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Abstracts of recently accepted papers

A 2.2 μm Imaging Survey of the Orion A Molecular Cloud

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We present results from a 2.2 μm ($K_{limiting}$ ≈14.5 mag) survey of the northern portion of the Orion A molecular cloud. A total of 3,548 sources were detected in the 1472 arcminute^2 area surveyed. We detect clustering of 2.2 μm sources at the locations of the Trapezium and OMC-2. No strict boundaries for these clusters could be drawn from our data because we find that the entire region surveyed shows an overabundance of sources when compared with background field levels.

We find that the form of the observed K luminosity function (KLF) of stars near the Trapezium is consistent with that predicted from a Miller and Scalo (1979) IMF, if the age of the cluster is $\sim 10^6$ years. Away from the Trapezium and the OMC-2 the KLF of stars suggests that either this population contains more low mass stars or that it is older than the Trapezium stars.

We have investigated how KLFs evolve with the age of a cluster, extinction, and excess emission from young stars by modeling KLFs of hypothetical clusters. Our results suggest that best fit slopes to the cumulative KLF provide a very crude method for characterizing KLFs, that age produces significant changes in the KLFs, and that turnovers in the observed KLF of young clusters do not conclusively demonstrate a "missing" low mass population.

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The Molecular Environment of the HH 34 System

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We present single-dish (angular resolution $\sim 40''$) and VLA (angular resolution $\sim 4''$) ammonia observations toward the HH 34 region. Two main condensations are distinguished both in our single-dish and VLA maps. The northern ammonia condensation is resolved by the VLA as an arc-like structure that surrounds the east side of the star HH 34-IRS (the exciting source of the jet) and coincides in projection with Re 24, the reflection nebula associated with the infrared source IRS5. We suggest that this ammonia structure is tracing the wall of a cavity around HH 34-IRS. Our results are in good agreement with the hypothesis that this cavity was created by the stellar wind from HH 34-IRS,

indicating that along the life of the star two kinds of stellar wind might have been present: a low collimation wind that has created the cavity, and a highly collimated wind that is at the origin of the jet. A second VLA ammonia condensation coincides with Re 23, the brightest part of the arc of optical nebulosity previously proposed to be tracing the western wall of a cavity that contains the jet. The inner edges of these two ammonia condensations coincide with zones of a high level of polarization of the optical emission. With the angular resolution of our VLA observations, no ammonia (1,1) emission is detected directly associated with the star HH 34-IRS, setting an upper limit of $0.1\,[X(\mathrm{NH_3})/10^{-8}]^{-1} M_\odot$ for the mass of a possible circumstellar disk. From our single-dish observations, we find that there is extended emission ($\sim 3'$) of high density gas, not seen with the VLA. For this gas we estimate a total mass of $\sim 15 M_\odot$ and a kinetic temperature of 15 K.

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Thermal infrared imaging of GGD27-IRS: The active pre-main sequence star revealed

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We present near-IR (NIR) 2.2–4.7μm imaging of the core region of the pre-main sequence bipolar CO outflow source GGD27-IRS. Indirect evidence from earlier imaging polarimetry and long-slit spectroscopy suggested that the true young active star in the region, GGD27-ILL, is heavily embedded and completely obscured even at 2μm. Our new 4.7μm images directly detect this source for the first time locating it at 2.0$''$ west, 1.3$''$ south of the bright NIR source IRS2. This position is 0.2$''$ from the position derived from our earlier NIR polarization maps. New mid-IR images of the core region show three point-like sources which are identified as GGD27-ILL, IRS7 and IRS8. We discuss the morphological composition of the core region in light of our discovery.

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The Gas Phase Iron Abundance in Herbig-Haro Objects

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The gas phase abundance ratios Fe/S and Fe/O have been determined for Herbig-Haro objects HH 1, HH 7, HH 11, HH 43A and "Burnham's Nebula" (HH 255). It is the purpose of this study to decide whether a sizeable fraction of the Fe in these HH objects is still bound in dust grains or whether the observed matter has gone through sufficiently fast shock waves so that the dust grains have been essentially destroyed and most of the iron has gone back into the gas phase.

We have determined the abundance ratios using statistical equilibrium calculations for the ions Fe^+, S^+ and O^+.(These are the most abundant ions of the elements in question.) Abundance determination have been made using homogeneous models of the HH objects for which electron temperatures and densities have been determined observationally from forbidden line ratios,

The results show that the Fe/S ratio in the objects HH 1, HH 7, HH 11 and HH 43A agrees very well with the population I abundance ratio. Only Burnham's Nebula (HH 255) shows an Fe/S ratio which is about 3 times lower indicating a shock history which is quite different from that of the other HH objects.

