THE STAR FORMATION NEWSLETTER

An electronic publication dedicated to early stellar evolution and molecular clouds

No. 53 — 19 Feb 1997 Editor: Bo Reipurth (reipurth@eso.org)

Abstracts of recently accepted papers

Optical Outburst of a Pre-Main Sequence Object

João Alves, Lee Hartmann, César Briceño and Charles J. Lada

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

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

We present a study of CB34V, a pre-main sequence object that has increased in brightness by ∼3.7 magnitudes in the red between November 1951 (1951.9) and February 1996 (1996.1). Our data consists of intermediate and high resolution optical spectroscopy as well as optical and near-infrared photometry ($BVRIJHK$). We find that the color behavior of the CB34V brightness variation is peculiar, corresponding to a gray brightening. We demonstrate that CB34V is a pre-main sequence object embedded in a small molecular cloud by 2.4 visual magnitudes. At optical wavelengths CB34V has a G5 (III−IV) spectral type and is rapidly rotating with a $v\sin i \sim 145 \pm 20$ km s^{-1}. We estimate a current bolometric luminosity of $7 < L_{CB34V} < 39$ (D/kpc)^2 L$_\odot$. If the optical light is stellar in origin, the object's position on the HR diagram implies a stellar mass of ~ 2 M$_\odot$ and an age of $\sim 1 \times 10^6$ years. We consider two possible explanations for the observed brightening: 1) a high accretion episode (FU Orionis type) and 2) time variable extinction due to motions of the non-uniform circumstellar environment. Although we favor the latter, CB34V seems difficult to classify into any of the known types of pre-main sequence variability.

Accepted by Astron. J. (April 1997)

Near-IR imaging photometry of NGC1333: a 3μm survey

Colin Aspin[1], and Göran Sandell[2]

[1] Nordic Optical Telescope, Apartado 474, E38700 Santa Cruz de la Palma, Canarias, Spain
[2] Joint Astronomy Centre, 660 N. Aohoku Place, Hilo, HI 96720, U.S.A.

e-mail contact: caa@not.iac.es

We combine new near-IR 3.42μm imaging photometry with JHK data from Paper I to further probe the membership and physical characteristics of the embedded pre-main sequence (PMS) population in the active star formation region NGC1333-S. Our new dataset covers approximately 44% of the $10' \times 10'$ area previously surveyed. In the current survey region we have detected 36 sources, 26 being brighter than our 5σ limiting magnitude of m_L=12.2. These 36 objects represent 45% of the 80 objects detected in the same region at K. From a near-IR J-K vs. K-L colour-colour diagram we imply the stars evolutionary state and compare the results with those obtained from our JHK data. We additionally discuss the effect of 3.08μm ice absorption on photometry at 3.42μm for heavily embedded objects.

Accepted by MNRAS

Preprint from www address http://www.not.iac.es/ caa/caa_papers.html

Dynamical Effects of the Parker Instability in the Interstellar Medium

Shantanu Basu[1], Telemachos Ch. Mouschovias[2] and Efthimios V. Paleologou[3]

[1] CITA, Univ. of Toronto, Toronto, Ontario M5S 3H8, Canada
[2] Astronomy Department, Univ. of Illinois, Urbana, IL 61801, USA
[3] Physics Department, Univ. of Crete, 71409 Heraklion, Crete, Greece

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

We investigate the nonlinear development of the Parker instability in the interstellar medium using two-dimensional MHD numerical simulations. The response of an initially unstable equilibrium to small random velocity perturbations is investigated. The horizontal wavelength with maximum growth rate in the linear theory grows preferentially and dominates the nonlinear evolution of the system during timescales of interest in the interstellar medium. The nonlinear evolution of the system also favors modes whose symmetry is such as to allow motions that cross the galactic plane. In a separate calculation, we investigate the dominant mode in more detail and discuss the effect of the nonlinear evolution on the structure of the interstellar medium.

Accepted by Ap. J. Letters

A Survey of the Chemical Properties of the M17 and Cepheus A Cloud Cores

Edwin A. Bergin[1,2], Hans Ungerecths[1,3], Paul F. Goldsmith[4], Ronald L. Snell[1], William M. Irvine[1], and F. Peter Schloerb[1]

[1] Five College Radio Astronomy Observatory, Department of Physics and Astronomy, University of Massachusetts, Amherst, MA 01003, USA
[2] Current address: Harvard-Smithsonian Center for Astrophysics MS-66, 60 Garden Street, Cambridge, MA 02138-1596, USA
[3] Current address: IRAM, Avenida Divina Pastora, 7-NC, E-18012 Granada, Spain
[4] National Astronomy and Ionosphere Center, Department of Astronomy, Cornell University, Ithaca, NY 14853-6801, USA

We present the results of a systematic survey of the chemical properties of two giant molecular cloud cores in M17 and Cepheus A. In all, we have mapped the emission from 32 molecular transitions from 13 molecules and 7 isotopic variants over a $4' \times 5'$ region in each core. Each map includes known sites of massive star formation as well as the more extended quiescent material. In M17 most molecules have emission peaks away from the H II region/molecular cloud interface, while two species, HC_3N and CH_3CCH, deviate from this structure with sharp maxima closer to this interface. In Cepheus A the core is influenced by a compact high-velocity molecular outflow and a more extended low-velocity flow. The molecular emission distributions in this source are generally quite similar, with most molecules peaking near the center of the core to the east of the compact H II region HW 2. A few molecules, SO, CH_3OH, $H^{13}CN$, and $C^{18}O$, have more extended emission. Only two molecules, CO and HCO^+, appear to trace the high and low velocity outflows, all other species are tracing the quiescent core.

We have used the results of previous studies of the density and temperature of the dense gas in the same cloud cores to derive accurate abundances relative to CO for several positions in each core. The principal result is that the chemical composition of all of the cores we have surveyed (which include OMC-1 as well as M1 7 and Cepheus A) show remarkable similarity, both within a given core and among the cores. This suggests that the chemical processes are similar in quiescent GMC core material. In M17 the lack of variation of molecular abundances is remarkable because the radiation field and the gas temperature are known to vary appreciably throughout the surveyed region, suggesting that the bulk of the emission arises from gas that is well shielded from radiation.

