# THE STAR FORMATION NEWSLETTER

*An electronic publication dedicated to early stellar evolution and molecular clouds*

No. 127 — 12 May 2003 Editor: Bo Reipurth (reipurth@ifa.hawaii.edu)


## *From the Editor*

Since its inception in 1992, the Star Formation Newsletter has seen a steady increase in its number of subscribers. Within the last month, *we passed the milestone of 1000 subscribers*, distributed in 34 countries. By submitting your results to the Newsletter, your research gets maximum exposure within the entire community of researchers and students working in the multiple fields of star and planet formation, molecular clouds, the interstellar medium, and the early solar system. So, please remember to submit your abstracts after a paper has been accepted for publication - there are still some abstracts of relevant papers that do not appear in these pages, which is unfortunate for our readers, but especially for the papers.

The Newsletter includes only abstracts of papers that are accepted but have not yet appeared in the journals. In the case of Letters to Nature and Science, however, the journals impose an embargo on any pre-publication announcements, and I have therefore tacitly accepted abstracts for papers to these two journals even if submitted right after publication. A number of Letters have appeared in these two journals for which abstracts did not appear in the Newsletter, so I would like to emphasize that, in the case of Nature and Science, abstracts will be accepted even if submitted right after publication.

## *Abstracts of recently accepted papers*

### Molecular Evolution in Collapsing Prestellar Cores II: The Effect of Grain-surface Reactions


**Yuri Aikawa[1], Nagayoshi Ohashi[2] and Eric Herbst[3]**

[1] Department of Earth and Planetary Sciences, Kobe University, Kobe 657-8501, Japan
[2] Academia Sinica Institute of Astronomy and Astrophysics, P.O. Box 23-141, Taipei 106, Taiwan
[3] Departments of Physics, Chemistry, and Astronomy, The Ohio State University, Columbus, OH 43210, USA

E-mail contact: aikawa@kobe-u.ac.jp



The molecular evolution that occurs in collapsing prestellar cores is investigated. To model the dynamics, we adopt the Larson-Penston solution and analogues with slower rates of collapse. For the chemistry, we utilize the new standard model (NSM) with the addition of deuterium fractionation and grain-surface reactions treated via the modified rate approach. The use of surface reactions distinguishes the present work from our previous model. We find that these reactions efficiently produce $H_2O$, $H_2CO$, $CH_3OH$, $N_2$, and $NH_3$ ices. In addition, the surface chemistry influences the gas-phase abundances in a variety of ways. For example, formation of molecular nitrogen on grain surfaces followed by desorption into the gas enhances the abundance of this gas-phase species and its daughter products $N_2H^+$ and $NH_3$. The current reaction network along with the Larson-Penston solution allows us to reproduce satisfactorily most of the molecular column densities and their radial distributions observed in L1544. The agreement tends to worsen with models that include strongly delayed collapse rates. Inferred radial distributions in terms of fractional abundances are somewhat harder to reproduce. In addition to our standard chemical model, we have also run a model with the UMIST gas-phase chemical network. The abundances of gas-phase sulphur-bearing molecules such as CS and CCS are significantly affected by uncertainties in the gas-phase chemical network. In all of our models, the column density of $N_2H^+$ monotonically increases as the central density of the core increases during collapse from $3 \times 10^4$ cm$^{-3}$ to $3 \times 10^7$ cm$^{-3}$. Thus, the abundance of this ion can be a probe of evolutionary stage. Molecular D/H ratios in assorted cores are best reproduced in the Larson-Penston picture with the conventional rate coefficients for fractionation reactions.

If we adopt the newly measured and calculated rate coefficients, the D/H ratios, especially $N_2D^+/N_2H^+$, become significantly lower than the observed values.

Accepted by ApJ

http://arXiv.org/abs/astro-ph/0305054
http://nova.scitec.kobe-u.ac.jp/~aikawa/paper_list.html

## Uncovering the Beast: Discovery of Embedded Massive Stellar Clusters in W49A

**João Alves**[1] **& Nicole Homeier**[1,2]

[1] European Southern Observatory, Karl-Schwarzschild Str. 2, 85748 Garching b. München, Germany
[2] University of Wisconsin, Dept. of Astronomy, 475 N. Charter St., Madison, WI 53706, USA

E-mail contact: jalves@eso.org

We present subarcsecond $J$, $H$, and $K_s$ images (FWHM $\sim 0.5''$) of an unbiased $5' \times 5'$ (16 pc $\times$ 16 pc) survey of the densest region of the W49A giant molecular cloud. The observations reveal 4 massive stellar clusters (with stars as massive as $\sim 120$ $M_\odot$), the larger (Cluster 1) about 3 pc East of the well known Welch ring of ultra-compact $H_{II}$ regions. Cluster 1 is a) extincted by at least $A_V > 20$ mag of foreground (unrelated and local) extinction, b) has more than 30 magnitudes of internal inhomogeneous extinction implying that it is still deeply buried in its parental molecular cloud, and c) is powering a 6 pc diameter giant $H_{II}$ region seen both at the NIR and radio continuum. We also identify the exciting sources of several UC $H_{II}$ regions. The census of massive stars in W49A agrees or is slightly overabundant when compared with the number of Lyman continuum photons derived from radio observations. We argue that although the formation of the Welch ring could have been triggered by Cluster 1, the entire W49A starburst region seems to have been multi-seeded instead of resulting from a coherent trigger.

Accepted by Astrophysical Journal Letters

http://www.eso.org/~jalves/W49A.pdf

## Irradiated Jets and Outflows in the Pelican Nebula

**John Bally**[1] **and Bo Reipurth**[2]

[1] CASA, University of Colorado, CB 389, Boulder, CO 80309, USA
[2] Institute for Astronomy, University of Hawaii, 2680 Woodlawn Drive, Honolulu, HI 96822, USA

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

We report the discovery of new Herbig-Haro objects in the Pelican Nebula (IC 4050). HH 555 is a bipolar jet emerging from the tip of a major elephant trunk protruding into the Pelican Nebula from the adjacent molecular cloud. Both beams of HH 555 bend towards the west, indicating deflection by a side-wind. A chain of three nearly equally spaced bow shocks, HH 563, HH 564, and HH 565, trace a bent flow bursting out of the southern rim of the Pelican molecular cloud, possibly driven by the moderate luminosity Class-I protostar, IRAS 20489+4406. HH 570 is a highly collimated jet emerging from a compact cloud located about 15 arcmin southwest of the Pelican molecular cloud. A parallel outflow, possibly driven by IRAS 20496+4354, powers the bright bow shock HH 569. These observations demonstrate that vigorous star formation is still occurring within the clouds that surround the evolved North-America / Pelican Nebula complex.

Accepted by Astron. J.

## The hierarchical formation of a stellar cluster

**Ian A. Bonnell**[1], **Matthew R. Bate**[2] **and Stephen G. Vine**[1]

[1] School of Physics and Astronomy, University of St Andrews, North Haugh, St Andrews, Fife, KY16 9SS, UK
[2] School of Physics, University of Exeter, Stocker Road, Exeter EX4 4QL, UK

E-mail contact: iab1@st-and.ac.uk

Recent surveys of star forming regions have shown that most stars, and probably all massive stars, are born in dense

stellar clusters. The mechanism by which a molecular cloud fragments to form several hundred to thousands of individual stars has remained elusive. Here, we use a numerical simulation to follow the fragmentation of a turbulent molecular cloud and the subsequent formation and early evolution of a stellar cluster containing more than 400 stars. We show that the stellar cluster forms through the hierarchical fragmentation of a turbulent molecular cloud. This leads to the formation of many small subclusters which interact and merge to form the final stellar cluster. The hierarchical nature of the cluster formation has serious implications in terms of the properties of the new-born stars. The higher number-density of stars in subclusters, compared to a more uniform distribution arising from a monolithic formation, results in closer and more frequent dynamical interactions. Such close interactions can truncate circumstellar discs, harden existing binaries, and potentially liberate a population of planets. We estimate that at least one-third of all stars, and most massive stars, suffer such disruptive interactions.

