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Abstracts of recently accepted papers

Kinematics of Optical Outflows in the Orion Nebula I: The Giant Outflow HH 400 and the Irradiated Jet HH 502

John Bally[1], Doug Johnstone[2], Gilles Joncas[3], Bo Reipurth[1], and Gabriela Mallén-Ornelas[4]

[1] Center for Astrophysics and Space Astronomy and Department of Astrophysical and Planetary Sciences, University of Colorado, Boulder, CO 80309, USA

[2] Department of Astronomy, University of Toronto, 60 St. George St., Toronto, ON M5S 3H8 Canada

[3] Département de physique and Observatoire du mont Mégantic, Université Laval, Québec, PQ, G1K 7P4 Canada

[4] Departamento de Astronomía y Astrofisíca, P. Universidad Católica de Chile, Casilla 306, Santiago 22, Chile and Princeton University Observatory, Peyton Hall, Princeton, NJ 08544, USA

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

We present narrow-band filter and high-resolution velocity-resolved Fabry-Perot images of outflows in the southern portion of the Orion Nebula. HH 400 is a giant low-velocity redshifted bow shock located about 10' south of the core of the Orion Nebula. Its axis of symmetry passes close to the Trapezium cluster 1.5 parsecs to the north. The most likely point of origin is a young stellar object in the OMC1 cloud core. HH 400 may be the remnant of a parsec-scale bipolar outflow powered by one of the young stars forming within this region. The radial velocity of gas in the limb-brightened rim of HH 400 is low, with redshifted speeds ranging from 8 to 20 km s^{-1} with respect to the emission from the Orion Nebula. The shape of the bow indicates that it lies close to the plane of the sky. For an inclination angle of 30 degrees to the plane of the sky and assuming that the plasma is flowing mostly along the axis of symmetry, the visible gas at the rim of HH 400 has a mean velocity of about 30 km s^{-1} , a mass of about 3×10^{-2} $M_\odot$, and a dynamical age of about 5×10^4 years assuming the source lies in the OMC1 cloud core. The estimated mass flux in the HH 400 bow is about 10^{-6} $M_\odot$ yr^{-1}. The bent bipolar irradiated jet HH 502 is superposed on the western rim of HH 400. We resolve the spatial and velocity structure of the jet and its multiple bow shocks. The jet consists of a chain of photoionized segments separated by wide gaps; bow shocks lie at the leading edges of these jet segments. The mean radial velocities of the jet segments decrease with increasing distance from the source. The large radial velocity dispersions of the gas at the tips of the HH 502 internal working surfaces, the small spreading angles of the HH 502 jet segments, combined with their low radial velocities indicate that this flow lies close to the plane of the sky. Assuming that the jet is fully ionized, that it spreads at the Mach angle, and that the internal sound speed in the photoionized gas is about 10 km s^{-1}, the jet must have a space velocity of about 400 km s^{-1}. Finally, we present velocity-resolved images of the bow shocks in HH 540, a flow that may originate from a large proplyd 181-826. Several additional high-velocity features identified in the Fabry-Perot data trace additional jets and outflows in this portion of the Orion Nebula.

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Highly abundant HCN in the inner hot envelope of GL 2591: probing the birth of a hot core?

A.M.S. Boonman[1], R. Stark[2], F.F.S. van der Tak[2], E.F. van Dishoeck[1], P.B. van der Wal[2], F. Schäfer[2], G. de Lange[3] and W.M. Laauwen[3]

[1] Sterrewacht Leiden, P.O. Box 9513, 2300 RA Leiden, The Netherlands

[2] Max-Planck-Institut für Radioastronomie, Auf dem Hügel 69, D-53121 Bonn, Germany

[3] Space Research Organisation of the Netherlands (SRON), P.O. Box 800, 9700 AV Groningen, The Netherlands

E-mail contact: boonman@strw.leidenuniv.nl

We present observations of the ν_2=0 and vibrationally excited ν_2=1 J=9–8 rotational lines of HCN at 797 GHz toward the deeply embedded massive young stellar object GL 2591, which provide the missing link between the extended envelope traced by lower-J line emission and the small region of hot ($T_{\rm ex} \geq 300$ K), abundant HCN seen in 14 μm absorption with the *Infrared Space Observatory (ISO)*. The line ratio yields $T_{\rm ex}$= 720^{+135}_{-100} K and the line profiles reveal that the hot gas seen with *ISO* is at the velocity of the protostar, arguing against a location in the outflow or in shocks. Radiative transfer calculations using a depth-dependent density and temperature structure show that the data rule out a constant abundance throughout the envelope, but that a model with a jump of the abundance in the inner part by two orders of magnitude matches the observations. Such a jump is consistent with the sharp increase in HCN abundance at temperatures $\gtrsim$230 K predicted by recent chemical models in which atomic oxygen is driven into water at these temperatures. Together with the evidence for ice evaporation in this source, this result suggests that we may be witnessing the birth of a hot core. Thus, GL 2591 may represent a rare class of objects at an evolutionary stage just preceding the "hot core" stage of massive star formation.

