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Abstracts of recently accepted papers

Hubble Space Telescope WFPC2 Observations of the Young Bipolar HII Region S106

John Bally[1], Ka Chun Yu,[1] John Rayner,[2] and Hans Zinnecker[3]

[1] Department of Astrophysical and Planetary Sciences and Center for Astrophysics and Space Astronomy, University of Colorado, Campus Box 389, Boulder, CO 80309-0389, USA
[2] Institute for Astronomy, University of Hawaii, 2680 Woodlawn Drive, Honolulu, Hawaii 96822, USA
[3] Astrophysikalisches Institut Potsdam, An der Sternwarte 16, D-14482 Potsdam, Germany

E-mail contact: bally@nebula.colorado.edu

We present narrow band *HST* WFPC2 images of the bipolar HII region S106 in the Hα line. The high resolution image shows unprecedented detail in the two nebular lobes including prominent scalloped structure of the emission at the ionization front. The illuminating source of the nebula, S106 IR, is detected in Hα but not in an adjacent passband that excludes bright nebular lines. Our estimates of the extinction of the exciting source is $A_V \approx$ 19–22, which is in agreement with past determinations. The northern lobe of S106 is seen through a nearly opaque veil of foreground material so that its structure is hard to discern. Most of the nebular emission towards the southern lobe emanates from the scalloped ionization fronts at the surfaces of hemispherical clumps located at the back side of the HII region. We infer the existence of a translucent layer of foreground extinction in front of the southern lobe that decreases with distance from the exciting source. Despite the presence of a cluster of 50 to 150 young stars, externally illuminated young stellar objects similar to the over 100 "proplyds" seen in the Orion nebula are not found in S106. This non-detection is most likely due to the complete absence of young stars within the nebular lobes. However, if some of the stars seen towards the nebular lobes are found to be low mass members of the S106 cluster and embedded within the photo-ionized region, the lack of extended Hα emission would imply a nebular photo-ionization age be $> 10^5$ years, the photo-evaporation time scale for circumstellar disks.

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Protostars in Perseus: Outflow Induced Fragmentation

Mary Barsony[1], Derek Ward-Thompson[2], Philippe André[3], and JoAnn O'Linger[1]

[1] Physics Department, University of California, Riverside, Riverside, CA 92521, USA
[2] University of Wales Cardiff, Dep't. of Physics & Astronomy, PO Box 913, 5 The Parade, Cardiff CF2 3YB, UK
[3] CEA, DSM, DAPNIA, Service d'Astrophysique, C.E. Saclay, F-91191, Gif-sur-Yvette Cedex, France

E-mail contact: barsony@earthlink.net

We present new far-infrared, submillimeter, and millimeter images of candidate protostars in the Perseus molecular cloud complex: L1448N/IRS3, L1448C, and IRAS 03282+3035. L1448N/IRS3 is now known to comprise three separate millimeter continuum sources: L1448N(A) + L1448N(B), which form a close (7$''$ separation) binary, and L1448NW, $\sim$ 20$''$ to the northwest (Terebey & Padgett 1997). The new maps presented here include 12, 25, 60, and 100 μm HIRES-processed IRAS images, 450 and 800 μm maps from the 15-m James Clerk Maxwell Telescope (JCMT), and a 1300 μm bolometer array map of the L1448 sources from the IRAM 30-m telescope.

We present new spectral energy distributions (SED's) for L1448C, L1448NW, and IRAS 03282. We confirm the Class 0 status of L1448C, L1448N(A), L1448N(B), and IRAS 03282. There is evidence for a modest compact "disk" component

in L1448C (~ 0.004 M$_\odot$). We deduce that a 1.4 M$_\odot$ circumbinary envelope surrounds the ~ 1 M$_\odot$ proto-binary system, L1448N(A) + L1448N(B).

The dust emission from IRAS 03282 is found to be somewhat extended, on scales of 0.015–0.03 pc. Extensive HIRES-processed point-source modelling of the 100 μm emission associated with IRAS 03282 reveals an elongated structure along a north-south axis, spatially coincident with the previously mapped NH_3 (1,1) emission (Bachiller, Martin-Pintado, & Planesas 1991). Both the 100 μm dust emission and the ammonia trace the dense core from which IRAS 03282 is currently forming (Tafalla et al. 1993).

We identify two distinct outflows in L1448N for the first time, one powered by L1448N(A) and the other by L1448N(B). A bridge of dust emission linking L1448C to L1448N is clearly evident in our HIRES-processed 100 μm map. This dust structure traces the surface where the L1448C and L1448N(A) outflows collide. Two new 100 μm emission peaks are found, one coinciding with HH 197, the other with an H_2 bow-shock feature. Both 100 μm peaks are located at positions where the blue-shifted L1448C jet is deflected. The luminosity radiated by the dust emission bridge is $\sim$ 6.5 L$_\odot$, which is a new estimate for the instantaneous L1448C outflow mechanical luminosity. We find L_{mech}/L_{bol} ratios $\geq 50\%$ for all of the confirmed Perseus Class 0 sources for which outflow data are available from the literature. Thus, we confirm a high L_{mech}/L_{bol} ratio as a new distinguishing characteristic of Class 0 outflows (Curiel et al. 1990, Bontemps et al. 1996, Wolf-Chase et al. 1998).

The dynamical times for the L1448N(B) and L1448C outflows have been revised upwards to 13,000 yr and 32,000 yr, respectively, based on the identification of L1448N(B) as the powering source of HH 196 and of L1448C as the driving source of HH 267. As a consequence, the outflow dynamical times now agree with the typical ages inferred for Class 0 sources.

There is strong evidence for outflow-induced star-formation in the L1448 cloud. Being older, the L1448C outflow has disrupted and fragmented the core that is now forming the younger L1448N(A) + L1448N(B) proto-binary. The interaction of the L1448N(A) and L1448N(B) outflows, in turn, may have produced the L1448NW condensation.

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Numerical simulations of protostellar encounters
I. Star-disc encounters

H.M.J. Boffin, S. Watkins, A.S. Bhattal, N. Francis, A.P. Whitworth

Department of Physics and Astronomy, P.O. Box 913, Cardiff University, CF2 3YB Cardiff, U.K.

E-mail contact: Henri.Boffin@astro.cf.ac.uk, A.Whitworth@astro.cf.ac.uk

It appears that most stars are born in clusters, and that at birth most stars have circumstellar discs which are comparable in size to the separations between the stars. Interactions between neighbouring stars and discs are therefore likely to play a key role in determining disc lifetimes, stellar masses, and the separations and eccentricities of binary orbits. Such interactions may also cause fragmentation of the discs, thereby triggering the formation of additional stars. We have carried out a series of simulations of disc-star interactions using an SPH code which treats self-gravity, hydrodynamic and viscous forces. We find that interactions between discs and stars provide a mechanism for removing energy from, or adding energy to, the orbits of the stars, and for truncating the discs. However, capture during such encounters is unlikely to be an important binary formation mechanism. A more significant consequence of such encounters is that they can trigger fragmentation of the disc, via tidally and compressionally induced gravitational instabilities, leading to the formation of additional stars. When the disc-spins and stellar orbits are randomly oriented, encounters lead to the formation of new companions to the original star in 20encounters. If most encounters are prograde and coplanar, as suggested by simulations of dynamically-triggered star formation, then new companions are formed in approximately 50

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New Young Stellar Object candidates in the Chamaeleon I molecular cloud discovered by DENIS

L. Cambrésy[1] , E. Copet[1] , N. Epchtein[2] , B. de Batz[1] , J. Borsenberger[3] , P. Fouqué[1,5] , S. Kimeswenger[4] and D. Tiphène[1]

[1] Observatoire de Paris, F-92195 Meudon Cedex, France
[2] Observatoire de la Côte d'Azur, BP 4229, F-06304 Nice Cedex, France
[3] Institut d'Astrophysique de Paris, France
[4] Institut für Astronomie der Leopold-Franzens-Universität Innsbruck, Austria
[5] European Southern Observatory, Casilla 19001, Santiago 19, Chile

E-mail contact: Laurent.Cambresy@obspm.fr

We present an analysis of point sources discovered by DENIS in an area of $\approx 1\overset{\circ}{.}5 \times 3\overset{\circ}{.}$ around the Chamaeleon I molecular cloud. Most of the 30 000 objects detected in the J band are background stars that were previously used to derive an accurate extinction map of the full area (Cambrésy et al., 1997) using star counts. Here, we investigate the young stellar population of the cloud using the $IJK_{\rm s}$ photometric DENIS data. The whole sample of 126 already known YSOs, which are mainly T Tauri stars, are identified in the DENIS catalogue. Besides, we propose 54 sources as new candidates of YSOs. These new faint objects are selected according to their extremely red near infrared colour, that cannot be explained only by the reddening of the cloud. Moreover they are concentrated near the most obscured areas of the cloud. Pending spectroscopic measurements, the sources are interpreted as probable classical T Tauri stars that have escaped previous spectroscopic, IRAS or X-ray observations and pertaining to the low-end of the luminosity function. Assuming that they are reliable YSOs with massive accretion disks, and using theoretical pre-main-sequence tracks we estimate the age of this sample to be ranging from $5\,10^5$ to $4\,10^6$ years, an elapse of time that spans the range between the end of the star formation in the cloud and the maximum life time of the circumstellar disk.

