 $\mu$m dust feature in low to intermediate mass protostars: calcite ?

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We present ISO spectra between 60 and 180 $\mu$m of about three dozens protostars of low to intermediate mass. About half of the spectra present a dust feature between $\sim$90 and $\sim$110 $\mu$m. We describe the observational characteristics of this feature, which seems to be due to one single carrier. In Class 0 sources the feature peaks around 100 $\mu$m, while in AeBe stars it peaks around 95 $\mu$m. The feature peak position seems to mostly depend on the temperature of the dust of the source, suggesting reprocessing of the dust. We present arguments for the identification of the observed feature as due to the calcite, and estimate that about 10% to 30% of elemental Ca is locked up into it. Therefore, calcite seems to be formed relatively easily around protostars despite that on Earth it needs aqueous solutions. This rises the outstanding question whether conditions simulating liquid water are common around forming stars and what creates them.

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http://www-laog.obs.ujf-grenoble.fr/$\sim$ceccarel/

## Structure of the Dense Molecular Gas in the NGC 1333 IRAS 4 Region

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The NGC 1333 IRAS 4 region was observed in the HCN and $HCO^+$ $J = 1 \rightarrow 0$ lines using a single-dish telescope and in the 2.1 mm continuum and the $H_2CO$ $J_{K_{-1}K_{+1}} = 2_{12} \rightarrow 1_{11}$ line using an interferometer. The single-dish maps show that there are at least two velocity components in emission: one at $V_{\rm LSR} = 6.7$ km s$^{-1}$ associated with the IRAS 4 core and the other at $\sim$8 km s$^{-1}$ associated with a cloud extended from the SVS 13 complex. In addition, there is a foreground cold layer at $\sim$8 km s$^{-1}$ that causes absorption over most of the mapped area. The cloud structure suggests that the blue-skewed line profile of IRAS 4A/B may not be a sign of protostellar collapse. Examinations of both single-dish and interferometric maps suggest that the dip previously seen in the interferometric spectra toward IRAS 4A/B may be caused mostly by the large-scale foreground layer and partly by missing short-spacing flux. Absorption by an infalling envelope with an unusual velocity profile cannot be ruled out. The $HCO^+$ map revealed other molecular cores, one associated with SK 1, and the other with SK 10/14. They are probable sites of star formation.

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## Observations of Massive Star Forming Regions with Water Masers: Mid-Infrared Imaging

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We present here a mid-infrared imaging survey of 26 sites of water maser emission. Observations were obtained at the InfraRed Telescope Facility 3-m telescope with the University of Florida mid-infrared imager/spectrometer OSCIR, and the JPL mid-infrared camera MIRLIN. The main purpose of the survey was to explore the relationship between water masers and the massive star formation process. It is generally believed that water masers predominantly trace outflows and embedded massive stellar objects, but may also exist in circumstellar disks around young stars. We investigate each of these possibilities in light of our mid-infrared imaging. We find that mid-infrared emission seems to be more closely associated with water and OH maser emission than cm radio continuum emission from UC HII regions. We also find from the sample of sources in our survey that, like groups of methanol masers, both water and OH masers have a proclivity for grouping into linear or elongated distributions. We conclude that the vast majority of linearly distributed masers are not tracing circumstellar disks, but outflows and shocks instead.

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http://www.ctio.noao.edu/∼debuizer/

## Molecular Line Profile Fitting with Analytic Radiative Transfer Models

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We present a study of analytic models of starless cores whose line profiles have "infall asymmetry," or blue-skewed shapes indicative of contracting motions. We compare the ability of two types of analytical radiative transfer models to reproduce the line profiles and infall speeds of centrally condensed starless cores whose infall speeds are spatially constant and range between 0 and 0.2 km $s^{-1}$. The model line profiles of $HCO^+$ ($J = 1 \rightarrow 0$) and $HCO^+$ ($J = 3 \rightarrow 2$) are produced by a self-consistent Monte Carlo radiative transfer code. The analytic models assume that the excitation temperature in the front of the cloud is either constant ("two-layer" model) or increases inward as a linear function of optical depth ("hill" model). Each analytic model is matched to the line profile by rapid least-squares fitting.

The blue-asymmetric line profiles with two peaks, or with a blue shifted peak and a red shifted shoulder, can be well fit by one or both of the analytic models. For two-peak profiles is best matched by the "HILL5" model (a five parameter version of the hill model), with an RMS error of 0.01 km $s^{-1}$, while the "TWOLAYER6" model underestimates the infall speed by a factor of $\sim 2$. For red-shoulder profiles, the HILL5 and TWOLAYER6 fits reproduce infall speeds equally well, with an RMS error of 0.04 km $s^{-1}$. The fits are most accurate when the line has a brightness temperature greater than 3 K. Our most accurate models tend to reproduce not only the line profile shape, but also match the excitation conditions along the line of sight. A better match to the line profile shape does not necessarily imply a better match to the infall speed and provide guidance on how to minimize the risk of obtaining a poor infall speed fit.

A peak signal to noise ratio of at least 30 in the molecular line observations is required for performing these analytic radiative transfer fits to the line profiles. Moderate amounts of depletion and beam smoothing do not adversely affect the accuracy of the infall speeds obtained from these models.

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Preprint available at: http://cfa-www.harvard.edu/∼cdevries/analytic_infall-paper/ or
http://arxiv.org/abs/astro-ph/0410748

## Probing the Surfaces of Interstellar Dust Grains: The Adsorption of CO at Bare Grain Surfaces

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A solid-state feature was detected at around 2175 $cm^{-1}$ towards 30 embedded young stellar objects in spectra obtained using the ESO VLT-ISAAC. We present results from laboratory studies of CO adsorbed at the surface of Zeolite wafers, where absorption bands were detected at 2177 and 2168 $cm^{-1}$ (corresponding to CO chemisorbed at the Zeolite surface), and 2130 $cm^{-1}$ (corresponding to CO physisorbed at the Zeolite surface), providing an excellent match to the observational data. We propose that the main carrier of the 2175-band is CO chemisorbed at bare surfaces of dust grains in the interstellar medium. This result provides the first direct evidence that gas-surface interactions do not have to result in the formation of ice mantles on interstellar dust. The strength of the 2175-band is estimated to be $\sim 4 \times 10^{-19}$ cm $molecule^{-1}$. The abundance of CO adsorbed at bare grain surfaces ranges from 0.06 to 0.16 relative to $H_2O$ ice, which is, at most, half of the abundance (relative to $H_2O$ ice) of CO residing in $H_2O$-dominated ice environments. These findings imply that interstellar grains have a large (catalytically-active) surface area, providing a refuge for interstellar species. Consequently the potential exists for heterogeneous chemistry to occur involving CO molecules in unique surface chemistry pathways not currently considered in gas-grain models of the interstellar medium.

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## Near-infrared imaging observations of the southern massive star-forming region G333.6−0.2

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We present near-infrared broadband $JHK'$ images of the southern massive star-forming region G333.6−0.2. The slope of $K$-luminosity function towards the region ($0.24 \pm 0.01$) is considered to be equivalent to that expected for main-sequence stars in the solar neighbourhood. Point sources with their $(H - K)$ colour greater than 1 are more likely to be located in extended emission and it is suggested that these objects are physically associated with the H II region.

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The accepted version is available at `http://www.naoj.org/staff/tak/preprints/g333-nir.html`

## The Chemistry of Transient Molecular Cloud Cores

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We assume that some, but not all, of the structure observed in molecular clouds is associated with transient features which are not bound by self-gravity. We investigate the chemistry of a transient density fluctuation, with properties similar to those of a core within a molecular cloud. We run a multi-point chemical code through a core's condensation from a diffuse medium to its eventual dispersion, over a period of ∼1 Myr. The dynamical description adopted for our study is based on an understanding of a particular mechanism, involving slow-mode wave excitation, for transient structure formation which so far has been studied in detail only with plane-parallel models in which self-gravity has not been included. We find a significant enhancement of the chemical composition of the core material on its return to diffuse conditions, whilst the expansion of the core as it disperses moves this material out to large distances from the core centre. This process transports molecular species formed in the high density regions out into the diffuse medium. Chemical enrichment of the cloud as a whole also occurs, as other cores of various sizes, lifespans and separations evolve throughout. Enrichment is strongly affected by freeze-out onto dust grains which takes place in high-density, high-visual extinction regions. As the core disperses after reaching its peak density and the visual extinction drops below a critical value, grain mantles are evaporated back into the gas phase, initiating more chemistry. The influence of the sizes, masses and cycle-periods of cores will be large both for the level of chemical enrichment of a dark cloud and ultimately for the low-mass star-formation rate. The cores in which stars form are almost certainly bound by their self-gravity and are not transient in the sense that the cores on which most of our study is focused are transient. Obviously, enrichment of the chemistry of low density material will not take place if self-gravity prevents the re-expansion of a core. We also consider the case of a self-gravitating core, by holding its peak density conditions for a further 0.4 Myr. We find that the differences near the peak densities between transient and gravitationally bound cores are generally small, and the resultant column densities for objects near the peak densities do not provide definitive criteria for discriminating between transient and bound cores. However, increases in fractional abundances due to re-injection of mantle-borne species may provide a criterion for detection of a non-bound core

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## Kinematics of water masers in high-mass star forming regions

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We have conducted multi-epoch EVN observations of the 22.2 GHz water masers towards four high-mass star forming regions (Sh 2-255 IR, IRAS 23139+5939, WB89-234, and OMC2). The (three) observing epochs span a time range of 6 months. In each region, the $H_2O$ maser emission likely originates close (within a few hundreds of AU) to a forming high-mass YSO. Several maser features ( 10) have been detected for each source and, for those features persistent over the three epochs, proper motions have been derived. The amplitudes of the proper motions are found to be larger than the range of variation of the line-of-sight velocities and in each of the observed sources the proper motion orientation seems to indicate an expansion motion. The gas kinematics traced by the 22.2 GHz $H_2O$ masers is compatible with the shock-excited nature of water maser emission.

