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From the Editor

With this issue, No. 150, the Star Formation Newsletter celebrates 12 1/2 years of continuous publication. With 1120 recipients, we now have reached a fairly stable number of subscribers, the main source of variation being students who begin subscriptions, and other students who move on to other activities. Our subscribers live in 35 different countries, testifying to the global spread of star formation studies. It has been gratifying to see that in recent years a growing number of planetary scientists and meteoriticists have become subscribers, an indication that studies of planet formation and the early Solar System are increasingly being tied to star formation studies.

Despite all efforts, a number of relevant papers still do not appear with abstracts in the Newsletter. This is a pity for the readers, but even more so for the authors. I receive numerous messages from readers who tell me that they are so busy that they no longer have time to check the latest issues of journals, but instead rely on the Newsletter to keep abreast of new results. Many people do not check astro/ph on a regular basis, and many papers do not appear there. So if an author can spend half a year or more to prepare a paper, it would seem to be a valuable investment of time to use 5 minutes to make sure that the paper is properly advertized, so it stands a chance of not disappearing in the continuous avalanche of papers.

In order to facilitate the submission of abstracts, a new web-based submission form has been developed. Those who prefer the usual submission by e-mail can continue to use that, the two modes will work in parallel. To see the new submission form, please go to the Newsletter website at http://www.ifa.hawaii.edu/users/reipurth/newsletter.htm and click on 'Abstract and Other Submissions' and follow instructions. The advantage of this new interface is that an abstract is processed immediately, and if there are errors or (very commonly) a missing personal LaTex command, then this can be identified and corrected on the spot.

The Newsletter archive at http://www.ifa.hawaii.edu/users/reipurth/newsletter.htm lists all issues of the Newsletter as LaTex files, as postscript files, and now also as PDF files.

Please send me suggestions and/or criticisms, if any, so the submission process can become as streamlined and easy to perform as possible. If you have problems with a submission you can, as always, send it to me directly, and I will deal with it.

Bo Reipurth

Abstracts of recently accepted papers

Infrared portrait of the nearby massive star-forming region IRAS 09002-4732

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We present high-resolution near-infrared and mid-infrared imaging, mid-infrared spectroscopy and millimetre wavelength continuum observations of the nearby massive star-forming complex IRAS 09002-4732. A rich cluster of young stars displaying near-infrared excess emission is detected. We identify the ionising source of the ultracompact H II region G268.42-0.85 and show that this star is the dominant heating and illuminating source of the region. Spectral type estimates based on different methods are consistent with a star of spectral type O9. The combination of the new observations with literature data allows us to set up the first structural model for the region. We argue that the ultracompact H II region is embedded in the rear side of the southern CS clump. Additionally, we detect several interesting objects. Among these objects is a network of dark dust filaments, an elongated, externally heated object with strong infrared excess inside the H II region and objects seen as silhouettes in the foreground of the large southern reflection nebulosity. The filamentary structures may play an important role in the star formation process.

Accepted by Astronomy & Astrophysics

Preprints are available at http://nautilus.as.arizona.edu/Publications/

High-spatial resolution observations of NH_3 and CH_3OH towards the massive twin cores NGC6334 I & I(N)

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Molecular line observations of NH_3 (J,K)=(1,1), (2,2) and CH_3OH at 24.93 GHz taken with the Australian Telescope Compact Array (ATCA) toward the massive twin cores NGC6334 I & I(N) reveal significant variations in the line emission between the two massive cores. The UCHII region/hot core NGC6334 I exhibits strong thermal NH_3 and CH_3OH emission adjacent to the UCHII region and coincident with two mm continuum peaks observed by Hunter et al. (in prep.). In contrast, we find neither compact NH_3 nor thermal CH_3OH line emission toward NGC6334 I(N). There, the NH_3 emission is distributed over a broad region ($> 1'$) without a clear peak, and we find Class I CH_3OH maser emission with peak brightness temperatures up to 7000 K. The maser emission peaks appear to be spatially associated with the interfaces between the molecular outflows and the ambient dense gas. Peak NH_3(1,1) line brightness temperatures ≥ 70 K in both regions indicate gas temperatures of the same order. NH_3 emission is also detected toward the outflow in NGC6334 I resulting in an estimated rotational temperature of $T_{\rm rot} \sim 19$ K. Furthermore, we observe CH_3OH and NH_3 absorption toward the UCHII region, the velocity structure is consistent with expanding molecular gas around the UCHII region. Thermal and kinematic effects possibly imposed from the UCHII region on the molecular core are also discussed.

Accepted by the Astrophysical Journal

Preprints available at http://cfa-www.harvard.edu/∼hbeuther/

Upper limits on CO 4.7 μm emission from disks around five Herbig Ae/Be stars

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We present the results of medium-resolution spectroscopy of five nearby Herbig Ae/Be stars at 4.7 μm: UX Ori, HD 34282, HD 50138, V380 Ori, HK Ori. The goal was to search for CO fundamental ro-vibrational emission. None of the targets show CO features, either in absorption nor in emission. We derive a 5σ upper limit of $< 10^{-12}$ cm^{-2} to the column density of hot CO (T $\approx$ 1500 K) in the sources. These upper limits are considerably lower than the values of Herbig Ae/Be stars for which warm and hot CO emission has been reported. The non-detection of CO ν=1-0 emission in these five targets suggest that Herbig Ae/Be stars are not a homogeneous group with respect to the structure of the gaseous disk and/or the amount of CO in the inner 50 AU of their disks.

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http://arXiv.org/abs/astro-ph/0503317

The onset of collapse in turbulently supported molecular clouds

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We examine the formation of bound coherent clumps within the environment of turbulent molecular clouds, with emphasis on determining the role that turbulent motions play in the star formation process. We use smoothed particle hydrodynamics (SPH) to simulate small molecular clouds (~ 30 solar masses), in which the gas is initially supported from gravitational collapse by a freely decaying turbulent field, consistent with a Larson relation of $\sigma \propto L^{1/2}$. We show that the turbulent field does not trigger the star formation via local decreases in the Jeans mass, as has been proposed elsewhere in the literature. Instead the role of the turbulence is simply to provide shocks which dissipate the supporting kinetic energy and generate structure which acts as seeds for the subsequent fragmentation. These structures are initially unbound, but grow through the self-gravity of the larger-scale region. Collapse proceeds once they attain the mean Jeans mass of the cloud. At this point they are in approximate equipartition of kinetic and thermal energies and can thus fragment to form a multiple system during collapse. Multiple systems are thus a natural consequence of star formation in a turbulent environment.

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For pre-prints, please email the contact address for Paul Clark above.

Models of class II methanol masers based on improved molecular data

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The class II masers of methanol are associated with the early stages of formation of high-mass stars. Modelling of these dense, dusty environments has demonstrated that pumping by infrared radiation can account for the observed masers. Collisions with other molecules in the ambient gas also play a significant role, but have not been well modelled in the past. Here we examine the effects on the maser models of newly available collision rate coefficients for methanol. The new collision data does not alter which transitions become masers in the models, but does influence their brightness and the conditions under which they switch on and off. At gas temperatures above 100 K the effects are broadly consistent with a reduction in the overall collision cross-section. This means, for example, that a slightly higher gas density than identified previously can account for most of the observed masers in W3(OH). We have also examined the effects of including more excited state energy levels in the models, and find that these play a significant role only at dust temperatures above 300 K. An updated list of class II methanol maser candidates is presented.

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High-Resolution Molecular Line Observations of the Environment of the Class 0 Source B1-IRS

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In this work we present VLA observations of the NH_3, CCS, and H_2O maser emission at 1 cm from the star forming region B1-IRS (IRAS 03301+3057) with $\simeq 5$" (=1750 AU) of angular resolution. CCS emission is distributed in three clumps around the central source. These clumps exhibit a velocity gradient from red- to blueshifted velocities toward B1-IRS, probably due to an interaction with the outflow from an embedded protostar. The outflow and its powering source are traced by a reflection nebula and an associated infrared point source detected in a 2MASS K-band image. We find that this infrared point source is associated with water maser emission distributed in an elongated structure ($\simeq$ 450 AU size) along the major axis of the reflection nebula and tracing the base of the outflow of the region. Ammonia emission is extended and spatially anticorrelated with CCS. This is the first time that this kind of anticorrelation is observed in a star forming region with such a high angular resolution, and illustrates the importance of time-dependent chemistry on small spatial scales. The relatively large abundance of CCS with respect to ammonia, compared with other star forming regions, suggests an extreme youth for the B1-IRS object ($\leq 10^5$ yr). We suggest the possibility that CCS abundance is enhanced via shock-induced chemistry.