Accepted by MNRAS

Preprint available at http://star-www.st-and.ac.uk/astronomy/Welcome.html
Animations available at http://star-www.st-and.ac.uk/~iab1/clusters.html

## Abundant $H_2D^+$ in the pre–stellar core L1544

**P. Caselli[1], F. F. S. van der Tak[2] , C. Ceccarelli[3], and A. Bacmann[4]**

[1] Osservatorio Astrofisico di Arcetri, Largo E. Fermi 5, I-50125 Firenze, Italy
[2] Max–Planck–Institut für Radioastronomie, Auf dem Hügel 69, 53121 Bonn, Germany
[3] Laboratoire d' Astrophysique de l' Observatoire de Grenoble; BP 53, 38041 Grenoble Cedex, France
[4] European Southern Observatory, Karl–Schwarzschild–Str. 2, D–85748 Garching bei München, Germany

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

We have detected the 372 GHz line of *ortho*–$H_2D^+$ towards the pre–stellar core L1544. The strongest emission ($T_{\rm mb}$ $\sim$ 1 K) occurs at the peak of the millimeter continuum emission, while measurements at offset positions indicate that $H_2D^+$ is confined within $\sim 20''$, where CO is highly depleted. The derived $H_2D^+$ abundance of $\sim 10^{-9}$ is comparable with previous estimates of the electron abundance in the core, which suggests that $H_2D^+$ is the main molecular ion in the central $20''$ (2800 AU) of L1544. This confirms the expectations that $H_2D^+$ is dramatically enhanced in gas depleted of molecules other than $H_2$. The measured abundance even exceeds the present model predictions by about a factor ten. One possibility is that all CNO–bearing neutral species, including atomic oxygen, are almost completely ($\gtrsim 98\%$) frozen within a radius of $\sim$2800 AU.

Accepted by A&A Letters

http://arxiv.org/abs/astro-ph/0304103

## *HST*/ACS Coronagraphic Imaging of the Circumstellar Disk around HD 141569A

**M. Clampin[1], J. E. Krist[1], D. R. Ardila[2], D. A. Golimowski[2], G. F. Hartig[1], H. C. Ford[2], G. D. Illingworth[3], and the ACS Science Team**

[1] Space Telescope Science Institute, 3700 San Martin Dr., Baltimore, MD 21218, USA
[2] Johns Hopkins University, Baltimore, MD, USA
[3] University of California at Santa Cruz, Santa Cruz, CA, USA

E-mail contact: Mark.Clampin@nasa.gov, krist@stsci.edu

Multicolor coronagraphic images of the circumstellar disk around HD 141569A have been obtained with the *Hubble Space Telescope (HST)* Advanced Camera for Surveys. $B$, $V$, and $I$ images show that the disk's previously-described multiple-ring structure is actually a continuous distribution of dust with a tightly-wound spiral structure. Two, more open spiral arms extend from the disk, one of which appears to reach the nearby binary star HD 141569BC. Diffuse dust is seen up to 1200 AU from HD 141569A. Although planets may exist in the inner region of the disk, tidal interaction with HD 141569BC seems more likely to be the cause of these phenomena. The star is located $25 \pm 7$ AU from the geometric center of the disk. The disk appears redder than the star ($B - V = 0.21$ and $V - I = 0.25$), and its color is spatially uniform. A scattering asymmetry factor of $g = 0.25$–$0.35$ is derived. The azimuthal density distribution is asymmetric, varying by a factor of $\sim 3$ at some radii.

Accepted by Astron. J.

Preprint available at http://arxiv.org/abs/astro-ph/0303605

## Accretion and Dynamical Interactions in Small-N Star-Forming Clusters: I. N=5 case

**E.J. Delgado-Donate[1], C.J. Clarke[1] and M.R. Bate[2]**

[1] Institute of Astronomy, University of Cambridge, Madingley Road, Cambridge, CB3 0DS, UK
[2] School of Physics, University of Exeter, Stocker Road, Exeter, EX4 4QL, UK

E-mail contact: edelgado@ast.cam.ac.uk

We present results from high-resolution hydrodynamical simulations which explore the effects of small scale clustering in star-forming regions. A large ensemble of small-N clusters with 5 stellar *seeds* have been modelled and the resulting properties of stars and brown dwarfs statistically derived and compared with observational data.

Close dynamical interactions between the protostars and competitive accretion driven by the cloud collapse are shown to produce a distribution of final masses which is bimodal, with most of the mass residing in the binary components. When convolved with a suitable core mass function, the final distribution of masses resembles the observed IMF, both in the stellar and sub-stellar regime. Binaries and single stars are found to constitute two kinematically distinct populations, with about half of the singles attaining velocities $\geq 2$ km s$^{-1}$, which might deprive low mass star-forming regions of their lightest members in a few crossing times. The eccentricity distribution of binaries and multiples is found to follow a distribution similar to that of observed long period (uncircularized) binaries.

The results obtained support a mechanism in which a significant fraction of brown dwarfs form under similar circumstances as those of *normal* stars but are ejected from the common envelope of unstable multiple systems before their masses exceed the hydrogen burning limit. We predict that many close binary stars should have wide brown dwarfs companions. Brown dwarfs and, in general, very low mass stars, would be rare as *pure* binary companions. The binary fraction should be a decreasing function of primary mass, with low-mass or sub-stellar primaries being scarce. Where such binaries exist, they are either expected to be close enough (semi-major axis $\sim 10$ AU) to survive strong interactions with more massive binaries or else born in very small molecular cloud cores.

Accepted by MNRAS

## An analysis of two-layer models for circumstellar disks

**C.P. Dullemond[1] and A. Natta[2]**

[1] Max Planck Institut für Astrophysik, Postfach 1317, D–85741 Garching, Germany
[2] Osservatorio Astrofisico di Arcetri, Largo E. Fermi 5, 50125 Firenze, Italy

E-mail contact: dullemon@mpa-garching.mpg.de

The two-layer disk models of Chiang & Goldreich (1997, henceforth CG) and its derivatives are popular among astronomers because of their simplicity and the clear predictions they make for the SEDs of T Tauri stars and Herbig Ae/Be stars. Moreover, they can be computed quickly, which is a great advantage when fitting observations using automated procedures. In this paper we wish to assess the accuracy and reliability of 2-layer models, by comparing them to detailed vertical structure models with accurate 1+1D radiative transfer. We focus on the shape of the SED, and the predicted height and "flaring index" of the disk. We first consider models where scattering is set to zero. We find that 2-layer models overestimate significantly the near-infrared flux, and we suggest a simple way of correcting this effect, at least in part. At longer wavelengths, the SED of two-layer models often show a two-bump structure, which is absent in 1+1D models. Nevertheless, overall agreement is reasonably good, and the differences are in most cases within 30%. At (sub)-mm wavelengths the differences may even be less. The shape of the disk, as measured by its pressure and surface scale height and by the flaring angle are also well reproduced by two-layer models. When scattering is included in the 1+1D models, the differences become larger, especially in the near-infrared. We suggest simple ways to include scattering in two-layer models and discuss their reliability. We do not compare the two-layer models to full 2-D/3-D models, so the conclusions remain valid only within the annulus-by-annulus approximation.