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The FU Orionis Outburst as a Thermal Accretion Event: Observational Constraints for Protostellar Disk Models

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The results of the time-dependent disk models developed in Bell & Lin (1994 ApJ 427, 987) are compared with observed properties of FU Orionis variables. Specific models are fit to the light curves of FU Ori, V1515 Cyg, and V1057 Cyg. The slow risetime of V1515 Cyg can be matched by a self-regulated outburst model. The rapid risetimes of FU Ori and V1057 Cyg can be fit with the application of modest perturbations to the disk surface density. Model disks display spectral features characteristic of observed objects. The color evolution of V1057 Cyg is naturally explained if mass flux drops in the inner disk ($r < 1/4$ AU) while remaining steady in the outer disk. The decrease in optical line width (rotational velocity) observed during the decay of V1057 Cyg may be accounted for by an outward-propagating ionization front. We predict that before final decay to the quiescent phase, short-wavelength line widths ($\lambda < 1.5$ μm) will again increase. It is suggested that FU Orionis outbursts primarily occur to systems during the embedded phase with ages less than several 10^5 yrs.

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Proximity of Jupiter-like Planets to Low Mass Stars

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The sensitivities of astrometric and radial velocity searches for extrasolar planets are strongly dependent on planetary masses and orbits. Because most nearby stars are less massive than the Sun, the first detection is likely to be a Jupiter-mass planet orbiting a low mass star, with a possible theoretical expectation being that Jupiter-like planets will be found much closer (inside the Earth-sun separation of 1 AU) to these low luminosity stars than Jupiter is to the Sun (5.2 AU). However, radiative hydrodynamical models of protoplanetary disks around low mass stars (0.1 to 1 solar mass) show that Jupiter-like planets should form at distances ($\sim$ 4 to 5 AU) that are only weakly dependent on the stellar mass.

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Powerful Jets and Weak Outflows: HH 1-2 and HH 34

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We have mapped the molecular outflows in the regions surrounding the HH 1-2 and HH 34 jets. The molecular outflows associated with the jets are predominantly redshifted, as expected for outflows that are near the front surfaces of clouds. The HH 1-2 region contains a 0.3 $M_\odot$ outflow originating near the VLA continuum and H_2O maser source $1.3'$ to the north-west of the driving source of the HH 1-2 optical flow. We can put a rough upper limit of 0.03 $M_\odot$ on the amount of molecular outflow associated with the HH 1-2 jet. The HH 34 molecular outflow is well aligned with the jet axis, but only amounts to a mass of 0.003 $M_\odot$, making it one of the weakest outflows measured.

Since these outflows are so weak, we estimate that the jets must have deposited more than two orders of magnitude more momentum in the intercloud medium (ICM) than the ambient cloud. This suggests that shocks generated by the jet may exist far outside the cloud boundaries, and have a significant effect on the ICM.

A postscript version of the paper can be obtained by anonymous ftp at cfa0.harvard.edu, cd incoming/masson

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Deep *ROSAT* HRI Observations of the Orion Nebula Region

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We present results from three deep *ROSAT* High Resolution Imager observations of the Orion Nebula star-forming region. The X-ray images contain over 1500 catalogued stars in a roughly 0.8 square degree region centered on the Trapezium. In all, 389 distinct X-ray sources have been detected, $\geq \frac{2}{3}$ of which are associated with a single proper-motion cluster member. X-ray emission is detected from stars of all spectral types, from the massive O and B-type components of the Trapezium to the coolest, low-mass pre-main sequence stars. In this paper, we focus primarily on X-ray emission from the late-type PMS stars. Of the ~ 100 late-type cluster members with measured spectral types, $\sim \frac{3}{4}$ have been detected; we have derived X-ray luminosity upper limits for the remaining stars. We find coronal X-ray emission turns on around spectral type F6, with the upper envelope of activity increasing with decreasing effective temperature. When plotted in an X-ray luminosity versus bolometric luminosity diagram, late-type PMS stars lie below a "saturation" line corresponding to $L_{\rm X}/L_{\rm bol} \sim 10^{-3}$. For approximately solar-mass PMS stars, we find a median X-ray luminosity $\sim 1 \times 10^{30}$ ergs s^{-1}. The late-G, K, and M-type stars exhibit a nearly two orders-of-magnitude spread in X-ray luminosity and in $L_{\rm X}/L_{\rm bol}$ at a given effective temperature. Plots of X-ray activity versus $v \sin i$ rotational velocity and rotational period appear to show no clear dependance of activity on rotation. However, because only a small fraction of late-type PMS stars in the Orion Nebula have measured $v \sin i$ or $P_{\rm rot}$ and because of uncertainties in $L_{\rm X}$ and $L_{\rm X}/L_{\rm bol}$, we feel the data are not conclusive on this point. Light curves of the detected X-ray sources have revealed at least 10 strong X-ray flares with characteristic rise times ≥ 1 hour and decay times ranging from $\sim 2-12$ hours. All the flares have X-ray energies in excess of 3×10^{35} ergs. Many of the X-ray sources associated with late-type cluster members have been observed in more than one *ROSAT* HRI exposure, allowing us to look for variability on the ~ 1 year timescale between HRI observations. A statistical analysis of the resulting count rate ratios suggests that $\geq \frac{1}{4}$ of the late-type cluster stars are significantly variable on this timescale.

