THE STAR FORMATION NEWSLETTER

An electronic publication dedicated to early stellar evolution and molecular clouds

No. 96 — 3 October 2000 Editor: Bo Reipurth (reipurth@casa.colorado.edu)

Abstracts of recently accepted papers

Suppression of giant planet formation in stellar clusters

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Photoevaporation driven by the ultraviolet radiation from massive stars severely limits the lifetime of protoplanetary discs around stars formed within stellar clusters. I investigate the resulting influence of clustered environments on the probability of giant planet formation, and show that for clusters as rich, or richer than, Orion, the time available for planet formation is likely to be limited to the length of any delay between low mass and high mass star formation. Under popular models for the formation of massive planets, the fraction of stars with giant planets in rich clusters is expected to be substantially suppressed as compared to less clustered star formation environments.

Accepted by Astronomy & Astrophysics

Preprints available at http://xxx.lanl.gov/abs/astro-ph/0007044

The origin of the HH 7–11 outflow

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New, high-sensitivity interferometric CO J=2–1 observations of the HH 7–11 outflow show that despite previous doubts, this system is powered by the Class I source SVS 13. The molecular outflow from SVS 13 is formed by a shell with a large opening angle at the base, which is typical of outflows from Class I sources, but it also contains an extremely-high-velocity jet composed of "molecular bullets", which is more typical of Class 0 outflows. This suggests that SVS 13 could be a very young Class I, which still keeps some features of the previous evolutionary stage. We briefly discuss the nature of some sources in the SVS 13 vicinity which are emitters of cm-wave continuum, but have no counterpart at mm wavelengths.

Accepted by Astron. & Astrophys.

Preprint available at http://www.oan.es/preprints/hh.ps.gz (173 kb, PS-gzipped). Also obtainable at http://arXiv.org/ as astro-ph/0009439.

The IRAM key-project: Small-scale structure of pre-star forming regions: III. Influence of and correction for the error beam pick-up

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The goal of the IRAM key-project "Small-scale structure of pre-star forming regions" is to map three nearby ($d \sim 150\,pc$), quiescent molecular clouds with a high angular and spectral resolution to study the molecular cloud structure down to the smallest linear scales currently accessible by single dish radio telescopes. Here, we give a detailed discussion of the influence and the correction of the error beam pick-up. A new set of corrected data is presented using the beam pattern parameters of the IRAM 30 m telescope recently published by Greve, Kramer and Wild (1998). For the correction we use observations made at lower angular resolution with the KOSMA 3 m telescope. Smeared to the resolution of the error beam, they provide an estimate of the pick-up therein.

The error beam pick-up accounts for a significant fraction of the observed intensity in the key-project maps: on average 31% to 50% for the ^{12}CO J=2→1 maps, 10% to 35% for the ^{13}CO J=2 →1 maps, and 16.5% in the ^{12}CO J=1→0 map of MCLD 123.5+24.9. In addition, the line profiles are significantly modified by the error beam pick-up.

The large data set available with the IRAM key-project allows us to investigate the accuracy of the correction method and its limitations in detail. For the corrected maps, we determine the overall accuracy of the temperature scale to be better than 15%, except for the ^{13}CO J=2 →1 map of MCLD123.5+24.9 and L1512 where we estimate an accuracy of 22% and 18%. The key-project maps presented here and the released maps published by Falgarone et al. 1998 (with the correction done using the previous beam pattern parameters determined by Garcia-Burillo et al. 1993) differ by no more than 10% and only in localized regions. Both data sets and the supplementary observations made with the KOSMA telescope will be available in electronic form at the CDS via anonymous ftp to cdsarc.u-strasbg.fr (130.79.128.5) or via http://cdsweb.u-strasbg.fr/Abstract.html

The "error beam problem" is not limited to observations obtained with the IRAM 30 m. Similar beam pattern are found for other large single dish (sub-)mm telescopes, although few quantitative studies exist. In particular for observations of spatially extended sources, the error beam contribution has to be considered and corrected for if necessary.

Accepted by Astronomy & Astrophysics

Methods and constraints for the correction of the error beam pick-up in single dish radio observations

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The beam pattern of a single dish radio telescope is given by the main beam and additional components at larger angles, usually called error beam or stray pattern. The latter have relatively small peak amplitudes (typ. below -25 dB), depending on the rms surface error of the primary reflector. However, because of their large angular extent, they are sensitive to extended sources, and a significant fraction of the observed intensity can result from error beam pick-up. For (sub-)mm observations suffering from error beam-pick-up we introduce a new temperature scale for the corrected data, the *corrected main beam brightness temperature* $T_{\rm mb,c}$, which provides a better approximation to the intensity detected by the main beam than the commonly used *antenna temperature* and *main beam brightness temperature*.

We consider two different correction methods. The first method uses complementary observations obtained with a smaller telescope. Smeared to the angular resolution of the error beam pattern they provide an estimate of the error beam pick-up in the observations of the large telescope. For the second method, the error beam pick-up is de-convolved from the observed map in Fourier space. The requirements for both correction methods and their advantages and limitations are discussed in detail. Both correction methods require additional observations, unless the full spatial extent of the emission is observed. We find that the de-convolution method is attractive for the correction of fully sampled maps with an angular extent much larger than the error beam pattern. For smaller maps and more sparsely sampled observations, the subtraction method is favorable, because they additional observations with a small telescope are less time consuming.

Accepted by Astronomy & Astroiphysics, Supplement Series

Occultation of young stellar objects by circumstellar disks I. Theoretical expectations and preliminary comparison with observations

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The hypothesis that partial occultation of young stars by their circumstellar disks is responsible for UX Ori and T Tauri Type III photometric variability is quantitatively studied. We construct accretion disk models in which reprocessing of stellar and accretion luminosity leads to flaring of the disk (assumed to be in vertical hydrostatic equilibrium), and compute the probability to observe the star through the disk atmosphere. The mass accretion rate is found to primarily determine the range of view angles over which the star is fully or partially obscured by the disk. For average disk/star parameters relevant to active T Tauri stars, the probability of observing occultation events is $\sim$0.15, while it is typically 0.2 for parameters relevant to UX Ori. A preliminary analysis of available photometric data confirms these estimates and allows us to uncover in some stars cyclic variability on a time-scale of weeks to years that may tentatively be attributed to disk inhomogeneities or warps. These results suggest that direct observational study of the disk structure may be possible for a sizable fraction of young stellar objects.

Accepted by A&A

High-latitude molecular clouds and near-by OB associations

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The Galactic distribution of the high-latitude molecular clouds is considered. It is suggested that the majority of these clouds are clustered in two large shells around the two closest OB associations, Per OB3/Cas-Tau and Sco OB2. The most prominent shell of high-latitude clouds is centred around the PerOB3/ Cas-Tau association which is also at the centre of the Gould's Belt. However, the Per OB3/Cas-Tau group of high-latitude clouds appears as an elliptical shell at nearly right angles to the plane of the Gould's Belt. Its kinematic age ($\sim$ 10 Myr) is much smaller than the expansion age ($\sim$ 35 Myr) of the ring of intertellar matter associated with the Gould's Belt. It is suggested that while, as is generally understood, the larger expanding ring of gas associated with the Gould's Belt was created by stellar winds and supernova explosions of the more massive OB stars of the Per OB3/Cas-Tau association $\sim$ 35 Myr ago, the Per OB3 shell of high-latitude clouds was formed from the back-falling gas as it was swept up by a more recent supernova explosion of an early B type star in Per OB3 $\sim$ 10 Myr ago. More distant OB associations also produce similar shells of clouds at large heights from the Galactic plane having relatively smaller angular sizes due to their greater distances. These can be seen as higher latitude extensions of cloud complexes at lower Galactic latitudes as, for example, in the case of Vela OB2.

