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Abstracts of recently accepted papers

Accretion disks around T Tauri stars. IV. The disk–star boundary layer

C. Bertout[1,2], J. Bouvier[1], W.J. Duschl[3,4] and W.M. Tscharnuter[3,4]

[1] Laboratoire d'Astrophysique, Observatoire de Grenoble, Université Joseph Fourier, B.P. 53X, F-38041 Grenoble Cedex, France
[2] Institut d'Astrophysique de Paris, 98bis Boulevard Arago, F-75014 Paris, France
[3] Institut für Theoretische Astrophysik, Universität Heidelberg, Im Neuenheimer Feld 561, D-69120 Heidelberg, Germany
[4] Interdisziplinäres Zentrum für Wissenschaftliches Rechnen, Universität Heidelberg, Im Neuenheimer Feld 368, D-69120 Heidelberg, Germany

We extended Bouvier and Bertout's (1992) analysis of T Tauri star spectra by incorporating Duschl and Tscharnuter's (1991) models for the global structure of boundary layers. Whereas this would allow for radially extended boundary layers, we indeed find radially thin boundary layers with typical extents of $\approx 3\%$ of the radius of the accreting star. Moreover, both the boundary layer width and the mass flow rate are better constrained in this new approach.

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A Comparison between Analytic and Numerical results of a Steady Jet Model

S. Biro[1,2], J. Cantó[1], A.C. Raga[3] and L. Binette[4]

1 Instituto de Astronomìa, UNAM, Apdo. Postal 70-264, Mèxico D.F. 04510, Mexico
2 Astronomy Dept., The University, Manchester M13 9PL, U.K.
3 Mathematics Dept., UMIST, P.O. Box 88, Manchester M60 1QD, U.K.
4 CITA, 60 St. George Street, Toronto, Ontario, M52 1A1, Canada

The structures of well aligned knots in stellar jets can be interpreted in terms of crossing shock models. In this paper, new analytic and numerical models for the formation of crossing shocks in steady jets are presented. The good agreement found between the analytic and numerical results allows us to present clear predictions of the properties of steady crossing shocks as a function of the flow parameters. These predictions should be useful for trying to identify the crossing shock structures that possibly exist in stellar jets.

A comparison has been made between the analytic and numerical solutions of a steady jet model. We now have a coherent analytic and numerical model for the formation of steady crossing shocks in stellar jets. The general predictions of this model are that the jet will present oblique ($\phi_I \sim 5^o$ and $\phi_R \sim 2^o$) internal crossing shocks with low shock velocities ($V_S \sim 15 \mathrm{kms}^{-1}$). The mechanism for the formation of these shocks, as well as analytic and numerical predictions of the observable parameters (e.g., the shock velocities and the lengths of the crossing shock cells) now appear to be well understood and on a firm theoretical footing.

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The Inner Disk and Stellar Properties of the Young Stellar Object WL 16

John S. Carr[1], Alan T. Tokunaga[2], Joan Najita[3], Frank H. Shu[3], and Alfred E. Glassgold[4]

[1] Department of Astronomy, The Ohio State University, 174 W. 18th Ave., Columbus, OH 43210
[2] Institute for Astronomy, University of Hawaii, 2680 Woodlawn Dr., Honolulu, HI 96822
[3] Astronomy Departmenmt, University of California, Campbell Hall, Berkeley, CA 94720
[4] Department of Physics, New York University, 4 Washington Place, New York, NY 10003

We present kinematic evidence for a rapidly rotating circumstellar disk around the young stellar object WL 16, based on new high-velocity resolution data of the v = 2-0 CO bandhead emission. A Keplerian disk provides an excellent fit to the observed profile and requires a projected velocity for the CO emitting region of ≈ 250 km s^{-1} at the inner radius and 140 km s^{-1} at the outer radius, giving a ratio for the inner to outer radii of about 0.3. We show that satisfying the constraints imposed by the gas kinematics, the observed CO flux, and the total source luminosity requires the mass of WL 16 to lie between 1.4 and 2.5 $M_\odot$. The inner disk radius for the CO emission must be less than 8 $R_\odot$.

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A Second Phase of Star Formation in the Serpens Core

Mark Casali[1], Carlos Eiroa[2] and William Duncan[1]

[1] Royal Observatory, Blackford Hill, Edinburgh EH9 3HJ, UK
[2] Departamento de Fisica Teorica, Facultad de Ciencias, Universitad Autonoma de Madrid, Cantoblanco 28049 Madrid, Spain

Submillimetre and millimetre continuum observations with the JCMT of the Serpens star forming cloud core have revealed six discrete objects, four of which have no near IR counterparts. We propose that these represent a second, more recent phase of star formation in the core. The strongest submm source corresponds to a known FIR and IRAS source - Serpens FIRS1, and shows an elongated lobe parallel to jet-like features seen at other wavelengths.