Accepted by Astronomy & Astrophysics

## From Molecular Cores to Planet-forming Disks: A SIRTF Legacy Program

**Neal J. Evans II[1] and 17 coauthors**

[1] The University of Texas at Austin, Astronomy Department, 1 University Station C1400 Austin, Texas 78712–0259, USA

E-mail contact: nje@astro.as.utexas.edu

Crucial steps in the formation of stars and planets can be studied only at mid-infrared to far-infrared wavelengths, where SIRTF provides an unprecedented improvement in sensitivity. We will use all three SIRTF instruments (IRAC, MIPS, and IRS ) to observe sources that span the evolutionary sequence from molecular cores to protoplanetary disks, encompassing a wide range of cloud masses, stellar masses, and star-forming environments. In addition to targeting about 150 known compact cores, we will survey with IRAC and MIPS (3.6 to 70 micron) the entire areas of five of the nearest large molecular clouds for new candidate protostars and substellar objects as faint as 0.001 solar luminosities. We will also observe with IRAC and MIPS about 190 systems likely to be in the early stages of planetary system formation(ages up to about 10 Myr), probing the evolution of the circumstellar dust, the raw material for planetary cores. Candidate planet-forming disks as small as 0.1 lunar masses will be detectable. Spectroscopy with IRS of new objects found in the surveys and of a select group of known objects will add vital information on the changing chemical and physical conditions in the disks and envelopes. The resulting data products will include catalogs of thousands of previously unknown sources, multiwavelength maps of about 20 square degrees of molecular clouds, photometry of about 190 known young stars, spectra of at least 170 sources, ancillary data from ground-based telescopes, and new tools for analysis and modeling. These products will constitute the foundations for many follow-up studies with ground-based telescopes, as well as with SIRTF itself and other space missions such as SIM, JWST, Herschel, and TPF.

Accepted by PASP

Available on astro-ph, or at http://peggysue.as.utexas.edu/SIRTF/ under SIRTF Memos and Presentations

## Further identification of ROSAT all-sky survey sources in Orion

**A. Frasca[1], J.M. Alcalá[2], E. Covino[2], S. Catalano[1], E. Marilli[1] and R. Paladino[2]**

[1] INAF, Osservatorio Astrofisico di Catania, via S. Sofia 78, I–95123 Catania, Italy
[2] INAF, Osservatorio Astronomico di Capodimonte, via Moiariello 16, I–80131 Napoli, Italy

E-mail contact: afr@ct.astro.it, jmae@na.astro.it

We report on the identification of 22 ROSAT All-Sky Survey (RASS) X-ray sources distributed in the general direction of the Orion star forming region. The X-ray sample contains sources from the ROSAT bright source catalogue and from previous detections. The optical identifications are based on intermediate-resolution spectroscopy and UBV Johnson photometry using a 1m-class telescope. The strengths of the H$\alpha$, Na I $D_2$ and Lithium lines for the stellar counterparts are evaluated applying the spectral subtraction technique, using templates of the same spectral type. Radial velocities of the optical counterparts are also reported. Thirteen of the optical counterparts show the lithium absorption line in their spectra and have radial velocities consistent with the Orion star forming region. Four of these objects can be classified as new bona-fide T Tauri stars.

Accepted by Astronomy & Astrophysics

## Observational study of reactive ions and radicals in PDR

**A. Fuente[1], A. Rodríguez-Franco[2], S. García-Burillo[3], J. Martín-Pintado[3], J.H. Black[4]**

[1] Observatorio Astronómico Nacional (IGN), Campus Universitario, Apdo. 1143, E-28800 Alcalá de Henares (Madrid),Spain
[2] Universidad Complutense de Madrid, Av. Arcos de Jalón s/n, 28037 Madrid, Spain
[3]Departamento Fısica Molecular, Instituto de Estructura de la Materia, CSIC, Serrano 121, E-28006 Madrid, Spain
[4]Onsala Space Observatory, Chalmers University of Technology, S-439 92 Onsala, Sweden

E-mail contact: a.fuente@oan.es

We have carried out a survey of reactive ions ($CO^+$, $HOC^+$, $HC^{18}O^+$, $SO^+$) and cyclopropenylidene ($C_3H_2$) towards three prototypical photodissociation regions (PDRs), the reflection nebula NGC 7023, the Orion Bar and the planetary

nebula (PN) NGC 7027. The reactive ion $CO^+$ has been detected towards all the targets with fractional abundances ranging from $\sim 10^{-11}$ to $\sim$ a few $10^{-9}$. Its spatial distribution in NGC 7023 and the Orion Bar show that $CO^+$ is arising in the innermost part ($A_v < 2$ mag) of the PDR. In NGC 7027, the $CO^+$ lines shows an expansion velocity larger than that of the CO lines. This large expansion velocity is consistent with the $CO^+$ emission arising in the high velocity layer of neutral gas which is being accelerated by the ionized gas. Photochemistry determines the chemical composition of this layer.

The reactive ions $HOC^+$ and $SO^+$ have been detected in NGC 7023 and the Orion Bar. In both sources, the fractional abundance of $HOC^+$ is enhanced by a factor $\sim 10$ towards the PDRs, with typical abundances, $X_{HOC^+} = 0.7 - 3\ 10^{-11}$. This enhancement produces a decrease of the $[HCO^+]/[HOC^+]$ abundance ratio towards the PDR. In fact, we have derived $[HCO^+]/[HOC^+] \sim 50 - 120$ in NGC 7023, **which is the lowest ratio measured thus far**. $HOC^+$ and $SO^+$ have not been detected towards NGC 7027. Interestingly, this is the source with the highest $CO^+$ abundance, $X_{CO^+} = 5\ 10^{-9}$. This lack of detection is interpreted as due to the peculiar chemistry of a C-rich PNs, in which the abundance of oxygenated molecules, in particular $H_2O$, is low.

We have detected cyclopropenylidene ($C_3H_2$) towards the three target PDRs. Similarly to the reactive ions, the abundance of $C_3H_2$ in NGC 7023 and the Orion Bar is **a factor of 10 – 100 larger towards the PDRs** than towards the foreground molecular cloud with peak values ranging from $10^{-10}$ to $10^{-9}$. In NGC 7027, we have measured the maximum $C_3H_2$ abundance with a value of $\sim 10^{-8}$. Similarly to the case of $CO^+$, the large expansion velocities of the $C_3H_2$ lines in NGC 7027 suggests that its emission arises in the neutral gas which is being accelerated by the ionized gas. Photodestruction of Polycyclic Aromatic Hydrocarbons (PAHs) is proposed to explain the enhanced $C_3H_2$ abundance in these PDRs.

Accepted by Astronomy & Astrophysics

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

## High $NH_2D/NH_3$ ratios in protostellar cores

**Jennifer Hatchell**[1]

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

E-mail contact: hatchell@mpifr-bonn.mpg.de

Observations of low mass protostars which probe small enough size scales to be within likely CO depletion regions show the highest $[NH_2D]/[NH_3]$ ratios yet measured, of 4–33%. These molecular D/H ratios are higher than those measured on larger scales, showing that deuterium fractionation increases towards protostellar cores. As in cold clouds, such high ratios can be produced by gas-phase ion-molecule chemistry in the presence of depletion. Grain surface chemistry is less likely to explain the deuterium enhancement, as it would require higher fractionation in ices than current models predict. The link between accretion, depletion and high molecular deuterium fractionation is strongly supported.

Accepted by Astronomy & Astrophysics

http://www.mpifr-bonn.mpg.de/staff/mhatchell/

## VLT/ISAAC H-band spectroscopy of embedded massive YSOs

**T.R. Kendall**[1], **W.J. de Wit**[2] **and J.L. Yun**[1]

[1] Centro de Astronomia e Astrofísica da Universidade de Lisboa, Observatório Astronómico de Lisboa, Tapada da Ajuda, 1349-018 Lisboa, Portugal
[2] Osservatorio Astrofisico di Arcetri, Largo E. Fermi 5, 50125 Florence, Italy

E-mail contact: tkendall@oal.ul.pt, dewit@arcetri.astro.it

We have performed intermediate resolution (R$\sim$5000), high signal-to-noise H-band spectroscopy of a small, initial sample of three massive embedded young stellar objects (YSOs), using VLT/ISAAC. The sample has been selected from sources characterised in previous literature as being likely of OB spectral type, to be unambiguously associated with bright (H$\leq$14) single point sources in the 2MASS database, and to have no optical counterparts. Of the targets observed, one object shows a $\sim$B3 spectrum, similar to a main sequence object of the same spectral type. A second object exhibits weak He I and H emission, indicating an early-type source: we detect He II absorption, which supports

a previous indirect derivation of the spectral type as mid-O. The third object does not show absorption lines, so no spectral type can de derived. It does, however, exhibit a rich spectrum of strong, broad emission lines and is likely to be surrounded by dense circumstellar material and at a very early evolutionary stage. Our results from this very small sample are in agreement with those of Kaper et al. (2002), who also find spectra similar to optically visible main sequence stars, together with emission line objects representing a very early evolutionary phase, in their much larger sample of K-band spectra.