Accepted by Ap.J. (June 10, 1997 issue)

Preprints available on the WWW in USA at http://cfa-www.harvard.edu/∼ebergin/
and in Europe at http://www.iram.es/Astronomy/paper.html

The Chemical Composition and Evolution of Giant Molecular Cloud Cores: A Comparison of Observation and Theory

Edwin A. Bergin[1,2], Paul F. Goldsmith[3], Ronald L. Snell[1], and William D. Langer[4]

[1] Five College Radio Astronomy Observatory, Department of Physics and Astronomy, University of Massachusetts, Amherst, MA 01003, USA

[2] Current address: Harvard-Smithsonian Center for Astrophysics MS-66, 60 Garden Street, Cambridge, MA 02138-1596, USA

[3] National Astronomy and Ionosphere Center, Department of Astronomy, Cornell University, Ithaca, NY 14853-6801, USA

[4] Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109, USA

We present the results of an observational and theoretical study of the chemical composition and evolution of three giant cloud cores in Orion A, M17, and Cepheus A. This study is the culmination of a chemical survey of 32 transitions of 21 different molecules and isotopic variants in these cloud cores. Using these data, combined with observationally derived physical conditions, chemical abundances were calculated for several positions in each cloud. A global analysis of the molecular abundances shows that, although abundance differences exist, the chemical composition of giant cloud cores is remarkably homogeneous. This agreement suggests that the chemical evolution of the individual giant cloud cores is not unique. The molecular abundances of giant cloud cores are also systematically lower than those observed in the more quiescent dark cloud core TMC-1.

A one-dimensional chemical model is presented which examines internal chemical structure induced by a radiation field enhanced by a factor of 10^{3-5} above the normal interstellar radiation field. This model integrates the abundances of the various species as a function of depth, producing column densities which can be compared with observations. The one-dimensional model is unable to reproduce the abundances of many molecules for any single time. Two assumptions have been investigated to improve the agreement between theory and observations. These are: adding clumps and raising the initial C/O ratio. We find that the inclusion of clumps in the chemical model can reproduce the abundance of C and C^+. However, due to the greater weight placed on the photon-dominated region within smaller clumps, clumps have a detrimental effect on reproducing the abundances of other species.

Models with a range of C/O ratios are also compared with the measured abundances. Good agreement between this model and the observations at two positions with disparate physical properties is found for early times (t $\sim 10^5$ yr) *and* for C/O increased to $\sim$ 0.8. We suggest that one possible interpretation of these results is that the cores are dynamically evolving objects. Either giant cloud cores are intrinsically young objects or the dense material is effectively young by virtue of a complex interchange of material between the clumps and the interclump medium. We suggest that the CS/SO ratio can be used to probe the evolutionary state of and the initial C/O ratio in dense molecular clouds.

Accepted by Ap.J. (June 10, 1997 issue)

Preprints available on the WWW at http://cfa-www.harvard.edu/~ebergin/

Far Infrared Spectroscopy of C II and High J CO Emission from Warm Molecular Gas in NGC 3576

R. T. Boreiko and A. L. Betz

Center for Astrophysics and Space Astronomy, University of Colorado, Boulder, CO 80309, USA

E-mail contact: boreiko@spot.colorado.edu

We have observed the 158 μm $^2P_{\frac{3}{2}} \leftarrow ^2P_{\frac{1}{2}}$ fine-structure line of C II, the J=9→8, J=12→11, and J=17→16 lines of ^{12}CO, and the J=9→8 rotational transition of ^{13}CO in the molecular cloud and photodissociation region associated with NGC 3576. The line profiles were fully resolved using a heterodyne spectrometer with <1 km s^{-1} resolution. The high J CO emission arises from a spatially compact region near the infrared peak which is characterized by a kinetic temperature near 150 K and a density $n_{H_2} \gtrsim 5 \times 10^5$ cm^{-3}. The ^{12}CO J=9→8 line is found to be optically thick and arises from a more extended, cooler region with T_{kin} ~60 K. The increase in excitation temperature with the rotational level of CO suggests that the ionizing source is located behind much of the molecular cloud. Less than 1% of the molecular cloud material is found in the warm PDR and cloud interface region. The C II fine-structure line emission is intense over $>4' \times 4'$ and shows a central "self-absorption" feature at many locations. This absorption may

represent a cooler or less dense ionized gas component associated with the foreground molecular cloud.

Accepted by Astrophys. J. Suppl.

Near-Infrared Emission of Protostars

Nuria Calvet[1,2,3], Lee Hartmann[2], and Steve E. Strom[1]

[1] Five College Astronomy Department, Amherst, MA 01003, USA
[2] Harvard-Smithsonian Center for Astrophysics, 60 Garden St., Cambridge, MA 02138, USA
[3] Centro de Investigaciones de Astronomia, Mérida, Venezuela

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

Models for the thermal emission from dusty infalling envelopes around protostars indicate that the envelope emission can greatly exceed the stellar + disk photospheric emission at wavelengths $\sim 2\mu$m. We argue that this thermal envelope emission accounts for the weakness of 2.3μm CO first-overtone absorption lines in protostellar sources. Disk emission alone is unlikely to explain the observed effect, either because disks exhibit their own CO absorption, or because inner disk holes eliminate the region of the disk which can emit in the near infrared. We find that this near infrared veiling is very dependent on the envelope density, increasing as mass infall rate increases and centrifugal radius decreases. The veiling also depends on the characteristics of the underlying object and it is largest when most of the luminosity is due to accretion and the disk hole size is several stellar radii. The observed veiling indicates that dust must be falling in to distances of ~ 0.1 AU of the central star.

