THE STAR FORMATION NEWSLETTER

An electronic publication dedicated to early stellar evolution and molecular clouds

No. 60 — 19 Sept 1997 Editor: Bo Reipurth (reipurth@casa.colorado.edu)

From the Editor

Please take note of my new e-mail and postal address:

reipurth@casa.colorado.edu

CASA, University of Colorado, Box 389, Boulder, CO 80309-0389, USA

Fax: 1-303-492-7178

Mail sent to my earlier address reipurth@eso.org will be forwarded until the end of the year.

Bo Reipurth

Abstracts of recently accepted papers

Radiation induced warping of protostellar accretion disks

P.J. Armitage[1] and J.E. Pringle[2]

[1] Canadian Institute for Theoretical Astrophysics, McLennan Labs, 60 St George St, Toronto, M5S 3H8, Canada
[2] Institute of Astronomy, Madingley Road, Cambridge, CB3 0HA, UK

E-mail contact: armitage@cita.utoronto.ca

We examine the consequences of radiatively driven warping of accretion disks surrounding pre-main-sequence stars. These disks are stable against warping if the luminosity arises from a steady accretion flow, but are unstable at late times when the intrinsic luminosity of the star overwhelms that provided by the disk. Warps can be excited for stars with luminosities of around $10L_{\odot}$ or greater, with larger and more severe warps in the more luminous systems. A twisted inner disk may lead to high extinction towards stars often viewed through their disks. After the disk at all radii becomes optically thin, the warp decays gradually on the local viscous timescale, which is likely to be long. We suggest that radiation induced warping may account for the origin of the warped dust disk seen in Beta Pictoris, if the star is only $\sim 10 - 20$ Myr old, and could lead to non-coplanar planetary systems around higher mass stars.

Accepted by ApJ Letters

Preprint available at: http://www.cita.utoronto.ca/~armitage/twist_abs.html

IRAS 06562−0337, the Iron-clad Nebula: a young star embedded in a molecular cloud

R. Bachiller[1], M. Pérez Gutiérrez[1] and P. García-Lario[2,3]

[1] IGN Observatorio Astronómico Nacional, Apartado 1143, E-28800 Alcalá de Henares, Spain
[2] Leiden Observatory, PO Box 9513, NL-2300 RA Leiden, The Netherlands
[3] LAEFF, Estación de Villafranca del Castillo. Apartado 50727, E-28080 Madrid, Spain

E-mail contact: bachiller@oan.es

We present millimeter and sub-millimeter observations of IRAS 06562−0337, the so-called Iron-clad Nebula. It had been suggested previously that this object could be an evolved star in the transitional phase between the AGB and a planetary nebula. However, our observations show that this IRAS source lies at the center of a dense massive molecular cloud which exhibits strong lines of CO, ^{13}CO, CS, and CI. The close association of the source with this molecular cloud, the proximity to other molecular complexes, the infrared spectral energy distribution, and the main

characteristics of the previously observed optical spectra, imply that IRAS 06562−0337 is a young stellar object (or a small cluster) still associated to its parent molecular cloud. IRAS 06562 is placed at 7±3 kpc from the Sun, in the anticenter direction. Its location in the Galaxy, at about 15 kpc from the galactic center, makes the object particularly interesting for studies of galactic structure.

Accepted by Astronomy and Astrophysics

Shock chemistry in the young bipolar outflow L 1157

R. Bachiller and M. Pérez Gutiérrez

IGN Observatorio Astronómico Nacional, Apartado 1143, E-28800 Alcalá de Henares, Spain

E-mail contact: bachiller@oan.es

We present the first results from a recent survey of molecular lines in L 1157, a highly-collimated bipolar molecular outflow driven by a Class 0 protostar. These observations are used to study the chemical alterations produced by a violent highly-collimated outflow. Different molecular lines are observed to trace different components of the gas. Some molecules (C_3H_2, N_2H^+, $H^{13}CO^+$, DCO^+) are abundant in the quiescent medium but are not observed at high velocities. Lines from these molecules are the best tracers of the concentration of dense gas around the protostar. In addition, we find that some otherwise rare molecules (e.g. SiO, CH_3OH, H_2CO, HCN, CN, SO, SO_2) are enhanced by at least an order of magnitude at the shocked region. Our observations provide estimates of the enhancement factors for such species. Strong gradients in the chemical composition are observed along the outflow blue lobe which could be due to the evolution in time of the chemical processes. We briefly discuss the chemistry of the most important molecules, devoting special attention to the species which are thought to be abundant in interstellar ice mantles.

Accepted by Astrophysical Journal Letters.

Photometric Variability of Southern T Tauri Stars

Celso Batalha[1], Germano R. Quast[2], Carlos A.O. Torres[2], Paulo C.R. Pereira[3], Marco A.O. Terra[1], Francisco Jablonski[3], Ricardo P. Schiavon[4] and Marilia J. Sartori [4]

[1] Observatório Nacional/CNPq/MCT Rua Gal. José Cristino, 77, 20921–400 Rio de Janeiro, RJ, Brazil
[2] Laboratório Nacional de Astrofísica/CNPq/MCT Rua Estados Unidos, 154, CP 21, 37500–000 Itajubá, MG, Brazil
[3] Divisão de Astrofísica - INPE/MCT, CP 515, 12201–970 São José dos Campos, SP, Brazil
[4] Instituto Astronômico e Geofísico - USP, CP 9638, 01065–970 São Paulo, SP, Brazil

E-mail contact: celso@on.br

We present photometric light curves of T Tauri Stars (TTS) observed in the Southern hemisphere. Our list includes 26 TTS, half of which were discovered by the Pico dos Dias survey (PDS). The majority of the observed PDS stars are weak TTS and present, on average, the low range of variability typical of such stars. We monitored some of the stars for several seasons in order to detect possible changes in rotational modulation. In particular, we find that the classical TTS, AS 216, shows a stable period of 3.12d for three consecutive years (between 1985 and 1987) which then does not reveal itself during the observing season of 1989 and 1990. Coupled with this change during the last two observing seasons is an overall increase in the amplitude of the photometric variability in all colors. We derive photometric periods for 13 previously unmonitored objects, and confirm the previously published rotational period of SY Cha. In addition, we confirm that TW Cha and SZ 82 do not reveal any signs of periodic modulation.

Accepted by AA Supp.Ser.

N V in the wind of the pre-main sequence Herbig Ae star AB Aur.