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Morphologies of Ultracompact HII Regions in W49A and Sgr B2: Prevalence of Shells and a Modified Classification Scheme

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We have used Very Large Array (VLA) observations of the massive star forming regions W49A and Sgr B2, obtained with resolutions from 2.0" to 0.04", to classify the morphologies of nearly 100 ultracompact HII regions. These high resolution, multi-frequency, multi-configuration VLA observations motivate several modifications of the existing morphological classification scheme for UC HII regions. In this work, we describe the modified morphology scheme and the criteria used in source classification. In particular, we drop the "core-halo" classification, add a "bipolar" classification, and change the shell classification to "shell-like". We tally the percentage of each morphology found in the Sgr B2 and W49A regions and find broad agreement with the Galactic plane surveys in the distribution of morphologies for most types. However, we find that nearly a third of the sources in these regions are shell-like, which is a higher percentage by nearly a factor of ten than found in the surveys of Galactic plane star forming regions by Wood & Churchwell (1989a) and Kurtz et al. (1994). This difference may be due to physical differences in the environments of these two extreme star forming regions. Alternatively, differences in observational technique may be responsible.

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Freeze-out and coagulation in pre–protostellar collapse

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We study the changes in physical and chemical conditions during the early stages of collapse of a pre-protostellar core, starting from initial conditions appropriate to a dense molecular cloud and proceeding to the "completely depleted" limit. We allow for molecular desorption from the grain surfaces and follow the evolution of the ionization degree and the ionic composition as functions of time and density. The timescale for collapse is treated as a parameter and taken equal to either the free–fall or the ambipolar diffusion time. The processes of freeze–out on to the dust grains and of coagulation of the grains were treated simultaneously with the chemical evolution of the medium in the course of its collapse. When proceeding at close to its maximum rate, coagulation has important consequences for the degree of ionization and the ionic composition of the medium, but its effect on the freeze–out of the neutral species is modest.

An innovation of our study is to calculate the grain charge distribution; this is done in parallel with the chemistry and the dynamics. The grain charge distribution is significant because H^+ ions recombine predominantly on the surfaces of negatively charged grains. We have also attempted to reproduce with our models the observational result that nitrogen–containing species, such as NH_3 and N_2H^+, remain in the gas phase at densities for which CO and other C–containing molecules appear to have frozen on to grain surfaces. We conclude that recent measurements of the adsorption energies of N_2 and CO invalidate the interpretation of these observations in terms of the relative volatilities of N_2 and CO. We consider an alternative explanation, in terms of low sticking coefficients for either molecular or atomic N; but this hypothesis requires experimental confirmation. We find that, irrespective of the nitrogen chemistry, the main gas phase ion is either H^+ or H_3^+ (and its deuterated isotopes) at densities above 10^5 cm^{-3}; whether H^+ or H_3^+ predominates depends sensitively on the rate of increase in grain size (decrease in grain surface area per unit volume of gas) during core contraction. Our calculations show that H^+ will predominate if grain coagulation proceeds at close to its maximum rate, and H_3^+ otherwise.

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HST and spectroscopic observations of the L1551 IRS5 jets (HH154)

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We have carried out a thorough optical study of the closest star formation jet. The inner arcminute surrounding the class 0/I binary protostar L1551 IRS5 and its associated jet (HH154) have been observed using the Hubble Space Telescope with the WFPC2 camera, the ESO New Technology Telescope with the EMMI spectrograph and the Nordic Optical Telescope with the ALFOSC spectrograph. This data set is compared to earlier ground based imaging with the aim to study the evolution of this particular jet, and its possible interaction with the molecular material in the bipolar molecular outflow associated with this source. The velocity field of the jet is mapped out. The highest velocities are found in the vicinity of the recently discovered X-ray source emanating from a shock in this jet. The energy radiated by the X-ray source is compatible with these velocities. The Hα and Hβ emission from the jet is used to determine the extinction, which is found to increase inwards in the jet towards the protostar. The extinction towards the X-ray source is consistent with the one determined from the X-ray spectrum.

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Proper Motion of H_2O Masers in IRAS 20050+2720 MMS1: An AU Scale Jet Associated with An Intermediate-Mass Class 0 Source

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We conducted a 4 epoch 3 month VLBA proper motion study of H_2O masers toward an intermediate-mass class 0 source IRAS 20050+2720 MMS1 (d =700 pc). The region of IRAS 20050+2720 contains at least 3 bright young stellar

objects at millimeter to submillimeter wavelengths and shows three pairs of CO outflow lobes: the brightest source MMS1, which shows an extremely high velocity (EHV) wing emission, is believed to drive the outflow(s). From milli-arcsecond (mas) resolution VLBA images, we found two groups of H_2O maser spots at the center of the submillimeter core of MMS1. One group consists of more than ~ 50 intense maser spots; the other group consisting of several weaker maser spots is located at 18 AU south-west of the intense group. Distribution of the maser spots in the intense group shows an arc-shaped structure which includes the maser spots that showed a clear velocity gradient. The spatial and velocity structures of the maser spots in the arc-shape did not significantly change through the 4 epochs. Furthermore, we found a relative proper motion between the two groups. Their projected separation increased by 1.13±0.11 mas over the 4 epochs along a line connecting them (corresponding to a transverse velocity of 14.4 km s^{-1}). The spatial and velocity structures of the intense group and the relative proper motions strongly suggest that the maser emission is associated with a protostellar jet. Comparing the observed LSR velocities with calculated radial velocities from a simple biconical jet model, we conclude that the most of the maser emission are likely to be associated with an accelerating biconical jet which has large opening angle of about 70°. The large opening angle of the jet traced by the masers would support the hypothesis that poor jet collimation is an inherent property of luminous (proto)stars.

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http://www.astro.caltech.edu/~rsf/publication.html

Enhanced X-ray variability from V1647 Ori, the young star in outburst illuminating McNeil's Nebula

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We report a ~38 ks X-ray observation of McNeil's Nebula obtained with *XMM-Newton* on 2004 April 4. V1647 Ori, the young star in outburst illuminating McNeil's Nebula, is detected with *XMM-Newton* and appears variable in X-rays. We investigate the hardness ratio variability and time variations of the event energy distribution with quantile analysis, and show that the large increase of the count rate from V1647 Ori observed during the second half of the observation is not associated with any large plasma temperature variations as for typical X-ray flares from young low-mass stars. X-ray spectral fitting shows that the bulk ($\sim$ 75%) of the intrinsic X-ray emission in the 0.5–8 keV energy band comes from a soft plasma component, with $kT_{\rm soft} = 0.9\,$keV (0.7–1.1 keV, at the 90% confidence limit), reminiscent of the X-ray spectrum of the classical T Tauri star TW Hya, for which X-ray emission is believed to be generated by an accretion shock onto the photosphere of a low-mass star. The hard plasma component, with $kT_{\rm hard} = 4.2\,$keV (3.0–6.5 keV), contributes $\sim$ 25% of the total X-ray emission, and can be understood only in the framework of plasma heating sustained by magnetic reconnection events. We find a hydrogen column density of $N_{\rm H} = 4.1\times10^{22}\,{\rm cm}^{-2}$ (3.5–$4.7\times10^{22}\,{\rm cm}^{-2}$), which points out a significant excess of hydrogen column density compared to the value derived from optical/IR observations, consistent with the picture of the rise of a wind/jet unveiled from ground optical spectroscopy. The X-ray flux observed with *XMM-Newton* ranges from roughly the flux observed by *Chandra* on 2004 March 22 (i.e. ~10 times greater than the pre-outburst X-ray flux) to a value two times greater than that caught by *Chandra* on 2004 March 7 (i.e. ~200 times greater than the pre-outburst X-ray flux). The X-ray variability of V1647 Ori in outburst is clearly enhanced. We have investigated the possibility that V1647 Ori displays a periodic variation in X-ray brightness as suggested by the combined *Chandra*+*XMM-Newton* data set. Assuming that the X-ray flux density is periodic, the folding of the two *Chandra* observed X-ray flux densities with the *XMM-Newton* ones leads to three periodic X-ray light curve solutions. Our best period candidate is 0.72 day, which corresponds to the time scale of the Keplerian rotation at a distance of 1 and 1.4 stellar radius for a one solar mass star aged of 0.5 and 1 Myrs, respectively. We propose that the emission measure, i.e. the observed X-ray flux, is modulated by the Keplerian rotation of the inner

part of the V1647 Ori accretion disk.

