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Abstracts of recently accepted papers

The small–scale structure and kinematics of B335

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High resolution (2.8–5″) aperture synthesis maps of the ^{13}CO, C^{18}O J=1→0, and continuum emission at 2.7 mm from the Bok globule B335 trace bipolar, high-velocity emission to within 250 AU of its source, and delineate a core which is elongated on scales of 1000 AU perpendicular to the outflow but unresolved along its minor axis. Our images in the optically thick ^{13}CO line show well-separated blue- and red-shifted outflow lobes, and imply the presence of limb-brightened shells. The outflow opening angle close to its origin is the same as at distances of $\sim 5'$, suggesting that its morphology is determined primarily by a collimated driving wind. The high density ($> 3 \times 10^6$ cm^{-3}) core is seen in both 2.7 mm continuum and C^{18}O maps, and has a mass of 0.2 M$_\odot$. The ^{13}CO and C^{18}O line profiles are consistent with those predicted by Zhou et al. (1993) for a collapsing core, and the continuum measurements also imply a density distribution typical of free-fall collapse.

Accepted by Astrophys. J. Letters

Physical Conditions In Photodissociation Regions : M17 Northern Bar

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We present results of long slit spectroscopy, from 2.0 to 2.5 μm, of the photodissociation region in the northern bar of the HII region, M17. The ionised emission peaks to the south of the molecular emission in agreement with previous measurements. The diagnostic 1-0 S(1) to 2-1 S(1) line ratio is approximately 3, larger than the ratio for pure fluorescence, implying that the H_2 is slightly thermalised. The ratio does not change along the molecular emission which fills the slit (approximately 60 arcsec) suggesting that the collisional deexcitation rate is constant. We take this to mean that the physical conditions are constant along the region implying that in the northern bar of M17 we are viewing the face of the molecular cloud. A model is proposed which describes the geometry.

Sixteen H_2 lines were detected and the column densities of the upper levels of the transitions show clearly the UV excitation is responsible for the emission. We have modelled thye physical conditions in the region by fitting 6 line ratios with a two component PDR model. This modelling suggest that the gas is clumpy and can be described if 76 percent of the beam is filled by gas at 10^5 cm^{-3} and 16 percent at 10^6 cm^{-3}. It is shown that a lower limit to the critical density for deexcitation of the v=1, J=3 level is 10^5 cm^{-3}. Also, we find that the ratio of the ortho to para states of H_2 cannot be equal to the LTE value of 3. We introduce two physical models which may explain the low value of the ortho to para ratio that is observed.

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The stellar population in the Rho Ophiuchi cluster

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We report a near infrared survey of 200 square arcmin in the cores of the ρ Ophiuchi interstellar clouds, leading to the detection of 91 sources. We develop a new method for estimating the luminosities of these sources based on fitting of isochrones from theoretical models. Application of these methods allows us to determine a luminosity function and accompanying initial mass function for the cluster of young stars forming in these clouds. The IMF extends to well below the bottom of the main sequence (0.08 $M_\odot$) with no obvious feature at the transition between stellar and substellar masses. The power law exponent of the IMF at low stellar and substellar masses is roughly -1.3 to -1.1, with formal errors of 0.2. These values are consistent with extrapolation of many estimates of the local IMF to substellar masses. At least 7 objects appear to be substellar, even allowing for the largest plausible errors in the observations, the analysis, and the theoretical evolutionary models for these sources. It therefore seems likely that brown dwarfs form in significant numbers and that the process of cloud fragmentation is not biased against substellar masses. These results indicate that the widespread difficulty in finding large numbers of brown dwarfs in older stellar populations arise from the rapid cooling and possibly from atmospheric absorptions that may depress the near infrared spectral outputs of these objects.

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Magnetohydrodynamic Wave Propagation in 1-D Nonhomogeneous Self-Gravitating Clouds

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We study the propagation of magnetohydrodynamic (MHD) waves through nonhomogeneous, self-gravitating, magnetic media representative of molecular cloud environments and focus on the issues of cloud support and line profiles. Since the general treatment of this topic is burdened by a complex mathematical formalism, we consider simplifying geometries which yield analytical solutions in the linear wave limit. In particular, we study both magnetoacoustic and Alfvén wave propagation along the density gradient in a one-dimensional slab. Of specific relevance to molecular clouds, we find that the back-reaction of the Alfvén waves can provide a pressure along the direction of the magnetic field lines; this pressure can help support a density enhancement against gravitational collapse. Furthermore, we find that the velocity amplitudes of these waves increase as the density decreases, in rough agreement with observational estimates of line-width vs density relations.