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A Keplerian disk around DM Tau ?

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Using the IRAM 30-m telescope, we have detected a rotating gas disk around the relatively old (5 10^6 yr) T Tauri star DM Tau. The kinematic pattern and line profiles obtained from ^{12}CO J $= 2 \rightarrow 1$ and ^{13}CO J $= 2 \rightarrow 1$ are consistent with a disk inclined about 30^o from face-on, with a rotation axis at PA $\simeq 90^o$, and orbiting a $0.65\,{\rm M}_\odot$ central star with a systemic velocity of $6.1\,{\rm km \cdot s^{-1}}$. All detected lines can be well fitted by a simple Keplerian disk model with outer radius $\simeq 750$ AU, mean temperature about 15 K, and standard isotopic ratios. If the CO abundance is normal, the total disk mass is 1.4 $10^{-3}\,{\rm M}_\odot$.

Such a mass is small compared to that derived from mm and sub-mm continuum emission ($\simeq 0.03\,{\rm M}_\odot$). This can be explained either by CO depletion, or by an anomalous gas-to-dust ratio, or by the existence of a dense, compact, optically thick core which dominates the mm continuum emission. The size derived for such a core is consistent with the size of the current solar system. In all cases, our results indicate that significant amount of gas still exists several Myr after star formation.

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Magnetic Fields Around Bok Globules: CCD Polarimetry of CB4

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The small Bok globule CB4 was probed using a CCD imaging polarimeter in order to create a detailed map of the magnetic field associated with this cloud. Stars as faint as 17th mag at V-band were measured polarimetrically with uncertainties less than 1%. Sky transmission variations were minimized via a system of synchronous polaroid rotation and bidirectional charge shifting. In all, 80 stars behind the periphery of the globule were accurately analyzed polarimetrically. The large-scale (1 – 2 pc) magnetic field direction around CB4 was found to be very uniform (PA= $63.3^\circ \pm 1.1^\circ$). Double gaussian fitting of the polarization position angle histogram gave a dispersion of 10° about the primary field direction. Possible field-line compression was found inward of about 0.2 pc from the cloud center. No appreciable twisting of field lines was found. By plotting stellar separations against differences of polarization position angles, CB4 was found to have a magnetic field decorrelation length of approximately 0.1 pc, similar to the size of the visually opaque core, but much smaller than the size of the bright optical rim or CO half-power contour of about 0.5 pc. The magnetic field decorrelation length may be related to a characteristic transient clumping size, or perhaps even to clumps of a more permanent nature.

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The Thumbprint Nebula: the distribution of molecular gas and dust in a regular Bok globule

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We have studied a regular bright-rimmed globule called Thumbprint Nebula, TPN, (size ~ 0.18 pc, distance ~ 200 pc) in millimeter molecular lines (CO isotopic lines), at optical wavelengths (scanned Schmidt plates) and at infrared wavelengths (IRAS maps and scans). The molecular line observations have been made with SEST in ^{12}CO(J=1-0) and (J=2-1), ^{13}CO(J=1-0) and (J=2-1), C^{18}O(J=1-0), C^{17}O(J=1-0), CS(J=2-1) and HNC(J=1-0) transitions. These observations reveal a centrally condensed cloud with an excitation temperature of $T_{\rm ex} \approx 6.6$ K, and a mass of $6\,M_\odot$. There is indication of a cloud rotation with a rotation rate of $\sim$0.6 km s^{-1} pc^{-1}, as measured using ^{13}CO lines. The rotational axis (projection on sky) is parallel to the minor axis of the cloud. The ratio between the turbulent, thermal and rotational energies is $E_{\rm turb} : E_{\rm therm} : E_{\rm rot}(\sin i)^{-2} = 1 : 0.6 : 0.03(\sin i)^{-2}$, where i is the angle between the rotational axis and the line of sight. As a result of the low kinetic temperature the turbulent energy is more important supporting force than the thermal energy. The ratio of the potential energy and the kinetic energy is found to be $|E_{\rm pot}|/E_{\rm kin} \approx 0.9$, thus the cloud is in or near the state of virial equilibrium. High angular resolution (20") C^{18}O observations have enabled us to determine the spatial density distribution of the dense gas in the centre of the cloud. The distribution can be well fitted using a density law of the form $n(r) = n_0 \exp(-(r/r_0)^\gamma)$, where n_0 is the central density, r is the distance from the center, and r_0 and γ are free parameters.

Optical surface brightness distribution as measured from blue and red ESO/SRC Schmidt plates has been used to determine the distribution of the dust particles in comparison with the distribution of the gas component. The position of the surface brightness minimum, which corresponds to the dust density maximum, is found to be about 40" to 50" north of the ^{13}CO and C^{18}O column density maximum. Our interpretation is that the dust is protecting molecules against the UV-radiation coming from the galactic disk (on the northern side of the TPN), causing the molecular density maximum to shift towards south.