J.-C. Bouret[1], C. Catala[1] and T. Simon[2]

[1] Laboratoire d'Astrophysique de Toulouse, CNRS UMR 5572, Observatoire Midi-Pyrénées, 14 avenue Edouard Belin, F-31400, Toulouse, France
[2] Institute for Astronomy, University of Hawaii, 2680 Wooodlawn Drive, Honolulu, Hawaii 96822, USA

E-mail contact: bouret@astro.obs-mip.fr

AB Aur was observed at intermediate spectral resolution with the Goddard High Resolution Spectrograph aboard the Hubble Space Telescope on 1996 February 23, in the spectral region between 1226–1253 Å which surrounds the N V

doublet at 1238.8, 1242.8 Å . We identified the emission feature detected at $\lambda \sim 1238.8$Å as one component of the 2s-2p resonance doublet of N V.
The presence of N V resonance lines lead us to introduce an additional high temperature zone to the current model of AB Aur's wind (Catala & Kunasz 1987). Spherically symmetric models produce features which are not observed, but that could be made undetectable by lowering the filling factor of the hot zone. We reduced this filling factor by assuming the presence of corotating interacting regions generated by a fast and slow stream structure controlled by the surface magnetic field. This assumption is supported because azimuthal structures are known to exist in the wind, as witnessed by the rotational modulation detected in some lines of AB Aur; The temperature in the CIRs being expected to rise far above that of the unperturbed stellar wind, we assumed that the N V resonance lines can originate in part of the CIRs, while X-ray emission is produced in the hottest parts of them.
The observed N V line is fairly well reproduced by such a model, assuming a filling factor of 7×10^{-3} for the CIR, and temperatures of the order of 140,000 K. If we assume that higher temperatures, with range 1-2 $\times 10^6$ K are also present in other regions within the CIRs, then the same filling factor is consistent with the observed X-ray flux of AB Aur.
When evaluating the amount of non-radiative energy deposited in the wind, we have found that the presence of CIRs keeps the global energetic balance of the wind of AB Aur almost unchanged. These results provide clues that the wind of AB Aur is very inhomogeneous and includes azimuthal structures giving rise to corotating interaction regions.

Accepted by Astronomy and Astrophysics

Magnetic field effects on the head structure of protostellar jets

Adriano H. Cerqueira[1], Elisabete M. de Gouveia Dal Pino[1] and Marc Herant[2, 3]

[1] Instituto Astronômico e Geofísico, Universidade de São Paulo, Av. Miguel Stéfano 4200, (04301-904) São Paulo, S.P., Brasil
[2] Theory Division, MS B228, Los Alamos National Laboratory, Los Alamos, NM 87545, USA
[3] Current address: Washington University School of Medicine, Box 8107, 660 S. Euclid, St. Louis, MO 63110, USA

E-mail contact: adriano@iagusp.usp.br

We present the results of three-dimensional smooth particle magnetohydrodynamics numerical simulations of super-magnetosonic, overdense, radiatively cooling jets. Together with a baseline non-magnetic calculation, two initial magnetic configurations (in $\sim$ equipartition with the gas) are considered: (i) a helical and (ii) a longitudinal field which permeate both the jet and the ambient medium. We find that magnetic fields have important effects on the dynamics and structure of radiative cooling jets, especially at the head. The presence of a helical field suppresses the formation of the clumpy structure which is found to develop at the head of *purely hydrodynamical* jets by fragmentation of the cold shell of shocked material. On the other hand, a cooling jet embedded in a longitudinal magnetic field retains clumpy morphology at its head. This fragmented structure resembles the knotty pattern commonly observed in HH objects behind the bow shocks of protostellar jets. This suggests that a strong (equipartition) helical magnetic field configuration is ruled out at the jet head. Therefore, if strong magnetic fields are present, they are probably predominantly longitudinal in those regions. In both magnetic configurations, we find that the confining pressure of the cocoon is able to excite short-wavelength MHD Kelvin-Helmholtz pinch modes that drive low-amplitude internal shocks along the beam. These shocks are not strong however, and it likely that they could only play a secondary role in the formation of the bright knots observed in protostellar jets.

Accepted by Ap. J. Letters

Preprints available at: http://www.iagusp.usp.br/preprints/preprint.html

SO observations towards Bok globules

C. Codella⋆ and D. Muders

Max-Planck-Institut für Radioastronomie, Auf dem Hügel 69, D-53121 Bonn, Germany
⋆ Present address: Observatorio Astronomico Nacional (IGN), Apartado 1143, E-28800 Alcalá de Henares (Madrid), Spain
E-mail contact: codella@oan.es

The results of a survey of 30.0 GHz ($J_N = 1_0$–0_1) SO emission towards 21 Bok globules associated with an IRAS counterpart are presented. Fully sampled SO maps of the region around the IRAS coordinates have been obtained.

We found SO emission in 13 (62%) Bok globules and, for 3 of them, we have mapped the whole SO structures, which have elongated shapes and contain clumps in their interior. The SO cloud sizes range from 0.20 to 1.13 pc, while the derived total SO column densities at the position of the SO peaks are between 0.6 10^{13} and 4.5 10^{13} cm^{-2}.

Accepted by MNRAS

The ionized wind of IRAS 08159-3543

Marcello Felli[1], Gregory B. Taylor[2], Th. Neckel[3] and H. J. Staude[3]

[1] Osservatorio Astrofisico di Arcetri, Largo E. Fermi 5, I-50125 Firenze, Italy
[2] NRAO, P.O. Box 0, Socorro, New Mexico 87801-0387 U.S.A.
[3] Max-Plank-Institut für Astronomie, Königstuhl 17, D-69117 Heidelberg, Federal Republic of Germany

E-mail contact: mfelli@arcetri.astro.it

We report the detection of cm radio emission from the ionized wind which had been suggested to exist in the inner part of the bipolar outflow around the embedded Young Stellar Object (YSO) IRAS 08159-3543. The small radio flux density, the spectral index and the unresolved size of the source are all consistent with an ionized stellar wind with a mass loss rate ($\sim 10^{-5}$ M$_\odot$/yr), slightly smaller than that predicted from the observed Hα radiation scattered in the neutral parts of the wind. This confirms that the fast flowing neutral material far out in the lobes must have been accelerated by the same mechanism at work near the luminous YSO.

The presence of an ionized wind implies the existence of a strong source of ionizing photons, which is much hotter than the star inferred from visible and NIR observations (and corresponding to a spectral type F - K). This could be an early spectral type star whose optical radiation is strongly attenuated by its surrounding disk. Alternatively, the ionizing radiation could be provided by the hot boundary layer of a highly active accretion disk surrounding a lower mass PMS star. This result is consistent with the notion, supported also by spectroscopic properties of the YSO, that the dominant source of optical and near IR radiation is a disk, whose color temperature depends on the spectral range within which it is determined.

IRAS 08159-3543, with its associated reflection nebula GN08.16.0, is one of the few cases where the inner ionized part of the wind and the outer neutral parts of a larger scale bipolar outflow can be observed simultaneously, and offers the opportunity to study the interaction of the wind with the surrounding disk in the first evolutionary stages of a YSO.

Accepted by Astronomy & Astrophysics

Water Masers in Orion

R.A. Gaume[1], T.L. Wilson[2], F.J. Vrba[3], K.J. Johnston[1], J. Schmid-Burgk[2]

[1] U.S. Naval Observatory, 3450 Massachusetts Ave., NW, Washington, DC 20392-5420, USA
[2] Max Planck Institut für Radioastronomie, Postfach 2024, D-53010 Bonn, Germany
[3] U.S. Naval Observatory, Box 1149, Flagstaff Station, Flagstaff, AZ 86002–1149, USA

E-mail contact: gaume@nh3.usno.navy.mil

Measurements of the $6_{16} \rightarrow 5_{23}$ line of H_2O at 1.3 cm in the Orion region of star formation are reported. With a spatial resolution of $\approx 0.1''$, H_2O maser emission was detected in two regions: Orion BN/KL and Orion S. The well-known masers in the BN/KL region are distributed in a $30''$ by $30''$ area. The "shell" masers, within the BN/KL region, are distributed in a $2''$ by $0.5''$ strip centered on radio source I, and are offset from IRc2. The average shell maser spectrum is doubly peaked, resembling the spectrum of the v=1 SiO masers. The shell masers have deconvolved sizes of (24–38 AU), slightly smaller than the synthesized beam. Newly detected H_2O masers in the Orion S region are distributed in a $15''$ by $20''$ area. One cluster of masers in the Orion S region is found in a thin $0.6''$ strip. The velocity range of the masers in this cluster is nearly 65 km s^{-1}. We suggest that this cluster of masers is associated with the energetic source of the Orion S molecular outflow. A search in the Orion S region for associated maser emission in the ground state OH main lines and the $9_2 \rightarrow 10_1A^+$ and $6_2 \rightarrow 6_1E$ lines of CH_3OH gave only upper limits, as did a search for centimeter wavelength continuum.