Accepted by Astronomy and Astrophysics

Preprints available at astro-ph/0009486

Polarization measurements of Vega-like stars

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Optical linear polarization measurements are presented for about 30 Vega-like stars. These are then compared with the polarization observed for normal field stars. A significant fraction of the Vega-like stars are found to show polarization much in excess of that expected to be due to interstellar matter along the line of sight to the star. The excess polarization must be intrinsic to the star, caused by circumstellar scattering material that is distributed in a flattened disk. A correlation between infrared excess and optical polarization is found for the Vega-like stars.

Accepted by Astronomy and Astrophysics

Preprints available at astro-ph/0009483

VLT-detection of two edge-on Circumstellar Disks in the ρ Oph dark cloud

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Observations of the ρ Ophiuchi star forming region with VLT ANTU and ISAAC under $0.35''$ seeing conditions reveal two bipolar reflection nebulosities intersected by central dust lanes. The sources (OphE-MM3 and CRBR 2422.8−3423) can be identified as spatially resolved circumstellar disks viewed close to edge-on, similar to edge-on disk sources discovered previously in the Taurus and Orion star forming regions. Millimeter continuum fluxes yield disk masses of the order of $0.01\,M_\odot$, i.e. about the mass deemed necessary for the minimum solar nebula. Follow-up spectroscopic observations with SUBARU and CISCO show that both disk sources exhibit featureless continua in the K-band. No accretion or outflow signatures were detected. The slightly less edge-on orientation of the disk around CRBR 2422.8−3423 compared to HH 30 leads to a dramatic difference in the flux seen in the ISOCAM $4.5\,\mu$m to $12\,\mu$m bands. The observations confirm theoretical predictions on the effect of disk geometry and inclination angle on the spectral energy distribution of young stellar objects with circumstellar disks.

Accepted by A&A Letters (Dec. 2000)

Online version available at http://arXiv.org/abs/astro-ph/0009141

2MASS Observations of the Perseus, Orion A, Orion B, and Monoceros R2 Molecular Clouds

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We use the 2MASS Second Incremental Release Point Source Catalog to investigate the spatial distribution of young stars in the Perseus, Orion A, Orion B, and MonR2 molecular clouds. After subtracting a semi-empirical model of the field star contamination from the observed star counts, stellar surface density maps are used to identify compact clusters and any stellar population found more uniformly distributed over the molecular cloud. Each cloud contains between 2 to 7 clusters, with at least half of the cluster population found in a single, rich cluster. In addition, a distributed stellar population is inferred in the Orion A and MonR2 molecular clouds within the uncertainties of the field star subtraction with a surface density between 0.013 - 0.083 arcmin^{-2}. Sensitivity calculations suggest, however, that the number of stars in the distributed population may be underestimated by a factor of 2 or more if stars have been forming with a Miller-Scalo IMF at a constant star formation rate for longer than 10 Myr. After considering the possible evolutionary status of the distributed population, the global star formation efficiency implied by the sum of the distributed and cluster populations ranges between 1-9% among the four clouds. The fraction of the total stellar population contained in clusters for the nominal extinction model ranges from $\approx$ 50-100% if the distributed population is relatively young ($<$ 10 Myr), to $\approx$ 25%-70% if it is relatively old ($\approx$ 100 Myr). The relatively high fraction of stars contained in clusters regardless of the age of the distributed population, in conjunction with the young ages generally inferred for embedded clusters in nearby molecular clouds, indicates that a substantial fraction of the total stellar population in these regions has formed within the past few million years in dense clusters. This suggests that either the star formation rate in each these clouds has recently peaked if one assumes clouds have ages $>$ 10 Myr, or molecular clouds are younger than typically thought if one assumes that the star formation rate has been approximately constant in time.

Accepted by AJ

Preprints available at http://astro.caltech.edu/~jmc/papers/2mass_clouds

Search for glycine in the solar type protostar IRAS16293-2224

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We report the first search for line emission from one of the simplest amino acids, glycine, from a solar type protostar, IRAS16293-2422. Previous searches for glycine have been carried out on bright massive star formation regions, so far without success. Recent observations show that although less luminous, solar type protostars also harbor complex molecules and may even be more favorable than massive protostars for the formation and survival of complex molecules. We did not detect any emission associated with glycine from IRAS16293-2422. Based on these observations, we claim that the glycine column density is less than $\sim 5 \times 10^{12}$ cm^{-2}. Using information we have on the structure of the envelope surrounding IRAS16293-2422, we derive an upper limit to the glycine abundance of $\sim 1 \times 10^{-10}$ in the cold outer envelope and $\sim 7 \times 10^{-9}$ in the hot core, respectively. These observations challenge recent theoretical estimates of glycine abundance in solar type protostars.

Accepted by Astronomy & Astrophysics

Preprints available on http://www-laog.obs.ujf-grenoble.fr/ ceccarel/

On the Timescale for the Formation of Protostellar Cores in Magnetic Interstellar Clouds

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We revisit the problem of the formation of dense protostellar cores due to ambipolar diffusion within magnetically supported molecular clouds, and derive an analytical expression for the core formation timescale. The resulting expression is similar to the canonical expression $\simeq \tau_{ff}^2/\tau_{ni} \sim 10\tau_{ff}$ (where τ_{ff} is the free-fall time and τ_{ni} is the neutral-ion collision time), except that it is multiplied by a numerical factor $\mathcal{C}(\mu_{c0})$, where μ_{c0} is the initial central mass-to-flux ratio normalized to the critical value for gravitational collapse. $\mathcal{C}(\mu_{c0})$ is typically ~ 1 in highly subcritical clouds ($\mu_{c0} \ll 1$), although certain conditions allow $\mathcal{C}(\mu_{c0}) \gg 1$. For clouds that are not highly subcritical, $\mathcal{C}(\mu_{c0})$ can be much less than unity, with $\mathcal{C}(\mu_{c0}) \to 0$ for $\mu_{c0} \to 1$, significantly reducing the time required to form a supercritical core. This, along with recent observations of clouds with mass-to-flux ratios close to the critical value, may reconcile the results of ambipolar diffusion models with statistical analyses of cores and YSO's which suggest an evolutionary timescale ~ 1 Myr for objects of mean density $\sim 10^4$ cm^{-3}. We compare our analytical relation to the results of numerical simulations, and also discuss the effects of dust grains on the core formation timescale.

Accepted by The Astrophysical Journal
http://xxx.lanl.gov/abs/astro-ph/0009262

RXJ 0529.4+0041: a low–mass pre–main sequence eclipsing–spectroscopic binary

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We report the discovery of a low–mass pre-main sequence eclipsing system among a sample of double-lined spectroscopic binaries found recently on the basis of ROSAT follow-up observations in the Orion star forming region.

From the analysis of the available photometric and spectroscopic data, we derive orbital elements as well as fundamental stellar parameters for the individual components of the eclipsing PMS binary RXJ 0529.4+0041. These results provide a new observational test for theoretical PMS evolutionary models setting some useful constraints on currently available PMS tracks and isochrones.