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Understanding the atmospheric structure of T Tauri stars - II. UV spectroscopy of RY Tau, BP Tau, RU Lupi, GW Ori and CV Cha

D. H. Brooks[1], V. M. Costa[1,2], M. T. V. T. Lago[1,3] and A. C. Lanzafame[4]

[1] Centro de Astrofisica da Universidade do Porto, Rua das Estrelas, Porto 4150, Portugal
[2] Departamento de Matemática, Instituto Superior de Engenharia do Porto, Portugal
[3] Departamento de Matemática Aplicada, Faculdade de Ciências da Universidade do Porto
[3] Istituto di Astronomia, Universita di Catania, Viale Andrea Doria 6, I-9512 5 Catania, Italy

E-mail contact: vcosta@astro.up.pt

We report results from our study of *IUE* (International Ultraviolet Explore r) data of a group of T Tauri stars (TTS). Comparisons between UV line fluxes in these stars and in the Sun indicate very high levels of activity in their atmospheres and comparatively higher electron densities. Spectroscopic diagnostic line ratios indicate densities over an order of magnitude higher than in the 'quiet' Sun at 'transition region' temperatures. At these densities metastable levels can attain comparable populations to the ground level and ionisation fractions can be altered due to the sensitivity of dielectronic recombination. In Brooks et al. (1999) we improved the treatment of these effects using the ADAS software package (Summers, 1994) whose atomic models and data are based on Collisional–Radiative theory. Here we extend the analysis to a sample of five TTS: RY Tau, BP Tau, RU Lupi, GW Ori and CV Cha.

Using these models and data we derive the emission measure (EM) distribution for each star in the sample. We find that the decrease in EM with increasing temperature appears to be sharper than that found in previous work. In comparison with the Sun the result suggests that the UV emission is formed in a region with a steeper density or volume gradient. We find mismatches between the theoretical and observed fluxes which cannot be explained by density effects and thus must be due to uncertainties in the atomic data, unreliabilities in the fluxes or the failure of physical assumptions in the method. We have made a series of tests and comparisons, including examination of opacity effects, and these clearly favour the latter explanation. They also lead us to suggest the presence of two separate co mponents in the UV emission for each of the TTS, although the case of CV Cha is more ambiguous. This supports and extends the earlier work of Jordan & Kuin (1988) on RU Lupi.

Interestingly we find that the EM distribution for GW Ori has values at least 10 times larger than those of RY Tau which appears to have approximately the same electron density. A similar difference is found between CV Cha and RU Lupi. Following geometrical arguments, we suggest that the UV emission in GW Ori and CV Cha is formed in a more extended region than in the other three stars.

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Multiple shocks around the low–luminosity protostar IRAS 16293–2422

A. Castets[1], C. Ceccarelli[1,2], L.Loinard[3], E. Caux[4] and B. Lefloch[2]

[1] Observatoire de Bordeaux, BP 89, 33270 Floirac, France
[2] Laboratoire d'Astrophysique, Observatoire de Grenoble - BP 53, F-38041 Grenoble Cedex 09, France
[3] Instituto de Astronomía, UNAM, Apdo Postal 72-3 (Xangari), 58089 Morelia, Michoacán, México
[4] CESR CNRS-UPS, BP4346, 31028 - Toulouse Cedex 04, France

E-mail contact: castets@observ.u-bordeaux.fr

Using the IRAM 30m and SEST 15m telescopes we mapped an area covering $300'' \times 220''$ around IRAS 16293−2422 in the N_2H^+ $J = 1 \rightarrow 0$, H_2CO $J = 3_{1,3} \rightarrow 2_{1,2}$, SiO $J = 2 \rightarrow 1$ $J = 3 \rightarrow 2$ and $J = 5 \rightarrow 4$ molecular transitions. Five positions were also observed in the FIR, between 45 μm and 200 μm, with the Long Wavelength Spectrometer on board ISO, revealing only [C II] 158 μm and [O I] 63 μm emission. All these observations are used to reconstruct the complex morphology of the region, in which several outflows from several sources co-exist. The N_2H^+ line emission is strong and centered on 16293E, a recently discovered low mass and very young protostar situated South-East of IRAS 16293–2422. Only weaker N_2H^+ line emission is associated with the binary system IRAS 16293–2422, presumably because the gas surrounding it is warmer. In addition to the previously known North-East – South-West outflow powered by IRAS 16293–2422, we suggest the existence of a second outflow in this binary system. We also report the discovery of a North-West – South-East flow driven by 16293E. The impact of the outflows with the ambient cloud is probed by the SiO and H_2CO maps, which reveal the presence of at least four, possibly six shocked regions. We discuss in some detail the nature of the shocks, deriving densities, temperatures and column densities of the shocked gas of the various observed components. We suggest that the wind and ambient shocks are probed by the high and low velocity components observed in the SiO lines. The morphology of the H_2CO, SiO and [O I] line emissions are rather different, showing almost all kind of combinations. We discuss the origin of these differences in terms of the age of the shocks, the pre-shock densities and of the composition of the ices which are partially desorbed by the shocks.

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preprint available at http://www.observ.u-bordeaux.fr/public/bibliotheque/publi_revues_lect.html

Wind-Driven Gas Networks and Star Formation in Galaxies: Reaction-Advection Hydrodynamic Simulations

David Chappell[1] and John Scalo[1]

[1] Astronomy Department, University of Texas, Austin, TX 78712, USA
E-mail contact: parrot@astro.as.utexas.edu

The effects of wind-driven star formation feedback on the spatio-temporal organization of stars and gas in galaxies is studied using two-dimensional intermediate-representational quasi-hydrodynamical simulations. The model retains only a reduced subset of the physics, including mass and momentum conservation, fully nonlinear fluid advection, inelastic macroscopic interactions, threshold star formation, and momentum forcing by winds from young star clusters on the surrounding gas. Expanding shells of swept-up gas evolve through the action of fluid advection to form a "turbulent" network of interacting shell fragments whose overall appearance is a web of filaments (in two dimensions). A new star cluster is formed whenever the column density through a filament exceeds a critical threshold based on the gravitational instability criterion for an expanding shell, which then generates a new expanding shell after some time delay. A filament-finding algorithm is developed to locate the potential sites of new star formation.

