THE STAR FORMATION NEWSLETTER

An electronic publication dedicated to early stellar evolution and molecular clouds

No. 107 — 9 September 2001 Editor: Bo Reipurth (reipurth@casa.colorado.edu)

Abstracts of recently accepted papers

The spectral variability of the Classical T Tauri star DR Tau

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We present the analysis of 103 spectra, collected over more than a decade, of the Classical T Tauri star DR Tau observed with the Hamilton echelle spectrograph at Lick Observatory. The star exhibits strong emission lines that show substantial variety and variability in their profile shapes. The emission lines show signatures of both outflow and infall which vary on multiple timescales. The system shows quasi-periodic variations in line intensity and wavelength, but we are unable to recover a unique period that describes all of the data. The Balmer and He I line changes are well correlated and appear to result from real variations in the accretion and wind flows, as opposed to apparent variations caused by changes in the veiling continuum flux. The Balmer line profiles are generally strongly peaked in the red ($v \sim 100$ km s^{-1}), and do not resemble published theoretical magnetospheric accretion profiles. We suggest that the system is seen nearly pole-on. Coupled with a line emissivity that increases strongly near the stellar surface, this can explain the strongly asymmetric Balmer line profiles. The Ca II and He I emission line components are found to be very symmetric and Gaussian in shape, suggesting production in a turbulent (possibly magnetic) region. An additional, sporadic, high-velocity outflow component is seen in the Balmer lines and He I. The main characteristic of the lines is their dramatic variability, which indicates a very dynamic interaction between the star and the disk. This is illustrated in several MPEGs showing the line profile variations of DR Tau which are available on CDROM and at http://sprg.ssl.berkeley.edu/∼cmj/html/drtau.html.

Accepted by Astron. J.

Preprints are available at http://www.iagusp.usp.br/∼alencar/drtau/

VLA Detection of the Exciting Sources of the HH 211 and HH 68 Outflows

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We present sensitive Very Large Array observations at 3.5-cm toward ten regions with Herbig-Haro flows. We detect for the first time at centimeter wavelengths the exciting sources of the HH 211 and HH 68 outflows. We also present 7-mm observations of the exciting source of HH 211. Our analysis of the cm and mm spectrum indicate that in this source the 3.5 cm emission is dominated by free-free emission from a thermal jet, while the 7-mm emission is dominated by dust emission most probably arising from a disk. This disk is small, with radius smaller than 10 AU, placing it in the category of compact protoplanetary disks. The exciting source of HH 68 coincides with the object HH 68b, as

previously suggested by other authors. We also find that the exciting source of the HH 119 flow in B335, previously reported at centimeter wavelenghts, is time-variable.

Accepted by Revista Mexicana de Astronomía y Astrofísica

http://www.astrosmo.unam.mx/˜r.avila/publis.html

Optical spectroscopy of isolated planetary mass objects in the σ Orionis cluster

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We have obtained low resolution optical spectra of 15 isolated planetary mass objects (IPMOs) in the σ Orionis cluster, and derived spectral types by comparison with nearby M and L dwarfs. The spectral types are in the range late M – mid L, in agreement with our expectations based on colors and magnitudes for bona fide members. Therefore, most of these objects have masses below the deuterium burning limit. About 2/3 show Hα in emission at our spectral resolution. From our spectroscopic and photometric data, we infer that three IPMOs in this sample may be binaries with components of similar masses. These results confirm that the substellar mass function of the σ Orionis cluster, in the form dN/dM, keeps rising in the planetary domain.

Accepted by Astronomy and Astrophysics Letters

http://xxx.lanl.gov/abs/astro-ph/0108249

Gas Giant Protoplanet Formation: Disk Instability Models with Thermodynamics and Radiative Transfer

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Doppler spectroscopy of nearby stars has shown that extrasolar gas giant planets often have masses considerably in excess of that of Jupiter, while observations of young stars imply that the gaseous portions of protoplanetary disks have lifetimes typically of no more than a few million years. Both discoveries raise questions about the universality of the mechanism long favored for Jupiter formation, core accretion. Forming Jupiter by core accretion requires a gas surface density at 5 AU of about 10^3 g cm^{-2}. Combined with midplane temperatures cold enough to form comets ($< 50K$), this leads to a marginally gravitationally unstable gas disk. High spatial resolution, three dimensional (3D) hydrodynamical models of "locally isothermal" disks have shown that gas giant protoplanets may form in such a marginally unstable disk, with masses comparable to the more massive extrasolar planets, and well within expected disk lifetimes. However, "locally isothermal" models err on the side of encouraging protoplanetary clumps to form, whereas models by other workers using less permissive thermodynamical assumptions have suggested that clump formation is prohibited. We present 3D models with an approximate treatment of heating and cooling, including radiative transfer in the diffusion approximation, which show that disk instability can still proceed in much the same manner as in "locally isothermal" models, because the time scale for significant nebular cooling is comparable to that for the instability to grow, i.e., an orbital period. The models suggest that disk instability remains as a likely means for the widespread formation of gas giant planets. Core accretion apparently requires exceptionally long-lived disks to form Jupiters, and so would predict that gas giant planets are relatively rare. If the disk instability mechanism can occur, however, extrasolar gas giant planets should be relatively abundant.

Accepted by Astrophys. J.

Preprint available at http://www.ciw.edu/boss/ftp/thermo/

Molecular ions in L 1544. I. Kinematics

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We have mapped the dense dark core L 1544 in $H^{13}CO^+$(1–0), DCO^+(2–1), DCO^+(3–2), N_2H^+(1–0), N_2H^+(3–2), N_2D^+(2–1), N_2D^+(3–2), $C^{18}O$(1–0), and $C^{17}O$(1–0) using the IRAM 30–m telescope. We have obtained supplementary observations of $HC^{18}O^+$(1–0), $HC^{17}O^+$(1–0), and $D^{13}CO^+$(2–1). Many of the observed maps show a general correlation with the distribution of dust continuum emission in contrast to $C^{18}O$(1–0) and $C^{17}O$(1–0) which give clear evidence for depletion of CO at positions close to the continuum peak. In particular N_2D^+(2–1) and (3–2) and to a lesser extent N_2H^+(1–0) appear to be excellent tracers of the dust continuum. Our DCO^+ maps have the same general morphology as the continuum while $H^{13}CO^+$(1–0) is more extended. We find also that many apparently optically thin spectral lines such as $HC^{18}O^+$ and $D^{13}CO^+$ have double or highly asymmetric profiles towards the dust continuum peak. We have studied the velocity field in the high density nucleus of L 1544 putting particular stress on tracers such as N_2H^+ and N_2D^+ which trace the dust emission and which we therefore believe trace the gas with density of order of 10^5 cm^{-3}. We find that the tracers of high density gas (in particular N_2D^+) show a velocity gradient along the minor axis of the L 1544 core and that there is evidence for larger linewidths close to the dust emission peak. We interpret this using the model of the L 1544 proposed by Ciolek & Basu (2000) and by comparing the observed velocities with those expected on the basis of their model. The results show reasonable agreement between observations and model in that the velocity gradient along the minor axis and the line broadening toward the center of L 1544 are predicted by the model. This is evidence in favour of the idea that amipolar diffusion across field lines is one of the basic processes leading to gravitational collapse. However, the double–peaked nature of the profiles is reproduced only at the core center and if a "hole" in the molecular emission, due to depletion, is present. Moreover, line widths are significantly narrower than observed and are better reproduced by the Myers & Zweibel (2001) model which considers the quasistatic vertical contraction of a layer due to dissipation of its Alfvénic turbulence, indicating the importance of this process for cores on the verge of forming a star.