Accepted by Astronomy & Astrophysics

## The dynamical evolution of Taurus–Auriga-type aggregates

**Pavel Kroupa**[1] **and Jerome Bouvier**[2]

[1] Institut für Theoretische Physik und Astrophysik, Universität Kiel, D-24098 Kiel, Germany
[2] Laboratoire d'Astrophysique de l'Observatoire de Grenoble, BP 53, F-38041 Grenoble Cedex 9, France

E-mail contact: pavel@astrophysik.uni-kiel.de

Star formation in the Taurus–Auriga (TA) molecular clouds is producing binary-rich aggregates containing at most a few dozen systems within a region spanning one pc without massive stars. This environment is very different to another well-studied star-forming event which produced the Orion Nebula cluster (ONC). The ONC contains a few thousand systems within a region of one pc including massive stars. Differences between these two environments have been found. Notably, the ONC has a significantly smaller binary proportion but a significantly larger number of isolated brown dwarfs (BDs) per star than TA. The aim of the present project is to investigate if these differences can be explained through stellar-dynamical evolution alone. The stellar-dynamical issue is very relevant because dense environments destroy binaries liberating BD companions, possibly leading to the observed difference between the TA and ONC populations. Here a series of high-precision $N-$body models of TA-like embedded aggregates are presented, assuming the standard reference star-formation model for the input populations according to which stars and BDs form with the same kinematical, spatial and binary properties. After a discussion of the general evolution of the aggregates, it is shown that the binary population indeed remains mostly unevolved. Therefore, TA-type star formation cannot have added significantly to the Galactic-field population. The standard model leads to BDs tracing the stellar distribution, apart from a high-velocity tail ($v > 1$ km/s) which leads to a more widely distributed spatial distribution of single BDs. The slow-moving BDs, however, retain a high binary proportion, this being an important observational diagnostic for testing against the embryo-ejection hypothesis. Inferences about the IMF and the binary-star orbital distribution functions are made in two accompanying papers with useful implications for star formation and the possible origin of BDs.

Accepted by MNRAS

http://xxx.uni-augsburg.de/abs/astro-ph/0304201

## Warm Molecular Hydrogen and Ionized Neon in the HH 2 Outflow

**B. Lefloch**[1], **J. Cernicharo**[2], **S. Cabrit**[3], **A. Noriega-Crespo**[4], **A. Moro-Martín**[5], **D. Cesarsky**[6]

[1] Laboratoire d'Astrophysique, Observatoire de Grenoble, BP 53, F-38041 Grenoble Cédex 9, France
[2] CSIC, IEM, Serrano 123, E-28006 Madrid, Spain
[3] LERMA, Observatoire de Paris, UMR 8112 du CNRS, France
[4] SIRTF Science Center, Caltech JPL, Pasadena, CA 91125, USA
[5] Steward Observatory, University of Arizona, Tucson, AZ, 85721, USA
[6] Max-Planck Institut für Extraterrestrische Physik, 85741 Garching, Germany

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

We report on spectro-imaging observations of the Herbig-Haro 2 outflow with the ISOCAM camera onboard the Infrared Space Observatory (ISO). The [NeII] $12.81\mu m$ and [NeIII] $15.55\mu m$ lines are detected only towards the jet working surface (HH 2H), consistent with the high excitation of this knot in the optical range, while $H_2$ pure rotational emission is found all over the shocked region HH 2. The low energy transition S(2) traces warm gas **(**$T \sim 400\,\mathbf{K}$**)** peaked towards knots E-F and extended ejecta ($T \sim 250 - 380$ K) with masses of a few $10^{-3}\,M_\odot$ in the high-velocity CO outflow extending between the powering source and HH 2. Such emission could arise from low-velocity C-type shocks ($v \simeq 10 - 15\,\mathrm{km\,s^{-1}}$). The higher

transitions S(3)-S(7) trace the emission of hot shocked gas ($T = 1000 - 1400$ K) from individual optical knots in the HH 2 region. The ortho to para (OTP) ratio exhibits large spatial variations between 1.2 (E) and 2.5 (H), well below its value at LTE. The emission of the S(3)-S(7) lines is well accounted for by planar C-shock models with a typical velocity $V_s = 20 - 30\,\mathrm{km\,s^{-1}}$ propagating into a medium of density $n_i = 10^4 - 10^5\,\mathrm{cm^{-3}}$ with an initial OTP ratio close to 1 in the pre-shock gas. In the leading edge of the jet, where the geometry of the emission allows a simple modelling, a good agreement is found with velocities derived from the optical proper motions measured in the ionized gas.

Accepted by ApJ Letters

http://arXiv.org/abs/astro-ph/0305108

## New Low-Mass Members of the Taurus Star-Forming Region

**K. L. Luhman[1], César Briceño[2], John R. Stauffer[3], Lee Hartmann[1], D. Barrado y Navascués[4], and Nelson Caldwell[1]**

[1] Harvard-Smithsonian Center for Astrophysics, 60 Garden St., Cambridge, MA 02138, USA
[2] Centro de Investigaciones de Astronomía, Apartado Postal 264, Mérida 5101-A, Venezuela
[3] SIRTF Science Center, Caltech MS 314-6, Pasadena, CA 91125, USA
[4] Laboratorio de Astrofísica Espacial y Física Fundamental, INTA, PO Box 50727, 28080 Madrid, Spain

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

Briceño et al. recently used optical imaging, data from the Two-Micron All-Sky Survey (2MASS), and follow-up spectroscopy to search for young low-mass stars and brown dwarfs in 8 deg$^2$ of the Taurus star-forming region. By the end of that study, there remained candidate members of Taurus that lacked the spectroscopic observations needed to measure spectral types and determine membership. In this work, we have obtained spectroscopy of the 22 candidates that have $A_V \leq 8$, from which we find six new Taurus members with spectral types of M2.75 through M9. The new M9 source has the second latest spectral type of the known members of Taurus ($\sim 0.02\ M_\odot$). Its spectrum contains extremely strong emission in H$\alpha$ ($W_\lambda \sim 950$ Å) as well as emission in He I 6678 Å and the Ca II IR triplet. This is the least massive object known to exhibit emission in He I and Ca II, which together with the strong H$\alpha$ are suggestive of intense accretion.

Accepted by Astrophysical Journal

http://cfa-www.harvard.edu/sfgroup/preprints.html

## A Census of the Young Cluster IC 348

**K. L. Luhman[1], John R. Stauffer[2], A. A. Muench[2], G. H. Rieke[3], E. A. Lada[4], J. Bouvier[5], and C. J. Lada[1]**

[1] Harvard-Smithsonian Center for Astrophysics, 60 Garden St., Cambridge, MA 02138, USA
[2] SIRTF Science Center, Caltech MS 314-6, Pasadena, CA 91125, USA
[3] Steward Observatory, The University of Arizona, Tucson, AZ 85721, USA
[4] Department of Astronomy, The University of Florida, Gainesville, FL 32611, USA
[5] Laboratoire d'Astrophysique de l'Observatoire de Grenoble, BP 53, 38041 Grenoble Cedex 9, France

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

We present a new census of the stellar and substellar members of the young cluster IC 348. We have obtained images at $I$ and $Z$ for a $42' \times 28'$ field encompassing the cluster and have combined these measurements with previous optical and near-infrared photometry. From spectroscopy of candidate cluster members appearing in these data, we have identified 122 new members, 15 of which have spectral types of M6.5-M9, corresponding to masses of $\sim 0.08$-$0.015\ M_\odot$ by recent evolutionary models. The latest census for IC 348 now contains a total of 288 members, 23 of which are later than M6 and thus are likely to be brown dwarfs. From an extinction-limited sample of members ($A_V \leq 4$) for a $16' \times 14'$ field centered on the cluster, we construct an IMF that is unbiased in mass and nearly complete for $M/M_\odot \geq 0.03$ ($\lesssim$M8). In logarithmic units where the Salpeter slope is 1.35, the mass function for IC 348 rises from high masses down to a solar mass, rises more slowly down to a maximum at 0.1-0.2 $M_\odot$, and then declines into the substellar regime. In comparison, the similarly-derived IMF for Taurus from Bričeno et al. and Luhman et al. rises quickly to a peak near 0.8 $M_\odot$ and steadily declines to lower masses. The distinctive shapes of the IMFs in IC 348

and Taurus are reflected in the distributions of spectral types, which peak at M5 and K7, respectively. These data provide compelling, model-independent evidence for a significant variation of the IMF with star-forming conditions.

