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Abstracts of recently accepted papers

Speckle Masking Observations of the Young Binary Z CMa

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We present the first speckle masking observations of the pre-main sequence binary system Z CMa at optical wavelengths (narrow-band R filter and edge filter RG 610). The diffraction-limited images confirm that Z CMa is a binary with a separation of $0.100'' \pm 0.008''$ at position angle $305° \pm 2°$. The intensity ratio of the stars is 7.2 for the narrow-band R filter and 7.7 for the RG 610 filter. The south-eastern component is the brighter component (i.e. the FU Ori object), in agreement with the results of Koresko et al. (1991) based on near-infrared speckle data. However, our optical detection of the north-western component (the infrared companion) would not have been expected according to Koresko et al.'s analysis. One possible explanation could be scattered light. This agrees with recent polarimetric evidence from Whitney et al. (1993) that scattering plays a role in seeing the infrared companion. We discuss the possibility that both components of the Z CMa system may be FU Ori objects.

Accepted by Astronomy and Astrophysics

Collapse and Fragmentation of Molecular Cloud Cores. II. Collapse Induced by Stellar Shock Waves

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The standard scenario for low-mass star formation involves the "inside-out" collapse of a dense molecular cloud core following loss of magnetic field support through ambipolar diffusion. However, isotopic anomalies in presolar grains and meteoritical inclusions imply that the collapse of the *presolar* cloud may have been triggered by a stellar shock wave. This paper explores "outside-in" collapse, that is, protostellar collapse initiated directly by the compression of quiescent dense cloud cores impacted by relatively slow stellar shock waves. A second-order accurate, gravitational hydrodynamics code has been used to study both the spherically symmetrical and three dimensional evolution of initially centrally condensed, isothermal, self-gravitating, solar-mass cloud cores that are struck by stellar shock waves with velocities up to 25 km s^{-1} and post-shock temperatures of 10 to 10,000 K.

The models show that such mild shock waves do not completely shred and destroy the cloud, and that the dynamical ram pressure can compress the cloud to the verge of self-gravitational collapse. However, compression caused by a high post-shock temperature is a considerably more effective means of inducing collapse.

Shock-induced collapse produces high initial mass accretion rates ($> 10^{-4} M_\odot$ yr^{-1} in a solar-mass cloud) that decline rapidly to much lower values, depending on the presence ($\sim 10^{-6} M_\odot$ yr^{-1}) or absence ($\sim 10^{-8} - 10^{-7} M_\odot$ yr^{-1}) of an infinite reservoir of mass. Stellar mass accretion rates $\sim 10^{-7} M_\odot$ yr^{-1} have been previously inferred from the luminosities of T Tauri stars; balanced mass accretion (stellar rate = envelope rate) at $\sim 10^{-7} M_\odot$ yr^{-1} could then be possible if accretion occurs from a finite mass reservoir.

Fluid tracers are used to determine what fraction of the stellar shock material is incorporated into the resulting protostellar object and disk; roughly half the impinging material is injected into the collapsing cloud core when there is a high post-shock temperature. The models are consistent with a scenario where an AGB star wind triggered the collapse of the presolar cloud while injecting about 0.01 $M_\odot$ of matter derived from the AGB star envelope, as has been separately inferred on the basis of nucleosynthesis calculations.

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ROSAT X-ray sources embedded in the ρ Ophiuchi cloud core

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We present a deep *ROSAT* PSPC image of the central region of the ρ Ophiuchi star-forming region. The selected area, about 35' $\times$ 35' in size, is rich with dense molecular cores and young stellar objects (YSOs). Fifty-five reliable X-ray sources are detected (and up to 50 more candidates may be present) above $\sim$ 1 keV, doubling the number of *Einstein* sources in this area. These sources are cross-identified with an updated list of 88 YSOs associated with the ρ Oph cloud core. A third of the reliable X-ray sources do not have optical counterparts on photographic plates. Most can be cross-identified with Class II and Class III infrared sources, which are embedded T Tauri stars, but three reliable X-ray sources and up to four candidate sources are tentatively identified with Class I protostars. Eighteen reliable, and up to 20 candidate, X-ray sources are probably new cloud members. The overall detection rate of the *bona fide* cloud population is very high (73% for the Class II and Class III objects).