Accepted by ApJ

http://arXiv.org/abs/astro-ph/0109021
http://www.arcetri.astro.it/~starform/publ2001.htm

Molecular ions in L 1544. II. The ionization degree

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The maps presented in Paper I are here used to infer the variation of the column densities of HCO^+, DCO^+, N_2H^+, and N_2D^+ as a function of distance from the dust peak. These results are interpreted with the aid of a crude chemical model which predicts the abundances of these species as a function of radius in a spherically symmetric model with radial density distribution inferred from the observations of dust emission at millimeter wavelengths and dust absorption in the infrared. Our main observational finding is that the $N(N_2D^+)/N(N_2H^+)$ column density ratio is of order 0.2 towards the L1544 dust peak as compared to $N(DCO^+)/N(HCO^+) = 0.04$. We conclude that this result as well as the general finding that $N_2H^+$and N_2D^+ correlate well with the dust is caused by CO being depleted to a much higher degree than molecular nitrogen in the high density core of L1544. Depletion also favors deuterium enhancement and thus N_2D^+, which traces the dense and highly CO–depleted core nucleus, is much more enhanced than DCO^+. Our models do not uniquely define the chemistry in the high density depleted nucleus of L1544 but they do suggest that the ionization degree is a few times 10^{-9} and that the ambipolar diffusion time scale is locally similar to the free fall

time. It seems likely that the lower limit which one obtains to ionization degree by summing all observable molecular ions is not a great underestimate of the true ionization degree. We predict that atomic oxygen is abundant in the dense core and, if so, H_3O^+ may be the main ion in the central highly depleted region of the core.

Accepted by ApJ

http://arXiv.org/abs/astro-ph/0109023
http://www.arcetri.astro.it/∼starform/publ2001.htm

The dispersal of circumstellar discs: the role of the ultraviolet switch

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We explore ultraviolet switch models for the dispersal of circumstellar discs in T Tauri stars that involve both photoevaporation by the central star *and* viscous evolution. We show that in combination these processes generate the observed 'two timescale' behaviour for the dispersal of such discs, whereby the disc is rapidly dispersed at the end of its life on a timescale that is a small fraction of the disc lifetime. This switch is activated when the accretion rate through the disc declines to the low level (a few times $10^{-10} M_\odot$ yr^{-1}) such that it roughly matches the rate of photoevaporative mass loss from the disc outside $5 - 10$ A.U.. At this point, the inner disc is deprived of further replenishment from larger radii and empties on to the central star on its own short viscous timescale. This causes the rapid ($\sim 10^5$ year) decline in accretion rate on to the central star and in all disc related emission shortward of 10μm. We discuss the implications of this model for the detection of mm emission around Weak Line T Tauri stars, and also point out the consequences of such a sudden draining for planet formation in the inner regions of circumstellar discs.

Accepted by MNRAS

Echelle spectroscopy of H_2 in the HH 111 jet

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Near-Infrared echelle spectra of the Herbig-Haro knots F-P in the western lobe of the HH 111 outflow are presented. 10 adjacent, parallel slits positions were observed so that the kinematics could be mapped across the width of the flow. We find broad (FWZI ~ 100 km s^{-1}), two-component H_2 profiles in the knots nearest the source; the profiles converge to a single, intermediate-velocity peak ($V_{\rm LSR} \sim 50$ km s^{-1}) at knot P. The kinematic signature of the HH 111 jet in H_2 is very similar to that seen at optical wavelengths (from both radial and tangential velocity meaurements). In conjunction with published proper-motion (knot/shock pattern speed) measurements, we interpret the data in terms of a simple geometrical bow shock model. The model infers a high pre-shock velocity, of the order of 200-250 km s^{-1} , with H_2 excitation in the extended bow wings in knots L, H and F, though exclusively near the bow head in knot P, with probably C-type shock excitation throughout.

Accepted by A&A

Preprints available from http://www.jach.hawaii.edu/∼cdavis/papers.html

A New Look at CO Outflows in the Dark Cloud Complex near IC 5146

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This paper presents the results of a search for CO outflows in a dark cloud complex near IC 5146 carried out using the 45 m telescope at Nobeyama Radio Observatory (HPBW = 17″) equipped with the S115Q multi-beam receiver system. A CO outflow was discovered by the present survey toward IRAS 21428+4732, whose physical parameters, such as molecular mass, mechanical momentum, and kinetic energy, were derived. In addition to IRAS 21428+4732, there are 5 other IRAS point sources accompanied by CO outflows in this cloud complex, which were found by earlier observations with lower angular resolutions (HPBW $\simeq$ 1′). We also made ^{12}CO (J = 1–0), ^{13}CO (J =1–0), and C^{18}O (J = 1–0) observations toward the 5 sources with the 45 m telescope in order to obtain new data with higher angular resolutions. CO maps as well as physical parameters of these outflows obtained by the 45 m telescope are also presented in this paper.

Accepted by PASJ (Vol.53, No.5, Oct. issue)

UV spectra of T Tauri stars from the HST and IUE satellites: BP Tau

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Ultraviolet spectra of BP Tau observed with HST/GHRS and IUE satellites were analysed. We found that BP Tau activity can be explained in the frame of a disk accretion model if we assume that the stellar magnetic axis is strongly inclined to the disk plane. The following set of accretion process parameters were derived: relative surface area of the accretion zone $f \simeq 0.25$, accretion rate $\dot{M}_{ac} \simeq 3.6 \times 10^{-8}$ M$_\odot$ yr^{-1}, accretion energy flux $\mathcal{F} = 2.3 \times 10^{10}$ erg s^{-1} cm^{-2} and accretion luminosity $L_{ac} \simeq 0.37$ L$_\odot$. The relevance of these parameters is discussed. We argue that the Calvet & Gullbring (1998, ApJ, 509, 802) accretion shock model is too crude to believe that the accretion spot surface area is indeed proportional to the square of the accretion rate, as Ardila & Basri (2000, ApJ, 539, 834) found through this model. A strong flare in the Fe II 2811.8, 2812.1 Å lines was detected, it was probably produced by an increase of the accretion rate. During the flare, the accretion luminosity was comparable to or even larger than the stellar bolometric luminosity.

