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Abstracts of recently accepted papers

The L1448 Molecular Jet

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We have obtained near-infrared images of the L1448 molecular outflow in the J, H, and K bands and through a 1% passband filter centered on the 2.122μm v=1-0 S(1) line of molecular hydrogen. We report the discovery of a highly collimated, clumpy, and bipolar molecular hydrogen jet associated with the L1448 molecular outflow. We estimate that the total H_2 luminosity of the L1448 outflow is about 0.2 $L_\odot$. Most of the line emission in the northern outflow lobe arises from a narrow, curving filament consisting of a chain of knots. Some H_2 knots and the bow-shaped emission regions protruding several arcseconds to the west of the filament may be shocks associated with CO- and SiO-emitting "bullets" seen in mm-wave observations. We interpret the H_2 emission in the context of a jet-driven model for molecular outflows. Bright H_2 emission near the molecular "bullets" may be produced by shocks propagating into the moving medium, while the extended and curving filament may be driven by expanding bow shocks in the wakes of the "bullets". A conical 2.2 μm continuum nebula extends from the driving source of the L1448 outflow towards the blueshifted outflow lobe. Several knots of H_2 emission to the northeast of the main L1448 H_2 filament may be associated with a separate outflow emerging from L1448 IRS 3, which we estimate has a total H_2 luminosity of about 0.01 $L_\odot$.

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Evolution of the Solar Nebula. II. Thermal Structure During Nebula Formation

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Models of the thermal structure of protoplanetary disks are required for understanding the physics and chemistry of the earliest phases of planet formation. Numerical hydrodynamical models of the protostellar collapse phase have not been evolved far enough in time to be relevant to planet formation, i.e., to a relatively low mass disk surrounding a protostar. One simplification is to *assume* a pre-existing solar-mass protostar, and calculate the structure of just the disk as it forms from the highest angular momentum vestiges of the placental cloud core. A spatially second-order accurate, axisymmetric (2D), radiative hydrodynamics code has been used to construct three sets of protoplanetary disk models under this assumption. Because compressional heating has been included, but not viscous or other heating sources, the model temperatures obtained should be considered lower bounds. The first set started from a spherically symmetric configuration appropriate for freely falling gas: $\rho \propto r^{-3/2}, v_r \propto r^{-1/2}$, but with rotation ($\Omega \propto r^{-1}$, where r is the spherical coordinate radius). These first models turned out to be unsatisfactory because in order to achieve an acceptable mass accretion rate onto the protostar ($\dot{M}_s \leq 10^{-5}$ $M_\odot$ yr^{-1} for low mass star formation), the disk mass became much too small ($\sim 0.0002 M_\odot$). The second set improved on the first set by ensuring that the late-arriving, high angular momentum gas did not accrete directly onto the protosun. By starting from a disk-like cloud flattened about the equatorial plane and flowing vertically toward the midplane, these models led to $\dot{M}_s \to 0$, as desired. However,

because the initial cloud was not chosen to be close to equilibrium, the disk rapidly contracted vertically, producing an effective *disk* mass accretion rate $\dot{M}_d \sim 10^{-2}\ M_\odot\ \mathrm{yr}^{-1}$, again too high. Hence, the third (and most realistic) set started from an approximate equilibrium state for an adiabatic, self-gravitating, "fat" Keplerian disk, with surface density $\sigma \propto r^{-1/2}$, surrounded by a much lower density "halo" infalling onto the disk. This initial condition produced $\dot{M}_s \to 0$ and $\dot{M}_d \sim 10^{-6}$ to $10^{-5}\ M_\odot\ \mathrm{yr}^{-1}$, as desired. The resulting nebula temperature distributions show that midplane temperatures of at least 1000 K inside 2.5 AU, falling to around 100 K outside 5 AU, are to be expected during the formation phase of a minimum mass nebula containing $\sim 0.02 M_\odot$ within 10 AU. This steady state temperature distribution appears to be consistent with cosmochemical evidence which has been interpreted as implying a phase of relatively high temperatures in the inner nebula. The temperature distribution also implies that the nebula would be cool enough outside 5 AU to allow ices to accumulate into planetesimals even at this relatively early phase of nebula evolution.

