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## *Abstracts of recently accepted papers*

### Fluorescent Molecular Hydrogen in the Eagle Nebula


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We used the University of New South Wales Infrared Fabry-Perot (UNSWIRF) to investigate the photodissociation region (PDR) associated with the "elephant trunk" features in the M16 H II region (the Eagle Nebula). Images were made in the $H_2$ 1–0 S(1) and 2–1 S(1) lines at 2.122$\mu$m and 2.248$\mu$m, respectively, and in the H I Br $\gamma$ line at 2.166$\mu$m. The trunk–like features have an average $H_2$ number density of $\sim 10^4 \mathrm{cm}^{-3}$ and are irradiated by a far-UV field $\sim 10^4 \times$ the ambient interstellar value. The $H_2$ intensity profile across the trunks is consistent with a simple model in which cylindrical columns of gas are illuminated externally, primarily by a direct component (the stars of NGC 6611), with an additional contribution from an isotropic component (scattered light). We find that most of the $H_2$ emission from the source is consistent with purely fluorescent excitation, however a significant fraction of the $H_2$ emission (∼25%) from the northernmost column shows evidence for "collisional fluorescence", i.e., redistribution of $H_2$ level populations through collisions. This emission is confined to clumps up to ∼0.01 pc in diameter, with densities $\geq 10^5\,\mathrm{cm}^{-3}$, and perhaps $> 10^6\,\mathrm{cm}^{-3}$, filling at most a few percent of the volume of the trunks. The line intensities and ratios are consistent with steady-state and not time-dependent PDR models.



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preprints available at http://sao-www.harvard.edu/ leallen/papers.html


### An Extinction Study of the Taurus Dark Cloud Complex


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We present a study of the detailed distribution of extinction in a region of the Taurus dark cloud complex. Our study uses new $BVR$ images of the region, spectral classification data for 95 stars, and IRAS Sky Survey Atlas (ISSA) 60 and 100 micron images. We study the extinction of the region in four different ways, and we present the first inter-comparison of all these methods, which are: 1) using the color excess of background stars for which spectral types are known; 2) using the ISSA 60 and 100 micron images; 3) using star counts; and 4) using an optical ($V$ and $R$) version of the average color excess method used by Lada et al. (1994). We find that all four methods give generally similar results —with important exceptions. As expected, all the methods show an increase in extinction due to dense dusty regions (i.e. dark clouds and IRAS cores), and a general increase in extinction with increasing declination, due to a larger content of dust in the northern regions of the Taurus dark cloud complex. Some of the discrepancies between the methods are caused by assuming a constant dust temperature for each line of sight in the ISSA extinction maps and not correcting for unexpected changes in the background stellar population (i.e. the presence of a cluster or Galactic gradients in the stellar density and average $V - R$ color). To study the structure in the dust distribution, we compare the ISSA extinction and the extinction measured for individual stars. From the comparison, *we conclude that in the relatively low extinction regions studied, with* $0.9 < A_V < 3.0$ *mag (away from filamentary dark clouds and IRAS cores), there are no fluctuations in the dust column density greater than 45% (at the 99.7% confidence level),*

*on scales smaller than 0.2 pc.* We also report the discovery of a previously unknown open cluster of stars behind the Taurus dark cloud near R.A 4h 19m, Dec. 27° 30′ (B1950).

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## Measuring Galactic Extinction: A Test

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We test the recently published all-sky reddening map of Schlegel, Finkbeiner & Davis (1998 [SFD]) using the extinction study of a region in the Taurus dark cloud complex by Arce & Goodman (1998 [AG]). In their study, AG use four different techniques to measure the amount and structure of the extinction toward Taurus, and all four techniques agree very well. Thus we believe that the AG results are a truthful representation of the extinction in the region and can be used to test the reliability of the SFD reddening map. The results of our test show that the SFD all-sky reddening map, which is based on data from COBE/DIRBE and IRAS/ISSA, overestimates the reddening by a factor of 1.3 to 1.5 in regions of smooth extinction with $A_V > 0.5$ mag. In some regions of steep extinction gradients the SFD map underestimates the reddening value, probably due to its low spatial resolution. We expect that the astronomical community will be using the SFD reddening map extensively. We offer this *Letter* as a cautionary note about using the SFD map in regions of high extinction ($A_V > 0.5$ mag), as it might not be giving accurate reddening values there.

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## Accretion disc evolution in single and binary T Tauri stars

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We present theoretical models for the evolution of T Tauri stars surrounded by circumstellar discs. The models include the effects of pre-main-sequence stellar and time dependent disc evolution, and incorporate the effects of stellar magnetic fields acting on the inner disc. For single stars, consistency with observations in Taurus-Auriga demands that disc dispersal occurs rapidly, on much less than the viscous timescale of the disc, at roughly the epoch when heating by stellar radiation first dominates over internal viscous dissipation. Applying the models to close binaries, we find that because the initial conditions for discs in binaries are uncertain, studies of extreme mass ratio systems are required to provide a stringent test of theoretical disc evolution models. We also note that no correlation of the infra-red colours of T Tauri stars with their rotation rate is observed, in apparent contradiction to the predictions of simple magnetospheric accretion models.

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Preprints are available from: `http://www.cita.utoronto.ca/~armitage/colour_abs.html`

## Ionization and density along the beams of Herbig-Haro jets

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Physical properties of several well-known Herbig-Haro jets are investigated using an improved version of the spectro-

scopic diagnostic technique originally developed by Bacciotti et al. (1995). The procedure allows one to derive in a model-independent way the hydrogen ionization fraction in regions of low excitation. The ionization fraction, the electron and gas density, and the average excitation temperature are derived for various positions along the flows.