Accepted by The Astrophysical Journal

Preprint available at: http://donald.phast.umass.edu/preprints/starform/chs/chs.html

VLA observations of 43 GHz continuum and CS J=1–0 emission from Orion-IRc2 and the hot core

Claire J. Chandler[1] and Douglas O. S. Wood[2]

[1] MRAO, Cavendish Laboratory, Madingley Road, Cambridge CB3 0HE, UK
[2] Eastman Kodak, Scientific Imaging Systems, 4 Science Park, New Haven, CT 06511, USA

E-mail contact: cjc@mrao.cam.ac.uk

We have used the VLA to image at $2''$ resolution the Orion-IRc2 region in 43 GHz continuum and CS(1–0) emission. In the continuum radio sources I and B are detected together with an extended emission component which peaks at source I. Comparison of this extended component with lower frequency data suggests it is free-free emission from a dusty HII region ionized by source I. The compact CS(1–0) emission originates from the hot core, the compact ridge, and the western clump. The hot core component has a line brightness temperature of ~ 150 K, and is optically thick. We derive an abundance for the CS relative to H_2 in the hot core of 1.2×10^{-8}, considerably higher than the previous upper limit based on a single-dish spectral line survey. The difference can be explained as being due to beam-dilution of the hot core component in the earlier, low-resolution study, and the confusion of the hot core with emission from the extended ridge. A similar result is also suggested for the sulphur-bearing molecules SO and SO_2, and existing models of sulphur chemistry are unable to reproduce these new abundance estimates. We conclude that models extending to higher temperatures and densities are required to explain these data.

Accepted by Monthly Notices of the Royal Astronomical Society

A postscript version of this preprint is available at http://www.mrao.cam.ac.uk/~cjc/

Four new dense molecular cores in the Taurus Molecular Cloud (TMC) – Ammonia and cyanodiacetylene observations

C. Codella[1], R. Welser[1], C. Henkel[1], P.J. Benson[2], P.C. Myers[3]

[1] Max Planck Institut für Radioastronomie, Auf dem Hügel 69, D-53121 Bonn, Germany
[2] Whitin Observatory Wellesley, Wellesley, Massachusetts 02181, USA
[3] Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA

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

Trying to obtain a more complete picture of star forming regions in the Taurus molecular cloud, four newly discovered dense molecular cores (L1521D, L1521F, L1524, L1507A) are identified and mapped through the ammonia (J,K) = (1,1) and (2,2) rotational inversion lines. These cores have sizes from 0.06 to 0.09 pc, hydrogen densities from 0.6 10^4 to 19.9 10^4 cm^{-3} and kinetic temperatures between 7.9 and 9.9 K. The masses range from 0.2 and 1.0 $M_\odot$, placing the cores with the lowest M values at the lower edge of the mass distribution for ammonia cores in the TMC. Turbulent, thermal and gravitational energies have been estimated. A comparison between these energy terms and considerations related to thermal and turbulent line broadening indicate that these cores are close to gravitational equilibrium. Moreover, we report detections of the J=9–8 transition of HC_5N towards the ammonia peak positions of these four molecular cores. The HC_5N column densities are between 1.6 10^{12} and 9.2 10^{12} cm^{-2}, in agreement with the values derived for the other molecular cores located in the TMC.

Accepted by Astron. Astrophys.

Chemistry of Protosolar-like nebulae: The molecular content of the DM Tau and GG Tau disks

Anne Dutrey, Stéphane Guilloteau, and Michel Guélin

Institut de Radio Astronomie Millimétrique, 300 Rue de la Piscine, F-38406 Saint Martin d'Hères, France

E-mail contact:dutrey@iram.fr

We report the detection of CN, HCN, HNC, CS, HCO^+, C_2H and H_2CO (ortho and para) in the protoplanetary disks of DM Tau and GG Tau. For the first time organic molecules are observed in objects representative of the presolar nebula. These molecules are underabundant with respect to the standard dense clouds. The depletions in the "outer" disk of DM Tau ($100 < r < 900$ AU), derived from the line intensities and state of excitation, range from $f \simeq 5$ (for CO) to 100 (for H_2CO). The relatively large abundances of CN and C_2H are typical of a photon-dominated chemistry.

Accepted by A&A letters (preprints are available from http://iram.fr)

Successive SiO Shocks along the L1448 Jet Axis

Anne Dutrey[1], Stéphane Guilloteau[1], and Rafael Bachiller[2]

[1]Institut de Radio Astronomie Millimétrique, 300 Rue de la Piscine, F-38406 Saint Martin d'Hères, France
[2] Centro Astronomico de Yebes (OAN, IGN). Apartado 148, E-19080 Guadalajara, Spain

E-mail contact:dutrey@iram.fr

We present a complete SiO $v = 0$ J=2-1 synthesis image of the red-shifted outflow lobe from the Class 0 protostar L 1448-mm. The image is a 5-field mosaic obtained with the IRAM interferometer at $\sim 3''$ angular resolution. The SiO emission arises in a highly-collimated jet extending over 0.2 pc. The jet consists of four main blobs, probably corresponding to successive episodes of mass-loss from the central object. The kinematical structure of the jet is studied by the means of velocity channel maps and position-velocity diagrams, and is compared to current models of jet-driven bipolar outflows. We have constructed a kinematical model of bow-shock to make such comparison as detailed as possible. We find that most of the SiO clumps delineate partial bow-shock structures, but important SiO emission is also seen along the jet axis itself. Shock-processing of the dust grains, and perhaps chemical gas-phase reactions in the protostellar wind and in the mixing layer, could explain the enhancement of SiO in the different jet blobs. The CO outflow in L1448, and perhaps in all bipolar outflows, is thought to be driven by a primary jet ejected from the central star/disk system. We conclude that, if not the primary wind itself, the material traced by the SiO emission reported here is very closely linked to this primary jet.

Accepted by A&A Main Journal (preprints are available from http://iram.fr)

A Universal Formation Mechanism for Open and Globular Clusters in Turbulent Gas

Bruce Elmegreen[1], **and Yuri Efremov** [2]

[1] IBM T.J. Watson Research Center, PO Box 218 Yorktown Heights NY 10598, USA
[2] Sternberg Astronomical Institute, Moscow 119899, Russia

E-mail contact: bge@watson.ibm.com

A universal mechanism for cluster formation in all epochs and environments is found to be consistent with the properties and locations of young and old globular clusters, open clusters and unbound associations, and interstellar clouds. The primary structural differences between various cluster types result from differences in pressure at the time of formation, combined with different ages for subsequent evolution. All clusters begin with a mass distribution similar to that for interstellar clouds, which is approximately $n(M)dM \propto M^{-2}dM$. Old halo globulars have a current mass distribution that falls off at low mass because of a Hubble time of cluster destruction. Young globulars have not yet had time for a similar loss, and some old open clusters have survived because of their low densities. The peak in the halo cluster luminosity function depends only on age, and is independent of the host galaxy luminosity, as observed. The peak globular cluster mass is not a characteristic or Jeans mass in the primordial galaxy, as previously suggested.