The spatial distribution of the X-ray sources closely follows that of the molecular gas. The visual extinctions A_V (estimated from near-IR data) of the *ROSAT* sources can be as high as 50 or more, confirming that most are embedded in the cloud core, and are presumably very young. Using bolometric luminosities L_{bol} estimated from J magnitudes, a tight correlation between L_x and L_{bol} is found, similar to that seen for older T Tauri stars in the Cha I cloud: $L_x \sim 10^{-4} L_{bol}$. A general relation $L_x \propto L_{bol} \propto L_J$ seems to apply to all T Tauri-like YSOs. The near-equality of the extinction in the IR J band and in the keV X-ray range implies that this relation is valid for the detected fluxes as well as for the dereddened fluxes. The X-ray luminosity function of the embedded sources in ρ Oph spans a range of $L_x \sim 10^{28.5}$ to $\gtrsim 10^{31.5}$ erg s^{-1}, and is statistically indistinguishable from that of X-ray detected visible T Tauri stars. We estimate a total X-ray luminosity $L_{x,Oph} \gtrsim 6\times\ 10^{32}$ erg s^{-1} from $\approx$ 200 X-ray sources in the cloud core, down to $L_{bol} \sim 0.1 L_\odot$ or $M_\star \sim 0.3 M_\odot$.

We discuss several consequences of *in situ* irradiation of molecular clouds by X-rays from embedded YSOs. These X-rays must partially ionize the inner regions of circumstellar disk coronae, possibly playing an important role in coupling magnetic fields and wind or bipolar outflows. Photon-stimulated desorption of large molecules by YSO X-rays may be partly responsible for the bright 12μm haloes seen in some molecular clouds. Because YSO X-ray emission exceeds cosmic ray ionization as the principal source of ionization in molecular cloud cores, it may play an important role as a feedback agent in the self-regulation of star formation.

Accepted by The Astrophysical Journal

On The Massive Star-Forming Capacity of Molecular Clouds

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Assuming that photoionization is the self-limiting process for continued star formation, we estimate the maximum number of massive (OB) stars that can form within a molecular cloud. The most efficient cloud destruction mechanism in the early stages of H II region evolution is the evaporation of the cloud by stars located near the cloud boundary. The maximum number of OB stars is of order 1 per 10^4 M$_\odot$ of *average* molecular gas, or 10 per 10^4 M$_\odot$ of *dense* molecular gas. The resulting star forming efficiencies within cloud complexes range from 2 to 16 %, depending on

both the location of the stars in the cloud and the details of the initial mass function, with an overall value of about 5 % for *average* molecular gas.

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The velocity field of the L1551 IRS5 jet

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High spatial resolution imaging observations of the L1551 IRS5 jet have been performed. The system has continued to evolve since it was observed by Neckel & Staude (1987). The tangential velocities of individual features within the jet suggest the presence of three different velocity systems. These velocities have all been constant over the past ten years of observation, although there is some indication that one of the components has recently been re-accelerated. The geometry suggested by the observational evidence is that of a conical volume, which is inclined towards the observer by some 30°. The jet knots appear to run along narrower channels near the surface of the cone. The flow times of the individual knots exhibit a regular pattern, which indicates precession of the jet and/or ejection of the knots with periods of about 20 years. The force required to accelerate the observable knot material to the inferred space velocities is of the order of 10^{-6} $M_\odot$ km s^{-1} yr^{-1}, which is very much smaller than the average momentum transfer rate to the molecular material in the immediate surroundings of the jet.