We have made infrared surface brightness maps using the IRAS ISSA survey plates at 12, 25, 60 and 100 μm and extracted individual IRAS scans crossing the TPN. The globule is seen at 100 and 60 μm, but the dust is apparently too cold to be visible at shorter wavelengths.

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On the evolutionary status of two very active visual binaries

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HD 36705 (AB Doradus) and HD 155555 (V824 Ara) are two nearby active cool stars. Both have strong Li I λ6708 resonance lines, implying high surface Li abundances, comparable to those of very young T Tauri stars. They also have late M-type visual companions which share their proper motion, as confirmed by new astrometric measurements presented in this paper.

We have carried out intermediate resolution optical spectroscopic observations of the faint companions to HD 36705 and HD 155555. Our main result is that these M-type companions show large Li depletions, and we argue that the dramatic difference in Li abundance between the components of these visual binaries can be understood if they are in an evolutionary stage intermediate between T Tauri stars and Pleiades low mass stars.

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Incorporation of Ambipolar Diffusion into the ZEUS Magnetohydrodynamics Code

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Magnetic fields tied to ions can diffuse through mostly neutral gas: this occurs in protostellar disks and in the cores of molecular clouds. We describe an algorithm that includes ambipolar diffusion in the astrophysical magnetohydrodynamics code ZEUS. We use the approximations that both electrons and ions have equal and constant temperature, that the ion inertia is negligible, and that the ion density is proportional to a power of the neutral density. Our algorithm is fully explicit, and treats the magnetic field using constrained transport and the method of characteristics. We test the algorithm by computing the gravitational collapse of a magnetically supported slab, and by comparing the computed solution for an oblique C-shock to a semi-analytic solution that we have derived. We then compute the development of the magnetic shear instability described by Balbus & Hawley in a magnetized accretion disk, including the effects of ambipolar diffusion. Our computation agrees with the published linear analysis of how diffusion prevents instability, and it allows us to describe the nonlinear development of the instability when diffusion is important but not dominant. We find that ambipolar diffusion indeed creates the sharp structures predicted by Brandenburg & Zweibel.

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ROSAT Survey observation of T Tauri stars in Taurus

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We study the X-ray emission of T Tauri stars (TTS) in Taurus–Auriga as observed with the spatially unbiased flux-limited ROSAT All-Sky Survey. Our detection rates are comparable with *Einstein Observatory* results: 43 out of 65 (66%) weak-line TTS (WTTS) and 9 out of 79 (11%) classical TTS (CTTS) exhibit X-ray emission above the ROSAT survey detection limit. Spectral fits give results consistent with Raymond-Smith spectra and emission temperatures of $\sim\ 1\ keV$ for both CTTS and for WTTS. However, we find that CTTS and WTTS have significantly different

X-ray luminosity functions, even when correcting luminosities for individual X-ray spectra (absorption and emission energy). Medians of X-ray luminosities log $(L_X/erg/sec)$ are 29.701 ± 0.045 erg/s for WTTS and 29.091 ± 0.032 erg/s for CTTS, all in 140 pc distance. A strong correlation between X-ray surface flux and stellar rotation indicates that WTTS are intrinsically more X-ray active than CTTS because WTTS rotate faster. However, rotation is not the only parameter that determines X-ray activity, we find that X-ray luminosity is correlated with stellar mass, bolometric luminosity, effective temperature, and stellar age. Furthermore, X-ray emission of CTTS appears to be harder than that of WTTS.

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Excitation and line profiles of CO molecules in clumpy interstellar clouds

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With a three dimensional Monte Carlo code, we have investigated how the clumpy structure of interstellar clouds would affect the excitation conditions of CO molecules and the resulting line profiles. The excitation conditions are shown to be sensitive to the volume filling factor f. For fixed n(H_2) the excitation temperature becomes generally higher in the cloud having large values of f than in the ones of small f. In completely filled cloud ($f = 1$), the excitation temperature drops sharply near the cloud boundary, which would accompany self-absorption dips in the optically thick ^{12}CO lines. As f approaches zero, the excitation condition becomes constant from the center to boundary. For the optically thin ^{13}CO transitions, the excitation temperature attains uniform distribution at higher values of f than it does for the ^{12}CO transitions. Macro-turbulence also tends to make the excitation conditions uniform throughout the cloud. For the optically thin transitions the radiation from adjacent clumps becomes unimportant, even at moderately low degree of clumpiness (*i.e.*, f in order of 10^{-1}); while for the optically thick transitions, it does so only at f la 10^{-2}. When the total turbulence dispersion is kept the same for both models of turbulence, the macro-turbulence yields higher excitation temperatures than the micro-turbulence does. In the cloud with $f \simeq 0.1$, the level population becomes thermalized at n(H_2) ga $2{\times}10^3$ cm^{-3}; whereas with $f \simeq 0.01$, it does at much higher densities, n(H_2) ga 10^4 cm^{-3}. Higher degree of clumpiness ($f \to 0$), less trapping of radiation brought by small optical depth, and less frequency-coupling among the clumps due to macro-turbulence all make the excitation conditions be uniform throughout the clumpy cloud.

