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Abstracts of recently accepted papers

The Expansion Rate and Distance of G5.89–0.39

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The expansion rate of the ionized shell in the UC H II region G5.89−0.39 has been measured using three VLA observations spanning 5.3 years. The nebular shell is expanding at a rate of 2.5 ± 0.5 milliarcseconds per year. ¿From the angular radius and expansion rate we find a dynamical age of 600^{+250}_{-125} years. Combined with a model for the nebular emission and H radio recombination line spectra, we estimate an expansion velocity of about 35 km s^{-1} and a source distance of $2.0^{+0.7}_{-0.4}$ kpc. This is slightly closer than most previous estimates of 2.5 to 3 kpc. We see no evidence for NE-SW expansion which might be associated with the molecular outflow seen in SiO; however, our data are consistent with previous observations of a N-S flow, indicating the SiO flow may originate from another young star along the line of sight.

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Preprint available at: `http://www.astro.uiuc.edu/~acord/preprints/`

Permitted Iron Emission Lines in the Classical T Tauri Star DR Tauri

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We present a study of permitted emission lines of Fe I and Fe II in the spectrum of the high accretion rate classical T Tauri star DR Tau. Echelle spectra collected at the 4m Mayall telescope at KPNO between 1988 and 1992 include 4 epochs with red spectral coverage (∼5000Å - 6800Å) and 3 with blue spectral coverage (∼4000Å - 4950Å). A total of 62 unblended Fe I and Fe II lines are identified, their profiles are examined, and ratios of line pairs that are sensitive to column density or temperature are analyzed.

The unblended Fe profiles exhibit a systematic behavior, with FWHM increasing from 20 to between 70-90 km s^{-1} as the equivalent width increases from 0.05 Å to several Å. Two component fits to the profiles suggest a composite origin, comprising a narrow component (NC), with FWHM ∼20 km s^{-1} and a radial velocity at rest with respect to the photosphere, and a broad component (BC), with FWHM ∼100 km s^{-1}, and a tendency to be blueshifted by $\leq$ 10 km s^{-1}. These two kinematic components are present in differing proportions among lines of differing intensity, thereby accounting for the systematic behavior of the profiles with line strength.

Estimates of opacities and column densities are obtained by comparing observed intensity ratios of lines from a common upper level with values expected from a local escape probability calculation. We find (1) opacities in the NC exceed those in the BC by factors of 2-4; and (2) for the BC, $N_{FeI} \sim 10^{17} - 10^{18}$ cm^{-2} and $N_{FeII} \sim 10^{18} - 10^{19}$ cm^{-2} for kinetic temperatures in the range to 4000 to 10,000K. Ratios of NC/BC emission from a pair of Fe I lines which are insensitive to opacity suggest that the kinetic temperature in the NC exceeds that in the BC by several thousand degrees.

The centroid velocity and width of the *NC* in Fe I and Fe II are comparable to those from photospheric lines, suggesting a thermal or turbulent origin further broadened by stellar rotation. In the context of a magnetospheric accretion model, the *NC* is consistent with an origin in the post-shock gas close to the stellar surface. In contrast, the *BC* is likely to be broadened by bulk motion, such as infalling gas in the accretion funnel or rotation in the region coupling the inner disk to the stellar magnetic field.

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Preprint available via anonymous ftp at *earth.ast.smith.edu*, in pub/preprint/drtau.ps.

Near–IR Fluorescent Molecular Hydrogen Emission from NGC 2023

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Spectra from 1 to 2.5μm, at 230–430 spectral resolution, are presented of the fluorescent molecular hydrogen line emission from two locations in the reflection nebula NGC 2023. Over 100 H_2 lines can be identified in the spectra, though blending and poor atmospheric transmission mean that reliable level column densities can only be obtained from 35 lines. These latter group include lines from v=1–8 and v=10, spanning an energy range from 6,000 to 45,000 K above ground. These data may be used to constrain models both of photodissociation regions and of fluorescent excitation for molecular hydrogen.