Accepted by Astronomy and Astrophysics (letter to the Editor)

WSRT and VLA Observations of the 6 cm and 2 cm lines of H_2CO in the direction of W 58 C1(ON 3) and W 58 C2

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Absorption in the $J_{K_-,K_+} = 2_{11} - 2_{12}$ transition of formaldehyde at 2 cm towards the ultracompact HII regions C1 and C2 of W 58 has been observed with the Very Large Array with an angular resolution of $\sim 0.2''$ and a velocity resolution of $\sim$1 km s^{-1}. The high resolution continuum image of C1 (also known as ON 3) shows a partial shell which opens to the NE. Strong H_2CO absorption is observed against W 58 C1. The highest optical depth ($\tau > 2$) occurs in the SW portion of C1 near the edge of the shell, close to the continuum peak. The absorption is weaker towards the nearby, more diffuse compact HII region C2, $\tau \leq 0.3$. The H_2CO velocity (-21.2 km s^{-1}) towards C1 is constant and agrees with the velocity of CO emission, mainline OH masers, and the H76α recombination line, but differs from the velocity of the 1720 MHz OH maser emission (~ -13 km s^{-1}).

Observations of the absorption in the $J_{K_-,K_+} = 1_{10} - 1_{11}$ transition of formaldehyde at 6 cm towards W 58 C1 and C2 carried out earlier with the Westerbork Aperture Synthesis Telescope at lower resolution ($\sim 4''$x$7''$) show comparable optical depths and velocities to those observed at 2 cm. Based on the mean optical depth profiles at 6 cm and 2 cm, the volume density of molecular hydrogen n(H_2) and the formaldehyde column density N(H_2CO) were determined. The n(H_2) is $\sim$6x10^4 cm^{-3} towards C1. N(H_2CO) for C1 is $\sim$8x10^{14} cm^{-2} while that towards C2 is $\sim$8x10^{13} cm^{-2}.

Accepted by Astron. J. (Jan 2001)

Preprint on LANL preprint server as astro-ph/0009359 [http://xxx.lanl.gov/abs/astro-ph]
Data are available on the web at http://adil.ncsa.uiuc.edu/document/00.HD.01

A Subarcsecond Binary Radio Source Associated with the X-ray Emitting YSO YLW 15

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YLW 15 is a remarkable object since it exhibits phenomena such as strong millimeter emission and association with a bipolar outflow that characterize extremely young stars (Class 0 or I objects), while at the same time presenting strong, time-variable X-ray emission that is ubiquitous and detected characteristically in more evolved objects. Our VLA observations reveal that YLW 15 is a subarcsecond ($0\farcs6$) radio binary, with one of the components spatially extended and the other unresolved. We discuss the possibility that the components of the binary system may have different characteristics also at other wavelengths, possibly as a result of different evolutionary status, and discuss future observations that may test this hypothesis.

Accepted by The Astrophysical Journal Letters

http://www.astro.uiuc.edu/∼jgirart/curro.html

New constraints on protostellar jets collimation from high density gas UV tracers

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The analysis of high resolution profiles of the semiforbidden UV lines of C III]$_{1908}$ and Si III]$_{1892}$ in the T Tauri stars (TTSs) spectra shows that: **1.** There is C III]$_{1908}$ and Si III]$_{1892}$ emission at velocities which are similar to those observed in the optical forbidden lines formed in the TTSs jets. The luminosity of the UV lines is comparable to that of the optical lines. **2.** The comparison between the optical and UV light curves indicates that the C III]$_{1908}$ and Si III]$_{1892}$ emission of RY Tau is not associated with accretion shocks but it is produced farther than $2R_*$ from the star. **3.** The profiles of the UV semiforbidden lines are significantly broader than those of the optical forbidden lines. These profiles cannot be produced in a narrow collimated beam and they are most likely produced in a bow-shaped shock wave formed at the base of the optical jet where the hot gas emits in a broad range of projected radial velocities. **4.** The atmosphere of RU Lup contributes significantly to the Si III]$_{1892}$ emission. **5.** A puzzling narrow feature is observed close to the C III]$_{1908}$ line. The feature is blueshifted by -260 km s^{-1} which corresponds to the wind terminal velocity measured in the P-Cygni profile of the Mg II (UV1) lines.

Moreover, constrains are derived on the characteristics of the C III]$_{1908}$ and Si III]$_{1892}$ emitting region in RY Tau. It is shown that $4.7 \leq \log T_e \leq 5.0$ and $10^9 \mathrm{cm}^{-3} \leq N_e \leq 10^{11} \mathrm{cm}^{-3}$ provided that the emission is produced in a collisional plasma and that the 1665 Å feature observed in low dispersion IUE spectra is confirmed to be O III]$_{1665}$ emission produced in the wind. These very high densities are difficult to generate in the shocks produced by the magnetic pinching of centrifugally driven magnetized disk winds. The data also suggests that the shocked layer has a radius of some few stellar radii and it is closer than $\sim 38R_*$ to the star.

Accepted by Astrophysical J.

Gravitational Collapse in Turbulent Molecular Clouds. II. Magnetohydrodynamical Turbulence

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Hydrodynamic supersonic turbulence can only prevent local gravitational collapse if the turbulence is driven on scales smaller than the local Jeans lengths in the densest regions, a very severe requirement (Klessen et al. 2000). Magnetic fields have been suggested to support molecular clouds either magnetostatically or via magnetohydrodynamic (MHD) waves. Whereas the first mechanism would form sheet-like clouds, the second mechanism not only could exert a

pressure onto the gas counteracting the gravitational forces, but could lead to a transfer of turbulent kinetic energy down to smaller spatial scales via MHD wave interactions. This turbulent magnetic cascade might provide sufficient energy at small scales to halt local collapse.

We test this hypothesis with MHD simulations at resolutions up to 256^3 zones, done with ZEUS-3D. We first derive a resolution criterion for self-gravitating, magnetized gas: in order to prevent collapse of magnetostatically supported regions due to numerical diffusion, the minimum Jeans length must be resolved by four zones. Resolution of MHD waves increases this requirement to roughly six zones. We then find that magnetic fields cannot prevent local collapse unless they provide magnetostatic support. Weaker magnetic fields do somewhat delay collapse and cause it to occur more uniformly across the supported region in comparison to the hydrodynamical case. However, they still cannot prevent local collapse for much longer than a global free-fall time.

Accepted by Astrophys. Journal, (Jan 2001)

preprints available under astro-ph/0009227

SiO Emission in the Multi-Lobe Outflow Associated with IRAS 16293−2422

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We have mapped the thermal emission line of SiO ($v = 0$; $J = 2$–1) associated with the quadrupolar molecular outflow driven by the very cold far-infrared source IRAS 16293−2422. The SiO emission is significantly enhanced in the northeastern red lobe and at the position $\sim 50''$ east of the IRAS source. Strong SiO emission observed at $\sim 50''$ east of the IRAS source presents evidence for a dynamical interaction between a part of the eastern blue lobe and the dense ambient gas condensation, however, such an interaction is unlikely to be responsible for producing the quadrupolar morphology. The SiO emission in the northeastern red lobe shows the spatial and velocity structure similar to those of the CO outflow, suggesting that the SiO emission comes from the molecular outflow in the northeastern red lobe itself. The observed velocity structure is reproduced by a simple spatio-kinematic model of bow shock with a shock velocity of 19–24 km s^{-1} inclined by 30–45° from the plane of the sky. This implies that the northeastern red lobe is independent of the eastern blue lobe and that the quadrupolar structure is due to two separate bipolar outflows.