Near-infrared images of the Orion region are presented, in the J, H, and K bands. Three objects with very red near-infrared colors were detected in the Orion S region, near the H_2O masers and the previously detected mm wavelength

dust continuum peak. One of these objects exhibits near-infrared colors consistent with a B2 ZAMS star. Although this object may heat the northern part of the Orion S dust cloud, its luminosity and separation from the dust maximum make it unlikely that it alone heats the entire Orion S region. More likely, the primary heat source of the Orion S region is deeply embedded in dust, and completely extincted in the near-infrared.

Accepted by Ap. J., currently scheduled for 1 February 1998 issue

Preprint available (soon) on NRAO Preprint page: http://www.cv.nrao.edu/library/nrao_preprints.html

Deep optical and near infrared photometry of the Serpens cloud core

P. Giovannetti[1], E. Caux[1] and D. Nadeau[2]

[1] Centre d'Etude Spatiale des Rayonnements, 9 avenue du Colonel Roche, BP 4346, F-31028 Toulouse Cedex 04, France
[2] Observatoire du Mont Megantic et Département de Physique, Université de Montréal, C.P. 6128, Succ. A. Montréal, Québec, Canada, H3C 3J7

E-mail contact: giova@cesr.cnes.fr

We present results from a deep optical (VRI) and near infrared (JHK) survey of the central part of the Serpens molecular cloud. A total of 138 sources were detected in the 19 arcmin^2 surveyed area down to a limiting magnitude of 16.3 in K. We find that the form of the observed K Luminosity Function (KLF) of stars belonging to the Serpens Molecular cloud is consistent with that predicted from a Miller & Scalo Interstellar Mass Function (IMF). We have investigated the KLF evolution with the age of a cluster by modeling KLFs of hypothetical clusters. Our results suggest that two phases of star formation could have taken place in the Serpens core.

Accepted by A&A

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

Disk Accretion Rates for T Tauri Stars

Erik Gullbring[1], Lee Hartmann[1], Cesar Briceño[1,2,3], and Nuria Calvet[1,3]

[1]Harvard-Smithsonian Center for Astrophysics, 60 Garden St., Cambridge, MA 02138, USA
[2]Also at Postgrado de Física, Universidad Central de Venezuela, Caracas, Venezuela
[3]Also at Centro de Investigaciones de Astronomía (CIDA), Mérida, Venezuela

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

We present new measurements of disk accretion rates for T Tauri stars in the Taurus molecular cloud complex. Our results are based on intermediate resolution spectrophotometry from 3200 Å to 5200 Å, which is used to derive the excess hot continuum emission produced by accretion onto the central star. Previous estimates of T Tauri accretion rates in the literature differ by as much as an order of magnitude; our measurements agree better with the lowest estimates, and we discuss the problems and systematic effects which led to the previous disagreement. In particular, we note that the stellar photospheric emission from non-accreting T Tauri stars exhibits color anomalies compared to main-sequence stars; these anomalies make the estimated extinction depend upon the color index used. We argue that the V-R index is a reasonable compromise to match with optically-derived spectral types, and that V-I and V-J are much more likely to be biased by cooler companion stars and starspots. We develop a calibration with which approximate mass accretion rates can be derived for T Tauri stars based on broad-band photometry and spectral types, which should enable accretion rates to be estimated for large samples with greater ease.

Accepted by Astrophysical Journal
Pre-prints available at http://cfa-www.harvard.edu/cfa/youngstars/

The SO-to-CS abundance ratio in molecular cirrus clouds

Andreas Heithausen[1], Uwe Corneliussen[2], and Volkmar Großmann[3]

[1] Radioastronomisches Institut der Universität Bonn, Auf dem Hügel 71, 53121 Bonn, Germany
[2] I. Physikalisches Institut der Universität zu Köln, Zülpicher Straße 77, 50937 Köln, Germany
[3] Institut für Astronomie und Astrophysik - Astronomie, Universität Tübingen, Waldhäuser Str. 64, 72076 Tübingen, Germany

E-mail contact: heith@astro.uni-bonn.de

We have extended our study of sulphur monoxide towards other less opaque cirrus cores and have clearly detected 3 out of 6 sources observed, for the Draco cloud, LVC 127+20, and MBM32. We find for at least one further cloud (MBM32) that SO is extended. Assuming that the lines are optically thin we derive column densities of about $N(\mathrm{SO})= 5\ 10^{12}$ cm^{-2}. Based on the visual extinction estimates we derive abundances $X(\mathrm{SO})=2\,10^{-9}$, thus again higher than can be predicted by chemical models with standard assumptions on a low initial S abundance in the gas phase. Our new observations therefore confirm our previous conclusion, that in cirrus clouds sulphur must be essentially undepleted to explain the amount of SO detected.

For MCLD 126.6+24.5 we present an analysis of our extensive SO ($N_J = 1_0 \rightarrow 0_1$) mapping. The SO emission reveals the clumpy structure of that cloud. We decompose the SO cloud into 17 individual clumps. Those clumps follow the same size-line width relation as high latitude molecular clouds (HLCs) on larger scales. Also, the size-density relation for the SO clouds has the same slope as that for other HLCs found from CO observations.

The clouds detected in SO were also observed in the CS ($J = 2 \rightarrow 1$) and ($3 \rightarrow 2$) lines. Only MCLD 126.6+24.5 and MBM32 were detected in CS. For the most intense SO clump in MCLD 126.6+24.5 we present a detailed study of SO and CS. The abundance ratio of CS and SO ranges from unity for MCLD 126.6+24.5 to less than 0.1 for the other clouds, indicating a low depletion of oxygen in that clouds. Our detailed comparison of CS and SO in MCLD 126.6+24.5 both in position and in velocity indicate that the molecules do not necessarily coexist in the cloud; we find that both molecules are not equally distributed, that the profiles of both molecules look different and that there is no correlation between the column densities of the molecules. Our findings let us suggest that these clouds are inhomogeneous clumpy objects, possibly not well described by simple equilibrium models.

Accepted by Astronomy & Astrophysics

The Apparent Sizes of the 6_2–6_1 E Type Methanol Masers in OMC–1

K.J. Johnston[1], R.A. Gaume[1], T.L. Wilson[2], H.A. Nguyen[3], & G.E. Nedoluha[3]

[1] U.S. Naval Observatory, 3450 Massachusetts Ave., NW, Washington, DC 20392-5420, USA
[2] Max Planck Institut für Radioastronomie, Postfach 2024, D-53010 Bonn, Germany
[3] Remote Sensing Division, Naval Research Laboratory, Washington, DC 20375-5351, USA

E-mail contact: gaume@nh3.usno.navy.mil

The 6_2–6_1 E transition of CH_3OH has been observed toward the Orion KL region with an angular resolution of 0.07" and frequency resolution of 12 kHz (0.15 km s^{-1}) at two epochs, one year apart. The observations have a sensitivity of 1 Jy beam^{-1} (corresponding to a main beam brightness temperature of 4×10^5 K). Only the brightest masers previously measured with 3" resolution are detected; these are resolved into several bright features. The brightness temperatures of the detected masers range from 2×10^6 to 3×10^7 K, with apparent sizes in the range 22 to 56 AU.