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The Ionization Fraction in Dense Cloud Cores

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The degree of ionization $x(e) = n(e)/n(H_2)$ and the cosmic ray ionization rate ζ in 24 cloud cores have been determined by comparing observational data from Butner et al. (1995) on the abundance ratios $R_D = [DCO^+]/[HCO^+]$ and $R_H = [HCO^+]/[CO]$ with a simple analytical chemical model and with a detailed "pseudo–time–dependent" chemical model. The results are dependent on the depletion of elemental carbon and oxygen from their cosmic abundances, especially for cores with a low degree of ionization. We determine the depletion of C and O from the measured HC_3N/CO abundance ratios using model results. We find that the range of fractional ionization in the dark cores extends between $\sim 10^{-6}$ and $\sim 10^{-8}$ with inferred cosmic ray ionization rates in the range 10^{-16} – 10^{-18} s^{-1}. This corresponds to ambipolar diffusion timescales between 3×10^7 and 3×10^5 yrs with a median value of 5×10^6 yrs. The ratio of ambipolar diffusion to the free–fall timescales varies between 3 and 200 with a median value of 50. We find rather surprisingly no clear segregation in the ambipolar diffusion timescales between cores with embedded stars and those without. An interesting by–product of our results is the conclusion that the cyanopolyyne rich core in TMC–1 is atypical in its abundance distribution and may be unusually young.

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ISO Detection of CO^+ toward the protostar IRAS 16293−2422

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In this letter we report the detection of eight high-N rotational transitions of CO^+ towards a low mass protostar, IRAS 16293−2422. The source was observed with the Long Wavelength Spectrometer on board the Infrared Space Observatory. This is the first time that CO^+ has been detected in a low luminosity source and the first time that high-N lines have been detected in any source. The detection of these lines was not predicted by models and consequently, their interpretation is a challenge. We discuss the possibility that the observed CO^+ emission originates in the dense inner regions illuminated by the UV field created in the accretion shock (formed by infalling material), and conclude that this is an improbable explanation. We have also considered the possibility that a strong, dissociative J-shock at $\sim$ 500 AU from the star is the origin of the CO^+ emission. This model predicts CO^+ column densities in rough agreement with the observations if the magnetic field is $\sim$ 1 mG and the shock velocity is 100 km s^{-1}.

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http://www-laog.obs.ujf-grenoble.fr/ ceccarel/papers/co+iras16293.ps

A radiation-driven disk wind model for massive young stellar objects.

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A radiation-driven disk wind model is proposed that offers great promise of explaining the extreme mass loss signatures of massive young stellar objects (the BN-type objects and more luminous Herbig Be stars). It is argued that the dense low-velocity winds associated with young late-O/early-B stars would be the consequence of continuing optically-thick accretion onto them. The launch of outflow from a Keplerian disk allows wind speeds of $\sim$200 km s^{-1} that are substantially less than the escape speed from the stellar surface. The star itself is not required to be a rapid rotator. Disk irradiation is taken into account in the hydrodynamical calculation presented, and identified as an important issue both observationally and from the dynamical point of view.

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Preprints on the web at `http://xxx.lanl.gov/abs/astro-ph/9801035`

On the Nature of the Molecular Condensation Downstream of HH 80 North

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We present HCO^+ (J=3→2), $H^{13}CO^+$ (J=3→2), CS (J=5→4) and ^{13}CO (J=2→1) CSO observations towards the dense quiescent clump downstream from HH 80 North. This condensation is one in a class of sources that show anomalous molecular abundances, probably produced by UV radiation from a nearby shock. The HCO^+ emission properties, location, size, center velocity, line widths and excitation temperature, are similar to the ones of the ammonia emission, suggesting that it arises from the same region. The $H^{13}CO^+$ (J=3→2) and CS (J=5→4) lines are marginally detected. Comparison between the NH_3, HCO^+ and CS implies an ammonia enhancement relative to CS of at least one order of magnitude, whereas the HCO^+ shows only a weak enhancement relative to CS. These results are compatible with the radiative shock-induced chemistry models (Taylor & Williams 1996 and Wolfire & Königl

1993) when we take into account the extinction. Our results suggest that the dense clump detected in NH_3 and HCO^+ is illuminated by HH 80 North, making this region a good laboratory to study the chemical processes in a quiescent clump radiatively excited by shocks.