Under the micro-turbulence condition, the synthesized ^{12}CO lines exhibit the flat-top features only, without being accompanied by the self-absorption dips. For each of the J = 1$\to$0 and 2$\to$1 transitions, the synthesized profiles from the macro-turbulence model put the ^{12}CO-to-^{13}CO ratios of the peak brightness temperature and of the line width right in their observed ranges. Clumpiness and macro-turbulence are the cloud attributes that are consistent with the observed profiles of CO lines from cold, dark, quiescent, molecular clouds.

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On the validity of grey radiation transfer in dusty envelopes

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Radiative transfer calculations in dusty protostellar envelopes have been performed to test the validity of the grey approximation which is often used in radiation hydrodynamic calculations. In the spherical symmetric (1D) case we compare grey calculations with the frequency dependent exact solution of radiation transport. In the 2D case we use the flux-limited diffusion approximation to solve the radiation transport equation in grey and frequency dependent form. In all cases the dust temperature distributions are determined self-consistently.

Model envelopes are considered with a density peaked structure $\rho \propto r^{-\alpha}$ and with different total optical depths in the 1D case. In the 2D case we use the density distributions of various disk models. A dust model consisting of amorphous

carbon and silicate grains, partially coated with "dirty ice", is assumed. We find that the dust temperatures are generally underestimated in the grey approximation (by factors up to three) and that the radiative acceleration can be underestimated by orders of magnitude. The importance of efficient but more accurate algorithms than the usual grey approximation is stressed.

Preprints are available per email from Th. Preibisch

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Another Look at the *UBV* Variability of T Tauri Stars

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The *UBV* variability of classical T Tauri stars is investigated using a large dataset compiled by Herbst et al. (1994). The analysis is based on the covariance of the *UBV* colors, which is independent of the obscuration and the temporal sampling, and is a powerful tool for finding trends that otherwise would be hidden in the complex time-dependence of the data. I find that there are two types of *UBV* variability, and introduce the nomenclature ortho- and para-*UBV* variations, or in short type O and type P variations. Objects with a predominance of ortho-*UBV* variability show strong variability in both the Balmer and Paschen continuum, whereas objects dominated by para-*UBV* changes vary mostly in the Paschen continuum. I show that type O variations can be explained in terms of rotating spots, variable obscuration, or changes intrinsic to the source that obey the law $\Delta T_{\rm S}/T_{\rm S} \propto \Delta n_{\rm H}/n_{\rm H}$, where $T_{\rm S}$ and $n_{\rm H}$ are, respectively, the gas temperature and the number density of hydrogen nuclei. Type P variations can be explained only by changes intrinsic to the source with $\Delta T_{\rm S}/T_{\rm S} \propto -\Delta n_{\rm H}/n_{\rm H}$, and I speculate on a possible origin for these changes. The covariance ellipse of the *UBV* colors is a versatile tool for studying the connection between variability and other spectral signatures of classical T Tauri stars; its use for this purpose is illustrated by studying the correlation between the presence of CO first overtone bands in emission and the type of variability. I find that objects with CO band emission are also those with type P variability, and propose an observational test to validate this conclusion.

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A Submillimeter Protostar near LkHα 198

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We present submillimeter and millimeter line and continuum observations of the region around LkHα 198 and V376 Cas. The continuum data reveal the presence of a very cool object, LkHα 198 MM located $\sim 19''$ northwest of LkHα198. LkHα 198 MM is not visible in the near-IR. The CO maps suggest that the mm-source, rather than LkHα 198 or its IR companion LkHα 198B, may drive the large CO outflow seen in this cloud or that both drive outflows which are roughly aligned with each other. In addition V376 Cas appears to power a small bipolar CO outflow.

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Atomic Carbon and CO Isotope Emission in the Vicinity of the Orion Bar

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We present observations of the $^3P_1 \rightarrow {}^3P_0$ fine structure transition of atomic carbon, as well as of the J=2→1 transition of ^{13}CO and C^{18}O toward the Orion Bar, the south–eastern rim of the cavity carved out in the Orion molecular cloud by the HII region surrounding the Trapezium stars. The Orion Bar is a dense region illuminated by an intense flux of UV photons, i.e. a photodissociation or photon–dominated region (PDR). The observed CI intensity agrees with models of uniform–density edge–on PDRs, which predict a spatially stratified morphology for the ionized, neutral, and

molecular components. Our observations, however, show a surprisingly good spatial correlation between CI and ^{13}CO. The bright neutral carbon and ^{13}CO emission from the Bar is superposed on a broad plateau of extended emission. The origin of this extended distribution may lie in the particular geometry of the region, which gives rise to face-on PDRs associated with the back and front walls of the cavity. Because of their weak emission, we infer that these face–on PDRs must be clumpy with a low beam filling factor (∼30–40%) in contrast to the Bar which has been shown to have a filling factor of ∼1 for radiation from the ionizing stars.