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Ultraviolet Spectroscopy of Herbig-Haro Objects: Spatial Structure, Spectroscopic Diagnostics, and Variability

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Using new long exposure (2 shift) SWP IUE spectra of HH2G, HH2(H + A'), and HH 1F and archival spectra of HH2(H + A') and of HH 1 we have obtained the following results:

1. For the first time we have determined a separate UV spectrum of the high excitation condensation HH2G. The spectrum shows similarity to that of HH2H. However, the emission lines are fainter with respect to the continuum than in HH2H. The H_2 line 1505 Å (which is the strongest of the fluorescent H_2 lines, that are usually typical of low excitation objects) seems to be present.

2. The continuous energy distributions of HH1F, of HH2(H + A') and HH2G are all surprisingly similar and show all in addition to a two-photon continuum rather strong additional continuous emission in the range 1400 Å $\leq \lambda \leq$ 1600 Å which is probably due to a fluorescent H_2 continuum.

3. The spatial distribution of the line emission shows separate maxima for the condensations HH2H and HH2A'(which are about $5''$ apart). The spatial distribution of the continuum emission shows, however, no maxima at HH2A', indicating that (relative to line emission) the continuum emission of this recently developed high excitation condensation must be weak.

4. We have attempted to separate the partially blended Si III] 1883 and 1892 lines and to use their ratio for a determination of the electron density in the "Si III zones" of the shock waves of the HH objects. We get values about 2.5-7 times larger than those determined from the [SII] lines.

5. The time variation of the CIV 1550 and the C III] 1909 lines has been determined for HH 1 and for HH2(H + A') during the time interval 1980-1991. In general the CIV 1550 line shows a larger variation than C III] 1909 line. Between 1980 and 1983 there has been a rather rapid flux increase for both lines in HH2(H + A'). We ascribe this to the rapid development of high excitation condensation HH2A' during these years.

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An ammonia study of the Orion streamer

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The north-south oriented, "$\int$-shaped" streamer of gas which contains Orion KL has been investigated in the (J, K)=(1,1) and (2,2) inversion lines of NH_3. Maps up to $25'$ north and south of Orion KL are presented. A complex structure is present; this may be due to a collection of clumps. From the NH_3, the kinetic temperatures, masses and sizes are determined. The positions and characteristics of the IRAS point sources in the region are discussed in relationship with the molecular gas. Finally, the ammonia distribution and velocity field in these regions are compared to the results obtained from other molecular tracers.

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Infrared CO emission from young stars: high resolution spectroscopy

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We have detected the high–density, high–temperature, neutral material within 10 – 200 $R_\odot$ of five young stars through high resolution (20 to 40 km s^{-1}) spectroscopy of the first overtone bands of CO at 2.3 μm. We find a remarkable diversity in the bandhead profiles towards these sources, ranging from distinctly double–peaked (DG Tau), through broad bumps with emission extending up to 200 km s^{-1} from the stellar velocity (WL16, NGC2024 IRS2 and S106 IRS4), to narrow lines having a FWHM velocity of $\sim$ 50 km s^{-1} (SVS13). Both the profiles and the fluxes of WL16, NGC2024 and S106 can be fitted by emission from Keplerian accretion disks. DG Tau is well described by the superposition of emission from a Keplerian accretion disk and the diluted photospheric absorption features of an M0 dwarf. SVS13 requires either a disk rotating at velocities slower than Keplerian, or a nearly face–on Keplerian disk plus an additional, broad velocity component, possibly the acceleration region of a neutral disk wind.