The initial mass distribution functions for young and old globular clusters, open clusters and associations, and interstellar clouds are all power laws with a slope of ~ -2. This distribution could be the result of fractal structure in turbulent gas. New data on clusters in the LMC also follow this power law. The slope is so steep that it implies a significant fraction of star formation occurs in small clusters. Numerous halo field stars should come from the evaporation of small halo clusters, and a high fraction of disk field stars should arise in small unbound disk clusters. This differs significantly from previous suggestions that most disk stars form in large OB associations.

Globular clusters of all ages preferentially form in high pressure regions. This is directly evident today in the form of large kinematic pressures from the densities and relative velocities of member stars. High pressures at the time of globular cluster formation are either the result of a high background virial density in that part of the galaxy (as in dwarf galaxies or galactic nuclei and nuclear rings), turbulence compression (in halo globulars), or large scale shocks (in interacting galaxies). Massive clusters that form in such high pressure environments are more likely to be bound than low mass clusters or clusters of equal mass in low pressure regions. This is because virialized clouds are more tightly bound at high pressure. A simple model illustrates this effect. One implication of this result is that starburst regions *preferentially* make globular clusters, in which case some elliptical galaxies could have formed by the violent merger of spiral galaxies.

Accepted by Astrophys. J. (May 1, 1997, Vol 480)

Cloud/Intercloud Structure from Non-linear Magnetic Waves

Bruce Elmegreen

IBM T.J. Watson Research Center, PO Box 218 Yorktown Heights NY 10598, USA

E-mail contact: bge@watson.ibm.com

One-dimensional numerical simulations of interacting plane polarized Alfven waves including magnetic diffusion and thermal energy dissipation form structures between the sources of excitation that are analogous to clumpy cool diffuse clouds surrounded by a warm low-density intercloud medium. The cloud oscillates slightly after formation, but has an average state that is in both thermal and total pressure equilibrium with the intercloud medium. The cloud substructure has a realistic size-linewidth relation, $\Delta v \propto R^{0.5}$, that is the result of a systematically decreasing correlation among random motions for increasingly large scales. The substructure also has a peak-density versus size relation $\rho \propto R^{-0.18}$ because of self-similar hierarchical structure. The gas continuously changes its temperature in response to density fluctuations in the turbulent medium, i.e., each region picks the temperature of the nearest equilibrium phase for the current density. The gas motions are generally less than the Alfven speed and comparable to the sound speed. This implies that supersonic turbulence in real clouds is probably the result of supersonic *relative* motions between very tiny clumps inside which the actual motions are nearly sonic. The magnetic field plays the important role of allowing energy from the perturbation to spread over a large distance with minimal dissipation.

Accepted by Astrophys. J. (Vol. 480, May 10 1997 issue)

Millimeter and Radio Interferometry of Herbig Ae/Be Stars

James Di Francesco[1,2], Neal J. Evans II[1], Paul M. Harvey[1]
Lee G. Mundy[3], Stephane Guilloteau[4], and Claire J. Chandler[5]

[1] Dept. of Astronomy, R.L.M. 15.308, The University of Texas at Austin, Austin, TX 78712-1083, USA
[2] Harvard-Smithsonian Center for Astrophysics, 60 Garden St., Mail Stop 42, Cambridge, MA 02138, USA
[3] Astronomy Program, University of Maryland, College Park, MD 20742, USA
[4] Institut de Radioastronomie Millimétrique, 300 rue de la Piscine, Domaine Universitaire 38406, St Martin d'Hères Cedex, France
[5] Mullard Radio Astronomy Observatory, Cavendish Laboratory, Madingley Road, Cambridge CB3 OHE, UK

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

Nine Herbig Ae/Be stars have been observed at $\lambda = 2.7$ mm with the IRAM and BIMA interferometers to place constraints on the presence of disk material around these objects. Only one Herbig Ae/Be star, Elias 3-1, was detected with certainty; two additional stars, MWC 137 and V645 Cyg, were possibly detected. The remaining six Herbig Ae/Be stars were not detected. Two deeply embedded objects near the target stars, LkHα 198-MM and V1318 Cyg S, were also detected. The emission from Elias 3-1 and V1318 Cyg S is unresolved, while that from LkHα 198-MM is resolved. Two stars (Elias 3-1 and V645 Cyg) were observed with the VLA at $\lambda = 7$ mm, 1.3 cm, and 3.6 cm. Based on our VLA data and those of Skinner et al. (1993), it appears that emission from ionized gas may contribute substantially to the millimeter emission from several sources. After correcting for this component where necessary, the remaining emission from most of the sample, attributed to dust, is considerably less than that predicted by assuming that the shorter wavelength emission arises in a disk. Much of the submillimeter and millimeter emission toward most of these stars must therefore arise in an extended envelope. For Elias 3-1, the data are consistent with a disk with mass around 0.1 $M_\odot$. We place limits on the masses of disks around the other stars.

Accepted by The Astrophysical Journal

The Star-Grazing Extra-Solar Comets in the HD 100546 System

C.A. Grady[1], M.L. Sitko[2], K.S. Bjorkman[3], M.R. Pérez[4], D.K. Lynch[5], R.W. Russell[5], M.S. Hanner[6]

[1] Eureka Scientific, 2452 Delmer St., Suite 100, Oakland CA 94602, USA
[2] Physics Department, University of Cincinnati, Cincinnati OH 45221, USA
[3] Department of Physics and Astronomy, University of Toledo, Toledo OH 43606-3390,USA
[4] Applied Research Corporation, Landover, MD 20785, USA
[5] The Aerospace Corporation, Los Angeles, CA 90009, USA
[6] Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109, USA

E-mail contact: cgrady@mtolympus.ari.net

Redshifted, absorption profiles resembling the high velocity circumstellar gas features in the spectrum of β Pic have been detected in IUE data for the 2 Myr-old Herbig Be star, HD 100546, on 1995 March 7. In addition to Mg II, Si II, and other refractory species similar to those seen in β Pic, the HD 100546 spectra are rich in accreting gas profiles from neutral, atomic gas including C I, and O I, as well as mildly refractory species such as Zn II and S II. The presence of accreting gas profiles including neutral atomic gas is consistent with detection of comae of star-grazing bodies potentially resembling either comets or asteroids. Overall, the IUE data for HD 100546 are consistent with the planetesimals in this system being more volatile rich and magnesium-rich than similar bodies in the β Pic system.