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COUP census of X-ray stars in BN-KL and OMC-1S

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We present a study of the X-ray sources detected in the vicinity of two density peaks in the Orion Molecular Cloud 1 (OMC-1) behind the Orion Nebula Cluster (ONC), as seen in the exceptionally deep ($\sim$10 days) exposure of the *Chandra* Orion Ultradeep Project (COUP). We focus on a $40'' \times 50''$ region around the Becklin-Neugebauer object and Kleinmann-Low nebula (collectively BN-KL) and a $60'' \times 75''$ region around OMC-1S, a secondary star-forming peak some $90''$ south of BN-KL. Forty-three and sixty X-ray sources were detected in BN-KL and OMC-1S, respectively, of which half and one-third, respectively, were found to be foreground members of the ONC, while the remaining sources are identified as obscured X-ray sources with column densities $22 \lesssim \log(N_{\rm H}/{\rm cm}^{-2}) \lesssim 24$. All but 5 and 18 of these sources have near-infrared stellar counterparts, and 22 of these appear to be young stellar objects (YSOs). X-ray sources are found close to four luminous mid-IR sources namely BN, IRc3-i2, IRc2-C, and Source n; their X-ray variability and spectral properties are typical of coronal activity in low-mass stars rather than wind emission from massive stars, suggesting that the X-ray emission may be arising from companions. The X-ray light curve of the X-ray source close to BN shows a periodicity of $\sim$8.3 days and from an X-ray image deconvolution of the region around BN, we conclude that either BN itself or a low mass companion with a projected separation of $\simeq$ 200 AU was detected. On the other hand, no emission is seen from the bright radio Source I, held by some to be the main source of luminosity in BN-KL. In OMC-1S, *Chandra* unveils a new subcluster of seven YSOs without infrared counterparts. We compare the hard band X-ray luminosity functions of obscured X-ray sources in BN-KL and OMC-1S with unobscured X-ray sources in the ONC, and estimate that the true population of obscured sources in BN-KL and OMC-1S is $\simeq$46 and 57 stars, with 90% confidence intervals of 34–71 and 42–82 stars, respectively.

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http://www-laog.obs.ujf-grenoble.fr/∼ngrosso/preprints/omc1.pdf
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Organic Molecules in the Hot Corinos and Circumstellar Disks of IRAS 16293-2422

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Using the recently-commissioned Submillimeter Array (SMA), we have detected several complex organic molecules, including $(CH_3)_2O$, C_2H_5OH, C_2H_5CN, and tentatively CH_2CDCN, toward the protostellar hot cores of IRAS 16293-2422 at arcsecond-resolution ($\lesssim$400 AU in radius). Vibrationally excited transitions of SO, SO_2 and HCN with energy levels up to 1800 K were also observed. In addition to the other organic molecules (HC_3N, CH_2CO, CH_3OH, CH_2CHCN and $HCOOCH_3$) previously reported by us (Kuan et al. 2004), these results clearly indicate the existence of a rich organic chemistry in low-mass 'hot corinos'. From the observation of optically thin $HC^{15}N$ emission, we conclude I16293A is a rotating circumstellar disk lying along the north-south direction $\sim10°$ to the east and with an inclination $\sim30°$ to the sky. We suggest that the observed vibrational SO and SO_2 emission may originate from shock waves near or in the circumstellar disks. Between the two cores, we find a strong anticorrelation in emission from C_2H_5OH and C_2H_5CN. The relative contribution of gas phase and grain-surface chemistries to the production of the observed complex molecules is discussed. We point out the shortcomings underlying recent claims that all the O-bearing organics are formed on grains.

The presence of so many well-known interstellar molecules in *solar-type hot corinos* strengthens the link between molecular cloud chemistry, the starting materials of protoplanetary disks such as the protosolar nebula, and the composition of comets. Establishing the fine details of this connection is crucial in answering fundamental questions concerning the importance of galactic astrochemistry for astrobiology.

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Binary star formation from ring fragmentation

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We present a simple model of binary star formation based on the assumption that rotating prestellar cores collapse to form rings and these rings then fragment into protostars. We assume that each ring spawns a small number ($\mathcal{N} \leq 6$) of protostars, and that the condensation of the protostars is sufficiently rapid that they can subsequently be treated as point masses.

The first part of the model is therefore to simulate the dynamical evolution of a ring of $\mathcal{N}$ stars and record the properties of the single stars, binaries and higher multiples that form as a result of the dissolution of the ring. The masses of the individual stars in a ring are drawn from a log-normal distribution with dispersion $\sigma_{\log M}$. This part of the model is perfomed for many different realizations of the ring, to obtain good statistics. It can be formulated using dimensionless variables and immediately yields the overall multiplicity.

The second part of the model is to convolve the results of these dimensionless simulations, *first* with the distribution of core masses, which yields the distributions of multiplicity, mass ratio and eccentricity, as a function of primary mass; and *second* with the distribution of core angular momenta, which yields the distributions of semi-major axis and period, again as a function of primary mass.

Using the observed distribution of core masses, and a distribution of core angular momenta which is consistent with the observations, our model is able to reproduce the observed IMF, the observed high multiplicity frequency of pre-Main Sequence stars, the observed distribution of separations, and – for long-period systems – the observed distributions of eccentricity and mass-ratio, provided we invoke $\mathcal{N} = 4$ or 5 and $\sigma_{\log M} = 0.6$.

We presume that for short-period systems the distributions of eccentricity and mass-ratio are modified by the dissipative effects of subsequent tidal interaction and competitive accretion; and that the reduced multiplicity frequency in the field, compared with young clusters, is the result of dynamical interactions between stars formed in different cores but the same cluster, following ring dissolution. Further numerical experiments are required to explore the consequences of such interactions.

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The Shape of the Inner Rim in Proto-Planetary Disks

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This paper discusses the properties of the inner puffed-up rim which forms in circumstellar disks when dust evaporates. We argue that the rim shape is controlled by a fundamental property of circumstellar disks, namely their very large vertical density gradient, through the dependence of grain evaporation temperature on gas density. As a result, the bright side of the rim is *curved*, rather than *vertical*, as expected when a constant evaporation temperature is assumed. We have computed a number of rim models, which take into account this effect in a self-consistent way. The results show that the curved rim (as the vertical rim) emits most of its radiation in the near and mid-IR, and provides a simple explanation to the observed values of the near-IR excess (the "3 μm bump" of Herbig Ae stars). Contrary to the vertical rim, for curved rims the near-IR excess does not depend much on the inclination, being maximum for face-on objects. We have then computed synthetic images of the curved rim seen under different inclinations; face-on rims are seen as bright, centrally symmetric rings on the sky; increasing the inclination, the rim takes an elliptical shape, with one side brighter than the other.