Three different kinematic models (a spherical expanding shell, a Keplerian rotating disk, and a conical outflow) were fitted to the 3-dimensional velocity field of the detected maser features. The results of these fits, together with the comparison of the VLBI maps with the highest-resolution images of the sources in several thermal tracers, suggest that the water maser features are most likely tracing the inner portion of the molecular outflows detected at much larger-scales.

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## Long-term monitoring of 6.7-GHz methanol masers

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The class II methanol maser source G9.62+0.20E undergoes periodic flares at both 6.7 and 12.2 GHz. The flare starting in 2001 October was observed at seven epochs over three months using the VLBA at 12.2 GHz. High angular resolution images (beam size $\sim$ 1.7 x 0.6 mas) were obtained, enabling us to observe changes in 16 individual maser components. It was found that while existing maser spots increased in flux density, no new spots developed and no changes in morphology were observed. This rules out any mechanism which disturbs the masing region itself, implying that the flares are caused by a change in either the seed or pump photon levels. A time delay of 1–2 weeks was observed between groups of maser features. These delays can be explained by light travel time between maser groups. The regularity of the flares can possibly be explained by a binary system.

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ftp://sharmila.hartrao.ac.za/pub/g962-meth-vlba.ps.gz

## Polarized dust emission of magnetized molecular cloud cores

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We compute polarization maps for molecular cloud cores modeled as magnetized singular isothermal toroids, under the assumption that the emitting dust grains are aspherical and aligned with the large-scale magnetic field. We show that, depending on the inclination of the toroid with the line-of-sight, the bending of the magnetic field lines resulting from the need to counteract the inward pull of gravity naturally produces a depolarization effect toward the centre of the map. We compute the decrease of polarization degree with increasing intensity for different viewing angles and frequencies, and we show that an outward increasing temperature gradient, as expected in starless cores heated by the external radiation field, enhances the decrease of polarization. We compare our results with recent observations, and we conclude that this geometrical effect, together with other mechanisms of depolarization, may significantly contribute to the decrease of polarization degrees with intensity observed in the majority of molecular cloud cores. Finally, we consider the dependence of the polarization degree on the dust temperature gradient predicted for externally heated clouds, and we briefly comment on the limits of the Chandrasekhar-Fermi formula to estimate the magnetic field strength in molecular cloud cores.

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preprints available at `http://www.arcetri.astro.it/~starform/publ2004.htm`

## Evaluating the Magnetic Field Strength in Molecular Clouds

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We discuss an extension to the Chandrasekhar-Fermi method for the evaluation of the mean magnetic field strength in molecular clouds to cases where the spatial orientation of the field is known. We apply the results to M17, using previously published data.

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or at http://www.astro.uwo.ca/~houde/pub.html

## Magnetic fields in Herbig Ae stars

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Herbig Ae stars are young A-type stars in the pre-main sequence evolutionary phase with masses of $\sim$1.5–3 $M_\odot$. They show rather intense surface activity (Dunkin et al. [**?**]) and infrared excess related to the presence of circumstellar disks. Because of their youth, primordial magnetic fields inherited from the parent molecular cloud may be expected, but no direct evidence for the presence of magnetic fields on their surface, except in one case (Donati et al. [**?**]), has been found until now. Here we report observations of optical circular polarization with FORS 1 at the VLT in the three Herbig Ae stars HD 139614, HD 144432 and HD 144668. A definite longitudinal magnetic field at $4.8\,\sigma$ level, $\langle \mathcal{B}_z \rangle = -450 \pm 93$ G, has been detected in the Herbig Ae star HD 139614. This is the largest magnetic field ever diagnosed for a Herbig Ae star. A hint of a weak magnetic field is found in the other two Herbig Ae stars, HD 144432 and HD 144668, for which magnetic fields are measured at the $\sim$1.6 $\sigma$ and $\sim$2.5 $\sigma$ level respectively. Further, we report the presence of circular polarization signatures in the CaII K line in the V Stokes spectra of HD 139614 and HD 144432, which appear unresolved at the low spectral resolution achievable with FORS 1. We suggest that models involving accretion of matter from the disk to the star along a global stellar magnetic field of a specific geometry can account for the observed Zeeman signatures.

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## On the Origin of the Very Young Groups $\eta$ and $\epsilon$ Chamaeleontis

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The 3D orbits of the kinematical centers of the $\eta$ and $\epsilon$ Chamaeleontis compact groups are retraced under the action of a general Galactic potential. The results show that both groups were formed at the same spatial region about 7 Myr ago. Their birthplace appears to be quite near the Lower Centaurus Crux (LCC) subgroup of the Sco-Cen OB association. The epoch of **minimum separation in the past** between $\eta$ Cha and $\epsilon$ Cha turns out to be consistent with the estimated evolutionary age.

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## A Multi-Wavelength Study of IC 63 and IC 59

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IC 63 and IC 59 are two nearby arc-shaped nebulae with relatively simple geometries and minimal obscuring material. The two regions, in spite of a similar projected distance from their ionizing star, have very different observational properties, both in continuum emission and in the presence and strength of line emission from molecular species. This paper conducts a multi-wavelength study of the two regions, using archived data from a variety of sources, including the Canadian Galactic Plane Survey and the Infrared Space Observatory. The multi-wavelength morphology and structure of the two nebulae are studied in detail, particularly the ionization fronts in IC 63. The possibility of triggered star formation in IC 63 in investigated, and determined to be spurious.

$H_2$ and PAH emission are detected in both IC 63 and IC 59, confirming the presence of molecular hydrogen in IC 59. The averaged line ratios are similar in the two regions, but variations are seen within each region. Temperatures and densities were calculated from the S(3) and S(5) pure-rotational lines of molecular hydrogen. We derived a temperature of 630 K in IC 63, comparable to previous results, and a column density of 5.8 $\times 10^{17}$ cm$^{-2}$, somewhat lower than previous values. New results for IC 59 show values of 590 K and 3.4 $\times 10^{17}$ cm$^{-2}$, slightly cooler and with lower column density than IC 63. The contrast in appearance between IC 63 and IC 59 is consistent with a difference in actual (rather than projected) distances, and a small variation in temperature and column density.

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## Membership, binarity and accretion among very low-mass stars and brown dwarfs of the $\sigma$ Orionis cluster

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Intermediate resolution ($R \sim 7000$) spectroscopy is presented for 76 photometrically selected very low mass ($0.04 < M < 0.3\,M_{\odot}$) candidate members of the young cluster around $\sigma$ Orionis. More than two thirds appear to be genuine cluster members on the basis that they exhibit Li I 6708Å absorption, weak Na I 8183/8195Å features and a radial velocity consistent with the cluster mean. Photometric selection alone therefore appears to be very effective in identifying cluster members in this mass range. Only 6 objects appear to be certain non-members, however a substantial subset of 13 have ambiguous or contradictory indications of membership and lack Li absorption. This together with an observed spread in the equivalent width of the Li absorption feature in the cooler stars of our sample indicates there may be deficiencies in our understanding of the formation of this line in cool, low-gravity objects.
Four candidate binary cluster members are identified. Consideration of sampling and radial velocity measurement precision leads us to conclude that either the fraction of very low mass stars and brown dwarfs in small separation ($a < 1\,$au) binary systems is larger than in field M-dwarfs, or the distribution of separations is much less skewed towards large separations. This conclusion hinges critically on the correct identification of the small number of binary candidates, although it remains significant even when only the candidate members displaying Li absorption are considered.
Broadened H$\alpha$ emission, indicative of circum(sub)stellar accretion discs is found in 5 or 6 of the candidate cluster members, 3 of which probably have substellar masses. The fraction of accretors ($10 \pm 5$ per cent) is similar to that found in stars of higher mass in the $\sigma$ Ori cluster using H$\alpha$ emission as a diagnostic, but much lower than found for very low mass stars and brown dwarfs of younger clusters. The timescale for accretion rates to drop to $\leq 10^{-11}\,M_{\odot}\,\mathrm{yr}^{-1}$ is hence less than the age of the $\sigma$ Ori cluster (3 to 7 Myr) for most low-mass objects.

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## Quiescent and coherent cores from gravoturbulent fragmentation

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We investigate the velocity structure of protostellar cores that result from non-magnetic numerical models of the gravoturbulent fragmentation of molecular cloud material. A large fraction of the cores analyzed are "quiescent"; i.e., have non-thermal linewiths smaller or equal to the thermal linewidth. Specifically, about 23% of the cores have subsonic turbulent line-of-sight velocity dispersions $\sigma_{\rm turb} \leq c_{\rm s}$. A total of 46% are "transonic", with $c_{\rm s} < \sigma_{\rm turb} \leq 2c_{\rm s}$. More than half of our sample cores are identified as "coherent", i.e., with $\sigma_{\rm turb}$ roughly independent of column density. Of these, about 40 % are quiescent, 40 % are transonic, and 20 % are supersonic.

The fact that dynamically evolving cores in highly supersonic turbulent flows can be quiescent may be understood

because cores lie at the stagnation points of convergent turbulent flows, where compression is at a maximum, and relative velocity differences are at a minimum. The apparent coherence may be due, at least in part, to an observational effect related to the length and concentration of the material contributing to the line.

In our simulated cores, $\sigma_{\rm turb}$ often has its local maximum at small but finite offsets from the column density maximum, suggesting that the core is the dense region behind a shock. Such a configuration is often found in observations of nearby molecular cloud cores, and argues in favor of the gravoturbulent scenario of stellar birth as it is not expected in star-formation models based on magnetic mediation.