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The Spectroscopic Orbit and Subsynchronous Rotation of the Herbig Ae/Be Star TY CrA

Brian W. Casey[1], Robert D. Mathieu[1], Nicholas B. Suntzeff[2], Chi-Wai Lee[1,3], and Jason A. Cardelli[1]

[1] Department of Astronomy, University of Wisconsin, 475 N. Charter St., Madison, Wisconsin, 53706
[2] Cerro Tololo Inter-American Observatory, National Optical Astronomy Observatories, Casilla 603, La Serena, Chile
[3] Currently at Pennsylvania State University, Department of Astronomy, 525 Davey Lab, University Park, PA 16802

Eighty-nine high-resolution spectra of the Herbig Ae/Be eclipsing binary TY CrA have been obtained with the CTIO 1.5m telescope, from which high-precision radial velocities ($\sigma \approx 1.5$ km/sec) have been measured. We find TY CrA to be a single-lined, spectroscopic binary having a circular orbit with a period of 2.88873 days, supporting a previous photometric period of 2.888777 days. We also place an upper limit of 15 km/sec on the *vsini* of the primary. Such a low rotational velocity corresponds to highly subsynchronous rotation, presuming the stellar rotation axis to have an inclination angle near 90 degrees. We argue that this remarkably slow rotation velocity in a circular orbit cannot be explained in the context of stellar evolution and tidal interactions alone. Presuming TY CrA to be a pre-main sequence star, the origin of its subsynchronism must lie in a braking mechanism early in the life of the primary. Finally, we note that the lack of near-infrared excess emission indicates that no optically thick disk material is present within a few orbital separations of the binary. In addition, the extinction of only 3 mag toward TY CrA places an upper limit on circumbinary disk mass that is several orders of magnitude below disk masses detected around T Tauri stars. However, this conclusion is sensitive to the precise geometry of the disk-binary system, so that a massive disk with a central hole in which the binary resides is not excluded.

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The Triple Radio Continuum Source in Serpens: The Birth of a Herbig-Haro System?

Salvador Curiel[1,2], Luis F. Rodríguez[2], James M. Moran[1], and Jorge Cantó[2]

[1] Harvard-Smithsonian Center for Astrophysics, Mail Stop 42, 60 Garden Street, Cambridge, MA 02138, USA
[2] Instituto de Astronomía, UNAM, Apdo. Postal 70-264, 04510 México, D.F., Mexico

VLA observations of the triple radio continuum source in Serpens have revealed its extraordinary characteristics. While it is associated with a star forming region, its outer components exhibit nonthermal spectra and large proper motions. Here, we present the results of high sensitivity, multifrequency VLA radio continuum observations of this source. These observations show that: a) the radio source consists of a central component, and two lobes with enhanced brightness at their ends, b) there is knotty and extended emission connecting the central source with the outer NW component which we identify as a radio jet, c) the central source exhibits an almost flat spectrum with a spectral index $\alpha = 0.15 \pm 0.09$, the NW component also has a flat spectrum with an index $\alpha = -0.05 \pm 0.05$ (characteristic of optically thin thermal emission), and the SE component has a negative index $\alpha = -0.30 \pm 0.04$ (consistent with nonthermal synchrotron emission), d) the outer sources break into a number of components (which we identify as "internal working surfaces" or "bullets") with similar tangential velocities and directions, and e) the central source has an elongated morphology, with its major axis nearly parallel to the outflow direction but having a significantly different direction, which suggests that the central source may be precessing or nutating.

These observations confirm the unusually large proper motions of about $0.12''$ per year, previously measured for the outer NW and SE components. Moreover, similar proper motions have been obtained for a time variable knot in the NW radio jet, suggesting that probably all the knots in the body of the jet have velocities similar to those of the outer components. The spectral indices of the main three components differ from those obtained previously. We suggest that the brightness variability of the outer sources, as well as the change in their spectral indices, could be the result of the passage of locally enhanced condensations through the bow-shock produced by the ejected material. We find that if the NW and SE clumps are moving through a medium with density of $n_\circ \sim 10^5$ cm^{-3}, then the thermal free-free emission produced by the shock waves around these objects can account for the observed emission. However, the non-thermal component requires of a different radiation mechanism.

We identify the triple radio continuum source in Serpens as a young radio jet, with a dynamical age of only ~ 50 years, emanating from the central component. This radio jet exhibits a one-sided morphology that is very similar to that observed in optical Herbig-Haro jets, suggesting that jets associated with young stellar objects are intrinsically unipolar within the dynamical ages of the main jets and not an extinction effect. We believe that the knotty structure in the NW radio jet and the SE components are the result of discrete ejection of material (or "bullets") from the central source. Finally, based on the morphological and kinematical similarities between this radio jet and optical Herbig-Haro jets, and their different length scales and dynamical ages, we propose that the Serpens radio jet could be a *proto-Herbig-Haro System*, in an early stage of evolution.