The SiO emission observed in the western red lobe has a broad pedestal shape with low intensity. Unlike the SiO emission in the northeastern red lobe, the spatial extent of the SiO emission in the western red lobe is restricted to its central region. The spatial and velocity structures and the line profiles suggest that three different types of the SiO emission are observed in this outflow; the SiO emission arises from the interface between the outflowing gas and the dense ambient gas clump, the SiO emission coming from the outflow lobe itself, and the broad SiO emission with low intensity observed at the central region of the outflow lobe.

Accepted by Ap. J.

http://xxx.laml.gov/abs/astro-ph/0010013

The alignment of the magnetic field and collimated outflows in star forming regions - the case of NGC 2071

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The magnetic field is believed to play a crucial role in the process of star formation. From the support it provides during the initial collapse of molecular clouds to the creation of strong collimated jets responsible for large mass losses, current theories predict its importance in many different stages during the formation of stars. Here we report on observational evidence which tests one aspect that can be inferred from these theories: the alignment between the local magnetic field and collimated bipolar outflows in such environments. There is good evidence of an alignment in the case of NGC 2071.

Accepted by The Astrophysical Journal 2001, Feb. 1 issue, 547

Preprints available at http://www.submm.caltech.edu/papers/

Infall models of Class 0 protostars

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We have carried out radiative transfer calculations of infalling, dusty envelopes surrounding embedded protostars to understand the observed properties of the recently identified "Class 0" sources. To match the far-infrared peaks in the spectral energy distributions of objects such as the prototype Class 0 source VLA 1623, pure collapse models require mass infall rates $\sim 10^{-4} M_{\odot} \mathrm{yr}^{-1}$. The radial intensity distributions predicted by such infall models are inconsistent with observations of VLA 1623 at sub-mm wavelengths, in agreement with the results of André et al. (1993) who found a density profile of $\rho \propto r^{-1/2}$ rather than the expected $\rho \propto r^{-3/2}$ gradient. To resolve this conflict, while still invoking infall to produce the outflow source at the center of VLA 1623, we suggest that the observed sub-mm intensity distribution is the sum of two components: an inner infall zone, plus an outer, more nearly constant-density region. This explanation of the observations requires that roughly half the total mass observed within 2000 AU radius of the source lies in a region external to the infall zone. The column densities for this external region are comparable to those found in the larger Oph A cloud within which VLA 1623 is embedded. This decomposition into infall and external regions is not unique, owing to uncertainty in the structure of the molecular gas outside of the infall zone, which in turn implies some uncertainty in estimating the infall rate. Nevertheless, the environment of Oph A is so dense that any protostellar clouds which fragment out are likely to collapse at very high infall rates, consistent with our spectral energy distribution modeling. The extreme environments of Class 0 sources lead us to suggest an alternative or additional interpretation of these objects: rather than simply concluding with André et al. that Class 0 objects only represent the earliest phases of protostellar collapse, and ultimately evolve into older "Class I" protostars, we suggest that many Class 0 sources could be the protostars of very dense regions, and Class I objects found in lower-density regions may be in comparable evolutionary states.

Accepted by Astrophysical Journal

Available on the WWW at http://arXiv.org/abs/astro-ph/0010051

Gravitational Stirring in Planetary Debris Disks

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We describe gravitational stirring models of planetary debris disks using a new multi-annulus planetesimal evolution code. The current code includes gravitational stirring and dynamical friction; future studies will include coagulation, fragmentation, Poynting-Robertson drag, and other physical processes. We use the results of our calculations to investigate the physical conditions required for small bodies in a planetesimal disk to reach the shattering velocity and begin a collisional cascade. Our results demonstrate that disks composed primarily of bodies with a single size will not undergo a collisional cascade which produces small dust grains at 30–150 AU on timescales of 1 Gyr or smaller. Disks with a size distribution of bodies reach conditions necessary for a collisional cascade in 10 Myr to 1 Gyr if the

disk is at least as massive as a minimum mass solar nebula and if the disk contains objects with radii of 500 km or larger. The estimated $\sim$ 500 Myr survival time for these disks is close to the median age of $\sim$ 400 Myr derived for nearby stars with dusty disks.

To appear in the Astronomical Journal (January 2001)

Preprint available at http://xxx.lanl.gov/abs/astro-ph/0009185

On the variation of the Initial Mass Function

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A universal initial mass function (IMF) is not intuitive, but so far no convincing evidence for a variable IMF exists. The detection of *systematic variations* of the IMF with star-forming conditions would be the *Rosetta Stone* for star formation.

In this contribution an average or Galactic-field IMF is defined, stressing that there is evidence for a change in the power-law index at only two masses: near $0.5\,M_\odot$ and $0.08\,M_\odot$. Using this supposed universal IMF, the uncertainty inherent to any observational estimate of the IMF is investigated, by studying the scatter introduced by Poisson noise and the dynamical evolution of star clusters. It is found that this apparent scatter reproduces quite well the observed scatter in power-law index determinations, thus defining the *fundamental limit* within which any true variation becomes undetectable. The absence of evidence for a variable IMF means that any true variation of the IMF in well studied populations must be smaller than this scatter.

Determinations of the power-law indices α are subject to systematic errors arising mostly from unresolved binaries. The systematic bias is quantified here, with the result that the single-star IMFs for young star-clusters are systematically steeper by $\Delta\alpha \approx 0.5$ between 0.1 and $1\,M_\odot$ than the Galactic-field IMF, which is populated by, on average, about 5 Gyr old stars. The MFs in globular clusters appear to be, on average, systematically flatter than the Galactic-field IMF (Piotto & Zoccali 1999; Paresce & De Marchi 2000), and the recent detection of ancient white-dwarf candidates in the Galactic halo and absence of associated low-mass stars (Méndez & Minniti 2000; Ibata et al. 2000) suggests a radically different IMF for this ancient population. Star-formation in higher-metallicity environments thus appears to produce relatively more low-mass stars. While still tentative, this is an interesting trend, being consistent with a systematic variation of the IMF as expected from theoretical arguments.

Accepted by MNRAS

astro-ph/0009005
http://www.ita.uni-heidelberg.de/publications/preprints/2000/index.html

Sputtering of grains in C-type shocks

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Sputtering yields are reported for the release of Mg, Fe, Si and O under impact of He, C, O, Si and Fe on grain material composed of Mg- and Fe-bearing silicates. The yields were derived using the TRIM code, which simulates the results of the transport of ions in matter by means of classical Monte Carlo techniques. The energetics of the sputtering process are a key factor in the sputtering calculations, and so detailed determinations have been made of the energy with which atoms are bound to the lattice, using solid state simulation programs. The probability of ejection of an atom is computed at a given energy, for a number of angles of incidence, and integrated to obtain the mean yield at that energy. These numerical results are then fitted with a simple function of energy for convenience in subsequent

applications.

A grid of C-type shock models has been computed, using our new sputtering yields, for preshock densities in the range $10^4 \leq n_H = n(\mathrm{H}) + 2n(\mathrm{H_2}) \leq 10^6$ cm^{-3} and shock speeds $20 \leq v_s \leq 45$ km s^{-1}. Sputtered fractions can be high, exceeding 50% for shock speeds in excess of approximately 40 km s^{-1}. The column densities of Si and SiO were also computed, for comparison with observations.