A comparison between the virial estimate $M_{\rm vir}$ for the mass of a core based on $\sigma_{\rm turb}$ and its actual value $M$ shows that cores with collapsed objects tend to be near equipartition between their gravitational and kinetic energies, while cores without collapsed objects tend to be gravitationally unbound, suggesting that gravitational collapse occurs immediately after gravity becomes dominant.

Finally, cores in simulations driven at large scales are more frequently quiescent and coherent, and have more realistic ratios of $M_{\rm vir}/M$, supporting the notion that molecular cloud turbulence is driven at large scales.

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## The Primordial Binary Population - I: A near-infrared adaptive optics search for close visual companions to A star members of Scorpius OB2

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We present the results of a near-infrared adaptive optics survey with the aim to detect close companions to Hipparcos members in the three subgroups of the nearby OB association Sco OB2: Upper Scorpius (US), Upper Centaurus Lupus (UCL) and Lower Centaurus Crux (LCC). We have targeted 199 A-type and late B-type stars in the $K_S$ band, and a subset also in the $J$ and $H$ band. We find 151 stellar components other than the target stars. A brightness criterion is used to separate these components into 77 background stars and 74 candidate physical companion stars. Out of these 74 candidate companions, 41 have not been reported before (14 in US; 13 in UCL; 14 in LCC). Companion star masses range from 0.1 to 3 $M_\odot$. The mass ratio distribution follows $f(q) = q^{-0.33}$, which excludes random pairing. No close ($\rho \leq 3.75''$) companion stars or background stars are found in the magnitude range $12 < K_S < 14$ mag. The lack of stars with these properties cannot be explained by low-number statistics, and may imply a lower limit on the companion mass of $\approx 0.1 M_\odot$. Close stellar components with $K_S > 14$ mag are observed. If these components are very low-mass companion stars, a gap in the companion mass distribution might be present. The small number of close low-mass companion stars could support the embryo-ejection formation scenario for brown dwarfs. Our findings are compared with and complementary to visual, spectroscopic, and astrometric data on binarity in Sco OB2. We find an overall companion star fraction of 0.52 in this association. This paper is the first step toward our goal to derive the primordial binary population in Sco OB2.

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## HST/ACS Coronagraphic Imaging of the AU Microscopii Debris Disk

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We present *Hubble Space Telescope* Advanced Camera for Surveys multicolor coronagraphic images of the recently discovered edge-on debris disk around the nearby ($\sim$ 10 pc) M dwarf AU Microscopii. The disk is seen between $r$ =0.75" – 15" (7.5 – 150 AU) from the star. It has a thin midplane with a projected full-width-at-half-maximum (FWHM) thickness of 2.5 – 3.5 AU within $r < 50$ AU of the star that increases to 6.5 – 9 AU at $r \sim 75$ AU. The disk's radial brightness profile is generally flat for $r < 15$ AU, then decreases gradually ($I \propto r^{-1.8}$) out to $r \approx 43$ AU, beyond which it falls rapidly ($I \propto r^{-4.7}$). Within 50 AU the midplane is straight and aligned with the star, and beyond that it deviates by $\sim 3°$, resulting in a bowed appearance that was also seen in ground-based images. Three-dimensional modelling of the disk shows that the inner region ($r < 50$ AU) is inclined to the line-of-sight by $< 1°$ and the outer disk by $\sim 3°$. The inclination of the outer disk and moderate forward scattering ($g \approx 0.4$) can explain the apparent bow. The intrinsic, deprojected FWHM thickness is 1.5 – 10 AU, increasing with radius. The models indicate that the disk is clear of dust within $\sim 12$ AU of the star, in general agreement with the previous prediction of 17 AU based on the infrared spectral energy distribution. The disk is blue, being 60% brighter at $B$ than $I$ relative to the star. One possible explanation for this is that there is a surplus of very small grains compared to other imaged debris disks that have more neutral or red colors. This may be due to the low radiation pressure exerted by the late-type star. Observations at two epochs show that an extended source seen along the midplane is a background galaxy.

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## Multi-seeded multi-mode formation of embedded clusters in the RMC: Clusters formed in swept-up shells

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This is the first of a series of three papers on clustered star formation in the Rosette Molecular Complex. Here we investigate star formation in the interfacing layers between the expanding Rosette Nebula and its surrounding cloud, based on an analysis of the spatially complete and unbiased 2MASS data. Two medium-mass infrared clusters with ages of around 1 Myr are identified in the south and south-east arcs of the fragmented shell. The majority of the candidate cluster members in these radiation and pressure-confined regions are found to be almost uniformly distributed, roughly following the compression layers traced by the distribution of optical depth at 100 $\mu$m, and may well develop into gravitationally unbound systems upon their emergence from the parental cloud. These expanding shells are believed to be playing important roles in impeding the emerging young open cluster NGC 2244 from intruding immediately and deeply into the ambient molecular cloud, where sequential formation of massive clusters is taking place.

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## Molecular abundance ratios as a tracer of accelerated collapse in regions of high mass star formation?

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Recent observations suggest that the behaviour of tracer species such as $N_2H^+$ and CS is significantly different in regions of high and low mass star formation. In the latter, $N_2H^+$ is a good tracer of mass, while CS is not. Observations show the reverse to be true in high-mass star formation regions. We use a computational chemical model to show that the abundances of these and other species may be significantly altered by a period of accelerated collapse in high mass star forming regions. We suggest these results provide a potential explanation of the observations, and make predictions for the behaviour of other species.

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## Physics of Outflows: the Binary Protostar L 1551 IRS 5 and its Jets

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Recent observations of the deeply embedded L 1551 IRS 5 system permit the detailed examination of the properties of both the stellar binary and the binary jet. For the individual components of the stellar binary, we determine their masses, mass accretion rates, effective temperatures and luminosities. For the atomic wind/jet flow, we determine the mass loss rate, yielding observationally determined values of the ratio of the mass loss to the mass accretion rate, $f$. For the X-ray emitting region in the northern jet, we have obtained the jet-velocity and derive the extinction and the densities on different spatial scales. Examining the observational evidence within the framework of the x-wind theory leads us to conclude that these models are indeed potentially able to account for the observational data for this *deeply embedded* source.

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## The pre-main sequence spectroscopic binary UZ Tau East: improved orbital parameters and accretion phase dependence

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We present radial-velocity measurements obtained using high- and intermediate-resolution spectroscopic observations of the classical T Tauri star UZ Tau East obtained from 1994 to 1996. We also provide measurements of H$\alpha$ equivalent widths and optical veiling. Combining our radial-velocity data with those recently reported by Prato et al. (2002), we improve the orbital elements for this spectroscopic binary. The orbital period is 18.979±0.007 days and the eccentricity is e=0.14. We find variability in the $H_\alpha$ emission and veiling, signposts of accretion, but at periastron passage the accretion is not as clearly enhanced as in the case of the binary DQ Tau. The difference in the behaviour of these two binaries is consistent with the hydrodynamical models of accretion from circumbinary disks because UZ Tau East has lower eccentricity than DQ Tau. It seems that enhanced periastron accretion may occur only in systems with very high eccentricity (e>0.5).

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## The near-infrared excitation of the HH 211 protostellar outflow

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The protostellar outflow HH 211 is of considerable interest since it is extremely young and highly collimated. Here, we explore the outflow through imaging and spectroscopy in the near-infrared to determine if there are further diagnostic signatures of youth. We confirm the detection of a near-infrared continuum of unknown origin. We propose that it is emitted by the driving millimeter source, escapes the core through tunnels, and illuminates features aligning the outflow. Narrow-band flux measurements of these features contain an unusually large amount of continuum emission. [FeII] emission at 1.644 $\mu$m has been detected and is restricted to isolated condensations. However, the characteristics of vibrational excitation of molecular hydrogen resemble those of older molecular outflows. We attempt to model the ordered structure of the western outflow as a series of shocks, finding that bow shocks with J-type dissociative apices and C-type flanks are consistent. Moreover, essentially the same conditions are predicted for all three bows except for a systematic reduction in speed and density with distance from the driving source. We find increased K-band extinctions in the bright regions as high as 2.9 magnitudes and suggest that the bow shocks become visible where the outflow impacts on dense clumps of cloud material. We propose that the outflow is carved out by episodes of pulsating jets. The jets, driven by central explosive events, are responsible for excavating a central tunnel through which radiation temporarily penetrates.

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http://star.arm.ac.uk/preprints/

## The structure and dynamics of the dense cores in the Perseus molecular cloud complex

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We have produced wide-field ($\sim 0.1$ deg$^2$) images of the molecular gas around the dense cores observed by Ladd et al. (1994) in the Perseus cloud complex in various CO (CO(1–0), $^{13}$CO(1–0), C$^{18}$O(1–0)) and CS (CS(2–1), C$^{34}$S(2–1)) isotopomers, and $N_2H^+$(1–0), using the 16-element focal plane array operating at a wavelength of 3mm at the Five College Radio Astronomy Observatory. We also performed mosaic observations in the $N_2H^+$(1–0) line and in the adjacent 3mm continuum with the OVRO interferometer. Only within one of the observed cores we unambiguously detected a 3mm continuum compact source with the interferometer. The single-dish large-scale maps of the densest gas, which in Perseus is concentrated within two large filamentary structures roughly aligned along a NE-SW axis, allowed us to analyse the spatial and kinematical properties of the cores and of the surrounding ambient gas. In the PER4/PER5 and PER7 regions we find that the large-scale and core velocity gradients have the same sign and similar magnitudes. In at least three cases we then find pairs of nearby cores with differences in the CS and $N_2H$ emission and in the line profile, which may have been caused by evolutionary effects. The small fraction of cores with compact continuum sources, the chemical differentiation and the inward motions observed suggest that we are observing objects in a phase preceeding the collapse and the formation of stars.