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An IRAS Sample from Co-added Images of L1641

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A sample of 224 IRAS sources was obtained from the IRAS co-added images in the dark cloud L1641. Most of these sources were also observed in CO and ^{13}CO (J = 1-0). The one hundred twenty-two sources within L1641 are likely to be embedded young stellar objects (YSOs). The sources outside L1641 are mostly extended far-infrared cirrus emission. The infrared and millimeter data were used to search for the indicators of the evolutionary state of YSOs. The IRAS sources associated with CO outflows are significantly different from the non-outflow sources because those with CO outflows have higher ^{13}CO column densities, higher far-infrared luminosities, and cooler IRAS color temperatures.

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Optical evidence for a poorly-collimated wind from Cepheus A

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The relationship between optical outflows, as represented by Herbig-Haro (HH) objects and HH-like jets, and their associated molecular outflows is not well known. While molecular outflows are in many instances poorly collimated, this may not be true of HH outflows and it is certainly not the case with jets. Here we examine, through direct imaging and spectroscopy, the optical flow in the region east of Cepheus A, a well known molecular outflow source. Our images reveal several previously unseen HH objects in this region linked together by a virtual ellipse of HH emission. The major axis of this "ellipse" points directly at what is thought to be the driving source of activity in this area and it is argued that the optical, shocked molecular hydrogen, and radio emission all derive from a poorly collimated wind from Cep A. As with the optical outflow to the west of Cep A, the bow shaped emission, seen in the case of the two brightest HH objects, suggests a clumpy wind at least near the interface between the wind and the ambient material. The idea that there is more than one major outflow direction in the Cep A region is examined. We find that the evidence presented here and at various other wavelengths supports a simple east-west orientation.

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ROSAT X-ray Study of the Chamaeleon I Dark Cloud. I. The Stellar Population

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Two soft X-ray images of the Chamaeleon I star forming cloud obtained with the *ROSAT* Position Sensitive Proportional Counter are presented. Seventy reliable, and 19 possible additional, X-ray sources are found. Eighty percent of these sources are certainly or probably identified with T Tauri stars formed in the cloud. Nineteen to 39 are proposed new "weak" T Tauri (WTT) stars which, when confirmed by optical spectroscopy, will significantly enlarge the known cloud population. Individual T Tauri X-ray luminosities range from $\sim 6 \times 10^{28}$ to $\sim 2 \times 10^{31}$ erg s^{-1} (0.4−2.5 keV), or $\sim 10^2 - 10^4$ times solar levels. The *ROSAT* images are an order of magnitude more sensitive, with 3-4 times more stellar identifications, that earlier *Einstein Observatory* images of the cloud.

A wide range of issues is addressed by these data. The spatial distribution and Hertzsprung-Russell diagram locations of the stars indicate that WTT stars and "classical" T Tauri (CTT) stars are coeval. Their X-ray luminosity functions are also essentially identical, suggesting that CTT stars have the same surface magnetic activity as WTT stars. The X- ray luminosities of well-studied Chamaeleon I cloud members are strongly correlated with a complex of four stellar properties: bolometric luminosity, mass, radius and effective temperature. The first relation can be expressed by the simple statement that low mass Chamaeleon I stars have $L_x/L_\star = 1.6 \times 10^{-4}$, within a factor of ± 2 ($1\ \sigma$) and the last relation by $F_x \propto R_\star$. There is thus no evidence of magnetic saturation of the stellar surfaces. We find no evidence for the absorption of soft X-rays in CTT winds and/or boundary layers traced by the strength of the Hα emission. The mean X-ray luminosity for an unbiased optically selected T Tauri sample is 1.6×10^{29} erg s^{-1}, and we find evidence for temporal evolution of X-ray emission for stars within the pre-main sequence evolutionary phase. The total pre-main sequence population ($M_\star > 0.1\ M_\odot$) of the cloud is estimated to be 200 stars or more, with X-ray emitting WTT stars outnumbering X-ray emitting CTT stars by at least 2:1. The inferred star formation efficiency for the cloud cores is at least 20%.