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Ammonia Downstream from HH 80 North

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HH 80-81 are two optically visible Herbig-Haro objects located about 5′ south of their exciting source IRAS 18162−2048. Displaced symmetrically to the north of this luminous IRAS source, a possible HH counterpart was recently detected as a radio continuum source with the VLA. This radio source, HH 80 North, has been proposed to be a member of the Herbig-Haro class since its centimeter flux density, angular size, spectral index, and morphology are all similar to those of HH 80. However, no object has been detected at optical wavelengths at the position of HH 80 North, possibly because of high extinction, and the confirmation of the radio continuum source as an HH object has not been possible. In the prototypical Herbig-Haro objects HH 1 and 2, ammonia emission has been detected downstream of the flow in both objects. This detection has been interpreted as a result of an enhancement in the ammonia emission produced by the radiation field of the shock associated with the HH object. In this paper we report the detection of the (1,1) and (2,2) inversion transitions of ammonia downstream HH 80 North. This detection gives strong support to the interpretation of HH 80 North as a heavily obscured HH object. In addition we suggest that ammonia emission may be a tracer of embedded Herbig-Haro objects in other regions of star formation. A 60-μm IRAS source could be associated with HH 80 North and with the ammonia condensation. A tentative explanation for the far-infrared emission as arising in dust heated by the optical and UV radiation of the HH object is presented.

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An Infrared Counter-flow in the HH 111 Jet Complex

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A near-infrared K-band mosaic of the HH 111 system shows a highly collimated infrared counterflow to the HH 111 jet, on the opposite side of the driving VLA source. Near-infrared long-slit spectra demonstrate that the newly detected knots are emission line objects with no continuum emission. The knots seen in the counter-flow show a strikingly symmetric spatial correspondence to knots seen in the HH 111 jet, making the system the most symmetric bipolar HH flow known. This remarkable symmetry provides evidence that the knots in the jets result from disturbances originating in the energy source, rather than from Kelvin-Helmholtz instabilities in the flow.

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The β Pictoris phenomenon among young stars. I. The case of the Herbig Ae star UX Ori.

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In this paper we present the first results of the study of very young stars having non-periodic Algol type brightness minima. It is based on cooperative observations between the Crimean Astrophysical Observatory (CAO), the European Southern Observatory (ESO) and the National Solar Observatory (NSO). In August-September, 1992, a very deep ($\Delta V = 2.^{m}5$), long lasting minimum of the light of the isolated Herbig Ae star UX Ori occurred. At this event the star was observed photometrically at the CAO, and spectroscopically (high resolution: Hα and NaI D) at the ESO. The spectroscopic observations were continued at the NSO with the McMath solar/stellar telescope in October-December, 1992, when the star returned to maximum brightness and again at the ESO in July and October, 1993, when the star was bright.
The main results of our observations can be briefly summarized as follows: 1) The photometric and polarimetric results are in agreement with the model according to which UX Ori is surrounded by an edge-on circumstellar disk-like envelope, and its variability is caused by variable obscuration of the star by opaque circumstellar dust clouds, 2) The double-peaked Hα profile observed at maximum light changed to single-peaked at deep minimum; obscuration of a part of the circumstellar gas by an optically thick dust cloud is causing this variation, 3) the inverse P Cygni profiles and variable redshifted absorption components have been observed in the NaI D lines indicating infall of cool gas onto the star.
We believe that such as in the case of the star β Pictoris, violent comet-like activity takes place in the young protoplanetary disk of UX Ori which causes the observed variability.

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[Fe II] 1.53 and 1.64 μm Emission From Pre-Main Sequence Stars

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We present flux calibrated profiles of the [Fe II] 1.53 and 1.64 μm lines in five pre-main sequence stars, PV Cep, V1331 Cyg, R Mon, and DG and HL Tau. The line centroids are blueshifted in all five sources, and four of the five have only blueshifted flux. In agreement with previous studies, we attribute the line asymmetries to local obscuration by dusty circumstellar disks. The absence of redshifted flux implies a minimum column density of obscuring material.