Accepted by MNRAS

preprints available at http://ccp7.dur.ac.uk/

Scanning Fabry-Pérot observations of the HH 7 – 11 outflow system

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Results of Fabry-Pérot scanning interferometry of the HH 7 – 11 complex of Herbig-Haro objects are presented. Line profiles and velocity fields are derived. In HH 7 and HH 11 morphological changes in various velocities are discovered, which are interpreted as spatially separated bow shocks and Mach disks. Several arcuate-shaped features, oriented in the direction of the outflow, are pointed out. To explain the nature of the difference in the physical parameters of HH 11 and other knots a suggestion is made about the probable intersection of the two outflows.

Accepted by Astronomy and Astrophysics.

Search for young stars among ROSAT All-Sky Survey X-ray sources in and around the R CrA dark cloud

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We present the ROSAT All-Sky Survey data in a 126 deg^2 area in and around the CrA star forming region. With low-resolution spectroscopy of unidentified ROSAT sources we could find 19 new pre-main sequence stars, two of which are classical T Tauri stars, the others being weak-lined. The spectral types of these new T Tauri stars range from F7 to M6. The two new classical T Tauri stars are located towards two small cloud-lets outside of the main CrA cloud. They appear to be $\sim$ 10 Myrs old, by comparing their location in the H-R diagram with isochrones for an assumed distance of 130 pc, the distance of the main CrA dark cloud. The new off-cloud weak-line T Tauri stars may have formed in similar cloud-lets, which have dispersed recently. High-resolution spectra of our new T Tauri stars show that they have significantly more lithium absorption than zero-age main-sequence stars of the same spectral type, so that they are indeed young. ¿From those spectra we also obtained rotational and radial velocities. For some stars we found the proper motion in published catalogs. The direction and velocity of the 3D space motion – south relative to the galatic plane – of the CrA T Tauri stars is consistent with the dark cloud being formed originally by a high-velocity cloud impact onto the galactic plane, which triggered the star formation in CrA. We also present VRIJHK photometry for most of the new T Tauri stars to derive their luminosities, ages, and masses.

Accepted by Astron. Astrophysics Suppl. Series

preprint at http://xxx.lanl.gov/abs/astro-ph/0008095

Magnetospheric Accretion and Winds on the T Tauri Star SU Aurigae: Multi-Spectral Line Variability and Cross-Correlation Analysis.

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SU Aurigae is a T Tauri star that was well monitored during the MUSICOS 96 multi-site campaign. We present the results of the spectroscopic analysis of the circumstellar environment of this star, particularly of the Hα, Hβ, Na I D and He I D3 line profiles. The signatures of modulated outflows and mass accretion events are analysed, as well as transient spectral features. We compute the cross-correlation function (CCF) of several pairs of (velocity bins in) spectral lines to better investigate the profiles' temporal variability. We found increasing time lags between the variability of He I D3, Na I D and Hβ. We propose this may be understood in terms of azimuthal distortion of the magnetic field lines due to the different rotation rates of the star and the disk. We find the slightly blueshifted absorption features in Hα, Hβ and Na I D to be anti-correlated with the accretion flow signatures. We propose that the transient absorption features in the blue wings of Hα, Hβ and Na I D (signatures of mass outflows), and flare brightenings are related to the disruption of distorted magnetospheric field lines.

Accepted by Astronomy & Astrophysics Main Journal

Stellar Contents of the Galactic Giant H II Region NGC 3603

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We present CCD $UBVRI$ and Hα photometry for the starburst cluster associated with the galactic giant H II region NGC 3603. The mean reddening of the cluster members comes out to be $< E(B-V) >= 1.48 \pm 0.21$ (s.d.). The surface distribution of the reddening shows a radial variation with a minimum near to the cluster center and two local maxima at radii $\sim 30''$ and $\sim 70''$. Our photometric data indicate an anomalous reddening law for the dust inside the cluster region, and the ratio of the total to the selective extinction, R, is found to be ~ 4.3. A comparison of the observational and intrinsic colour-magnitude digrams (CMDs) yields a mean distance modulus of $(m - M)_0 = 14.0$, which corresponds to a distance of 6.3 ± 0.6 kpc. This distance is smaller than those obtained in earlier works (e.g., 7.2 kpc, Melnick et al. 1989, A&A 213, 89) but is in good agreement with the kinematic distance (6.1 ± 0.6 kpc) recently reported by De Pree et al. (1999, AJ 117, 2902). The cluster shows a large age spread, containing stars as old as up to several Myr. However, the mean age of the cluster is found to be ≤ 1 Myr. We estimate a minimum star formation efficiency of $\sim 25\%$ and a gas removal time of $\tau \sim 4.6$ Myr.

Accepted by Pub. Astron. Soc. Japan (Vol. 52, no. 5)

Hα spectropolarimetry of the Herbig Ae star AB Aurigae

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We present spectropolarimetric observations, obtained at Hα, of the Herbig Ae star AB Aurigae. Changes in linear

polarization across the Hα line probe structure in the immediate circumstellar environment of the central star, down to scales of the order one to a few stellar radii. In the case of AB Aurigae the observed polarimetric signature is complex. After applying a correction for foreground continuum polarization, we find there is a linear-polarized Hα emission component intrinsic to the source. Rotation of the angle of polarization through the emission line profile suggests scattering in a rotating circumstellar disk. The magnetic accretor model commonly applied to T Tau stars shows promise of explaining these data.

Accepted by MNRAS

Disintegrating Multiple Systems in Early Stellar Evolution

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An analysis of the multiplicity of 14 sources driving giant Herbig-Haro flows has revealed an observed binary frequency between 79% and 86%, of which half are higher-order multiples. These sources represent the hitherto youngest sample of stars examined for binarity. I postulate that the dynamical decay of triple or multiple systems leads to strong outflow activity. It is well known that a large fraction of non-hierarchical triple systems rapidly break up and eject the lightest member. At the same time a closer binary in a highly eccentric orbit is formed. Massive disk truncation results, accompanied by large-scale accretion, with a consequent burst of outflow activity, which produces the observed giant HH bow shocks. Some of the material culled from the individual circum*stellar* disks may settle into a circum*binary* disk around the newly bound stellar pair. The small remaining and truncated circumstellar disks are fed from the circumbinary disk through gas streams, and this as well as other dynamical effects cause the binary orbit to shrink. Gas streams together with disk interactions at periastron drive cyclic accretion modulated on an orbital time scale. As the stellar components gradually spiral towards each other, the increasingly frequent mass loss events form chains of HH objects until eventually the binary has a semi-major axis of only 9-12 AU, at which point the closely spaced shocked ejecta appear as a finely collimated jet. Thus, such HH flows can be read as a fossil record of the evolution of orbital motions of a binary, newly formed in a triple disintegration event, as it shrinks from a typical separation of 100 AU or more to 10 AU or less. When the triple system disintegrates and a single star is ejected, the newly formed binary recoils, and as a result both components (star and close binary) leave their nascent envelope. While one component becomes visible as a T Tauri star, the other will be obscured for a while by the envelope and will appear as a bright near-infrared object. For typical parameters, this geometry persists for only 5000 yr or so. If the ejected star does not escape, cyclic motion of a hierarchical triple begins. This explains the socalled IRC binaries which are infrequently found in star forming regions. The standard model of early stellar evolution states that young stars gradually and smoothly make the transitions from Class 0 through Class I and II objects to eventually become Class III objects. In contrast, stars born in multiple systems can abruptly transit from a Class 0 or I object to a visible T Tauri star. The main accretion phase may be terminated by the stochastic process of triple decay. Depending on the moment of triple disintegration, the ejected objects can range from stellar embryos, which will emerge as very low mass stars or even brown dwarfs, to essentially fully built up stars. In this picture, the initial mass function towards its low mass end has an important stochastic component which can only be described by the half-life of the decay processes. Because the ejected stars can take only limited circumstellar material with them, they will soon lose their classical T Tauri characteristics and join the halo of weak-line T Tauri stars which surround star forming clouds. Differences in ejection may explain why two apparently similar T Tauri stars of about the same age can have major differences in the size of their circumstellar disks.