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Preprints available at http://www.astro.uiuc.edu/ jgirart/curro.html

SiO shocks in the L 1157 molecular outflow

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We report high angular resolution IRAM Plateau de Bure interferometric observations of the SiO $v = 0$ $J = 2 \rightarrow 1$ and $J = 5 \rightarrow 4$ transitions in the southern lobe of the young L 1157 molecular outflow. The resolution of these observations ($\sim 2.5''$) makes them directly comparable to available high-resolution CO maps of the flow. The known precession of the L 1157 flow is fully confirmed. We find a remarkable morphological agreement between the strong SiO shocks revealed by these observations and the two CO cavities of the southern lobe of the outflow: the positions, shapes and opening angles are similar in both tracers, with the SiO emission ahead of or at the edges of the CO emission. Each CO cavity is associated with a shock which is placed exactly at its apex and exhibits a linear feature pointing exactly towards the protostellar position. The CO appears in the wake of these leading shocks. These coincidences, as well as the presence of two independent shock/cavity systems, strongly support shock-entrainment models for the formation of molecular outflows.

These observations also provide detailed information on the internal structure of the shocked regions. They confirm that a strong enhancement of the SiO abundance occurs within shocks. The comparison with high-angular resolution images of other shock-tracers (NH_3, H_2) shows that chemical and evolution effects play a crucial role in the observed brightness distributions. The SiO velocity distribution is mainly forward, but the kinematics seems to result from both the complex formation processes of SiO and the velocity field produced by bow-shocks. Finally, we briefly discuss the apparent density structure of the shocks, and especially the possible origin of the linear precursor seen downstream from the main bow-shock.

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Preprint available at: `http://iram.fr/PP/papers.html`

The DCN/HCN abundance ratio in hot molecular cores

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We have observed the 3-2 transitions of DCN and $HC^{15}N$ in a number of hot molecular cores previously surveyed by us with the interesting result that the DCN/HCN ratio is low, a few times 10^{-3}, in the hot cores. The abundance ratio of DCN/HCN is derived both 'on-core' and 'off-core' and, in general is larger at the 'off-core' positions. Comparision with chemical models of these sources indicates that DCN liberated from evaporated ices can be destroyed rapidly in the hot gas by reaction with atomic hydrogen, which works to reset the the initial DCN/HCN ratio in the ice to the gas-phase atomic D/H ratio. The low DCN/HCN abundance ratio we measure can be reached in less than 10^4 years, consistent with previous estimates of the core ages, if the activation energy of the reaction is less than 500 K.

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preprints at http://www.phy.umist.ac.uk/cgi-bin/zyview/D=preprint/V=mhv (no. 181)

The IRAM key project: Small-scale structure of pre-star forming regions – Combined mass spectra and scaling laws

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One objective of the IRAM key project *small-scale structure of pre-star forming regions* is to determine the continuation of the mass spectra for molecular cloud fragments and other scaling laws from large scales down to smallest scales accessible with single-dish telescopes. In this Letter we present first results of the combination of the small scale data from this project and large scale data obtained with the CfA 1.2 m and the KOSMA 3 m telescopes for the Polaris Flare analyzed using a Gaussian clump decomposition. For data in the ^{12}CO J=1→0 and 2→1 lines we find no deviation from the power law slope of the mass spectra ($\frac{dN}{dM} \propto M^{-1.84}$), over a range in masses of more than at least 5 orders of magnitudes, from masses of several 10 $M_\odot$ down to Jupiter masses. The size spectrum is in agreement with a power law of the form $\frac{dN}{dr} \propto r^{-3.0}$. The mass-size relation is a power law of the form $M \propto r^{2.31}$ over a range of more than 2 orders of magnitudes in size.