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Thermal Material In Dense Cores: A New Narrow-line Probe and Technique Of Temperature Determination

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A survey of dense cores in nearby dark clouds indicates that the J= $4 \rightarrow 3$ transition of HC_3N is a good tracer of very quiescent, dense gas. High spectral resolution observations at 12 positions show the line to have a median intrinsic velocity dispersion of 0.088 km s^{-1} as compared to 0.100 km s^{-1} for new high spectral resolution measurements of the NH_3 (1,1) transition at the same positions. The narrowest HC_3N line has an observed FWMH of only 0.14 km s^{-1}, corresponding to an intrinsic velocity dispersion of only 0.058 ± 0.002 km s^{-1}. Maps of two regions show the HC_3N emission to be colocated with the NH_3 emission and to be comparable, or smaller, in extent. This colocation, together with the similar velocities of the transitions, suggests that these two transitions are tracing the same material within these cores. Adopting a two component model for the velocity dispersion of these lines, we estimate the kinetic temperature and the nonthermal velocity dispersion in these cores. The mean kinetic temperature derived from the velocity dispersions in the cores is 9.2 ± 0.2K, in good agreement with the value of 10.2 ± 0.6K determined from NH_3 observations of the same objects. The kinetic temperature of 9.2 K is also similar to to the mean excitation temperature of HC_3N line, 8.4 K. This similarity suggests that the transition is close to being thermalized and indicates that the number density in these cores is close to $3 \times 10^4 \text{cm}^{-3}$. These new temperature and nonthermal velocity dispersion determinations indicate that the nonthermal velocity dispersion increases as the 0.6 ± 0.1 power of the map size, while the total velocity dispersion increases as the 0.05 ± 0.07 power of the map size. In an equilibrium model, these relations correspond to a number density profile $n \sim r^{-1.9}$, which is very close to that expected for an isothermal sphere. The magnetic field strength whose energy density equals that of the nonthermal motions is typically 10 μG over the range of core sizes 0.02−0.11 pc.

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Collapse of Magnetized Molecular Cloud Cores. I. Semi-analytical Results

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In this paper we follow the evolution of an unstable magnetized cloud core modeled with the density distribution of a singular isothermal sphere and threaded by a uniform magnetic field. We include neutral-ion slip, and we solve the equations by an expansion about the known self-similar problem without magnetism. We find that the magnetic field does not significantly modify the standard rate of mass infall because of two offsetting effects: the Lorentz force that impedes gravitational collapse, and the increased characteristic speed that causes the initiation of infall to travel outward faster (as a fast magnetohydrodynamic wave rather than an acoustic wave). Strong magnetic pinching forces deflect infalling gas towards the equatorial plane to form a flattened disequilibrium structure ("pseudo-disk") around the central protostar. The perturbative approach allows us to calculate analytically the dependence of the radius of the pseudo-disk at small times on the physical parameters of the problem when a dimensionless coefficient of order unity is supplied by a separate numerical calculation for the nonlinear flow in the inner region (Paper II).

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Collapse of Magnetized Molecular Cloud Cores. II. Numerical Results

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In a previous paper (Paper I) we presented a perturbative analysis of the collapse of a molecular cloud core threaded by an ordered magnetic field, obtaining a semi-analytical solution applicable over a moderate range of temporal and spatial scales. In the present paper we supplement this analysis with a numerical solution of the magnetohydrodynamic (MHD) equations that include the effects of ambipolar diffusion, valid in the region where magnetic effects dominate the dynamics of the collapse. We focus on the formation of a flattened disequilibrium structure ("pseudo-disk") around the central protostar. The numerical solution gives dimensionless values for the radius of the pseudo-disk as a function of time. Combined with the analytical scaling laws found in Paper I, these results provide in the small time limit a simple power-law expression for the dimensional radius of the pseudo-disk as a function of the initial magnetic field B_0 and effective sound speed a of the unstable molecular cloud core. We tabulate in nondimensional form the velocity, density, and magnetic fields as functions of the radius, polar angle, and time for two values ($\chi = 11.3$ and ∞) of the ion-neutral coupling constant. We apply the results to the density and magnetic field structures on the astronomically interesting scale of a few hundred to a few thousand AU around protostars with mass in the range 0.57 to 2.0 $M_\odot$. The resultant magnetic field topology causes us to speculate on the importance of neutral-ion slip, ohmic dissipation, and reconnection in the overall problems of the loss of flux and the isolation of the magnetic fields in the pseudo-disk (and smaller centrifugal disk) from their interstellar origins. We conclude by comparing our results with observations of flattened dense structures around young stellar objects in various stages of evolution.