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## The "Mysterious" Origin of Brown Dwarfs

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Hundreds of brown dwarfs (BDs) have been discovered in the last few years in stellar clusters and among field stars. BDs are almost as numerous as hydrogen burning stars and so a theory of star formation should also explain their origin. The "mystery" of the origin of BDs is that their mass is two orders of magnitude smaller than the average Jeans' mass in star–forming clouds, and yet they are so common. In this work we investigate the possibility that gravitationally unstable protostellar cores of BD mass are formed directly by the process of turbulent fragmentation. Supersonic turbulence in molecular clouds generates a complex density field with a very large density contrast. As a result, a fraction of BD mass cores formed by the turbulent flow are dense enough to be gravitationally unstable. We find that with density, temperature and rms Mach number typical of cluster–forming regions, turbulent fragmentation can account for the observed BD abundance.

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## HDO abundance in the envelope of the solar-type protostar IRAS16293−2422

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We present IRAM 30 m and JCMT observations of HDO lines towards the solar-type protostar IRAS 16293−2422. Five HDO transitions have been detected on-source, and two were unfruitfully searched for towards a bright spot of the outflow of IRAS 16293−2422. We interpret the data by means of the Ceccarelli, Hollenbach and Tielens (1996) model, and derive the HDO abundance in the warm inner and cold outer parts of the envelope. The emission is well explained by a jump model, with an inner abundance $x_{in}^{HDO} = 1 \times 10^{-7}$ and an outer abundance $x_{out}^{HDO} \leq 1 \times 10^{-9}$ ($3\sigma$). This result is in favor of HDO enhancement due to ice evaporation from the grains in the inner envelope. The deuteration ratio HDO/$H_2O$ is found to be $f_{in} = 3\%$ and $f_{out} \leq 0.2\%$ ($3\sigma$) in the inner and outer envelope respectively and therefore, the fractionation also undergoes a jump in the inner part of the envelope. These results are consistent with the formation of water in the gas phase during the cold prestellar core phase and storage of the molecules on the grains, but do not explain why observations of $H_2O$ ices consistently derive a $H_2O$ ice abundance of several $10^{-5}$ to $10^{-4}$, some two orders of magnitude larger than the gas phase abundance of water in the hot core around IRAS 16293−2422.

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## The enigmatic brown dwarf candidate [KG2001] 102 in the Chamaeleon I cloud: Is it a multiple system?

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We present deep $IJHK_s$ and $H_2$ images of a region in the Chamaeleon I dark cloud containing the very low-mass young object [KG2001]102, in an attempt to search for multiplicity and molecular outflow in the vicinity of this object. No low-velocity shocked structures were detected on our $H_2$ image. The broad-band and narrow-band images show that [KG2001]102 is composed of four objects within a radius of $\sim 2$ arcsec. The brightest component [KG2001]102 A shows near-IR excess emission and its mass is estimated to be in the range 33 to 55 $M_{\rm Jup}$, depending on which model is adopted. Red spectra were obtained of the two fainter components B and C. The spectrum of the former suggests a K7V spectral type while the spectrum of component C is too noisy to allow a reliable classification but rules out a late M-type. The three faint components (B, C and D) have $IJHK$ colors that suggest a much later spectral type, with extinctions similar to other members of the cloud. The computed probability of finding randomly a pair of field stars like [KG2001]102 AB is $1.5 \times 10^{-3}$ while for a triple optical system like [KG2001]102 ABC, it would be $3.8 \times 10^{-5}$ and more than an order of magnitude lower for finding a quadruple system like this by chance projection.

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## A general catalogue of 6.7 GHz methanol masers. I: data

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Methanol masers are often detected in regions of intense star formation. Several studies in the last decade indicate that they may even be the earliest signpost of a high-mass star-forming region. Their powerful emission make them very good candidates for observations using both single–dish telescopes and interferometers, the latter allowing detailed structural and dynamical studies of those objects. We have prepared a catalogue of all known 6.7-GHz methanol masers, discovered both by surveys which targetted possible associated objects and unbiased surveys covering a large fraction of galactic longitudes across the Galactic plane ($-0.5^o \leq b \leq 0.5^o$ for most of the regions). The catalogue contains 519 sources which are listed with their kinematic (galactocentric and heliocentric) distances as well as possibly associated IR objects. We find that 6.7-GHz methanol masers clearly trace the molecular ring of our Galaxy, where most of the OB associations are located. The present list of masers also reports detections of other masing transitions of methanol as a further piece of information for the study of the maser phenomenon. In a further publication we will address some statistical considerations.

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## *ISO* observations of 3 − 200 $\mu$m emission by three dust populations in an isolated local translucent cloud

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We present ISOPHOT spectrophotometry of three positions within the isolated high latitude cirrus cloud G 300.2 − 16.8, spanning from the near- to far-infrared. The positions exhibit contrasting emission spectrum contributions from the UIBs, very small grains and large classical grains, and both semi-empirical and numerical models are presented. At

all three positions, the UIB spectrum shapes are found to be similar, and the large grain emission may be fitted by an equilibrium temperature of ∼17.5 K. The energy requirements of both the observed emission spectrum and optical scattered light are shown to be satisfied by the incident local ISRF. The FIR emissivity of dust in G 300.2 − 16.8 is found to be lower than in globules or dense clouds, and is even lower than model predictions for dust in the diffuse ISM. The results suggest physical differences in the ISM mixtures between positions within the cloud, possibly arising from grain coagulation processes.

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## Mid-IR observations of circumstellar disks. Part I: Pre-main sequence objects

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We present new N-band photometry and spectroscopy for a sample of eight pre-main sequence stars including T Tauri, Herbig Ae/Be stars and FU Ori objects using the ESO TIMMI2 camera at the La Silla observatory (Chile). For some objects this is their first N-band spectroscopic observation ever. The FU Ori stars V 346 Nor, V 883 Ori and Z CMa show a broad absorption band which we attribute to silicates, while for BBW 76 we find silicate emission. A comparison with ISO-SWS spectra of V 346 Nor and Z CMa taken in 1996/1997 reveals no differences in spectral shape. All T Tauri and Herbig Ae/Be stars possess N-band emission features. We model the emission spectra with a mixture of silicates consisting of different grain sizes and composition. The Herbig Ae star HD 34282 shows strong features of PAHs but none of silicate, while the emission spectrum of the Herbig Ae star HD 72106 resembles those of solar-system comets and known Herbig sources of evolved dust. We demonstrate that HD 72106 is host to highly processed silicates and find evidence for enstatite, which is not common in young objects. Evolved dust is also seen in the T Tauri stars HD 98800 and MP Mus. We further detected MP Mus at 1200 $\mu$m with the bolometer array SIMBA at the SEST in La Silla. The findings of our analysis are given in the context of previous dust studies of young stellar objects.

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## Mid-IR observations of circumstellar disks. Part II: Vega-type stars and a post-main sequence object

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We present spectral energy distributions and new N-band photometry and spectroscopy for a sample of six main sequence stars and one post-MS object using the ESO TIMMI2 camera at La Silla observatory (Chile). All objects are thought to possess circumstellar material and for the majority of the targets this is their first N-band spectroscopic observation. The emission spectra (observed in three cases), modelled with a mixture of silicates consisting of different grain sizes and composition, confirm the suspected presence of disks around these targets. The most important discovery is that HD 113766, a young Vega-type star, is host to highly processed dust which is probably second generation. It is the first time a Vega-type star with such highly evolved dust has been observed. Silicate emission of basically unevolved dust is seen in case of the post-MS object HD 41511 and the Vega-type star HD 172555. In addition, to study the cold dust, we observed a subsample at 1200 $\mu$m with the bolometer array SIMBA at the SEST in La Silla but we only got upper limits for those five objects. This shows that these Vega-type stars have a smaller amount of dust than their precursors, the T Tauri and Herbig Ae/Be stars.

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## Opening the Treasure Chest: A Newborn Star Cluster Emerges from its Dust Pillar in Carina

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We present detailed observations of the Treasure Chest, a compact nebula at the head of a dust pillar in the southern Carina nebula. This object is of interest because it is an example of a dense young cluster containing at least one massive star, the formation of which may have been triggered by feedback from the very massive stars in the Carina nebula, and possibly $\eta$ Carinae itself. Our observations include narrowband images of H$\alpha$, [S II], [O III], Pa $\beta$, [Fe II], and $H_2$, broadband *JHK* images, and a visual-wavelength spectrum of the nebula. We use these data to investigate both the nebular and stellar content of the object. The near-infrared emission-line images reveal a cavity inside the head of the dust pillar, which contains a dense cluster of young stars, while the observed spectrum of the nebula is consistent with an H II region ionized by the O9.5 V star cpd. The embedded infrared cluster was discovered in 2MASS data, but our new *JHK* images have improved spatial resolution and sensitivity, allowing an analysis of the stellar content of the newborn cluster. After subtracting contamination of field stars within the Carina nebula itself, we compare the cluster's color magnitude diagram with pre-main-sequence isochrones to derive a likely cluster age less than about 0.1 Myr. This is in reasonable agreement with the dynamical age of a few times $10^4$ yr for the expanding nebular cavity, indicating extreme youth. Stars in the Treasure Chest cluster are highly reddened, with extinction values as large as $A_V \sim 50$. Two-thirds of cluster members show strong infrared excess colors indicative of circumstellar disks, which may prove to be among the highest fraction yet seen for a young cluster once L-band photometry is considered. All evidence suggests that the Treaure Chest is an extremely young cluster that is just now breaking out of its natal cloud into the surrounding massive star forming region, and is a good target for more detailed study.