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H_2CO and CH_3OH abundances in the envelopes around low-mass protostars

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This paper presents the third in a series of single-dish studies of molecular abundances in the envelopes around a large sample of 18 low-mass pre- and protostellar objects. It focuses on typical grain mantle products and organic molecules, including H_2CO, CH_3OH and CH_3CN. With a few exceptions, all H_2CO lines can be fit by constant abundances of 7×10^{-11}–8×10^{-9} throughout the envelopes if ortho- and para lines are considered independently. The current observational dataset does not require a large H_2CO abundance enhancement in the inner warm regions, but this can also not be ruled out. Through comparison of the H_2CO abundances of the entire sample, the H_2CO ortho-para ratio is constrained to be 1.6±0.3 consistent with thermalization on grains at temperatures of 10–15 K. The H_2CO abundances can be related to the empirical chemical network established on the basis of our previously reported survey of other species and is found to be closely correlated with that of the nitrogen-bearing molecules. These correlations reflect the freeze-out of molecules at low temperatures and high densities, with the constant H_2CO abundance being a measure of the size of the freeze-out zone. An improved fit to the data is obtained with a 'drop' abundance structure in which the abundance is typically a few $\times10^{-10}$ when the temperature is lower than the evaporation temperature and the density high enough so that the timescale for depletion is less than the lifetime of the core. The location of the freeze-out zone is constrained from CO observations. Outside the freeze-out zone, the H_2CO abundance is typically a few $\times10^{-9} - 10^{-8}$. The observations show that the CH_3OH lines are significantly broader than the H_2CO lines, indicating that they probe kinematically distinct regions. CH_3OH is moreover only detected toward a handful of sources and CH_3CN toward only one, NGC 1333-IRAS2. For NGC 1333-IRAS2, CH_3OH and CH_3CN abundance enhancements of two-three orders of magnitude at temperatures higher than 90 K are derived. In contrast, the NGC 1333-IRAS4A and IRAS4B CH_3OH data are fitted with a constant abundance and an abundance enhancement at a lower temperature of 30 K, respectively. This is consistent with a scenario where CH_3OH probes the action of compact outflows on the envelopes, which is further supported by comparison to high frequency, high excitation CS J = 10–9 and HDO line profiles which uniquely probe warm, dense gas. The extent to which the outflow dominates the abundance enhancements compared with the passively heated inner envelope depends on the filling factors of the two components in the observing beam.

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Long-duration simulations of the evolution of jet-driven molecular outflows

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We use numerical simulations to examine the mass-velocity, $m(v)$, and intensity-velocity, $I(v)$, relations in jet-driven molecular outflows up to an age of 2300 yrs. We find that the $m(v)$ relation is a power-law, $m(v) \propto v^{-\gamma}$, the exponent of which increases with time up to $\gamma \approx 1.6$ at $t \approx 1500$ yrs. It then becomes roughly constant. This indicates that γ does not evolve throughout the lifetime of a molecular outflow, at least in the context of the jet-driven model.

We also investigate the effect of long-period episodicity of the jet on the $m(v)$ and $I(v)$ relations. We find that, contrary to previous expectations, these relations are not significantly changed with the introduction of such variability into the jet.

Finally, we present a novel, and relatively simple, parallelisation method for the code used in these simulations. This gives an increase of roughly a factor of 4 in speed over standard methods, and allows the simulations presented here to be run fairly easily, even with modest computational resources.

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Available at `http://www.dcu.ie/$\sim$downest/documents/papers/keegan-downes.pdf`

Prospects for Detection of Catastrophic Collisions in Debris Disks

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We investigate the prospects for detecting dust from two body collisions during the late stages of planet formation at 1–150 AU. We develop an analytic model to describe the formation of a dusty cloud of debris and use numerical coagulation and n-body calculations to predict observable signals from these events. In a minimum mass solar nebula, collisions of 100–1000 km objects at distances of 3–5 AU or less from the parent star are observable at mid-infrared wavelengths as bright clumps or rings of dust. At 24 μm, the clumps are $\sim$ 0.1–1 mag brighter than emission from dust in the background debris disk. In edge-on systems, dusty clumps produce eclipses with depths of ≤ 1.0 mag that last for $\sim$ 100 orbital periods. Large-scale surveys for transits from exosolar planets, such as *Kepler*, can plausibly detect these eclipses and provide important constraints on the terrestrial environment for ages of $\leq$ 100–300 Myr.

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Outflow interaction in the late stages of star formation

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We have mapped the CO, HCO^+, N_2H^+ and CS emission around a nearby T Tauri star, IRAS 16316-1540. A molecular outflow is seen in CO, HCO^+, N_2H^+ and CS emission originating from the IRAS source, while an envelope is seen in N_2H^+ and HCO^+ emission surrounding the IRAS source. The molecular outflow is bipolar with a southeastern (SE) lobe and a northwestern (NW) lobe. The structure and the kinematics of the SE lobe are well defined and can be explained with a simple kinematic model. In this model, the SE lobe is a U-shaped shell consisting of a wide-opening base mimicking the reflection nebula RNO 91 and a cylindrical shell with a constant radius mimicking the CO outflow shell. The wide-opening base is expanding toward the circumstellar envelope, while the cylindrical shell is expanding mainly laterally into the ambient medium. If the base of the SE lobe continues to expand at its current velocity, it will

meet with the base of the NW lobe and disperse the circumstellar envelope in a few 10^4 yrs. The circumstellar envelope is elongated perpendicular to the outflow axis, extending to the northeast and southwest of the IRAS source. The envelope has differential rotation with the velocity increasing toward the source. It may result from material infalling toward the source carrying its angular momentum. The HCO^+ emission near the source may arise from an unresolved inner ring of the envelope, showing two peaks with one on each side of the IRAS source and a PV structure consistent with the rotation law derived from the N_2H^+ emission. The HCO^+emission in the outer part of the envelope likely traces the swept up envelope material, showing both the outflow motion and probably rotation.

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Star Formation in Isolated Disk Galaxies. I. Models and Characteristics of Nonlinear Gravitational Collapse

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We model gravitational collapse leading to star formation in a wide range of isolated disk galaxies using a three-dimensional, smoothed particle hydrodynamics code. The model galaxies include a dark matter halo and a disk of stars and isothermal gas. Absorbing sink particles are used to directly measure the mass of gravitationally collapsing gas. They reach masses characteristic of stellar clusters. In this paper, we describe our galaxy models and numerical methods, followed by an investigation of the gravitational instability in these galaxies. Gravitational collapse forms star clusters with correlated positions and ages, as observed, for example, in the Large Magellanic Cloud. Gravitational instability alone acting in unperturbed galaxies appears sufficient to produce flocculent spiral arms, though not more organized patterns. Unstable galaxies show collapse in thin layers in the galactic plane; associated dust will form thin dust lanes in those galaxies, in agreement with observations. We find an exponential relationship between the global collapse timescale and the minimum value in a galaxy of the Toomre instability parameter for a combination of stars and gas $Q_{\rm sg}$. Furthermore, collapse occurs only in regions with $Q_{\rm sg} < 1.6$. Our results suggest that vigorous starbursts occur where $Q_{\rm sg} \ll 1$, while slow star formation takes place at higher values of $Q_{\rm sg}$ below 1.6. Massive, or gas-rich, galaxy has low initial $Q_{\rm sg}$, giving high star formation rate, while low-mass, or gas-poor galaxy has high initial $Q_{\rm sg}$, giving low star formation rate.

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Optimal column density measurements from multiband near-infrared observations

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We consider from a general point of view the problem of determining the extinction in dense molecular clouds. We use a rigorous statistical approach to characterize the properties of the most widely used optical and infrared techniques, namely the star count and the color excess methods. We propose a new maximum-likelihood method that takes advantage of both star counts and star colors to provide an optimal estimate of the extinction. Detailed numerical simulations show that our method performs optimally under a wide range of conditions and, in particular, is significantly superior to the standard techniques for clouds with high column-densities and affected by contamination by foreground stars.