Accepted by Ap.J., to appear in Vol. 483, July 1, 1997

On the Stellar Population and Star-Forming History of the Orion Nebula Cluster

Lynne A. Hillenbrand

University of California, Berkeley; 601 Campbell Hall; Berkeley, CA 94720, USA

E-mail: lynne@astron.berkeley.edu

We report on the first phase of a study of the stellar population comprising the Orion Nebula Cluster (ONC). Approximately 50% of the ~3500 stars identified to date within ~2.5 pc of the namesake Trapezium stars are optically visible, and in this paper we focus on that sample with I < 17.5 mag. The large number and number density ($n_{peak} > 10^4$ pc^{-3})

of stars, the wide range in stellar mass ($\sim 0.1 - 50 M_\odot$), and the extreme youth (< 1-2 Myr) of the stellar population, make the ONC the best site for investigating: 1) the detailed shape of a truly "initial" mass spectrum; 2) the apparent age spread in a region thought to have undergone triggered star formation; 3) the time sequence of star formation as a function of stellar mass; and 4) trends of all of the above with cluster radius.

Nearly 60% of the $\sim$ 1600 optical stars have sufficient data (spectroscopy and photometry) for placement on a theoretical HR diagram; this subsample is unbiased with respect to apparent brightness or cluster radius, complete down to $\sim 1 M_\odot$, and representative of the total optical sample below $\sim 1 M_\odot$ for the age and extinction ranges characteristic of the cluster. Comparison of the derived HR diagram with traditional pre-main sequence evolutionary calculations shows a trend of increasing stellar age with increasing stellar mass. To avoid the implication of earlier characteristic formation times for higher-mass stars than for lower-mass stars, refinement of early evolutionary theory in a manner similar to the birthline hypothesis of Palla & Stahler (1993), is required. Subject to uncertainties in the tracks and isochrones, we can still investigate stellar mass and age distributions in the ONC. We find the ONC as a whole to be characterized by a mass spectrum which is not grossly inconsistent with "standard" stellar mass spectra. In particular, although there are structural differences between the detailed ONC mass spectrum and various models constructed from solar neighborhood data, the observed mass spectrum appears to a peak at $\sim 0.2 M_\odot$ and to fall off rapidly towards lower masses; several substellar objects are present. The abundance of low-mass stars relative to high-mass stars suggests that there is no bi-modal star formation mode; somewhat ironically, the ONC probably contains fractionally more low-mass stars than the solar neighborhood since the population not yet located on the HR diagram is dominated by sub-solar-mass stars. Nonetheless, the ONC mass spectrum is biased towards higher-mass stars within the innermost cluster radii ($r_{projected} < 0.3$ pc). We find the ONC as a whole to be characterized by a mean age of < 1 Myr and an age spread which is probably less than 2 Myr, but also by a bias towards younger stars at smaller projected cluster radii. Although the *most massive* stars and the *youngest* stars are found preferentially towards the center of the ONC it does not follow that the most massive stars are the youngest stars. A lower limit to the total cluster mass in stars is $M_{stars} \approx 900 M_\odot$ (probably a factor of < 2 underestimate). A lower limit to the recent low-mass star formation rate is $\approx 10^{-4} M_\odot yr^{-1}$. All observational data in this study as well as stellar parameters derived from them are available in electronic format.

Accepted by A.J.

WWW: http://astron.berkeley.edu/lynne/home.html (scroll down to "Publications")

A Near-Infrared Imaging Survey of NGC 2282

Donald J. Horner[1], Elizabeth A. Lada[2] and Charles J. Lada[3]

[1] Department of Astronomy, University of Maryland, College Park, MD 20742, USA
[2] Department of Astronomy, University of Florida, Gainesville, FL 32611, USA
[3] Smithsonian Astrophysical Observatory, 60 Garden Street, Cambridge, MA, 02138, USA

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

We present the first near-infrared (JHK) imaging and photometry of a young cluster associated with NGC 2282, a reflection nebula in Monoceros. Our observations reveal that the cluster is centrally concentrated with a surface density that falls as r^{-1}. The cluster has a radius of roughly 1.6 pc and contains at least 100 members, approximately 9% of which exhibit infrared excess emission characteristic of young stellar objects. Infrared extinction maps suggest that the cluster is located at the edge of a molecular cloud and is not heavily reddened. We construct the K-band luminosity function (KLF) of the cluster and find that it increases with magnitude up to the completeness limit of our observations ($m_K = 15.0$). The shape of the KLF is similar to those of other young clusters, such as IC 348 and the Trapezium, which suggest that the cluster contains a significant population of pre-main sequence stars. However, at the distance of NGC 2282 (1.7 kpc) our observations are not deep enough to sample the low mass end of the cluster IMF. Consequently, our KLF does not provide meaningful constraints on either the age of the cluster or the duration of star formation within it. On the other hand, the low extinction toward the cluster, its location at the edge of a molecular cloud, and the relatively small fraction of infrared excess sources suggest that it is a relatively evolved cluster of pre-main sequence stars with an age of 5-10 $\times 10^6$ years.

Accepted by Astronomical Journal

Preprints are available at http://www.astro.umd.edu/ djh/ngc2282.html

Variability and a vanishing YSO in the Serpens cloud core.

M.J. Horrobin[1], M.M. Casali[2] and C. Eiroa[3]

[1] Institute for Astronomy, University of Edinburgh, Blackford Hill, Edinburgh EH9 3HJ, U.K.
[2] Royal Observatory, Blackford Hill, Edinburgh EH9 3HJ, U.K.
[3] Dept. de Fisicia Teorica, Facultad de Ciencias, UNAM, 28049 Madrid, Spain

E-mail contact: mjh@roe.ac.uk

This letter compares data from a recent near-IR study of the Serpens cloud core with data from previously published studies. It is found that one object, irs 81 has completely vanished, fading by more than 3.8 magnitudes at K, while a total of 10 of the observed objects have varied by over 0.5 magnitudes in H or K, with little change in colour. We have also discovered 13 new objects in the cloud core which were below the magnitude limit of previous studies.