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The star forming region around HH24–26 — a revised morphology

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High resolution observations of the star–forming region around the Herbig–Haro objects 24 to 26 have been made in J=4–3 HCO^+, J=5–4 CS and J=2–1 CO (resolutions 14, 20 and 22 arcsec respectively). The former show that the gas appears to be clumped into small (0.05pc), dense condensations probably of several solar masses, some of which may be associated with known infrared sources. These clumps are embedded in a previously mapped molecular ridge. The HCO^+ and CS lines show significant wings in places highlighting the interaction between outflows and the surrounding dense gas.

Also resolved are two separate, roughly parallel bipolar outflows, with projected maximum velocities of $8\,\mathrm{km\,s^{-1}}$ and $18\,\mathrm{km\,s^{-1}}$ for the north and south outflows respectively. The mass of material in each outflow is calculated (in the optically thin limit) to be rather similar at about $0.5\mathrm{M}_\odot$, somewhat smaller than previous estimates. Optical depth effects may explain this. A third CO flow may also be present, roughly centred on HH25 and probably associated with the largest HCO^+ clump. None of the remaining clumps are situated near the centres of the main outflows and it seems unlikely that these are powered by any previously known infrared object.

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Optical/Ultraviolet Excess in Stochastic Winds of T Tauri Stars

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T Tauri stars show non-photospheric excess emission at ultraviolet and optical wavelengths. The interpretation of this excess is usually done in terms of the deep chromosphere or boundary layer model. In this paper we show that the emission of stochastic stellar winds could contribute significantly to the formation of the excess emission blueward of 1μm. Stochastic stellar winds have already been discussed by Mitskevich, Natta & Grinin (1993, Paper I) and proved able to reproduce the observed line profiles. We show here that, with the same parameters, they are also able to fit the amount of the ultraviolet and visual excess, its spectral slope and the luminosities of the Balmer lines.

The slope of the optical/UV excess depends mainly on gas density. According to our modeling it is formed by a gas with density $10^{13} - 10^{14}$ cm^{-3} and can be easily explained by chromosphere, boundary layer, or stochastic wind model. Therefore, the slope of the excess by itself cannot discriminate between the above models.

Free-free emission from stochastic winds cannot account for the observed infrared excess. The possible role of dust will be discussed in a following paper.

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Spectrophotometric Evidence for Velocity Variability in the HH 34 and HH 111 Stellar Jets

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We present Fabry-Perot observations and long-slit spectrophotometry of the collimated jet regions of the HH 34 and HH 111 outflows. There is a close correlation between the observed [S II] flux and the electron density in the bright low-excitation knots in both the HH 34 jet and the HH 111 jet. The electron densities in some of the low-excitation HH 111 jet knots exceed 2500 cm^{-3}, from which we infer that the true gas densities may be significantly higher than $\sim 10^4$ cm^{-3} because the peak ionization is only a few percent for such weak shocks.

We detect weak [O III]λ5007 emission from the HH 111 jet knot L, which implies that the shock velocity for this knot

is ~ 100 km s^{-1}. This knot also has a large velocity dispersion (~ 200 km s^{-1}) and bow-shaped morphology (Reipurth *et al.* 1992). We argue that such a feature cannot be explained by models in which knots correspond to internal shock waves excited by boundary layer instabilities, but is consistent with an internal working surface in a velocity-variable outflow. We review evidence for multiple ejections in each of these stellar jets.