The largest limit, $N_H > 3 \times 10^{22}$ cm^{-2}, derived for V1331 Cyg, suggests disk surface densities >0.05 g cm^{-2} and disk masses >0.001 M$_\odot$ within a radius of ∼200 AU.

The narrow high velocity lines in PV Cep, V1331 Cyg and HL Tau require formation in well collimated winds. The *maximum* full opening angles of their winds range from $<20^o$ in V1331 Cyg to $<40^o$ in HL Tau. The [Fe II] data also yield estimates of the electron densities ($n_e \sim 10^4$ cm^{-3}), hydrogen ionization fractions ($f_{H^+} \sim 1/3$), mass loss rates (∼10^{-7} to 2×10^{-6} M$_\odot$ yr^{-1}), and characteristic radii of the emitting regions (∼32 to ∼155 AU). The true radial extents will be larger, and the mass loss rates smaller, by factors of a few for the outflows with limited opening angles. In our limited sample the higher mass stars have stronger lines, larger emitting regions, and greater mass loss rates. These differences are probably limited to the scale and "energetics" of the envelopes, because the inferred geometries, kinematics and physical conditions are similar.

The measured [Fe II] profiles sample both "high" and "low" velocity environments. Recent studies indicate that these regions have some distinct physical properties and may be spatially separate. The [Fe II] data show that similar sizes and densities can occur in both environments.

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Isolated Star-Forming Regions Containing Herbig Ae/Be Stars I: The Young Stellar Aggregate Associated with BD+40° 4124

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We use optical and infrared photometry in combination with red optical spectra to study the star-forming region associated with the two Herbig Ae/Be stars BD+40 4124 and V1686 Cyg. We identify a partially embedded, dense, isolated cluster of pre-main sequence stars concentrated within 0.15 pc of the two young high-mass stars. The cluster is isolated in that it is separated by approximately 0.7 pc from a surrounding $H\alpha$-bright rim and lies at the center of a molecular core with peak column density corresponding to 45 magnitudes of visual extinction. The fraction of the stellar population with evidence for circumstellar activity is 100% amongst the optically visible cluster members and at least 50% amongst the embedded sources. This small region is characterized by an age spread of approximately 3 Myr with evidence for both high- and low-mass stars forming relatively simultaneously (within several hundred thousand years). Comparison of the derived stellar mass distribution to that expected from monte-carlo sampling of the solar neighborhood mass spectrum reveals that this region is producing an unusually large number of intermediate- and high-mass stars. Our result suggests that not all star formation sites yield identical mass spectra, and that "universal" mass functions may be produced only when integrating over large spatial areas and/or over many star formation epochs. Furthermore, our data appear to exclude for the BD+40 4124 region, the popular scenario that low-mass star formation proceeds quietly and stochastically for several-to-ten Myr until the birth of an early type star, and its subsequent dynamical interaction with the cloud, ends all star formation processes in the core. Instead, we consider the hypothesis that star formation was induced in this region by the propogation of an external shock wave into the cloud core. This picture is similar to that invoked for other star-forming sites displaying a "bright-rim" morphology on optical images and cometary molecular structure, as we see in the vicinity of BD+40 4124.

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A New Optical Extinction Law and Distance Estimate for the Taurus-Auriga Molecular Cloud

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This paper presents optical spectrophotometry of field stars projected on the Taurus-Auriga molecular cloud. We derive extinction laws for heavily reddened stars in this sample and show that the reddening law through the dark cloud is nearly identical to the standard law for $\lambda\lambda$3600–6100 and $A_V < 3$ mag. Our spectroscopic parallaxes suggest a distance of 140 ± 10 pc for the northern portion of the cloud and show no compelling evidence for a substantial variation in distance across the leading edge of the cloud.