The major result is the dominance of multiple interactions between advectively-distorted shells in controlling the gas and star morphology, gas velocity distribution and mass spectrum of high mass density peaks, and the global star formation history. The gas morphology strongly resembles the model envisioned by Norman & Silk (1980), and observations of gas in the LMC and in local molecular clouds. The dependence of the frequency distribution of present-to-past average global star formation rate on a number of parameters is investigated. Bursts of star formation only occur when the *time-averaged* star formation rate per unit area is low, or the system is small. Percolation does not play a role. The broad distribution observed in late-type galaxies can be understood as a result of either small size or small metallicity, resulting in larger shell column densities required for gravitational instability. The star formation rate increases with density, but dependences on gas velocity dispersion and average shell column density suggest that the dependence is multivariate. The distribution of gas velocities exhibits exponential tails over a broad range of parameter values and the velocity distribution for gas in filaments is nearly exponential. Decay simulations with no

star formation suggest that the exponential tails are due to multiple shell interactions, not individual stellar winds. The cloud mass spectra, estimated using a simplified version of the structure tree method, tend to be power laws at the higher-mass end, with an index that is nearly independent of the star formation activity or model parameters. Kinetic energy decay in simulations without star formation yields a t^{-1} dependence. We discuss how the simulations can be viewed in the context of various incomplete conceptual models, including collisional cloud coalescence, wind-driven turbulence, propagating star formation, forced mass-conserving Burgers turbulence, and granular fluids.

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High-Resolution Observations of the Molecular Clouds in the NGC 1333 IRAS 4 Region

Minho Choi

Institute of Astronomy and Astrophysics, Academia Sinica, Nankang P.O. Box 1-87, Taipei 11529, Taiwan

E-mail contact: minho@asiaa.sinica.edu.tw

The molecular outflows and the dense cores in the NGC 1333 IRAS 4 region were observed in several molecular lines and in the millimeter continuum with $\sim 4''$ angular resolution. The outflows were particularly well traced by the HCN line. The IRAS 4A northeast-southwestern outflow consists of several compact knots which are spaced regularly and have alternating position angles. This "wiggle" could be produced either by a "precessing" jet or by quasi-periodic outbursts of the driving source. In the former case, the binary separation causing either the precession or the "wobbling" of the protostellar disk should be smaller than the separation between IRAS 4A1 and 4A2. The HCN map shows yet another outflow to the south of IRAS 4A and a compact bipolar outflow driven by IRAS 4BI, but no outflow activity was found near IRAS 4BII. The central velocity of the IRAS 4A dense core is determined to be $V_{\rm LSR} = 6.7$ km s^{-1} using the C^{18}O line. With this central velocity, the optically thick lines toward IRAS 4A are not significantly blue-skewed, and the double-peaked line profile may not be a signature of infall motion in this particular case. IRAS 4BII has a steeper spectral index from 3.4 to 2.7 mm than IRAS 4A/4BI, suggesting that IRAS 4BII may be more evolved than its companions.

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Near-infrared imaging of compact HII regions in Cygnus X

F. Comerón[1] and J. Torra[2]

[1] European Southern Observatory, Karl-Schwarzschild-Str.2, D-85748 Garching bei München, Germany
[2] Departament d'Astronomia i Meteorologia, Universitat de Barcelona, Av. Diagonal 647, E-08028 Barcelona, Spain
E-mail contact: fcomeron@eso.org

We present a near-infrared imaging survey of compact HII regions in the direction of the Cygnus X complex, for which no previous observations at those wavelengths have been published so far. The targets have been selected from a catalog of sources in that region having a thermal spectral energy distribution between 408 and 4800 MHz (Wendker, Higgs, and Landecker, 1991, A&A, 241, 551), and an inferred angular size smaller than 5 arcmin across. We present images in the JHK filters, color-magnitude, and color-color diagrams for each region. We also suggest and apply a method for estimating the distance by comparing the dereddened H-band flux from all the stars in the area of the HII region and the radio-continuum flux. Many of the regions imaged are clearly associated with stellar aggregates with different degrees of concentration, whose components show varying amounts of extinction. Some objects are often found in the region of the $(J-H)$, $(H-K)$ diagram indicating excess emission of circumstellar nature. A detailed discussion on each object is provided in the context of existing published observations at different wavelengths, in particular regarding the existence of ultracompact components. A number of ultracompact HII regions are found to have clearly visible unresolved or nearly unresolved K-band counterparts characterized by very red $H-K$ colors, suggesting that the extinction may be low enough in their direction so as to allow the direct observation of the star ionizing the ultracompact component.

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http://www.eso.org/~fcomeron/publicat.html

A Jet From a High Mass Young Star

G. A. Fuller, A. A. Zijlstra, and S. J. Williams

Physics Department, UMIST, P.O. Box 88, Manchester, M60 1QD, UK

E-mail contact: G.Fuller@umist.ac.uk

Jets are a direct consequence of accretion in the inner regions of circumstellar disks. They trace the structure of the accretion disk and, indirectly, the star formation mechanism. Here we report on the discovery of a near-infrared jet from a young B1 star, one of the most luminous young stars known to exhibit such a structure. The jet is seen in L′ images of IRAS 18556 + 0136 in the G32.5−0.74N region; a significant fraction of the emission is due to Brα line emission. At shorter wavelengths the jet is obscured: the colours of the bipolar nebula are consistent with 25 magnitudes visual extinctions to the near lobe and 40 magnitudes to the far lobe. A previously detected radio continuum source and an elongated clump of OH maser spots coincide with a break in the jet. This is interpreted as the location of the circumstellar disk surrounding the embedded young star. A lower limit of $\sim$ 170 magnitudes is derived for the extinction to the exciting source. This provides an estimate of 0.15$M_\odot$ for the mass of the circumstellar disk within $\sim$ 1500AU of the central source. Emission knots on either side of a second, weaker radio continuum source offset $\sim 3''$ from the jet source suggests the presence of a second outflow source in the region. The lack of known jets in high mass protostars, in contrast to their prevalence among low-mass systems, points to a difference in the star formation process, e.g. mergers. The jet from this B1 star suggests that the mechanisms which form low-mass stars can operate upto at least 10 $M_\odot$ stars.