Accepted by Astrophysical Journal

http://cfa-www.harvard.edu/sfgroup/preprints.html

## Unified catalogue of class II methanol masers at 6 GHz

**A. V. Malyshev**[1] **and A. M. Sobolev**[1]

[1] Ural State University, Lenin Street 51, Ekaterinburg 620083, Russia

E-mail contact: Andrej.Sobolev@usu.ru

In this paper we present a unified catalogue which contains published data about class II methanol masers at 6 GHz. Our catalogue contains information about 495 maser sources. The data on some parameters of emission in "quasi-thermal" molecular lines CS (2-1) and SiO (2-1) is included in our catalogue as well.

Using the unified catalogue we studied correlations between some parameters of the sources. Analysis of the data shows that: physical conditions within the usual maser source vary considerably; maser brightness is determined by parameters of some distinguished part of the object - maser formation region; class II methanol masers are formed not in the shocks but in the regions affected by their propagation.

Accepted by Astron. and Astrophys. Transactions

## $N_2H^+$(1–0) survey of massive molecular cloud cores

**L. Pirogov** [1], **I. Zinchenko** [1,2,3], **P. Caselli** [4], **L. E. B. Johansson** [5], **P. C. Myers** [6]

[1] Institute of Applied Physics of the Russian Academy of Sciences, Ulyanova 46, 603950 Nizhny Novgorod, Russia
[2] Nizhny Novgorod University , Gagarin av. 23, 603950 Nizhny Novgorod, Russia
[3] Helsinki University Observatory, Tähtitorninmäki, P.O. Box 14, FIN-00014 University of Helsinki, Finland
[4] INAF – Osservatorio Astrofisico di Arcetri, Largo E. Fermi 5, I-50125 Firenze, Italy
[5] Onsala Space Observatory, S-43992, Onsala, Sweden
[6] Harvard-Smithsonian Center of Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA

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

We present the results of $N_2H^+$(1–0) observations of 35 dense molecular cloud cores from the northern and southern hemispheres where massive stars and star clusters are formed. Line emission has been detected in 33 sources, for 28 sources detailed maps have been obtained. Peak $N_2H^+$ column densities lie in the range: $3.6 \cdot 10^{12} - 1.5 \cdot 10^{14}$ cm$^{-2}$. Intensity ratios of (01–12) to (23–12) hyperfine components are slightly higher than the LTE value. The optical depth of (23–12) component toward peak intensity positions of 10 sources is $\sim 0.2-1$. In many cases the cores have elongated or more complex structures with several emission peaks. In total, 47 clumps have been revealed in 26 sources. Their sizes lie in the range 0.3–2.1 pc, the range of virial masses is $\sim 30 - 3000\ M_\odot$. Mean $N_2H^+$ abundance for 36 clumps is $5 \cdot 10^{-10}$. Integrated intensity maps with aspect ratios $< 2$ have been fitted with a power-law radial distribution $\sim r^{-p}$ convolved with the telescope beam. Mean power-law index for 25 clumps is close to 1.3. For reduced maps where positions of low intensity are rejected mean power-law index is close to unity corresponding to the $\sim r^{-2}$ density profile provided $N_2H^+$ excitation conditions do not vary inside these regions. In those cases where we have relatively extensive and high quality maps, line widths of the cores either decrease or stay constant with distance from the center, implying an enhanced dynamical activity in the center. There is a correlation between total velocity gradient direction and elongation angle of the cores. However, the ratio of rotational to gravitational energy is too low ($4{\cdot}10^{-4}$–$7.1{\cdot}10^{-2}$) for rotation to play a significant role in the dynamics of the cores. A correlation between mean line widths and sizes of clumps has been found. A comparison with physical parameters of low-mass cores is given.

Accepted by Astronomy and Astrophysics

http://arxiv.org/abs/astro-ph/0304469

## Detection of abundant solid methanol toward young low mass stars

**K. M. Pontoppidan[1], E. Dartois[2], W.-F. Thi[3], E. F. van Dishoeck[1] and L. d'Hendecourt[2]**

[1] Leiden Observatory, P.O.Box 9513, 2300 RA Leiden, The Netherlands
[2] Institut d'Astrophysique Spatiale, Bât. 121, CNRS UMR8617, Université Paris XI, 91405 Orsay Cedex, France
[3] Astronomical Institute "Anton Pannekoek", University of Amsterdam, Kruislaan 403, 1098 SJ Amsterdam, The Netherlands

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

We present detections of the absorption band at 3.53 $\mu$m due to solid methanol toward three low-mass young stellar objects located in the Serpens and Chameleon molecular cloud complexes. The sources were observed as part of a large spectroscopic survey of $\approx 40$ protostars. This is the first detection of solid methanol in the vicinity of low mass ($M \leq 1\ M_{\odot}$) young stars and shows that the formation of methanol does not depend on the proximity of massive young stars. The abundances of solid methanol compared to water ice for the three sources are in the range 15-25% which is comparable to those for the most methanol-rich massive sources known. The presence of abundant methanol in the circumstellar environment of some low mass young stars has important consequences for the formation scenarios of methanol and more complex organic species near young solar-type stars.

Accepted by Astronomy & Astrophysics Letters

Preprint available at xxx.sissa.it/astro-ph/0304476

## On the origin of diffuse clouds

**Richard J. Price[1], Serena Viti[2] and David A. Williams[1]**

[1] Department of Physics and Astronomy, University College London, Gower Street, London, WC1E 6BT, UK
[2] CNR-Istituto di Fisica dello Spazio Interplanetario, Area di Ricerca di Tor Vergata, via del Fosso del Cavaliere 100, I-00133, Roma, Italy

E-mail contact: viti@ifsi.rm.cnr.it

We explore the possibility that observational differences might exist between diffuse clouds which have been formed from the dissipation of unbound molecular clouds and those that have been formed from less dense atomic gas. Using single point chemical models we show that molecular-rich initial conditions will significantly enrich the gas phase chemistry of diffuse clouds in the former scenario. An injection of hydrogenated grain mantles through photoevaporation will also further enrich this chemistry. If the population of interstellar diffuse clouds contains some members that are in contraction and others in expansion, then wide variations in atomic and molecular abundances in this population are to be expected. We predict several signatures of this effect.

Accepted by MNRAS

## Fabry-Pérot observations of the HH 110 jet

**A. Riera[1,2,3], A. C. Raga[4], B. Reipurth[5], Ph. Amram[6], J. Boulesteix[6]**

[1] Departament de Física i Enginyeria Nuclear, Universitat Politécnica de Catalunya, Av. Víctor Balaguers/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] On sabbatical leave at the Instituto de Ciencias Nucleares, UNAM
[4] Instituto de Ciencias Nucleares, UNAM, Ap. 70-543, 04510 D.F., México
[5] Institute for Astronomy, University of Hawaii, 2680 Woodlawn Drive, Honolulu, HI 96822, USA
[6] Laboratoire d'Astrophysique de Marseille, 2 Place Le Verrier, 13248 Marseille, France

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

We have obtained a H$\alpha$ position-velocity cube from Fabry-Pérot interferometric observations of the HH 110 flow. We analyze the results in terms of anisotropic wavelet transforms, from which we derive the spatial distribution of the knots as well as their characteristic sizes (along and across the outflow axis). We then study the spatial behaviour of the line width and the central radial velocity. The results are interpreted in terms of a simple "mean flow+turbulent eddy" jet/wake model. We find that most of the observed kinematics appear to be a direct result of the mean flow,

on which are superposed low amplitude ($\sim 35$ km s$^{-1}$) turbulent velocities.