We find that the hydrogen ionization fraction, with typical initial values of 20 – 30 %, generally decreases along the whole jet or along parts of the flow, following well-defined recombination laws. These results are consistent with the idea that the gas is initially ionized in the jet acceleration region, and then slowly recombines while traveling away from the source. If shocks along the jet beam are present, they can at most have a minor contribution to the ionization of the gas, as apparent in HH 34 and in the first 45″ of the HH 46/47 jet, where the ionization fraction decreases almost monotonically. In the jets in which re-ionization episodes occur (i.e. HH 24C/E and HH 24G), the ionization fraction suddenly increases and then gently decays *downstream of the re-ionization event.* Both findings apparently disfavour a mini-bow shock interpretation for the production of the ionization of the beam.

The total densities derived from the ratio between the electron density and the ionization fraction range from about $10^3$ to a few $10^4\,\mathrm{cm}^{-3}$. Without applying a correction for shock compression, the average mass loss rate varies from $3.8\ 10^{-8}$ (in the HL Tau jet) to $1.2\ 10^{-6}\,\mathrm{M}_\odot\,\mathrm{yr}^{-1}$ (in HH24 G), while momentum supply rates vary between $1.6\ 10^{-5}$ (in the HL Tau jet) and $3.1\ 10^{-4}\,\mathrm{M}_\odot\,\mathrm{yr}^{-1}\,\mathrm{km\,s}^{-1}$ (in HH 24G). Taking shock compression into account, these values may be reduced by a factor 3 – 5.

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Preprint available at: http://www.tls-tautenburg.de/research/research.html

## BIMA Survey of Protostellar Collapse Candidates in HCO+ and HCN Lines

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We observed protostellar collapse candidates in the lambda=3.4 continuum, the HCO+ J=1-0 line, and the HCN J=1-0 line using the Berkeley-Illinois-Maryland Association interferometer. Regions observed are NGC 1333 IRAS4, L1527, HH 25 MMS, IRAS 16293-2422, Serpens SMM4/2, B335, IRAS 20050+2720, and L1157. These sources were selected from their infall signature (blue-skewed line profile) in a single-dish survey of class 0 sources (Gregersen et al. 1997).

In our HCO+ and HCN spectra, most of the sources show the blueshifted side stronger than the redshifted side, which is consistent with the selection criteria. IRAS 16293 and IRAS 20050B line profiles are more complicated than a simple blue-skewed profile. Serpens SMM2 shows symmetric, single-peaked line profiles. Most of the sources in our survey drive molecular outflows.

We found that NGC 1333 IRAS4A/B, L1527, B335, and L1157 are strong cases for protostellar collapse with relatively simple structures suitable for detailed study. The HCN spectrum toward IRAS 16293 shows that its infall signature from other molecular lines needs careful interpretation. HH 25 MMS, Serpens SMM2-4, and IRAS 20050A/B are embedded in clouds with complex structure and prone to confusion.

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## Low and High Velocity SiO Emission around Young Stellar Objects

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We present a multiline mm-wave survey of SiO emission towards a sample of star-forming regions associated with molecular and Herbig-Haro outflows. The sample includes sources in the northern and southern hemispheres. We extensively mapped some particularly interesting objects (IRAS00338+6312, HH7-11 and CepA). The high detection rate in the sample (52%) confirms that the SiO emission is closely associated with outflows. There exists a trend

so that the more intense SiO sources are associated with higher luminosities, with an average $L_{\rm SiO}/L_{\rm IR}$ ratio of 1.8 $10^{-10}$.

The SiO lines exhibit a variety of profiles, ranging from narrow lines (1-3 km s$^{-1}$ width) at ambient velocities to broad profiles (10-20 km s$^{-1}$), with complex profiles consisting of a blend of low and high velocity components as intermediate stages. In the regions where SiO was mapped, the low velocity SiO emission comes from regions definitely offset from the position where the high velocity emission is present, indicating that the *low* and *high* velocity SiO emissions trace two distinct regimes. The SiO abundances are different in those two regimes: we estimate that typical SiO abundances are $\simeq 10^{-9}$-$10^{-8}$ in the high velocity components, but they decrease by two orders of magnitude ($10^{-11}$-$10^{-10}$) when SiO is detected at low velocities.

The hydrogen volume densities estimated from the multiline SiO observations are in the range $10^5$ to fews $10^6$ cm$^{-3}$, in both the low and the high velocity regimes, indicating that all the SiO emission arises in shock-compressed regions. We argue that the different observed SiO profiles could be caused by an evolutionary effect: the SiO molecules produced at high velocities could be slowed down because of their interaction with the surrounding gas before they stick onto the dust grains. However, the possibility that the low velocity SiO emission is due to slow shocks cannot be ruled out, but this would require the presence of a small amount of silicon compounds on the dust grain mantles.

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## Faint members of the Chamaeleon I cloud

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We present a survey of the central $\sim 100$ arcmin$^2$ of the Chamaeleon I star forming cloud, including objective prism spectroscopy in the H$\alpha$ region and deep imaging in the near-infrared. We estimate the expected number of very low mass objects within the survey, taking as a reference the higher mass members identified in previous studies, and assuming different ages and slopes of the initial mass function of the Chamaeleon I population. A new approach is introduced to estimate the contribution of background objects to the counts of low luminosity sources. This method takes advantage of the fact that the contribution of Chamaeleon I members should be negligible at the faintest magnitudes covered by our survey for any reasonable shape of the initial mass function.