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Evidence of High Excitation in the Herbig-Haro 111 Jet

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We obtained long slit spectrophotometric observations in the blue spectral region, 3600 - 5400 Å, of the Herbig-Haro (HH) 111 jet in Orion. Our purpose was to search for the high excitation [O III] 5007 Å line and medium-to-high excitation [O II] 3727/29 Å lines in the internal condensations or knots of the jet. We found [O III], which indicates shock velocities ≥ 80 km s^{-1}, and strong [O II] in condensation L. The morphology and excitation of this condensation gives more support to a multiple bow shock structure in HH 111, and therefore, strengthens the case for a time variability of its source. Strong emission in [O II] was also found in most of the bright condensations, indicating shock velocities ≥ 40 km s^{-1}. Estimates of the extinction in HH 111 give values of E(B$-$V)$\sim$1, a relatively large value for an optical HH object.

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Water masers associated with Herbig Ae/Be stars

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We present the results of repeated observations of the H_2O line at 22.2 GHz towards a sample of 54 Herbig Ae/Be stars. Maser emission has been detected in three sources only, V645 Cyg, LkHα 234, and BD+40°4124, the latter being a first time detection. The main properties of BD+40°4124 and of the associated maser are discussed.

With the detection of BD+40°4124, the number of Herbig Ae/Be stars with H_2O masers amounts to a total of 7, with a detection rate of $\sim 10\%$. This figure is intermediate between that typical of low-mass stars, $\sim 1\%$, and of massive stars, $\sim 30\%$. In addition, 6 out of the 7 known masers are also CO outflow sources, strongly suggesting a common physical origin for the two phenomena.

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The Pre-Main-Sequence Evolution of Intermediate-Mass Stars

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We calculate numerically the structure and evolution of pre-main-sequence stars with masses from 1 to 6 $M_\odot$. These stars are assumed to originate from protostars accreting within diffuse molecular clouds. For masses from 2 to 4 $M_\odot$, the stellar luminosity first increases markedly during a protracted epoch of nonhomologous contraction and thermal relaxation. Deuterium burns in a subsurface shell throughout this period. More massive objects are thermally relaxed from the start; they contract homologously, with fully radiative interiors. Stars with masses greater than 8 $M_\odot$ have no pre-main-sequence phase, since they are already burning hydrogen by the time protostellar accretion has ended. We summarize our results by presenting a new set of evolutionary tracks in the H-R diagram.

Our calculations imply that Herbig Ae and Be stars are substantially younger than previously believed. The upper boundary to their distribution in the H-R diagram is well matched by our theoretical birthline. The presence in these stars of emission lines and strong winds is *not* linked to an outer convection zone, since our models show that such

convection always vanishes with rising effective temperature. Finally, while residual accretion from circumstellar disks may be occurring, we argue that the associated mass transfer rates are not high enough to account for the stars' observed infrared excesses.

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Cometary globules in the southeast quadrant of the Rosette nebula

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We present a study of newly identified cometary globules in the southeast quadrant of the Rosette Nebula using the J=1-0 transition of carbon monoxide. The globules are found to be blue-shifted by about 6 $km\ sec^{-1}$ with respect to the adjacent Rosette Molecular Cloud. The masses of the globules vary from 50 to 300 $M_{\odot}$, and their sizes are between 1 and 3 pc. Two of the globules have cometary morphology and show velocity gradients of $\sim 1.5\ km\ sec^{-1}$ along their symmetry axes. These globules are associated with the IRAS sources 06314+0421, X0632+043, 06322+0427 and 06327+0423 which coincide with local maxima in the ^{13}CO emission. The derived physical parameters of the globules are found to be consistent with those predicted by recent theoretical models of photoevaporating cometary clouds. We suggest that star formation induced by radiation driven implosion has occurred.