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Evidence for Chemical Processing of Pre-Cometary Icy Grains in the Circumstellar Environments of Pre-Main-Sequence Stars

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We report the detection of a broad absorption feature near 2166 cm^{-1} in the spectrum of the Taurus cloud source Elias 18. This pre-main-sequence source is the second in Taurus, the third in our survey, and the fifth known in the sky to show the broad 2166 cm^{-1} absorption feature. Of equal importance, this feature is not seen toward several other embedded sources in our survey, nor is it seen toward the source Elias 16, located behind the Taurus cloud. Laboratory experiments with interstellar ice analogs show that such a feature is associated with a complex C≡N containing compound (called X(C≡N)) that results from high energy processing (ultraviolet irradiation or ion bombardment) of simple ice components into more complex, organic components. We find a non-linear anticorrelation between the abundance of X(C≡N) and frozen CO in non-polar lattices. We find no correlation between the abundance of X(C≡N) and frozen CO in polar lattices. Because the abundances of frozen CO and H_2O are strongly correlated with each other and with visual extinction toward sources embedded in and located behind the Taurus molecular cloud, these ice components usually are associated with intracloud material. Our results indicate that X(C≡N) molecules result from chemical processing of dust grains dominated by non-polar icy mantles in the local environments of pre-main-sequence stars. Such processing of icy grains in the early solar system may be an important source of organic compounds observed in minor solar system bodies. The delivery of these organic compounds to the surface of the primitive Earth through comet impacts may have provided the raw materials for pre-biotic chemistry.

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The Formation of Protostellar Disks II. Disks around Intermediate Mass Stars

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Hydrodynamical calculations of the evolution of a collapsing, rotating axisymmetric 10 $M_\odot$ molecular clump, including the effects of radiative acceleration but without magnetic fields, are presented. The initial cloud is assumed to be a uniformly rotating centrally condensed sphere with $\rho \propto r^{-2}$. Several cases are considered, in which both the overall clump size and the total amount of angular momentum are varied. The calculations show how a warm, quasi-hydrostatic disk surrounding a central unresolved core of only a few $M_\odot$ forms and grows in size and mass. The disk is encased in two distinct accretion shock fronts, both of which are several scale heights above the equatorial plane. At the end of the calculation of our standard case the central unresolved region is found to have a mass of 2.7 $M_\odot$ and a ratio of rotational to gravitational energy of ~ 0.45, sufficiently large to be unstable to non-axisymmetric perturbations. In addition, the inner portions of the disk containing most of the mass are unstable according to the local Toomre criterion, implying that also in this region non-axisymmetric perturbations will lead to rapid evolution. Under the assumption that gravitational torques would transport angular momentum out of this region, a central core

of about $\lesssim$ 8 $M_\odot$ with a stable disk of $\gtrsim$ 2 $M_\odot$ should result. Frequency-dependent radiative transfer calculations of the standard case at selected ages show how the continuum spectrum of the structure depends on the disk's orientation and age and how the observed isophotal contours vary with wavelength. Because of the strong dependence on viewing angle, continuum spectra alone should not be used to estimate the evolutionary stage of development of these objects. Comparable results were obtained for the other cases considered.

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Infrared Spectral Energy Distributions of Young Stellar Objects in Bok Globules

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We present near-infrared photometry from a J, H, and K-band imaging survey towards IRAS sources in Bok globules. Analysis of the photometry provided near-infrared magnitudes, fluxes, and colors of these YSOs. Using the near-infrared colors together with the coordinates of the objects, the most likely near-infrared counterparts to the *IRAS* far-infrared point sources are identified.

Broad-band spectral energy distributions (SEDs) for the YSOs were established and the sources classified according to the shapes of their SEDs. Of the 22 *bona fide* YSOs found, 10 are Class I. Half of the remaining 12 sources are classified as Class II and the other half as Class II-D.

We find that the Class I sources seem to be particularly well identified by the 12/25 μm spectral index.

For Class I and Class II sources, the 12/25 μm spectral index and the 2/25 μm spectral index both give the same information about the embeddedness and type of YSO.

Accepted by *The Astronomical Journal*

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 (following the end-document command).

The Star Formation Newsletter is available on the World Wide Web. You can either access it via the ESO Portal (http://http.hq.eso.org/eso-homepage.html) or directly in two ways: by issue number (http://http.hq.eso.org/star-form-newsl/star-form-list.html) or via a wais index (wais://http.hq.eso.org:2010/starform). You can also access it through the University of Massachusetts Astronomy World Wide Web server, the URL for its home page is http://www-astro.phast.umass.edu/

Numerical Simulations of Time-dependent Herbig-Haro Jets

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Ph.D degree awarded: November 1994

Recent observations of Herbig-Haro jets (or optical jets) show evidence that these highly collimated, supersonic flows associated with young stellar objects are not steady, but rather show many types of variations. The string of shock excited nebulae that make up such jets have highly supersonic proper motions, substantial variations of radial velocity along the length of the jet and often several working surfaces. Several models (both analytic and numerical) exist which explain some of the observed properties of optical jets. However, these jets have a wide variety of shapes, sizes and velocities, so a general model for them is not possible.