$K$-band source counts indicate the absence of a significant population of very low mass stars, implying that the initial mass function at very low masses, approximated by a power law, has a form $\Phi(\mathcal{M})d\mathcal{M} \propto \mathcal{M}^{-1}d\mathcal{M}$ or flatter. This conclusion is in qualitative agreement with the discovery of six new emission line objects in the objective prism survey, and with the fact that only 2-3 faint objects are detected in the region of the $(J-H)$, $(H-K)$ diagram diagnostic of near infrared excesses of circumstellar origin. The masses of the new emission line objects, derived from recent pre-main sequence evolutionary tracks, are found to be near, and possibly below, the hydrogen burning limit, and their ages to be younger than $3 \times 10^6$ years. One of them is found to be a bona-fide brown dwarf, and its detection in a deep ROSAT exposure makes it the first, and so far the only, brown dwarf known to emit X-rays (Neuhäuser & Comerón 1998, *Science*, 282, 83). The near-infrared properties of the H$\alpha$ emission objects suggest that, unlike at higher masses, strong H$\alpha$ emission near the hydrogen-burning limit is not accompanied by infrared excess detectable in the $K$ band. Comparing the numbers of very low mass objects expected from $K$ band counts with the number of new H$\alpha$-emitting members, for which we derive individual masses and ages, we find that the spectroscopic survey samples the initial mass function completely, or nearly completely, down to the hydrogen-burning limit.

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## A search for HAeBe spectroscopic binaries

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Since 1994, we have carried out in both hemispheres a systematic search for spectroscopic Herbig Ae/Be (HAeBe) binaries. We obtained high resolution visible spectra for 42 stars ($\approx 70\,\%$ of the HAeBe candidates with $m_V < 11$ from Table 1 of the Thé et al. (1994) catalogue).
Two methods were used to spectroscopically identify a HAeBe as a binary star. 1): search for radial velocity variations: we mainly used the He I 5 876 and 6 678, Na I 5 890 and 5 895, Si II 6 347 and 6 371 Å lines. 7 stars show radial velocity variations, namely TY CrA, T Ori, MWC 1080, all already known as variable, plus MWC 300, AS 442, MWC 361 and HD 53367, which are new spectroscopic binaries candidates. Besides of the well studied TY CrA triple system (see authors' previous papers), tentative orbital solutions are proposed for HD 53367 ($P = 166$d., $e = 0.18$) and for AS 442 ($P = 64$d., $e = 0.24$). 2): search for Li I 6 708 Å absorption: Martin (1994) pointed out that in hot intermediate-mass stars, the Li I absorption line, extremely weak, is not detected. If the spectroscopic signature of this element is present in the spectrum of a HAeBe star, it reveals then the presence of a young lower mass companion. The Li I 6 708 Å absorption line is found in 7 HAeBe spectrum binaries: HK Ori, V380 Ori, TY CrA, plus V586 Ori, NX Pup(A+B), HD 203024 and MWC 863 which are new detections. We note that the Fe I 6 678 and Ca I 6 718 Å lines, even if harder to detect that the Li I line, are other features that sign the existence of a cooler companion.
We found the trend that X-ray emission is a possible indicator of binarity for HAeBe stars: it would be worth to observe 7 spectroscopic binary systems whose X-ray properties are unknown to definitively assert it. Within our reduced sample, the observed binary frequency for short-period ($P < 100$d.) spectroscopic HAeBe systems is roughly comparable to the one of T Tauri or Main Sequence stars ($fb \approx 10\,\%$). We however emphasize that, because of strong biases working against the detection of spectroscopic HAeBe binary stars (velocity measurement difficulties or unfavorable luminosity ratio between components), *at least* 50 % of the spectroscopic binaries could have been missed.

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## The jet-driven molecular outflow of HH 211

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We present high angular resolution (down to $\sim 1.5''$) interferometric maps of the CO J = 1→0 and J = 2→1 emission in the molecular outflow associated with the extremely young HH 211 jet, which is located in the IC 348 molecular complex. At velocities close to the systemic velocity, the CO emission traces the outflow cavities, while an extremely collimated, continuous jet-like structure is observed at high CO velocities. The continuum emission reveals a $\sim 0.2\ M_\odot$ dust condensation surrounding the central exciting (Class 0) protostar, clearly resolved and elongated perpendicular to the jet axis. The strong (bow-)shocks observed in vibrationally excited $H_2$ emission are located at the terminal ends of the jet and the low-velocity CO cavities are precisely situated in their wake. Hence, the overall structure of HH 211 perfectly fits into the picture of a jet-driven flow and strongly supports shock-entrainment models as the formation mechanisms of young, embedded molecular outflows. The shape of the cavities traced by the low-velocity CO emission can actually be (surprisingly well) reproduced by a simple, semi-analytical toy-model of a jet-driven flow, in which prompt entrainment occurs at the head of a travelling bow-shock. The estimated jet mass and mass loss rate yield a timescale of order one thousand years, in agreement with the kinematical age. Finally, we discuss the physical properties of the different parts of the outflow, and especially the actual nature of the high-velocity CO jet.