Accepted by Astronomy & Astrophysics

First Astronomical Detection of the Cumulene Carbon Chain Molecule H_2C_6 in TMC1

W. D. Langer[1], T. Velusamy[1], T. B. H. Kuiper[1], R. Peng[1], M. C. McCarthy[2], M. J. Travers[2], A. Kovács[2], C. A. Gottlieb[2], and P. Thaddeus[2]

[1] MS 169-506, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109, USA
[2]Division of Engineering and Applied Sciences, Harvard University, 29 Oxford Street, Cambridge, MA 02138, USA

E-mail contact: langer@langer.jpl.nasa.gov

The cumulene carbenes are important components of hydrocarbon chemistry in low mass star forming cores. Here we report the first astronomical detection of the long chain cumulene carbene H_2C_6 in the interstellar cloud TMC1, from observations of two of its rotational transitions: $J_{K,K'} = 7_{1,7} \rightarrow 6_{1,6}$ at 18.8 GHz and $8_{1,8} \rightarrow 7_{1,7}$ at 21.5 GHz, using NASA's Deep Space Network 70 m antenna at Goldstone, California. In addition we also observed the shorter cumulene carbene, H_2C_4 at the same position. The fractional abundance of H_2C_6 relative to H_2 is about 4.7×10^{-11} and H_2C_4 is about 1.1×10^{-9}. The abundance of H_2C_6 is in fairly good agreement with gas phase chemical models for young molecular cloud cores, but the abundance of H_2C_4 is significantly larger than predicted.

Accepted by Astrophys. J. (Letters)

Gold alignment & internal dissipation

A. Lazarian

Department of Astrophysical Sciences, Princeton University, Princeton NJ 08544, USA

E-mail contact: lazarian@astro.princeton.edu

The measures of mechanical alignment were obtained for both prolate and oblate grains when their temperature is comparable with grain kinetic energy devided by k, the Boltzmann constant. For such grains, the alignment of angular momentum, **J**, with the axis of maximal inertia, **a**, is only partial. This substantially alters the alignment as compared with the results in Lazarian (1995) and Roberge, Hanany & Messinger (1996) obtained on the assumption of perfect alignment. We also describe the Gold alignment when the Barnett dissipation is suppressed and derive an analytical expression which relates the measure of alignment with parameters of grain nonsphericity and the direction of the gas - grain drift. This solution provides the lower limit for the alignment measure, while the upper limit is given by the analytics derived in Lazarian (1994). Using results of a recent study of incomplete internal relaxation in Lazarian & Roberge (1996), we find measures of alignment for the whole range of ratios of grain rotational energy to k over T_s, where T_s is the grain temperature. To describe alignment for mildly supersonic drifts, we suggest an analytical approach which provides good correspondence with the results of direct numerical simulations in Roberge, Hanany & Messinger (1995). We also extend our approach to account for the simultaneous action of the Gold and Davis-Greenstein mechanisms.

Accepted by ApJ

http://www.astro.princeton.edu/ library/prep.html

Paramagnetic alignment of thermally rotating dust

A. Lazarian

Department of Astrophysical Sciences, Princeton University, Princeton NJ 08544, USA

E-mail contact: lazarian@astro.princeton.edu

Paramagnetic alignment of thermally rotating oblate dust grains is studied analytically for finite ratios of grain to gas temperatures. For such ratios, the alignment of angular momentum **J** in respect to the grain axis of maximal inertia is only partial. We treat the alignment of **J** using perturbative methods and disentangle the problem of **J** alignment in grain body axes from that of **J** alignment in respect to magnetic field. This enables us to find the alignment of grain axes to magnetic field and thus relate our theory to polarimetric observations. Our present results are applicable to the alignment of both paramagnetic and superparamagnetic grains.

Accepted by MNRAS

http://www.astro.princeton.edu/ library/prep.html

Barnett Relaxation in Thermally-Rotating Grains

A. Lazarian[1], W. Roberge[2]

[1] Department of Astrophysical Sciences, Princeton University, Princeton NJ 08544, USA
[2] Dept. of Physics, Applied Physics, & Astronomy, Rensselaer Polytechnic Institute, Troy, NY 12180, USA

E-mail contact: lazarian@astro.princeton.edu

We present an exact formulation of the physics of Barnett relaxation. Our formulation is based on a realistic kinetic model of the relaxation mechanism which includes the alignment of the grain angular momentum in body coordinates by Barnett dissipation, disalignment by thermal fluctuations, and coupling of the angular momentum to the gas via gas damping. We solve the Fokker-Planck equation for the measure of internal alignment using numerical integration of the equivalent Langevin equation for Brownian rotation. The accuracy of our results is calibrated by comparing our numerical solutions with exact analytic results obtained for special cases. We describe an analytic approximation for the measure of alignment which fits our numerical results for cases of practical interest.

Accepted to ApJ

http://www.astro.princeton.edu/ library/prep.html

A Search for Methanol Masers in Star-Forming Regions in the Outer Galaxy

David A. Lyder[1,2] and John Galt[1]

[1] Dominion Radio Astrophysical Observatory, Box 248, Penticton, B.C., Canada, V2A 6K3
[2] Department of Physics and Astronomy, University of Victoria, P.O. Box 3055, MS 7700, Victoria, B.C., Canada, V8W 3P6

E-mail contact: david.lyder@hia.nrc.ca,john.galt@hia.nrc.ca

A recent survey with the DRAO 25.6m telescope operating at 6.6 GHz has detected a new methanol maser in the vicinity of W5. The position of the maser relative to CO emission and IRAS source 02455+6034 strongly suggests they are coincident. CS emission in the region also suggests an association with the maser. Radio continuum observations of the region have not revealed any particular radio emission sources associated with the maser. It is not possible with the sensitivity and resolution of the current observations to identify the maser's pumping mechanism.