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Dust scattering of emission lines in H II regions. I. Plane-parallel models and application to the Orion nebula (M42)

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I present a comprehensive plane-parallel radiative transfer model for the scattering by dust of emission lines in a blister H II region on the surface of a molecular cloud. The effects of dust in the molecular cloud, within the H II region, and in a layer of overlying neutral material are all included. The spectral intensity and polarization profiles of the scattered lines are calculated, as well as the effective albedo of the scattering. Analytical, semi-analytical and Monte Carlo numerical techniques are used, as appropriate. The model is applied in detail to observations of the [O III]λ5007Å line in the inner Orion nebula. It is shown that the observations are consistent with a back scattering origin for the broad redshifted component that is seen in this line, as well as in lines of other ionized species. High resolution spectropolarimetry of the emission line would provide a conclusive test of the scattering model. Model fits suggest that the optical depth of dust between the ionization front and the [O III] emitting region is in the range 0.5–1.0 in the visible. Foreground scattering in the neutral lid that overlies the nebula is shown to have little effect on the line profile, although it could account for some of the unexplained broadening seen in all optical lines.

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Available at http://www.astrosmo.unam.mx/∼will/papers/orion.html

The Young Cluster IC 348

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CCD photometry in BVRI was obtained for about 260 stars in and around IC 348, and multi-object spectroscopy for 80 of these. A somewhat larger region was surveyed for stars having Hα in emission; over 110 emission- line stars brighter than about R = 19 were discovered. Because Hα emission could be detected to a limit near W = 3 Å, division into weak-line (WTTS) and classical T Tauris (CTTS) was possible on purely spectroscopic grounds. There is a steep rise in the number of emission-line stars below W(Hα) = 10 Å; the proportion of WTTS:CTTS in the area surveyed is 58:51. ROSAT detected only 58% of the spectroscopic WTTS, and about 65% of the CTTS, although these numbers

are sensitive to the survey thresholds. The bulk of the ages of about 100 stars, read off the theoretical tracks of D'Antona & Mazzitelli, range between about 0.7 and 12 Myr, but the emission- line stars, which are most likely to be members of IC 348, have a mean age of 1.3 Myr. Allowance for unresolved binaries would increase this somewhat, but there is a firm upper limit at 2.95 Myr. There is no indication that the ages of the emission-line stars depend upon W(Hα): the IC 348 WTTS as a population are not systematically older than the CTTS, but there is a tendency for the WTTS to be concentrated toward the center of IC 348, while the CTTS are more widely distributed. There is a scattering of emission-Hα stars over the entire area surveyed. There are too many to be explained as low-mass members of an earlier generation of star formation in Per OB2, or as foreground dMe stars. The mass frequency function, based upon some 125 stars fitted to theoretical tracks, rises from 1.5 $M_\odot$ to about 0.2 $M_\odot$, with a slope very much like that of the Scalo IMF. The optical cluster IC 348 radius is about $4'.0$, or 0.37 pc. The total mass of optically-detectable stars in this volume is 57 $M_\odot$, while the mean space density is about 520 stars pc^{-3}. The amount of interstellar material remaining within the cluster is small in comparison. Star formation in the Per OB2/IC 348 region cannot be characterized by one unique age: it appears that stars have been forming in the region now occupied by the association for 10-20 Myr.

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Photoevaporation of Disks and Clumps By Nearby Massive Stars: Application to Disk Destruction in the Orion Nebula

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We present a model for the photoevaporation of circumstellar disks or dense clumps of gas by an external source of ultraviolet radiation. Our model includes the thermal and dynamic effects of 6 – 13.6 eV FUV photons and Lyman continuum EUV photons incident upon disks or clumps idealized as spheres of radius r_d and enclosed mass M_*. For sufficiently large values of r_d/M_*, the radiation field evaporates the surface gas and dust. Analytical and numerical approximations to the resulting flows are presented; the model depends on r_d, M_*, the flux of FUV and EUV photons, and the column density of neutral gas heated by FUV photons to high temperatures. Application of this model shows that the circumstellar disks ($r_d \sim 10^{14} - 10^{15}$ cm) in the Orion Nebula ("proplyds") are rapidly destroyed by the external UV radiation field.