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Proto-Brown Dwarfs I. Method and Results for High Latitude Clouds

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We describe a method for finding substellar mass self-gravitating clumps ("proto-brown dwarfs") in nearby molecular clouds, using mm-wave telescopes. This method represents a novel approach to looking for brown dwarfs and, for the nearest molecular clouds, has a greater mass sensitivity than traditional methods. We describe how the method can distinguish between various functional forms of the low-mass (< 0.2 M$_{\odot}$) stellar initial mass function, which is currently poorly constrained.

We present results of a search for proto-brown dwarfs in high galactic latitude molecular clouds. The clouds have relatively low densities (n(H_2) $\lesssim 10^4$ cm^{-3}), are at an average distance of 100 pc, and are apparently not forming stars. We find little unambiguous evidence for self-gravitating objects *of any mass* in them, although there are clearly clumps with masses as low as 3 $M_{Jupiter}$. We find two clumps in MBM12(=L1457), the nearest molecular cloud to the sun, which have luminous masses within a factor of 3 of that needed to be gravitationally bound. One of these has a dense core which appears to be in hydrostatic equilibrium. If so, then it is the first known self-gravitating core in a high-latitude cloud.

The mean pressure in the clumps is P/k $= 2.9 \times 10^5$ K cm^{-3}, at least an order of magnitude higher than the general ISM pressure We therefore conclude that either the clumps are transient structures in regions of typical ISM pressure or the clouds themselves are short-lived objects in overpressured regions. In the latter case, the clouds will disperse in less than about 10^6 yr.

The search for proto-brown dwarfs is being expanded to include known star-forming regions in the Ophiuchus and Taurus complexes. The results in Ophiuchus and Taurus will tightly constrain the functional form of the stellar initial mass function at very low masses *regardless* of whether or not any proto-brown dwarfs are found. The present results already exclude a single power-law initial mass function with index $\gtrsim 2$.

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Infrared photometry of the young stellar objects V346 Nor and Re 13

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We have examined the infrared properties of Re 13 and V346 Nor which excite Herbig-Haro objects 56 and 57 respectively. We provide the first detection of Re 13 in the infrared. In the IRAS Point Source Catalog Re 13 and V346 Nor are confused into a single source IRAS 16289−4449. We have applied maximum entropy based deconvolution techniques to demonstrate that Re 13 and V346 Nor are distinct far infrared sources. The IRAS fluxes are deduced from the raw scans by taking advantage of the known relative positions of Re 13 and V346 Nor. Both objects emit most of their energy at far infrared wavelengths suggesting that they are at an early evolutionary phase. We estimate $L_{\rm bol} = (50 \pm 10) \times (d/700\,{\rm pc})^2\,{\rm L}_\odot$ for Re 13 and $L_{\rm bol}(1983) = (135 \pm 8) \times (d/700\,{\rm pc})^2\,{\rm L}_\odot$ for V346 Nor. This indicates that the stars are at the high luminosity end among the group of sources exciting Herbig-Haro objects. Nevertheless, V346 Nor has a rather low luminosity with respect to its classification as an FU Orionis star.

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Machine-Gun Jets from Time-Dependent Sources

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The sources of astrophysical jets (e. g., active galactic nuclei and young stellar objects) many times appear to have complex, time-dependent properties. This leads us to expect that the jet flows are likely to be ejected with a time-dependent velocity and/or direction of ejection.

In this paper, we study the coupled effect of a velocity and a direction time-variability of the jet source. We show that such a time-variability has the effect of breaking up the jet into high density clumps (or "bullets"), which travel away from the source in different directions. This model appears to be attractive for explaining astrophysical outflows that have a number of discrete, disconnected clumps rather than a continuous, jet-like morphology. An application of these models to the case of Herbig-Haro objects is discussed.

The models presented in this paper apply for "heavy" jets (*i. e.*, denser than the surrounding environment). This of course limits the application of these models for extragalactic jets, which are most likely to be "light" jets (*i. e.*, with densities lower than the surrounding environment). However, these models can be applied for describing jet beams surrounded by hot, low density "cocoons", a regime which is probably relevant for many extragalactic jets.