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The Physical Properties of the MSX Galactic Infrared-Dark Clouds

Sean J. Carey[1], F. O. Clark[2], M. P. Egan[2], S. D. Price[2], R. F. Shipman[2] and T. A. Kuchar[2]

[1] Institute for Scientific Research, Boston College, St. Clement's Hall, 140 Commonwealth Avenue, Chestnut Hill, MA 02467, USA
[2] Department of the Air Force, Air Force Research Laboratory, VSBC, 29 Randolph Road, Hanscom AFB, MA 01731-3010, USA

E-mail contact: carey@pldac.plh.af.mil

The SPIRIT III infrared telescope on the Midcourse Space Experiment (MSX) satellite has provided an unprecedented view of the mid-infrared emission (8-25 μm) of the Galactic plane. An initial analysis of images from MSX Galactic plane survey data reveals dark clouds seen in silhouette against the bright emission from the Galactic plane (Egan *et al.* 1998). These clouds have mid-infrared extinctions in excess of 2 magnitudes at 8 μm.

We probed the physical properties of 10 of these MSX dark clouds using millimeter-wave molecular rotational lines as an indicator of dense molecular gas. All ten clouds were detected in millimeter spectral lines of H_2CO, confirming the presence of dense gas. The distances to these clouds range from one to eight kiloparsecs and their diameters from 0.4-15.0 pc. Excitation analysis of the observed lines indicates that the clouds are cold (T $<$ 20 K) and dense (n(H_2) $>$ 10^5 cm^{-3}). Some of the clouds have nearby HII regions, H_2O masers and other tracers of star formation at comparable spectral line velocities; however, only one cloud contains embedded centimeter or infrared sources. The lack of mid to far-infrared emission associated with these clouds suggests that they are not currently forming high mass stars. If star formation is present in these clouds, it is clearly protostellar class 0 or earlier.

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An X-ray Survey of Very Young Stellar Objects

Lee Carkner[1], Jennifer A. Kozak[1] and Eric D. Feigelson[1]

[1] Department of Astronomy and Astrophysics, Penn State University, University Park, PA 16802, USA

E-mail contact: acarkner@astro.psu.edu

Several recent studies with the ROSAT and ASCA satellites have reported X-ray emission from Class I protostars. We present here an X-ray survey of 156 protostellar sources using archived ROSAT PSPC pointed observations. Targets are drawn from four samples: low temperature objects in near-by star forming regions, Herbig-Haro outflow sources, CO outflow sources, and Class 0 embedded protostars. Over 90% are not detected at the 3 sigma limit over the $1.0-2.4$ keV band, with upper limits of $0.1-40$ counts ksec^{-1} corresponding to $\log L_X \simeq 28-33$ erg s^{-1}. Of the 11 detected objects, 10 are either Class II or III stars or previously detected Class I protostars. One new Class I source, Ced 110 IRS 6 in the Chamaeleon I cloud, is found. The X-ray luminosity function of protostars is calculated, but is quite uncertain. We conclude that X-ray emission from protostars has a broad luminosity function and that very X-ray luminous ($L_X > 10^{31}$ erg s^{-1}) protostars are rare.

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Preprints are available at: http://www.astro.psu.edu/users/carkner/ttauri/intro.html

The W51 Giant Molecular Cloud

John M. Carpenter[1,2] and D. B. Sanders[1]

[1] University of Hawaii, Institute for Astronomy, 2680 Woodlawn Drive, Honolulu, HI 96822, USA
[2] Current address: Department of Astronomy, California Institute of Technology, MS 105-24, Pasadena, CA 91125, USA

E-mail contact: jmc@astro.caltech.edu

We present 45″-47″ angular resolution maps at 50″ sampling of the ^{12}CO and ^{13}CO J=1-0 emission toward a 1.39° × 1.33° region in the W51 H II region complex. These data permit the spatial and kinematic separation of several spectral features observed along the line of sight to W51, and establish the presence of a massive ($1.2 \times 10^6\ M_\odot$), large ($\Delta\ell \times \Delta b = 83\,\mathrm{pc} \times 114\,\mathrm{pc}$) giant molecular cloud (GMC), defined as the W51 GMC, centered at $(\ell, b, V)_\mathrm{c} \sim (49.5°, -0.2°, 61\ \mathrm{km\,s^{-1}})$. A second massive ($1.9 \times 10^5\ M_\odot$), elongated (136 pc × 22 pc) molecular cloud is found at velocities of ~ 68 km s^{-1} along the southern edge of the W51 GMC. Of the five radio continuum sources that classically define the W51 region, the brightest source at $\lambda\,6$ cm (G49.5-0.4) is spatially and kinematically coincident with the W51 GMC and three (G48.9-0.3, G49.1-0.4, and G49.2-0.4) are associated with the 68 km s^{-1} cloud. Published absorption line spectra indicate that the fifth prominent continuum source (G49.4-0.3) is located behind the W51 molecular cloud. The W51 GMC is among the upper 1 % of clouds in the Galactic disk by size and the upper 5–10 % by mass. While the W51 GMC is larger and more massive than any nearby molecular cloud, the average H_2 column density is not unusual given its size and the mean H_2 volume density is comparable to that in nearby clouds. The W51 GMC is also similar to other clouds in that most of the molecular mass is contained in a diffuse envelope that is not currently forming massive stars. We speculate that much of the massive star formation activity in this region has resulted from a collision between the 68 km s^{-1} cloud and the W51 GMC.

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Pre-Main Sequence Stars in the Young Galactic Cluster IC 4996: A CCD Photometric Study

Antonio J. Delgado[1], Emilio J. Alfaro[1], André Moitinho[1], José Franco[2]

[1] Instituto de Astrofísica de Andalucía. CSIC. P.O. Box 3004, E-18080, Granada, Spain
[2] Instituto de Astronomía-UNAM. P.O. Box 70-264, 04510 México DF, México

E-mail contact: delgado@iaa.es

The results of a *UBV* CCD photometric study of the cluster IC 4996 are presented. We obtain new values for the cluster parameters: $E(B-V) = 0.71 \pm 0.08$, $V_0 - M_V = 11.9 \pm 0.1$, $Age = 7.5 \pm 3 \times 10^6$ yr. The combined evidence from the photometric diagrams suggests the presence of a number of Pre-Main Sequence (PMS) cluster members with spectral types ~A0 to F5. The interpretation of these objects as PMS candidates is further supported by independent results from CCD *uvby* $H\beta$ observations. If confirmed, these stars would bridge the existing gap in the sample of PMS stars, between the coolest Herbig' AeBe stars (HAeBe), and the hottest T-Tauri stars. These PMS candidates are located some 0.5 and 1 mags above the Main Sequence in the $V-(B-V)$ diagram, around the location of spectral

types AF. This feature, together with their locations in the $(U-B)-(B-V)$ diagram and the interpretation that they are PMS members, suggest an additional reddening law with a slope $\alpha = E(U-B)/E(B-V) \simeq 0.55$, probably caused by circumstellar material.

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Mid-Infrared Emission Features in WL 16

B. DeVito and T. L. Hayward

Center for Radiophysics and Space Research, Cornell University, Ithaca, NY 14853, USA

E-mail contact: hayward@astrosun.tn.cornell.edu

We present long-slit 7.5 – 13.5 μm spectra of WL 16, a Herbig Ae star in the ρ Ophiuchi dark cloud that is surrounded by a ∼1000 AU diameter infrared-emitting nebula. Mid-IR emission features are detected in every region of the nebula from center to edge, and the underlying continuum color temperature is approximately 10 times hotter than would be expected from large grains in thermal equilibrium. The 7.7 and 8.6 μm features decrease in intensity more rapidly with distance from the central star than the 11.3 and 12.7 μm features, suggesting that PAH ionization effects proposed to explain similar spectral variations in other ISM sources may be important in WL 16 as well.

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Photoionized and Photo-dissociated Regions around Main Sequence Stars

Rosa Izela Diaz-Miller[1], José Franco[1] and Steven N. Shore[2]

[1]Instituto de Astronomía-UNAM, Apdo Postal 70-264, 04510 México D. F., Mexico

[2]Department of Physics and Astronomy, Indiana University South Bend, 1700 Mishawaka Avenue, South Bend, IN 46634-7111, USA

E-mail contact: rmiller@stsci.edu

Within a molecular cloud the strong ultraviolet radiation field produced by newly formed stars dissociates and ionizes the surrounding molecular gas. The radiative flux depends on the effective temperature and metallicity of the star. Using the most recent line blanketed atmosphere models of Kurucz, we obtain the rates of ionizing and dissociating photons from stars with effective temperatures of 7.5×10^3 K to 5×10^4 K, and for metallicities between 0.01 times solar and solar. With a radiative transfer model, we then compute the basic structures and sizes of the photoionized and photo-dissociated regions produced by stars embedded in a molecular gas with uniform densities. Absorption by dust of the UV flux decreases the mass of H II and H I produced within the cloud, and its effects are taken into account in our model. We also discuss the constraints imposed by photo-dissociated regions on the number of intermediate and high mass stars that can form in molecular clouds.