Three simple time-dependent effects have been simulated for this thesis using the approximate Riemann solver, Flux-Vector-Splitting. A periodic variation in the magnitude of the velocity of the flow produces a straight jet with a head (or working surface) and several regularly spaced pairs of shocks (internal working surfaces, IWS). This structure is similar to that of the HH34 and HH111 jets. Special attention is given to a single IWS. The evolution and emission properties of this structure are determined.

A periodic variation in the direction of the flow produces a jet with a sinuous body and a complex working surface. Pairs of shocks appear at the bends of this sinuous beam. An adiabatic simulation of the complete jet serves to illustrate the general structure of the flow. The sinuous body and knotty working surface are similar to the HH46/47 jet. A non-adiabatic simulation of the body of the jet (excluding the head) permits the calculation of emission maps which show a structure similar to that observed in HH46/47.

By combining the variations in magnitude and direction of the velocity, a jet is created which eventually breaks-up into independent knots (or "bullets"). Maps of the emission obtained from this simulation present a structure reminiscent of the flow in L1551+IRS5. In general, groups of bow-shaped HH objects flowing away from one source may be explained in this way.

The qualitative agreement between observations and the results of these simulations seems to indicate that some properties of HH jets can be explained as a result of a variability in the ejection mechanism which generates them.

Formation and Evolution of Cometary Globules

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Ph.D dissertation directed by: Bernard Lazareff

Ph.D degree awarded: June 1994

We have conducted a detailed study both numerical and analytical of Cometary Globules (CGs), related to their possible mechanism of formation. CGs are small dense clouds commonly found in the vicinity of O–B stars in HII regions; they consist of a dense head, surrounded by a bright rim, prolonged by a diffuse tail. Recent surveys have shown that CGs are active sites of star formation . One of the models advanced to explain the formation and the evolution of CGs is the "Radiation-Driven Implosion"(RDI) : the UV flux of the O–B association ionizes the external layers of the cloud. The ionised gas expands freely into the interstellar medium while an ionization front preceded by a shock propagates into the cloud.

We have built a 2-D radiative hydrodynamical code based on the piece-wise linear method. The equations of radiative transfer are solved using the "on-the-spot" approximation. The equation of state $P = P(\rho, x)$, where x is the ionised fraction per atom, couples the equations of hydrodynamics and radiation. Gravity is neglected.

We have shown that photo-ionisation alone can account for the formation and evolution of CGs. For physical parameters typical of HII regions, RDI is a two-stage process : a *brief collapse phase* ($\sim 10^5$ yrs, 10% of the cloud life) followed by a transient phase during which the cloud undergoes a series of radial expansions and re-compressions, leading to the commonly observed *cometary phase*. The collapse phase is characterised by a double kinematic emission component, the second component being associated with shocked gas. In the cometary phase, the globule is in a quasi-hydrostatic equilibrium and has no remarkable spectroscopic signature. This phase lasts a few 10^5 to 10^6 yrs. The results of numerical simulations were confirmed by a simple analytic model and extended to the case of a non-thermal support. It appears that small- and large-scale instabilities, Rayleigh-Taylor like, similar to the surface corrugations observed in CGs of the Gum Nebula, can develop in the cometary phase, eventually leading to the cloud disruption. We found that globules with realistic masses and supported by a non-thermal pressure are *gravitationally stable*.

From simulations, we generated emissivity maps and position-velocity diagrams in order to allow a direct observational confrontation with our model. The maps of emission measure exhibit a striking resemblance to various types of CGs and other bright-rimmed structures found in HII regions. The globule CG7S in IC1848 was observed at the IRAM 30-m radio-telescope (in CO + isotopes and CS) in order to test the RDI model. This globule is remarkable in that a) it has not yet developped the common cometary structure, b) the main body of the cloud is accelerated by an overall velocity gradient of $3\,\mathrm{kms^{-1}pc^{-1}}$, c) a second blueshifted kinematic component is associated to some dense and brighter surface gas of the front side. The main features of CG7S are easily reproduced numerically, suggesting CG7S is a young "pre-cometary" object which has already collapsed once and is now re-expanding.

From a small sample of clouds in the (quasi-equilibrium) cometary stage, some of which exhibiting signs of pre-stellar activity, we found that a) globules are supported against the ionised gas pressure by the pressure of a static magnetic field which seems to obey Heiles'law, b) there is no equipartition between the different terms of energy, c) they are gravitationally stable. Star formation is very likely to be triggered in the initial collapse phase but the way globules get rid of their magnetic flux is still unclear, and star formation remains a puzzle in Cometary Globules.