From the trends of radial velocity versus position, the observed line widths of the masers may be explained as blends of individual narrower features, each with line widths less than the frequency resolution of these measurements. The intensities of the masers increase with decreasing apparent size. This is interpreted as evidence that the excitation process plays a larger role than path length in determining maser intensity; our measurement of narrow linewidths supports this interpretation.

The CH_3OH masers are probably collisionally pumped and formed in very turbulent regions. The kinetic temperatures are ≈100 K, corresponding to sound speeds of order 2 km s^{-1}. From this, intensity variations are expected on time scales of years, or longer. At both epochs the majority of the maser features are located in the same relative positions with approximately the same flux densities. However some of the masers appear to vary on time scales of a year. Variations in intensity of the strongest maser feature may have been detected over a year's time. Further, two weak

maser features which appeared in 1990 were not detected in 1991.

Accepted by Ap. J., currently scheduled for 1 December 1997 issue

Preprint available on NRAO Preprint page: http://www.cv.nrao.edu/library/nrao_preprints.html

Star formation in the Cepheus Flare molecular clouds I. Distance determination and the YSO candidates

M. Kun

Konkoly Observatory of Hungarian Academy of Sciences,
H-1525 Budapest, XII, P.O.Box 67. E-mail contact: kun@buda.konkoly.hu

Results of an objective prism Schmidt survey are combined with IRAS survey data in order to assess the star forming activity in the Cepheus Flare, a nearby giant molecular cloud complex at $\sim +15^o$ above the galactic equator. The distribution of absorbing matter along the line of sight was also studied. The Wolf diagrams, displaying the cumulative distribution of field star distance moduli, show that the interstellar matter in this region is concentrated at three characteristic distances: 200, 300 and 450 pc. The three components, though partly overlapping, can be separated along the galactic latitude. Within the area of the Cepheus Flare, distances are determined for 14 Lynds dark clouds and for some other clouds.

In order to compile a sample of young stellar object (YSO) candidates, three types of star formation sign-post were searched for:

- prestellar cores in the IRAS 100μm optical depth image of the region,
- far infrared sources representing embedded YSOs and optically visible pre-main-sequence star candidates using IRAS Point Source Catalog, Faint Source Catalog and calibrated IRAS detector scans,
- Hα emission stars appearing on low-dispersion objective prism Schmidt plates as candidate pre-main-sequence stars.

The IRAS 100μm optical depth image of the region revealed 107 dense cores. Most of them are probably 'starless' cores, and as such potential sites of future star formation. 122 IRAS point sources were selected as probable YSOs at various evolutionary stages. An objective prism search for Hα emission stars covering an area of about 150 square degrees resulted in the detection of 142 Hα emission stars. Infrared fluxes taken from the IRAS catalogs or determined from the detector scans are listed for 95 of them. This sample is expected to consist of mostly T Tauri stars associated with the cloud complex.

Finding charts and catalogues of the young stellar object candidates are also given. These results may serve as a basis for further dedicated studies of the region and will be useful for comparison when star forming activity in other cloud complexes is investigated.

Accepted by Astrophys. J. Suppl.

$C^{18}O$ and $C^{17}O$ Observations of Embedded Young Stars in the Taurus Molecular Cloud I. Integrated Intensities and Column Densities

E. F. Ladd[1], G. A. Fuller[2] and J. R. Deane[3]

[1] Five College Radio Astronomy Observatory, 619 Lederle Graduate Research Center, University of Massachusetts, Amherst, MA 01003, USA
Present address: Department of Physics, Bucknell University Lewisburg, PA 17837, USA
[2] National Radio Astronomy Observatory, 520 Edgemont Road, Charlottesville, VA 22903, USA
Present address: Physics Dept., UMIST, P.O. Box 88, Manchester, M60 1QD, UK
[3] Institute for Astronomy, University of Hawaii, 2680 Woodlawn Drive, Honolulu, HI 96822, USA

E-mail contact: gfuller@umist.ac.uk

We report on the results of a survey of $C^{18}O$ and $C^{17}O$ towards the 20 most deeply embedded young stars in the Taurus molecular cloud. Most of the sources have been observed in both the J = 1–0 and J = 2–1 transitions of each

species. The analysis shows that in general the $C^{17}O$ emission is optically thin whereas the $C^{18}O$ emission has optical depths between 0.5 and 1.0. The material traced by these lines has an excitation temperature of ~ 8 K and column density ranging from 3 to 42×10^{21} cm^{-2}. The column density toward a source is found to be inversely correlated with the source's bolometric temperature, T_{bol}. The correlation between T_{bol} and source age is re-examined and the new correlation is used to find the rate at which mass is removed from the circumstellar environment of these sources. We find that the outflows observed towards the sources and infall with a constant mass accretion rate typical of a 10-20 K singular isothermal sphere are individually unlikely to produce the observed reduction in mass over the Class I phase. However, a scenario where a highly efficient outflow dominates the beam mass loss during the first 3×10^4 years and then standard infall dominates the beam mass loss thereafter is plausible.

Accepted by Ap.J.

Outflow collimation in young stellar objects

Garrelt Mellema[1] and Adam Frank[2]

[1] Stockholm Observatory, SE-13336 Saltsjöbaden, Sweden
[2] Department of Physics and Astronomy, Bausch and Lomb Building, University of Rochester, Rochester, NY 14627-0171, USA

E-mail contact: garrelt@astro.su.se

In this paper we explore the effect of radiative losses on purely hydrodynamic jet collimation models applicable to Young Stellar Objects (YSOs). In our models aspherical bubbles form from the interaction of a central YSO wind with an aspherical circum-protostellar density distribution. Building on a previous non-radiative study (Frank & Mellema 1996) we demonstrate that supersonic jets are a natural and robust consequence of aspherical wind-blown bubble evolution. The simulations show that the addition of radiative cooling makes the hydrodynamic collimation mechanisms studied by Frank & Mellema (1996) more effective. We find a number of time-dependent processes contributing to the collimation whose relative strength depends on the age of the system and parameters characterising the wind and the environment. As predicted by Frank & Mellema (1996) the flow-focusing at an oblique inner shock becomes more effective when radiative cooling is included. An unexpected result of this is the production of cool ($T < 10^4$ K), dense ($n \approx 10^4$ cm^{-3}) jets forming through conical converging flows at the poles of the bubbles. For steady winds the formation of these jets occurs early in the bubble evolution. At later times we find that the dynamical and cooling time scales for the jet material become similar and the jet beam increases in temperature ($T \approx 10^6$ K). The duration of the cool jet phase depends on the mass loss rate, $\dot{M}_{\rm w}$, and velocity, $V_{\rm w}$, of the wind. High values of $\dot{M}_{\rm w}$ and low values of $V_{\rm w}$ produce longer cool jet phases.