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High-Resolution Far-Infrared Studies of Intermediate-Mass Pre-Main Sequence Objects

James Di Francesco[1,2], Neal J. Evans[2], Paul M. Harvey[2], Lee G. Mundy[3] and Harold M. Butner[4]

[1] Harvard-Smithsonian Center for Astrophysics, Cambridge, MA 02138, USA
[2] The University of Texas at Austin, Austin, TX 78712, USA
[3] Dept. of Astronomy, University of Maryland, College Park, MD 20742, USA
[4] Steward Observatory, University of Arizona, Tucson, AZ 85721, USA

E-mail contact: jdifran@cfa.harvard.edu

We have obtained high-resolution far-infrared maps of 9 regions with 10 Herbig Ae/Be stars (intermediate-mass pre-main-sequence stars). Similar maps were obtained for 10 embedded IRAS sources with $S_\nu(100\ \mu\mathrm{m}) > S_\nu(60\ \mu\mathrm{m})$ and $L \sim 200$ L$_\odot$, which are possible evolutionary precursors of Herbig Ae/Be stars. Single far-infrared sources were found in most maps. The embedded sources have positions in agreement with those of the IRAS PSC, but some of the Herbig Ae/Be stars are offset significantly from the position of peak far-infrared emission. For all objects where it was possible to obtain 100 μm flux densities, they are consistent with those observed by IRAS, but derived 50 μm flux densities are larger than expected. The far-infrared maps reveal that objects in at least 17 of 19 emission regions are significantly extended at the 30″–40″ resolution of the Kuiper Airborne Observatory at 100 μm. Only sources associated with AB Aur and possibly IRAS 05338-0624 have unresolved far-infrared emission. Detailed analyses of the flux densities and positions from our maps suggest the far-infrared emission in regions with Herbig Ae/Be stars may not immediately surround these stars in all cases. Instead, far-infrared emission from these objects may originate from dust heated externally by the Herbig stars, or from dust heated internally by other sources. For other objects arguably surrounded by far-infrared emission, the Herbig stars or embedded IRAS objects have similar mean deconvolved sizes (i.e., 0.10–0.15 pc), but possibly different mean deconvolved shapes (i.e., aspect ratios). Thus, far-infrared emission here may originate from flattened dust envelopes; the appearance of a far-infrared object as either a Herbig Ae/Be star or an embedded IRAS source may be merely a matter of viewing orientation.

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Kinematics of T Tauri stars in Chamaeleon

Sabine Frink [1], Siegfried Röser [1], Juan M. Alcalá [2,3], Elvira Covino [2], Wolfgang Brandner [4]

[1] Astronomisches Rechen-Institut Heidelberg, Mönchhofstraße 12-14, D-69120 Heidelberg, Germany
[2] Osservatorio Astronomico di Capodimonte, Via Moiariello 16, I-80131 Napoli, Italy
[3] Instituto Nacional de Astrofísica, Optica y Electrónica, A.P. 51 y 216 C.P. 72000, Puebla, México
[4] Caltech - JPL/IPAC, Mail Code 100-22, Pasadena, CA 91125, USA

E-mail contact: sabine@ari.uni-heidelberg.de

We study the kinematics of T Tauri stars (TTS) located in the cores of the Chamaeleon clouds as well as far off these clouds. Our sample comprises 2 early type stars known to be related to Cha I, 6 classical (CTTS) and 6 weak-line T Tauri stars (WTTS) known before the ROSAT mission, and 8 bona-fide pre-main sequence (PMS) stars as well as 23 presumably older stars discovered with ROSAT (Alcalá et al. 1995; Covino et al. 1997). Altogether we present proper motions for 45 stars, taken from the Hipparcos, ACT and STARNET catalogues. For 12 stars of our sample parallaxes measured by Hipparcos are available, and we use them to derive constraints on the distance distribution of the other stars in our sample. Our analysis of the proper motions allows us to divide the sample into several subgroups.

We analyse the motions of the stars in connection with different star formation scenarios and find them consistent with both the high velocity cloud (HVC) impact model (Lépine & Duvert 1994) and the cloudlet model (Feigelson 1996), whereas the data seem to be inconsistent with any kind of a dynamical ejection model.

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On the nature of cyclic variability of the UX Ori type stars

V.P.Grinin [1,2], A.N.Rostopchina [1] and D.N.Shakhovskoy [1]

[1] Crimean Astrophysical Observatory, Crimea, 334413, Nauchny, Ukraine
[2] Astronomical Institute of St.Petersburg University, St.Petersburg, Russia

E-mail contact: grinin@vg1723.spb.edu; grinin@crao.crimea.ua

On the basis of the long term photoelectric observations of UX Ori type stars: BF Ori, CO Ori and RR Tau the evidence of the cyclic character of their photometric activity on the time scale from few years to 10 and more years are found. Since the brightness variations of these stars are caused by the variable circumstellar (CS) extinction and determined by the current value of the dust column density on the line of sight, an existance of cycles points out an existance of the large scaled perturbations of the dust distribution in the CS disks periodically appearing on the line of sight. Either components of the binary (multiple) system or protoplanets can be a source of such perturbations.

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Structure, Excitation and Kinematics of the Luminous Herbig-Haro Objects 80/81

Steve Heathcote[1], **Bo Reipurth**[2] **and A.C. Raga**[3]

[1] Cerro Tololo Inter-American Observatory, National Optical Astronomy Observatories, Casilla 603, La Serena, Chile
[2] Center for Astrophysics and Space Astronomy, University of Colorado, CB 389, Boulder, Colorado 80309, USA
[3] Instituto de Astronomía, UNAM, Ap. 70-264, México, D.F., 04510 México

E-mail contact: sheathcote@noao.edu

We present a detailed study of the Herbig-Haro objects HH 80/81, twin working surfaces in the highly collimated outflow driven by a luminous young star. High angular resolution emission line images obtained with the *Hubble Space Telescope* are used together with ground based low- and high-dispersion spectroscopy, and proper motion measurements to provide a comprehensive picture of the structure and kinematics of these remarkable objects. The two principle knots HH 80A and HH 81A have emission lines with widths of 700 $\mathrm{km\,s^{-1}}$ and 625 $\mathrm{km\,s^{-1}}$ (FWZI) respectively, far broader than previously observed in any HH object and also have large tangential velocities of about 350 $\mathrm{km\,s^{-1}}$. In addition they are both of exceptionally high excitation having the strongest [O III] emission of any known HH object. Although the kinematics of these objects are broadly consistent with expectations from radiative bow shock models the very high shock velocities implied, in excess of 600 $\mathrm{km\,s^{-1}}$, mean that the post shock cooling distance at the apex is a few times greater than their size. Consequently, these bow shocks must have adiabatic tips and only become radiative in their wings. At the spatial resolution of our HST images the structure of HH 80/81 is seen to be far more complex than was thought on the basis of ground based images. While HH 80A does bear some resemblance to a bow shock, HH 81A has an intricate filamentary structure. The HH 80/81 outflow is highly collimated from the source out to HH 81A and HH 80A, but then abruptly broadens into a network of faint shock excited streamers, terminating in a giant bow shock. The point where the flow begins to diverge coincides with the apparent edge of the molecular cloud. We suggest that this morphology results because fast, very hot bullets like HH 80A and HH 81A violently expand as they escape from the cloud into its low pressure surroundings.

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Circumstellar Disks in the Orion Nebula Cluster

Lynne A. Hillenbrand[1], **Stephen E. Strom**[2], **Nuria Calvet**[3], **K. Michael Merrill**[4], **Ian Gatley**[4], **Russell B. Makidon**[2], **Michael R. Meyer**[2], **and Michael F. Skrutskie**[2]

[1] U.C. Berkeley and CalTech
[2] University of Massachusetts
[3] Harvard-Smithsonian Center for Astrophysics
[4] National Optical Astronomy Observatory

E-mail contact: lah@astro.caltech.edu

We combine our previous optical spectroscopic and photometric analysis of ∼1600 stars located in the Orion Nebula Cluster (ONC), with our own and published near-infrared photometric surveys of the region, in order to investigate the evidence for and properties of circumstellar disks. We use the near-infrared continuum excess as our primary disk diagnostic, although we also study sources with Ca II triplet emission and those designated as "proplyds." The measured near-infrared excess is influenced by 1) the presence or absence of a circumstellar disk; 2) the relative importance of disk accretion and inner disk holes; 3) the relative contrast between photospheric and disk emission; and 4) system inclination. After attempting to understand the effects of these influences, we estimate the frequency of circumstellar disks and discuss the evidence for trends in the disk frequency with stellar mass (over the mass range <0.1-50 $M_\odot$), stellar age (over the age range <0.1-2 Myr), and projected cluster radius (over the radial range 0-3 pc).