ESO WORKSHOP

on

THE ROLE OF DUST IN THE FORMATION OF STARS

to be held **Sept. 11-14, 1995**, at **ESO headquarters in Garching b. München (Germany)**. The workshop will start on Monday Sept. 11th at 9h00 and will end on Thursday, Sept. 14th at 17h00.

The objective of the workshop is to have an exchange between observers, experimentalists and theoreticians. The discussion shall encompass the status of observations and observational techniques, laboratory experiments and theoretical research with emphasis on what observations are needed to test predictions and to constrain models.

The **scientific organization** of the workshop will be by:

- Rolf Chini and Endrik Krügel, MPIfR, Bonn, Germany
- Thomas Henning, MPG-AG Dust and Star Formation, Jena, Germany
- John Mathis, Univ. Wisconsin, Madison, USA
- Antonella Natta, Oss. Astronomico Arcetri, Italy
- Jean-Loup Puget, IAS, Orsay, France
- Alexander Tielens, NASA Ames, Moffet Field, USA
- Nikolai Voshchinnikov, Astronomical Institute, St. Petersburg, Russia

The workshop will be **organized locally** by:

Ralf Siebenmorgen
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As an introduction to the sessions a series of **review talks** is planned. Submission of and proposals for review talks from the community are still strongly encouraged. There will be a series of contributed oral presentations of about 20–30 min. Additional papers may be given as posters.

Speakers are expected to present new and original results and the organizers are committed to publish the proceedings shortly after the workshop. The workshop is restricted to app. 110 participants.

The workshop shall address the following topics:

I. Present observations of YSO

- suspected protostars and protostellar clumps,
- T Tauri stars,
- Herbig Ae/Be stars,
- OB stars associated with ultracompact HII regions,
- YSO in binary (tertiary?) systems, infrared companions,
- circumstellar disks,
- Vega-type stars

II. Properties of dust around YSO

- difference in dust properties as compared to the ISM,
- fluffy grains and fractal structures, dust agglomerates,
- electrical charging of dust in the radiation field of YSOs
- interpretation of spectral dust features such as e.g. PAHs, dirty ice, "diamond", silicates

III. Processing of dust in YSO

- grain coagulation
- physics of the grain surface
- outgassing of mantles, its influence to the surrounding gas chemistry
- interaction of dust with shocks and MHD waves
- the case of circumstellar disks

IV. Models

- radiative transfer and synthetic spectra
- evolutionary scenarios

V. Dust as a catalytic agent for star formation

- interaction of charged grain components with protostellar clouds
- influence on the magnetohydrodynamic support of the cloud and the collapse of protostellar clumps

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Pre-registration by: **31 Dec. 1994**
(n.b. papers will be selected and arranged according to quality of abstract and date of submission)

ELECTRONIC ONLINE INFORMATION SERVICES

All information about this workshop is available via *www*
`http://http.hq.eso.org/stardust.html`

or using the *finger* command
`finger stardust@mc6.hq.eso.org`

Preliminary Announcement

EVOLUTIONARY PROCESSES IN BINARY STARS

Institute of Astronomy, Cambridge, UK.

10 - 21 July 1995

Since the first conference on binary stars held in Cambridge in 1975, further research and new discoveries have increased the size and scope of the field to such an extent that it is no longer possible even to contemplate encompassing all known types of binary star at a single meeting. For example, in the last decade, progress in infrared astronomy has made possible investigations as to how binary stars form (and since most stars are indeed binaries this means as to how most stars form). What has become evident, however, over the last decade, is that the common thread that runs through all our understanding of the structure and evolution of binary stars, is the set of physical processes which they each undergo at various stages of their evolution. The aim, therefore, of the meeting is to provide a forum in which these common processes will be discussed and considered, not just from the point of view of understanding the basic physics involved, but also with the aim of showing how similar processes apply to disparate groups of stars, and of how a realisation of this fact can lead to a better understanding of the field as a whole. The invited lectures will explain and review our current understanding from both theoretical and observational points of view.

TOPICS:

- Formation of binary stars
- Pre-main sequence binaries
- Binaries in star clusters
- Common envelope evolution
- Contact binaries
- Winds in binary systems
- Millisecond pulsars
- Supernovae in binary systems
- Compact objects in binary systems
- Binary population synthesis

Invited Speakers

A. Ghez, R. Matthieu, J. E. Pringle, S. Lubow, P. Hut, M. Davies, M. Livio, F. Rasio, S. Rucinski, D. Vanbeveren, H. Spruit, H. Ritter, F. d'Antona, S. Kulkarni, C. Wheeler P. Posiadlowski, F. Verbunt, C. Bailyn, M. de Kool, H. Jonstone

Scientific Organizing Committee

J.E. Pringle (Cambridge, chair), M. Livio (STScI, Baltimore), H. Ritter (MPI, Garching), F. Verbunt (Utrecht)

Local Organizing Committee

J.E. Pringle (chair), I.A. Bonnell, P.P. Eggleton, C.A. Tout, R.A.M.J. Wijers

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