Accepted by A&A

Preprints are available via anonymous ftp from lnfm1.sai.msu.ru pub/PEOPLE/lamzin/HST_Papers

Infrared polarimetry of the southern massive star-forming region G333−0.2

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We present 8−13 μm spectropolarimetry, and 12- and 2-μm imaging polarimetry of the southern massive star-forming region G333.6−0.2. Spectropolarimetry measurements show that the polarization observed towards the nebula contains a mixture of both absorptive and emissive polarizations. Model fitting to the spectra indicates that the temperature of the mid-infrared emitting dust grains is generally ∼200 K and the optical depth of the absorbing dust at 9.7 μm is ∼1.5. Fits are also made to the polarimetry spectra, which show a reasonably constant peak absorptive polarization (∼3.4 per cent at 43 degrees) across the face of the H II region. This absorptive polarization position angle is consistent with that found by the 2-μm imaging polarimetry (38 ± 6 degrees) and is most likely due to the Galactic magnetic field

local to G333.6−0.2. When the absorptive polarization is subtracted from the 12-μm polarization image, the emissive polarization pattern that is intrinsic to the star-forming region is revealed. A probable magnetic field configuration implied by the intrinsic polarization suggests a star formation initially influenced by the Galactic magnetic field which is eventually perturbed by the star formation process.

Accepted by MNRAS

Water Maser Survey towards Low-Mass Young Stellar Objects in the Northern Sky: Observational Constraints on Maser Excitation Conditions

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We present the results from a multi-epoch H_2O maser survey towards low-mass young stellar objects (YSOs) using the Nobeyama 45 m telescope and the Very Large Array. Our Nobeyama survey is the first complete H_2O maser survey towards known class 0 sources in the northern sky ($\delta > -35°$). During the series of the monitoring observations, we detected the maser emission towards none of 31 preprotostellar cores, 15 of 30 class 0, 2 of 32 class I, and 0 of 9 class II sources. ¿From this, we conclude that class 0 sources are favorable sites to harbor the masers: the detection rates are derived to be 39.7% for class 0, 4.0% for class I, and 0.0% for class II sources taking time variation into acount. In addition, we found that the H_2O maser luminosities in low-mass stars are more closely related to the luminosities of 100 AU scale radio jets rather than the mechanical luminosities of large scale CO outflows. This fact suggests that the masers are associated with the shocked regions which are impacted by neutral protostellar jets emanating from the central stars. The drastic decrease of the maser detection rate in class I sources is likely to be caused by the dissipation of dense gas around the central objects. We base this on the fact that the radio jets are found to have similar luminosities in class 0 and class I. It seems difficult even for active protostellar jets to excite masers in the remaining tenous gas around class I sources.

Accepted by the ApJ Letters

[ps] http://www.arcetri.astro.it/˜ starform/publ2001.htm
[pdf] http://www.arcetri.astro.it/˜ furuya/preprint/2001/

Atomic T Tauri disk winds heated by ambipolar diffusion. I. Thermal structure

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Motivated by recent subarcsecond resolution observations of jets from T Tauri stars, we extend the work of Safier (1993a,b) by computing the thermal and ionization structure of self-similar, magnetically-driven, atomic disk winds heated by ambipolar diffusion. Improvements over his work include: (1) new magnetized cold jet solutions consistent with the underlying accretion disk (Ferreira, 1997); (2) a more accurate treatment of ionization and ion-neutral momentum exchange rates; and (3) predictions for spatially resolved forbidden line emission (maps, long-slit spectra, and line ratios), presented in a companion paper, (Garcia, 2001b).
As in (Safier, 1993a), we obtain jets with a temperature plateau around 10^4 K , but ionization fractions are revised downward by a factor of 10-100. This is due to previous omission of thermal speeds in ion-neutral momentum-exchange rates and to different jet solutions. The physical origin of the hot temperature plateau is outlined. In particular we

present three analytical criteria for the presence of a hot plateau, applicable to any given MHD wind solution where ambipolar diffusion and adiabatic expansion are the dominant heating and cooling terms. We finally show that, for solutions favored by observations, the jet thermal structure remains consistent with the usual approximations used for MHD jet calculations (thermalized, perfectly conducting, single hydromagnetic cold fluid calculations).

Accepted by Astronomy & Astrophysics

Preprint available at ftp://ftp.astro.up.pt/pub/preprints/95.ps.gz or http://www.astro.up.pt/investigacao/publicacoes/

Atomic T Tauri disk winds heated by ambipolar diffusion. II Observational tests

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Thermal and ionization structures of self-similar, magnetically-driven disk winds obtained in a companion paper (Garcia, 2001a) are used to compute a series of jet synthetic observations. These include spatially resolved forbidden line emission maps, long-slit spectra, as well as line ratios. Line profiles and jet widths appear to be good tracers of the wind dynamics and collimation, whereas line ratios essentially trace gas excitation conditions.
All the above diagnostics are confronted to observations of T Tauri star microjets. Convolution by the observing beam is shown to be essential for a meaningful test of the models. We find that jet widths and qualitative variations in line profiles with both distance and line tracers are well reproduced. A low-velocity [OI] component is also obtained, originating from the disk wind base. However, this component is too weak, predicted maximum velocities are too high and electronic and total densities are too low. Denser and slower magnetized winds, launched from disks with warm chromospheres, might resolve these discrepancies.

Accepted by Astronomy & Astrophysics

Preprint available at ftp://ftp.astro.up.pt/pub/preprints/96.ps.gz or http://www.astro.up.pt/investigacao/publicacoes/

Far infrared mapping of three Galactic star forming regions : W3(OH), S 209 & S 187

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Three Galactic star forming regions associated with W3(OH), S209 and S187 have been simultaneously mapped in two trans-IRAS far infared (FIR) bands centered at $\sim$ 140 and 200 μm using the TIFR 100 cm balloon borne FIR telescope. These maps show extended FIR emission with structures. The HIRES processed IRAS maps of these regions at 12, 25, 60 & 100 μm have also been presented for comparison. Point-like sources have been extracted from the longest waveband TIFR maps and searched for associations in the other five bands. The diffuse emission from these regions have been quantified, which turns out to be a significant fraction of the total emission. The spatial distribution of cold dust (T $<$ 30 K) for two of these sources (W3(OH) & S209), has been determined reliably from the maps in TIFR bands. The dust temperature and optical depth maps show complex morphology. In general the dust around S 209 has been found to be warmer than that in W3(OH) region.

Accepted by Journal of Astrophysics & Astronomy

Available at `http://www.arXiv.org/abs/astro-ph/0108087`

Proper Motions of the HH 111 Jet Observed with the Hubble Space Telescope

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New Hα and [S II] images of the HH 111 jet taken with the *Hubble Space Telescope* reveal marked proper motions and morphological changes when compared with similar images obtained four years earlier. Knots in the jet, which are dominated by emission from nested bow shocks, generally move ballistically, with no evidence for turbulent motions even in regions where the emission has a complex morphology. These bow shocks sometimes overtake one another; the new images show this occurred in knot L about 80 years ago. Photometric variability, clearly visible for the first time at subarcsecond scales, can confuse ground-based measurements that require many years between epochs to detect reliable proper motions. With the exception of the bow shock L, whose wings expand laterally, the jet moves mainly along its long axis. Because HH 111 lies nearly in the plane of the sky, the proper motions translate accurately to space velocities, which range from 220 $\mathrm{km\,s^{-1}}$ to 330 $\mathrm{km\,s^{-1}}$ with a typical uncertainty of $\pm$ 5 $\mathrm{km\,s^{-1}}$. The fastest knots are associated with object E at the base of the visible jet, where a cooling layer is in the process of forming behind one of the shocks. Velocity differences between adjacent knots within the optically bright part of the jet are typically 40 $\mathrm{km\,s^{-1}}$, in line with predictions of nonmagnetic shock models based on emission line fluxes. This agreement limits the component of the magnetic field perpendicular to the axis of the jet to be $\lesssim$ 1 mG.