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Eclipses by a Circumstellar Dust Feature in the Pre-Main Sequence Star KH15D

Catrina M. Hamilton[1],[2], William Herbst[1], Candice Shih[3], and Anthony J. Ferro[4]

[1] Astronomy Department, Wesleyan University, Middletown, CT 06459
[2] Department of Physics, Astronomy, and Geophysics, Connecticut College, New London, CT 06320, USA
[3] Department of Astronomy, Haverford College, Haverford, PA 19041, USA
[4] University of Arizona, Steward Observatory/NICMOS, Tucson, AZ 85721, USA

E-mail contact: catrina@astro.wesleyan.edu

Photometry and spectroscopy of the unique pre-main sequence eclipsing object KH15D in the young cluster NGC 2264 is presented. The orbital period is 48.34 days and both the length ($\sim$16 d) and depth ($\sim$3 mag) of the eclipse have increased with time. A brightening near the time of central eclipse is confirmed in the recent data but at a much smaller amplitude than was originally seen. Spectra taken when the star is bright show that the primary is a weak T Tauri star of spectral type K7. During eclipse there is no detectable change in spectral type or reddening, indicating that the obscuration is caused by rather large dust grains and/or macroscopic objects. Evidently the star is eclipsed by an extended feature in its circumstellar disk orbiting with a semi-major axis of $\sim$0.2 AU. Continued photometric monitoring should allow us to probe the disk structure with a spatial resolution of $\sim$3 x 10^6 km or better.

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The Mass Dependence of Stellar Rotation in the Orion Nebula Cluster

W. Herbst[1], C. A. L. Bailer-Jones[2] and R. Mundt[2]

[1] Astronomy Dept., Wesleyan University, Middletown, CT 06459, USA
[2] Max-Planck-Institut für Astronomie, Königstuhl 17, D-69117 Heidelberg Germany

E-mail contact: wherbst@wesleyan.edu

We have determined new rotation periods for 404 stars in the Orion Nebula Cluster using the Wide Field Imager attached to the MPG/ESO 2.2 m telescope on La Silla, Chile. Mass estimates are available for 335 of these and most have M < 0.3 $M_\odot$. We confirm the existence of a bimodal period distribution for the higher mass stars in our sample and show that the median rotation rate decreases with increasing mass for stars in the range 0.1<M<0.4 $M_\odot$. While the spread in angular momentum (J) at any given mass is more than a factor of 10, the majority of lower mass stars in the ONC rotate at rates approaching 30% of their critical break-up velocity, as opposed to 5-10% for solar-like stars.

This is a consequence of *both* a small increase in observed specific angular momentum (j=J/M) and a larger decrease in the critical value of j with decreasing mass. Perhaps the most striking fact, however, is that j varies by so little - less than a factor of two - over the interval 0.1-1.0 $M_{\odot}$. The distribution of rotation rates with mass in the ONC (age$\sim$1 My) is similar in nature to what is found in the Pleiades (age$\sim$100 My). These observations provide a significant new guide and test for models of stellar angular momentum evolution during the proto-stellar and pre-main sequence phases.

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ADONIS observations of hard X-ray emitting late B-type stars in Lindroos systems

N. Huélamo[1], W. Brandner[2,3], A.G.A. Brown[2], R. Neuhäuser[1,3] and H. Zinnecker[4]

[1] Max Planck Institut für Extraterrestrische Physik, Giessenbachstrasse 1, D-85741 Garching, Germany
[2] European Southern Observatory, Karl Schwarzchildstrasse 2, D-85748 Garching, Germany
[3] University of Hawaii, Institute for Astronomy, 2680 Woodlawn Dr., Honolulu, HI 96822, USA
[4] Astrophysikalisches Institut Potsdam, An der Sternwarte 16, 14482 Potsdam, Germany

E-mail contact: huelamo@mpe.mpg.de

We present adaptive optics (AO) JHK_S observations of three main sequence late B-type stars listed in the Lindroos Catalogue: HD 123445, HD 127971 and HD 129791. Given their spectral types, these stars should not be X-ray emitters. However, they have been detected by *ROSAT* and their X-ray emission has been attributed to possible unresolved pre-Main Sequence (PMS) late-type companions. We have carried out diffraction limited near-IR observations of the 3 targets but we have not detected any late-type companion close to HD 127971 and HD 129791. This result leads us to conclude that either (i) they are spectroscopic binaries with unresolved late-type companions or (ii) they are intrinsic X-ray emitters. While the former case would be consistent with the reported high multiplicity of early-type stars (A and B), the latter would yield a revision of stellar activity theories which do not predict X-ray emission from these stars. On the other hand, HD 123445 does indeed show visual companions, namely an apparent subarcsecond ($0.26''$) faint (K$\sim$10) binary system at a projected separation of $5''$ from the B-type star. The near-IR colors of the components are consistent with a pair of Pre-Main Sequence (PMS) K-type stars at 140 pc, i.e. possible members of the Upper Centaurus Lupus association to which HD 123445 belongs. In this case, the reported X-ray emission can be ascribed to the new pair. Nevertheless, spectroscopy is required to confirm the PMS nature of the new binary system.