Close ($d \lesssim 10^{17}$ cm) to θ^1Ori C, the ionizing EUV photon flux controls the mass-loss rate and the ionization front (IF) is approximately coincident with the disk surface. Gas evaporated from the cold disk moves subsonically through a relatively thin photodissociation region (PDR) dominated by FUV photons and heated to ~ 1000 K. As the distance from θ^1Ori C increases, the Lyman continuum flux declines, the PDR thickens, and the IF moves away from the disk surface. At $d \sim 3 \times 10^{17}$ cm, the thickness of the PDR becomes comparable to the disk radius. Between 3×10^{17} cm $\lesssim d \lesssim 10^{18}$ cm, spherical divergence and the resultant pressure gradient in the 10^3 K PDR forms a mildly supersonic ($\sim 3-6$ km s^{-1}) but neutral Parker wind. This wind flows outward until it passes through a shock, beyond which gas moves subsonically through a stationary D-type IF. The IF is moved away from the disk surface to a stand-off distance $r_{IF} \gtrsim 2.5\, r_d$. In this regime, the mass-loss rate is determined by the incident FUV photon flux and not the ionizing flux. However, at very large distances, $d \gtrsim 10^{18}$ cm, the FUV photon flux drops to values which cannot maintain the disk surface temperature at $\sim 10^3$ K. As the PDR temperature drops, the pressure of the FUV powered flow declines with increasing distance from θ^1Ori C and again the EUV ionizing photons can penetrate close to the disk surface and dominate the evaporation rate.

Radio, Hα, and [OIII] observations of externally illuminated young stellar objects in the Trapezium region are used to determine r_{IF} and the projected distances $d_\perp$ from θ^1Ori C. The observed values of r_{IF} and $d_\perp$ are combined with the theory to estimate the disk sizes, mass-loss rates, surface densities, and disk masses for the ensemble of extended sources in the Trapezium cluster. Observations of r_{IF}, $d_\perp$, *and* r_d in HST 182-413 and a few other sources are used to calibrate parameters of the theory, especially the column of heated PDR gas. The disks have a range in sizes between $14 < \log(r_d/(\mathrm{cm})) < 15.2$, mass-loss rates of $-7.7 < \log(\dot{M}/(M_\odot/\mathrm{yr})) < -6.2$, surface densities at

disk edge $0.7 < \log(\Sigma(r_d)/(\mathrm{gm/cm^2})) < 2.5$ implying disk surface densities at 1 AU from the central, embedded star $2.8 < \log(\Sigma_0/(\mathrm{gm/cm^2})) < 3.8$, and disk masses $0.002 < M_d/M_\odot < 0.07$. Σ and M_d scale with the adopted ionization time t_i which we take to be 10^5 yrs. The inferred $\Sigma(r_d)$ for the ensemble of disks suggest the initial surface density power law of an individual disk, $\Sigma \propto r^{-\alpha}$, is bounded $1 \lesssim \alpha \lesssim 1.5$.

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Preprints available from: http://www.cita.utoronto.ca/∼johnston/orion.html

An ultraviolet, optical and infrared study of Herbig Ae/Be stars

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We have selected a list of 45 Herbig Ae/Be-type candidates on the base of their IRAS colors and their spectral types. We propose the presence of a broad infrared excess as a defining criterion for these stars, rather than the detection of circumstellar nebulosity. In this way, our selection also includes more evolved young stars, that are no longer embedded in their star-forming region. A few objects in our sample are well-known Herbig Ae/Be stars, others are new. New optical and near-infrared photometric observations, as well as ultraviolet ones, are presented. The position of the objects in several color-color diagrams, as well as their de-reddened energy distributions, permit a reliable classification. Three objects probably are binaries with a cool secondary, 9 appear to be related to the Vega-type stars and 33 objects can be classified as genuine Herbig Ae/Be stars. The majority of the Herbig Ae/Be stars have a dusty environment consisting of a distinct hot and cool component. These isolated Herbig Ae/Be stars suggest an evolution from embedded Herbig Ae/Be stars to β Pictoris-like main-sequence stars, an evolution in which planet formation may play an important role.