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Study of L 1340: a star forming cloud in Cassiopeia

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We report results of radio, optical and IRAS observations aimed at revealing some basic properties of the dark cloud Lynds 1340 (α_{1950}=$2^h26.0^m$, δ_{1950}=+72^o44'). Study of the cumulative distribution of field star distance moduli and photometry of stars embedded in reflection nebulae within the cloud yield distance values close to 600 pc for L 1340.

^{13}CO and C^{18}O observations reveal three dense cores within the cloud having masses of 280, 470 and 180 $M_\odot$, respectively. Young stellar object candidates, namely IRAS point sources, Hα emission stars and stars illuminating reflection nebulae are found to be associated with the cores.

We detected 13 Hα emission stars within the area of the cloud on objective prism plates. They can be regarded as candidate pre-main sequence stars born in the cloud. 22 IRAS point sources with flux density distribution characteristic of young stellar objects are found in the cloud area. Seven of them can be associated with Hα emission stars. We give objective prism spectral types and photoelectric UBV magnitudes for the stars illuminating reflection nebulosities within the cloud.

The young stellar population associated with the cloud apparently contains four B and A type stars illuminating reflection nebulae and 17 low and intermediate mass pre-main sequence star candidates appearing as IRAS point sources and Hα emission stars. Nine IRAS point sources have infrared colours characteristic of deeply embedded protostellar objects. The surface distribution of the young stellar object candidates closely correlates with the three cores of the cloud.

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Relative Lithium Abundances in Pre-Main Sequence Spectroscopic Binaries

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We present a study of the lithium abundance of five pre-main sequence (PMS) double-lined binaries. These binaries are composed of weak-lined T Tauri stars having spectral types ranging from K3 to K7. For each binary, Lee (1992) has determined domains of spectral type and luminosity for the binary components. Lithium abundances in LTE and non-LTE are then derived from the Li I λ6707 resonance line. Considering the entire range of spectral type and luminosity available to each binary component, we place an upper limit on lithium abundance differences between binary components of 1.0 dex. However, within the more limited range of spectral type and luminosity where a binary's components have theoretical mass ratios consistent with their dynamical mass ratios we find smaller abundance differences. For such pairs of components the lithium abundance differences are less than 0.4 dex for four of the binaries; for the binary 162814-2427 the upper limit remains 1.0 dex. We conclude that for each binary the components formed from similar material, and that the formation and early evolution of the binaries did not alter their relative lithium abundances. These results are also consistent with previous suggestions that effective temperature uncertainties are the origin of observed ranges of lithium abundances as large as 1 dex in star-forming regions. The mean non-LTE lithium abundance of the five binaries is $\log N(\mathrm{Li}) = 3.1 \pm 0.4$, very near the present cosmic abundance, although we find a higher lithium abundance of 3.8 ± 0.3 for the binary P1540.

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Sub-mm Observations of Herbig Ae/Be Systems

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Pre-main-sequence intermediate-mass stars have been observed in continuum emission between 0.35 and 1.3 mm in an effort to study the geometrical distribution of circumstellar dust. Flux measurements were made for a total of 13 Herbig Ae/Be systems and the use of 8 filter bandpasses has now essentially filled-in much of the sub-mm portion of the spectral energy distributions of these objects for the first time. Eight of the sources are classified as Group I (possibly disc-dominated) systems by Hillenbrand et al. (1992). The remaining five sources belong to Group II and are characterised by substantial far-IR and mm-wave emission from dusty envelopes.

The new measurements of 1.3-mm flux provide rough estimates of the total mass of dust and gas in each source. It is shown that flat, disc-like distributions of grains would be consistent with these masses for the Group I sources. However, it is also found that the masses are, for the majority of Herbig Ae/Be systems studied, within a factor ≈ 2 to 3 of predictions of the masses of infalling envelopes ($\dot{M} \approx 10^{-5}$ $M_\odot$ yr^{-1}) observed with a 20-arcsec-FWHM beam. To decide between the two geometries, the observed Group I sub-mm spectral energy distributions (SEDs) have been compared with SEDs computed using a standard disc model ($T(r) \propto r^{-3/4}$).