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Mid-Infrared Imaging of Candidate Vega-Like Systems

Ray Jayawardhana[1], R. Scott Fisher[2], Charles M. Telesco[2], Robert K. Piña[2], David Barrado y Navascués[3], Lee W. Hartmann[4], and Giovanni G. Fazio[4]

[1] Department of Astronomy, University of California, Berkeley, 601 Campbell Hall, Berkeley, CA 94720, USA
[2] Department of Astronomy, University of Florida, Gainesville, FL 32611, USA
[3] Departamento de Física Teórica, C-XI., Universidad Autónoma de Madrid, E-28049 Madrid, Spain
[4] Harvard-Smithsonian Center for Astrophysics, 60 Garden St., Cambridge, MA 02138, USA
E-mail contact: rayjay@astro.berkeley.edu

We have conducted deep mid-infrared imaging of a relatively nearby sample of candidate Vega-like stars using the OSCIR instrument on the CTIO 4-meter and Keck II 10-meter telescopes. Our discovery of a spatially-resolved disk around HR 4796A has already been reported (Jayawardhana et al. 1998). Here we present imaging observations of the other members of the sample, including the discovery that only the primary in the HD 35187 binary system appears to harbor a substantial circumstellar disk and the possible detection of extended disk emission around 49 Ceti. We derive global properties of the dust disks, place constraints on their sizes, and discuss several interesting cases in detail. Although our targets are believed to be main sequence stars, we note that several have large infrared excesses compared to prototype Vega-like systems, and may therefore be somewhat younger. The disk size constraints we derive, in many cases, imply emission from relatively large ($\gtrsim 10\mu$m) particles at mid-infrared wavelengths.

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A Survey for Infall Motions toward Starless Cores. I. CS $(2-1)$ and N_2H^+ $(1-0)$ Observations

Chang Won Lee[1,2], Philip C. Myers[1], & Mario Tafalla[1,3]

[1]Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, MS 42, Cambridge, MA 02138, USA [2] Taeduk Radio Astronomy Observatory, Korea Astronomy Observatory, 36-1 Hwaam Dong, Yusung Ku, Taejon 305-348, Korea [3] Observatorio Astronómico Nacional, Alfonso XII, 3, E-28014 Madrid, Spain

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

We present the results of an extensive mapping survey of 'starless' cores in the optically thick line of CS(2-1) and the optically thin lines of N_2H^+ $(1-0)$ and $C^{18}O$ $(1-0)$. The purpose of this survey was to search for signatures of extended inward motions. A total of 53 targets were observed in the three lines with the FCRAO 14m telescope. Thirty three regions were mapped in both CS and N_2H^+, and thirty seven well-defined N_2H^+ cores have been identified. The N_2H^+ emission is generally compact enough to find a peak, while the CS and $C^{18}O$ emissions are more diffuse. For each core, we have derived the normalized velocity difference (δV_{CS}) between the thick CS and thin N_2H^+ peak velocities. We define 10 'strong' and 9 'probable' infall candidates, based on δV_{CS} analysis and on the spectral shapes of CS lines.

From our analysis of the blue-skewed CS spectra and the δV_{CS} parameter, we find typical infall radii of $0.06-0.14$ pc. Also, using a simple two layer radiative transfer model to fit the profiles, we derive one-dimensional infall speeds, half of whose values lie in the range of $0.05-0.09$ km s^{-1}. These values are similar to those found in L1544 by Tafalla et al., and this result confirms that infall speeds in starless cores are generally faster than expected from ambipolar diffusion in a strongly sub-critical core. In addition, the observed infall regions are too extended to be consistent with the 'inside-out' collapse model applied to a very low-mass star. In the largest cores, the spatial extent of the CS spectra with infall asymmetry is larger than the extent of the N_2H^+ core by a factor of $2-3$. All these results suggest that extended inward motions are a common feature in starless cores, and that they could represent a necessary stage in the condensation of a star-forming dense core.

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Infrared Spectroscopy of Substellar Objects in Orion

P W Lucas[1], P F Roche[2], France Allard[3] and Peter H. Hauschildt[4]

[1] Dept. of Physical Sciences, University of Hertfordshire, College Lane, Hatfield AL10 9AB, UK
[2] Astrophysics Dept., University of Oxford, 1 Keble Road, Oxford OX1 3RH, UK
[3] CRAL, Ecole Normale Superieure, 46 Allee d'Italie, Lyon, 69364 France
[4] Dept. of Physics and Astronomy & Centre for Simulational Physics, University of Georgia, Athens, GA 30602-2451, USA

E-mail contact: pwl@star.herts.ac.uk

We present broad band spectra of a sample of 21 low luminosity sources in the Trapezium Cluster, with masses in the range 0.008 - 0.10 $M_\odot$ (assuming an age of 1 Myr). These were selected for low extinction in most cases and are located west of the brighter nebulosity. The spectra are in the *H* bandpass (1.4-1.95 μm) and *K* bandpass (1.9-2.5 μm) also for most of the brighter sources, with a resolution of 50 nm. They were taken with the United Kingdom Infrared Telescope (UKIRT) using the CGS4 spectrometer. Absorption by water vapour bands is detected in all the substellar candidates except one, which is a highly reddened object with strong H_2 emission and an anomalously blue *(I-J)* colour, implying that it is a very young cluster member with circumstellar matter. The observation of prominent water vapour bands confirms the low Effective Temperatures implied by our *(I-J)* colour measurements in an earlier paper and would imply late M or L spectral types if these were older field dwarfs. However, the profiles of the *H* bandpass spectra are very different from those of field dwarfs with similar water absorption strength, demonstrating that they are not foreground or background objects. In addition, the CO absorption bands at 2.3 μm and the NaI absorption feature at 2.21 μm are very weak for such cool sources. All these features are quite well reproduced by the AMES-Dusty-1999 model atmospheres of Allard et al.(2000,2001), and arise from the much lower gravities predicted for the Trapezium sources ($3.5 < log(g) < 4.0$) compared to evolved objects (log g $\sim$ 5.5). This represents a new proof of the substellar status of our sources, independent of the statistical arguments for low contamination, which are reexamined here. The very late spectral types of the planetary mass objects and very low mass brown dwarfs

demonstrate that they are cluster members, since they are too luminous to be field dwarfs in the background. We also present additional UKIRT photometry of a small region in the south of the Trapezium cluster where the extinction and nebular brightness are low, which permitted the detection of objects with 1 Myr masses slightly lower than our previous least massive source at 8 M_{Jup}. Following a minor update to our previous J band photometry, due to a new UKIRT filter calibration, there are ~ 15 planetary mass candidates in the full dataset.