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New insights on the AU-scale circumstellar structure of FU Orionis

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We report new near-infrared, long-baseline interferometric observations at the AU scale of the pre-main-sequence star FU Orionis with the PTI, IOTA and VLTI interferometers. This young stellar object has been observed on 42 nights over a period of 6 years from 1998 to 2003. We have obtained 287 independent measurements of the fringe visibility with 6 different baselines ranging from 20 to 110 meters in length, in the H and K bands. Our data resolves FU Ori at the AU scale, and provides new constraints at shorter baselines and shorter wavelengths. Our extensive (u, v)-plane coverage, coupled with the published spectral energy distribution data, allows us to test the accretion disk scenario. We find that the most probable explanation for these observations is that FU Ori hosts an active accretion disk whose temperature law is consistent with standard models and with an accretion rate of $\dot{M} = (6.3 \pm 0.6) \times 10^{-5} (M_\star/M_\odot)^{-1} M_\odot/\mathrm{yr}$. We are able to constrain the geometry of the disk, including an inclination of 55^{+5}_{-7} deg and a position angle of 47^{+7}_{-11} deg. In addition, a 10 percent peak-to-peak oscillation is detected in the data (at the two-sigma level) from the longest baselines, which we interpret as a possible disk hot-spot or companion. The still somewhat limited (u, v) sampling and substantial measurement uncertainty prevent us from constraining the location of the spot with confidence, since many solutions yield a statistically acceptable fit. However, the oscillation in our best data set is best explained with an unresolved spot located at a projected distance of 10 ± 1 AU at the 130 ± 1 deg position angle and with a magnitude difference of $\Delta K \approx 3.9 \pm 0.2$ and $\Delta H \approx 3.6 \pm 0.2$ mag moving away from the center at a rate of $1.2 \pm 0.6\,\mathrm{AU\,yr^{-1}}$. Although this bright spot on the surface of the disk could be tracing some thermal instabilities in the disk, we propose to interpret this spot as the signature of a companion of the central FU Ori system on an extremely eccentric orbit. We speculate that the close encounter of this putative companion and the central star could be the explanation of the initial photometric rise of the luminosity of this object.

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Water masers in the massive protostar IRAS 20126+4104: ejection and deceleration

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We report on the first multi-epoch, phase referenced VLBI observations of the H_2O maser emission in a high-mass protostar associated with a disk-jet system. The source under study, IRAS 20126+4104, has been extensively investigated in a large variety of tracers, including H_2O maser VLBA data acquired by us three years before the present observations. The new findings fully confirm the interpretation proposed in our previous study, namely that the maser spots are expanding from a common origin coincident with the protostar. We also demonstrate that the observed 3-D velocities of the maser spots can be fitted with a model assuming that the spots are moving along the surface of a conical jet, with speed increasing for increasing distance from the cone vertex. We also present the results of single-dish monitoring of the H_2O maser spectra in IRAS 20126+4104. These reveal that the peak velocity of some maser lines decreases linearly with time. We speculate that such a deceleration could be due to braking of the shocks

from which the maser emission originates, due to mass loading at the shock front or dissipation of the shock energy.

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Centrally Condensed Collapse of Starless Cores

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Models of self-gravitating gas in the early stages of pressure-free collapse are compared for initial states which are equilibrium layers, cylinders, and "Bonnor-Ebert" spheres. For each geometrical case the density profile has an inner region of shallow slope surrounded by an outer region of steep slope, and the profile shape during early collapse remains similar to the profile shape of the initial equilibrium. The two-slope density structure divides the spherical collapse history into a starless infall phase and a protostellar accretion phase. The similarity of density profiles implies that Bonnor-Ebert fits to observed column density maps may not distinguish spherical cores from oblate or prolate cores, and may not distinguish static cores from collapsing cores. The velocity profiles discriminate better than the density profiles between initial geometries and between collapse ages. The infall velocity generally has a subsonic maximum value, which is approximately equal to the initial velocity dispersion times the ratio of collapse age to central free-fall time.

Observations of starless core line profiles constrain collapse models. Collapse from initial states which are strongly condensed and slightly prolate is consistent with "infall asymmetry" observed around starless cores, and is more consistent than collapse from initial states which are weakly condensed, and/or oblate. Spherical models match observed inward speeds 0.05-0.09 km s^{-1} over 0.1-0.2 pc, if the collapse has a typical age 0.3-0.5 free fall times, and if it began from a centrally condensed state which was not in stable equilibrium. In a collapsing core, optically thin line profiles should broaden and develop two-peak structure as seen in L1544, once the typical infall velocity approaches the molecular velocity dispersion, or when the collapse age exceeds $\sim$ 0.4 free fall times, for typical parameters, independent of depletion.

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VLA observations of broad 6-cm excited state OH lines in W49A

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Using the Very Large Array (VLA), we observed all three of the 6-cm lines of the $^2\Pi_{1/2}, J = 1/2$ state of OH with sub-arcsecond resolution ($\sim$0.4 arcsec) in W49A. While the spatial distribution and the range in velocities of the 6-cm lines are similar to those of the ground state (18-cm) OH lines, a large fraction of the total emission in all three 6-cm lines has large linewidths ($\sim 5 - 10$ km s^{-1}) and is spatially-extended, very unlike typical ground state OH masers which typically are point-like at VLA resolutions and have linewidths $\leq$1 km s^{-1}. We find brightness temperatures of 5900 K, 4700 K, and $\geq$730 K for the 4660-MHz, 4750-MHz, and 4765-MHz lines, respectively. We conclude that these are indeed maser lines. However, the gains are $\sim$0.3, again very unlike the 18-cm lines which have gains $\geq 10^4$. We compare the excited state OH emission with that from other molecules observed with comparable angular resolution to estimate physical conditions in the regions emitting the peculiar, low-gain maser lines. We also comment on the relationship with the 18-cm masers.

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Sub-arcsec imaging of the AB Aur molecular disk and envelope at millimeter wavelenghts: a non Keplerian disk

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We present sub-arcsecond images of AB Auriga obtained with the IRAM Plateau de Bure interferometer in the isotopologues of CO, and in continuum at 3 and 1.3 mm. These observations allow us to trace the structure of the circumstellar material of AB Aur in regions where optical and IR imaging is impossible because of the emission from the star. These images reveal that the environment of AB Aur is widely different from the proto-planetary disks that surround T Tauri stars like DM Tau and LkCa15 or HAeBe stars like MWC 480, in several aspects. Instead of being centrally peaked, the continuum emission is dominated by a bright, asymmetric (spiral-like) feature at about 140 AU from the central star. Little emission is associated with the star itself. The molecular emission shows that AB Aur is surrounded by a very extended flattened structure ("disk"), which is rotating around the star. Bright molecular emission is also found towards the continuum "spiral". The large scale molecular structure suggests the AB Aur disk is inclined between 23 and 43 degrees, but the strong asymmetry of the continuum and molecular emission prevents an accurate determination of the inclination of the inner parts. Analysis of the emission in terms of a Keplerian disk provides a reasonable fit to the data, but fails to give a consistent picture because the inclinations determined from ^{12}CO J=2→1, ^{13}CO J=2→1, ^{13}CO J=1→0 and C^{18}O J=1→0 do not agree. The mass predicted for the central star in such Keplerian models is in the range 0.9 to 1.2 $M_\odot$, much smaller than the expected 2.2 $M_\odot$ from the spectral type of AB Aur. Better and more consistent fits to the ^{13}CO J=2→1, ^{13}CO J=1→0 data are obtained by relaxing the Keplerian hypothesis. We find significant non-Keplerian motion, with a best fit exponent for the rotation velocity law of 0.41 ± 0.01, but no evidence for radial motions. The disk has an inner hole about 70 AU in radius. The disk is warm and shows no evidence of depletion of CO. The dust properties suggest the dust is less evolved than in typical T Tauri disks. Both the spiral-like feature and the departure from purely Keplerian motions indicates the AB Aur disk is not in quasi-equilibrium. Disk self-gravity is insufficient to create the perturbation. This behavior may be related either to an early phase of star formation in which the Keplerian regime is not yet fully established and/or to a disturbance of yet unknown origin. An alternate, but unproven, possibility is that of a low mass companion located about 40 AU from AB Aur.