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## The magnetic field structure of the DR21 region

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We present results of imaging polarimetry of the $H_2$ v=1-0 S(1) line towards the outflow lobes of DR21. The polarisation vectors are produced by dichroic absorption in a medium of aligned grains and therefore delineate the direction of the magnetic field, projected onto the plane of the sky, aligning those grains. It is argued that the polarisation is dominated by grains within the DR21 cloud. The magnetic field strength, estimated from the dispersion of position angles of the polarisation vectors, is $\sim 0.07$ mG, which is not sufficient to play a significant role in either halting the outflow, or confining its lateral expansion.

The polarimetry of the $H_2$ v=1-0 S(1) line suggests that the magnetic field is parallel to the outflow axis for the eastern outflow lobe, whereas it appears twisted perpendicular to this axis for the western lobe. This peculiar morphology for the magnetic field may imply either the presence of a two component magnetic field along the line of sight, or of a complex, wound up magnetic field.

A copy of the paper maybe obtained directly from : http://www.jach.hawaii.edu/∼acc/pubs.html

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## Gravitational Collapse of Filamentary Clouds

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We consider gravitational collapse of a filamentary cloud under the assumption that it is axisymmetric and uniform along the axis. The pressure is approximated by a polytrope of $P = K\,\rho^{\gamma}$. We found a similarity solution for the collapse when the polytropic index lies in the range $0 < \gamma < 1$. According to the similarity solution, the collapse consits of two phases. In the first phase the filament becomes denser and thiner. The density at the center ($\rho_{\rm c}$) increases in proportion to $(t_0 - t)^{-2}$, where $t_0$ denotes the epoch at the end of the first phase. Meanwhile, the filament diameter (FWHM) decreases in proportion to $(t_0 - t)^{(2-\gamma)}$. The line density of the central filament of $\rho > 0.1\,\rho_{\rm c}$ vanishes at $t = t_0$, since it is proportional to the central density and the square of the diameter [$\propto (t_0 - t)^{2(1-\gamma)}$]. In the second phase the central filament grows in mass by accretion. The collapse in the second phase is similar to the inside-out collapse of a spherical gas cloud. When the polytropic index $\gamma$ is closer to unity, the collapse is slower. When $\gamma = 0.999$, the collapse is 12-times slower than the dynamical one. We also found from numerical simulations having various initial conditions that the collapse of a filamentary cloud approaches asymptotically the similarity solution irrespectively of the initial condition.

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## On the Azimuthal Structure of Thermal Convection in Circumstellar Disks

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We study the three-dimensional global structure of thermal convection in a protoplanetary accretion disk. For that

purpose, we have developed a new versatile 3D hydrocode which incorporates radiation transport and tensor viscosity in different coordinate systems. The code was extensively tested internally by recalculating the most recent models of circumstellar disk convection. With our new code we were able, for the first time, to simulate the large-scale (azimuthal) structure of circumstellar disk convection as it will develop under the assumption of an $\alpha$ viscosity. We find that axisymmetry is broken and convective motions with an azimuthal wavelength of about four pressure scale heights form.

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## Near-infrared Spectropolarimetry of Three Prototype Low-mass YSOs in Taurus Dark Cloud

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We present near-infrared spectropolarimetric data between 0.9 and 4.2 $\mu$m for three prototypes of low-mass young stellar objects (YSOs), L1551 IRS5, HL Tau and T Tau in Taurus dark cloud. Those sources are in different classes in the standard spectral classification scheme of low-mass YSOs by Lada.

The polarization curves of the observed sources show distinct differences. The Class I protostar L1551 IRS5 shows a flat polarization curve with high polarization through the observed wavelengths. It also shows a polarization excess at the 3.1 $\mu$m ice band abosorption feature. The "flat-spectrum source" HL Tau, which is thought to be in a transient phase from Class I to Class II, shows a steep decrease of polarization with increasing wavelengths from 1.0 to 2.5 $\mu$m, while it shows a flat polarization curve with high polarization in optical wavelengths and a slowly decreasing slope with small polarization in 3$-$4 $\mu$m. The Class II source "T Tau" shows small polarization no more than 2% through the observed wavelengths; the polarization in the shorter wavelengths from optical to 1.3 $\mu$m decreases with increasing wavelengths. T Tau also shows an increasing polarization curve in the longer wavelengths over 1.6 $\mu$m, which is most likely to come from the infrared companion T Tau S (Kobayashi et al.).

The prominent differences of the observed near-infrared polarization curves can be clearly understood in terms of the standard spectral classification scheme of low-mass YSOs. Thus, near-infrared spectropolarimetry could serve as a potentially powerful diagnostic of circumstellar material, complementary to the standard spectral classification.

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## Looking at the bright side of the $\rho$ Ophiuchi dark cloud

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We present far infrared (45–195 $\mu$m) spectrophotometric observations with the Iso-Lws of the active star forming $\rho$ Oph main cloud (L 1688). The [C II] 158 $\mu$m and [O I] 63 $\mu$m lines were detected at each of the 33 positions observed,

whereas the [O I] 145 $\mu$m line was clearly seen toward twelve.

The principal observational result is that the [C II] 158 $\mu$m line fluxes exhibit a clear correlation with projected distance from the dominant stellar source in the field (HD 147889). We interpret this in terms of PDR-type emission from the surface layers of the $\rho$ Oph cloud. The observed [C II] 158 $\mu$m/[O I] 63 $\mu$m flux ratios are larger than unity everywhere. A comparison of the [C II] 158 $\mu$m line emission and the FIR dust continuum fluxes yields estimates of the efficiency at which the gas in the cloud converts stellar to [C II] 158 $\mu$m photons ($\chi_{\rm C\,II} \gtrsim 0.5\%$).