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## Three-dimensional Continuum Radiative Transfer Images of a Molecular Cloud Core Evolution

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We analyze a three-dimensional Smoothed Particle Hydrodynamics simulation of an evolving and later collapsing pre-stellar core. Using a three-dimensional Continuum Radiative Transfer program, we generate images at 7$\mu$m, 15$\mu$m, 175 $\mu$m, and 1.3 mm for different evolutionary times and viewing angles. We discuss the observability of the properties of pre-stellar cores for the different wavelengths. For examples of non-symmetric fragments, it is shown that, misleadingly, the density profiles derived from a one-dimensional analysis of the corresponding images are consistent with one-dimensional core evolution models. We conclude that one-dimensional modeling based on column density interpretation of images does not produce reliable structural information and that multidimensional modeling is required.

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http://www.mpia-hd.mpg.de/homes/stein/Science/slbbhapjl.ps.gz

## 3D Continuum radiative transfer in complex dust configurations around young stellar objects and active nuclei. II. 3D Structure of the dense molecular cloud core $\rho$ Oph D

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Constraints on the density and thermal 3D structure of the dense molecular cloud core $\rho$ Oph D are derived from a detailed 3D radiative transfer modeling. Two ISOCAM images at 7 and 15 $\mu$m are fitted simultaneously by representing the dust distribution in the core with a series of 3D Gaussian density profiles. Size, total density, and position of the Gaussians are optimized by simulated annealing to obtain a 2D column density map. The projected core density has a complex elongated pattern with two peaks. We propose a new method to calculate an approximate temperature in an externally illuminated complex 3D structure from a mean optical depth. This "$T_{\overline{\tau}}$"-method is applied to a 1.3 mm map obtained with the IRAM 30m telescope to find the approximate 3D density and temperature distribution of the core $\rho$ Oph D. The spatial 3D distribution deviates strongly from spherical symmetry. The elongated structure is in general agreement with recent gravo-turbulent collapse calculations for molecular clouds. We discuss possible ambiguities of the background determination procedure, errors of the maps, the accuracy of the $T_{\overline{\tau}}$-method, and the influence of the assumed dust particle sizes and properties.

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http://www.mpia-hd.mpg.de/homes/stein/Science/publicf.htm

## B-Star Rotational Velocities in h and $\chi$ Persei: A Probe of Initial Conditions During the Star-Formation Epoch?

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Projected rotational velocities ($v\ sin\ i$) have been measured for 216 B0–B9 stars in the rich, dense h and $\chi$ Persei double cluster and compared with the distribution of rotational velocities for a sample of field stars having comparable ages ($t \sim$ 12-15 Myr) and masses (M $\sim$ 4-15 $M\odot$). For stars that are relatively little evolved from their initial locations on the Zero Age Main Sequence (those with masses M $\sim$ 4-5 $M\odot$), the mean $v\ sin\ i$ measured for the h and $\chi$ Per sample is slightly more than 2 times larger than the mean determined for field stars of comparable mass, and the cluster and field $v\ sin\ i$ distributions differ with a high degree of significance. For somewhat more evolved stars with masses in the range 5-9 $M\odot$, the mean $v\ sin\ i$ in h and $\chi$ Per is 1.5 times that of the field; the $v\ sin\ i$ distributions differ as well, but with a lower degree of statistical significance. For stars that have evolved significantly from the ZAMS and are approaching the hydrogen exhaustion phase (those with masses in the range 9-15 $M\odot$), the cluster and field star means and distributions are only slightly different. We argue that both the higher rotation rates and the pattern of rotation speeds as a function of mass that differentiate main sequence B stars in h and $\chi$ Per from their field analogs were likely imprinted during the star formation process rather than a result of angular momentum evolution over the 12-15 Myr cluster lifetime. We speculate that these differences may reflect the effects of the higher accretion rates that theory suggests are characteristic of regions that give birth to dense clusters, namely: (a) higher initial rotation speeds; (b) higher initial radii along the stellar birthline, resulting in greater spinup between the birthline and the ZAMS; and (c) a more pronounced maximum in the birthline radius-mass relationship that results in differentially greater spinup for stars that become mid- to late- B stars on the ZAMS.

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## A Pre-Protostellar Core in L1551

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Large field surveys of $NH_3$, $C_2S$, $^{13}CO$ and $C^{18}O$ in the L1551 dark cloud have revealed a prolate, pre-protostellar molecular core (L1551-MC) in a relatively quiescent region to the northwest of the well-known IRS 5 source. The kinetic temperature is measured to be 9 K, the total mass is $\sim 2\,M_\odot$, and the average particle density is $10^4$–$10^5$ cm$^{-3}$ . L1551-MC is $2\farcm25 \times 1\farcm11$ in projection oriented at a position angle of 133°. The turbulent motions are on the order of the sound speed in the medium and contain 4% of the gravitational energy, $E_{grav}$, of the core. The angular momentum vector is projected along the major axis of L1551-MC corresponding to a rotational energy of $2.5 \times 10^{-3}\ \sin^{-2} i\,|E_{grav}|$. The thermal energy constitutes about a third of $|E_{grav}|$ and the virial mass is approximately equal to the total mass. L1551-MC is gravitationally bound and in the absence of strong, $\sim 160\,\mu$G, magnetic fields will likely contract on a $\sim 0.3$ Myr time scale. The line profiles of many molecular species suggest that the cold quiescent interior is surrounded by a dynamic, perhaps infalling envelope which is embedded within the ambient molecular gas of L1551.

Accepted by ApJ

## Subarcsecond mid-infrared and radio observations of the W3 IRS5 protocluster

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Observations at mid-infrared (4.8–17.65 $\mu$m) and radio (0.7–1.3 cm) wavelengths are used to constrain the structure of the high-mass star-forming region W3 IRS5 on $0\farcs1$ (200 AU) scales. Two bright mid-infrared sources are detected, as well as diffuse emission. The bright sources have associated compact radio emission and probably are young high-mass stars. The measured sizes and estimated temperatures indicate that these sources together can supply the observed far-infrared luminosity. However, an optically thick radio source with a possible mid-infrared counterpart may also contribute significant luminosity; if so, it must be extremely deeply embedded. The infrared colour temperatures of 350–390 K and low radio brightness suggest gravitational confinement of the H II regions and ongoing accretion at a rate of a few $10^{-8}$ M$_\odot$ yr$^{-1}$ or more. Variations in the accretion rate would explain the observed radio variability. The low estimated foreground extinction suggests the existence of a cavity around the central stars, perhaps blown by stellar winds. At least three radio sources without mid-infrared counterparts appear to show proper motions of $\sim$100 km s$^{-1}$, and may be deeply embedded young runaway OB stars, but more likely are clumps in the ambient material which are shock-ionized by the OB star winds.

Accepted by A&A

Preprint at http://www.arXiv.org/abs/astro-ph/0411142

## Jet Rotation: launching region, angular momentum balance, and magnetic properties in the bipolar outflow from RW Aur

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Using STIS on board the HST we have obtained a spectroscopic map of the bipolar jet from RW Aur with the slit parallel to the jet axis and moved across the jet in steps of 0.″07. After applying a velocity correction due to uneven slit illumination we find signatures of rotation within the first 300 AU of the jet (1.″5 at the distance of RW Aur). Both lobes rotate in the same direction (i.e. with different helicities), with toroidal velocities in the range 5 - 30 km $s^{-1}$ at 20 and 30 AU from the symmetry axis in the blueshifted and redshifted lobes, respectively. The sense of rotation is anti-clockwise looking from the tip of the blue lobe (P.A. 130° north to east) down to the star. Rotation is more evident in the [OI] and [NII] lines and at the largest sampled distance from the axis. These results are consistent with other STIS observations carried out with the slit perpendicular to the jet axis (Coffey et al. 2004), and with theoretical simulations in Pesenti et al. (2004).

Using current magneto-hydrodynamic models for the launch of the jets, we find that the mass ejected in the observed part of the outflow is accelerated from a region in the disk within about 0.5 AU from the star for the blue lobe, and within 1.6 AU from the star for the red lobe. Using also previous results we estimate upper and lower limits for the angular momentum transport rate of the jet. We find that this can be a large fraction (two thirds or more) of the estimated rate transported through the relevant portion of the disk. The magnetic lever arm (defined as the ratio $r_A/r_0$ between the Alfvèn and footpoint radii) is in the range 3.5 - 4.6 (with an accuracy of 20 - 25 %), or, alternatively, the ejection index $\xi = d\ln(\dot{M}_{\rm acc})/dr$ is in the range 0.025 - 0.046 (with similar uncertainties). The derived values are in the range predicted by the models, but they also suggest that some sort of heating must be provided at the base of the flow.

Finally, using the general disk wind theory we derive the ratio $B_\phi/B_p$ of the toroidal and poloidal components of the magnetic field at the observed location (i.e. about 80 - 100 AU above the disk). We find this quantity to be 3.8 $\pm$ 1.1 at 30 AU from the axis in the red lobe, and -8.9 $\pm$ 2.7 at 20 AU from the axis in the blue lobe (assuming cylindrical coordinates centred on the star and with positive $z$ along the blue lobe). The toroidal component appears to be dominant, which would be consistent with magnetic collimation of the jet. The field appears to be more tightly wrapped on the blue side.

Accepted by Astron. & Astrophys.

Preprint available at: http://www.arcetri.astro.it/∼starform/
or at http://www.tls-tautenburg.de/research/research.html

## CO J=$2-1$ maps of bipolar outflows in massive star forming regions

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Using the eight beam array receiver of the NRAO 12m telescope, we mapped the CO $J$ = 2−1 emission toward eleven high mass star forming regions. In the sample, four are previously detected outflows in the CO $J$ =1−0 line and seven are outflow candidates. A total of six bipolar outflows were identified in the CO $J$ =2−1 line. For the remaining five sources, including one previously detected bipolar outflow, the CO $J$ = 2−1 emission shows multiple velocity components. Therefore, high velocity line wings or bipolar structure cannot be identified. The CO $J$ = 2−1 spectra of the four of the non bipolar outflow sources exhibit broad line emission due to the blending of weak velocity components. The complex CO spectra underscore the importance of large scale mapping in identifying outflows.