We find that the fraction of stars which have retained their inner (< 0.1 AU) circumstellar disks to the present time is at least 55% and probably no more than 90%, averaged over the entire range in stellar mass and stellar age represented in the ONC, and over the entire area of our survey. We find no trend in the disk fraction with stellar age, at least not over the limited age range of the cluster. We find that more massive stars are less likely to have disks, consistent with a scenario in which the evolutionary timescales are more rapid for disks surrounding more massive stars than for disks surrounding less massive stars. We also find that the disk frequency begins to decrease towards the lowest masses, although objects of all masses (including those which appear to be substellar) can have disks. We find that the disk frequency increases towards the cluster center.

We then argue using several lines of evidence that a large fraction of the disks associated with stars in the ONC are accretion disks. The observed trends with stellar age, with stellar mass, and with projected cluster radius in the disk frequency may, in fact, be driven primarily by trends in the disk accretion properties. From the magnitude of the near-infrared excess above that expected from pure-irradiation disks, we find an accretion-disk fraction among the stars identified as having disks, of 61-88%. In addition, approximately 20% of the stars in our optical spectroscopic sample show broad (several hundred $\mathrm{km s^{-1}}$ FWHM) Ca II emission lines, features often associated with accretion-disk/wind phenomena; another 50% of the sample have Ca II lines which (at our spectral resolution) are "filled in," thus indicating an independently derived accretion disk frequency of $\sim$70%. Finally, we discuss the near-infrared and optical emission-line properties of that portion of our sample which has been identified from HST imaging as having dark silhouette or externally ionized structure. This sample, which has been proposed in the literature to have accretion disks, appears no different in terms of its stellar or circumstellar properties from the rest of the ONC population. The only feature distinguishing these objects from their ONC siblings thus may be their current (but short-lived) proximity to the massive stars near the cluster center.

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A survey of dust features in the 3 μm spectra of YSO candidates

Miki Ishii[1], Tetsuya Nagata[1], Shuji Sato[1], Makoto Watanabe[1], Yongqiang Yao[2], and Terry Jay Jones[3]

[1] Department of Astrophysics, Nagoya University, Furo-cho, Chikusa-ku, Nagoya, 464-8602, Japan
[2] Purple Mountain Observatory, Chinese Academy of Sciences, China
[3] Department of Astronomy, University of Minnesota, Minneapolis, Minnesota 55455, USA

E-mail contact: ishii@z.phys.nagoya-u.ac.jp

We present the results of spectrophotometry from 1.3 to 4.2 μm of 45 IRAS sources in the list by Campbell, Persson, & Matthews (1989, AJ, 98, 643), which have been presumed to be luminous young stellar objects because of their infrared colors and their large IRAS fluxes. About 70 % of the objects show the 3.1 μm H_2O ice absorption or the 3.3 μm unidentified infrared emission or both. Among the objects with the 3.1 μm H_2O ice absorption, three objects seem to have a distinct absorption near 3.4 μm, and their absorption profiles are different from the optical depth profiles of the young stellar objects in the literature. In the HKL two-color diagram, the objects with the ice absorption occupy the same region as previously known young stellar objects with the ice feature, and those with the UIR emission overlap with Herbig Ae/Be stars. We interpret the distribution in the HKL two-color diagram as indicating the evolutionary sequence of intermediate to high mass young stars.

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Class II maser candidates in substituted methanol: CH_3OD, $^{13}CH_3OH$, $CH_3{}^{18}OH$ and CH_3SH

K.P. Johns[1], D.M. Cragg[1], P.D. Godfrey[1] and A.M. Sobolev[2]

[1] Department of Chemistry, Monash University, Clayton, Victoria 3168, Australia
[2] Astronomical Observatory, Ural State University, Lenin Street 51, Ekaterinburg 620083, Russia

E-mail contact: Dinah.Cragg@sci.monash.edu.au

We investigate the possibility of interstellar masers in transitions of the methanol isotopomers CH_3OD, $^{13}CH_3OH$ and $CH_3{}^{18}OH$, and of CH_3SH. The model used, in which masers are pumped through the first and second torsionally excited states by IR radiation, has accounted successfully for the Class II masers in main species methanol, $^{12}CH_3{}^{16}OH$. Several potential maser candidates are identified for CH_3OD, their detectability depending on the enrichment of this species in star-forming regions. In $^{13}CH_3OH$ and $CH_3{}^{18}OH$ the best maser candidates are direct counterparts of the well known 6.7 and 12.2 GHz methanol masers, but the lower interstellar abundance of these substituted species means that the expected brightness is greatly reduced. The maser candidates in CH_3SH are also weak. By comparing these species we find that the large *b*-component of the dipole moment in methanol plays a significant role in its propensity to form masers, as does the strong torsion-rotation interaction due to the light hydroxyl frame. Thus the exceptional brightness of interstellar methanol masers is due to a favourable combination of molecular properties as well as high interstellar abundance.

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Expansion of W 3(OH)

Jonathan H. Kawamura[1,2] and Colin R. Masson[1,3]

[1] Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, Massachusetts 02138, USA
[2] California Institute of Technology, 320-47, Pasadena, California 91125, USA
[3] Renaissance Technologies Corp., 600 Route 25A, East Setauket, New York 11733, USA

E-mail contact: kawamura@socrates.caltech.edu

A direct measurement of the expansion of W 3(OH) is made by comparing Very Large Array images taken $\sim 10\,\mathrm{yr}$ apart. The expansion is anisotropic with a typical speed of 3 to $5\,\mathrm{km\,s^{-1}}$, indicating a dynamical age of only 2300 yr. These observations are inconsistent with either the freely expanding shell model or a simple bow shock model. The most favored model is a slowly expanding shell-like H II region, with either a fast rarefied flow or another less massive diffuse ionized region moving towards the observer. There is also a rapidly evolving source near the projected center of emission, perhaps related to the central star.

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Fragmentation of Molecular Clouds: The Initial Phase of a Stellar Cluster

Ralf S. Klessen[1], Andreas Burkert[1], Matthew R. Bate[1]

[1] Max-Planck-Institut für Astronomie, Königstuhl 17, 69117 Heidelberg, Germany

E-mail contact: klessen@mpia-hd.mpg.de

The isothermal gravitational collapse and fragmentation of a region within a molecular cloud and the subsequent formation of a protostellar cluster is investigated numerically. The clump mass spectrum which forms during the fragmentation phase can be well approximated by a power law distribution $\mathrm{d}N/\mathrm{d}M \sim M^{-1.5}$. In contrast, the mass spectrum of protostellar cores that form in the centers of Jeans-unstable clumps and evolve through accretion and N-body interactions is described by a log-normal distribution with a width that is in excellent agreement with observations of multiple stellar systems.

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Widespread SiO emission in NGC 1333

B. Lefloch[1,2], A. Castets[2], J. Cernicharo[1], and L. Loinard[2,3]

[1] Consejo Superior de Investigaciones Científicas, Instituto de Estructura de la Materia, Serrano 123, E-28006 Madrid; lefloch@astro.iem.csic.es
[2] Laboratoire d'Astrophysique, Observatoire de Grenoble, BP 53, F-38041, Grenoble Cedex 9, France
[3] IRAM, 300 rue de la piscine, 38406 St Martin d'Heres, France

E-mail contact: lefloch@obs.ujf-grenoble.fr

We have mapped the IRAS4-SVS13 region in the NGC1333 star-forming complex in the SiO $v = 0$ lines at 3, 2 and 1.3mm, using the IRAM 30m-telescope. In addition to high-velocity components associated with protostellar activity in IRAS4 and other sources, we report the detection of an extended layer of gas at ambient velocities, traced by an extremely narrow and fairly bright component ($\Delta v = 0.4 - 1.2\,\mathrm{km\,s^{-1}}$, $\mathrm{T_B} = 2$ K). The SiO abundance in that layer is typically $1 - 3 \times 10^{-10}$. This is two orders of magnitude lower than in the high-velocity flows, but about two orders of magnitude higher than the abundance in quiescent clouds. Several mechanisms which could account for such emission are briefly discussed : high-temperature chemical reactions in the gas surrounding the protostellar wind of SVS13 and interaction between the neighboring protostellar outflows and local small gas condensations in the vicinity of IRAS4.

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Using polarimetry to check rotation alignment in PMS binary stars. Principles of the method and first results

J.-L. Monin, F. Ménard and G. Duchêne

Observatoire de Grenoble, BP 53, 38041 Grenoble cedex, France

E-mail contact: Jean-Louis.Monin@obs.ujf-grenoble.fr

We study polarimetric measurements to determine an estimate of the relative orientations of the star+disk system in each component of Pre Main Sequence (PMS) T Tauri binary stars. The principles of the method are presented, together with a review of polarimetric data available in the literature on large systems (8-40 arcsec) in Taurus. We show that this method can be subject to a bias introduced by the interstellar polarization, but we find that in four of our sources that are not affected by this bias, the rotation axes of both components are preferentially parallel. We also find at least one system where the axes are clearly *not* parallel. This findings probably reflect the initial binary formation conditions. In order to test the method on tighter systems, we have also obtained imaging polarimetric measurements and spectra for each components of closer binaries ($< 3.2''$). Our first polarimetric measurements lack S/N, but the spectra of individual components of these close binaries provide information on their respective spectral types and their accretion rate through H_α equivalent widths and fluxes. We use these spectra to confirm the nature and the pairing tendency of the TTS under study. Implications on the binary formation mechanism are discussed.