Accepted by Astron. J.

astro-ph/0304161

## Simulations of Evolving or Outbursting Molecular Protostellar Jets

**A. Rosen[1] and M.D. Smith[1]**

[1] Armagh Observatory, College Hill, Armagh BT61 9DG, Northern Ireland

E-mail contact: rar@star.arm.ac.uk

The kinematic and radiative power of molecular jets is expected to change as a protostar undergoes permanent or episodal changes in the rate at which it accretes. We study here the consequences of evolving jet power on the spatial and velocity structure, as well as the fluxes, of molecular emission from the bipolar outflow. We consider a jet of rapidly increasing density and a jet in which the mass input is abruptly cut off. We perform three dimensional hydrodynamic simulations with atomic and molecular cooling and chemistry. In this work, highly collimated and sheared jets are assumed. We find that position-velocity diagrams, velocity-channel maps and the relative $H_2$ and CO fluxes are potentially the best indicators of the evolutionary stage. In particular, the velocity width of the CO lines may prove most reliable although the often-quoted mass-velocity power-law index is probably not. We demonstrate how the relative $H_2$ 1–0 S(1) and CO J=1–0 fluxes evolve and apply this to interpret the phase of several outflows.

Accepted by MNRAS

## NGC 7538 S - a High-Mass Protostar with a Massive Rotating Disk

**Göran Sandell[1], Melvyn Wright[2] and James R. Forster[2]**

[1] USRA-SOFIA, NASA Ames Research Center, MS 144-2, Moffett Field, CA 94035, U.S.A.
[2] Radio Astronomy Laboratory, University of California, Berkeley 601 Campbell Hall, Berkeley, CA 94720, U.S.A

E-mail contact: gsandell@mail.arc.nasa.gov

We report the detection of a massive rotating disk around the high-mass Class 0 candidate NGC 7538 S. The disk is well-resolved with BIMA ($\theta_A = 3\farcs7$) in 3.4 mm continuum and in $H^{13}CN$ J=1→0. It is seen nearly edge on and has a size of ∼30,000 AU. A young, powerful outflow perpendicular to the rotating disk is mapped in SiO J=2→1 and $HCO^+$ J=1→0. The dynamical age of the outflow is ≤ 10,000 yr. The velocity gradient seen in $H^{13}CN$ is consistent with Keplerian rotation. Assuming that the gas is gravitationally bound, the mass of the central object is $\sim 40$ $M_\odot$. The mass of the continuum "disk" is $\geq 100$ $M_\odot$ and has a luminosity of $\sim 10^4$ $L_\odot$. $H^{13}CN$ gives a mass ∼400 $M_\odot$ for the rotating disk, and ∼1000 $M_\odot$ for the extended (20″) envelope. Our observations confirm that this is an extremely massive protostar in its earliest stages.

Accepted by The Astrophysical Journal (Letters)

Preprint available at http://arXiv.org/abs/astro-ph/0305135

## Formation scenarios for the young stellar associations between galactic longitudes $l = 280° - 360°$

**Marília J. Sartori[1,2], Jacques R. D. Lépine[2] and Wilton S. Dias[2]**

[1] Laboratório Nacional de Astrofísica/MCT, C.P. 21, 37500-000, Itajubá, MG, Brazil
[2] Instituto de Astronomia, Geofísica e Ciências Atmosféricas/USP, C.P. 3386, 01060-970, São Paulo, SP, Brazil

E-mail contact: marilia@lna.br

We investigate the spatial distribution, the space velocities and age distribution of the pre-main sequence (PMS) stars belonging to Ophiuchus, Lupus and Chamaeleon star-forming regions (SFRs), and of the young early-type star members of the Scorpius-Centaurus OB association. These young stellar associations extend over the galactic longitude range from 280° to 360°, and are at a distance interval of around 100 and 200 pc. This study is based on a compilation of distances, proper motions and radial velocities from the literature for the kinematic properties, and of basic stellar

data for the construction of Hertzsprung-Russel diagrams. Although there was no well-known OB association in Chamaeleon, the distances and the proper motions of a group of 21 B- and A-type stars, taken from the Hipparcos Catalogue, lead us to propose that they form a young association. We show that the young early-type stars of the OB associations and the PMS stars of the SFRs follow a similar spatial distribution, i.e., there is no separation between the low and the high-mass young stars. We find no difference in the kinematics nor in the ages of these two populations studied. Considering not only the stars selected by kinematic criteria but the whole sample of young early-type stars, the scattering of their proper motions is similar to that of the PMS stars and all the young stars exhibit a common direction of motion. The space velocities of the Hipparcos PMS stars of each SFR are compatible with the mean values of the OB associations. The PMS stars in each SFR span a wide range of ages (from 1 to 20 Myr). The ages of the OB subgroups are 8–10 Myr for Upper Scorpius (US), and 16–20 Myr for Upper Centaurus Lupus (UCL) and for Lower Centaurus Crux (LCC). Thus, our results do not confirm that UCL is older than the LCC association. Based on these results and the uncertainties associated with the age determination, we cannot say that there is indeed a difference in the age of the two populations. We analyze the different scenarios for the triggering of large-scale star-formation that have been proposed up to now, and argue that most probably we are observing a spiral arm that passes close to the Sun. The alignment of young stars and molecular clouds and the average velocity of the stars in the opposite direction to the Galactic rotation agree with the expected behavior of star formation in nearby spiral arms.

Accepted by Astronomy and Astrophysics

Preprint available at http://arXiv.org/abs/astro-ph/0304426

## High Spectral Resolution $H_2$ Measurements of Herbig-Haro Objects 38, 46/47, and 120

**Richard D. Schwartz**[1] **and Thomas P. Greene**[2]

[1] Dept. of Physics and Astronomy, U. of Missouri-St. Louis, 8001 Natural Bridge Road, St. Louis, MO 63121, USA
[2] NASA's Ames Research Center, MS 245-6, Moffett Field, CA 94035, USA

E-mail contact: schwartz@umsl.edu

We report high spectral resolution (R$\simeq$ 20,000) measurements of the $H_2$ 1-0 S(1) line in Herbig-Haro Objects 38, 46/47, and 120. The long-slit spectra reveal complex velocity structure with evidence for bow shock structures as well as prompt entrainment and shock heating of ambient molecular gas. Individual knots within HH 38 show distinct double peaked velocity structure, consistent with that expected from spatially unresolved bow shocks. A portion of the HH 47A bow shock is resolved in our measurements, and the kinematics of the $H_2$ trace closely that found for H$\alpha$ emission. The evidence indicates that the preshock medium for HH 47A that formed in the wake of a previous ejection contains molecular clumps. The HH 46CjetA feature in the HH 46/47 counterflow is suggestive of a bow shock emerging from near the base of the flow, with $H_2$ emission arising from ambient cloud material excited in the oblique flanks of the bow shock. HH 46F is situated downstream at the boundary between an ovoid cavity and the ambient cloud material, and represents either entrainment by a stellar wind that fills the cavity or entrainment in the far wing of a giant bow shock. For HH 120, the $H_2$ velocity results also corroborate those found from atomic emission, and there is substantial evidence that the preshock medium is inhomogeneous, producing clumps of $H_2$ emission on the wings of a bow shock that has an apex at HH 120A.

Accepted by Astron. J.