Compared with the outflows detected with the CO $J$ = 1−0 line, the CO $J$ = 2−1 outflow often has broader line wings and smaller spatial extent, indicating that the high velocity gas measured with the CO $J$ = 2−1 arises from warm regions closer to the central source.

The masses in the outflows range from a few to 60 $M_\odot$. The linear momenta in the outflows are as large as a few hundred $M_\odot$ $kms^{-1}$. Both parameters are much larger than the typical values in low mass outflows. The average dynamic time scale of the outflows is $2\times10^4$ yrs.

The driving sources of the bipolar outflows are further identified. All bipolar outflows detected have a near infrared source except for IRAS 23385+6053 and all are associated with centimeter or millimeter continuum emission except

for IRAS 22506+5549.

We investigated the correlation between the outflow parameters and the properties of the driving source. The outflow luminosity and mechanical force correlate with the bolometric luminosity of the star. However, the mechanical force required to drive CO outflow are more than an order of magnitude higher than the radiation pressure from the star. We reexamined the relation between the mass entrainment rate of the outflows and the bolometric luminosity of the central source with an up-to-date sample. Result shows that the mass outflow rate increases with increasing bolometric luminosity, suggesting that the mass outflow rate is related to the luminosity of the central source.

Accepted by Astron. J.

## Sub-millimeter images of a dusty Kuiper belt around $\eta$ Corvi

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We present sub-millimeter and mid-infrared images of the circumstellar disk around the nearby F2V star $\eta$ Corvi. The disk is resolved at 850 $\mu$m with a size of $\sim$ 100 AU. At 450 $\mu$m the emission is found to be extended at all position angles, with significant elongation along a position angle of $130 \pm 10^{\circ}$; at the highest resolution (9.3 arcsec) this emission is resolved into two peaks which are to within the uncertainties offset symmetrically from the star at 100 AU projected separation. Modeling the appearance of emission from a narrow ring in the sub-mm images shows the observed structure cannot be caused by an edge-on or face-on axisymmetric ring; the observations are consistent with a ring of radius $150 \pm 20$ AU seen at $45 \pm 25^{\circ}$ inclination. More face-on orientations are possible if the dust distribution includes two clumps similar to Vega; we show how such a clumpy structure could arise from the migration over 25 Myr of a Neptune mass planet from 80-105 AU. The inner 100 AU of the system appears relatively empty of sub-mm emitting dust, indicating that this region may have been cleared by the formation of planets, but the disk emission spectrum shows that IRAS detected an additional hot component with a characteristic temperature of $370 \pm 60$ K (implying a distance of 1-2 AU). At 11.9 $\mu$m we found the emission to be unresolved with no background sources which could be contaminating the fluxes measured by IRAS. The age of this star is estimated to be $\sim$ 1 Gyr. It is very unusual for such an old main sequence star to exhibit significant mid-IR emission. The proximity of this source makes it a perfect candidate for further study from optical to mm wavelengths to determine the distribution of its dust.

Accepted by Astrophys. J., (scheduled for February 10, 2005)

Preprint available at astro-ph/0411061
Also available from http://www.roe.ac.uk/∼wyatt/

*Dissertation Abstracts*

# Tracing the Physical and Chemical Evolution of Low-Mass Protostars

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Ph.D dissertation directed by: Ewine van Dishoeck

Ph.D degree awarded: October 2004

The main aim of this thesis is to constrain the physical and chemical properties of deeply embedded low-mass young stellar objects, i.e., typical class 0 protostars. The cornerstone of this thesis is a large (sub)millimeter molecular line survey of a sample of 18 pre- and protostellar sources using the James Clerk Maxwell (JCMT) and Onsala 20 m telescopes. Previous studies have focused on either just a few individual sources or on a small number of selected molecular species. This single-dish survey is complemented by continuum and aperture-synthesis observations all tied together through detailed radiative transfer modeling.

The main conclusions are:

- The physical structure of the envelopes is constrained from single-dish submillimeter continuum (JCMT/SCUBA) observations and detailed dust radiative transfer modeling. It is found that all protostellar sources are well-described by spherically symmetric power-law density profiles ($n \propto r^{-p}$ with $p = 1.5 - 2$) on scales from a few thousand AU up to $\approx$ 10,000 AU.
- High angular resolution millimeter continuum imaging from OVRO and BIMA shows that the envelope structures from the single-dish observations can be extrapolated down to $\approx$ 500 AU scales. In combination with mid-infrared observations, these data reveal the presence of circumstellar disks around some, but not all, embedded low-mass protostars.
- The general features of the chemistry in the protostellar envelopes are constrained through the line survey, whereas the radial variation of the chemistry is directly probed through millimeter interferometer observations for individual sources. The line observations indicate that significant time, density and temperature dependent depletion occurs in protostellar environments. In particular, the average CO abundances throughout the envelopes decrease with increasing envelope masses. In the most massive envelopes the average CO abundance is one-two orders of magnitude lower than the abundance found in local molecular clouds suggesting that freeze-out takes place in the densest and coldest envelopes. The freeze-out of CO is found to be important for regulating the chemistry of other species and an empirical chemical network has been established by statistical comparisons between the derived sets of abundances.
- An empirical "drop abundance" profile provides good fits to both single-dish and interferometer observations of, e.g., CO, $HCO^+$ and $H_2CO$: in these models depletion occurs in a zone within the envelope bounded inwards by the radius where the temperature becomes so high that the molecule desorbs, and outwards by the radius where the density is so low that the timescales for freeze-out become longer than the age of the core. These structures can be used as a tracer of the thermal and dynamical evolution of the cores from their dense pre-stellar through protostellar stages. It is found that the timescale for the evolution through these stages is short, $\sim 10^5$ years.
- The presence of outflows may dramatically affect the physical and chemical evolution of low-mass protostellar cores, for example by enhancing species such as $CH_3OH$ through grain mantle liberation – or by creating outflow cavities through which UV radiation can escape increasing, for example, the CN abundance.

The thesis is available for download at `http://www.strw.leidenuniv.nl/~joergens/thesis`

# Identification and Characterization of Young, Nearby, Solar-Type Stars

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Ph.D degree awarded: July 2004

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Post-T Tauri stars (PTTSs) are low-mass, pre-MS stars which have ceased accreting, and are not necessarily near star-forming molecular clouds. Historically, they have been difficult to identify due to their benign spectroscopic signatures. With recent all-sky X-ray surveys and proper motion catalogs, it is now possible to find PTTSs in large numbers. The nearest PTTSs will be important targets for future imaging surveys characterizing dust disks and planetary systems around young solar analogs. The goal of this work is to systematically identify samples of PTTSs, investigate the evolution of circumstellar disks, to infer the fossil star-formation history of molecular clouds, and to estimate kinematic distances to young stars lacking trigonometric parallaxes. We present the results of a spectroscopic survey which identified 110 PTTS members of the nearest OB association (Sco-Cen). We find that 2/3rds of the low-mass star-formation in each OB subgroup occurred in <5 Myr, and that only ∼1% of solar-type stars with mean age ∼13 Myr shows signs of accretion from a circumstellar disk. In order to assess how long circumstellar material is detectable around PTTSs, we conducted a 10 $\mu$m imaging survey of post-T Tauri members of the ∼30-Myr-old Tuc-Hor association. The goal was to find evidence of either remnant accretion disks or dusty debris disks with orbital radii of <10 AU. Combined with data from other surveys, we conclude that mid-IR emission from warm dust grains in the terrestrial planet zones around young stars become undetectable compared to the stellar photosphere for nearly all stars by age ∼20 Myr. Lastly, we present a technique for calculating distances isolated young field stars that currently lack trigonometric parallax measurements. The technique is a generalization of the classical cluster parallax method, but can handle anisotropic velocity dispersions and non-zero Oort parameters. Distances and isochronal ages are estimated for a subsample of PTTSs included in the *Formation and Evolution of Planetary Systems* (FEPS) Spitzer Space Telescope (SST) Legacy Science program. The techniques developed in this thesis will expediate efforts to find new, nearby PTTS candidates from current X-ray, photometric, and proper motion databases.

# Sulphur Chemistry in Low Mass Star Forming Regions

**Valentine Wakelam**

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Ph.D dissertation directed by: Alain Castets & Cecilia Ceccarelli

Ph.D degree awarded: September 2004

Solar type stars are formed by the gravitational collapse of molecular clouds. This collapse goes with the formation a hot core region, inside the protostar, and shocked regions induced by protostellar outflows. In these hot regions, hot core and shocks, the sulphur depleted on the grain mantles evaporates in the gas phase in an unknown form and participate to a rich warm gas phase chemistry.

The main goal of my thesis is to make a detailed study of the sulphur chemistry in star formation regions using both observations and theoretical modelling. Precisely, I study the possibility to use sulphur bearing species as chemical clocks of star formation and try to give news clues to solve the interstellar sulphur problem. I first analysed millimeter observations of two low mass protostars and their environment with the aim to understand the behavior of S-molecules with respect to the gas density and temperature. I also made a theoretical study of SO and $SO_2$ emission in protostellar envelopes using a radiative transfer code associated with a dynamical collasing model. I selected the best transitions of these two molecules to compute the SO and $SO_2$ abundance profiles through the protostar envelopes. Finally, I constructed a chemical interstellar model depending on time in order to check if S-bearing species can be used to date star forming regions. I used the most up-to-date reaction rates for sulphur chemistry.

The main conclusions of my work is that the abundance ratios of the main S-bearing species depend more on the physical conditions of the gaz and on the form of sulphur evaporated from the grain than on the time. However, the situation is not totally hopeless. A careful comparison between observations and model predictions can give some useful hints on time estimates and on the mantle composition. As a result, my work suggests that sulphur is depleted on the grain mantles in the atomic form or in form quickly converted into S once evaporated.