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On the MBM12 Young Association

K. L. Luhman[1]

[1] Harvard-Smithsonian Center for Astrophysics, 60 Garden St., Cambridge, MA 02138, USA

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

I present a comprehensive study of the MBM12 young association (MBM12A). By combining infrared (IR) photometry from the Two-Micron All-Sky Survey (2MASS) survey with new optical imaging and spectroscopy, I have performed a census of the MBM12A membership that is complete to 0.03 $M_\odot$ ($H \sim 15$) for a $1.75^\circ \times 1.4^\circ$ field encompassing the MBM12 cloud. I find five new members with masses of 0.1-0.4 $M_\odot$ and a few additional candidates that have not been observed spectroscopically. From an analysis of optical and IR photometry for stars in the direction of MBM12, I identify M dwarfs in the foreground and background of the cloud. By comparing the magnitudes of these stars to those of local field dwarfs, I arrive at a distance modulus 7.2 ± 0.5 (275 pc) to the MBM12 cloud; it is not the nearest molecular cloud and is not inside the local bubble of hot ionized gas as had been implied by previous distance estimates of 50-100 pc. I have also used Li strengths and H-R diagrams to constrain the absolute and relative ages of MBM12A and other young populations; these data indicate ages of 2^{+3}_{-1} Myr for MBM12A and ~ 10 Myr for the TW Hya and η Cha associations. MBM12A may be a slightly evolved version of the aggregates of young stars within the Taurus dark clouds (~ 1 Myr) near the age of the IC 348 cluster (~ 2 Myr).

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Spectrum of PV Cep and GM1-29 (RNO125) in 1976-1997

T.Yu. Magakian and T.A. Movsessian

Byurakan Astrophysical Observatory, 378433 Aragatsotn reg., Armenia

E-mail contact: tigmag@sci.am; tigmov@bao.sci.am

Basic spectral features of the T Tau star PV Cep and of related with it variable nebula GM1-29 are described. Their changes on the 1976-1997 time span are studied by observations on 6-m telescope and literature. In the period of maximal brightness (1977-1979) the star possessed developed emission spectrum, typical for classic T Tau stars, with pronounced P Cyg components in Hα and Hβ lines, strong blueshifted NaD absorptions and with prominent fluorescence in FeI lines.

After the last eruption spectrum of the star is more or less stable, with reduced strength of emission lines. Erupted matter can be observed as shifted components in emission lines. Besides, there are evidences of the existence of visible collimated outflow of 1.5-2$''$ length in the close environments of the star. Also HH215 P1 - the first HH-knot in the giant outflow of PV Cep - is well visible.

During the period of maximal brightness of the nebula its spectrum demonstrated clear evidences of the spectral anisotropy of the stellar envelope, created by directed outflow and manifesting itself as variations of profiles and intensities of Balmer lines. Thus, PV Cep and GM1-29 became yet one more object with such phenomenon, which was firstly discovered in R Mon and NGC2261.

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NGC 7654: An interesting cluster to study star formation history

A. K. Pandey[1], Nilakshi[1], K. Ogura[2], Ram Sagar [1], and K. Tarusawa[3]

[1] State Observatory, Manora Peak, Naini Tal, 263 129, India
[2] Kokugakuin University, Higashi, Shibuya-ku, Tokyo 150-8440, Japan
[3] Kiso Observatory, School of Science, University of Tokyo, Mitake-mura, Kiso-gun, Nagano 397-0101, Japan

E-mail contact: pandey@upso.ernet.in

CCD $UBVI_C$ photometry in a wide field around the open cluster NGC 7654 has been carried out for $\sim$ 17860 stars, down to V$\sim$20. The reddening across the cluster region is found to be variable with $E(B-V)_{min} = 0.46$ to $E(B-V)_{max} = 0.80$. The cluster is situated at a distance of 1380 $\pm$ 70 pc. The colour magnitude diagrams show a large age spread in the ages. Star formation was biased towards relatively higher masses during the early phase of star formation whereas most of the low mass stars of the cluster were formed during the later phase. The star formation seems to have been a gradual process that proceeded sequentially in mass and terminated with the formation of most massive stars.

The present data do not support a uniform mass function (MF) for different regions in the cluster. Although for the whole cluster region, the MF in the observed mass range $0.8 \leq M_{\odot} \leq 4.5$, can be represented by a single power law with a slope $\Gamma = -1.40 \pm 0.07$, however it indicates various features when examined carefully. In three subregions of the cluster the slope Γ, for the mass range $\sim 1.5 < M_{\odot} < 4.0$, comes out to be -1.07 ± 0.08 and -1.28 ± 0.20 for the inner and intermediate regions and it becomes steeper in the outermost region ($\Gamma = -2.78 \pm 0.21$). For stars having masses $<\sim 1.5 M_{\odot}$ the MF, in the inner and intermediate regions, can be represented by a power law having a steeper slope, whereas in the outer region a turnover can be seen in the MF at $M \sim 1.5 M_{\odot}$.

The age of NGC 7654 is found to be comparable to its two-body relaxation time-scale; therefore this may also be a reason for the observed mass segregation in the cluster.