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The Discovery of Two FU Orionis Objects in L1641

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We have obtained spectra of the reflection nebulosity illuminated by two heavily embedded IRAS sources in the L1641 molecular cloud, Re 50 and IC 430 (V883 Ori). Examination of these spectra in combination with their other properties indicates that these objects are FU Orionis objects. Our spectrum of L1551 IRS 5 confirms the FU Ori classification made for this star by Mundt et al. (1985).

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Ammonia Emission Downstream of the Herbig-Haro Object 1

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We report VLA-D NH_3(1,1) and (2,2) observations of HH 1. In direct analogy to the case of HH 2 (Torrelles et al. 1992b), we have found ammonia emission immediately adjacent to and downstream of HH 1. As in the case of HH 2, there is no evidence of any significant perturbation in terms of heating and broadening of the ammonia lines. This high degree of symmetry between the HH 1 and 2 ammonia clumps implies a causal physical relationship between the HH objects and the ammonia emission, discarding the possibility that these clumps are just ambient clumps *projected by chance* downstream of the HH objects. In particular, we think that there is the possibility that these clumps delineate nearby ambient gas whose ammonia emission is enhanced by some still unknown process related to the radiation field generated at the head of the VLA-1 jet. However, detailed theoretical calculations will be needed to investigate this possibility. We also detected two other clumps located to the southwest of HH 1. One of them, seen only in the (2,2) line, coincides with an H_2O maser, and its temperature ($\geq$ 30 K) suggests that there might be a young star embedded in this clump. The other clump is located $\sim 15''$ south of the H_2O maser. We also detected ammonia emission from the previously reported condensation associated with VLA-1 (Rodríguez et al. 1990a). As it was also previously reported, this condensation consists of two halves with a velocity shift of $\sim$ 2 km s^{-1} of the same direction and sign as those of the HH 1-2 optical outflow. However, on dynamical considerations, we argue that this shift could represent expanding or contracting motions of a flattened structure seen almost edge-on, rather than a molecular outflow of low collimation.

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Spectrum of the "Invisible" Companion of Z CMa Revealed in Polarized Light

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Optical spectropolarimetry of the FU Orionis variable (FUor) Z CMa in 1991-1992 shows larger polarization in the emission lines than in the continuum. The intensity spectrum at this time has absorption lines with some narrow weak emission. The polarized flux spectrum appears similar to an intensity spectrum of Z CMa obtained in 1987 when it was $\sim$ 0.9 magnitudes brighter at V and showed strong emission lines. We argue that the primary component of the Z CMa binary is an emission line source, perhaps an Ae/Be star, that varies at V by 1-3 magnitudes and was responsible for the 1987 outburst. The primary is mostly obscured from view by an asymmetrical distribution of dust which polarizes the light scattered into our line of sight. The secondary, a normal FUor, is seen more directly, and therefore contributes a large amount of unpolarized flux, about 80% of the total optical flux. Most of the polarization is intrinsic to the system and oriented perpendicular to the jet axis. We propose that independent variations in the brightness of both sources are responsible for the appearance and disappearance of a narrow emission line spectrum on the broader FUor absorption line spectrum.

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Meetings

Violent Star Formation from 30 Doradus to QSOs

November 8 – 12, 1993

Puerto Naos, La Palma, Canary Islands, Spain

Scientific Organizing Committee

B.Elmegreen (USA), F.Mirabel (France), R.Terlevich (UK), G.Tenorio-Tagle (Spain)

The Instituto de Astrofisica de Canarias and the Royal Greenwich Observatory are jointly organizing a conference on Violent Star Formation, which covers theory and observations of Giant HII regions, Starburst Galaxies, HII Galaxies, IRAS Ultraluminous Galaxies, QSOs and Nuclear Starbursts with special emphasis on ionization structure, physics of the interaction with the ISM, triggering mechanisms, hydrodynamics, and cosmological implications: Galaxy formation, chemical evolution at large redshift, QSO luminosity function, UV and X-ray background.

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