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Spectroscopic behaviour of the unusual Ae star HD 190073

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The results of high-resolution spectroscopy of the peculiar Ae star HD 190073 obtained within the framework of a cooperative observing programme in 1994–2002 are presented. The temporal behaviour of the Hα, Hβ, Hγ, Hδ, He I λ 5876Å, Na I D and other circumstellar line profiles are investigated in detail. Special attention has been paid to the analysis of the deep multicomponent blueshifted Ca II H and K absorption lines. It has been found that the fine structure of their profiles is variable on timescales from months to decades. The analysis of the circumstellar spectrum of HD 190073, rich in shell-like and emission lines with narrow absorption cores, allows us to conclude that all absorption lines and cores are likely to be of photospheric origin. The emission lines are variable in time and demonstrate signs of a stellar wind as well as a dense equatorial circumstellar disk. As a preliminary hypothesis, we propose that a global magnetic field of a specific topology can be responsible for the formation of stable latitudinal stratification of the outflowing gas resulting in appearance of the complex structure of the Ca II H and K line profiles.

We emphasise that a measurement of the stellar magnetic field and an investigation of its detailed configuration would be an important step in understanding the nature of HD 190073.

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The formation and habitability of terrestrial planets in the presence of close-in giant planets

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'Hot jupiters,' giant planets with orbits very close to their parent stars, are thought to form farther away and migrate inward via interactions with a massive gas disk. If a giant planet forms and migrates quickly, the planetesimal population has time to re-generate in the lifetime of the disk and terrestrial planets may form (Armitage 2003). We present results of simulations of terrestrial planet formation in the presence of hot/warm jupiters, broadly defined as having orbital radii $\leq$ 0.5 AU. We show that terrestrial planets similar to those in the Solar System can form around stars with hot/warm jupiters, and can have water contents equal to or higher than the Earth's. For small orbital radii of hot jupiters (e.g. 0.15, 0.25 AU) potentially habitable planets can form, but for semi-major axes of 0.5 AU or greater their formation is suppressed. We show that the presence of an outer giant planet such as Jupiter does not enhance the water content of the terrestrial planets, but rather decreases their formation and water delivery timescales. We speculate that asteroid belts may exist interior to the terrestrial planets in systems with close-in giant planets.

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High Angular Resolution Observations of the Collimated Jet Source Associated with a Massive Protostar in IRAS 16547-4247

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A triple radio source recently detected in association with the luminous infrared source IRAS 16547-4247 has been studied with high angular resolution and high sensitivity with the Very Large Array at 3.6 and 2 cm. Our observations confirm the interpretation that the central object is a thermal radio jet, while the two outer lobes are most probably heavily obscured HH objects. The thermal radio jet is resolved angularly for the first time and found to align closely with the outer lobes. The opening angle of the thermal jet is estimated to be $\sim 25°$, confirming that collimated outflows can also be present in massive protostars. The proper motions of the outer lobes should be measurable over timescales of a few years. Several fainter sources detected in the region are most probably associated with other stars in a young cluster.

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Proper Motions of the BN Object and the I Radio Source in Orion: Where and When Did BN Become a Runaway Star?

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We present absolute astrometry of the core of the Orion molecular cloud, made with Very Large Array archive data taken over the last two decades. Our analysis reveals that both the BN object and the radio source I have proper motions: the BN object has a proper motion of 12.6 ± 0.6 mas yr^{-1} (corresponding to a velocity of 27 ± 1 km s^{-1} at an adopted distance of 450 pc) to the northwest, while the radio source I has a proper motion of 5.6 ± 0.7 mas yr^{-1} (corresponding to a velocity of 12 ± 2 km s^{-1}) to the southeast. The motion of the two sources is nearly antiparallel, diverging from a point in between them, where they were located about 500 years ago. These results suggest that the BN object and the radio source I were part of a multiple young stellar system that disintegrated in the recent past.

Accepted by Ap. J. (Letters)

astro-ph/0504134

Number Ratios of Young Stellar Objects in Embedded Clusters

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Embedded clusters usually contain young stellar objects in different evolutionary stages. We investigate number ratios of objects in these classes in the star-forming regions ρ Ophiuchi, Serpens, Taurus, Chamaeleon I, NGC 7129, IC 1396A, and IC 348. They are compared to the temporal evolution of young stars in numerical simulations of gravoturbulent fragmentation in order to constrain the models and to possibly determine the evolutionary stage of the clusters. It turns out that Serpens is the youngest, and IC 348 the most evolved cluster, although the time when the observations are best represented varies strongly depending on the model. Furthermore, we find an inverse correlation of the star formation efficiency (SFE) of the models with the Mach number. However, the observational SFE values cannot be reproduced by the current isothermal models. This argues for models that take into account protostellar feedback processes and/or the effects of magnetic fields.

Accepted by A&A

astro-ph/0503611

Cep OB2: Disk Evolution and Accretion at 3-10 Myr

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We present the results of the MMT observations of young stars for our study of protoplanetary disks at the ages 1-10 Myr, in two young clusters located in the Cep OB2 region: Tr37 (embedded in the H II region IC 1396) and NGC 7160. Using low resolution optical spectra from the Hectospec multifiber spectrograph, we have tripled the number of known low-mass members, identifying ∼130 new members in Tr37, and ∼30 in NGC 7160. We use indicators of youth (Li absorption at 6707 Å) and accretion/chromospheric activity (Hα emission) to identify and to classify the low-mass cluster members. We derive spectral types for all the low-mass candidates, and calculate the individual extinction and its average over the clusters. With the extended member samples, we estimate disk fraction in the clusters, finding that ∼40% of the low-mass stars in Tr 37 are actively accreting, whereas only 1 out of the ∼55 low-mass stars in NGC 7160 shows indications of accretion. Optical photometry and theoretical isochrones are used to determine the age of the cluster members, confirming the estimates of ∼4 Myr for Tr 37 and ∼10 Myr for NGC 7160. Accretion rates in Tr 37 ($\sim 10^{-8} M_{\odot} yr^{-1}$ on average) are derived from U band photometry. We find that only ∼50% of the accreting stars have near-IR excesses (from 2MASS), which could be due to the geometry of their disks or be an indication dust settling/grain growth. Finally, we study the high- and intermediate-mass members of the clusters. With the extended member list, we revise the spatial distribution of stars with disks. Our results are crucial for interpreting

Spitzer studies of accretion disks at the ages of planet formation (3-10 Myr).

Accepted by Astron. J.

http://cfa-www.harvard.edu/cfa/youngstars/publications.html

Detection of steam in the circumstellar disk around a massive Young Stellar Object

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We report on the observation of hot water vapor (steam) in the inner AU of a young massive star located in the star-forming region IRAS 08576-4334. The water lines are detected in a medium resolution ($R \sim$10,000) K-band spectrum taken by the infrared spectrometer *ISAAC* mounted on the *VLT-ANTU*. The water vapor is at a mean temperature of 1565±510 K, cooler than the hot CO found in the same object, which is at $\simeq$ 1660 K and the column density is $N(H_2O)= (2.5 \pm 0.4) \times 10^{18}$ cm^{-2}. The profile of both H_2O and CO lines is best reproduced by the emission from a Keplerian disk. To interpret the data, we also investigate the formation of molecules and especially CO and water vapor in the inner hot and dense part of disks around young high mass stars using a pseudo time-dependent gas-phase chemical model. Molecules are rapidly photodissociated but this destruction is compensated by an efficient formation due to fast neutral-neutral reactions. The ability of CO molecules to self-shield significantly enhances its abundance. Water molecules are sufficiently abundant to be detectable. The observed H_2O/CO ratio is reproduced by gas at 1600 K and an enhanced UV field over gas density ratio $I_{\rm UV}/n_{\rm H}$=10^{-4}–10^{-6}. The simulations support the presence of CO and H_2O molecules in the inner disks around young massive stars despite the strong UV radiation and show that the OH radical plays an essential role in hot gas chemistry.

Accepted by Astronomy & Astrophysics

astro-ph/053547

Can Photo-evaporation Trigger Planetesimal Formation?

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We propose that UV radiation can stimulate the formation of planetesimals in externally-illuminated protoplanetary disks. We present a numerical model of disk evolution including vertical sedimentation and photo-evaporation by an external O or B star. As solid material grows and settles toward the disk midplane, the outer layers of the disk become dust depleted. When such a disk is exposed to UV radiation, heating drives photo-evaporative mass-loss from its surface, generating a dust-depleted outflow. The dust:gas ratio in the disk interior grows until dust in the disk midplane becomes gravitationally unstable. Thus, UV radiation fields may induce the rapid formation of planetesimals in disks where sedimentation has occurred.