We first develop an empirical model, which provides us with a three dimensional view of the far and bright side of the dark $\rho$ Oph cloud, showing that the cloud surface towards the putative energy source is concave. This model also yields quantitative estimates of the incident flux of ultraviolet radiation ($G_0 \sim$ $10^1$ – $10^2$) and of the degree of clumpiness/texture of the cloud surface (filling of the 80″ beam $\sim 0.2$).

Subsequently, we use theoretical models of PDRs to derive the particle density, $n$(H), and the temperature structures, for $T_{\rm gas}$ and $T_{\rm dust}$, in the surface layers of the $\rho$ Oph cloud. $T_{\rm gas}$ is relatively low, $\sim 60$ K, but higher than $T_{\rm dust}$ ($\sim 30$ K), and densities are generally found within the interval (1–3) $10^4$ cm$^{-3}$. These PDR models are moderately successful in explaining the LWS observations. They correctly predict the [O I] 63 $\mu$m and [C II] 158 $\mu$m line intensities and the observed absence of any molecular line emission. The models do fail, however, to reproduce the observed small [O I] 63 $\mu$m/[O I] 145 $\mu$m ratios. We examine several possible explanations, but are unable to uniquely identify (or to disentangle) the cause(s) of this discrepancy.

From pressure equilibrium arguments we infer that the total mass of the $\rho$ Oph main cloud (2 pc$^2$) is $\sim 2\,500\ M_\odot$, which implies that the star formation efficiency to date is $\lesssim 4\%$, significantly lower than previous estimates.

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ftp://ftp.astro.su.se/pub/rene/rhoOph_I.ps.gz (339 Kb; 2 colour figs.)

## L1448 IRS2: A HIRES-Identified Class 0 Protostar

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We present far-infrared and submillimeter images and millimeter continuum photometry for L1448 IRS2, a low-luminosity (5.2 $L_\odot$), embedded young stellar object discovered by *IRAS* (the *Infrared Astronomical Satellite*). New far-infrared maps were produced from the archival *IRAS* data via HIRES processing, the name given to the implementation of the Maximum Correlation Method for image construction from the *IRAS* data streams. The HIRES-processed images of L1448 IRS2 presented here have effective resolutions of $\sim 35'' \times 28''$, $\sim 35'' \times 37''$, and $\sim 45'' \times 40''$ at 25, 60, and 100 $\mu$m, respectively, which represent an order of magnitude improvement over previously available far-infrared maps. L1448 IRS2 was mapped at 450 microns and 850 microns and we acquired continuum photometry at 1.3 mm. With these new data, we plot the most complete spectral energy distribution (SED) for L1448 IRS2 to date.

We also present sensitive $^{12}$CO J=1→0 emission line maps of a $47' \times 7'$ area of the L1448 dark cloud, centered on L1448 IRS2, obtained with the On-The-Fly (OTF) imaging capability of the NRAO 12-meter telescope. As a direct consequence of this mapping, we have discovered a parsec-scale molecular outflow associated with L1448 IRS2.

The combined continuum and molecular line data confirm the classification of L1448 IRS2 as a new member of the rare, short-lived (a few $\times 10^4$ yr), Class 0 phase of protostellar evolution. The use of HIRES imaging of *IRAS* data as a promising tool for identifying protostellar candidates is demonstrated by the example of L1448 IRS2.

Accepted by Astrophysical Journal

## (Sub)mm continuum observations of NGC 6334A

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We present 2 mm, 1.1 mm, 850 $\mu$m, 800 $\mu$m, and 450 $\mu$m mapping and photometry of the field surrounding NGC 6334A. We find a prominent east–west dust ridge, approximately centered on NGC 6334A. We interpret this ridge as a collimating dust disk or torus and derive a mass of $\sim$60 $M_\odot$ from our continuum data. It is possible though, that this disk–like structure is contaminated on the west-side by a protostellar source, seen as an $H_2O$ maser. We find a second strong source MM2, near MM1 in the immediate vicinity of the HII region. $H^{13}CO^+$ J = 4 - 3 spectra of MM1 and MM2 confirm that it is a separate source. MM2 approximately coincides with IRS3, a 10 $\mu$m source, which in earlier studies has been proposed to be a protostar. We estimate MM2/IRS3 to have a mass of $\sim$50 $M_\odot$. We find two other protostellar candidates: MM3 and MM4. MM3 is a relatively compact source with a mass of 150 $M_\odot$ and connected by a ridge of dust to the HII region, while MM4 is is fainter and more extended.

We also see a thin shell of dust surrounding the red–shifted ionized outflow lobe, presumably swept up by the outflow. The dust shell has a mass of $\sim$60 $M_\odot$. There is clearly less dust emission towards the north, and we do not see the same interaction between the ionized outflow and the surrounding molecular cloud as we see to the south.