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3D Simulations of Proto-Stellar Jets

Elisabete M. de Gouveia Dal Pino[1,2], and Willy Benz[3]

[1] Inst. Astrôn. e Geofísico, Univ. de São Paulo, Av. Miguel Stéfano 4200, São Paulo, SP 04301-904, Brazil
[2] Harvard-Smithsonian Center for Astrophysics, 60 Garden St., Cambridge, MA 02138 [3] Steward Observatory and Lunar and Plan. Lab., University of Arizona, Tucson, AZ 85721, USA

We present the first results of fully 3D simulations of supersonic, radiatively cooling jets using the smoothed particle hydrodynamics technique (SPH). Our results qualitatively agree with the 2D simulations of Blondin, Fryxell, and Konigl (1990), although the removal of the axisymmetry has resulted in relevant structural differences, especially at the jet head where a cold shell is formed from the condensation of the shock-heated material. In particular, we found that the shell is not only dynamically unstable but also may undergo oscillations in density, which are attributed to global thermal instabilities. These effects may have important consequences on the dynamics and emission pattern of the observed HH objects associated to proto-stellar jets. We discuss the implicatons of our results in the interpretation of the observed properties of the stellar jets and HH objects. We also compare the structure of radiative cooling and adiabatic 3D jets.

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HCO^+ emission in the HH7-11 region: the slowest component of the outflow?

W.R.F. Dent[1], C. Cunningham[2], R. Hayward[2], S.R. Davies[3], D. Wade[2], L. W. Avery[2], C.J. Mayer[1], N.T. Masuda[1]

[1] Joint Astronomy Centre, 660 N. A'ohoku Place, University Park, Hilo, Hawaii, 96720, USA
[2] Herzberg Institute of Astrophysics, 100 Sussex Drive, Ottawa, Ontario, Canada
[3] Electronic Engineering Laboratory, University of Kent, Canterbury, Kent CT2 7NT, England

The region of the high velocity outflow in HH7-11 has been mapped in the J=4-3 transition of HCO^+. The results are compared with published optical, CO and J=1-0 HCO^+ maps. Unlike the latter interferometry data we see a bright compact source associated with the exciting star, plus weaker emission throughout the region. Extended emission surrounds the line of HH objects, and has a morphology very similar to the blue-shifted CO outflow. Spectra of the J=4-3 and 3-2 lines in selected positions within the flow region indicate two physical components: (1) cool gas at a density of a few $10^6 cm^{-3}$ at the velocity of SSV13 and the ambient cloud; (2) warm (35K) gas at a few $10^5 cm^{-3}$ blue-shifted by $\approx 1 kms^{-1}$. The close agreement between the HCO^+ and higher-velocity CO suggests that the former arises from the densest, slowest component of the molecular flow. The morphology appears to favour a confined jet rather a shocked cloudlet model.

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Polarization of Astronomical Maser Radiation II. Polarization Modes and Unsaturated Growth

Moshe Elitzur[1,2]

[1] Department of Physics and Astronomy, University of Kentucky, Lexington, KY 40506
[2] NASA Ames Research Center, MS 245-3, Moffett Field, CA 94035

Maser polarization is analyzed in the limit of overlapping Zeeman components ($g\nu_B \ll \Delta\nu_D$, where $g\nu_B$ is the Zeeman splitting and $\Delta\nu_D$ is the Doppler width). All the discrepancies among the conflicting conclusions of previous studies that identified maser polarizations in this limit are fully resolved. In the case of m-independent pumping, proper application of the eigenvalue technique of Goldreich, Keeley and Kwan shows that the polarization eigenvectors are the same for saturated and unsaturated masers and are independent of spin for pure spin states, in agreement with the results of the first paper in this series. Stable eigenvectors correspond to the peak of the polarization mode distribution of self-amplified radiation at any degree of saturation. But the distribution average, the actually measured polarization, does not necessarily coincide with its peak. The mode distribution starts with a rectangular shape, because the seed radiation generated in spontaneous decays is unpolarized, and evolves toward a sharply peaked profile whose average, and not just its peak, coincides with the eigenvector solution because of the following two effects:

First, interaction with the maser molecules induces rotation of the polarization vectors of individual modes, similar to Faraday rotation. The rotation rate is different for different modes and the polarization eigenvectors correspond to stationary modes that do not rotate. Starting from unpolarized radiation generated by the source terms and containing an equal mix of all modes, all individual polarization vectors rotate into the stationary stable modes, resulting in a radiation field polarized according to the solution of the eigenvalue problem. As a result of this rotation the ensemble-averaged Stokes parameters reach the eigenvector solution when $J \gtrsim J_s$, where J is the angle-averaged intensity and J_s is the saturation intensity, i.e., only after the maser saturates. This explains the results of numerical studies of the maser polarization problem presented in the literature.

Second, and more important, maser growth is highly unstable during the unsaturated phase for any polarization configuration except for that of the eigenvector solution. The Stokes parameters of all other polarization structures include terms proportional to $\exp|aI|$, where I is the intensity and $a \neq 0$, and thus are highly unstable against arbitrarily small intensity perturbations. Such perturbations induce runaway divergence of the ensemble averaged Stokes parameters away from their initial values, a divergence that stops only when the polarization settles into the appropriate eigenvector solution. The e-folding growth rate of the instabilities increases with J and reaches unity when $J \sim J_s/\tau_s$, where τ_s is the optical depth of the maser when it saturates; pumping schemes of astronomical masers typically produce $\tau_s \sim 12 - 17$. Instabilities impose an upper bound on the intensity of radiation whose polarization differs from that of the eigenvector solution and are the dominant factor in narrowing the polarization mode distribution around its peak. Only radiation whose ensemble-averaged polarization corresponds to the eigenvector solution can grow to saturation and beyond. Furthermore, all polarization configurations are unstable for propagation at $0 < \theta < \theta_0$,

where θ is measured from the magnetic axis and $\sin^2\theta_0 = 1/3$. One eigenvector solution, corresponding to fully polarized radiation, is stable in this region during the unsaturated growth phase against perturbations that rotate the polarization at a fixed intensity, but not against intensity perturbations. As a result, stable buildup of maser radiation in a magnetic field with $g\nu_B \ll \Delta\nu_D$ is possible only for $\theta \geq \theta_0$; propagation directions too close to the field axis, corresponding to a fractional volume of ~ 0.09, are excluded. Propagation along the axis, $\theta = 0$, is allowed, but the corresponding radiation is unpolarized.