Accepted by Ap. J. Letters

Preprints available from http://sparky.rice.edu/ hartigan/pub.html

Structure of Protostellar Collapse Candidate B335 Derived from Near-Infrared Extinction Maps

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We present a near-infrared extinction study of the dark globule B335, a protostellar collapse candidate, using data from HST/NICMOS and the W.M. Keck Observatory. These data allow a new quantitative test of the "inside-out" collapse model previously proposed to explain molecular line profiles observed toward this region. We find that the *shape* of the density profile is well matched by the collapse model, but that the *amount* of extinction corresponds to larger column densities than predicted. An unstable Bonnor-Ebert sphere with dimensionless outer radius $\xi_{\mathrm{max}} = 3D12.5 \pm 2.6$ provides an equally good description of the density profile, and is indistinguishable from the collapse model over the range in radius sampled by the extinction data. The bipolar outflow driven by the embedded young stellar object has an important effect on the extinction through the core, and modeling the outflow as a hollowed-out bipolar cone of constant opening angle provides a good match to the observations. The complete exinction map is well reproduced by a model that includes both infall and outflow, and an additional 20% dispersion that likely results from residual turbulent motions. This fitted model has an infall radius of $R_{\mathrm{inf}} = 3D26 \pm 3''$ (0.031 pc for 250 pc distance), and an outflow cone semi-opening angle of $\alpha = 3D41 \pm 2^\circ$. The fitted infall radius is consistent with those derived from molecular line observations and supports the inside-out collapse interpretation of the density structure. The fitted opening angle for the outflow is slightly larger than = observed in high velocity CO emission, perhaps because the full extent of the outflow cone in CO becomes confused with ambient core emission at low velocities.

Accepted by The Astrophysical Journal

astro-ph/0108470

Multiplicity of X-Ray Selected T Tauri Stars in Chamaeleon

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We report on a multiplicity survey of a sample of X-ray selected young stars in the Chamaeleon association. We used speckle-interferometry and direct imaging to find companions in the separation range $0.13''$ to $6''$. After correction for chance alignment with background stars, we find a multiplicity (number of binaries or multiples divided by number of systems) of $(14.0 \pm 4.3)\,\%$ and a companion star frequency (number of companions divided by number of systems) of $(14.7 \pm 5.1)\,\%$. Compared to solar-type main-sequence stars, the companion star frequency is lower by a factor of 0.61 ± 0.27. This is remarkably different from the high multiplicity found in the Taurus-Auriga star-forming region and for T Tauri stars in Chamaeleon known before ROSAT. We find only a few binaries with projected separations of more than 70 AU, also in contrast to the results for stars known before ROSAT. This indicates that the X-ray selected stars belong to a different population than the stars known before ROSAT, a hypothesis further supported by their Hipparcos distances and proper motions.

Accepted by Astronomical Journal (December 2001 issue)

Available at `http://hex.ucsd.edu/koehler/Papers/index.html`

Laboratory Astrophysics and Collimated Stellar Flows: The Production of Radiatively Cooled Hypersonic Plasma Jets

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We present first results of astrophysically relevant experiments where highly supersonic plasma jets are generated via conically convergent flows. The convergent flows are created by electrodynamic acceleration of plasma in a conical array of fine metallic wires (a modification of the wire array Z-pinch). Stagnation of plasma flow on the axis of symmetry forms a standing conical shock effectively collimating the flow in the axial direction. This scenario is essentially similar to that discussed by Canto´ and collaborators as a purely hydrodynamic mechanism for jet formation in astrophysical systems. Experiments using different materials (Al, Fe and W) show that a highly supersonic ($M \sim 20$), well-collimated jet is generated when the radiative cooling rate of the plasma is significant. We discuss scaling issues for the experiments and their potential use for numerical code verification. The experiments also may allow direct exploration of astrophysically relevant issues such as collimation, stability and jet-cloud interactions.

Accepted by Ap.J.L.

preprints may be found at http://xxx.lanl.gov/astro-ph/0108067

Mapping the interstellar dust with near-infrared observations: An optimized multi-band technique

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We generalize the technique of Lada et al. (1994) to map dust column density through a molecular cloud (Nice) to an optimized multi-band technique (Nicer) that can be applied to any multi-band survey of molecular clouds. We present a first application to a $\sim 625\ \mathrm{deg}^2$ subset of the Two Micron All Sky Survey (2MASS) data and show that when compared to {Nice, the optimized Nicer technique (i) achieves the same extinction peak values, (ii) improves the noise variance of the map by a factor of 2 and (iii) is able to reach $3\,\sigma$ dust extinction measurements as low as

$A_V \simeq 0.5$ magnitudes, better than or equivalent to classical optical star count techniques and below the threshold column density for the formation of CO, the brightest H_2 tracer in radio-spectroscopy techniques. The application of the NICER techniques to near-infrared data obtained with a 8 meter-class telescope with a state-of-the-art NIR camera, such as the VLT-ISAAC combination, will be able to achieve dynamic ranges from below 10^{21} protons cm^{-2} to over 10^{23} protons cm^{-2} (A_V in the range $[0.3, 60]$) and spatial resolutions $< 10''$, making use of a single and straightforward column density tracer, extinction by interstellar dust.

Accepted by Astronomy and Astrophysics

http://www.astro.uni-bonn.de/∼lombardi/ms1526.pdf

Near-IR H_2 and [FeII] imaging and spectroscopy of new jets in the Vela molecular clouds

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We present narrow band imaging in the 2.122μm transition of H_2 and in the 1.644μm transition of [FeII] of a sample of 12 protostellar candidates and 3 Herbig-Haro (HH) objects belonging to the Vela Molecular Ridge (VMR). Out of the 15 investigated fields we detected H_2 emission in IRS 63, 17, 19, 21, 8 (according to our catalogue), while [FeII] was observed only towards one source (IRS 8), where a counter-jet has been identified for the first time. H_2 and [FeII] images have been combined to trace the different shock conditions along this jet.

In addition, a new pure molecular H_2 jet was discovered in IRS 17, which results in about 20 knots of emission extending up to 0.3 pc from the central driving source. IR spectroscopy (1.55 - 2.55μm) at a resolution ≈ 600 of the most prominent knots has revealed a large number of H_2 emission lines, which were used to evaluate both the extinction and the excitation temperature along the flow. The observed increase of the excitation temperature with the distance from the central source was interpreted as due to a decrease of the flow velocity with time or, alternatively, to the fact that internal knots travel in a medium already put into motion by previous shock events. Comparisons with model predictions indicate non dissociative C-shocks as the most likely mechanism for line excitation.

Finally, the presence of a common alignment of the detected flows with the galactic plane indicates that the galactic B-field affects the star formation on large scales in VMR.

Accepted by Astrophys. J.