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The circumstellar gleam from the T Tauri star RY Lupi

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The T Tauri star RY Lupi was followed simultaneously spectroscopically and photometrically over 7 nights covering one of its deepest brightness minima ever recorded. As reported earlier the star first becomes redder with decreasing brightness. At V = 12.5 this trend is changed towards the blue and this time the object was as blue as in maximum at the deepest minimum. The spectral type (G8) remains constant over the entire range of 3 mag in V. During the deep minimum, when the star brightened from V = 13.12 to V = 12.45, the line-to-continuum ratios and equivalent widths of absorption features in the U- and B-bands did not change with time. We show that the additional light component, present when the star is heavily occulted by circumstellar dust, can not be due to an emission component that either is produced at low brightness levels or is always present. Instead it is due to stellar radiation scattered into the line-of sight by dust in the immediate surrrounding of the star. We test this result by assuming that the

scattering occurs in a circumstellar disk which is inclined so that the line-of-sight passes its fluffy upper layers with variable degree of foreground circumstellar dust. Standard values of such a disk model together with standard values of the properties of the dust particles give a good theoretical agreement with the observed colour pattern, both for the location of the turning point in the colour diagrams and the energy distribution and flux at minimum brightness. At this point the optical flux from the object is totally dominated by the gleam from the disk. Polarization data are in agreement with this scenario. It is also pointed out that even though the component of scattered light may stay constant over one night, there are considerable long-term changes in the details of the scattering. We also discuss the behaviour of the emission lines, which most likely form in a halo/wind, not occulted much by circumstellar dust. Complementary Far-UV data and one CO-observation are discussed and future tests of the model are proposed.

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A search for cold dust around post-T Tauri stars

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We have made 1.3 mm continuum observations of 15 age-dated post-T Tauri candidates that occur as secondaries in binary systems with a primary of early spectral type (so-called Lindroos systems). Most of the objects have estimated ages of 10 - 100 Myr. None of the companions were detected at 3 sigma upper limits ranging from 13 - 134 mJy. This implies upper limits on the mass of cold circumstellar dust of $\sim 8 \cdot 10^{-6}$ to $3 \cdot 10^{-4}$ $M_\odot$. The absence of dust emission suggests that the dust grains may have grown into planetesimals or planets, or they may have been dispersed or accreted. Our observations put a limit on the lifetime of optically thin dusty disks of order 10^7 yr in these systems. Two primaries were also included in this survey, again with no detections.

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Rotational velocities for T Tauri stars with strong emission lines

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We discuss the use of the FFT technique in the determination of stellar rotational velocities and of its applicability to slow rotators, namely identifying the limiting (smallest) rotational velocity that is possible to measure as a function of the observations resolution and signal to noise ratio. We have applied this technique to new observations of five T Tauri stars with strong emission. The first measurements of *vsini* for one of these stars, LkHα 264, are presented.

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Observations of Entrainment and Time Variability in the HH 47 Jet

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We present new Fabry-Perot images of the HH 47 jet that show the first clear evidence for entrainment in a jet from a young star. The material in the jet moves faster down the axis of the flow and slower at the edges, similar to viscous flow in a pipe. The higher excitation lines occur along the edges of the jet, as expected if entrainment accelerates and heats the ambient material. We confirm previous observations of multiple bow shocks in this system. Together, time variability and entrainment produce much of the observed shock-excited gas in this object. Our data show that the 'wiggles' along the jet are not caused by jet material tied to a spiraling magnetic field, but instead result from time

variability, variable ejection angles, or inhomogeneities in the flow. The gas entrained in the HH 47 jet may be atomic; our results do not provide direct evidence that stellar jets drive molecular outflows.

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A systematic search for binaries in Taurus

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We surveyed all those young stars in the Taurus star forming region for duplicity which are contained in the Herbig-Bell catalogue and are brighter than K = 9.5 mag, in total a sample of 104 systems. The range in separation observed is 0.13 arcsec - 13 arcsec, with the lower limit given by the diffraction limit of the telescope and the upper limit by confusion due to the surface density of background stars. Within this range we found 39 systems to be double (of which 24 are new detections), 3 triples and 2 quadruples. The resulting degree of multiplicity of $44/104 = 42 \pm 6\%$ is higher than found for main sequence solar type field stars for the same interval of separation (Duquennoy and Mayor 1991) by a factor of 1.9 ± 0.3. We suggest two possible lines of interpretation: If the distribution with separation is similar for young stars and for main sequence stars, this result is compatible with the assumption that all young stars are born double. On the other hand, if one assumes that the total degree of duplicity is about the same in both the sample of main sequence stars and in the sample of pre-main sequence stars, then the distribution with separation must be quite different for these two samples. In either case we have evidence for evolution of the binary properties before the systems reach the main sequence. However, these conclusions hold only if our census in Taurus is typical for the average star forming region. In our sample, multiplicity occurs with the same frequency for weak-lined as for classical T Tauri stars.