Preprints are available at http://arxiv.org/abs/astro-ph/0304258

## Photometric and Polarimetric Activity of the Herbig Ae star VX Cas

**D.N. Shakhovskoi,**[1]**, A.N. Rostopchina**[1]**, V.P. Grinin**[1,2] **and N.Kh. Minikulov**[3]

[1] Crimean Astrophysical Observatory, 98409, Nauchny, Crimea, Ukraine
[2] Central Astronomical Observatory Pulkovo, 196140, St. Petersburg, Russia
[3] Institute of Astrophysics, Academy of Sciences of Tadjikistan, Bukhoro str. 22, Dushanbe, 734670 Tadjikistan

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

We present the results of our simultaneous photometric and polarimetric observations of the Herbig Ae/Be star VX Cas acquired in 1987 - 2001. The star belongs to the UX Ori type of young variable stars and exhibits a rather low level of photometric activity: only six Algol-type minima with amplitudes $\Delta V > 1^m$ were recorded in 15 years

of observations. Two of these minima, in 1998 and 2001, were the deepest in the history of the stars's photometric studies, with V amplitudes of about $2^m$. In each case, the dimming was accomanied by an increase of the linear polarization in agreement with the law expected for the variable circumstellar extinction. The highest polarization in V band was about 5%. Observations of VX Cas in the deep minima revealed a turnover of the color tracks, typical for stars of this type and due to an increased contribution from radiation scattered in the circumstellar disk. We separated the observed polarization of VX Cas into interstellar ($P_{is}$) and intrinsic ($P_{in}$) components. Their position angles differ by approximately 60°, with $P_{is}$ dominating in the bright state, and $P_{in}$ dominating during the deep minima. The competition of these two polarization components leads to chages in both the degree and position angle of the polarization during the star's brightness variations. Generally speaking, in terms of the behavior of the brightness, color indices, and linear polarization, VX Cas is similar to other UX Ori stars studied by us earlier. A number of episodes of its photometric and polarimetric activity suggests that, in their motion along highly eccentric orbits, circumstellar gas and dust clouds can enter the close vicinity of the star (and be disrupted there).

Accepted by Astronomy Reports.

## Periodic Variability in the Pre-Main Sequence Object CB34V

**Sarah Tackett[1], William Herbst[2] and Eric Williams[2]**

[1] Physics and Astronomy Dept., Vassar College, Poughkeepsie, NY 12604, USA
[2] Astronomy Department, Wesleyan University, Middletown, CT 06459, USA

E-mail contact: wherbst@wesleyan.edu

A photometric study of the G-type pre-main sequence star CB34V was undertaken at Van Vleck Observatory during the 2001/2002 observing season. The star remained in its bright state throughout the five-month monitoring period, showing no evidence of the large amplitude variability which originally drew attention to it. However, it did exhibit periodic variability with an amplitude of ∼0.6 mag. A highly significant peak is present in the periodogram at 1.186 days, but analysis of the light curve suggests that the actual rotation period of the star is twice that — 2.372 days. Apparently the star had similar spots on opposite hemispheres during this time and we view it close to equator-on. This circumstance allows us to place additional constraints on the radius and luminosity of the star. The new data argue against the star being a FUor and in favor of its being either an UXor or an object (similar to KH 15D) which is eclipsed episodically by circumstellar matter.

Accepted by Astron. J.

## Coronal X-ray emission from an intermediate-age brown dwarf

**Yohko Tsuboi[1], Yoshitomo Maeda[2], Eric D. Feigelson[3], Gordon P. Garmire[3], George Chartas[3], Koji Mori[3], Steven H. Pravdo[4]**

[1] Department of Science and Engineering, Chuo University, Kasuga 1-13-27, Bunkyo-ku, Tokyo 112-8551, Japan
[2] High Energy Astrophysics Division, Institute of Space and Astronautical Science, Yoshinodai 3-1-1, Sagamihara, Kanagawa 229-8510, Japan
[3] Department of Astronomy and Astrophysics, The Pennsylvania State University, 525 Davey Laboratory, University Park, PA 16802, USA
[4] Jet Propulsion Laboratory, Mail Stop 306-438, California Institute of Technology, Pasadena, CA 91109, USA
E-mail contact: tsuboi@phys.chuo-u.ac.jp

We report the X-ray detection of the brown dwarf (BD) companion TWA 5B in a $\simeq$ 12 Myr old pre-main sequence binary system. We clearly resolve the faint companion (35 photons) separated from the X-ray luminous primary by 2 arcsec in a *Chandra* ACIS image. TWA 5B shows a soft X-ray spectrum with a low plasma temperature of only 0.3 keV and a constant flux during the 3 hour observation, of which the characteristics are commonly seen in the solar corona. The X-ray luminosity is $4\times10^{27}$ erg s$^{-1}$ (0.1–10 keV band) or $\log L_X/L_{bol} = -3.4$.

Comparing these properties to both younger and older BDs, we discuss the evolution of the X-ray emission in BDs. During their first few Myr, they exhibit high levels of X-ray activity as seen in higher mass pre-main sequence stars. The level in TWA 5B is still high at $t \simeq 12$ Myr in $\log L_X/L_{bol}$ while $kT$ has already substantially cooled.

Accepted by ApJL

Preprints are available at http://arxiv.org/abs/astro-ph/0304231

*New Books*

# Astrophysics of the Diffuse Universe

## Michael A. Dopita and Ralph S. Sutherland

It is a rare occasion when one sees the appearance of what will become a "classic" textbook, one of those that are known, owned, and used by everybody. In the field of the interstellar medium, perhaps the most famous such book is the one by Lyman Spitzer, which by now is out of date. The appearance of this book by Dopita and Sutherland is likely to mark such an occasion.

Dopita and Sutherland have set out to provide a comprehensive overview of the interstellar and intergalactic medium, and the processes that control its phases and transformations, with an emphasis on the underlying physics. The book serves well as a reference book for the researcher who needs to check up on a point, but it is most likely to serve as a textbook for many graduate courses on the interstellar medium. Indeed, in writing the book, the authors have drawn on their own experience in teaching such a course. Students will find excercises at the end of each chapter with which they can test their understanding, and for some of the excercises answers have been provided at the end of the book. Throughout the text, the authors provide extensive references (more than 500) to the key research papers in the literature, and each chapter is concluded with notes on further reading, such as review articles or chapters in other books.

The chapters and main subsections of the book are listed below.

**1. What is the Diffuse Universe?**

1.1 Phases - 1.2 Observability

**2. Line Emission Processes**

2.1 Atomic Spectra - 2.2 Molecular Spectra - 2.3 Rotating Molecules - 2.4 Vibrating Molecules - 2.5 Ro-vibrational Spectra - 2.6 Electronic Molecular Spectra

**3. Collisional Excitation**

3.1 Collisional Excitation by Electron Impact - 3.2 The Three-level Atom - 3.3 The General Multilevel Atom

**4. Line Transfer Effects**

4.1 Resonance Line Transfer - 4.2 The H I 21 cm Line - 4.3 Fluorescent Processes - 4.4 Astrophysical Masers

**5. Collisional Ionization Equilibrium**

5.1 Collisional Ionization - 5.2 Recombination - 5.3 Photoionization - 5.4 Charge-Exchange - 5.5 Coronal Equilibrium

**6. Continuum and Recombination Line Processes**

6.1 Free-Free Continuum Emission - 6.2 The Free-Bound Continuum - 6.3 Continuum Emission Coefficients - 6.4 The Two-Photon Process - 6.5 Recombination Line Emission

**7. Cooling Plasmas**

7.1 The Cooling Function - 7.2 Conditions for Nonequilibrium Cooling - 7.3 Heat Transport - 7.4 Cold Clouds in Hot Gas - 7.5 Thermal Instabilities - 7.6 The Recombination Era of the Universe - 7.7 Hot Galactic Coronae

**8. Interstellar Shocks**

8.1 Why Do Shocks Exist? - 8.2 J-Shocks - 8.3 The Drivers of Interstellar Shocks - 8.4 The Radiative Properties of J-Shocks - 8.5 C-Shocks

**9. The Theory of Photoionized Regions**

9.1 Photoionization of Hydrogen H II Regions - 9.2 H II Regions with Heavy Elements - 9.3 Photoionization by X-ray Sources - 9.4 Radio Continuum of H II Regions

**10. Parameters of Photoionized Regions**

10.1 Nebular Parameters - 10.2 Ionizing Source Parameters - 10.3 Photoionization Modelling - 10.4 Abundances

**11. Photoionizing Shocks**

11.1 Radiative Properties of Fast Shocks - 11.2 The Oxygen-Rich Supernova Remnant

**12. Interstellar Dust**

12.1 Stardust Formation - 12.2 The Optical Properties of Dust - 12.3 Radiation Pressure Effects - 12.4 Grain Photoheating - 12.5 Grain Charging - 12.6 The Life Cycle of Grains - 12.7 Spectral Signatures of Grain Materials