Polarimetric variations of binary stars. II. Numerical simulations for circular and eccentric binaries in Mie scattering envelopes

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Following a previous paper on Thomson scattering, we present numerical simulations of the periodic polarimetric variations produced by a binary star placed at the center of an empty spherical cavity inside a circumbinary ellipsoidal and optically thin envelope made of dust grains. Mie single-scattering (on spherical dust grains) is considered along with pre- and post-scattering extinction factors which produce a time-varying optical depth and affect the morphology of the periodic variations. The orbits are circular or eccentric. The mass ratio (and luminosity ratio) is equal to 1.0. We are interested in the effects that various parameters (grain characteristics, geometry of the envelope, orbital eccentricity, etc.) will have on the average polarization, the amplitude of the polarimetric variations, and the morphology of the variability.

We show that the absolute amplitudes of the variations are smaller for Mie scattering than for Thomson scattering, which makes harder the detection of polarimetric variations for binary stars surrounded by dust grains.

The average polarization produced depends on the grains' composition and size, and on the wavelength of observation.

Among the four grain types that we have studied (astronomical silicates, graphite, amorphous carbon, and dirty ice), the highest polarizations are produced by grains with sizes in the range $a \sim 0.1-0.2\,\mu$m ($x = 2\pi a/\lambda \sim 1.0-2.0$ for $\lambda = 7000$ Å). Composition and size also determine if the polarization will be positive or negative.

In general, the variations are double-periodic (seen twice per orbit). In some cases, because spherical dust grains have an asymmetric scattering function, the polarimetric curves produced show single-periodic variations (seen once per orbit) in addition to the double-periodic ones. A mixture of grains of different sizes does not affect those conclusions.

Circumstellar disks produce polarimetric variations of greater amplitude (up to $\sim 0.3\%$ in our simulations) than circumbinary envelopes (usually $\lesssim 0.1\%$). Other geometries (circumbinary flared disks or prolate envelopes, and non-coplanar envelopes) do not present particularly interesting polarimetric characteristics.

Another goal of these simulations is to see if the 1978 BME (Brown, McLean, & Emslie) formalism, which uses a Fourier analysis of the polarimetric variations to find the orbital inclination for Thomson-scattering envelopes, can still be used for Mie scattering. We find that this is the case, if the amplitude of the variations is sufficient and the true inclinations is $i_{\rm true} \gtrsim 45°$. For eccentric orbits, the first-order coefficients of the Fourier fit, instead of second-order ones, can be used to find almost all inclinations.

Accepted by the Astronomical Journal

astro-ph/0108124

Polarimetric variations of binary stars. III. Periodic polarimetric variations of the Herbig Ae/Be star MWC 1080

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We present polarimetric observations of a massive pre-main sequence short-period binary star of the Herbig Ae/Be type, MWC 1080. The mean polarization at 7660 Å is 1.60% at 81.6°, or 0.6% at 139° if an estimate of the interstellar polarization is subtracted. The intrinsic polarization points to an asymmetric geometry of the circumstellar or circumbinary environment while the 139° intrinsic position angle traces the axis of symmetry of the system and is perpendicular to the position angle of the outflow cavity. The polarization and its position angle are clearly variable, at all wavelengths, and on time scales of hours, days, months, and years. Stochastic variability is accompanied by periodic variations caused by the orbital motion of the stars in their dusty environment. These periodic polarimetric variations are the first phased-locked ones detected for a pre-main sequence binary. The variations are not simply double-periodic (seen twice per orbit) but include single-periodic (seen once per orbit) and higher-order variations. The presence of single-periodic variations could be due to non equal mass stars, the presence of dust grains, an asymmetric configuration of the circumstellar or circumbinary material, or the eccentricity of the orbit. MWC 1080 is an eclipsing binary with primary and secondary eclipses occurring at phases 0.0 and 0.55. The signatures of the eclipses are seen in the polarimetric observations.

Accepted by the Astronomical Journal

astro-ph/0108328

The Orion Nebula and its Associated Population

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The Orion Nebula is one of the best studied objects in the sky. The advent of multi-wavelength investigations and quantitative high resolution imaging has produced a rapid improvement in our knowledge of what is widely considered the prototype H II region and young galactic cluster. Perhaps uniquely among this class of object, we have a good three dimensional picture of the nebula, which is a thin blister of ionized gas on the front of a giant molecular cloud, and the extremely dense associated cluster. The same processes that produce the nebula also render visible the circumstellar material surrounding many of the pre-main sequence low mass stars, while other circumstellar clouds are seen in silhouette against the nebula. The process of photoevaporation of ionized gas not only determines the structure of the nebula that we see, but is also destroying the circumstellar clouds, presenting a fundamental conundrum about why these clouds still exist.

Accepted by Annual Reviews of Astronomy & Astrophysics

New Proplyds, Outflows, Shocks, and a Reflection Nebula in M 43 and the Outer Parts of the Orion Nebula

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Hubble Space Telescope WFPC2 images made as planned parallel observations have produced emission line images of fields in the outer portions of the Orion Nebula and near the center of the companion H II region, M 43. Examination of these images have uncovered three new bright proplyds and one silhouettte proplyd. Two of the bright proplyds lie within M 43 and are photoionized by its central star, NU Ori. The new bright proplyd in the Orion Nebula shows a monopolar microjet and analysis of its size and surface brightness indicates that it lies well in the foreground. Symmetric shocks indicate bipolar flow around the K8e star V1348 Ori (304-539) near θ Ori C. Evidence for multiple outflows from a source SE of 036-927, well south of the bright bar feature of the nebula, is indicated. A bright reflection nebula was found around the B1.5 Vp star LP Ori (098-753). The form of this object indicates that this star is moving within the veil of neutral material that lies in front of M 42.

Accepted by Astron. J. (November, 2001 issue)

Sub-arcsec resolution near-infrared images of the Cederblad 110 region

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We present the results of deep (K_s=18.9) sub-arcsec resolution ($0.3''$) imaging observations of the Cederblad 110 region in the Chamaeleon I dark cloud. This region (roughly $5'\times5'$) is characterized by the presence of six ISOCAM detected young stellar objects (YSOs). Our images have recovered all these sources at near-infrared (near-IR) wavelengths. Ced 110 IRS4, the brightest object in the region, is associated with a remarkable near-IR bipolar nebulosity. Ced 110 IRS6 is resolved in a double system IRS6a and IRS6b with a separation of $\sim 2''$ ($\sim$ 320 AU at the distance of the Cha I cloud). We have combined 1.3 mm, far and mid-IR fluxes from the literature with our JHK data and obtained the spectral energy distributions (SEDs) for three (IRS4, IRS6a and ISO-ChaI86) of the six ISOCAM sources in the region. We modelled the SEDs of IRS6a and ISO-ChaI86 with a spherically symmetric dusty envelope, using the DUSTY code. These objects are clear Class I sources of the cloud. Finally, we report the detection of three new objects in this region (NIR 72, 84 and 89) with significant near-IR excess. If these sources are associated with the cloud, the derived luminosities and masses suggest that they are candidate young brown dwarf of Chamaeleon I.

Accepted by Astron. Astrophys.