Accepted by Astrophys. J. Letters

http://arxiv.org/abs/astro-ph/0411647

Very compact radio emission from high-mass protostars. II. Dust disks and ionized accretion flows.

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This paper reports 43 GHz imaging of the high-mass protostars W 33A, AFGL 2591 and NGC 7538 IRS9 at $\sim 0.04''$ and $\sim 0.6''$ resolution. In each case, weak (∼mJy-level), compact (Ø∼100 AU) emission is detected, which has an elongated shape (axis ratio ∼3). For AFGL 2591 and NGC 7538 IRS9, the emission is single-peaked, while for the highest-luminosity source, W 33A, a 'mini-cluster' of three sources is detected. The derived sizes, flux densities, and broad-band radio spectra of the sources support recent models where the initial expansion of H II regions around very young O-type stars is prevented by stellar gravity. In these models, accretion flows onto high-mass stars originate in large-scale molecular envelopes and become ionized close to the star. These models reproduce our observations of ionized gas as well as the structure of the molecular envelopes of these sources on 10^3–10^4 AU scales derived previously from single-dish sub-millimeter continuum and line mapping. For AFGL 2591, the 43 GHz flux density is also consistent with dust emission from a disk seen in near-infrared 'speckle' images. However, the alignment of the 43 GHz emission with the large-scale molecular outflow argues against an origin in a disk for AFGL 2591 and NGC 7538 IRS9. In contrast, the outflow from W 33A does not appear to be collimated. Together with previously presented case studies of W 3 IRS5 and AFGL 2136, our results indicate that the formation of stars and stellar clusters with luminosities up to $\sim 10^5$ $L_\odot$ proceeds through accretion and produces collimated outflows as in the solar-type case, with the 'additional feature' that the accretion flow becomes ionized close to the star. Above $\sim 10^5$ $L_\odot$, clusters of H II regions appear, and outflows are no longer collimated, possibly as the result of mergers of protostars or pre-stellar cores.

Accepted by A&A

Preprint at http://arxiv.org/abs/astro-ph/0504026

Warp signatures of the Galactic disk as seen in mid infrared from Midcourse Space Experiment

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The gross features in the distribution of stars as well as warm ($T \geq 100$ K) interstellar dust in the Galactic disk have been investigated using the recent mid infrared survey by Midcourse Space Experiment (MSX) at 8, 12, 14 & 21 μm bands. An attempt has been made to determine the location of the Galactic mid-plane at various longitudes, using two approaches : (i) fitting exponential functions to the latitude profiles and (ii) statistical indicators. The former method is successful for the inner Galaxy ($-90^\circ < l \leq 90^\circ$), and quantifies characteristic angular scales, γ, along latitude. These γs have been translated to linear scale heights (z_h) and radial length scales (R_l) using geometric description of the Galactic disk. The distribution of warm dust in the Galactic disk is found to be characterised by $R_l < 6$ kpc and $60 < z_h \leq 100$ pc, consistent with other studies.

The location of the Galactic mid-plane as a function of longitude (in all 4 MSX bands), for stars as well as warm dust, has been searched for signatures of warp-like feature in their distribution, by fitting sinusoid with phase and amplitude as parameters. In every case, the warp signature has been detected. Carrying out an identical analysis of the DIRBE/COBE data (with lower angular resolution) in all its ten bands covering the entire infrared spectrum (1.25–240 μm), also leads to detection of warp signatures with very similar phase as found from the MSX data. Our results have been compared with those from other studies.

Accepted by A&A

`arXiv:astro-ph/0503388`

The effect of a finite mass reservoir on the collapse of spherical isothermal clouds and the evolution of protostellar accretion

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Motivated by recent observations which detect an outer boundary for starless cores, and evidence for time-dependent mass accretion in the Class 0 and Class I protostellar phases, we reexamine the case of spherical isothermal collapse in the case of a finite mass reservoir. The presence of a core boundary, implemented through a constant volume approximation in our simulation, results in the generation of an inward propagating rarefaction wave. This steepens the gas density profile from r^{-2} (self-similar value) to r^{-3} or steeper. After a protostar forms, the mass accretion rate $\dot{M}$ evolves through three distinct phases: (1) an early phase of decline in $\dot{M}$, which is a non-self-similar effect due to rapid and spatially nonuniform infall in the prestellar phase; (2) for large cores, an intermediate phase of near-constant $\dot{M}$ from the infall of the outer part of the self-similar density profile which has low (subsonic) infall speed in the prestellar phase; (3) a late phase of rapid decline in $\dot{M}$ when accretion occurs from the region affected by the inward propagating rarefaction wave. Our model clouds of small to intermediate size make a direct transition from phase (1) to phase (3) above. Both the first and second phase (if the latter is indeed present) are characterized by a temporally increasing bolometric luminosity $L_{\rm bol}$, while $L_{\rm bol}$ is decreasing in the third (final) phase. We identify the period of temporally increasing $L_{\rm bol}$ with the Class 0 phase, and the later period of terminal accretion and decreasing $L_{\rm bol}$ with the Class I phase. The peak in $L_{\rm bol}$ corresponds to the evolutionary time when $50\% \pm 10\%$ of the cloud mass has been accreted by the protostar. This is in agreement with the classification scheme proposed by André et al. (1993); our model adds a physical context to their interpretation. We show how our results can be used to explain tracks of envelope mass $M_{\rm env}$ versus $L_{\rm bol}$ for protostars in Taurus and Ophiuchus. We also develop an analytic formalism which successfully reproduces the protostellar accretion rate from profiles of density and infall speed in the prestellar phase. It shows that the spatial gradient of infall speed that develops in the prestellar phase is a primary cause of the temporal decline in $\dot{M}$ during the early phase of protostellar accretion.

Accepted by MNRAS

Preprint available at http://www.astro.uwo.ca/∼basu/pub.html

Abstracts of recently accepted major reviews

Star Formation in the Galaxy: An Observational Overview

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The problems of star and planet formation are among the most important challenges facing modern astrophysical research. Stars and their accompanying planetary systems are continuously being formed in the Galaxy enabling direct observation and investigation of the star forming process. However, stars form invisibly deep within cold and dark molecular clouds. Observations of these stellar birth sites at infrared and millimeter wavelengths from space and the ground have resulted in considerable progress toward a physical understanding of stellar origins. In this contribution I will review the empirical basis for our current understanding of the process of star formation with an emphasis on the origin of low mass (sunlike) stars.

To appear in "Origins: From Early Universe to Extrasolar Planets" Proceedings of the 19th Nishinomiya-Yukawa Memorial Symposium, Progress in Theoretical Physics, 2005 in press

http://cfa-www.harvard.edu/∼clada/pubs_html/YUKAWA.html

Abstracts of papers in Nature and Science

Because of embargoes on preprints for Nature and Science, abstracts for these two journals will be accepted for papers that have already been published

Enhanced atmospheric loss on protoplanets at the giant impact phase in the presence of oceans

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The atmospheric compositions of Venus and Earth differ significantly, with the venusian atmosphere containing about 50 times as much ^{36}Ar as the atmosphere of the Earth. The different effects of the solar wind on planet-forming materials for Earth and Venus have been proposed to account for some of this difference in atmospheric composition, but the cause of the compositional difference has not yet been fully resolved. Here we propose that the absence or presence of an ocean at the surface of a protoplanet during the giant impact phase could have determined its subsequent atmospheric amount and composition. Using numerical simulations, we demonstrate that the presence of an ocean significantly enhances the loss of atmosphere during a giant impact owing to two effects: evaporation of the ocean, and lower shock impedance of the ocean compared to the ground. Protoplanets near Earth's orbit are expected to have had oceans, whereas those near Venus' orbit are not, and we therefore suggest that remnants of the noble-gas rich proto-atmosphere survived on Venus, but not on Earth. Our proposed mechanism explains differences in the atmospheric contents of argon, krypton and xenon on Venus and Earth, but most of the neon must have escaped from both planets' atmospheres later to yield the observed ratio of neon to argon.