Accepted by Astronomical Journal

A Funnel Flow Origin For CO Bandhead Emission In Young Stellar Objects

Steven C. Martin

Department of Astronomy and Astrophysics, University of Chicago, 5640 S. Ellis Ave, Chicago, IL 60637, USA

E-mail contact: smartin@jets.uchicago.edu

Many young stellar objects show near-infrared CO overtone emission. The observed bandhead profiles are consistent with gas motion in the gravitational field of a central mass and have been interpreted as arising from the innermost regions of a circumstellar disk. However, there is evidence that many of these pre–main-sequence stars possess strong magnetic fields that disrupt the inner disk and channel the gas onto the stellar surface, thereby forming an accretion funnel. It is demonstrated that this funnel can naturally give rise to the observed CO emission. It is shown that gas free-falling along the field lines yields bandhead profiles in agreement with those observed, with the shape of the profile determined mainly by the viewer's inclination. At large inclinations (with respect to the stellar rotation axis) the bandhead has a blue shoulder and a redshifted peak relative to the rest wavelength of the bandhead, whereas at small inclinations the bandhead is narrow. Using stellar parameters appropriate to a low-mass young stellar object and an accretion rate typical of a classical T Tauri star ($\sim 10^{-7}$ $M_\odot$ yr^{-1}), the computed luminosity of the v=2–0 bandhead is near the low end of the observed range. Since the predicted bandhead luminosity is proportional to the accretion rate, it is concluded that only young stellar objects with large accretion rates should have detectable CO emission, which is consistent with the observations. The lower overtone transitions of CO (e.g., v=2–0) are not strongly affected by the ambient radiation field since the densities in the funnel flow ($n_H \approx 10^{12}$ cm^{-3}) are large enough to ensure LTE. However, higher transitions ($v \geq 4$) are more susceptible to IR and UV pumping. The calculations imply that radiative effects leading to deviations from LTE will be most noticeable for sources with large bolometric luminosities.

Accepted by Astrophysical Journal Letters, to appear in the March 20 1997 issue

Near-Infrared Spectroscopy of Molecular Filaments in the Reflection Nebula NGC 7023

Paul Martini[1], K. Sellgren[1] and Joseph L. Hora[2]

[1] Astronomy Department, Ohio State University, Columbus, OH 43210, USA
[2] Institute for Astronomy, University of Hawaii, Honolulu, HI 96822, USA

We present near-infrared spectroscopy of fluorescent molecular hydrogen (H_2) emission from molecular filaments in the reflection nebula NGC 7023. We derive the relative column densities of H_2 rotational-vibrational states from the measured line emission and compare these results with several model photodissociation regions covering a range of densities, incident UV-fields, and excitation mechanisms. Our best-fit models for one filament suggest, but do not require, either a combination of different densities, suggesting clumps of 10^6 cm^{-3} in a $10^4 - 10^5$ cm^{-3} filament, or a combination of fluorescent excitation and thermally-excited gas, perhaps due to a shock from a bipolar outflow. We derive densities and UV fields for these molecular filaments that are in agreement with previous determinations.

Accepted by The Astrophysical Journal

The Classical T Tauri Spectroscopic Binary DQ Tau. I. Orbital Elements and Light Curves

Robert D. Mathieu[1], Keivan Stassun[1], Gibor Basri[2], Eric L. N. Jensen[1,3], Christopher Johns-Krull[4], Jeff A. Valenti[5], and Lee W. Hartmann[6]

[1] Department of Astronomy, University of Wisconsin-Madison, Madison, WI 53706, USA
[2] Department of Astronomy, University of California, Berkeley, CA 94720, USA
[3] Now at the Department of Physics and Astronomy, Arizona State University, P.O. Box 871504, Tempe, AZ 85287, USA
[4] McDonald Observatory, University of Texas, Austin, TX 78712, USA. Now at JILA, University of Colorado.
[5] JILA, University of Colorado, Boulder, CO 80309, USA
[6] Harvard-Smithsonian Center for Astrophysics, 60 Garden St., Cambridge, MA 02138, USA

E-mail contact: mathieu@astro.wisc.edu

We report the discovery that the classical T Tauri star DQ Tau is a double-lined spectroscopic binary. The orbital period is 15.804 days, with a large orbital eccentricity $e = 0.556$. The mass ratio is 0.97 ± 0.15.

We have monitored DQ Tau photometrically over two observing seasons and observed recurring episodes during which the stars get brighter (≈ 0.5 mag in V) and bluer (≈ -0.2 mag in V−I). When combined with photometry in the literature (time span ≈ 5000 days), a Scargle periodogram analysis reveals a highly significant periodicity of 15.80 days, essentially identical to the binary orbital period. These brightening events occur shortly before or at periastron

passage. They occur during at least 65% of periastron passages, but not during all periastron passages.

DQ Tau is surrounded by a circumbinary disk with mass of 0.002–0.02 $M_\odot$. The infrared spectral energy distribution resembles a power law from 1 μm to 60 μm. Remarkably, there is no paucity of near-infrared emission indicative of the inner disk having been cleared by the binary; there is clearly warm material within the binary orbit. We interpret the brightening events as due to a variable mass accretion rate regulated by the binary orbit. The periodic brightenings, the associated increases in emission line strength and veiling reported in an accompanying paper (Basri *et al.* 1997), and the circumstellar material together are consistent with a recent theoretical finding that circumbinary disk material can stream across a binary orbit at certain orbital phases, resulting in a pulsed accretion flow onto the stars (Artymowicz & Lubow 1996). The theoretically predicted phase of maximum accretion rate is shortly before periastron, in good agreement with the phasing of the brightenings of DQ Tau. The periastron separation is smaller than the inferred stellar magnetospheric radii of classical T Tauri stars, so that such magnetospheres would interact at each periastron passage. The magnetic energies are plausibly adequate to power the brightenings. However, the strongly enhanced continuum veiling and long duration of some of the brightenings are not naturally explained in a pure flaring scenario. Nonetheless, magnetospheres likely play a role in the detailed accretion flow near the stars.

Accepted by the Astronomical Journal; scheduled for the May 1997 issue.