Dense cores in the L1630 molecular cloud: discovering new protostars with SCUBA

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Maps of the 450 μm and 850 μm dust continuum emission from three star-forming condensations within the Lynds

1630 molecular cloud, made with the SCUBA bolometer array, reveal the presence of four new submillimetre sources, each of a few solar masses, two of which are probably Class I, two Class 0, as well as several sources whose existence was previously known. The sources are located in filaments and appear elongated when observed at 450 μm. They likely have dust temperatures in the range 10 to 20 K, in good agreement with previous ammonia temperature estimates. Attempts to fit their structures with power-law and Gaussian density distributions suggest that the central distribution is flatter than expected for a simple singular isothermal sphere.

Although the statistics are poor, our results suggest that the ratio of 'protostellar core' mass to total virial mass may be similar for both large and small condensations.

Accepted by MNRAS

Preprint available at astro-ph/0108359

Molecular and Ionic shocks in the Supernova Remnant 3C 391

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New observations of the supernova remnant 3C 391 are presented in the near-infrared, using the H_2 2.12 μm and [FeII] 1.64 μm narrow-band filters in the Prime Focus Infrared Camera on the Palomar Observatory Hale 200″ telescope, and in the mid-infrared, using the circular-variable filters in the ISOCAM on the *Infrared Space Observatory.* Shocked H_2 emission was detected from the region 3C 391:BML (40″ size), where broad millimeter CO and CS lines had previously been detected. A small H_2 clump, 45″ from the main body of 3C 391:BML, was confirmed to have broad CO emission, demonstrating that the near-infrared H_2 images can trace previously undetected molecular shocks. The [FeII] emission has a significantly different distribution, being brightest in the bright radio bar, at the interface between the supernova remnant and the giant molecular cloud, and following filaments in the radio shell. The near-infrared [FeII] and the mid-infrared 12–18 μm filter (dominated by [NeII] and [NeIII] images are the first images to reveal the radiative shell of 3C 391. The mid-infrared spectrum is dominated by bright ionic lines of [FeII] 5.5 μm, [ArII] 6.9 μm, [NeII] 12.8 μm, and [NeIII] 15.5 μm, as well as the series of pure rotational lines of H_2 S(2) through S(7). There are no aromatic hydrocarbons associated with the shocks, nor is their any mid-infrared continuum, suggesting that macromolecules and very small grains are destroyed in the shocks. Comparing 3C 391 to the better-studied IC 443, both remnants have molecular- and ionic-dominated regions; for 3C 391, the ionic-dominated region is the interface into the giant molecular cloud, showing that the main bodies of giant molecular clouds contain significant regions with densities 10^2 to 10^3 cm^{-3} and a small filling factor of higher-density regions. The broad-molecular line region 3C 391:BML was imaged in the 1-0 S(1) line at 1.5″ resolution. The molecular shocked region resolves into 16 clumps of H_2 emission, with some fainter diffuse emission but with no associated near-infrared continuum sources. One of the clumps is coincident with a previously-detected OH 1720 MHz maser to within our 0.3″ astrometry. These clumps are interpreted as a cluster of pre-stellar, dense molecular cores that are presently being shocked by the supernova blast wave.

Accepted by Astrophys. J.

Herbig-Haro Flows: Probes of Early Stellar Evolution

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Outflow activity is associated with all stages of early stellar evolution, from deeply embedded protostellar objects to visible young stars. Herbig-Haro (HH) objects are the optical manifestations of this powerful mass loss. Analysis of HH flows, and in particular of the subset of highly collimated HH jets, provide indirect but important insights into the nature of the accretion and mass loss processes which govern the formation of stars. The recent recognition that HH flows may attain parsec scale dimensions opens the possibility to partially reconstruct the mass ejection history of the newly born driving sources and therefore their mass accretion history. Furthermore, HH flows are astrophysical laboratories for the analysis of shock structures, of hydrodynamics in collimated flows, and of their interaction with

the surrounding environment. HH flows may be an important source of turbulence in molecular clouds. Recent technological developments have enabled detailed observations of outflows from young stars at near-infrared, mid-infrared, sub-mm, mm and cm wavelengths, providing a comprehensive picture of the outflow phenomenon of young stars.

Accepted by Annual Reviews of Astronomy and Astrophysics

Preprints available from http://origins.colorado.edu/∼reipurth/preprints.htm

A Single Distance Sample of Molecular Outflows from High-Mass Young Stellar Objects

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We have made ^{12}CO 2–1 and 1–0 maps of eleven molecular outflows associated with intermediate to high-mass young stellar objects (YSOs) in order to establish whether the correlations between outflow parameters and source bolometric luminosity hold in the high-mass regime. It is important to consider the effects of Malmquist-type biases when looking at high-mass YSOs, as they are generally much more distant than their low mass counterparts. We therefore chose only objects located at ∼2 kpc. We find that the relations show much more scatter than is seen in similar studies of low-mass YSOs. We also find that the mass-spectrum is significantly steeper in high-mass outflows, indicating a larger mass-fraction at lower velocities, a low collimation factor (∼ 1–2) and no Hubble-like relationship.

Accepted by A&A

Preprint available at http://roobarb.astro.umass.edu/∼naomi/pubs/rm01abs.html

Spectroscopic Variability of the UXOR Star RR Tau

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We present moderate resolution optical spectra of the highly variable Herbig Ae star RR Tau over 12 epochs spanning ∼ 2.5 magnitudes in V. Combining normalized spectra with contemporaneous photometry from two databases, we analyze both equivalent width and flux behavior as a function of system brightness for lines from the Ca RomanII K line in the blue to the Paschen lines in the far-red. The wings ($\Delta v > 400$ km s^{-1}) of the Balmer lines and the equivalent widths of several weak metal lines are essentially constant, indicating very little change in the underlying photosphere over a factor of ten change in brightness. We detect no measurable change in spectral type. Variability is apparent in the cores of Hα and Hβ, but the total flux in these lines is not correlated with photometric variability. Forbidden oxygen ([O RomanI]6300Å) has essentially constant flux, indicating a stable low density wind component. The low-ionization permitted lines of Fe RomanII, Ca RomanII, O RomanI and Na RomanI are seen strongly in absorption for $V \leq 12.2$ in these normalized spectra, but change dramatically from absorption to emission during deep minima ($V \geq 12.6$). Analysis of the Fe RomanII (42) triplet indicates that these lines originate in circumstellar gas which is partially affected by the photometric minima, in that the absorbing gas changes with the stellar continuum (conserving equivalent width) while a weak emitting region is unaffected (roughly constant flux). Our results are consistent with a model in which the stellar minima are caused by an occulting screen of size such that it obscures the stellar surface and the innermost region of circumstellar gas producing permitted metal absorption lines, but not the outer parts, or the wind. The circumstellar hydrogen, while variable, is not strongly affected by the occultations.