Published in Nature, vol.433, p. 842, 24 February 2005

A non-terrestrial ^{16}O-rich composition for the protosolar nebula

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The discovery in primitive components of meteorites of large oxygen isotopic variations that could not be attributed to mass-dependent fractionation effects has raised a fundamental question: what is the composition of the protosolar gas from which the host grains formed? This composition is probably preserved in the outer layers of the Sun, but the resolution of astronomical spectroscopic measurements is still too poor to be useful for comparison with planetary material. Here we report a precise determination of the oxygen isotopic composition of the solar wind from particles implanted in the outer hundreds of nanometres of metallic grains in the lunar regolith. These layers of the grains are enriched in ^{16}O by $>20\pm4$ relative to the Earth, Mars and bulk meteorites, which implies the existence in the solar accretion disk of reactions - as yet unknown - that were able to change the $^{17}O/^{16}O$ and $^{18}O/^{16}O$ ratios in a way that was not dependent strictly on the mass of the isotope. Photochemical self-shielding of the CO gas irradiated by ultraviolet light may be one of these key processes, because it depends on the abundance of the isotopes, rather than their masses.

Published by Nature vol. 434, p.619 (31 March 2005)

New Jobs

Post-doctoral position at Meudon Observatory

A post-doctoral position on "*Dynamical models of photodissociation regions*" (ref SDU17) is opened at Meudon Observatory, France, starting from 1st of september. The position is for 2 years.

All indications and a description of the position are to be found on the CNRS web site (french research governmental agency) at:

http://www.k-projects.com/cnrs_postdocs_2005/public/departement_details.php?IdDpt=9
&Dep=SDU&NumOffre=17&Langue=en

Application forms are available at:

http://www.sg.cnrs.fr/drhchercheurs/Post_doc_2005/index.html

The deadline is May 16th. All applications should be sent to Dr. Jacques Le Bourlot (Jacques.Lebourlot@obspm.fr), preferably with a copy to Drs Evelyne Roueff (Evelyne.Roueff@obspm.fr) and Maryvonne Gerin (gerin@lra.ens.fr).

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.

New Books

The Interstellar Medium

James Lequeux, Edith Falgarone, and Charles Ryter

This book provides an in-depth discussion of the interstellar medium, and is likely to be widely used as a textbook in graduate courses on the interstellar medium. The classic book on the interstellar medium by Lyman Spitzer has been extremely influential for many years, but so many new developments have happened in the intervening years that it is now outdated. It is therefore welcome with a new text that examines our current understanding of the interstellar medium. The book emphasizes methods rather than results, thus providing the reader with the main tools to understand the current literature. The following lists the chapters and their sections:

15. Changes of State and Transformations
15.1 Atomic, Molecular and Warm Ionized Gas * 15.2 Hot Gas and the Galactic Fountain * 15.3 Gas-Dust Exchange * 15.4 Evolution of Interstellar Dust

ISBN 3-540-21326-0, 437 pages, published 2005
Hardbound US$89.95

Springer-Verlag New York

http://www.springeronline.com

Early Stages of Star Formation

Edited by Mária Kun

The 12th meeting of the European Astronomical Society was held in Budapest, Hungary between 2003 August 25 and 30. A number of minisymposia were held on particular topics, including one on 'Early Stages of Star Formation'. The proceedings of the meeting were published in a volume of the journal *Baltic Astronomy* (vol. 13-3, p.341-552) in 2004. A special edition was printed of this volume, which is available separately.

The book is divided into 4 sections:

I. Initial Conditions of Star Formation: Theory
II. Initial Conditions of Star Formation: Observations
III. Protostars, disks, Outflows
IV. Brown Dwarfs and Pre-Main Sequence Stars

A total of 39 articles are printed in the book. Of these, the following are the Invited Talks:

Formation of the first massive stars and the reionization history of the Universe *Z. Haiman*
The slow mode of star formation: a critical appraisal *F. Palla*
Dynamical and radiation processes in star and planet formation *J. Bally*
Gravoturbulent fragmentation *R. Klessen and J. Ballesteros-Paredes*
Detailed studies of cloud cores: probing the initial conditions for protostellar collapse *Ph. André, A. Belloche, P. Hennebelle, and D. Ward-Thompson*
The formation and early evolution of very low-mass objects *J. Eislöffel, A. Scholz, and B López Marti*
First MIDI science observations on VLT *O. Chesneau, Ch. Leinert, F. Przygodda et al.*

The price of the book is 25 Euros. Orders should be sent to V. Straizys, Baltic Astronomy Editor, Moletai Observatory, Lithuania (*straizys@itpa.lt*).

Astrophysics of Dust

Edited by A.N. Witt, G.C. Clayton, and B. T. Draine

These are the proceedings of a conference held in Estes Park, Colorado during May 25-30, 2003. The purpose of the conference was to provide a comprehensive assessment of cosmic dust in all astrophysical environments where it plays a major role. Since almost all the authors have gone to the trouble of presenting long and detailed accounts, the resulting book is a very substantial statement on the current status of research into cosmic dust.

The following lists all the chapters in the book:

ISBN 1-58381-159-1, 812 pages, published 2004
Hardbound, price US$77.00 ($69.30 for ASP members)

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Short Announcements

We are pleased to announce the opening of the ESA European Users Support web site for use of Open Time on the Japanese mission ASTRO-F:

http://www.astro-f.vilspa.esa.int/

ASTRO-F is a second-generation infrared sky survey mission, with higher sensitivity and longer wavelength coverage than IRAS. It is a near-earth orbiting satellite dedicated to infrared astronomical observations, equipped with a 68.5 cm cooled telescope and two scientific instruments, namely the Far-Infrared Surveyor (FIS) and the Infrared Camera (IRC). The main goal of the mission is to perform an all-sky survey at far-infrared wavelengths (50-180 micron).

An additional survey at 9 and 20 micron will be carried out simultaneously. ASTRO-F is expected to add significant information on many important astrophysical problems (e.g. evolution of galaxies, formation of stars and planets, brown dwarfs and their relation to dark matter). Catalogues of millions of sources are expected to be generated from the survey.

In addition to the survey observations, ASTRO-F will carry out thousands of pointed observations with both the FIS and IRC. Deep imaging as well as spectroscopic observations will be possible, but subject to severe visibility and duplication constraints.

ESA is committed to provide tracking support and assistance with the survey data reduction, in return for 10non-survey and post-helium parts of the mission, to be made available to European astronomers.

ASTRO-F is planned to be launched from the ISAS/JAXA Uchinoura Space Center on an M-V rocket by January 2006 at the earliest. The launch date is not yet formally determined.

The Announcement of Opportunities for European astronomers will be published on this web site about half a year before launch, in parallel to that issued by ISAS/JAXA for Japanese and Korean observers. It will be preceded by a Call for Letters of Intent, to be issued with more detailed information this spring.

Best regards,

Alberto Salama
ESA ASTRO-F Project Scientist

Ultralow-mass star formation and evolution workshop
June 30- July 1, 2005 La Palma, Canary Islands, Spain

The Instituto de Astrofisica de Canarias (IAC) and the Fundacion Galileo Galilei - INAF (operating the Telescopio Nazionale Galileo (TNG)) are pleased to announce the Scientific Workshop Ultralow-mass star formation and evolution which will be held from June 28th through 1st July 2005 at the Hotel La Palma Princess in the Canary Islands, Spain.

SCIENCE TOPICS:
Very low-mass cores and the core mass function
Initial conditions of brown dwarf and planet formation
Very young brown dwarfs and planets
Spectroscopy of substellar-mass objects
Models of ultralow-mass star formation and evolution
Brown dwarf companions and binary brown dwarfs
A special evening session will be dedicated to celebrating the 10th anniversary
of the discoveries of Gl 229B and Teide 1

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Early registration deadline: 11 May 2005

To keep a "small atmosphere" and to foster interactions among all participants, no more than 60 people will be selected to attend. The early registration fee will be 140 euros, and the late registration fee will be 180 euros. Researchers from developing nations and students can apply for financial assistance. For logistics, registration and additional information please check:

http://www.iac.es/workshop/ulmsf05