Three of the eight Group I sources – AB Aur, MWC 147 and MWC 297 – can be modelled by assuming that a disc either dominates or is entirely responsible for all excess emission. Other geometrical distributions are not ruled out for these three sources, but it is claimed that a pure disc model is not inconsistent with available measurements. Four of the Group I sources – MWC 137, LkHα 215, HD 163296 and MWC 1080 – have measured 0.35-mm or 0.45-mm flux densities which are significantly in excess of those which can be generated even by standard discs which are entirely optically thick at all wavelengths. A second dust component is dominating the long-wavelength emission from these sources. Finally, it is speculated that possible optically thin mm/sub-mm disc emission in HD 163296 might provide indirect evidence of the presence of large grains.

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Photoevaporating Stellar Envelopes Observed with Rayleigh Beacon Adaptive Optics

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We present H-alpha and I band images of a ~ 1 arc minute diameter field centered on θ^1C Orionis made with a unique adaptive optics system that uses either starlight or Rayleigh-backscattered laser light to correct for atmospheric wavefront distortion. Approximately one half of the stars in this region are positionally associated with knots of ionized gas, which are interpreted as photoevaporating envelopes of low mass stars. The acronyms PIGs, EIDERs, or ProPlyDs all refer to these same knots.

The H-alpha fluxes of the PIGs are proportional to their 2-cm radio continuum flux densities, and for nearly all the ionized knots, the 2-cm brightness temperatures are consistent with θ^1C Ori as the primary source of ionization. The comet-like morphology of the bright nebulosities is modeled as the result of an equilibrium between photoionization, recombination, and shadowing. The radii of the ionized "head" of the cometary PIGs grow with distance from θ^1C Ori; the radii range from less than about 0.05 arc seconds to $\sim$0.25 arc seconds. We interpret the size-distance relationship as evidence that the envelopes all have the same density profile and mass loss rate within a factor of two. Faint, arcuate wisps are observed 1 arc second to 2 arc seconds distant from some of the cometary nebulosities; these are modeled as bow shocks caused by the wind from θ^1C Orionis. The positions of the stars associated with the PIGs in the observational HR diagram indicate they are pre-main-sequence stars with masses less than $\sim 3M_\odot$, with $\sim 1M_\odot$ being typical. Their median I-K color is 2.9.

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Continued Decline in the 1–5μm Brightness of B5 IRS1: 1990–93

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J H K L L′ & nbM photometry of B5 IRS1 in 1992 and 1993 shows that this low-mass YSO continues to fade in the near-infrared at an average rate around 0.24 magnitudes per year and that by September 1993 the J to K luminosity had fallen to one third of its December 1988 value. The change in luminosity continues to be virtually colour-independent between J and K, although the K–M colour is increasing with time. The changes are consistent with an increase in extinction by a dust population depleted of grains with radii smaller than $\sim$0.4μm, or with the short-wavelength emission ($\lambda \lesssim 3\mu$m) being dominated by light scattered in a changing circumstellar geometry.

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Molecular Shocks in Herbig-Haro 1

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We present low resolution, infrared spectroscopic observations (1.2$-$2.4μm) near two optical condensations (A & G) of the leading working surface of Herbig-Haro object 1, in order to study the nature of their molecular shocks. Condensation A spectra show several molecular hydrogen lines, besides the strong (1,0) S(1) 2.121μm and (2,1) S(1) 2.247μm lines, as well as [Fe II] 1.257μm and [Fe II] 1.644μm. Condensation G does not show H_2 lines, but its [Fe II] lines are as strong as those in A. We compare the H_2 column densities of HH 1A, with those predicted by J-type and C-type shock models. It is difficult to distinguish between these models given our observations. From the [Fe II] lines we estimate an extinction of A_V = 6.7±1.4 magnitudes (or an E($B-V$) of 2.2±0.4 magnitudes), which it is higher than what it is obtained from the [S II] lines measurements.