Since observations of YSO jets show considerable variability in the jet beam we present a simple one-dimensional (1-D) model for the evolution of a variable wind interacting with an accreting environment. We find that the accretion ram pressure can halt the expansion of the bubble on time scales comparable to the periodicity of the wind and length scales less than 100 AU, the approximate observed scale for YSO jet collimation. These models indicate that, in the presence of a varying protostellar wind, the hydrodynamic collimation processes studied in our simulations can produce cool jets with sizes and time scales consistent with observations.

Accepted by MNRAS

Preprints can also be obtained from http://www.astro.su.se/preprints.html

The Transitional PMS Object DI Tauri: Evidence for a Sub-stellar Companion and Rapid Disk Evolution

Michael R. Meyer[1], S.V.W. Beckwith[1], T.M. Herbst[1], and M. Robberto[1,2]

[1] Max–Planck–Institut für Astronomy, Königstuhl 17, Heidelberg, Germany D–69117
[2] Also at Osservatorio Astronomico di Torino, Italy.

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

We report mid–IR observations of two young stars found in the Taurus dark cloud spatially resolving for the first time their 10 μm emission. The weak–emission T Tauri star DI Tau, tentatively identified by Skrutskie *et al.* (1990) on the basis of 12 μm IRAS data as an object in the process of dissipating its circumstellar disk, is found to have

no infrared excess at a wavelength of 10 μm. The nearby classical T Tauri star DH Tau exhibits excess emission at 10 μm consistent with predictions based on circumstellar disk models. While both objects appear to have the same stellar mass, age, and rotation rate, they differ in two fundamental respects: DH Tau is a single star with an active accretion disk and DI Tau is a binary system lacking such a disk. The companion to DI Tau has a very low luminosity and is located at a projected distance of ~ 20 A.U. from the primary. Assuming the system to be co–eval, we derive a mass below the hydrogen burning limit for the companion. We speculate that the formation of a sub–stellar mass companion has led to the rapid evolution of the circumstellar disk that may have surrounded DI Tau.

Accepted by the Astrophysical Journal Letters.

http://www.mpia-hd.mpg.de/MPIA/Projects/STARS

Magnetospheric Accretion Models for the Hydrogen Emission Lines of T Tauri Stars

James Muzerolle[1,2], Nuria Calvet[2,3] and Lee Hartmann[2]

[1] Five College Astronomy Department, University of Massachusetts, Amher st, MA 01003, USA
[2] Harvard-Smithsonian Center for Astrophysics, Mail Stop 42, 60 Garden Street, Cambridge, MA 02138, USA
[3] Centro de Investigaciones de Astronomia, Mérida, Venezuela

E-mail contact: jamesm@inyo.phast.umass.edu

Using a statistical equilibrium radiative transfer treatment, we examine the behavior of hydrogen emission lines arising from the magnetospheric infall zones of classical T Tauri stars. Having calculated self-consistent line profiles of the Balmer lines, Paβ and Brγ, we explore parameter space, examining the effects of the magnetospheric gas temperature and size on the line fluxes. We compare model and observed line fluxes for the Balmer lines, and find a good match using a relatively small range of parameters. We are also able to match the observed Brγ line profile of the embedded object WL 16, supporting the use of the infrared lines in studying magnetospheric infall even in the earliest stages of star formation. Finally, we discuss constraints on the physical parameters and the possibility of using the emission lines as accretion rate indicators.

Accepted by Ap. J.

Preprint available at: http://cfa-www.harvard.edu/cfa/youngstars

High Velocity Features in the Orion Nebula

C. R. O'Dell[1], Patrick Hartigan[1], John Bally[2], & Jon A. Morse[2]

[1] Department of Space Physics & Astronomy, 6100 S. Main, Rice University, Houston TX 77005-1892, USA
[2] Center for Astrophysics and Space Astronomy, University of Colorado, Boulder, CO 80309, USA

E-mail contact: odell@spacsun.rice.edu

We have surveyed the inner $7'$ of the Orion Nebula for high velocity outflows with Fabry-Perot images in [S II] and [O III]. The new survey recovers all known HH objects in the region, and also reveals a number of new high velocity flows. New flows include (1) jets over an arcminute in length that extend from the center of the nebula to HH 202 in the north and HH 203-204 in the south; (2) an east-west jet in the center of the nebula that aligns with the elliptical HH object HH 269 to the west; (3) a second blueshifted flow that moves eastward from the east-west jet and appears as a series of [O III] arcs in HST images; (4) a blueshifted HH object south of HH 202 that may be driven by a nearby H_2 jet; (5) a redshifted 'microjet' that emerges northward from the proplyd 170-337; (6) a chain of redshifted [O III] arcs that may originate from the proplyd 159-350; (7) redshifted and blueshifted emission from several other proplyds; (8) an extended east-west low surface brightness region of blueshifted [O III] emission $65''$ south of θ^1C Ori which may be associated with the cavity generated by the intense stellar wind from θ^1C Ori; and (9) blueshifted [S II] emission along two features that originate from the BN/IRc2 region.

Accepted by A. J.

ftp://sparky.rice.edu/pub/papers/orion2

Infrared Spectroscopy of Herbig-Haro Energy Sources

Bo Reipurth[1,2] and Colin Aspin[3]

[1] European Southern Observatory, Casilla 19001, Santiago 19, Chile
[2] CASA, Univ. of Colorado, Boulder, CO 80309, USA
[3] Nordic Optical Telescope, E-38700 Santa Cruz de la Palma, Canarias, Spain

Herbig-Haro energy sources are, as a class, among the youngest stars known. Based on the presence of multiple working surfaces in many HH flows, it has previously been argued that repetitive FU Orionis disk accretion events power the Herbig-Haro flows emanating from newborn stars. Since the dynamical timescales for HH flows are mostly rather longer than the expected timescales for high luminosity FU Orionis stars to decay to their low (presumably T Tauri) states, it follows that a perhaps significant fraction - but certainly not all - of HH energy sources should show FU Orionis characteristics. All but one of the known FU Orionis stars for which near-infrared spectroscopy is available show pronounced 2.3 μm CO absorption bands; the one exception shows very weak CO emission. Apart from FU Orionis stars, deep CO absorption is seen only in the photospheric spectra of late K or M type stars. We present 2.0 - 2.5 μm spectroscopy of 14 Herbig-Haro energy sources plus, for comparison, of 4 known FU Orionis stars. Of these 14 HH sources, 9 have been deliberately selected to have luminosities equal or higher than that (28 $L_\odot$) of the lowest luminosity FU Orionis star known, L1551 IRS5. Among these 9 more luminous sources, 5 have CO absorption, 2 have CO emission, and 2 have continuous spectra. Among the five lower luminosity sources, 3 show continuous spectra, 1 has CO absorption, and 1 has CO emission. Altogether, it appears that the majority of the *high luminosity* HH sources observed are presently in elevated FU Orionis states.

Accepted by Astron. J.