Accepted by Astrophysical Journal

Preprint available at http://ftp.gemini.edu/staff/brodgers/RRTAU

Total linear polarization in the OH maser W75N: VLBA polarization structure

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W75N is a star-forming region containing ultra-compact HII regions and OH, H_2O, and methanol masers. Our VLBA map shows that the OH masers are located in a thin disk (as was first suggested by Haschick et al.1981) rotating around an O-star which is the exciting star of the ultra-compact HII region VLA1 (Torrelles et al. 1997). Two separate sets of maser spots are connected with the ultra-compact HII region VLA2. Radial velocity of OH maser spots varies across the disc from 3.7 km s^{-1} to 10.9 km s^{-1}. The diameter of the disk is 4000 A.U. All maser spots are strongly polarized. These are the first OH masers showing nearly 100 per cent linear polarization in several spots. Two maser spots show Zeeman pairs corresponding to the magnetic field 5.2 mgauss and 7.7 mgauss. The linearly polarized maser spots are shown to be σ-components in the case of the magnetic field perpendicular to the line of sight (Goldreich, Keely and Kwan 1973) and in one case we tentatively found a Zeeman pair of two linearly polarized components. The direction of the magnetic field as determined for linearly polarized spots is perpendicular to the plane of the disk, althought the galactic Faraday rotation may significantly affect this conclusion.

Accepted by Astrophys. J.

Submillimeter lines from circumstellar disks around pre-main sequence stars

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Observations of submillimeter lines of CO, HCO^+, HCN and their isotopes from circumstellar disks around low mass pre-main sequence stars are presented. CO lines up to J=6→5, and HCO^+ and HCN lines up to J=4→3, are detected from the disks around LkCa 15 and TW Hya. These lines originate from levels with higher excitation temperatures and critical densities than studied before. Combined with interferometer data on lower excitation lines, the line ratios can be used to constrain the physical structure of the disk. The different line ratios and optical depths indicate that most of the observed line emission arises from an intermediate disk layer with high densities of $10^6 - 10^8$ cm^{-3} and moderately warm temperatures in the outer regions. The data are compared with three different disk models from the literature using a full 2D Monte Carlo radiative transfer code. The abundances of the molecules are constrained from the more optically thin ^{13}C species and indicate depletions of $\approx 1 - 30$ for LkCa 15 and very high depletions of > 100 for TW Hya with respect to dark cloud abundances. Evidence for significant freeze-out (factors of 10 or larger) of CO and HCO^+ onto grain surfaces at temperatures below 22 K is found, but the abundances of these molecules must also be low in the warmer upper layer, most likely as a result of photodissociation. A warm upper layer near the surface of a flaring disk heated by stellar and interstellar radiation is an appropriate description of the observations of TW Hya. LkCa 15 seems to be cooler at the surface, perhaps due to dust settling. The density constraints are also well fitted by the flared disk models.

Accepted by Astronomy & Astrophysics

http://xxx.lanl.gov/abs/astro-ph/0108375

The environment of FS Tau observed with HST WFPC2 in narrow-band emission line filters

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We present the results of HST WFPC2 observations of FS Tau and its environment obtained in the narrow-band emission line filters Hα and [S II] $\lambda\lambda$ 6716, 6731 Å. Based on these data the morphology of line emission within this region can be studied on a size scale of 0.1″ for the first time.
Despite the fact that FS Tau A has strong forbidden emission lines, there is no evidence for extended emission at these wavelengths beyond 0.5″ from the components of this close T Tauri binary system. In the FS Tau B outflow interesting morphological properties can be studied at high spatial resolution. In this jet we find a fine structure where circular or elliptical jet knots are correlated with minima of the jet width. The overall width of this jet decreases with distance from the source. The FS Tau B jet is thus a rare example of a jet which may be recollimated far away from its source. The jet is much more prominent in Hα than in [S II], while the counterjet shows the opposite behaviour. The line ratio Hα/[S II] increases with lateral distance from the jet axis, which is indicative of entrainment of ambient material.

Accepted by the Astrophysical Journal

http://www.tls-tautenburg.de/research/tls-research/pub2001.html

The first million years of the Sun: A calculation of formation and early evolution of a solar-mass star

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We present the first coherent dynamical study of the cloud fragmentation-phase, collapse and early stellar evolution of a solar mass star. We determine young star properties as the consequence of the parent cloud evolution. Mass, luminosity and effective temperature in the first million years of the proto-Sun result from gravitational fragmentation of a molecular cloud region that produces a cluster of prestellar clumps. We calculate the global dynamical behavior of the cloud using isothermal 3D hydrodynamics and follow the evolution of individual protostars in detail using a 1D radiation-fluid-dynamic system of equations that comprises a correct standard solar model solution, as a limiting case. We calculate the pre-main sequence (PMS) evolutionary tracks of a solar mass star in a dense stellar cluster environment and compare it to one that forms in isolation. Up to an age of 950 000 years differences in the accretion history lead to significantly different temperature and luminosity evolution. As accretion fades and the stars approach their final masses the two dynamic PMS tracks converge. After that the contraction of the quasi-hydrostatic stellar interiors dominate the overall stellar properties and proceed in very similar ways. Hence the position of a star in the Hertzsprung-Russell diagram becomes a function of age and mass only. However, our quantitative description of cloud fragmentation, star formation and early stellar evolution predicts substantial corrections to the classical, i.e. hydrostatic and initially fully convective models: At an age of 1 million years the proto-Sun is twice as bright and 500 Kelvin hotter than according to calculations that neglect the star formation process.

Accepted by ApJ Letters

Preprints available at http://arXiv.org/abs/astro-ph/0109051

What's Happening Around Herbig Ae Stars? Investigating Circumstellar Activity in Young Intermediate Mass Stars with Optical and Near-Infrared Spectroscopy

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We have investigated the optical and near-infrared spectral behavior of the intermediate-mass, pre-main sequence Herbig Ae stars, with particular emphasis on variability and evolution. The evolutionary state of Herbig Ae (HAe) stars is intermediate between very young, pre-main sequence objects and the young main sequence Vega, or β Pic, stars. The majority of HAe stars are estimated to span a small range in ages, between 2 and 6 million years. Near-infrared (H and K) spectra of over 30 young stars reveal an evolutionary sequence from strong Brackett emission in the youngest sources to photospheric absorption with little or no emission in Vega-like stars. Most of the Ae stars fall in the middle, exhibiting nearly featureless spectra in the near-infrared, a combination of photospheric absorption veiled by strong excess continuum, and only weak Brackett line emission. The data suggest that the strength of the Brackett emission decreases with age between 1 and 10 Myrs, while the thermal emission drops for stars $>$ 10 Myrs old. In the evolutionary sequence, the hot gas creating the Brackett emission disappears before the hot dust responsible for the thermal emission. Our high resolution spectra of Brγ in two HAe stars indicate that the Brackett emission is associated with accreting gas. Therefore, near-infrared Brackett emission offers an important diagnostic of inner disk evolution in late pre-main sequence intermediate mass stars.