Accepted by Astron. J.

Preprints at http://casa.colorado.edu/reipurth/preprints.htm

CO Observations Toward Supernova Remnants with Associated OH 1720 MHz Masers

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The environs of three supernova remnants (SNR) with associated OH 1720 MHz masers, G349.7+0.2, CTB 37A and G16.7+0.1, have been surveyed in the CO J=1-0 transition with the 12 Meter Telescope of the NRAO, using the On-The-Fly technique. These observations have revealed a number of molecular clouds interacting with the SNR shock fronts. Most of the OH 1720 MHz masers have been found to lie over CO concentrations, and the maser velocities are coincident with the CO peak velocities to an accuracy better than 2 km/s. The present data trace the interstellar medium (ISM) structures interacting with the SNRs; however, to probe the shocked molecular gas in which the OH 1720 MHz emission originates, higher excitation transitions and more complex species should be observed. In CTB 37A, where the shock velocity into the molecular cloud could be determined, it has been found to be of C-type, in agreement with theoretical predictions. Part of the rim of G16.7+0.1 appears to be flattened by a dense external cloud, yet the only associated OH 1720 MHz maser lies near the opposite region of the remnant. This behavior, also observed in IC 443 and 3C 391, seems to contradict the suggestion that OH 1720 MHz maser emission occurs mainly for transverse shocks.

Accepted by Ap. J.

http://www.iafe.uba.ar/astronomia/iSNRs.html

A Molecular Shell with Star Formation Toward the Supernova Remnant G349.7+0.2

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A field of $\sim 38' \times 38'$ around the supernova remnant (SNR) G349.7+0.2 has been surveyed in the CO J=1–0 transition with the 12 Meter Telescope of the NRAO, using the On-The-Fly technique. The resolution of the observations is $54''$. We have found that this remnant is interacting with a small CO cloud which, in turn, is part of a much larger molecular complex, which we call the "Large CO Shell". The Large CO Shell has a diameter of about 100 pc, an H_2 mass of 9.3×10^5 $M_\odot$ and a density of 35 cm^{-3} . We investigate the origin of this structure and suggest that an old supernova explosion ocurred about 4×10^6 years ago, as a suitable hypothesis. Analyzing the interaction between G349.7+0.2 and the Large CO Shell, it is possible to determine that the shock front currently driven into the molecular gas is a non-dissociative shock (C-type), in agreement with the presence of OH 1720 MHz masers. The positional and kinematical coincidence among one of the CO clouds that constitute the Large CO Shell, an IRAS point-like source and an ultracompact H II region, indicate the presence of a recently formed star. We suggest that the formation of this star was triggered during the expansion of the Large CO Shell, and suggest the possibility that the same expansion also created the progenitor star of G349.7+0.2. The Large CO Shell would then be one of the few observational examples of supernova-induced star formation.

Accepted by A. J.

http://www.iafe.uba.ar/astronomia/iSNRs.html

Diffraction-limited bispectrum speckle interferometry and speckle polarimetry of the young bipolar outflow source S140 IRS1

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We present bispectrum speckle interferometry and speckle polarimetry of the deeply embedded infrared bipolar outflow source S140 IRS1, a massive protostellar object in the L1204 molecular cloud. Using the SAO 6 m telescope, we obtained 280 mas resolution polarization maps of S140 IRS1 as well as a K-band image with diffraction-limited resolution λ/D of 76 mas, which is the highest angular resolution image of a young outflow source ever obtained in the infrared. Our data suggest that the central source is marginally resolved with a FWHM diameter of approximately 20

mas ($\sim$ 20 AU). The most remarkable feature in our image is a bright extended and very clumpy structure pointing away from the central source in exactly the same direction as the blue-shifted CO outflow lobe. A centro-symmetric pattern of high polarization in this feature suggests that we see scattered light from the central source. We interprete this feature as the clumpy inner surface of a partially evacuated cavity in the circumstellar envelope around IRS1, which has been excavated by the strong outflow from IRS1.

Accepted by Astron. & Astrophys.

`http://www.mpifr-bonn.mpg.de/div/speckle/publications.html` or
`http://www.mpifr-bonn.mpg.de/staff/tpreibis/publications.html`

Hard X-Ray Emission from Massive Star Clusters in a Giant Molecular Cloud NGC 6334

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We report on detection with the ASCA satellite of hard X-rays from far infrared (FIR) star clusters in the giant molecular cloud (GMC) cores of the NGC 6334 star-forming region. Five FIR cores are visible in the hard X-ray band ($E > 2$ keV), while in the Soft X-ray band ($E < 2$ keV) the emission is absorbed, except for one core. The observed spectra can be fitted with thermal emission from a hot plasma, whose temperature of ~ 9 keV is significantly higher than those reported of low-mass Class I pre–main-sequence stars (PMSs) (~ 3 keV) in nearby dark clouds and those of OB-type main-sequence stars (~ 1 keV). The X-ray luminosity of each core is typically 10^{33} erg s^{-1} or 10^3 times that of typical low-mass PMSs. The observed hard X-rays may be emitted from young massive stars and loss-mass/intermediate-mass PMSs in the FIR cores. The observed hard X-ray flux can ionize the inner part ($r \sim 0.3$ pc) of the GMC cores at a rate comparable to that by cosmic-ray particles. If the $L_{\rm X}/M$ ratio of $\sim 10^{-5}$ $L_\odot/M_\odot$ observed in NGC 6334 is typical among GMCs, the X-ray flux from all GMCs in the Galaxy ($\sim 10^9 M_\odot$) can account for about 20% of the diffuse galactic ridge hard X-ray emission.

Accepted by PASJ

http://www.nro.nao.ac.jp/ sekimoto/preprints/ngc6334.pdf

A Comparison of the Spatial Distribution among the $H^{13}CO^+$, CH_3OH and $C^{34}S$ Emission and its Implication in Heiles Cloud 2

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We have mapped the Heiles Cloud 2 region in the Taurus molecular cloud complex with $H^{13}CO^+$ (J=1–0), CH_3OH (J_K=2_0–1_0 A$^+$), and $C^{34}S$ (J=2–1) lines. Dense gas traced by the mapped lines with critical densities higher than 10^4 cm^{-3} is concentrated in four condensations, that is, the TMC-1 and TMC-1C filaments, L1527, and TMC-1A. We have found that the three emission lines have remarkably different spatial distributions. The $H^{13}CO^+$ emission traces well dense cores harboring protostars, while the CH_3OH emission is weak toward the protostars, and is rather enhanced toward cores without protostars. We found that there are two starless cores with enhanced CH_3OH emission at the north-western ends of the TMC-1 and TMC-1C filaments, toward which the $H^{13}CO^+$ emission is barely seen. On the basis of the analyses using the Large Velocity Gradient (LVG) model, we show that the CH_3OH abundance

relative to $H^{13}CO^+$ is enhanced by up to one order of magnitude in the cores without protostars. The $C^{34}S$ abundance relative to $H^{13}CO^+$ also shows a similar trend to that of CH_3OH. Such an abundance variation between $H^{13}CO^+$ and CH_3OH, $C^{34}S$, can be explained in the scheme of time-dependent gas-phase chemical evolution, which predicts that CH_3OH and $C^{34}S$ are abundant in the early stages of chemical evolution and become deficient in the later stages. A comparison of the spatial-velocity structures in TMC-1 observed with the three molecular lines suggests that this cloud consists of multiple components with different velocities and different chemical compositions along the line of sight.