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http://www-laog.obs.ujf-grenoble.fr/liens/starform/formation.html

Methanol Masers and Their Environment at High Resolution

C.J. Phillips[1], R.P. Norris[2], S.P. Ellingsen[1] and P.M. McCulloch[1]

[1] Department of Physics, University of Tasmania, GPO Box 252-21, Hobart, TAS 7001, Australia
[2] CSIRO Australia Telescope National Facility, PO Box 76, Epping, NSW 2121, Australia.

E-mail contact: phillips@jive.nfra.nl

We have used the Australia Telescope Compact Array (ATCA) to make high-resolution images of the 6.7-GHz $5_1 \rightarrow 6_0$ A$^+$ maser transition of methanol towards 33 sources in the Galactic Plane. Including the results from 12 methanol sources in the literature we find 17 out of 45 sources have curved or linear morphology. Most of the 17 have a velocity gradient along the line, which is consistent with masers lying in an edge-on circumstellar disc surrounding a massive star. We also made simultaneous continuum observations of the sources at 8.6 GHz, in order to image any associated Hii region. Twenty-five of the sources are associated with an ultra-compact Hii region, with a detection limit of $\sim$0.5 mJy beam^{-1}. We argue that the methanol sources without an associated Hii region represent less massive embedded stars, not an earlier stage in the lifetime of the star, as previously suggested.

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The Effects of Thermal Energetics on 3D Hydrodynamic Instabilities in Massive Protostellar Disks

Brian K. Pickett[1], Patrick Cassen[1,2], Richard H. Durisen[3,4] and Robert Link[3]

[1] NASA/Ames Research Center, MS 245-3, Moffett Field, CA 94035, USA
[2] Division of Geological and Planetary Sciences, 170-25, Caltech, Pasadena, CA 91125, USA
[3] Department of Astronomy, Indiana University, Bloomington, IN 47405, USA
[4] Max-Planck-Institut für Extraterrestriche Physik, 85740 Garching, Germany

E-mail contact: pickett@cosmic.arc.nasa.gov

We use numerical 3D hydrodynamics to investigate how assumptions about local thermal energetics affect the strength and outcome of nonaxisymmetric instabilities in massive protostellar disks. Building on work presented in earlier papers, we generate two protostellar core models which represent equilibrium states which could form from the axisymmetric collapse of uniformly rotating, singular isothermal spheres. Both models are continuous star/disk systems,

in which the star, the disk, the star/disk boundary, and the free disk outer boundary are resolved in three dimensions. The models are distinguished primarily by the temperature distribution in the disk, and both can be considered to represent the same early evolutionary stage of disk development, when the disk is massive but small in radial extent. In the "Hot" Model, the disk is assumed to have the same entropy per gram as the central isentropic star, giving a Toomre Q-parameter ~ 2.5 over the disk region. In the other "Cool" Model, the entropy per gram decreases radially outward in the disk, resulting in more realistic, cooler disk temperatures and a $Q \approx 1.5$. Each of these protostellar star/disk systems is evolved in our 3D hydrodynamics code under two different assumptions about thermal equilibrium in the disk, namely that either the entropy per gram or the temperature remains constant with position in the disk. We refer to these two cases as locally isentropic evolution and locally isothermal evolution, respectively.

All four calculations have been run for at least two outer rotation periods of the disk. With either assumption about the thermal equilibrium, the one- and two-armed spiral disturbances, which grow in the Hot Models saturate at low amplitude (~ 1 %) and do not alter the protostellar core significantly. On the other hand, the Cool Model is highly unstable to multiple low-order spirals which induce significant mass and angular momentum transport in a few dynamical times. Under locally isentropic evolution, the star and star/disk boundary in the Cool Model are unstable to three- and four-armed disturbances and the disk is unstable to a two-armed spiral, but all these modes saturate at moderate nonlinear ($\sim$ 10's %) amplitudes after about 1.5 outer rotation periods. The same instabilities occur under locally isothermal evolution; however, the two-armed spiral in the disk grows more vigorously and does not saturate, ultimately disrupting the disk and concentrating material into thin, dense arcs and arclets which approach stellar densities. In both Cool Model calculations, there is substantial inward transport of mass and outward transport of angular momentum during the growth phase of the two-armed spiral, but the transport rate drops by over an order of magnitude for locally isentropic evolution when the two-armed spiral saturates. It is clear from these calculations that thermal energetics play a critical role in the development of self-gravitating instabilities and that, under conditions of strong cooling, such instabilities can disrupt a disk very early in its development. We compare these calculations with previous work on gravitational instabilities in disks and discuss implications for star and planet formation.

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The density jump across internal working surfaces in HH jets

A. C. Raga and J. Cantó

Instituto de Astronomía, UNAM, Ap. 70-264, 04510 México, D. F., México

E-mail contact: raga@astroscu.unam.mx

Knots in some of the jet-like Herbig-Haro (HH) objects have been successfully modeled as "internal working surfaces" resulting from a time-variability of the ejection velocity. The emission from these knots appears to be almost invariably dominated by the emission from the bow shock, and has at most a small contribution from the jet shock (or Mach disk). As has been previously pointed out, this observational result implies that the flow upstream of the working surface is considerably denser than the downstream flow. This density jump could either be generated by the jet flow itself, or it might be the result of a time-dependence in the ejection density.

We study a simple, semi-analytic model for the propagation of an internal working surface. With this model, we show that jets ejected with a sinusoidal velocity variability (and with a time-independent density) always develop a strong up- to down-stream density jump across internal working surfaces. From this result, we conclude that the observed density jumps can be straightforwardly explained without recurring to a time-dependent ejection density.

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The Rosette Molecular Complex : I. CO Observations

N. Schneider[1], J. Stutzki[1], G. Winnewisser[1], and D. Block[2]

[1]I. Physikalisches Institut, Universität zu Köln, Zülpicher Straße 77, D–50937 Köln, Germany
[2]Dep. Comp.&Appl. Mathematics, Witwatersrand University, Wits 2050, South Africa

E-mail contact: schneider@ph1.uni-koeln.de

We present ^{12}CO,^{13}CO and C^{18}O J=1→0, and ^{12}CO and ^{13}CO 2→1 and 3→2 observations of the **Rosette Molecular Complex** (RMC), obtained with the KOSMA 3m and IRAM 30m telescopes. We introduce a method for correcting error beam pick-up of single-dish telescopes in spectral line radio maps by using observations of a smaller telescope and apply it to correct the IRAM 30m data presented in this paper by the large scale KOSMA 3m data.

The observations indicate that the RMC is clumpy on a size scale of down to at least 0.1 pc. The molecular density structure is well correlated with the optical picture in the H_α line emission. From a CO multiline analysis, incorporating the incident UV field, we derive a density of lower than 10^5 cm^{-3} for the emitting gas at a beam filling factor of unity. In direction to the molecular outflow source AFGL 961, we find that the ^{12}CO lines up to J=3→2 have broad wings. They show, as well as the ^{13}CO J=2→1 and 1→0 lines, self-absorption features due to colder forground material. A second outflow is firstly detected close to the embedded IR source IR06314+0427. The KOSMA and IRAM ^{13}CO J=2→1 data were analyzed with the clump finding algorithm 'Gaussclumps'. Appropriate scaling shows that the small scale clump mass distribution overlaps and continues the low mass end of the large scale distribution. The observed structures are therefore self-similar over a length scale covering at least 0.1 to a few parsec. The clump mass spectral index α for both individual data sets and the combined distribution equals 1.6, in good agreement with typical values for other molecular clouds. The molecular clumps were classified using the 'Initial Cloud Parameter Space' of Bertoldi & McKee (1990, ApJ 354, 529). All clumps belong to the regime of 'Post Implosion Clouds' and possibly form stars.

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The Rosette Molecular Complex : II. [CII] 158μm Observations

N. Schneider[1], J. Stutzki[1], G. Winnewisser[1], and A. Poglitsch[2], and S. Madden[3]

[1]I. Physikalisches Institut, Universität zu Köln, Zülpicher Straße 77, D–50937 Köln, Germany
[2]Max-Planck-Institut für extraterrestrische Physik, Postfach 1603, D–85740 Germany
[3]CEA Saclay, Service d'Astrophysique, Gif-sur-Yvette, 91191 France

E-mail contact: schneider@ph1.uni-koeln.de

We present an extended map in the [CII] 158 μm fine structure line of the Rosette Molecular Cloud Complex, obtained with the Far Infrared Fabry-Perot Imaging Spectrometer FIFI onboard the NASA Kuiper Airborne Observatory. Very weak but significant C^+ emission was found deep in the cloud at a distance of around 25 pc from the central OB cluster. The observed intensity distribution is consistent with the picture of a clumpy molecular cloud, exposed to an UV flux of around 200 $G_\circ$ from the central OB cluster NGC 2244 at the cloud edge. The UV radiation creates Photon Dominated Regions (PDRs) on the clump surfaces throughout the cloud which give rise to the observed weak [CII] 158 μm line emission (peak intensity 5×10^{-4} erg s^{-1} sr^{-1} cm^{-2}). In contrast to more luminous PDR regions, the emergent C^+ intensity scales logarithmically with the incident UV field but is in agreement with PDR models for a weak UV illumination. The density of the [CII] emitting gas is around 10^4 cm^{-3}. The rather high value of 1% for the [CII] to FIR flux ratio in Rosette indicates a large grain photoelectrical heating efficiency which might be due to the low incident UV field. With an average density of 300 cm^{-3}, obtained from CO observations, we derive a high (30–300) clump to interclump density contrast, where the UV radiation can penetrate deep into the cloud and induces emission from many PDRs along the line of sight.