A large fraction ($\sim 25-50\%$) of HAe stars are UXORs (after the prototype UX Ori) that exhibit large optical variability, $\Delta V > 1.5$ mag and sometimes as large as 4 magnitudes. This behavior is commonly attributed to obscuration of the central star by circumstellar dust. We have collected moderate resolution optical spectra of about two dozen Herbig Ae/Be stars, including multi-epoch observations of five UXORs: AB Aur, CO Ori, CQ Tau, RR Tau and UX Ori. The spectra of RR Tau span an order of magnitude in brightness from $V = 11$ to $V \sim 13.5$ mag. The data reveal a system in which the photosphere of the star and the wind flux are unchanged during brightness minima, while circumstellar permitted metal lines (FeII, CaII, OI, NaI) change from absorption to emission when the star fades. We suggest a model that attributes the metal absorption to a higher density region obscured with the star, while the metal emission lines come from a more extended region that remains unobscured. (See abstract of ApJ article in this newsletter.) These results exemplify the potential of spectral monitoring to constrain the physical size and location of obscuring material and its effects on the circumstellar environment in UXOR stars.

An unbiased infrared H_2 search for embedded flows from young stars in Orion A

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The presence of outflows, often in the form of well-collimated jets, is a phenomenon commonly associated with the birth of young stars. Emission from shock-excited molecular hydrogen at near-infrared wavelengths is one of the signposts of the presence of such an outflow, and generally can be observed even if the flow is obscured at optical wavelengths. In this thesis, I present the results of an unbiased, sensitive, wide-field search for flows from protostellar objects in the H_2 v=1–0 S(1) line at a wavelength of 2.12 μm, covering a 1 square degree area of the Orion A giant molecular cloud. Further data covering a wide wavelength range are used to search for the driving sources of the flows. The aim of this work is to obtain a sample of outflows which is free from biases as far as possible, to derive the typical properties of the outflows, to search for evolutionary trends, and to examine the impact of outflows on the ambient cloud.

The first result from this survey is that outflows are indeed common in star forming regions: more than 70 candidate jets are identified. Most of them have a fairly ill-defined morphology rather than a regular or symmetric structure, which is interpreted to be due to the turbulent, clumpy ambient medium into which the jets are propagating. The jets are randomly oriented. In particular, no alignment of the jets with the large scale ambient magnetic field is found, suggesting that the spin and symmetry axis in a protostellar object is determined by random, turbulent motions in the cloud.

Candidate driving sources are identified for 49 jets, and their evolutionary stage and bolometric luminosity is estimated. The jet lengths and H_2 luminosities evolve as a function of the age of the driving source: the jets grow quickly from zero length to a size of a few parsec and then slowly shorten again. The jets are very luminous early on and fade during the protostellar evolution. The evolution in length and H_2 luminosity is attributed to an early phase of strong accretion, which subsequently decreases. The shortening of the jets with time requires the presence of a continuous deceleration of the jets. A simple model of the simultaneous evolution of a protostar, its circumstellar environment, and its outflow (Smith 2000) can reproduce the measured values of H_2 luminosity and driving source luminosity under the assumption of a strong accretion plus high ejection efficiency phase early in the protostellar evolution.

Tatematsu et al. (1993) found 125 dense cloud cores in the survey area. The jet driving sources are found to have formed predominantly in quiet cores with a low ratio of internal kinetic energy to gravitational potential energy; these are the cores with higher masses. The cores which are associated with jets have on average larger linewidths than cores without jets. This is due to the preferred presence of jets in more massive cores, which generally have larger linewidths. There is *no* evidence for additional internal motions excited by the interaction of the jets with the cores. The jet H_2 luminosity and the core linewidth (as predicted by theory) are related, if Class 0 and Class I jets are considered separately; the relation lies at higher values of the H_2 luminosity for the Class 0 jets than for Class I jets. This also suggests a time evolution of the accretion rate, with a strong peak early on and a subsequent decay.

Finally, the impact of a protostellar jet population on a molecular cloud is considered. Under the conservative assumption of strict forward momentum conservation, the jets appear to fail to provide sufficient momentum to replenish decaying turbulence on the scales of a giant molecular cloud and on the scales of molecular cloud cores. At the intermediate scales of molecular clumps with sizes of a few parsec and masses of a few hundred solar masses, the jets provide enough momentum in a short enough time to potentially replenish turbulence and thus might help to stabilize the clump against further collapse.

Thesis available at: http://www.mpifr-bonn.mpg.de/staff/tstanke/thesis/thesis.html

UMIST

DEPARTMENT OF PHYSICS

POSTDOCTORAL RESEARCH ASSISTANT IN ASTROPHYSICS

The Astrophysics Group has an opening for a Postdoctoral Research Assistant in the field of Molecular Astrophysics, starting in January 2002 or as soon as possible thereafter, for a period of at least two years.

The Group, which includes G A Fuller, M D Gray, T J Millar and A A Zijlstra, has research interests in all branches of molecular astrophysics including the physics and chemistry of interstellar clouds and circumstellar regions, maser theory, the properties of interstellar dust and the dynamics of outflows and jets from young stars.

The successful applicant will work with Professor T J Millar and other Group members on the theory and/or observation of protoplanetary disks or evolved stars. The Group is actively involved in e-MERLIN, the upgrade to the national facility at Jodrell Bank, and is setting up a Centre for Interferometry and Imaging. Applicants with research experience in this area, or interests in the astrochemical modelling of small-scale structures, are encouraged to apply.

The appointment will be at the lower end of the PDRA 1A research scale. Applicants should send a letter outlining their research interests, a CV, and the names and addresses of two referees, to Professor T J Millar, Department of Physics, UMIST, PO Box 88, Manchester M60 1QD, UK (Tel. +44-(0)161-200-3677, e-mail: Tom.Millar@umist.ac.uk) before 15 November 2001. Further information on the Astrophysics Group can be found on our Web page at http://saturn.phy.umist.ac.uk:8000.

An Equal Opportunities Employer

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).

Latex macros for submitting abstracts and dissertation abstracts are appended to each issue of the newsletter.

The Star Formation Newsletter is available on the World Wide Web at http://casa.colorado.edu/reipurth or at http://www.eso.org/gen-fac/pubs/starform/ .

RESEARCH POSITIONS

Centre for Astrophysics
University of Porto - Portugal

CAUP accepts applications for positions of

- **Invited Researcher -** from one to twelve months
- **Advanced Post-Doctoral -** one year, renewable up to six years (prior experience as a postdoc for a minimum of four years required)
- **Post-Doctoral -** one year, renewable up to six years

Review of applications will be done regularly until these positions are filled, beginning on the **13th of October 2001**. Future review dates will be announced at the WWW site.

CAUP is a young Research Institute with a staff of 19 researchers, Ph.D. students and two Master Programs, involving more than 40 postgraduate students. The Institute is located at the Campus of the University.

Current research projects cover Stellar Astrophysics, Extragalactic Astronomy and Cosmology, involving both observations and theory. Particular attention is given to *Star Formation*. Portugal is a member of ESO and also of ESA. CAUP staff uses regularly the ESO facilities and other international observatories and participates in some of the current missions of ESA as well as in the preparation of future missions. There is a wide international collaboration on research and teaching projects. For further information see *http://www.astro.up.pt/*.

Applicants should forward a curriculum vitae, list of publications, a brief description of past experience and of research interests and a proposal for future research projects. For applications to Post-Doctoral positions the name, address and email of three referees are also required (reference letters will be requested to these persons).

Researchers working on *Star Formation and related subjects* are encouraged to apply.

Inquiries on the positions may be directed to

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