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The active source in the region of the Herbig stars BD+40°4124.

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We present new near-infrared, millimeter and radio observations of the region associated with BD+40°4124, a Herbig Be star located in the direction of the Cygnus arm. BD+40°4124 is the optically brightest member of a small group of young emission line stars, including V 1318 Cygni and V 1686 Cygni. Near-IR broad-band imaging of V 1318 Cygni reveals the presence of two distinct stellar components oriented north-south, a result recently reported by Aspin et al. (1994). On a larger scale, the near-IR images also indicate the presence of many highly embedded sources concentrated in the vicinity of the bright visible stars. In the central part of the cluster, the near-IR sources outnumber the optically visible ones by a factor of three.

The distribution of the high density molecular gas traced by the CS J=5$\rightarrow$4 emission is highly concentrated around V1318 and V1686 Cygni, while the total column density of gas traced by the $C^{18}O$ J=2$\rightarrow$1 shows a ridge morphology centered on these sources. The Herbig star BD+40°4124 lies at the edge of both structures. From the otpically thin $C^{18}O$ emission, we derive a total molecular mass of $M_{\rm core}$=280 $M_\odot$. A molecular outflow has been detected in CO J=2$\rightarrow$1. The high velocity gas is confined to a compact region of size $\approx$ 20″, corresponding to a physical length of

0.1 pc. The outflow is not well resolved, or collimated, on the observed scales. We have also detected H_2O maser emission at 22.2 GHz at a position coincident with the center of the bipolar outflow. Both the maser and the outflow are located at the position of the southern source V 1318 S which we identify as the source responsible for the activity observed in the BD+40 region.

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Extended mid infrared emission around Herbig Ae/Be stars

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We have observed 7 young intermediate mass stars in the mid infrared with two diaphragms of different sizes in order to detect extended emission. The mid infrared part of the spectral energy distribution of HD 97048, HD 97300, and HD 176386 is dominated by extended emission. The extended mid infrared emission can best be explained with emission from large molecules and small grains in a dust shell with a large inner cavity devoid of small particles. The 4 strong mid infrared sources of our sample (T CrA, R CrA, HD 104237 and IRAS 12496−7650) are dominated by emission within the smallest diaphragm (5.4″) used in this work. When extended emission around Herbig Ae/Be stars is present, it contributes significantly to the mid infrared luminosity and must be taken into account both in future observational and theoretical studies.

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The Evolutionary Status of the Stellar Population in the ρ Oph Cloud Core

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This contribution reports the results of an infrared imaging survey aimed at characterizing the stellar populations associated with the three densest star-forming cores in the Ophiuchus molecular cloud complex. The survey has sufficient sensitivity at J, H and K (at 5σ limits of 16.5, 15.4 and 14.2) to provide a complete census of embedded YSOs with masses greater than the hydrogen-burning limit, provided that their ages are less than 3 Myr, and that they are obscured by no more than $\sim$18 magnitudes of visual extinction. Our data suggest that (1) a large fraction ($>$ 70 %) of the sources located within the cores are still surrounded by circumstellar disks and/or envelopes; and (2) the shape of the initial mass function for masses, $M < 1\ M_\odot$, appears to be consistent with that derived for the solar-neighborhood.

We also report the results of a deeper imaging survey of cm-continuum sources (14 sources) in these star-forming cores and in the larger Ophiuchus complex (8 sources). A large fraction (11/14) of the radio sources associated with the cores appear to have infrared excesses diagnostic of circumstellar accretion disks and/or infalling circumstellar envelopes. In these cases, the cm-continuum radiation most likely diagnoses the ionized component of energetic winds or jets which characterize YSOs during the disk accretion phase. By contrast, of the 8 radio sources located outside dense cores, only 2 show infrared excesses. For the sources which lack infrared excesses, the cm-continuum emission is probably produced by gyrosynchrotron radiation arising in the stellar magnetospheres of weak emission T Tauri stars.