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Bolometric Temperatures of Young Stellar Objects

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We propose the "bolometric temperature" T_{bol} as a measure of the circumstellar obscuration and evolutionary development of a young stellar object (YSO). T_{bol} is the temperature of a blackbody having the same mean frequency as the observed continuum spectrum. A log-log plot of bolometric luminosity L_{bol} vs. T_{bol} has the same main sequence as the Hertzsprung - Russell diagram, but for YSOs T_{bol} can have much lower values ($\sim$30 K) than can the photospheric temperature T_{eff} ($\sim$2800 K). We present three indications that a YSO evolves toward the main sequence from low to high T_{bol} as a YSO clears its natal circumstellar dust: (1) For 129 YSOs in Taurus-Auriga, T_{bol} ranges continuously from 60 to 5250 K, from "protostars" to "classical" T Tauri stars (CTTs) to "weak-line" T Tauri stars (WTTs), and a plot of L_{bol} vs. T_{bol} terminates abruptly at the main sequence. (2) In T_{eff} CTTs and WTTs are indistinguishable, with $T_{eff} \sim 4200$ K, but in T_{bol} WTTs are distinctly hotter (3600 K) than CTTs (2100 K). These temperatures indicate that circumstellar matter intercepts a larger fraction of the stellar luminosity for CTTs (0.5) than for WTTs (0.2). (3) In stellar groups, YSOs with low T_{bol} are fewer and more concentrated, while YSOs with high T_{bol} are more numerous and widespread. As T_{bol} increases, an increasing fraction of YSOs lie outside a fiducial contour of ^{13}CO line emission: more than half the YSOs are excluded when $T_{bol} > 2500$K. Thus colder YSOs are probably younger, and hotter YSOs older, than the dispersal time for gas traced by the ^{13}CO line, estimated to be 1-3 Myr.

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Ammonia and methyl cyanide in hot cores

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We have used the IRAM 30-m telescope to observe the J=6–5, J=8–7, and J=12–11 rotational transitions of methyl cyanide (CH_3CN) towards 11 ultracompact HII regions in the inner galaxy. The sources observed were taken from a recent study of high-excitation ammonia lines by Cesaroni et al. (1992). All of the sources in our list were detected. We have analysed the data assuming the observed lines to be optically thin and have derived "rotation temperatures" and column densities. For four of the sources, we have carried out a more sophisticated analysis allowing for the effects of optical thickness using a large velocity gradient statistical equilibrium program. We find in this way methyl cyanide column densities in the range $3\,10^{15}$–$8\,10^{16}$ cm^{-2}, and kinetic temperatures in the range 85–160 K. We also present results of a small survey of similar sources which we have observed in NH_3(4,4) and (5,5) using the Bonn 100-m telescope. An interesting feature of the new 100-m results is the discovery of two new sources showing high excitation ammonia in absorption. There is no obvious preference for sources to have ammonia absorption lines red-shifted relative to emission or vice-versa. Comparison with these and earlier ammonia (NH_3) results of Cesaroni et al. (1992) show that the inferred rotation temperatures are similar below 50 K, but there are large deviations between temperature estimates from the two molecules at higher temperatures. The abundance ratio $[CH_3CN]/[NH_3]$ which we derive varies between $2\,10^{-4}$ and $8\,10^{-3}$.

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Warm dense gas in high latitude clouds: Multiline CO and NH_3 observations of MBM32

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We present the results of a multiline CO and NH_3 study of a molecular condensation in MBM32. These observations give clear evidence that the gas in this high latitude cloud is unexpectedly warm and dense. The clump was selected from a complete map in ^{12}CO(1→0) and subsequently observed in six other ^{12}CO, ^{13}CO, and C^{18}O transitions and in the NH_3 (1,1) and (2,2) transitions. We present the first detection of the ^{13}CO(3→2) and NH_3 (2,2) lines in a high latitude cloud. For the core we derive from the NH_3 data a kinetic temperature of 24^{+10}_{-5} K. The CO data could not be fitted applying the usually adopted LVG or escape propability models which assume constant excitation conditions for the whole cloud. We applied a spherically symmetric radiative transfer code, which allows radial variation of e.g. density and kinetic temperature. The CO data can best be modelled by a cloud with a beam averaged column density of 1.8 10^{20} cm^{-2} and a power law density distribution with an exponent $\alpha = 0.25$ increasing inwards from 160 cm^{-3} at the cloud radius $R = 0.24$pc. The kinetic temperature increases from about 40 K in the core to about 53 K in the outer shell.

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Near Infrared Mapping of Jets and Outflow Cavities Associated with Young Stellar Objects

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This paper discusses high spatial resolution, infrared maps of HH34, HH46/HH47 and HH54 made using the Anglo Australian Observatory's infrared camera , IRIS, in H_2 and Brγ and 2.16 mum continuum.