Giant Herbig-Haro Flows

Bo Reipurth[1,2], J. Bally[2] and D. Devine[2]

[1] European Southern Observatory, Casilla 19001, Santiago 19, Chile
[2] Center for Astrophysics and Space Astronomy, University of Colorado, Boulder, CO 80309, USA

We present the discovery of a number of Herbig-Haro flows which extend over parsec-scale distances. The largest of these is the well known HH 111 jet complex, which is shown, through CCD images and a proper motion study, to have an angular extent of almost one degree on the sky, corresponding to 7.7 pc, making it the largest known HH flow. In our imaging survey we also found that T Tauri is at the center of a huge bipolar HH flow, HH 355, with a total extent of 38 arcminutes, corresponding to 1.55 pc, and aligned with the axis of the tiny HH 255 flow surrounding the infrared companion T Tau S. We additionally have found a number of other giant HH flow candidates, including HH 315 at PV Cep, HH 41/295 at Haro 5a/6a, HH 300 in B18w, HH 354 in L1165, HH 376 in L1152, and HH 114/115 and HH 243/244/245/179 in the λ Orionis molecular ring. It thus appears that it is common for HH flows to attain parsec-scale dimensions. The ubiquity of parsec-scale HH flows profoundly alters our view of the impact of young stars on their environment. Giant flows have dynamical ages comparable to the duration of the accretion phase of the sources, and provide a fossil record of their mass loss and accretion history. Multiple internal working surfaces and their S-shaped point symmetry provide evidence for variability of ejection velocity and orientation of the source jets. Giant HH flows are either longer or comparable in length to associated CO outflows, providing evidence for unified models in which HH flows power CO flows. Many giant flows have burst out of their source cloud cores and are dissociating molecules and injecting momentum and kinetic energy into the interclump medium of the host clouds. They contribute to the UV radiation field, and may produce CI and CII in cloud interiors. Giant flows may contribute to the chemical rejuvenation of clouds, the generation of turbulent motions, and the self-regulation of star formation. The terminal working surfaces of giant flows may be used to probe the nature of the interclump medium of clouds.

Accepted by Astron. J.

CN emission in Orion. The high density interface between the H II region and the molecular cloud

A. Rodríguez−Franco[1,2], J. Martín−Pintado[2] and A. Fuente[2]

[1] Departamento de Matemática Aplicada II, Sección departamental de Optica, Universidad Complutense de Madrid. Escuela Universitaria de Optica. 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

E-mail contact: arturo@oan.es

We present high angular–resolution ($12'' - 26''$) large–scale mapping ($19' \times 22'$) of the Orion A molecular complex in the $N = 1 \rightarrow 0$ and $N = 2 \rightarrow 1$ rotational transitions of the CN radical. The CN emission is not only confined to the molecular ridge and the optical bar, but it reveals filamentary emission toward the north and southwest of the Trapezium cluster and surrounding M 43. The morphology and the kinematics of the CN emission supports the idea that the CN filaments represent the interfaces between the molecular cloud and the major ionization fronts of M 42 and M 43.

The CN lines have been used to estimate the physical conditions of the molecular gas which confines the ionized material in M 42 and M 43. Surprisingly, the largest line intensity ratios between the $N = 1 \rightarrow 0$ and the $N = 2 \rightarrow 1$ lines are not observed toward the molecular ridge or the ionization fronts, but towards the Trapezium cluster and in the direction of the ionized gas in M 43. Model calculations for the CN excitation implies H_2 densities of $\sim 10^5\,\mathrm{cm}^{-3}$ toward the ridge and ionization fronts and $> 6 \times 10^6\,\mathrm{cm}^{-3}$ toward the region surrounding the Trapezium stars. This suggests that for the first time we have detected the confining material behind M 42. We estimate that the CN emission arises from a thin ($\sim 1.2 \times 10^{15}$ cm), dense ($> 6 \times 10^6\,\mathrm{cm}^{-3}$) layer which might have been compressed by the expansion of the H II region. The morphology of the CN emission, dominated by the ionization fronts of the H II regions, indicates that this molecule is an excellent tracer of regions affected by UV radiation. The comparison between the HC_3N and the CN abundance shows dramatic changes (more than 4 orders of magnitude) between the different features observed in OMC 1. The $[HC_3N]/[CN]$ abundance ratio varies from values of $\sim 10^{-3}$ for the ionization fronts surrounding the H II regions, to 100 for the hot core in Orion. Our data shows that the $[HC_3N]/[CN]$ abundance ratio is an excellent tracer of photon dominated regions (PDRs) and hot cores within regions of massive star formation.

Accepted by Astronomy & Astrophysics

Preprints are available on the WWW at:

http://www.oan.es/preprints/lista.html

A Critique of Current Magnetic-Accretion Models for Classical T-Tauri Stars

Pedro N. Safier

University of Maryland, Laboratory for Millimeter-Wave Astronomy, College Park, MD 20742, USA

E-mail contact: safier@astro.umd.edu

Current magnetic-accretion models for classical T-Tauri stars rely on a *strong*, *dipolar* magnetic field of stellar origin to funnel the disk material onto the star, and assume a steady-state. In this paper, I critically examine the physical basis of these models in light of the observational evidence and our knowledge of magnetic fields in low-mass stars, and find it lacking. I also argue that magnetic accretion onto these stars is inherently a time-dependent problem, and that a steady-state is not warranted.

Finally, directions for future work towards fully-consistent models are pointed out.

Accepted by ApJ.

Preprint available at `http://www.astro.umd.edu/~safier/preprints/magnetic_accretion.html`

Similarity Solution for Formation of Circumstellar Disk through the Collapse of a Flattened Rotating Cloud

Kazuya Saigo and Tomoyuki Hanawa

Department of Astrophysics, School of Science, Nagoya University, Chikusa-ku, Nagoya 464-01, Japan

E-mail contact: saigo@a.phys.nagoya-u.ac.jp

We present similarity solutions which describe the runaway collapse of a rotating isothermal disk and its subsequent inside-out collapse. The similarity solutions contain the sound speed, c_s, and the ratio of the specific angular momentum to the mass, ω, as model parameters. During the runaway collapse, the surface density of the disk is nearly constant in the central part and inversely proportional to the radius in the tail. As the central surface density increases by collapse, the central high surface density part shrinks its radius. Thus the surface density becomes a $1/r$ power-law

at the end of runaway collapse. In the subsequent inside-out collapse phase, the disk has two parts: an inner rotating disk in quasi-equilibrium and an outer dynamically infalling envelope. The inner disk and outer envelope are bounded by a shock wave. The mass and outer edge of the inner disk grow at a constant rate. The accretion rate is proportional to the cubic of the sound speed, i.e., $\dot{M} \propto {c_s}^3/G$, where G denotes and gravitational constant. The similarity solution of the runaway collapse can reproduce numerical simulations of dynamical collapse of either rotating or magnetized disks. The similarity solution of the inside-out collapse denotes growth of a centrifugally supported circumstellar disks. This solution can apply to a proto star which accretes gas substantially through disk.

Accepted by ApJ, to be published January 20, 1998

Preprint (PostScript and PDF files) available: http://www.a.phys.nagoya-u.ac.jp/cgi-bin/matsu/preprint.pl

X-Rays and Fluctuating X-winds from Protostars

Frank H. Shu[1,4], Hsien Shang[1], Alfred E. Glassgold[2], and Typhoon Lee[3,4]

[1] Astronomy Department, University of California, Berkeley, CA 94720-3411, USA
[2] Physics Department, New York University, New York, NY 10003, USA
[3] Institute of Earth Science, Academia Sinica, Taipei 115,Taiwan
[4] Institute of Astronomy and Astrophysics, Academia Sinica, Taipei 115, Taiwan

E-mail contact: fshu@astro.berkeley.edu

Protostars emit more x-rays, hard and soft, than young sunlike stars in more advanced stages of formation. The x-ray emission becomes harder and stronger during flares. The excess x-rays may arise as a result of the time-dependent interaction of an accretion disk with the magnetosphere of the central star. Flares produced by such fluctuations have important implications for the the x-wind model of protostellar jets, for the flash-heating of the chondrules found in chondritic meteorites, and for the production of short-lived radioactivities through the bombardment of primitive rocks by solar cosmic-rays.