There is some evidence that the frequency of binary companions among the sample of cm-continuum sources in the molecular cores may be higher (by as much as a factor of 3-4) than that among the older, distributed population of young stars in the larger Ophiuchus cloud complex.

(A preprint of this paper may be found at **http://www-astro.phast.umass.edu/sfpreprints.html** where all new preprints from the Five College Astronomy Department Star Formation Group may be perused.)

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Dense clumps in the Mon R2 outflow

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We present high-resolution CS and ^{13}CO observations of the central part of the MonR2 outflow. We find that the accelerated gas is distributed in two opposed, highly fragmented, limb-brightened shells. The fragments in these shells correspond to clumps of gas, that although partaking in the outflow motion, have their own peculiar velocities. The clumps appear in the spectra as secondary components, well separated in velocity from the ambient line. They are as dense as the ambient cloud (few 10^5 cm^{-3}), and each of them contains several M_O of gas. From the clumps we directly observe, and from those whose presence we infer by the sudden changes in the shape of the spectra from one position to the other, we conclude that very likely most of -if not all- the gas in the MonR2 outflow is in the form of dense clumps.

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Monte Carlo simulation of light scattering in the envelopes of young stars

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We present the results of Monte Carlo simulations of light scattering in the non-spherical envelopes of young stars. The parameters of the circumstellar dust envelopes have been taken from our previous single scattering modelling of colour excesses and linear polarization variations during deep minima for two Herbig Ae/Be stars, UX Ori and WW Vul. The calculations of intensity and linear polarization were carried out for the wavelength range from 1000 Å to 1 μm.

It is shown that the contribution of the scattered light to the total radiation of a homogeneous oblate spheroidal envelope with a central star can reach 20–30% in the ultraviolet region of the spectrum near 2000–3000 Å. A minimum influence of the dust envelope occurs at about 1 μm where the scattered stellar radiation as well as the obscurity of the star by circumstellar dust are already quite small, whereas thermal dust emission is not large yet. This wavelength region may be used for investigations of the stellar continuum unpolluted by circumstellar dust. In the envelope of WW Vul, the wavelength dependence of circumstellar extinction (taking into account scattered radiation) is almost neutral.

The degree of linear polarization does not exceed 1% for the shell models of both stars, but it increases tremendously when circumstellar dust clouds screen the star. When a full stellar eclipse occurs, the maximum polarization is 8–10 % in the red part of the spectrum. The polarization shows the local minimum at wavelengths 1300–2000 Å for WW Vul and the double polarization reversal at wavelengths 1600–1700 Å and 1900–2000 Å for UX Ori.

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X-ray emission from colliding winds in pre-main-sequence binary systems.

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We present model calculations of the X-ray emission from colliding supersonic winds in young binary systems. For typical winds with velocities between 300 and 500 km s^{-1} and mass-loss rates $10^{-8} - 10^{-6}$ $M_\odot$ yr^{-1} we find that the X-ray luminosity of the interaction region amounts to $10^{30} - 10^{33}$ erg s^{-1} for binary separations less than 50 AU. While the luminosity is in accordance with the observed range for pre-main-sequence stars, the bulk of the emission occurs in the soft part of the spectrum below 1 keV.

We have considered the effects of the interaction of winds with different velocities. In this case, the X-ray emission consists of a "soft" component, due to the slower wind, and a "hard" component from the fast one. Such a double-peaked spectrum is also found in the case where, in addition to the shocked emitting gas, a stellar emission with temperature $\sim$1 keV is present. Thus, the soft X-ray excess represents the signature of interacting stars and can be used as an effective diagnostic to search for binary systems.

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