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Magnetized Accretion-Ejection Structures I – General Statements

Jonathan Ferreira, Guy Pelletier

Laboratoire d'Astrophysique, Observatoire de Grenoble, Universite Joseph Fourier, B.P. 53X, F38041 Grenoble Cedex, France

The structure of accretion disks thread by opened magnetic field lines that drive jets by extracting angular momentum has been investigated. Accretion and ejection are thus complementary processes that cannot be separated, the magnetohydrodynamic (MHD) structure of accretion-ejection must be understood globally. Several classes of such structures have been selected for both active galactic nuclei (AGN) and young stellar objects (YSOs). A continuous transition from a standard hydrodynamic disk to a fully MHD accretion-ejection configuration can be achieved under three circumstances. The first one concerns the innermost radiative part of AGN accretion disks, whereas the other two concern YSOs disks, precisely, the grain and the molecular opacity dominated regions.

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The accreting circumstellar gas envelope of HD 176386, a young star in the R CrA star formation region

C. A. Grady[1], M. R. Pérez[2], P. S. Thé[3]

[1] Applied Research Corp., Suite 1120, 8201 Corporate Dr., Landover, MD 20785, USA
[2] Astronomy Programs-CSC, IUE Observatory-Code 684.9, NASA-GSFC, Greenbelt, MD 20771, USA
[3] Astronomical Institute "Anton Pannekoek", University of Amsterdam, Kruislaan 403, 1098 SJ Amsterdam, The Netherlands

We report recent and archival IUE observations of the Herbig Be star HD 176386. We find accreting gas toward the star with velocities up to +300 km s^{-1} in C IV and Si IV. Detection of these species in a B9.5 star is consistent with collisional ionization of the accreting gas to temperatures in excess of the stellar T_{eff}. The IUE data also provide evidence for the presence of discrete absorption features similar to those observed in optical and UV spectra of β Pic. The accreting gas column densities, and maximum accretion velocity are intermediate between those seen in younger Herbig Ae/Be stars such as HR 5999 and HD 45677 and field systems such as β Pic and 51 Oph. These data suggest a gradual transition from the optically thick (continuum), high mass accretion rates seen in the younger Herbig Ae/Be stars to optically thin accretion typical of systems such as β Pic, and that the time scale for such a transition for a B9.5 star appears to be $1.5 \leq t \leq 2.8$ Myr.

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Star formation in the Vela molecular clouds II. The luminosity function of the Class I sources

D. Lorenzetti[1], L. Spinoglio[1] and R. Liseau[1] [2]

[1] Istituto di Fisica dello Spazio Interplanetario, CP 27, I–00044 Frascati, Italy.
e-mail: user@hp.ifsi.fra.cnr.it (user: dloren, lspino, liseau)
[2] Stockholm Observatory, S–133 36 Saltsjöbaden, Sweden. e-mail: rene@astro.su.se

We present the results of an unbiased survey of a flux limited sample of red IRAS point sources [$F_\nu(12\mu\mathrm{m}) \geq 1.0$ Jy] in a region of the southern sky being situated close to the plane of the Galaxy and containing the Giant Molecular Clouds (GMCs) of the Vela Molecular Ridge (VMR). From multifrequency observations we identify the Lada & Wilking (LW) Class I sources of low to intermediate luminosity in the actively star forming VMR. These clouds have probably been forming stars for at least some million years and the overall efficiency is estimated to lie in the range $5 - 15\%$, i.e. being comparable to the average value found for the solar neighbourhood. The shape of the bolometric luminosity function of the Class I sources of the VMR is similar to that observed in other star forming regions of the solar neighbourhood. These LFs are commonly very flat and can be fit by a mean power law of index -0.4 ± 0.2 over five orders of magnitude in luminosity, i.e. the *form* of the Class I LFs appears invariant under luminosity translation. Such similarity suggests that the *shape* of the Class I LFs is not strongly dependent on the different cloud properties, which can vary appreciably from cloud to cloud. For the VMR, we have also obtained a statistically more reliable Class I LF, containing more than one hundred sources and which is the result of subtracting the source content of an adjacent reference field being void of molecular material at the LSR-velocities of the VMR. Besides of also being flat, this LF does furthermore reveal that a single power law representation seems inadequate over the observed range in luminosity. We identify the indicated power law break tentatively as the result of a turnover of the Class I LF at lower luminosities. Such turnover has been predicted by some recent theories of protostellar evolution and is introduced by the development of a characteristic mass scale during the mass accretion time of the star forming cloud. Our observations would thus lend support to the evolutionary model according to which the LW-Class I sources, as a class, are protostars accreting matter at (normally) relatively high rates. It would further be implied that the prevailing accretion rates are not predominantly determined by the mass of the accreting protostar, but largely by the effective isothermal sound speeds of the cloud. For a given star forming cloud, this would determine the exact location of the peak of the LF, thus introducing a dependence on global properties of the cloud. We argue that in typical GMCs like the VMR a Salpeter-like IMF is determined already by the time of appearance of the Class I sources, whose mass spectrum is that observed for molecular cloud clumps. Any initial differences in local IMFs produced by, e.g., less massive molecular clouds would become 'ironed out' with time, as the GMCs develop stellar mass functions similar to the field star IMF at comparable efficiency. We present, finally, some heuristic arguments which indicate that the average mass column through a molecular cloud provides an observable measure of the efficiency at which the cloud is producing stars.