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NICMOS Narrow-band Images of OMC-1

A.S.B. Schultz[1,2], Sean W.J. Colgan[1], E.F. Erickson[1], M.J. Kaufman[1], D.J. Hollenbach[1], C.R. O'Dell[3], E.T. Young[4], H. Chen[4]

[1] MS 245-6 NASA-Ames Research Center, Moffett Field, CA 94035, USA
[2] SETI Institute
[3] Department of Space Physics and Astronomy, MS-108, Rice University, 6100 S. Main St., Houston, TX 77005-1892, USA
[4] Steward Observatory, University of Arizona, Tucson, AZ 85721, USA

E-mail contact: schultz@ssa1.arc.nasa.gov

We present images of a 90″ × 90″ field centered on BN in OMC-1, taken with the Near-Infrared Camera and Multi-Object Spectrograph (NICMOS) aboard the *Hubble Space Telescope.* The observed lines are H_2 1-0 S(1), Pα, [FeII] 1.64 μm, and the adjacent continua.

The region is rich in interesting structures. The most remarkable are the streamers or "fingers" of H_2 emission which extend from 15″ to 50″ from IRc2, seen here in unprecedented detail. Unlike the northern H_2 fingers, the inner fingers do not exhibit significant [FeII] emission at their tips, which we suggest is due to lower excitation.

These observations also show that the general morphology of the Pα and [FeII] emission (both imaged for the first time in this region) bears a striking resemblance to that of the Hα and [SII] emission previously observed with WFPC2. This implies that these IR and optical lines are produced by radiative excitation on the surface of the molecular cloud. The Pα morphology of HH 202 is also very similar to its Hα and [OIII] emission, again suggesting that the Pα in this object is photo-excited by the Trapezium, as has been suggested for the optical emission.

We find evidence of shock-excited [FeII] in HH 208, where it again closely follows the morphology of [SII]. There is also H_2 coincident with the [SII] and [FeII] emission, which may be associated with HH 208.

Finally, we note some interesting continuum features: diffuse "tails" trailing from IRc3 and IRc4, more extensive observations of the "crescent" found by Stolovy, et al. (1998), and new observations of a similar oval object nearby. We also find a "V"-shaped region which may be the boundary of a cavity being cleared by IRc2.

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Outflows and Luminous YSOs: A New Perspective on the G192.16 Massive Bipolar Outflow

D.S. Shepherd[1], A.M. Watson[2], A.I. Sargent[1] and E. Churchwell[3]

[1] Division of Physics, Mathematics & Astronomy, California Inst. of Technology, MS105-24, Pasadena, CA 91125, USA

[2] Instituto de Astronomía, Universidad Nacional Autonóma de México, J. J. Tablada 1006, 58090 Morelia, Michoacán, México

[3] Department of Astronomy, University of Wisconsin – Madison, 475 N. Charter St., Madison, WI 53706, USA

E-mail contact: Debra Shepherd: dss@astro.caltech.edu

We have obtained new observations of the massive molecular outflow in G192.16-3.82 in CO(J=1-0) line and 3 mm continuum using the Owens Valley Radio Observatory millimeter-wave array. We have also imaged the outflow in the near infrared J, H, & K-bands and 2.12 μm H_2 at Lowell Observatory and in K_s-band at the Apache Point Observatory. A large-field Palomar image shows that the outflow structure may extend more than 4 pc from the YSO making it one of the largest known Galactic outflows. There is approximately 80 $M_\odot$ of molecular material in the high-velocity flow and the mass flow rate is $\sim 5 \times 10^{-4}$ $M_\odot$ yr^{-1}. The flow appears to be driven by an early-B star that is surrounded by approximately 17 $M_\odot$ of material. A biconical infrared reflection nebula is centered near the millimeter continuum peak and shock-excited H_2 emission is detected at the brightest peak in the K-band reflection nebula. H_2 emission is also detected just beyond the highest velocity gas in the blue-shifted CO outflow. The slope of the mass spectrum is approximately -2 at velocities below 15 km s^{-1} and decreases to as low as -8 at higher velocities. This is significantly steeper than in low-mass outflows suggesting that the powering mechanism is less efficient at accelerating material in the flow. Alternatively, the outflow may have built up a substantial reservoir of low-velocity gas that steepens the mass spectrum. The observation of a wide outflow opening angle ($\sim 60°$) and limb-brightened shell surrounding the high-velocity gas, together with shock-excited H_2 emission and large bow shocks that extend up to 4 pc from the YSO, are consistent with the presence of both a poorly collimated disk-wind and a jet.

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ASCA Observations of the T Tauri Star SU Aurigae and Surrounding L1517 Dark Cloud

Stephen L. Skinner[1] **and Frederick M. Walter**[2]

[1] JILA, Univ. of Colorado, Boulder, CO 80309-0440 USA

[2] Dept. of Physics and Astronomy, State Univ. of New York, Stony Brook, NY 11794-3800, USA

E-mail contact: skinner@jila.colorado.edu

We present results of a ≈40 ksec pointed *ASCA* observation of the L1517 star-forming region, centered on the X-ray bright T Tauri star SU Aurigae. This star has the highest X-ray luminosity of any classical T Tauri star in the Taurus-Auriga region and its optical spectra show evidence for both mass inflow and outflow.

Strong X-ray emission was detected from SU Aur ($L_x = 10^{30.9}$ ergs s^{-1}) as well as weaker emission from five other pre-main-sequence stars. Although no large-amplitude flares were detected, the X-ray emission of SU Aur showed clear variability in the form of a slow decline in count rate during the 1.3 day observation.

We provide the first direct comparison of the coronal differential emission measure (DEM) distribution of a classical T Tauri star with that of a young main-sequence star of similar spectral type. The DEM distributions of SU Aur (G2; age 3 Myr) and the young solar-like star EK Draconis (G0V; age 70 Myr) are qualitatively similar, with both showing a bimodal temperature distribution characterized by a cool plasma component peaking at ∼8 - 9 MK and a hot component peaking at ∼20 - 21 MK. However, there is a striking difference in the relative proportion of plasma at high temperatures in the two stars, with hot plasma (≥20 MK) accounting for ≈80% of the volume emission measure of SU Aur as compared to only ≈40% in EK Dra.

These results provide new insight into the changes that will occur in the corona of a T Tauri star as it descends onto the main sequence. A sharp decline in the fraction of coronal plasma at flare-like temperatures will occur during the late T Tauri and post-T Tauri phases, and other recent X-ray studies have shown that this decline will continue after the young solar-like star reaches the main sequence.

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HST Imaging of the Circumstellar Nebulosity of T Tauri

Karl R. Stapelfeldt[1]**, Christopher J. Burrows**[2]**, John E. Krist**[2] **Alan M. Watson**[3]**, Gilda E. Ballester**[4]**, John T. Clarke**[4]**, David Crisp**[1]**, Robin W. Evans**[1]**, John S. Gallagher III**[5]**, Richard E. Griffiths**[6]**, J. Jeff Hester**[7]**, John G. Hoessel**[5]**, Jon A. Holtzman**[8]**, Jeremy R. Mould**[9]**, Paul A. Scowen**[7]**, John T. Trauger**[1]**, and James A. Westphal**[10]

[1] Mail Stop 183-900 Jet Propulsion Laboratory, 4800 Oak Grove Drive Padadena CA 91109, USA

[2] Space Telescope Science Institute, 3700 San Martin Drive, Baltimore MD 21218, USA

[3] Instituto de Astronomi'a UNAM, 58090 Morelia, Michoacan, Mexico

[4] Dept. of Atmospheric, Oceanic, and Space Sciences, University of Michigan, 2455 Hayward, Ann Arbor MI 48109, USA

[5] Dept. of Astronomy, University of Wisconsin, 475 N. Charter St., Madison WI 53706, USA

[6] Dept. of Physics, Carnegie-Mellon University, Wean Hall 8311, 5000 Forbes Ave., Pittsburgh, PA 15213-3890, USA

[7] Dept. of Physics and Astronomy, Arizona State University, Tyler Mall, Tempe AZ 85287, USA

[8] Dept. of Astronomy New Mexico State University, Box 30001 Dept. 4500 Las Cruces NM 88003-8001, USA

[9] Mt. Stromlo and Siding Springs Observatories, Australian National University, Weston Creek Post Office, ACT 2611 Australia

[10] Division of Geological and Planetary Sciences, Mail Stop 170-25 Caltech, Pasadena CA 91125, USA

E-mail contact: krs@wfpc2-mail.jpl.nasa.gov

Short exposure Planetary Camera images of T Tauri have been obtained using broadband filters spanning the wavelength range 0.55-0.80 μm. The optically visible star lies very close to an arc of reflection nebulosity. The arc's northern arm extends approximately 5″ from the star, while its southwestern arm appears brighter and extends only 2″. The arc shows an approximate symmetry along an axis toward the WNW, the direction of Hind's Nebula and the blueshifted molecular outflow. The morphology of the reflected light is similar to models of scattered light within an illuminated, axisymmetric outflow cavity in a circumbinary envelope, viewed ≈ 45° from the outflow axis. However, our model images do not successfully account for the amount of limb brightening which is seen. No optical counterpart

to the infrared companion is seen to a limiting magnitude of V=19.6, which suggests $A_V > 7$ mag toward this source. There is no evidence for an optical tertiary, to a limiting ΔV=5.1 mag fainter than the primary, at the position where such an object has been previously reported.