Accepted by Ap. J.

http://www.asiaa.sinica.edu.tw/takakuwa/HLC2paper/

The Temperature of Nonspherical Circumstellar Dust Grains

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The temperatures of prolate and oblate spheroidal dust grains in the envelopes of stars of various spectral types are calculated. Homogeneous particles with aspect ratios $a/b \leq 10$ composed of amorphous carbon, iron, dirty ice, various silicates, and other materials are considered. The temperatures of spherical and spheroidal particles were found to vary similarly with particle size, distance to the star, and stellar temperature. The temperature ratio $T_{\rm d}$(spheroid)/$T_{\rm d}$(sphere) depends most strongly on the grain chemical composition and shape. Spheroidal grains are generally colder than spherical particles of the same volume; only iron spheroids can be slightly hotter than iron spheres. At $a/b \approx 2$, the temperature differences do not exceed 10 %. If $a/b \gtrsim 4$, the temperatures can differ by 30–40 %. For a fixed dust mass in the medium, the fluxes at wavelengths $\lambda \gtrsim 100$ μm are higher if the grains are nonspherical, which gives over estimated dust masses from millimeter observations. The effect of grain shape should also be taken into account when modeling Galactic-dust emission properties, which are calculated when searching for fluctuations of the cosmic microwave background radiation in its Wien wing.

Accepted by Astronomy Letters (v. 26, N 10, 2000)
preprint: astro-ph/0009149

An empirical model for protostellar collapse

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We propose a new analytic model for the initial conditions of protostellar collapse in relatively isolated regions of star formation. The model is non-magnetic, and is based on a Plummer-like radial density profile as its initial condition. It fits: the observed density profiles of pre-stellar cores and Class 0 protostars; recent observations in pre-stellar cores of roughly constant contraction velocities over a wide range of radii; and the lifetimes and accretion rates derived for Class 0 and Class I protostars. However, the model is very simple, having in effect only 2 free parameters, and so should provide a useful framework for interpreting observations of pre-stellar cores and protostars, and for calculations of radiation transport and time-dependent chemistry. As an example, we model the pre-stellar core L1544.

Accepted by Astrophys. J., Jan 20th issue, 2001.

astro-ph/0009325
Also available from: http://www.astro.cf.ac.uk/pub/Derek.Ward-Thompson/publications.html

Small Scale Structure of the Protostellar Collapse Candidate B335 Imaged in CS J=5–4 Emission

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We present interferometer observations of CS J=5–4 emission in B335, an isolated round globule generally recognized from single dish spectral line mapping to be the best candidate for a collapsing protostar. The images, with $\sim 2\farcs5$ (0.003 pc) spatial resolution and 0.13 km s^{-1} velocity resolution, show complex structure in the purported infall zone. The emission is dominated by a clumpy conical structure oriented in the east-west direction that we identify with a slow, dense component of the bipolar flow visible on larger size scales. Comparison with the detailed predictions of the inside-out collapse model previously derived from single dish observations show important discrepancies. The high resolution CS J=5–4 images show no evidence for infalling material at velocities greater than 0.5 km s^{-1} coincident with the protostar that corresponds to emission in the wings of the single dish spectrum. Instead, the emission at velocities expected for collapse is found to be associated with the outflow lobes, offset from the protostar position. Depletion may diminish the signal from infall of the densest gas. Bright clumps at blueshifted velocities within the outflow may contribute to the asymmetric appearance of optically thick lines observed with beam sizes too large to resolve these small scale structures.

Accepted by The Astrophysical Journal (Letters)

Preprint available at http://cfa-www.harvard.edu/sfgroup/

Optical Variability of the T Tauri Star HH30 IRS

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We report results of VRI photometric monitoring of the T Tauri star plus disk system HH30 IRS. We find that HH30 IRS is highly variable over timescales of a few days with $\Delta V \sim 1.5$ mag, $\Delta I \sim 1.1$ mag. Furthermore we find hints of periodicity with periodograms indicating possible periods of 11.6 and 19.8 days. The VRI photometry is available through the `anonymous ftp` service. We model the variability with Monte Carlo radiation transfer simulations for a spotted star plus disk system and find that the large variability is best reproduced with a single hot spot and circumstellar grains that are larger than typical interstellar grains. The apparent existence of a single hot spot and the need for larger, more forward throwing grains is consistent with previous modeling of *HST* imagery.

Accepted by ApJ (Letters).

Preprint at astro-ph/0008301. Data available from anonymous ftp at ftp://cfa-ftp.harvard.edu/pub/kstanek/HH30

Discovery of Young, Isolated Planetary Mass Objects in the σ Orionis Star Cluster

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We present the discovery by optical and near-infrared imaging of an extremely red, low-luminosity population of isolated objects in the young, nearby stellar cluster around the multiple, massive star σ Orionis. The proximity (352 parsecs), youth (1 million to 5 million years), and low internal extinction make this cluster an ideal site to explore the substellar domain from the hydrogen mass limit down to a few Jupiter masses. Optical and near-infrared low-resolution spectroscopy of three of these objects confirms the very cool spectral energy distribution (atmospheric effective temperatures of 1700 to 2200 kelvin) expected for cluster members with masses in the range 5 to 15 times that of Jupiter. Like the planets of the solar system, these objects are unable to sustain stable nuclear burning in their interiors, but in contrast they are not bound to stars. This new kind of isolated giant planet, which apparently forms on time scales of less than a few million years, offers a challenge to our understanding of the formation processes of planetary mass objects.

Science, October 6th, 2000 issue

Multi-field Mosaic of the NGC 7538 Region

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We present mosaics of six VLA images made in the NH_3 (1,1) and (2,2) lines toward NGC7538. Both the NH_3 (1,1) and (2,2) emissions show clumpy and filamentary structures. The dense clumps are found near water maser emission or near the youngest member of groups of infrared sources. At the edges of clumps, temperature enhancements indicate external heating possibly by the nearby HII regions. The outflows in this region are conspicuously located in the voids between the clumps. Because there is more mass in the dense clumps than in the outflows, we suggest that the dense medium shapes the outflows and channels the swept-up material to the low density regions.

Accepted to ApJ

Preprint: http://cfa-www.harvard.edu/~qzhang

Dissertation Abstracts

The Star Formation Scenario in the Galactic Range from Ophiuchus to Chamaeleon

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Ph.D degree awarded: July 2000

The molecular cloud complexes of Chamaeleon, Lupus and Ophiuchus, and the OB sub-groups of stars that form the Scorpius OB2 association are located at galactic longitudes in the interval 290° to 360°, all of them in a distance range from 100 to 200 pc. The distribution of known young stars in this region, both of low and of high mass, suggests that they belong to a single large structure. Moreover, a significant number of pre-main sequence (PMS) stars far from the star-forming clouds have been recently discovered. This scenario suggests that a global analysis of the star formation must be performed, especially of such nearby regions for which a large amount of data can be obtained.