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The transverse velocity structure of the HH 111 jet

A. Riera[1,2], R. López[2], A. C. Raga[3], G. Anglada[4], and R. Estalella[2]

[1] Departament de Física i Enginyeria Nuclear, Universitat Politècnica de Catalunya, Av. Víctor Balaguer s/n, E-08800 Vilanova i la Geltrú, Spain
[2] Departament d'Astronomia i Meteorologia, Universitat de Barcelona, Av. Diagonal 647, E-08028 Barcelona, Spain
[3] Instituto de Astronomía, UNAM, Apdo. Postal 70-264, 04510 México, D. F., Mexico
[4] Instituto de Astrofísica de Andalucía, CSIC, Apdo. de Correos 3004, E-18080 Granada, Spain

E-mail contact: angels.riera@upc.es

We present long-slit spectroscopic observations of the HH 111 jet obtained with the 4.2 m William Herschel Telescope. We have obtained spectra for slit positions along and across the jet axis, in order to search for radial velocity, electron density and excitation variations across the jet. We have detected faint emission across knots HH 111 D and F, extending to large ($\sim 15''$) distances from the flow axis. This extended emission shows a radial velocity stratification, with higher radial velocities on the jet axis and lower velocities away from the axis. Knot D has a low central electron density surrounded by material with higher electron densities, while the electron density is approximately constant across knot F. We argue that the extended emission and the radial velocity variations observed across the HH 111 flow are compatible with a jet beam with a transverse gradient in velocity or with a jet which is entraining low velocity material.

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A High Density Thin layer confining the H II region M 42. HHT measurements

A. Rodríguez−Franco[1 2 3], T.L.Wilson[4], J. Martín−Pintado[2] and A. Fuente[2]

[1] Departamento de Matemática Aplicada (Biomatemática), Sección departamental de Optica, Escuela Universitaria de Optica. Universidad Complutense de Madrid. Av. Arcos de Jalón s/n. E-28037 Madrid. Spain
[2] Observatorio Astronómico Nacional (IGN), Campus Universitario, Apdo. 1143, E-28800, Alcalá de Henares, Spain

[3] LMSA Project Office National Astronomical Observatory of Japan 2-21-1 Osawa, Mitaka, Tokyo 181-8588 Japan.
[4] Sub-mm Telescope Observatory, Steward Observatory, The University of Arizona, Tucson, AZ, 8572, USA

E-mail contact: arturo@oan.es

We present HHT observations in the $N = 3 \rightarrow 2$ rotational transition of the CN radical toward selected positions of the Trapezium region and of the molecular Ridge in the Orion molecular cloud. Two of the positions in the Ridge were also observed in the $N = 2 \rightarrow 1$ line of CN and ^{13}CN. The $N = 3 \rightarrow 2$ CN lines have been combined with observations of the $N = 2 \rightarrow 1$ and $N = 1 \rightarrow 0$ transitions of CN, and of the $N = 2 \rightarrow 1$ of ^{13}CN to estimate the physical conditions and CN abundances in the molecular gas. We analyze in detail the excitation of the CN lines and find that the hyperfine ratios of the $N = 3 \rightarrow 2$ line are always close to the Local Thermodynamic Equilibrium (LTE) optically thin values even in the case of optically thick emission. This is due to different excitation temperatures for the different hyperfine lines. From the line intensity ratios between the different CN transitions we derive H_2 densities of $\sim 10^5\,\mathrm{cm}^{-3}$ for the molecular Ridge and of $\sim 3 \times 10^6\,\mathrm{cm}^{-3}$ for the Trapezium region. The CN column densities are one order of magnitude larger in the Ridge than in the Trapezium region, but the CN to H_2 ratio is similar both in the Trapezium and in the Ridge. The combination of the low CN column densities, high H_2 densities and relatively high CN abundances toward the Trapezium region requires that the CN emission arises from a thin layer with a depth along the line of sight of only $\sim 5 \times 10^{15}$ cm. This high density thin layer of molecular gas seems to be related with material that confines the rear side of the H II region Orion A. However the molecular layer is not moving as expected from the expansion of the H II region, but it is "static" with respect to the gas in the molecular cloud. We discuss the implication of a high density "static" layer in the evolution of an H II region.

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The metal-rich nature of stars with planets

Nuno C. Santos[1], Garik Israelian[2] and Michel Mayor[1]

[1] Observatoire de Genève, 51 ch. des Maillettes, CH–1290 Sauverny, Switzerland
[2] Instituto de Astrofisica de Canarias, E–38205 La Laguna, Tenerife, Spain

E-mail contact: Nuno.Santos@obs.unige.ch

With the goal of confirming the metallicity "excess" present in stars with planetary-mass companions, we present in this paper a high-precision spectroscopic study of a sample of dwarfs included in the CORALIE extrasolar planet survey. The targets were chosen according to the basic criteria that 1) they formed part of a limited volume and 2) they did not present the signature of a planetary host companion. A few stars with planets were also observed and analysed; namely, HD 6434, HD 13445 (Gl 86), HD 16141, HD 17051 (ι Hor), HD 19994, HD 22049 (ϵ Eri), HD 28185, HD 38529, HD 52265, HD 190228, HD 210277 and HD 217107. For some of these objects there had been no previous spectroscopic studies.
The spectroscopic analysis was done using the same technique as in previous work on the metallicity of stars with planets, thereby permitting a direct comparison of the results. The work described in this paper thus represents the first uniform and unbiased comparison between stars with and without planetary-mass companions in a volume-limited sample. The results show that 1) stars with planets are significantly metal-rich, and 2) that the source of the metallicity is most probably "primordial". The results presented here may impose serious constraints on planetary system formation and evolution models.

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On disc driven inward migration of resonantly coupled planets with application to the system around GJ876

M.D. Snellgrove, J.C.B Papaloizou and R.P. Nelson

Astronomy Unit, Queen Mary, University of London, Mile End Rd, London E1 4NS, United Kingdom

E-mail contact: m.d.snellgrove@qmw.ac.uk

We consider two protoplanets gravitationally interacting with each other and a protoplanetary disc. The two planets orbit interior to a tidally maintained disc cavity while the disc interaction induces inward migration. When the migration is slow enough, the more rapidly migrating outer protoplanet approaches and becomes locked in a 2 : 1

commensurability with the inner one. This is maintained in subsequent evolution. We study this evolution using a simple analytic model, full hydrodynamic 2D simulations of the disc planet system and longer time N body integrations incorporating simple prescriptions for the effects of the disc on the planet orbits. The eccentricities of the protoplanets are found to be determined by the migration rate and circularization rate induced in the outer planet orbit by the external disc.