**13. Introduction to Astrochemistry**

13.1 Molecular Formation and Destruction - 13.2 Chemistry of Particular Regions

**14. Thermal Phases of Diffuse Matter**

14.1 Phase Stability - 14.2 Thermal Phases of Galactic Interstellar Gas - 14.3 Feedback and Mass Exchange - 14.4 Back to the Beginning: The Epoch of Galaxy Formation

ISBN 3-540-43362-7
Hardback - published 2003 - 439 pages - Price US$ 69.95 plus postage

Springer-Verlag New York, Inc.
P.O. Box 19386
Newark, NJ 07195-9386

Fax: (201)-348-4505

E-mail: service@springer-ny.com

http://www.springer-ny.com

## 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.

# Dust in the Galactic Environment
## 2nd Edition

## D.C.B. Whittet

This is the second edition of the well known book on interstellar dust by Doug Whittet. It is now 12 years since the first edition was completed, and major developments have taken place in the intervening period. It is thus most welcome to see the appearance of a second edition that has been extensively revised and greatly expanded (by more than 30%), thus offering a detailed and up-to-date overview of the properties of interstellar dust and its role in astrophysical processes. Extensive references are given to the literature, including the most recent results. Each chapter ends with a set of problems.

The book contains the following chapters;

**1. Dust in the Galaxy: Our view from within**

1.1 Introduction - 1.2 Historical perspective: Discovery and assimilation - 1.3 The distribution of dust and gas - 1.4 Interstellar environments and physical processes - 1.5 The significance of dust in modern astrophysics - 1.6 A brief history of models for interstellar dust

**2. Abundances and depletions**

2.1 The origins of the condensible elements - 2.2 The solar system abundances - 2.3 Abundance trends in the Galaxy - 2.4 The observed depletions - 2.5 Implications for grain models

**3. Extinction and scattering**

3.1 Theoretical methods - 3.2 Observational technique - 3.3 The average extinction curve and albedo - 3.4 Spatial variations - 3.5 The 2175 A absorption feature - 3.6 Structure in the visible - 3.7 Modelling the interstellar extinction curve

**4. Polarization and grain alignment**

4.1 Extinction by anisotropic particles - 4.2 Polarimetry and the structure of the galactic magnetic field - 4.3 The spectral dependence of polarization - 4.4 Polarization and grain models - 4.5 Alignment mechanisms

**5. Infrared absorption features**

5.1 Basics of infrared spectroscopy - 5.2 The diffuse ISM - 5.3 The dense ISM -

**6. Continuum and line emission**

6.1 Theoretical considerations - 6.2 Galactic continuum emission - 6.3 Spectral emission features - 6.4 Extended red emission

**7. Dust in stellar ejecta**

7.1 The formation of dust in stellar outflows - 7.2 Observational constraints on stardust - 7.3 Evolved stars as sources of interstellar grains

**8. Evolution of the interstellar medium**

8.1 Grain surface reactions and the origin of molecular hydrogen - 8.2 Gas-phase chemistry - 8.3 Mechanisms for growth - 8.4 Ice mantles: deposition and evolution - 8.5 Refractory dust

**9. Dust in the envelopes of young stars**

9.1 The early phases of stellar evolution - 9.2 Protoplanetary discs - 9.3 Clues from the early Solar System - 9.4 Ingredients for life

**10. Toward a unified model for interstellar dust**

10.1 Areas of consensus - 10.2 open questions

ISBN 0 7503 0624 6
Paperback - published 2003 - 390 pages - US$ 49.99 plus postage

Institute of Physics Publishing

Dirac House
Temple Back
Bristol
BS1 6BE England

E-mail (European orders): direct.order@marston.co.uk
E-mail (USA orders): orders@aidcvt.com
Fax: +44 (0) 117 929 4318
http://bookmarkphysics.iop.org

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

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

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

# *Meetings*

## ASTRONOMICAL POLARIMETRY
## CURRENT STATUS AND FUTURE DIRECTIONS
15-19 March 2004
Waikoloa Beach Marriott, Waikoloa, Hawaii

**First Announcement**

Dear Colleague,

We are pleased to announce the convening of a Workshop on optical - infrared - mm/submm (OIM) Astronomical Polarimetry, in the wonderful surroundings of the north Kona coast in March 2004. The aim of the Workshop is to bring together workers in all areas of OIM astronomical polarimetry to discuss the most recent results in this exciting and crucial field, and to consider the potential for polarimetry in the era of eight- and ten-metre optical and infrared telescopes. The meeting will concentrate on ground-based polarization measurements, and will include a session devoted to new and novel instrumentation. The remaining sessions will be organized according to the astronomical source rather than to wavelength regime or specific technique. Neither Radio polarimetry nor Solar polarimetry are within the conference remit, but each will be the subject of review talks which will set the scene for two of the conference sessions.

If you are interested in attending this meeting, please note that the conference web site, including registration pages, will open for business on 1-Jun-2003. Emails sent to the conference address (given at the bottom of this note) will give a useful indication of the likely interest. Space may be limited, so we would strongly encourage you to do this at this point.

SCIENCE AREAS

Sessions will be divided into two, with approximately 80% of the time guaranteed for current results and 20% for presentations on future directions, facilities etc. Proceedings, including posters, will be published. Details of the division between oral and poster presentations will be given in the June announcement. The following science areas will be covered:

- Techniques and Instrumentation
- Theory and Modelling
- Interstellar Dust and Gas
- Galaxies, Radio Galaxies and AGN
- Star Formation
- Circumstellar Disks and Extrasolar Planets
- Stars, CVs, Magnetic Stars, Stellar Evolution
- High-redshift and Cosmological Polarimetry

DATES AND DEADLINES

Second Announcement and Web site opens: 1-Jun-2003
Commencement of Registration: 1-Jun-2003
Third Announcement: 1-Sep-2003
End of Early Registration: 1-Dec-2003
Abstract Deadline: 1-Jan-2004

Late Registration Deadline: 1-Feb-2004

SPONSORING ORGANIZATIONS

Joint Astronomy Centre - Subaru Telescope - Canada-France Hawaii Telescope - Gemini Observatory - University of Hawaii Institute for Astronomy - W.M.Keck Observatory - Caltech Submillimetre Observatory

SCIENCE ORGANIZING COMMITTEE

Andy Adamson (Joint Astronomy Centre), Chris Davis (Joint Astronomy Centre), Motohide Tamura (National Astrophysical Observatory of Japan), Pierre Bastien (University of Montreal), Chris Packham (University of Florida), Colin Aspin (Gemini Observatory), Gary Schmidt (University of Arizona), Martin Houde (Caltech Submillimetre Observatory), Ian Robson (UK Astronomy Technology Centre), Jim Hough (University of Hertfordshire), Jeff Kuhn (University of Hawaii Institute for Astronomy), Nadine Manset (Canada-France Hawaii Telescope), and Bob Goodrich (Keck Observatory).

Contact email address: pol2004@jach.hawaii.edu

# *Short Announcements*

## SIRTF Observation Planning Workshop

Dates: July 25-26, 2003

Website: http://sirtf.caltech.edu/SSC/ost/workshop/2003b/

The SIRTF Science Center (SSC) is pleased to announce a 2-day observation planning workshop to be held at the SSC, Pasadena, CA, on 25-26 July 2003. The format of this workshop will be similar to the ones held at the SSC in November and December 2002 and will provide insight and information on SIRTF capabilities, plus the observation and proposal planning tools available for download from the SSC website.

There is no registration fee associated with the workshop, but we only have 40 workshop places available. Ph.D.-level astronomers and graduate students are eligible to attend. No restrictions are made as to nationality or institution. Places at the workshop will be given on a first-come-first-served basis.

If you are interested in attending, workshop information, registration and hotel information is available online at:

http://sirtf.caltech.edu/SSC/ost/workshop/2003b/

The deadline for the hotel block booking is 11 July.