In order to test the models that intend to describe the history of star formation in these nearby star-forming regions, we collected information on the distribution of gas and dust and on the related young stellar populations. We mapped the molecular clouds of the complexes located in Chamaeleon, Lupus and Ophiuchus by means of an automatic method for star counting on plates of the Digitized Sky Survey. Another improvement with respect to the traditional star counts method is that we have adopted a relation between the extinction and the number of stars based on the predictions of the Galaxy's model by Ortiz & Lépine (1993, A&A 279, 90). Our maps confirm that there is an extended distribution of dust in the regions between the main clouds. We built a complete list of PMS and early-type stars from the literature, including all the available distance, radial velocity and proper motion data. We completed these data with our own determinations of proper motions of PMS stars, using positions obtained with the Valinhos Meridian Circle (IAG/USP, Brazil), photographic plates and public catalogs (Teixeira et al. 2000, A&A *in press*). Using these kinematical data and comparing the positions and spatial velocities of PMS stars to those of early-type stars, we verified that the kinematics of the two stellar populations is very similar. We estimated the age of the PMS stars using H-R diagrams constructed with photometric data, spectral type and HIPPARCOS parallaxes, when available. We also re-determined the age of the OB associations using the same method. The comparison of the ages of the two populations shows that they are also similar.

Our conclusion is that the two stellar populations have a common global origin. The arrangement of stars and molecular clouds in this extended region and the average velocity of the stars in the opposite direction of the galactic rotation, agree with the expected behavior of the star formation in a nearby spiral arm. On the other hand, the star formation by impact of high velocity clouds on the galactic disk and the sequential star formation do not explain our results. We conclude that the extended complex we have studied probably belongs to a spiral arm close to the Sun.

The Embedded Phase of Massive Star Formation

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This thesis studies the physical and chemical structure of a set of massive young stars which are surrounded by a thick envelope of dust and gas, the earliest known phase of massive star formation. The primary scientific questions addressed are: (i) What is the evolutionary order of the phenomena associated with massive star formation? (ii) What is the physical and chemical structure of the envelopes of massive young stars? How do they compare to those of low-mass stars? Do specific molecules trace different stages? (iii) What are the masses of any circumstellar disks, and on what time scales are they dispersed? To answer these questions, a sample of infrared and submillimeter sources has been selected on high luminosity, close distance, isolated location and high mid-infrared flux.

We present observations of these sources with single-dish submillimeter antennas, millimeter interferometers and near-infrared spectroscopy, and also discuss ISO spectra. For the interpretation, we have developed models with a detailed physical structure, combined with chemical differentiation, which is strongly coupled to the temperature. Some of the conclusions are:

- The envelopes of massive young stars are well described by centrally heated spherical models, with masses of $\sim 100 - 1000$ $M_\odot$ within radii of ~ 0.1 pc. For a power-law density structure $n(r) = n_0(r/r_0)^{-\alpha}$, we find $\alpha = 1.0 - 1.5$ for the younger sources, significantly lower than $\alpha \approx 2$ found for the envelopes of low-mass stars at a comparable stage of evolution. This difference may indicate that the support against gravitational collapse in high-mass cores is by nonthermal (e.g., turbulent) pressure, and in low-mass cores by thermal pressure. For the more evolved sources, $\alpha = 1.5 - 2.0$ fits the data best. Unlike in low-mass star formation, the near-infrared emission decreases as the envelope warms up, indicates that the hot dust close to the star is destroyed and/or pushed out by stellar radiation or mass loss.

- The evolutionary order of phenomena associated with massive star formation appears to be: embedded infrared source → hot core → (ultra-) compact H II region. In the first two stages, CH_3OH and H_2O masers occur, which are replaced by OH masers in the third. Chemically, the low deuterium fractionation and total abundances of H_2CO and CH_3OH argue for a short duration of the cold (≈ 10 K) pre-stellar phase.

- The fractional ionization of the envelopes of massive young stars is consistent with cosmic-ray ionization at an average rate of $\zeta_{CR} = (2.6 \pm 1.8) \times 10^{-17}$ s^{-1}. Variations in ζ_{CR} are a factor ≈ 2 on a $\sim$kpc scale, in good agreement with $\gamma-$ray data. Ionization by local X-rays and shielding against cosmic rays appear unimportant. The differences in ζ_{CR} for a given source derived using H_3^+ or $H^{13}CO^+$, and the correlation of the H_3^+ column density with distance suggest that significant H_3^+ absorption occurs in intervening translucent clouds.

- The abundances of several molecules are found to increase with increasing temperature. Four types of species can be distinguished: (i) 'passive' molecules, which are formed in the gas phase, freeze out onto grains during the cold collapse phase and are released during warm-up without chemical modification (e.g. CO); (ii) molecules which form by reactions on or inside the ice layer, and subsequently evaporate (e.g. CH_3OH); (iii) molecules formed by gas-phase reactions with evaporated species (e.g. CH_3OCH_3); (iv) molecules which are formed in the hot gas by high-temperature reactions (e.g. HCN).

- In 5 out of 5 sources, compact (radius < 300 AU) dust emission is detected with the OVRO interferometer, which resides in a dense shell or in a disk. The mass of this component is not well constrained because of optical depth effects, but it may be as high as 10 $M_\odot$, which is comparable to the stellar mass.

New Jobs

Research Position in Infrared Studies of Young Stellar Objects

The Infrared High-Resolution Imaging Group of the Max Planck Institute for Radioastronomy in Bonn invites applications for a postdoctoral position in the field of young stellar objects. The successful applicant is expected to work primarily on the interpretation of high-resolution observations of young binary stars and/or embedded young stellar objects with outflows.

Applicants should have a Ph.D. and observational or theoretical experience in the field of young stellar objects. The appointment is initially for one year, and is renewable for up to five years. Interested scientists should send a letter of application with a summary of relevant experience and research interests, a curriculum vitae, a list of publications, and two letters of recommendation to Gerd Weigelt at the above address.

Review of applications will begin on 15 Nov. 2000 and continue until the position is filled. The Max Planck Society is an equal opportunity employer.

Interested scientists should send their application to:

Prof. Gerd Weigelt
Max-Planck-Institut fuer Radioastronomie
Auf dem Huegel 69
D-53121 Bonn
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Tel: +49-228-525243
Fax: +49-228-525229
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URL: http://www.mpifr-bonn.mpg.de/div/speckle

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Tenure Track Faculty Position

Observational Astronomy/Astrophysics at Rice University

Astronomy Search Committee
Department of Physics & Astronomy
MS 61 Rice University
Houston, TX 77005-1892, USA

Attn: Astronomy Search Committee, R.J. Dufour, chair

The Department of Physics & Astronomy at Rice University invites applications for a tenure-track faculty position in the field of observational astronomy/astrophysics related to star formation and origins. Specific research areas of interest include protostellar objects and outflows, young clusters and associated emission nebulae and molecular clouds, and global star formation processes on galactic and extragalactic scales. Candidates with multiwavelength research experience (UV-optical-IR-radio) and/or instrumentation experience (instrument development or participation in a development team) are particularly encouraged to apply.

This appointment is expected to be made at the assistant professor level, but outstanding applicants can receive consideration for accelerated promotion or appointment as associate professor with tenure. Review of applications will begin on 1 December 2000 and continue until the position is filled. Interested applicants should send a resume and statement of current research activities and future interests, reprints of two recent publications, and arrange to have three letters of reference sent to the address above.

Rice University is one of the premier small private universities in the nation (www.rice.edu) with an exceptionally talented undergraduate student body and a strong commitment to excellence in research and graduate education. The Department of Physics & Astronomy (dacnet.rice.edu/depts/ricephys/) currently has several faculty engaged in research in observational and theoretical astrophysics. Rice University encourages applications from qualified women and minorities. AAE/EOE.

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