Accepted by Astronomy & Astrophysics

## A jet–driven, extreme high–velocity outflow powered by a cold, low–luminosity Protostar near NGC2023

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We have discovered an extreme high-velocity bipolar CO outflow in the vicinity of NGC 2023, with total outflow velocities of $\sim$ 200 km $s^{-1}$. At very high velocities this outflow is jet–like with an opening angle $\leq 4°$, while it shows a separate outflow lobe at low velocities. The outflow is bipolar and exhibits a clear mirror symmetry, suggesting that the source powering the outflow is episodic or precessing. The dynamical timescales for the outflow are $\leq$ 3000 yr. We identify the source driving the CO jet with a deeply embedded low luminosity sub–mm double source (separation $\sim 23''$ ), where the primary component lies on the symmetry axis of the outflow and has all the signatures of a "Class 0" protostellar object. Analysis of molecular data and (sub)-mm photometry suggests that the driving source is cold and compact, with a luminosity of $\leq$ 10 $L_\odot$ and a total mass of 1.8 – 4.6 $M_\odot$. It has no near-IR counterpart, it drives an extremely young ouflow and emits a large fraction of its luminosity in the sub–mm regime. Both mm–sources have low dust emissivity, $\beta \sim 0.8 - 1.3$, similar to what is found for other Class 0 objects, while the surrounding molecular cloud core appears to have a $\beta \sim 2.0$, the canonical value for "normal" interstellar dust in the sub–mm regime.

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## Rapid variations of T Tauri spectral features: Clues to the morphology of the inner regions

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We have monitored the optical spectra of six T Tauri stars, AA Tau, BP Tau, CI Tau, DR Tau, RY Tau and SU Aur, approximately hourly over 5 successive nights. Our spectral range extends from 3800Å to 7300Å, including the Balmer series lines from H$\alpha$ to H$\delta$, Ca II H+K and various Fe II lines. We construct time series of equivalent widths for each species to study the variations of the strengths of the different lines, and the correlations between them. We can discern a range of physical processes at work, such as the slow rotation of the stars (timescales of days), magnetic flaring activity (timescales of about an hour), variable accretion (timescales of several hours) and obscuration by circumstellar material (again, timescales of several hours). The sample objects show a range of activity in each of these categories, from DR Tau (dominated entirely by hour-timescale activity) to those with only slowly-varying line activity consistent with rotation (AA Tau). For objects in between these extremes, we differentiate the activity according to timescale, short timescale events often appearing superimposed on longer timescale variations. We examine the correlation in time between the rapid activity of the different emission features, which are formed under a wide range of excitation conditions. The lower Balmer lines (H$\alpha$ and H$\beta$) and Ca II K are usually strongly correlated with one another, as are the higher Balmer lines (H$\gamma$ and H$\delta$), but the behaviour of these two groups sometimes becomes decoupled. In one particular case for the active object DR Tau, we see well-correlated but time-lagged activity, occurring sequentially with the high energy lines varying first, followed by lines of successively lower excitation temperature. We tentatively conclude that this may be the signature of an accretion shock moving over the stellar limb.

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http://www.astro.phys.ethz.ch/papers/smith/smith.html

## Shocked $H_2$ and $Fe^+$ Dynamics in the Orion Bullets

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Observations of $H_2$ velocity profiles in the two most clearly defined Orion bullets are extremely difficult to reconcile with existing steady-state shock models. We have observed [FeII] 1.644 $\mu$m velocity profiles of selected bullets and $H_2$ 1-0 S(1) 2.122 $\mu$m velocity profiles for a series of positions along and across the corresponding bow-shaped shock fronts driven into the surrounding molecular cloud. Integrated [FeII] velocity profiles of the brightest bullets are consistent with theoretical bow shock predictions. However, observations of broad, singly-peaked $H_2$ 1-0 S(1) profiles at a range of positions within the most clearly resolved bullet wakes are not consistent with molecular shock modelling. A uniform, collisionally broadened background component which pervades the region in both tracers is inconsistent with fluorescence due to the ionizing radiation of the Trapezium stars alone.

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http://ast.leeds.ac.uk/∼jat/index.html

## Precession of collimated outflows from young stellar objects

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We consider several protostellar systems where either a precessing jet or at least two misaligned jets have been observed. We assume that the precession of jets is caused by tidal interactions in noncoplanar binary systems. For Cep E, V1331 Cyg and RNO 15–FIR the inferred orbital separations and disk radii are in the range 4–160 AU and

1–80 AU, respectively, consistent with those expected for pre–main sequence stars. Furthermore, we assume or use the fact that the source of misaligned outflows is a binary, and evaluate the lengthscale over which the jets should precess as a result of tidal interactions. For T Tau, HH1 VLA 1/2 and HH 24 SVS63, it may be possible to detect a bending of the jets rather than 'wiggling'. In HH 111 IRS and L1551 IRS5, 'wiggling' may be detected on the current observed scale. Our results are consistent with the existence of noncoplanar binary systems in which tidal interactions induce jets to precess.

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Also available at http://www.ucolick.org/~ct/home.html and http://www.tls-tautenburg.de/research/research.html

## Proper motions of faint ROSAT WTT stars in the Chamaeleon region

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We present proper motions of 59 stars of the ROSAT All-Sky Survey (RASS) located in direction of the Chamaeleon star forming region (SFR) in the magnitude range B=5.1 - 17 mag. Proper motions of the fainter stars were newly derived utilizing survey Schmidt plates from the GSC II plate archive and from a set of special plates taken with the ESO Schmidt telescope. The vector point diagram (VPD) indicates that the certified WTT stars cluster away from the region occupied by the brighter pre-main-sequence stars (PMS) in Cha I. The distance to this new association is estimated at $\sim$ 100 pc, sensibly smaller than the 150 pc generally assumed for the SFR. This yields an upper limit of 2 km $s^{-1}$ for the velocity dispersion of this new kinematic group.