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Preprints available at http://www.ster.kuleuven.ac.be/homepage/publications.html

Remnant Molecular Clouds in the Ori OB 1 Association

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We suggest and give some evidence that as an HII region expands and the O star(s) evolve(s) into B giant(s) remains of the molecular clouds first appear as bright-rimmed clouds, then as cometary globules and finally as small clouds which are visible by the reflected light from the B giants. We propose to call the last one "reflection clouds" and all three categories collectively "remnant clouds". A list is presented of about 80 objects of these remnant clouds in the Ori OB 1 association. In the Belt region there is a beautiful spatial sequence from bright-rimmed clouds through cometary globules to reflection clouds. We suspect that retarded star formation in remnant clouds can explain the presence of so-called dispersed T Tau stars in the peripheries of OB associations.

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The Multiplicity of the Hyades and its Implications for Binary Star Formation and Evolution

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A 2.2 μm speckle imaging survey of 167 bright (K < 8.5 mag) Hyades members reveals a total of 33 binaries with

separations spanning 0".044 to 1".34 and magnitude differences as large as 5.5 mag. Of these binaries, 13 are new detections and an additional 17 are now spatially resolved spectroscopic binaries, providing a sample from which dynamical masses and distances can be obtained. The closest 3 systems, marginally resolved at Palomar, were re-observed with the 10m Keck telescope in order to determine accurate binary star parameters. Combining the results of this survey with previous radial velocity, optical speckle, and direct imaging Hyades surveys, the detected multiplicity of the sample is: 98 singles, 59 binaries, and 10 triples.

A statistical analysis of this sample investigates a variety of multiple star formation and evolution theories. Over the binary separation range 0".1 to 1".07 (5 to 50 AU), the sensitivity to companion stars is relatively uniform, with $< \Delta K_{lim} > = 4$ mag, equivalent to a mass ratio $< q_{min} > = 0.23$. Accounting for the inability to detect high flux ratio binaries results in an implied companion star fraction (csf) of 0.30 ± 0.06 in this separation range. The Hyades csf is intermediate between the values derived from observations of T Tauri stars (csf_{TTauri} =0.40±0.08) and solar neighborhood G-dwarfs (csf_{SN} =0.14±0.03). This result allows for an evolution of the csf from an initially high value for the pre-main sequence to that found for main sequence stars.

Within the Hyades, the csf and the mass ratio distribution provide observational tests of binary formation mechanisms. The csf is independent of the radial distance from the cluster center and the primary star mass. The distribution of mass ratios is best fit by a power law $q^{-1.3\pm0.3}$ and shows no dependence on the primary mass, binary separation, or the radial distance from the cluster center. Overall, the Hyades data are consistent with scale-free fragmentation, but inconsistent with capture in small clusters and disk-assisted capture in small clusters. Without testable predictions, scale-dependent fragmentation and disk fragmentation cannot be assessed with the Hyades data.

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Increase of emission and shell features in the spectrum of the FUor V1057 Cyg

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High–resolution échelle spectra of the FUor V1057 Cyg were taken during its minimum brightness in 1996–97. The spectra show the appearance of strong shell–components in the lines of low excitation, an increase of the splitting of the photospheric absorption lines, and the appearance of weak emission lines. It is argued that the mysterious line splitting of the absorption lines in the spectrum of V1057 Cyg, which has been interpreted as originating from an accretion disk, can be explained simply by the presence of central emission cores in the broad absorption lines. This emission spectrum of V1057 Cyg has increased in strength relative to the continuum as the star has faded.

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Broad band infrared spectroscopy of massive young stellar objects

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We present intermediate resolution 0.9–2.5μm IR spectra of 12 highly reddened stars, including some well known and some unfamiliar sources. A new technique for extracting calibration curves from standard star data is employed, and is found to be very successful.

The reddening to each object is fully discussed and is calculated from both the continua (which was split into short- and long-wavelength regions $\lambda\lambda < 1.5\mu$m and $\lambda\lambda > 1.5\mu$m) and the HI lines. We find that, typically, there is consistency between the values derived from the HI lines and the short-wavelength continua, but not with the value from the long-wavelength continua. This discrepancy is due to an IR excess at $\lambda\lambda \gtrsim 1.5\mu$m , which is consistent with emission

from hot dust (we derive dust temperatures in the range 750–1500K).