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The response of accretion disks to bending waves: angular momentum transport and resonances

Caroline E.J.M.L.J. Terquem[1,2]

[1] UCO/Lick Observatory, University of California, Santa–Cruz, CA 95064, USA
[2] Isaac Newton Institute for Mathematical Sciences, University of Cambridge, 20 Clarkson Road, Cambridge, CB3 0EH, UK

E-mail contact: ct@ucolick.org

We investigate the linear tidal perturbation of a viscous Keplerian disk by a companion star orbiting in a plane inclined to the disk. We consider $m = 1$ perturbations with odd symmetry with respect to the $z = 0$ midplane. The response frequency may be either finite or vanishing. These long–wavelength perturbations produce a well–defined warp.
Since the response of a viscous disk is not in phase with the perturbing potential, a tidal torque is exerted on the disk. When the perturber rotates outside the disk, this torque results in a decrease of the disk angular momentum, and thus in an increase of its accretion rate.
We show that this tidal torque is comparable to the viscous horizontal stress acting on the background flow when the perturbed velocities in the disk are on the order of the sound speed. If these velocities remain subsonic, the tidal torque can exceed the viscous horizontal stress only if the viscous parameter $\alpha_{\rm v}$ which couples to the vertical shear is larger than the parameter $\alpha_{\rm h}$ coupled to the horizontal shear. In protostellar disks, bending waves, which are predominantly excited in the outer regions, are found to propagate and transport a significant fraction of the negative angular momentum they carry deep into the disk inner parts.
If the waves are reflected at the center, resonances occur when the frequency of the tidal waves is equal to that of some free normal global bending mode of the disk. If such resonances exist, tidal interactions may then be important even when the binary separation is large. Out of resonance, the torque associated with the secular perturbation, which is proportional to $\alpha_{\rm v}$, is generally much larger than that associated with the finite frequency perturbations. As long as the waves are damped before they reach the center, the torque associated with the finite frequency perturbations does not depend on the viscosity, in agreement with theoretical expectation (Goldreich & Tremaine 1982).
These calculations are relevant to disks around young stars and maybe also to disks in X–ray binary systems.

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A Survey for Dense Cores and Young Stellar Clusters in the W3 Giant Molecular Cloud

A.R. Tieftrunk[1,2]**, S.T. Megeath**[3,4]**, T.L. Wilson**[2,5] **and J.T. Rayner**[6]

[1] European Southern Observatory, Casilla 19001, Santiago 19, Chile
[2] Max Planck Institut für Radioastronomie, Auf dem Hügel 69, D-53121 Bonn, FRG
[3] Harvard Smithsonian Center for Astrophysics, 60 Garden St. MS-72, Cambridge, MA 02138, USA
[4] MIT Haystack Observatory, Off Route 40, Westford, MA 01886, USA
[5] Sub-Millimeter Telescope Observatory, The University of Arizona, Tucson, AZ 85721, USA
[6] Institute for Astronomy, University of Hawaii, 2680 Woodlawn Dr., Honolulu, HI 96822, USA

E-mail contact: atieftru@eso.org

We simultaneously mapped the metastable (J,K) = (1,1) and (2,2) inversion lines of NH_3 toward W3 Main, W3(OH), and the region between these two star–forming clouds with a 40” angular resolution using the 100-m Effelsberg telescope. We observed a 120 square–arcminute region with 20” spacing and a significantly higher sensitivity than previous maps. We also measured the (J,K) = (3,3) line of NH_3 in 28 positions toward W3 Main. For comparison with our NH_3 survey, we present a K'–band (2.1 μm) survey conducted by J. T. Rayner. The K'–band survey detects five distinct stellar clusters within the mapped region. In addition, we compare the NH_3 survey to the CO (1-0) maps of the FCRAO 2nd quadrant survey (Heyer et al. 1998) and to the distribution of H II regions.

The goals of this new survey are to a) map the extent of dense gas in the W3 Main and W3(OH) molecular clouds, b) search for previously undetected molecular cores in the intervening molecular cloud, c) measure column densities and T_kin for regions of strong NH_3 emission, d) compare the distribution of the NH_3 emission to that of the CO emission and e) study the relationship between the ammonia gas and sites of star formation as traced by stellar clusters and H II regions.

In the W3 Main cloud, we find strong and extended NH_3 emission toward the relatively quiescent western core, but only weak and non-extended emission toward the highly active star–forming eastern core. We argue that the NH_3 relative abundance in the eastern core is an order of magnitude lower than that in the western core. Southeast of W3 Main we detect a new NH_3 core, which we denote W3 SE. From our NIR images we detect a jet toward this core. Toward the W3(OH) cloud, we find an extended (2 × 1.3 pc) and cold ammonia gas component. We show that the narrow plume of NH_3(1,1), detected toward W3(OH) in VLA maps, is part of a larger NH_3 structure extending toward a chain of stellar clusters and nebulosities found in our NIR images. We find that the strong NH_3 emission detected in the three cores covers 9% of the surveyed region. We estimate virial masses for each NH_3 core and find that the total sum of the virial masses is 3300 M⊙. The total mass measured from the CO emission, surveyed in this region, is 1.6×10^4 $M_\odot$, thus 20% of the molecular gas in the surveyed region is found in the dense cores. This indicates that the dense cores fill only small fraction of the total GMC and are concentrated in regions of active star formation. We also find extensive weak NH_3 emission which covers one fourth of the surveyed region. This weak emission may trace gas with densities just sufficient to excite the NH_3 emission (10^4 cm^{-3}) as well as strongly beam-diluted knots and filaments. We compare in detail the distribution of NH_3 cores, young stellar clusters, and H II regions, and discuss the effects of star formation on the NH_3 cores. We also compare the results of our survey to those discussed by Lada(1992) from the CS (2-1) and 2.2μm surveys obtained for the Orion B giant molecular cloud by Lada et al. (1991a,1991b).

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Systems with H_2O Maser and 1.3 cm Continuum Emission in Cepheus A

José M. Torrelles[1], José F. Gómez[2], Guido Garay[3], Luis F. Rodríguez[4], Salvador Curiel[4], R. Jim Cohen[5], and Paul T. P. Ho[6]

[1] Instituto de Astrofísica de Andalucía, CSIC, Apdo. Correos 3004, E-18080 Granada, Spain
[2] Laboratorio de Astrofísica Espacial y Física Fundamental, INTA, Apdo. Correos 50727, E-28080 Madrid, Spain
[3] Departamento de Astronomía, Universidad de Chile, Casilla 36-D, Santiago, Chile
[4] Instituto de Astronomía, UNAM, Apdo. Postal 70-264, DF 04510, México
[5] University of Manchester, Nuffield Radio Astronomy Laboratories, Jodrell Bank, Macclesfield, Cheshire SK11 9DL
[6] Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA
E-mail contact: torrelles@iaa.es

We report continuum (1.3 cm) and H_2O maser line observations, made with the Very Large Array (A configuration), toward the cluster of radio continuum sources in the star-forming region Cepheus A East. 1.3 cm continuum emission is detected toward HW2, HW3b, HW3c, HW3d, and HW9. In addition, a new continuum source (Cep A:VLA 1), undetected previously, is observed at this wavelength. We detected three spatial clusters of H_2O masers which are associated with the 1.3 cm continuum sources HW2, HW3b, and HW3dii (the brightest component of HW3d), indicating that these objects may harbor an energy source as suggested by Garay et al. (1996). The spatial distribution of the H_2O masers with respect to the continuum emission is different in each one of these objects. Toward source HW2 the H_2O masers are spread over $\sim 1''$ and aligned in a direction almost perpendicular to the associated radio jet. In HW3b the H_2O masers are spread over a more compact region ($\sim 0.''5$) and aligned along the major axis of the elongated radio continuum emission. The masers associated with the compact object HW3dii are distributed over a compact region ($\sim 0.''5$) but do not show any clear spatial trend. By comparing the H_2O (this paper) and OH (Migenes et al. 1992) maser distributions in the region, we propose that object HW2, with the strongest H_2O - OH maser activity, could represent the “oldest” YSO of the region, while HW3b, with no reported OH maser activity, could be the “youngest” source of these three objects.