The de-reddened CM diagram of the group members suggest the WTT stars are still PMS objects, but older (3-30 Myr) and less massive than previous determinations. These revised age estimates, the newly derived group peculiar velocity, and current distance estimates to the Cha I/II/III complex would favour in-situ formation against that predicted by high velocity cloud models. Finally, based on a redetermination of the peculiar motions of stars and gas, we speculate that the whole SFR originated from the local Orion spur as a result of more classical mechanisms like interactions with the spiral arms.

Accepted by Astronomy & Astrophysics Letters

## Numerical hydrodynamic simulations of molecular outflows driven by hammer jets

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Very young protostars eject collimated jets of molecular gas. Although the protostars themselves are hidden, some of their properties are revealed through the jet dynamics. We here model velocity shear, precession, pulsation and spray within dense jets injected into less-dense molecular clouds. We investigate the Hammer Jet, for which extreme velocity variations as well as strong ripping and spray actions are introduced. A three dimensional ZEUS-type hydrodynamics code, extended with molecular physics, is employed.

Jet knots, previously shown to be compact in simulations of smoother jets, now appear as prominent bow shocks in $H_2$ and as bullets in CO emission lines. High proper motions are predicted in the jet. In the lobes we uncover wide tubular low-velocity CO structures with concave bases near the nozzle. Proper motion vectors in the lobes delineate a strong accelerated flow away from the head with some superimposed turbulent-like motions. The leading bow is gradually distorted by the hammer blows and breaks up into mini-bow segments. The $H_2$ emission line profiles are wide and twin-peaked over much of the leading bow.

On comparison with the simulations, we identify observed outflows driven by various dynamical types of jet. Shear

is essential to produce the jet bows, spray or precession to widen the outflows and hammer blows to generate knotty jets. We identify the proper motions of maser spots with the pattern speed of density peaks in the inner jet and shell.

Accepted by A&A

Preprints from http://star.arm.ac.uk/ mds/

## Submillimeter Imaging of T Tauri's Circumbinary Disk and the Discovery of a Protostar in Hind's Nebula

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We have obtained images at 2.2, 450 and 850 $\mu$m of the pre-main sequence binary T Tauri and of Hind's Nebula, which is located less than one minute of arc west of T Tauri. The three maps reveal that the nebulosity around T Tauri is extended, with a full-width-half-maximum size of several hundred AU in thermal emission and more than 1000 AU in reflected light. Dust clearly connects the circumstellar nebula around T Tauri to the southwestern tip of Hind's Nebula, where we have identified a secondary intensity peak in the submillimeter maps. Calculations of the long wavelength emissivity demonstrate that the dust emissivity index $\beta$ is $\sim$2 for the large nebula but is $\sim$1.2 for the secondary intensity peak. These results for $\beta$ suggest that we have found a Class I protostar 30$''$ southwest of T Tauri and that star formation is more active in the vicinity of T Tauri than previously had been thought. This protostar is detected directly at submillimeter wavelengths; however, polarization mapping at 2.2 $\mu$m demonstrates that the disk-shaped dust cloud around the protostar is illuminated externally at short wavelengths, making it similar to the Orion proplyds.

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## Episodic accretion around the Herbig Ae star BF Ori: Evidence for the presence of extra-solar comets

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The results of a monitoring programme of high and intermediate resolution spectra covering He I 5876 Å, Na I$D_{2,1}$ and H$\alpha$ of the isolated Herbig Ae star BF Ori are presented. We detect the presence of blue and redshifted emission and absorption components of these lines which vary from day-to-day with correlated changes suggesting a similar origin.

The appearance, strength and variations of the redshifted Na I $D$ absorption component on a time scale of days show variable accretion activity similar to that seen toward the Herbig Ae star UX Ori and $\beta$ Pic, suggesting evaporation of star-grazing bodies. We estimate for one event that such a body is kilometer sized, evaporates at a distance of about 0.4 AU from the central star and has a mass comparable to comets in the solar system.

A dependence was found of the H$\alpha$ line profile on the photometric brightness of BF Ori similar to that observed for UX Ori. It is evidence for obscuration of a dense dusty body located in the outer disk regions as no extra absorption

components from a gaseous content and no direct influences on the cometary activity were observed. More complex variations of the H$\alpha$ profile could be explained in part by absorption of star-grazer material, equal to the absorption at the sodium lines, and in part by obscuration of its line forming region by the cometesimal. More evidences for detections of revolving clumpy material are: observed changes in the velocity direction of the very strong Na I$D_{2,1}$ low velocity absorption components and the observed flip over of the relative strength of the blue and red peak of H$\alpha$ simultaneous with the change of blue to redshifted absorption components in both the Na I$D_{2,1}$ and He I lines. In case of orbiting bodies, the estimated period lies between 60 and 100 days with a distance from 0.35 to 0.57 AU, respectively.

The detection of possible orbiting and comet-like objects in the disk of BF Ori, a $3^{+2}_{-1}$ Myr old pre-main sequence A5 - 6 IIIe star, making it a possible progenitor of the HR 4796 (protoplanetary) disk system, suggests the existence of structures similar to those probably present in the solar system at a time of formation of planetesimals. The estimated much higher than cosmic abundances of refractory (Na) over volatile (H, He) gases for the detected bodies supports this suggestion.