We note that some of our sources have highly discrepant Paschen decrements, and may have a significant amount of scattered light for $\lambda\lambda < 1.5\mu$m .

The spectra show a variety of metallic emission lines and some evidence for different distinct emission regions in the same source. The range of line-to-continuum contrast between the sources is high, and where previous observations have been taken, there is evidence of variability of emission line strength in some sources.

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First results of an unbiased H_2 survey for protostellar jets in Orion A

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We are conducting an unbiased search at $\lambda 2.12\mu$m for embedded molecular hydrogen jets thought to be associated with very young stellar objects, deeply embedded in dense cores in the Orion A molecular cloud. As a first result, we show a 0.4×0.5 degree mosaic centred on the L 1641-N complex, revealing a number of previously unknown knots and chains of H_2 emission. A 5×5 arcmin close-up of L 1641-N shows it to be a very active region, with at least one parsec-scale jet originating in the small embedded cluster: we also show 10μm imaging to help identify the outflow source. Elsewhere in the mosaic, several knots in the HH 34 jet are detected for the first time in H_2, and a new, deeply embedded jet is discovered next to it. These preliminary results demonstrate the power of H_2 imaging surveys in studying the large-scale role of jets and outflows in star formation.

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Preprints available at http://www.aip.de:8080/~preprint/preprints/1998/1998_h2jets.html

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Dissertation Abstracts

Interferometric Observations of the L 1157 and HH 211 Molecular Outflows

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Ph.D degree awarded: October 1997

One of the signatures of the powerful ejections of matter that occur during the very first steps of star formation is the presence of bipolar molecular outflows around most protostars. This thesis studies the internal structure of two extremely young outflows, through millimeter interferometric observations performed with the IRAM Plateau de Bure interferometer. Large mosaics (of one complete lobe of L 1157 and of the whole HH 211 flow) are presented, for various molecular transitions at λ 3 mm and/or λ 1.3 mm. These maps belong to the very first images of molecular outflows that have been obtained at such a high angular resolution (1–3 arcsecond).

The main results of this thesis can be summarized as follows :

- Two distinct CO cavities are present in the southern lobe of the L 1157 outflow, with slightly different axes. Their brightness distributions and kinematical properties have been explained by a precession model. The SiO emission traces two main shocks, which present a remarkable morphological agreement with the CO flow. Each CO cavity is associated with a shock placed exactly at its apex. The density and velocity distributions of the cavities and (bow-)shocks have also been investigated.
- Continuum and spectral observations of the protostar L 1157-mm have been obtained and provide a detailed description of the close environment of such an extremely young (Class 0) source. The protostellar envelope is strongly perturbated by the powerful outflow. Modelisation shows that such an interacting structure can explain the observed λ 3 mm continuum morphology and the spectral energy distribution of the source. A signature of gravitational infall has also been detected in the ^{13}CO J = 1 $\rightarrow$ 0 line.
- The HH 211 outflow, observed through the CO J = 2 $\rightarrow$ 1 line, presents a remarkable structure in which a fast, extremely collimated, molecular jet emerges from a flattened protostellar condensation. This jet terminates exactly at the position of strong H_2 bow-shocks. It is surrounded by a low-velocity CO cavity, whose shape can be accurately reproduced by simple shock-travelling models. HH 211 appears thus to be a prime test-case for the jet-driven outflow paradigm.

Several aspects of the L 1157 and HH 211 observations are also discussed, among which the formation mechanisms of molecular outflows (the propagation of large bow-shocks seems to be the most promising model) and the formation processes of the SiO molecule within the flows.

Finally, the second part of this thesis presents the algorithms that have been developped to reconstruct and deconvolve images in the case of mosaic interferometric observations. These methods have been used for the L 1157 and HH 211 observations. A multi-resolution algorithm based on `CLEAN` and adapted to the case of mosaics is also presented.