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HH 80-81: A Highly Collimated Herbig-Haro Complex Powered by a Massive Young Star

J. Martí[1,2], L. F. Rodríguez[1] and Bo Reipurth[3]

[1] Apdo. Postal 70-264, 04510 México, D. F., Mexico
[2] Departament d'Astronomia i Meteorologia, UB, Av. Diagonal 647, 08028 Barcelona, Spain
[3] European Southern Observatory, Casilla 19001, Santiago 19, Chile

We present multifrequency, matching-beam VLA continuum observations of the HH 80-81 system as well as high resolution observations of its central exciting source. A highly collimated bipolar jet emanates from this central source along a line between the source and HH 80-81. The jet consists of a multitude of knots, with a spacing of about 1400 AU and widths of less than 500 AU. This is strikingly similar to the structure of HH jets emanating from young stars more than a thousand times less luminous. The southern lobe terminates in the visible HH objects HH 80-81 at a projected distance of 2.3 pc from the central source. These objects are detected and resolved at 6 cm and 3.6 cm with a spectral index of $\alpha = -0.3$. We find another resolved object 3.0 pc to the north of the source along the well-defined flow axis and with the same negative spectral index, but without any known optical counterpart. We here call this object HH 80 North. The total projected dimension of 5.3 pc for this highly collimated outflow complex far exceeds all other known HH complexes and is more than an order of magnitude larger than the typical dimensions of such flows. There is clear evidence for a gentle wiggling of the flow axis, suggesting that the driving source may be precessing. The remarkable structural similarity between the HH 80-81 jet and HH jets from low-luminosity stars suggests that massive newborn stars pass through very similar evolutionary phases.

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Very Small Dust Grains in the Circumstellar Environment of Herbig AeBe Stars

A. Natta[1], T. Prusti[2] and E. Krügel[3]

[1] Osservatorio Astrofisico di Arcetri, Largo Fermi 5, 50125 Firenze, Italy.
[2] Astrophysics Division, Space Science Department, ESTEC, Postbus 299, 2200 AG Noordwijk, The Netherlands.
[3] Max-Planck-Institut für Radioastronomie, Auf dem Hügel 69, W-5300 Bonn 1, Germany.

We present calculations of the spectral energy distribution of Herbig AeBe stars surrounded by spherically symmetric, dusty envelopes where very small grains (VSGs) and polycyclic aromatic hydrocarbons (PAHs) are included. VSGs and PAHs radiate in the near and middle infrared, approximately from 2 to 20 μm. The resulting spectral energy distribution is quite flat in this range of wavelenghts, depending mostly on the amount and size of the VSGs. Energetically, we find that VSGs and PAHs can contribute a significant fraction of the observed middle infrared luminosity, but not all, unless there is an extremely large amount of VSGs. Also, the model predicted near infrared colours indexes do not fit the observations significantly better than those of models where only large grains, in equilibrium with the local radiation field, are considered.

Nevertheless, VSGs and PAHs do emit significantly more radiation in the mid-infrared than large grains. We suggest that VSGs and PAHs may be an important ingredient in models of Herbig AeBe stars as star+disk+envelope systems.

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UV spectral variability in the Herbig Ae star HR 5999: XI. The accretion interpretation

M. R. Pérez[1], C. A. Grady[2], P. S. Thé[3]

[1] Astronomy Programs-CSC, IUE Observatory-Code 684.9, NASA-GSFC, Greenbelt, MD 20771, USA
[2] Applied Research Corp., Suite 1120, 8201 Corporate Dr., Landover, MD 20785, USA
[3] Astronomical Institute "Anton Pannekoek", University of Amsterdam, Kruislaan 403, 1098 SJ Amsterdam, The Netherlands