Accepted by Science

Chemical stratification in the Orion Bar region: CN and CS submillimeter observations

R. Simon [1], J. Stutzki[1], A. Sternberg[2] and G. Winnewisser[1]

[1] I. Physik. Institut, Universität Köln, Zülpicher Str.77, 50937 Köln , Germany
[2] School of Physics and Astronomy, Tel Aviv University, Ramat Aviv 69978, Israel

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

We present fully sampled spectral line maps of the Orion Bar region observed simultaneously in the CN N=3→2 and CS J=7→6 rotational transitions with the JCMT at an angular resolution of 14″. We find that the CN emission specifically traces an intermediate cloud layer located between the peaks of vibrationally excited H_2 and HCO^+ emission located closer to the ionization front, and CS emission originating closer to the cloud core. By comparing the observed spatial displacement of CN and CS emission with PDR models we infer a density of $\sim 2{\times}10^5 \mathrm{cm}^{-3}$ for these cloud layers. This value is in agreement with the results of an escape probability radiative transfer analysis of our CN and CS line observations. We conclude that the observed distribution of H_2/CN/CS is consistent with chemical stratification in an edge-on PDR in which high density gas ($\sim 2{\times}10^5 \mathrm{cm}^{-3}$) is distributed homogeneously.

Accepted by Astronomy and Astrophysics

The formation of C-shocks: structure and signatures

Michael D. Smith[1] & Mordecai-Mark Mac Low[2]

[1] Astronomisches Institut, Universität Würzburg, Am Hubland, D-97074 Würzburg, Federal Republic of Germany.
[2] Max-Planck-Institut für Astronomie, Königstuhl 17, D-69117 Heidelberg, Germany

E-mail contact: smith@astro.uni-wuerzburg.de, mordecai@mpia-hd.mpg.de

Shock waves in molecular clouds should evolve into continuous or C-type structures due to the magnetic field and

ion-neutral friction. We here determine whether and how this is achieved through plane-parallel numerical simulations using an extended version of ZEUS. We first describe and test the adapted code against analytical results, laying the necessary foundations for subsequent works on supersonic ambipolar diffusion, including C-type jets and shock instability.

The evolution away from jump shocks toward the numerous steady C-shock sub-types is then investigated. The evolution passes through four stages, which possess distinctive observational properties. The time scales and length scales cover broad ranges. Specific results are included for shock types including switch, absorber, neutralised, oblique, transverse and intermediate. Only intermediate Type II shocks and 'slow shocks', including switch-off shocks, remain as J-type under the low ion levels assumed. Other shocks transform via a steadily growing neutral precursor to a diminishing jump. For neutralised shocks, this takes the form of an extended long-lived ramp.

Molecular hydrogen emission signatures are presented. After the jump speed has dropped to under $25\,\mathrm{km\,s^{-1}}$, a non-dissociative jump section can dominate the spectra for a long period. This produces a high-excitation spectrum. Once the jump has further weakened, to $<8\,\mathrm{km\,s^{-1}}$, the fully developed ion front is responsible for brisk progress towards a constant C-type excitation. The time scale for emission-line variations is $\sim (6/n_i)\,\mathrm{yr}$, where n_i is the pre-shock ion number density.

Accepted by A&A

Preprints: http://www.mpia-hd.mpg.de/MPIA/Projects/THEORY/preprints#maclow

The ortho and para fractions of molecular hydrogen in protostellar outflows and Herbig-Haro objects

Michael D. Smith[1], Christopher J. Davis[2] & Alain Lioure[3]

[1] Astronomisches Institut, Universität Würzburg, Am Hubland, D-97074 Würzburg, Federal Republic of Germany.
[2] Dublin Institute for Advanced Studies, School of Cosmic Physics, 5 Merrion Square, Dublin 2, Ireland
[3] CEA / Bruyères-le-Châtel, Service PTN, BP12, F-91690 Bruyères-le-Châtel, France

E-mail contact: smith@astro.uni-wuerzburg.de, cdavis@cp.dias.ie

Hydrogen molecules exist in two forms, according to the alignment of the nuclear spins. We present an accurate method for extracting the distributions of the two forms from three K-band infrared transitions. Images of the 1-0 S(0), S(1) and S(2) emission lines yield the ortho and para spatial distributions with negligible extinction and model dependence. The ortho-para ratio from individual pointings to various Herbig-Haro outflows are (re-)calculated using our analytical approach. All accurate determinations yield a value between 2.5 and 3.0. The vibrational temperature remains in the range 2000-2500 K although rotational temperatures vary between 1100-2100 K.

Applied to new data for OMC-1, we find no strong evidence for spatial variations in the ortho/para ratio (3.0 ± 0.4) on all scales down to $1''$. The vibrationally-excited molecules have either (1) not been modified since their formation in a warm state or (2) have reached equilibrium through conversions within a warm state. Collisional excitation to the first vibrational level dominates, with no fluorescent component. We suggest that collisions with atomic hydrogen in the warm shock layers converts the ortho-para ratio to 3 locally.

We also find strong evidence for spatial variations in the rotational excitation in OMC-1: the rotational temperature increases from east to west.

Accepted by A&A

Preprints: http://www.astro.uni-wuerzburg.de/ smith/homepage.html

Hipparcos photometry of Herbig Ae/Be stars

M.E. van den Ancker[1], D. de Winter[2], H.R.E. Tjin A Djie[1]

[1] Astronomical Institute "Anton Pannekoek", University of Amsterdam, Kruislaan 403, NL-1098 SJ Amsterdam, The Netherlands
[2] Dpto. Física Téorica C–XI, Facultad de Ciencias, Universidad Autónoma de Madrid, Cantoblanco, E–28049 Madrid, Spain

E-mail contact: mario@astro.uva.nl

The photometric behaviour of a sample of 44 Herbig Ae/Be (HAeBe) candidate stars was studied using a uniform set of optical photometry obtained by the Hipparcos mission. Astrophysical parameters (distance, temperature, luminosity, mass, age) of this sample of stars were derived as well by combining the astrometric data provided by Hipparcos with data from literature. Our main conclusions can be summarized as follows: (1) More than 65% of all Herbig Ae/Be stars show photometric variations with an amplitude larger than $0\overset{\mathrm{m}}{.}05$; (2) HAeBes with a spectral type earlier than A0 only show moderate (amplitude $< 0\overset{\mathrm{m}}{.}5$) variations, whereas those of later spectral type can (but not necessarily have to) show variations of more than $2\overset{\mathrm{m}}{.}5$. We explain this behaviour as being due to the fact that stars with lower masses become optically visible, and hence recognizable as Herbig Ae stars, while still contracting towards the zero-age main sequence (ZAMS), whereas their more massive counterparts only become optically visible after having reached the ZAMS; (3) The Herbig stars with the smallest infrared excesses do not show large photometric variations. This can be understood by identifying the stars with lower infrared excesses with the more evolved objects in our sample; (4) No correlation between the level of photometric variability and the stellar $v \sin i$ could be found. If the large photometric variations are due to variable amounts of extinction by dust clouds in the equatorial plane of the system, the evolutionary effects probably disturb the expected correlation between the two.