The tidally induced warping, precession and truncation of accretion discs

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A three-dimensional smoothed particle hydrodynamics code is applied to the study of gaseous accretion discs. The numerical accretion disc models are developed and tested. These models are used to investigate the disc response to tidal forcing, for various scenarios, and also to study the stability of self-gravitating discs.

The initial consideration is of a circular orbit binary system in which one of the component stars carries a non-self-gravitating accretion disc and the other is naked and circulating at some inclination to the midplane of the disc. The degree of disc warping and global precession is determined analytically, in a linear perturbation treatment of the fluid equations, and these results are compared with simulations. The disc response is studied as a function of binary mass ratio, separation, inclination and disc thickness. It is demonstrated that differentially rotating discs can precess approximately as rigid bodies provided that the precessional timescale is sufficiently long when compared with the sound-crossing timescale for the disc. For circumbinary discs it is found that if the disc is sufficiently extended then the precession frequency tends to zero and a small warp is maintained at the inner regions. For parabolic encounters it is found that a small precessional displacement effectively tilts the disc midplane. In all cases it is found that tidal truncation can operate effectively in highly inclined systems, although at a lower level than for coplanar systems.

For the self-gravitating disc models, a simple cooling algorithm is developed and incorporated into the hydrodynamics code. It is found that the usual condition for instability to non-axisymmetric perturbations is insufficient to also ensure fragmentation, and instead a higher level of instability than is usually considered appears to be required.

Relevant astrophysical applications of the results are discussed. These include: the precession of jets in X-ray binary systems and star formation regions, the observational appearance of protoplanetary discs in the Orion Nebula, and the origins of supermassive extrasolar planets.

New Jobs

Postdoctoral Position For Study of the Interstellar Medium and Star Formation

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Attention: Prof. K. Mattila

Applications are invited for a postdoc position in the Interstellar Medium research group of the Observatory, University of Helsinki, to begin early 1998. The appointee is expected to participate in observational studies of the interstellar medium and star formation. The studies concern ISM of the Milky Way and some other galaxies using data mainly from from the Infrared Space Observatory, the SEST radio telescope, and the ODIN submillimetre satellite to which the group has access. Focus is on the infrared studies of dust and (sub)millimetre molecular line studies of dense clouds, both with and without star formation. The appointment will be initially until the end of 1999, and can be extended until the end of 2000.

The group consists currently of Prof. K. Mattila, Dr. J. Harju, Dr. M. Juvela, Lic. Paivi Harjunpaa, and MSc K. Lehtinen, with MSc P. Vaisanen and two or three graduate students joining the group during 1998. We have close collaboration with the ISOPHOT PI Team at the MPIA in Heidelberg. Finland has a 5 per cent share of the SEST observing time and a ca. 7 per cent share in ODIN. Standard computing and relevant data analysis facilities are available at the Observatory.

Applicants are requested to submit a curriculum vitae, a list of publications, and a summary of experience and research interests. They should arrange for two letters of reference to be sent directly to the above address.

Application deadline: January 31st 1998.

University of Lisbon / Lisbon Astronomical Observatory

Postdoctoral Position in Star Formation and the Interstellar Medium

Applications are invited for a post-doctoral position to work on a project which combines a theoretical and an observational approach to explore the physical properties, dynamics, and star-forming potential of molecular clouds. The successful applicant should have, or expect to have, a PhD in Astronomy & Astrophysics. Preference will be given to candidates with experience in developing models but good observational skills will also be considered an asset.

He or she will join a small research group working on star formation and the interstellar medium at the University of Lisbon/Lisbon Astronomical Observatory.

The post is available for a period of 2 years starting from 1 May 1998. The salary will be PTE 280,000 monthly or PTE 3,360,000 per anuum. Applicants should include a curriculum vitae, list of publications, a statement of research interests and should arrange for at least three letters of reference sent directly to: *Joao Yun, Dep. Fisica - Faculdade de Ciências, Universidade de Lisboa, Campo Grande, 1700 Lisboa, PORTUGAL.* All materials are due by 28th February 1998.

Additional information may be obtained by contacting Prof. Joao Yun, e-mail: yun@astro.cc.fc.ul.pt.