We report recent IUE high- and low-dispersion observations with the IUE long wavelength camera (LWP) and short wavelength camera (SWP) of the Herbig Ae star HR 5999. We have found a dramatic change in the structure of the Mg II h and k lines (2795.5, 2802.7 Å) along with some continuum flux excesses especially at the short end of the SWP camera. LWP high-dispersion observations of HR 5999 obtained between 1979 and 1990, at times of comparatively low UV continuum fluxes, exhibit P Cygni type III profiles in the Mg II resonance doublet. In contrast, observations made from September 1990 through March 16-18, 1992, with high UV continuum fluxes, present Mg II lines with reverse P Cygni profiles indicative of some active episodic accretion. Accreting gas can also be detected in the additional red wings of the various Fe II and Mn II absorption lines, with velocities up to +300-350 km s^{-1} (September 1990). By September 10, 1992 the Mg II profile had returned to the type III P Cygni profile similar to those from earlier spectra. The correlation between the presence of large column densities of accreting gas and the continuum light variations supports suggestions by several authors that HR 5999 is surrounded by an optically thick, viscously heated accretion disk. Detection of accreting gas in the line of sight to HR 5999 permits us to place constraints on our viewing geometry for this system. A discussion is included comparing the spectral and physical similarities between HR 5999 and the more evolved proto-planetary candidate system, β Pictoris.

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Visual Binaries among Pre-Main Sequence Stars

Bo Reipurth[1] **and Hans Zinnecker**[2]

[1] European Southern Observatory, Casilla 19001, Santiago 19, Chile
[2] Inst. f. Astronomie und Astrophysik der Universität Würzburg, Am Hubland, W-8700 Würzburg, Germany

In an effort to determine statistical properties of visual pre-main sequence (PMS) binaries, we have carried out an extensive systematic CCD imaging survey of young low-mass stars in nearby southern dark clouds, all at about 150 pc distance. The observations were made with the ESO New Technology Telescope at a wavelength of 0.9 μm under sub-arcsecond seeing conditions. Among the 238 young stars systematically observed, we detect 37 binaries (22 new discoveries) and 1 triple system (Sz 30, also new) in the range of separations between $1''$ and $12''$. Further binaries were identified outside these limits, including 6 sub-arcsec binaries. The lower limit of $1''$ was imposed to ensure completeness of our sample, which we have tested through numerical simulations. We show that the upper limit is small enough that we have essentially no contamination by fore- and background stars. Thus, we find a frequency of 16% for PMS binaries with projected separations between about 150 AU and 1800 AU. The distribution of separations is a steeply rising function towards smaller separations. We compare these observations with the known main sequence (MS) distributions of G and K dwarfs in the same interval of separations, and find an apparent excess of PMS binaries. Under the assumption that total PMS and MS binary frequencies should be the same, the excess may imply that binary orbits undergo secular evolution towards the main sequence.

The histogram of flux-ratios at 0.9 μm shows a gradual increase towards unequal components. We find very few binaries with components of nearly equal brightness. We discuss the difficulties involved in translating this flux-ratio distribution for PMS binaries into a distribution of mass-ratios. There is no significant dependence of flux-ratio on the separation of the components. We briefly discuss implications of our results for the star formation efficiency and the initial mass function. Our data suggest that in T associations binary star formation appears to be the rule, while the formation of single stars is probably the exception.

Our distance-limited systematic survey sample is actually a sub-sample of our total survey sample which comprised most known PMS objects accessible from the southern hemisphere except Orion objects. We have in the same way searched for multiplicity in this extended sample. As a result, we have additionally discovered another 18 new PMS binaries and have reobserved another 32 already known PMS binaries. Therefore, in total we here provide information (component separations, brightness-ratios, and position angles) on 87 PMS binaries and 1 triple, approximately half of which are newly discovered.

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Hubble Space Telescope Imaging of Herbig-Haro Object No. 2

R. D. Schwartz[1], **M. Cohen**[2], **B. F. Jones**[3], **K.-H. Böhm**[4], **J. C. Raymond**[5], **L. W. Hartmann**[5], **R. Mundt**[6], **M. A. Dopita**[7], **and A. S. B. Schultz**[8]

[1] Dept. of Physics and Astronomy, University of Missouri-St. Louis, 8001 Natural Bridge Rd., St. Louis, MO, 63121 USA
[2] Radio Astronomy Laboratory, University of California, 601 Campbell Hall, Berkeley, CA 94720 USA
[3] Lick Observatory, University of California, Santa Cruz, CA 95064 USA
[4] Astronomy Dept., FM-20, University of Washington, Seattle, WA 98195 USA
[5] Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138 USA
[6] Max-Planck-Institut für Astronomie, Königstuhl 17, D-6900 Heidelberg, Germany
[7] Mt. Stromlo and Siding Spring Observatories, Private Bag, Weston Creek P.O, ACT 2611, Woden, Australia
[8] Dept. of Physics and McDonnell Center for the Space Sciences, Washington University, St. Louis, MO, 63130 USA

Images of Herbig-Haro Object No. 2 obtained with the Planetary Camera of the *Hubble Space Telescope* are presented and discussed. The images, obtained in the emission lines of Hα, [S II], and [O III] at a scale of 0.044 arcsec pixel^{-1}, have been registered to within 11 mas, and the spherically-aberrated images have been restored with the Richardson-Lucy algorithm. The A and H complexes in HH2, which appear as somewhat extended (2"-3"), amorphous features on ground-based images, are found to resolve into a rich array of structures with sizes in the range 0.2"-0.4", embedded within faint extended emission. A wide range of excitation is evident throughout each complex. Although a few of the structures are suggestive of bow shock wave geometry, most of the features appear chaotic with complex excitation

structure. It is tentatively suggested that the features in HH2 may be the result of the fragmentation of a bow wave.