Accepted by Astronomy & Astrophysics

*Preprints are available on anonymous ftp site: ftp.iac.es pub/preprints/dwinter_bfori.ps*

## Vibrationally excited $HC_3N$ toward hot cores

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We report IRAM 30-m observations of vibrationally excited rotational transitions of $HC_3N$ toward a sample of six ultra–compact HII regions. In addition, Effelsberg 100-m and Plateau de Bure Interferometer measurements were conducted toward the region G10.47+0.03. We detected the $v_7 = 1$ state of cyanoacetylene toward all six regions and the $v_6 = 1$ line toward five of them. Toward G10.47+0.03, we detected lines from 11 different vibrationally excited states with excitation energies up to 1600 K above ground. Of these, six are first detections. We also have detected several transitions of $^{13}$C substituted cyanoacetylene in the $v_6 = 1$, $v_7 = 1$, and $v_7 = 2$ states and provide improved rest frequencies for several of these. The population distribution of the vibrationally excited $HC_3N$ molecules is analyzed and it is concluded that our results are consistent with thermalised level populations at a temperature of 270 K. From the interferometer results we find the source of $HC_3N$ emission to be coincident with $NH_3$(4,4) and $CH_3CN$ emission within the positional error of 1″.

In an appendix, we report the first astronomical detection of lines from vibrationally excited HNCO in G10.47+0.03.

Accepted by A&A

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## Postdoctoral Research Fellowship

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Further details can be obtained from Dr. Burton (email: M.Burton@unsw.edu.au; tel: +61-2-9385-5618; fax: +61-2-9385-6060; URL: www.phys.unsw.edu.au/astro.html). Applications should include a CV, a bibliography and a statement of research interests and plans. They should be sent to Dr. Burton at the School of Physics, University of New South Wales, Sydney, NSW 2052, Australia before March 1, 1999. Applicants should arrange for up to three letters of recommendation to arrive at the same address by this date.

*New Books*

# Origins

**Edited by C.E. Woodward, J.M. Shull, & H.A. Thronson, Jr.**

These are the proceedings of a meeting focused on our many-sided origins. In this book, astronomers, planetary scientists, exobiologists and atmospheric physicists are examining a range of fundamental questions related to the origin of galaxies, stars, planets, and life. Since NASA has adopted *Origins* as one of its strategic themes, these questions are being addressed by the launch of a series of advanced space missions, also discussed in the book. The combination of these missions with significant efforts from groundbased observations as well as theoretical work offers the promise that Origins-related disciplines will be at the forefront of research in the coming decade. This book provides an interdisciplinary overview of the current status of these fields.

The following lists the sections and chapters of the book.

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The Star Formation Newsletter is a vehicle for fast distribution of information of interest for astronomers working on star formation and molecular clouds. You can submit material for the following sections: *Abstracts of recently accepted papers* (only for papers sent to refereed journals, not reviews nor conference notes), *Dissertation Abstracts* (presenting abstracts of new Ph.D dissertations), *Meetings* (announcing meetings broadly of interest to the star formation and interstellar medium community), *New Books* (giving details of books relevant for the same community), *New Jobs* (advertising jobs specifically aimed towards persons within our specialty), and *Short Announcements* (where you can inform or request information from the community).

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*Meetings*

# DISKS, PLANETESIMALS & PLANETS

**Puerto de la Cruz, Tenerife**

**24-28 January 2000**

A conference organized by EXPORT
(EXoPlanetary Observational Research Team)

Preliminary Announcement

The recent discoveries of extrasolar planets and the progress in studies of disks around pre-main sequence and main sequence stars highlight the need of better understanding the formation and evolution of planetary systems. Many groups and observatories are dedicating important efforts towards these goals. The 1998 international time of the Canary Islands Observatories is fully devoted to studies related to these topics, making use of spectroscopic, polarimetric and photometric techniques in the optical, as well as near-IR photometry.

The conference is the frame where the large amount of data collected with the facilities in the Canary Islands will be presented. In addition, contributions from participants addressing theoretical models and observations in all wavelength ranges will provide an updated overview of the field.

The conference will last five days (including a free afternoon) and will consist of sessions with invited and contributed talks and poster. Sessions will devoted to:

(a) PMS objects: circumstellar (protoplanetary) disks around protostellar objects, PMS stars and Vega-type stars; (b) Planetesimals in PMS and MS stellar systems; (c) Planets around stars; (d) Searches for planets; (e) Impact on planetary system studies of future space and ground-based facilities.

Scientific Organizing Committee: C. Eiroa (chair), R. Ferlet, A. Penny, A. Quirrenbach, H. Rauer, P.R. Wesselius, D. de Winter (co-chair).

A detailed scientific programme will be elaborated in the next few months. We can anticipate, however, contributions from EXPORT observations addressing (not necessarily this distribution):

* Intermediate and high spectral resolution observations of PMS and Vega-type stars

* Optical polarimetry and photometry and near-ir photometry of PMS and Vega-type stars

* Spectral signatures of the atmospheres of exo-planets

* Search for planets: microlensing and transits in clusters

The 1st Announcement of the meeting will be issued March 1, 1999. It will include a preliminary scientific programme, membership of the SOC, invited speakers, registration forms and instructions for abstracts, hotel reservation and travel information, social events, etc.

Information on the meeting will regularly be updated at the Conference Web page that can be found from January 1999 on: http://www.iac.es/MEETINGS.html

Inquiries about the meeting can be e-mailed to the address: planet@ll.iac.es

or post to:

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