HH34 : An infrared source HH34 IRS is observed coincident with the visible source at the top of the jet. To the north lies a second fainter knot observed in both line and continuum emission frames. No infrared molecular emission is observed from the two working surfaces. A diffuse arc of 2 micron continuum emission extending from near IRS5 is coincident with visible reflection nebulosity, and HCO emission (Rudolph and Welch,1992). The northern part of this continuum emission blends into molecular hydrogen emission extending across the red shifted flow. To the south a narrow ridge of molecular hydrogen emission runs N-S along the western edge of the approaching flow. This has no

optical counterpart and is aligned with the source.

HH46/47 : The molecular hydrogen frame is dominated by emission from the edges of the blue and red shifted flows. The emission from the NE approaching lobe closely parallels that seen in the visible and terminates in a bright knot of emission coincident with HH 46A. The emission from the SW receding lobe resembles that from the edges of a ovoid cavity in which the opposing edges converge on the visible nebulosity HH47C suggestive of entrained molecular material associated with the edge of the flow. A cometary nebula observed in both molecular and continuum emission near the infrared driving source. A jet-like feature extending SW from the central region is wholly due to molecular hydrogen emission.

HH52,53 and 54 complex: IRIS images reveal for streamers of faint molecular emission running from HH54 toward HH52 and HH53. Other emission can also be seen coincident with the visible emission running toward HH54X. The overall impression is of a V-shaped emission region with the HH54 at its vertex.

Conclusions: Molecular hydrogen emission has been observed for the first time from the edges of an outflow cavity of HH46/47. Molecular hydrogen emission has been observed from the jet in HH46/47.

Faint emission associated with HH52/53/54 lead us to support the view for a common association. HH34, an outflow upon which we base our typical models of flow structures is not as simple as at first thought.

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An unusual case of HCN hyperfine anomalies in S76E: physical implications

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The HCN $J = 1 - 0$ line emission in the region around the H_2O maser source S76E demonstrates unusual ratios of the intensities of the hfs components: the $F = 1 - 1$ component is much stronger than the main $F = 2 - 1$ component and the other satellite component $F = 0 - 1$. The most plausible explanation of this anomaly is the shielding of the core emission by a large amount of blue-shifted low density cold molecular gas on the line of sight.

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Dissertation Abstracts

Observational Study of Protoplanetary Disks and Outflows in Star-Forming Regions

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We have studied several outflow phenomena in star-forming regions, as well as the ambient molecular gas with which they interact, all this for different spacial scales. These scales range from $\sim$ 1 pc in the champagne flow of the HII region GM 24 and in the molecular outflows of AFGL 437 and NGC 2024, to the 100 AU in the protoplanetary disks of HL Tau and L1551-IRS 5. Such disks, in addition to being the likely precursors of new planetary systems, seem to be responsible for the collimation of stellar jets, like the ones present in the regions of Serpens and HH 1-2. With these studies we intend to obtain an overview of the process of star formation, instead of focusing in only one of its manifestations.

In the regions of high-mass star formation of GM 24, AFGL 437 and NGC 2024 we find that anisotropic distributions of the ambient molecular gas determine the geometry, kinematics and evolution of the outflow processes, leading in some cases to novel interpretations on the nature of these outflows.

We find ammonia emission downstream of the Herbig-Haro object 2. The lack of heating and turbulence in the ammonia condensations, as well as the fast proper motions of HH 2 make us favor a stellar jet model to explain the origin of this HH object.

Also with ammonia observations we confirm that the triple radio-continuum source in Serpens is located in our galaxy, since local heating of the galactic molecular gas and widening of the molecular lines are observed toward its position. We think that the heating may be produced by the radiation field from the central low-mass star. On the other hand, the most likely cause of the line widening is the presence of shocks produced by a stellar jet.

Using the VLA with $0\farcs4$ resolution, we tried to obtain the first direct detection of protoplanetary disks of $\sim$ 100 AU radius around young stars. The continuum observations at 1.3 cm of HL Tau show an elongated structure whose size and flux density suggest that it represents the protoplanetary disk we are looking for. However, we can not confirm this interpretation, since the orientation of the observed structure is not consistent with the orientation of the outflow processes and other structures interpreted as disks in HL Tau. Our ammonia observations of the postulated protoplanetary molecular disks around HL Tau and L1551-IRS 5 did not show any emission of this molecule. This non-detection allowed us to derive upper limits of 0.02 and 0.1 $M_{\odot}$ to the mass of the disks in HL Tau and L1551-IRS 5, respectively. By comparing these limits with the masses deduced from previous indirect observations, we conclude that even though we must be close to detect protoplanetary structures with the current instruments, we may have to wait for a new generation of telescopes to confirm their existence.