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Grain Mantles in the Taurus Dark Cloud

R. G. Smith[1], K. Sellgren[2], and T. Y. Brooke[3]

[1] Department of Physics, University College, Univ. of New South Wales, Campbell, ACT 2600, Australia
[2] Department of Astronomy, Ohio State University, 174 West 18th Av., Columbus, OH 43210, U.S.A.
[3] Jet Propulsion Laboratory, MS 169-237, 4800 Oak Grove Dr., Pasadena, CA 91109, U.S.A.

We have obtained low resolution ($\lambda/\Delta\lambda \sim 160$) 3 μm spectra of a selection of field stars lying behind the Taurus dark cloud. Several of these stars have abnormal extinction laws, which is best characterised by $A_K \leq 0.27$ E(J–K) and $A_V \leq 5.4$ E(J–K). We find a very good correlation between A_V and $\tau_{3.05}$ (the H_2O ice feature), confirming a previous result, and between A_V and $\tau_{3.45}$ (the long wavelength wing), yielding the ratios $\tau_{3.05}/A_V = 0.059 \pm 0.003$ and $\tau_{3.45}/A_V = 0.0077 \pm 0.0005$. The threshold extinctions for the H_2O iceband and the long wavelength wing are found to be the same, within the uncertainties, at $A_{V_0} = 2.6$. The fact that these thresholds are the same means that the long wavelength wing cannot be due to a highly refractory hydrocarbon residue. The lack of substructure in the long wavelength wing also argues against a hydrocarbon origin for the wing.

By modelling the H_2O ice feature with a model employing silicate and graphite grain cores following a power law size distribution, we find that the iceband observations can only be fit by models in which either (i) only the largest grains have significant ice mantles, or (ii) there are two grain populations throughout the cloud, one of 'bare' grains and one of grains which have a constant ice mantle thickness of 0.35 ± 0.05 μm. In the latter model we estimate the ratio of bare to mantled grains to be $\sim 3 \times 10^4$:1. Both models, combined with the observed $\tau_{3.05}/A_V$ ratio, imply 8–9 % of the oxygen is depleted onto the grains as H_2O ice mantles. We discuss a number of mechanisms for producing the H_2O ice and long wavelength wing thresholds, and conclude that photodesorption is the most likely means of preventing H_2O ice mantle formation near the cloud edges. Photodesorption, combined with a clumpy cloud structure, also naturally explains the bare/mantled grain distribution, as UV photons penetrating into the cloud prevent ice mantle formation everywhere except within dense clumps.

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High-Resolution Long-Slit Spectral Imaging of the Mass Outflow in the Immediate Vicinity of DG Tauri

J. Solf[1], and K.H. Böhm[2]

[1] Max-Planck Institut für Astronomie, Königstuhl 17, W-6900 Heidelberg 1, Germany
[2] Astronomy Department, FM-20, University of Washington, Seattle WA 98195, USA

High-resolution long-slit spectra of DG Tau and the associated mass outflow are presented. The detailed spatio-kinematic structure of the outflow regions in the immediate vicinity of the central star and the variations of the electron density and excitation have been deduced on a sub-arcsecond scale from the analysis of the spatially resolved forbidden lines. Following the model of Kwan & Tademaru, we suggest that two separate gas components in the outflow, a rather compact low-speed component and a more extended high-speed component, contribute to the observed emission

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JHKL Imaging and K Polarimetry of the Bipolar Outflow NGC2071.

D. M. Walther[1], E. I. Robson[1,2], C. Aspin[1], and W. R. F. Dent [1]

[1] Joint Astronomy Centre, 660 N. A'Ohoku Pl., University Park, Hilo, Hawaii 96720
[2] University of Central Lancashire, Preston, PR1 2TQ, United Kingdom

We present the first JHK and NBL high spatial resolution images of NGC2071IR. A 5' × 9' K band contour map of NGC2071 is presented along with a 5' × 9' K image of the NGC2071 morphology, and the first high resolution K polarimetry of the NGC2071 core region. We find that IRS1 is highly polarized, while IRS2,4 and 6 are stellar like objects with low polarization. IRS2, IRS4, and IRS6 are stars located behind the bipolar outflow which is generated by IRS1 in the NE-SW direction. IRS5 is a peak of molecular hydrogen emission from IRS1.

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A CO and IRAS study of Cometary Globule 12

Glenn J White[1]

[1] Department of Physics, Queen Mary and Westfield College, University of London, Mile End Road, London E1 4NS, England. Email GJW@STAR.QMW.AC.UK, Phone +44-81-975-5056, Fax +44-71-981-9465

Observations of the J = 2-1 CO and $C^{18}O$ lines are reported towards the reflection nebula NGC 5367 in the head of Cometary Globule CG 12, which show it to be only the second example known to date of molecular outflow activity in such an object. The CO has a bipolar shape, centred close to the infrared source IRAS 13547-3944. This has a bolometric luminosity ∼110 $L_\odot$, and lies close to a 13.5 $M_\odot$ molecular core whose kinetic temperature ∼20K and diameter ∼0.15 pc. This core appears virialised, and offset from the highest temperature material along the eastern edge of the dense gas - which is probably heated by the UV radiation of a nearby B4 star. A highly collimated (axial ratio ≥5) and low-luminosity molecular outflow originates close to this core, extends over a length of 0.9 pc, and contains ∼0.05 $M_\odot$ of outflowing material. The structure of the outflow is discussed along with its relationship to the rest of the globule. This is an example of a relatively isolated low-intermediate mass star formation region, which is speculated to have formed as the result of a nearby supernova event 10 - 20 million years ago, and has to date converted about 20 percent of its gas mass into stars.