*New Jobs*

# Two PhD positions on substellar mass objects

## Max-Planck-Institute for Astronomy, Heidelberg, Germany

The Max-Planck-Institute for Astronomy is looking to fill two PhD studentships on the topic *Properties and formation of substellar mass objects*. The positions are available as part of a new Emmy-Noether research group under Dr. Coryn Bailer-Jones. This group will focus on observational tests of the formation of brown dwarfs and giant exosolar planets as well as the study of their cool atmospheres.

The two PhD projects available are:

1. Brown dwarf origins: Deep photometric surveys to search for brown dwarfs and free-floating planets.
2. Brown dwarf atmospheres: Study of the atmospheres of ultra cool dwarfs using, e.g., photometric and spectroscopic monitoring.

The group has access to the world's most advanced observational facilities, including the Very Large Telescope (VLT) in Chile and the Calar Alto Observatory in Spain. Travel to the observatories is an essential part of the work, which includes observing, the reduction and analysis of data and their scientific interpretation. The group will also develop and apply data mining techniques to large databases for studying the formation and evolution of stellar clusters. The group has access to data from the Sloan Digital Sky Survey, and involvement with the future satellite mission Gaia will be possible. The opportunity to participate in international conferences and summer schools will be provided.

The positions are available on the German BAT federal public service scale (BAT IIa/2) for up to three years starting in early 2005. Completion of an undergraduate degree in Physics or closely related subject is a prerequisite. Some programming experience is also required. Applicants should send a CV giving details of their education and relevant experience, including degree courses and grades obtained. Applications may be sent by mail or email (as PS or PDF files) in English or German to

Dr. Coryn Bailer-Jones
Max-Planck-Institut für Astronomie
Königstuhl 17
D-69117 Heidelberg
Germany
email: calj@mpia-hd.mpg.de
phone: +49 6221 528224

Applicants should also arrange for at least one (but preferably two) letters of recommendation to be sent by mail to the above address. The deadline for the receipt of applications and letters is 10 December 2004, although applications will be considered until the positions are filled. Informal enquiries are welcome. For more information visit `http://www.mpia-hd.mpg.de/`

The Max Planck Society is an equal opportunity employer. Applications from women, disabled people and minority groups are particularly welcome.

## RESEARCH FELLOWSHIP IN STAR FORMATION
## leading to a PERMANENT LECTURESHIP IN ASTROPHYSICS

UNIVERSITY OF EXETER, UK

Applications are invited for a permanent position in Exeter's astrophysics group which is available from March 1st 2005. The first five years of this post are funded as a research fellowship, after which the post-holder will take on the normal duties of a permanent member of academic staff, joining Matthew Bate, Andy Bunker, Tim Harries, Mark McCaughrean, and Tim Naylor. Our research was rated excellent (RAE grade 5) in the last national assessment exercise and we are seeking to further strengthen our research programme by appointing either an observational or theoretical astrophysicist in an area which would enhance the astrophysics group's research. The main theme of that programme is *star formation, including observations both within our own galaxy and at high redshift, and large-scale numerical simulations*. The appointment would either be directly in those areas or in a related field such as *star formation in local galaxies, accretion phenomena, young stars, or extra-solar planets*. Further information on the Astrophysics Group can be found at http://www.astro.ex.ac.uk.

The successful applicant would be expected to make use of the UK's current and future access to forefront astrophysical tools which include ESO facilities (e.g., VLT, VLTI, VST, VISTA, ALMA), Gemini, HST, XMM, UKIRT/WFCAM, JCMT/SCUBA-2, and UKAFF. The successful applicant will have an appropriate first degree and a PhD (or equivalent), with at least three years experience at postdoctoral level and a strong record of publication in international journals. In addition, experience of teaching and obtaining research contracts is desirable.

Salary will be up to £30,363 per annum on the Research scale £19,460pa–£35,883pa, depending on qualifications and experience.

Application packs available from www.exeter.ac.uk/jobs; Email submission: j.e.orr at exeter.ac.uk; phone +44-1392-263103; fax +44-1392-263414, quoting reference no. 6587. Applications may also be sent to: Joanne Orr, Personnel, Lectureship in Astrophysics, University of Exeter, Northcote House, Exeter, EX4 4QJ, United Kingdom.

For informal enquiries, please contact Prof. Mark McCaughrean, email mjm at astro.ex.ac.uk, phone +44-1392-264127.

Closing date for complete applications is December 15th 2004.

EQUAL OPPORTUNITIES EMPLOYER

## Postdoctoral Research Position at Leiden Observatory, The Netherlands

# Structure and Evolution of Protoplanetary Disks

Deadline for application: **December 15, 2004**

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-2005.

The successful applicant will work with Dr. Michiel Hogerheijde and a group a 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 (see http://www.strw.leidenuniv.nl for more information).

Applications should include a curriculum vitae with a list of publications, a brief description of past research experience, a brief statement of research the candidate is interested in carrying out, and contact information of two persons who can provide letters of reference. Candidates with experience in hydrodynamical modeling or radiative transfer are especially encouraged to apply. Deadline for application is 15 December 2004.

Send applications to:

Dr. M.R. Hogerheijde
Leiden Observatory
P.O. Box 9513
2300 RA Leiden
The Netherlands
Tel: +31-71-5275590
FAX: +31-71-5275819
e-mail: michiel@strw.leidenuniv.nl

## Post-doctoral Position:

## Theoretical Star/Planet Formation, University of Rochester

The Astrophysics group in the Department of Physics and Astronomy at the University of Rochester is seeking an outstanding postdoctoral researcher in theoretical astrophysics. We are particularly interested in a star formation, planet formation, or circumstellar disk dynamical theorist with numerical modeling and computational experience, however outstanding candidates in related fields will also be considered. The UR astrophysics group has an active and energetic collection of faculty, postdocs and graduate students offering many opportunities for collaboration as well as considerable independence. The initial appointment will be for 2 years and is renewable for a third year. To apply, please send a CV, statement of research interests and three letters of recommendation to Adam Frank, afrank@pas.rochester.edu, Department of Physics and Astronomy, University of Rochester, Rochester NY, 14627

## Postdoctoral Position in Star Formation

## Dublin City University, Ireland

A post-doctoral position is available to work on a joint Dublin City University and Dublin Institute for Advanced Studies project in star formation as part of the CosmoGrid consortium (http://www.cosmogrid.ie/). Ideally, the successful candidate would have a background in astrophysical numerical simulations. Candidates must have a PhD, or have recently submitted their thesis.

The position will be paid in the range 32,000-39,000 Euro per annum depending upon experience. This position is for two years initially with a possibility of extension for a further year. Application is by letter and CV naming 3 academic referees. The letter should contain a description of research interests. The closing date for applications is Friday 7th January, 2005. Letters of application and CVs should be sent to: Ms. Karen O'Shea, School of Mathematical Sciences, Dublin City University, Glasnevin, Dublin 9, Ireland.

For further details please contact Dr. Turlough Downes (turlough.downes@dcu.ie), School of Mathematical Sciences, Dublin City University, Glasnevin, Dublin 9, Ireland.

Funded by the Program for Research in Third Level Institutions under the Irish National Development Plan and with assistance from the European Regional Development Fund.

*Meetings*

# Protostars and Planets V

**24 - 28 October 2005**

**Hilton Waikoloa Village, The Big Island, Hawaii**

## Call for Talks

The Protostars and Planets meetings date back to 1978, when Tom Gehrels had the vision to "develop the interface between studies of star formation and those of the origin of the solar system". Throughout a series of highly successful meetings, the overall goal has remained to bring scientists from the star formation community, planetologists, and meteoriticists together approximately every 7 years to review what we have learned in these areas and their interfaces. The discovery of extrasolar planets, and rapid advances in our understanding of circumstellar disks, planet formation, the Kuiper belt, and chondrule and CAI formation, to mention only a few areas, promise that PP-V will be an exciting meeting. The goals of the meeting are four-fold: 1) to present an overview of our current understanding with special focus on the major areas of progress since PP-IV; 2) to bring researchers together for discussions and exchanges of ideas; 3) to strengthen future interdisciplinary research in these areas; and 4) to encourage the participation of young researchers and advanced students in these fields of research.

The PP-V conference will give an overview of star and planet formation processes, recent results in planetary science, the early solar system, and meteoritics. Topics will include

- Cloud Cores and Collapse
- Binary and Multiple Star Formation
- Protostars and Embedded Clusters
- Jets and Outflows
- Disk Accretion and Eruptive Phenomena
- Chemistry and Evolution of Disks
- Early Stages of Brown Dwarfs
- Herbig Ae/Be Stars and Young OB Stars
- Planet Formation and Exoplanets
- Meteorites and the Early Solar Nebula
- Satellites and Rings
- Kuiper Belt Objects and Comets
- Interplanetary and Interstellar Dust
- Planets and Debris Disks

*We are now inviting the community to submit proposals for review talks and invited talks at PP-V.* If you would like to submit a proposal in your area of expertise, please send an abstract summarizing the science you suggest to present. Review talks will summarize developments and key issues within a larger topic, while invited talks will focus on specific subtopics. Proposers of review talks are encouraged to form teams of experts within an area, who will work together on the corresponding chapter for the PP-V book. All *proposals submitted before January 31, 2005* will be considered together by the Scientific Advisory Committee, which will then recommend a list of speakers to the

Organisers. *Proposals should be submitted to ppv@ifa.hawaii.edu.* Historically there have been many more proposals than speaking slots at the PP conferences, and most presentations at PP-V will therefore be in the form of posters, for which ample space and time will be devoted. Calls for poster papers will be made during the spring of 2005.