We apply our results to the recently discovered resonant planets around GJ876. Simulation shows that a disc with parameters expected for protoplanetary discs causes trapping in the 2 : 1 commensurability when the planets orbit in an inner cavity and that eccentricities in the observed range may be obtained.

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A Dynamical Mass Constraint for Pre-Main-Sequence Evolutionary Tracks: The Binary NTT 045251+3016

Aaron T. Steffen[1], Robert D. Mathieu[1], Mario G. Lattanzi[2], David W. Latham[3], Tsevi Mazeh[4], L. Prato[5], Michal Simon[6], Hans Zinnecker[7] and Davide Loreggia[2]

[1] Department of Astronomy, University of Wisconsin–Madison, 475 North Charter Street, Madison, WI 53706-1582, USA
[2] Osservatorio Astronomico di Torino, Strada Osservatorio 20, I-10025 Pino Torinese, Italy
[3] Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA
[4] School of Physics and Astronomy, Raymond and Beverly Sackler Faculty of Exact Sciences, Tel Aviv University, Tel Aviv 69978, Israel
[5] Department of Physics and Astronomy, UCLA, Los Angeles, CA 90095-1562, USA
[6] Department of Physics and Astronomy, SUNY, Stony Brook, NY 11794-3800
[7] Astrophysikalisches Institut Potsdam, An der Sternwarte 16, D-14482 Potsdam, Germany

E-mail contact: steffen@astro.wisc.edu ¡mailto:steffen@astro.wisc.edu¿

We present an astrometric/spectroscopic orbital solution for the pre-main-sequence binary NTT 045251+3016. Interferometric observations with the HST FGS3 allowed stellar separations as small as 14 mas to be measured. Optical spectra provided 58 radial-velocity measurements of the primary star and near-infrared spectra provided 2 radial-velocity measurements of both the primary and secondary, giving a mass ratio for the binary system. The combination of these data allows the dynamical masses and the distance of the stars to be derived. Our measurements for the primary and secondary masses are 1.45 ± 0.19 $M_\odot$ and 0.81 ± 0.09 $M_\odot$, respectively, and 145 ± 8 pc for the distance of the system, consistent with prior estimates for the Taurus-Auriga star-forming region. The evolutionary tracks of D'Antona & Mazzitelli (1997), Baraffe et al. (1998), and Palla & Stahler (1999) are tested against these dynamical mass measurements. Due to the intrinsic color/T_{eff} variation within the K5 spectral class, each pre-main-sequence model provides a mass range for the primary. The theoretical mass range derived from the Baraffe et al. (1998) tracks that use a mixing length parameter $\alpha = 1.0$ is closest to our measured primary mass, deviating between 1.3 and 1.6 sigma. The set of Baraffe et al. (1998) tracks that use $\alpha = 1.9$ deviate between 1.6 and 2.1 sigma from our measured primary mass. The mass range given by the Palla & Stahler (1999) tracks for the primary star deviate between 1.6 and 2.9 sigma. The D'Antona & Mazzitelli (1997) tracks give a mass range that deviates by at least 3.0 sigma from our derived primary mass, strongly suggesting that these tracks are inconsistent with our observation. Observations of the secondary are less constraining than those of the primary, but the deviations between the dynamical mass of the secondary and the mass inferred for the secondary from the various pre-main-sequence tracks mirror the deviations of the primary star. All of the pre-main-sequence tracks are consistent with coevality of the components of NTT 045251+3016.

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Spherical Episodic Ejection of Material from a Young Star

J.M. Torrelles[1], N.A. Patel[2], J.F. Gómez[3], P.T.P. Ho[2], L.F. Rodríguez[4], G. Anglada[5], G. Garay[6], L. Greenhill[2], S. Curiel[7], J. Cantó[7]

[1] Institut d'Estudis Espacials de Catalunya (IEEC/CSIC) and Instituto de Ciencias del Espacio (CSIC), Gran Capità,2 08034 Barcelona, Spain
[2]Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA
[3]Laboratorio de Astrofísica Espacial y Física Fundamental (INTA), Apdo. Correos 50727, 28080 Madrid, Spain
[4]Instituto de Astronomía (UNAM), Apdo. Postal 72-3, 58089 Morelia, México
[5]Instituto de Astrofísica de Andalucía (CSIC), Ap. Correos 3004, 18080 Granada, Spain
[6]Departamento de Astronomía, Universidad de Chile, Casilla 36-D, Santiago, Chile
[7]Instituto de Astronomía (UNAM), Apdo. Postal 70-264, DF 04510, México

E-mail contact: torrelles@ieec.fcr.es

The exact processes by which interstellar matter condenses to form young stars are of great interest, in part because they bear on the formation of planets like our own from the material that fails to become part of the star. Theoretical models suggest that ejection of gas during early phases of stellar evolution is a key mechanism for removing excess angular momentum, thereby allowing material to drift inwards towards the star through an accretion disk. Such ejections also limit the mass that can be accumulated by the stellar core. To date, these ejections have been observed to be bipolar and highly collimated, in agreement with theory. Here we report observations at very high angular resolution of the proper motions of an arc of water-vapour masers near a very young, massive star in Cepheus. We find that the arc of masers can be fitted to a circle with an accuracy of one part in a thousand, and that the structure is expanding. Only a sphere will always produce a circle in projection, so our observations strongly suggest that the perfectly spherical ejection of material from this star took place about 33 years earlier. The spherical symmetry of the ejecta and its episodic nature are very surprising in the light of present theories.

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