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New VLA Observations of NH_3 in S140

Shudong Zhou [1,2], Neal J. Evans II [1], Lee G. Mundy[3], Marc L. Kutner[4]

[1] Department of Astronomy, The University of Texas at Austin, Austin, TX 78712-1083
[2] Postal address: Department of Astronomy, University of Illinois, Urbana, IL 61801
[3] Department of Physics and Astronomy, University of Maryland, College Park, MD 20742
[4] Department of Physics, Rensselaer Polytechnic Institute, Troy, NY 12180

The S140 molecular cloud was observed in the NH_3 (1,1) and (2,2) lines with 5″ resolution. Compared to the previous VLA observations, the new observations have 3 times better flux sensitivity, 4 times better spatial resolution, and 2.5 times better velocity resolution. These advantages allowed the detection of 80%-85% of the single-dish flux in the two NH_3 lines. The NH_3 emission region consists of a long filament perpendicular to the optical bright rim and an arc-like structure along the edge of the bright rim. Within 15″ of IRS 1, there is an absence of NH_3 emission which is probably caused by a true decrease in NH_3 column density, not by missing short spacings or changes in the partition function due to a temperature increase. Comparison with a multitransition analysis of CS observations shows that this low NH_3 column density indicates a low NH_3 abundance in the dense gas near the infrared sources rather than an absence of molecular gas. The gas temperature is derived from the NH_3 data and can be accounted for mostly by heating from IRS 1-3. We also detected a compact continuum source at 2.7 mm with the Owens Valley Millimeter Interferometer. This continuum source coincides with the peak of low J CS emission and an NH_3 emission peak. The NH_3 lines at this position are unusually wide and the profiles are consistent with models of gravitational collapse.

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Dissertation Abstracts

A Near-Infrared Survey of the Star-Forming Region NGC 2264

François Piché

Thesis work conducted at: Dept. of Astronomy, Univ. of Washington, USA

Current address: Dept. of Physics and Astronomy, Univ. of Rochester, Rochester, NY, 14607, USA

Electronic mail: piche@sherman.pas.rochester.edu

Ph.D dissertation directed by: Bruce Balick

Ph.D degree awarded: December 1992

We present the results of a large-scale near-infrared (J, H, K) survey of the star-forming region NGC 2264. The survey covers 48' (Dec) X 27' (RA) with a completeness limit of 15.5, 14.5, and 14 mag at J, H, and K, respectively. Complementary observations of NGC 2023, NGC 2068, and NGC 7023 are also discussed.

Young stars in NGC 2264 are concentrated in two clusters. The northern cluster is highlighted by the bright star S Monocerotis. The infrared source NGC 2264 IRS, the molecular outflow NGC 2264D, and the Cone Nebula are associated with the southern cluster. The northern cluster is divided into two subclusters: the southern cluster has three subclusters.

The luminosity functions (LFs) of NGC 2264 subclusters have slopes in the range 0.28-0.30. This is also the case for NGC 2068. NGC 2023's LF is shallower (0.21). There is a break in the LF of NGC 7023 around K=10.5 mag. All LFs are consistent with a Salpeter IMF and a Miller-Scalo IMF. For NGC 7023, we obtain a better agreement with a Miller-Scalo IMF. The differences in LF can be attributed to cluster ages. NGC 2023 is approximately one million years old. NGC 7023 is old enough for its LF to be consistent with a cluster of main-sequence stars. The NGC 2264 clusters and NGC 2068 have ages intermediate between NGC 2023 and NGC 7023.

A large fraction of LFs have turn-offs at their faint end. These can be interpreted as turns-offs at the low-mass end of the corresponding initial-mass function.

We present a new optical-infrared color-color diagram (V-J vs. J-K) that is more efficient at detecting stars with infrared excesses than the infrared color-color diagram (J-H vs. H-K). The luminosity function of infrared excess stars in NGC 2264 peaks around K=11 mags.

Finally, we report the detection of a pedestal stellar population in NGC 2264. Dissipation of the main clusters could explain the properties of this stellar population.

STARS, GAS AND DUST IN THE GALAXY

A Symposium in honor of Dr. Eugenio E. Mendoza

August 25-27, 1993

MEXICO CITY

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GRANTS

A limited number of grants will be allocated by the Scientific Organizing Committee. Priority will be given to students and young scientists.

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For further information please contact:

Dr. Armando Arellano Ferro
Instituto de Astronomia
Apartado Postal 70-264
Cd. Universitaria
04510 Mexico, D.F.
Fax 548-37-12
e-mail stars@astroscu.unam.mx