For a variety of reasons, the PP-III and PP-IV books took a very long time to come out. All efforts will be made to publish the PP-V book as fast as possible after the meeting, while the content still reflects the current status of the field. It is therefore essential that speakers at the PP-V meeting arrange their schedule such that they can work on and complete their chapters within a few months following the meeting.

**Organisers**:
*Bo Reipurth* (Chair) (Institute for Astronomy, Univ. of Hawaii, USA)
*David Jewitt* (Institute for Astronomy, Univ. of Hawaii, USA)
*Klaus Keil* (Hawaii Institute for Geophysics, Univ. of Hawaii, USA)

**Scientific Advisory Committee**:
*John Bally* (CASA, Univ. of Colorado, Boulder, USA)
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*Nuria Calvet* (Harvard-Smithsonian Center for Astrophysics, Cambridge, USA)
*Cathie Clarke* (Institute of Astronomy, Cambridge, UK)
*Thomas Henning* (MPIA, Heidelberg, Germany)
*Scott Kenyon* (Harvard-Smithsonian Center for Astrophysics, Cambridge, USA)
*Katharina Lodders* (Department of Earth and Planetary Sciences, Washington University, Saint Louis, USA)
*Guenter Lugmair* (Max Planck Institut für Chemie, Mainz, Germany)
*Renu Malhotra* (Department of Planetary Sciences, Univ.of Arizona, Tucson, USA)
*Michel Mayor* (Geneva Observatory, Sauverny, Switzerland )
*Karen Meech* (Institute for Astronomy, Univ. of Hawaii, USA)
*Michael Meyer* (Steward Observatory, Department of Astronomy, Univ. of Arizona, Tucson, USA)
*Allesandro Morbidelli* (Observatoire de la Cote d'Azur, Nice France)
*Antonella Natta* (Osservatorio Astrofisico di Arcetri, Firenze, Italy)
*Luis Felipe Rodríguez* (Instituto de Astronomia, Morelia, Mexico)
*Ewine van Dishoeck* (Leiden Observatory, Leiden, The Netherlands)
*Jun-Ichi Watanabe* (National Astronomical Observatory, Tokyo, Japan)
*Hans Zinnecker* (Astrophysikalisches Institut, Potsdam, Germany)

As further information becomes available, it will be posted at the web site of the conference:

**http://www2.ifa.hawaii.edu/cspf/ppv/ppv.html**

You can also sign up at this web site for short bulletins which will be circulated by e-mail.

Second Announcement

**IAU SYMPOSIUM 231**

# Astrochemistry throughout the Universe: Recent Successes and Current Challenges

**Aug 29 - Sep 2, 2005, Asilomar, Monterey, California, USA**

Some information is provided below, but please visit the conference web site, **http://asilomar.caltech.edu**, for further information. Due to space restrictions there is a limit of 300 participants. Registration will be accepted on a "first-come, first-served" basis.

1. TOPICS

- Physics and chemistry of star-forming regions: low-mass, high-mass, energetic interfaces, prestellar cores, deuterium fractionation
- Chemistry in the envelopes and disks around young stars
- Solar-system connection: comets, meteorites and IDPs
- Chemistry in the inner and outer Solar Nebula
- Atmospheres of planets
- Basic molecular processes: gas-phase and gas-grain interactions
- Molecules in diffuse and translucent clouds
- Molecules and dust formation in envelopes around late-type stars
- Complex molecules
- Extragalactic molecules

Invited Speakers include:

S. Aalto, T. Abel, E. Bergin, O. Biham, G. Blake, O. Botta, D. Brownlee, S. Cazaux, C. Ceccarelli, S. Charnley, L. Colangeli, P. Cox, A. Dalgarno, D. Despois, S. Doty, M.-L. Dubernet, M. Gerin, W. Geppert, T. Giesen, L. Hornekaer, D. Hudgins, I. Kamp, G.-J. Kroes, S. Kurtz, R. Liseau, H. Liszt, B. McCall, A. Markwick, M. McCoustra, T. Millar, M. Moore, J. Najita, G. Pineau des Forets, H. Roberts, E. Roueff, S. Schlemmer, S. Seager, V. Shematovich, I. Sims, T. Snow, H. Spoon, R. Srianand, A. Sternberg, M. Tafalla, G. Vidali, S. Viti, N. Watanabe, D. Williams, C. Wilson, L. Ziurys

Scientific Organizing Committee

L. Allamandola, NASA Ames Research Center, USA; J.H. Black, Onsala Space Observatory, Sweden; G.A. Blake, Caltech, USA; P. Caselli, Observatorio Astrofisico di Arcetri, Italy; P. Ehrenfreund, University of Leiden, The Netherlands; G. Garay, Universidad de Chile, Chile; M. Guelin, IRAM Grenoble, France; C. Henkel, Max-Planck-Institut fuer Radioastronomie, Germany; E. Herbst, Ohio State University, USA (Secretary); U.G. Jorgensen, Niels Bohr Institute, Denmark; J.P. Maier, University of Basel, Switzerland; K.M. Menten, Max-Planck-Institut feur Radioastronomie, Germany; T.J. Millar, UMIST, United Kingdom; Y.C. Minh, Korea Astronomy Observatory, South Korea; M. Ohishi, National Astronomical Observatory, Japan; A.C. Raga, Institute Astronomia, IA-UNAM, Mexico; B. Rowe, Universite de Rennes I, France; E.F. van Dishoeck, University of Leiden, The Netherlands (Chair); J. Yang, Purple Mountain Observatory, China

IMPORTANT DATES

Dec 1, 2004 Registration opens
Feb 1, 2005 Deadline for applications for travel grants
May 16, 2005 Deadline for conference registration and payment
May 16, 2005 Abstract deadline
Jun 1, 2005 Cancellation deadline
Aug 1, 2005 Final program sent out to participants
Aug 28, 2005 Opening reception for the symposium
Aug 29 - Sep 2, 2005 Scientific Sessions
Sep 15, 2005 Deadline for submission of proceeding papers

**http://asilomar.caltech.edu**

# Astrochemistry - From Laboratory Studies to Astronomical Observations

**Pacifichem 2005 - Symposium 47**

**Honolulu, Hawai'i, December 15-20, 2005**

The formation of molecules in extraterrestrial environments has fascinated scientists since the pioneering detection, of CH and CN in interstellar space. We now know of about 130 species, ranging in complexity from diatomics such as molecular hydrogen to polyatomics like the sugar glycolaldehyde, benzene, and cyanopentaacetylene, which have been identified as gas-phase constituents of extraterrestrial environments. Nevertheless, many facets of the question "How do these molecules arise?" remain unanswered or contentious. This symposium focuses on the interdisciplinary field of astrochemistry, bringing together speakers from the fields of laboratory astrochemistry (dynamics, kinetics, and spectroscopy), astrochemical modeling (physicists), theoretical astrochemistry (computational chemists), and observational astrochemistry (astronomers). By focusing on the interplay between observational data, kinetic modeling, and fundamental investigations of the details of specific molecular processes, we seek also to evaluate the emerging generalized concepts on the formation of astrochemically important molecules on the molecular level. Furthermore, by exploring the current boundaries of astrochemical knowledge, we can more effectively design new laboratory experiments under well-defined conditions (and recommend promising directions for further astronomical searches) to resolve critical unanswered aspects of molecular synthesis in extraterrestrial space on the molecular level.

Presentations & Proceedings

This symposium features 30 invited talks (30 min each). In addition we allocated time slots for 10 contributed talks (15 min each) and poster presentations. Registrations and abstracts shall be submitted through the Pacifichem Webpage (http://www.pacifichem.org/) before April 13, 2005. Contributors will be notified by May 30, 2005, if submissions have been selected for oral or poster presen?ta?tions. Proceedings are published by the American Institute of Physics. Additional information (invited speakers, submission process) can be found on

**http://www.chem.hawaii.edu/Bil301/AstroPacifichem.html**

The Organizers:

Peter Bernath, Department of Chemistry, University of Waterloo, 200 University Avenue West, Canada. Email: bernath@uwaterloo.ca

Ralf I. Kaiser, Department of Chemistry, University of Hawaii at Manoa, Honolulu, HI 96822, USA.
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Simon Petrie, Department of Chemistry, Australian National University, Canberra, ACT 0200, Australia. Email: spetrie@rsc.anu.edu.au

There will be a meeting of the Astrophysical Chemistry Group at Cardiff University on 2005 January 6-7th. The title of the meeting is:

## Astro-chemistry from Laboratory to Telescope

The purpose of this meeting is to bring together observational and theoretical astronomers, instrument specialists and theoretical and laboratory chemists, to discuss topics of mutual interest from a broad range of overlapping fields.

Further details of the meeting can be found at:

**www.astro.cf.ac.uk/conferences/astrochemistry/**

Early Registration closes Dec 1st although will still be possible up to the meeting itself.

Please address any questions regarding the meeting to: ac05@astro.cf.ac.uk

We look forward to welcoming you to Cardiff in the New Year.

Derek Ward-Thompson
(on behalf of the organising committee)

The Star Formation Newsletter is a vehicle for fast distribution of information of interest for astronomers working on star formation and molecular clouds. You can submit material for the following sections: *Abstracts of recently accepted papers* (only for papers sent to refereed journals, not reviews nor conference notes), *Dissertation Abstracts* (presenting abstracts of new Ph.D dissertations), *Meetings* (announcing meetings broadly of interest to the star formation and interstellar medium community), *New Books* (giving details of books relevant for the same community), *New Jobs* (advertising jobs specifically aimed towards persons within our specialty), and *Short Announcements* (where you can inform or request information from the community).

**Latex macros for submitting abstracts and dissertation abstracts are appended to each issue of the newsletter**.

The Star Formation Newsletter is available on the World Wide Web at http://www.ifa.hawaii.edu/∼reipurth or at http://www.eso.org/gen-fac/pubs/starform/ .

## 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.