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The ISO–SWS 2.4–45.2 μm spectrum toward Orion-IRc2

Ewine F. van Dishoeck[1], Christopher M. Wright[1], José Cernicharo[2], Eduardo González-Alfonso[2,3], Thijs de Graauw[4], Frank P. Helmich[1,5], Bart Vandenbussche[6,7]

[1] Leiden Observatory, P.O. Box 9513, 2300 RA Leiden, The Netherlands
[2] CSIC–IEM, Serrano 121, E–28006 Madrid, Spain
[3] Universidad de Alcalá de Henares, Dept. de Física, Campus Universitario, E–28871 Alcalá de Henares, Madrid, Spain
[4] SRON, P.O. Box 800, NL–9700 AV Groningen, The Netherlands
[5] SRON, Sorbonnelaan 2, NL–3584 CA Utrecht, The Netherlands
[6] Instituut voor Sterrenkunde, Katholieke Universiteit Leuven, Celestijnenlaan 200B, B–3001 Heverlee, Belgium
[7] ISO–SOC, ESA Astrophysics Division, P.O. Box 50727, E–28080 Villafranca/Madrid, Spain

The complete infrared spectrum from 2.4 to 45.2 μm toward the prototypical massive star-forming region Orion IRc2 is presented, obtained with the *Short Wavelength Spectrometer* (SWS) on board the *Infrared Space Observatory* (ISO) at a resolving power $\lambda/\Delta\lambda \approx$ 1300–2500. A wealth of emission and absorption features is found, including H_2 vibration–rotation lines, the full set of H_2 pure rotational lines (0,0) S(1) – S(17), H recombination lines, ionic fine-structure lines, PAH emission features, and absorption and emission bands by interstellar ices and gas-phase molecules, including CO_2, CH_4 and SO_2. Particularly interesting is the detection of strong emission and absorption lines in the H_2O ν_2 bending mode at 6.2 μm, and the observation of highly–excited pure rotational lines of H_2O in absorption at 25–45 μm. The origin of these lines in each of the physical components included in the ISO–SWS beam (H II region, PDR, quiescent ridge, shocked low-velocity plateau) is briefly discussed.

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Numerical simulations of protostellar encounters II. Coplanar disc-disc encounters

S. Watkins, A.S. Bhattal, H.M.J. Boffin, N. Francis, A.P. Whitworth

Department of Physics and Astronomy, P.O. Box 913, Cardiff University, CF2 3YB Cardiff, U.K.

E-mail contact: Henri.Boffin@astro.cf.ac.uk, A.Whitworth@astro.cf.ac.uk

It is expected that an average protostar will undergo at least one impulsive interaction with a neighbouring protostar whilst a large fraction of its mass is still in a massive, extended disc. Such interactions must have a significant impact upon the evolution of the protostars and their discs. We have carried out a series of simulations of coplanar encounters between two stars, each possessing a massive circumstellar disc, using an SPH code that models gravitational, hydrodynamic and viscous forces. We find that during a coplanar encounter, disc material is swept up into a shock layer between the two interacting stars, and the layer then fragments to produce new protostellar condensations. The truncated remains of the discs may subsequently fragment; and the outer regions of the discs may be thrown off to form circumbinary disc-like structures around the stars. Thus coplanar disc-disc encounters lead efficiently to the formation of multiple star systems and small-N clusters.

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Numerical simulations of protostellar encounters III. Non-coplanar disc-disc encounters

S. Watkins, A.S. Bhattal, H.M.J. Boffin, N. Francis, A.P. Whitworth

Department of Physics and Astronomy, P.O. Box 913, Cardiff University, CF2 3YB Cardiff, U.K.

E-mail contact: Henri.Boffin@astro.cf.ac.uk, A.Whitworth@astro.cf.ac.uk

It is expected that an average protostar will undergo at least one impulsive interaction with a neighbouring protostar whilst a large fraction of its mass is still in a massive, extended disc. If protostars are formed individually within a cluster before falling together and interacting, there should be no preferred orientation for such interactions. As star formation within clusters is believed to be coeval, it is probable that during interactions, both protostars possess

massive, extended discs. We have used an SPH code to carry out a series of simulations of non-colpanar disc-disc interactions. We find that non-coplanar interactions trigger gravitational instabilities in the discs, which may then fragment to form new companions to the existing stars. (This is different from coplanar interactions, in which most of the new companion stars form after material in the discs has been swept up into a shock layer, and this then fragments.) The original stars may also capture each other, leading to the formation of a small-N cluster. If every star undergoes a randomly oriented disc-disc interaction, then the outcome will be the birth of many new stars. Approximately two-thirds of the stars will end up in multiple systems.

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HV Tau C – Herbig-Haro flow or stellar companion with strong forbidden emission lines?

Jens Woitas and Christoph Leinert

Max-Planck-Institut für Astronomie, Königstuhl 17, 69117 Heidelberg, Germany

E-mail contact: woitas@mpia-hd.mpg.de

We present new near- and mid-infrared photometry of the infrared source near HV Tau that was proposed as a Herbig-Haro object by Magazzù & Martin (1994). We draw a different conclusion, namely that this object is a T Tauri star with strong forbidden emission lines as had been suggested originally. The presence of a Herbig-Haro flow in the vicinity of a weak-lined T Tauri star like HV Tau would have imposed a problem on models of T Tauri stars and their environment. With the reinstatement of the companion to HV Tau as a T Tauri star this problem disappears.

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Studies of dense molecular cores in regions of massive star formation. VII. Core properties on the galactic scale

I. Zinchenko[1,2], L. Pirogov[1] and M. Toriseva[2]

[1] Institute of Applied Physics of the Russian Academy of Sciences, 46 Uljanov str., 603600 Nizhny Novgorod, Russia
[2] Helsinki University Observatory, Tähtitorninmäki, P.O.Box 14, FIN-00014 University of Helsinki, Finland

E-mail contact: zin@appl.sci-nnov.ru

We surveyed 55 northern non-stellar H_2O masers in the CS $J = 2-1$ line with the 20-m Onsala radio telescope and detected 47 CS cores associated probably with 50 masers. The CS emission for this sample is weaker on the average than for the similar southern sample studied by us earlier at SEST. Most of the detected cores were mapped in CS. The CS peaks were observed also in the $C^{34}S$ $J = 2-1$ and in the CO $J = 1-0$ lines. We present CS maps as well as CO, CS and, when available, $C^{34}S$ spectra for the 26 best studied cores.

¿From the CS maps and optically thin $C^{34}S$ emission we derive the basic physical parameters of the cores: size, LTE mass, mean density, virial mass. Combining the present results with the previous SEST data we obtain statistical distributions of the core parameters. The CO brightness temperature distribution for most cores ranges from ~ 15 K to ~ 50 K with a peak at 20–30 K. The typical sizes of the cores are $L \sim 1.0-1.5$ pc. The *mean* density lies in the range $n \sim 10^3-10^5$ cm^{-3} which is much lower than densities needed for CS excitation from multitransitional analysis. The slope of the mass spectrum for $M \gtrsim 1000$ M$_\odot$ is 1.6 ± 0.3. The ratio of the IR luminosity of associated IRAS point sources to mass peaks at ~ 10 L$_\odot$/M$_\odot$. The CS line widths are highly supersonic ($\sim 1.5-9$ km s^{-1}).

We analyze the dependences of these parameters on galactocentric distance R. The mean density of the cores drops with increasing R in the interval $R \approx 7-14$ kpc. It is consistent with an exponential law with a scale length of ~ 3 kpc. The IR luminosity to mass ratio changes probably in a similar way. The core size increases with R in accordance with the density decrease and constant mass.

The comparison of the CS and $C^{34}S$ data shows almost no broadening of the CS lines due to optical depth effects. This can be probably explained by small scale clumpiness in the cores. The velocity difference between the CS cores and H_2O masers is close to zero on the average with the standard deviation of ~ 7 km s^{-1}.

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ftp://astar.astro.helsinki.fi/pub/igor/cs-oso.ps.gz
http://zin.appl.sci-nnov.ru/~igor/papers/cs-oso.ps.gz

A symmetric pulsed jet of gas from an invisible protostar in Orion

Hans Zinnecker[1], Mark J. McCaughrean[1], and John T. Rayner[2]

[1] Astrophysikalisches Institut Potsdam, An der Sternwarte 16, D-14482 Potsdam, Germany
[2] Institute for Astronomy, University of Hawaii, 2680 Woodlawn Drive, Hawaii 96882, USA

E-mail contact: mjm@aip.de

Young stars are thought to accumulate most of their mass through an accretion disk, which channels the gas and dust of a collapsing cloud onto the central protostellar object. The rotational and magnetic forces in the star-disk system often produce high-velocity jets of outflowing gas. These jets can in principle be used to probe the accretion and ejection history of the system, which is hidden from direct view by the dust and dense gas of the parent cloud. But the structures of these jets are often too complex to determine which features arise at the source and which are the result of subsequent interactions with the surrounding gas. Here we present infrared observations of a very young jet (HH 212) driven by an invisible protostar (IRAS 05413−0104) in the vicinity of the Horsehead Nebula in Orion. These observations reveal a sequence of geyser-like eruptions occurring at quasi-regular intervals and appearing in near-perfect mirror symmetry on either side of the source. This degree of symmetry is strong evidence that such features must be associated with the formation of the jet, probably related to recurrent or even chaotic instabilities in the accretion disk.

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