Accepted by Astronomy & Astrophysics

A preprint of this paper is available via the WWW at http://www.astro.uva.nl/preprints/preprints.html

Near Infrared Spectroscopy of G29.96−0.02: The First Spectral Classification of the Ionizing Star of an Ultracompact HII Region

Alan M. Watson[1] **and Margaret M. Hanson**[2]

[1] Instituto de Astronomía UNAM, J. J. Tablada 1006, Col. Lomas de Santa Maria, 58090 Morelia, Michoacán, Mexico
[2] Steward Observatory, University of Arizona, Tucson, AZ 85721, USA

E-mail contact: alan@astrosmo.unam.mx

We have obtained the first classification spectrum and present the first direct spectral classification of the ionizing star of an ultracompact HII region. The ultracompact HII region is G29.96−0.02, a well-studied object with roughly twice solar metallicity. The near infrared K-band spectrum of the ionizing star exhibits CIV and NIII emission and HeII absorption, but lines of HI and HeI are obliterated by nebular emission. We determine that the star has a spectral type of O5 to O7 or possibly O8. We critically evaluate limits on the properties of the star and find that it is compatible with zero-age main-sequence properties only if it is binary and if a significant fraction of the bolometric luminosity can escape from the region. G29.96−0.02 will now be an excellent test case for nebular models, as the properties of the ionizing star are independently constrained.

Accepted by ApJ Letters.

http://xxx.lanl.gov/abs/astro-ph/9709120

Rotational evolution of pre-main sequence stars in Lupus

R. Wichmann[1], **J. Bouvier**[2], **S. Allain**[3] **and J. Krautter**[1]

[1] Landessternwarte Königstuhl, D-69117 Heidelberg, Germany
[2] Canada-France-Hawaii Telescope Corporation P.O. Box 1597 Kamuela, 96743 HI, USA
[3] Laboratoire d'Astrophysique, Observatoire de Grenoble, Université Joseph Fourier, B.P. 53X, 38041 Grenoble Cedex, France

E-mail contact: rwichman@lsw.uni-heidelberg.de

We present results of a study of the rotational periods of Post-T Tauri stars (PTTSs) in the Lupus star forming region. These stars have been discovered by spectroscopic follow-up observations of ROSAT x-ray sources. Photometric observations have allowed to determine their luminosity, and by comparison with theoretical evolutionary tracks they were found to be significantly older on average than typical T Tauri stars.

46 stars have been monitored photometrically, and for 34 of them photometric variations were found that are consistent with rotational brightness modulations caused by starspots. The large number of data on rotational periods of pre-main-sequence (PMS) / zero-age main-sequence (ZAMS) stars available by now allows us to study the impact of

stellar mass on the evolution of angular momentum. For several different mass bins, we compare the available data on rotational periods with theoretical models, and find good agreement between theory and observations for the mass-dependency of the pre-main-sequence evolution of angular momentum.

We also study the relation between activity, rotation, mass, and age of low mass stars, and demonstrate that activity is driven by rotation mainly, while it seems to be rather independent of mass and age.

Accepted by Astronomy & Astrophysics

Preprint available at http://www.lsw.uni-heidelberg.de/∼rwichman/YS.html

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

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

The Star Formation Newsletter is available on the World Wide Web, where you can access it via the ESO Portal (http://http.hq.eso.org/eso-homepage.html). You can also access it through the University of Massachusetts Astronomy World Wide Web server, the URL for its home page is http://www-astro.phast.umass.edu/

Moving ... ??

If you move or your e-mail address changes, please send the editor your new address. If the Newsletter bounces back from an address for three consecutive months, the address is deleted from the mailing list.

New Books

A History of Modern Planetary Physics, Vol. 1

Nebulous Earth

Stephen G. Brush

Part I: Nebular Birth and Heat Death

1. Introduction
2. The founders: Laplace and Herschel
3. Followers and critics
4. The Nebular Hypothesis and the evolutionary worldview
5. Thermodynamics and the cooling Earth
6. Saturn's rings
7. Revisions of the Nebular Hypothesis, 1860-1885
8. Poincaré and cosmic evolution

Part II: Inside the Earth

1. A journey to the center of the Earth
2. Nineteenth-century debates: Solid, liquid, or gas?
3. Discovery of the Earth's core
4. Chemical history of the core
5. Geomagnetic secular variation
6. Time and tide

A History of Modern Planetary Physics, Vol. 2

Transmuted Past

Stephen G. Brush

Part I: Earth/History

1. Introduction
2. History and geology as ways of studying the past
3. Kelvin and geological time
4. Planetary science: From underground to underdog

Part II: Time and the Elements

1. Cosmic evolution of matter
2. Geochronology in the 20th century
3. Stellar evolution and the origin of the elements

A History of Modern Planetary Physics, Vol. 3

Fruitful Encounters

Stephen G. Brush

Part I: Planetesimals and Stellar Encounters

1. Introduction
2. A geologist among astronomers: The Chamberlin-Moulton theory
3. Jeans, Jeffreys, and the decline of encounter theories

Part II: Nebular Rebirth and Stellar Death

1. Introduction
2. Methodology

3. Nuclear cosmochronology and Hoyle's research programme
4. Cameron's programme
5. Isotopic anomalies and the supernova trigger

Part III: Planetogony and Plasma
1. Safronov's programme
2. The giant planets
3. Chemical cosmogony: The terrestrial planets
4. Alfvén's electromagnetic programme

Part IV: Whence the Moon?
1. Introduction
2. Early history of selenogony
3. Harold Urey and the origin of the Moon
4. History of modern selenogony

For astronomers working on star formation problems, these three volumes, that together make up *A History of Modern Planetary Physics*, offer an overview of the early theories of the origin of our own Solar System which form the historical background and basis for our present-day work. In the first volume, theories of the origin of the Solar System in the 19th century are examined, principally Laplace's Nebular Hypothesis, followed by a discussion of ideas about the Earth's core up to about 1970. In the second volume, attempts to estimate the age of the Earth in the 19th and 20th centuries are outlined, together with related developments in nuclear physics and stellar evolution. The age of the Earth is a key number in the development of a modern understanding of the formation of the Solar System. In the third and final volume, the development of theories of the origin of the Solar System in the 20th century are surveyed, including the replacement of the Nebular Hypothesis with the idea that the Solar System resulted from the encounter of the Sun with a passing star, and the eventual re-emergence of a modern nebular hypothesis. It also discusses the impact of the Apollo lunar missions on ideas about the origin of the Moon.

Cambridge University Press 1996

Nebulous Earth 312 pages, ISBN 0 521 44171 4 (hardback) £35.00 (US$ 54.95)

Transmuted Past 134 pages, ISBN 0 521 55213 3 (hardback) £30.00 (US$ 44.95)

Fruitful Encounters 354 pages, ISBN 0 521 55214 1 (hardback) £37.50 (US$ 54.95)

Payment: cheques and all major credit cards.

For customers in USA, Canada and Mexico:
Cambridge University Press
40 West 20th Street, New York, NY 10011-4211, USA
Fax: 212 691 3239
E-mail: information@cup.org

For the rest of the world:
Cambridge University Press
The Edinburgh Building
Shaftesbury Road, Cambridge CB2 2RU, UK
Fax: 01223 315052