This paper is available via the World Wide Web at http://www.astro.wisc.edu/prints/prints.html

Detection and Confirmation of Interstellar Acetic Acid

David M. Mehringer[1,2], Lewis E. Snyder[2], Yanti Miao[2], and Frank J. Lovas[3]

[1]California Institute of Technology, Downs Laboratory of Physics
[2]University of Illinois, Department of Astronomy
[3]National Institute of Standards and Technology, Optical Technology Division

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

We have detected acetic acid (CH_3COOH) in the Sgr B2 Large Molecule Heimat source using the Berkeley-Illinois-Maryland Association (BIMA) and Caltech Owens Valley (OVRO) Millimeter Arrays. With the BIMA Array, we initially detected the $8_{*,8}$-$7_{*,7}$ A blend near 90.2 GHz. The corresponding line from the E symmetry species was sought but may be blended with a line from another species. Interstellar CH_3COOH was confirmed using the OVRO Array, where we detected the $9_{*,9}$-$8_{*,8}$ E blend near 100.9 GHz. The corresponding line from the A symmetry species was sought but found to be blended with the 7_1-7_0E line of CH_3SH. Our CH_3COOH observations represent the first detection and confirmation of an interstellar molecule using interferometric arrays; all past detections and confirmations of new molecules have been made on the basis of single element telescope observations.

Accepted by ApJ Letters

Preprints available at http://socrates.caltech.edu/~dmehring/preprints/vinegar.ps

The Dynamics of Low Mass Molecular Clouds in External Radiation Fields

Richard P. Nelson[1,2], William D. Langer[1]

[1] MS 169–506, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109, USA
[2] Now at: Astronomy Unit, School of Mathematical Sciences, Queen Mary & Westfield College, London, E1 4NS, UK

E-mail contact: R.P.Nelson@qmw.ac.uk

We present the results of three dimensional hydrodynamic calculations of the evolution of low mass molecular clouds, performed using the numerical method of smoothed particle hydrodynamics. The clouds that we consider are subject to heating by the interstellar radiation field and by cosmic rays. They are able to cool through molecular line emission (primarily CO and its isotopes), and by emission from the fine structure lines of C^+ and OI. We also include gas–dust thermal coupling in our models. A simplified chemical network is incorporated which models the conversion between C^+ and CO, where the chemical balance is determined by the local flux of dissociating radiation. Calculations are performed for initially uniform density clouds, with masses in the range $M = 100$ to $400 M_\odot$, sizes in the range $R = 1.7$ to 3.4 pc, with the initial number density in all cases being $n = 100$ cm^{-3}. We performed calculations for clouds with different geometrical shapes, these being spherical, prolate, and oblate. Additionally, we considered the effects of an

anisotropic radiation field on the cloud evolution.

The main results are:

(i) Clouds which are initially Jeans stable are able to collapse because of the coupling between the dynamical and thermal evolution. This collapse results in core–halo structure where we have a cold, dense, CO core surrounded by a warmer, tenuous, C^+ envelope.

(ii) A pressure gradient is set up in the clouds by the attenuation of the UV radiation field. When a cloud is anisotropically heated, this pressure gradient leads to the formation of a highly flattened cloud core when it collapses.

(iii) The combined thermal and dynamical evolution of the prolate and oblate clouds, leads to the formation of highly elongated or flattened structures. These structures are able to fragment, typically with 4 to 8 subcondensations forming, which have masses in the range $3M_\odot$ to $7.5M_\odot$.

These calculations are relevant to observations of isolated, low mass, quiescent clouds and Bok globules, where the interstellar radiation field plays an important role in the thermal and chemical evolution, and thermal pressure provides substantial support against gravitational collapse.

To appear in Ap. J. on June 20 1997, Vol. 482.

Multifrequency, High Resolution Radio Recombination Line Observations of the Massive Star-Forming Region W49A

C. G. De Pree[1,2], David M. Mehringer[3,4], and W.M. Goss[2]

[1] Department of Physics and Astronomy, Agnes Scott College
[2] National Radio Astronomy Observatory
[3] Department of Astronomy, University of Illinois
[4] Downs Laboratory of Physics, California Institute of Technology

E-mail contact: cdepree@scottlan.edu, dmehring@socrates.caltech.edu

We have carried out a multi-frequency, multi-configuration VLA observational program of the massive Galactic star forming region W49A (D = 11.4 kpc). Radio continuum observations were carried out at 0.7, 1.3 and 3.6 cm. In the highest sensitivity 3.6 cm images, we have detected 45 distinct continuum sources (located within a $\sim 4'$ [13 pc] diameter region) exhibiting a wide variety of sizes and morphological types. Several sources have rising continuum spectra ($\alpha > 0.6$) up to the shortest wavelengths observed (7 mm). We observe a larger fraction of sources with shell morphologies (11%) than were observed in the Galactic plane survey of Wood & Churchwell (1989). A correlation between the rms electron density and the radius of the ultracompact HII regions is observed for the spherical, unresolved and cometary sources in W49A.

We have observed W49A in the H92α, He92α, H66α, and H52α recombination lines. We detect hydrogen line emission from 39 of the 45 continuum sources observed at 3.6 cm (H92α). We derive LTE electron temperatures from the H92α, H66α and H52α lines to have mean values of T_e^*=6700±300 K, 10400±600 K and 9100±600 K respectively. The mean singly ionized helium abundance in the 13 sources where He92α emission is detected is $< Y^+ >$=11±1%. Several of the most compact continuum sources in W49A have broad radio recombination lines ($\Delta V_{H52\alpha} >$45 km s^{-1}), including W49A/B and the western portion of W49A/G (which contains a large number of high velocity H_2O masers). The high frequency radio recombination line velocities are utilized to discriminate between various models that propose to explain the origin of the central "ring" of HII regions.

Accepted by ApJ

X-ray emitting stars in the NGC1333 star forming region

Thomas Preibisch

Astronomisches Institut der Universität Würzburg, Am Hubland, D–97074 Würzburg, Germany

E-mail contact: preib@astro.uni-wuerzburg.de

We present the results of a very deep ROSAT HRI X-ray observation of the highly active star forming region NGC1333. In total we could detect 20 X-ray sources, 16 of which we assume to be members to the cluster of pre main sequence stars. Since most of the stars in NGC1333 are still deeply embedded in the molecular cloud ($A_V \approx 5 - 30$ mag), we use near infrared data to estimate individual extinctions for the calculation of X-ray luminosities.

One of the X-ray sources is identified with the optically invisible, very deeply embedded ($A_V \approx 28$ mag) infrared class I source SVS16, for which we find an extremely high X-ray luminosity of 2.8×10^{32} erg/sec, making this object one of the most X-ray luminous pre main sequence stars known to date.

Since we have already performed similar sensitive ROSAT observations of the young cluster IC348 (the second active star forming region in the Perseus molecular cloud complex), we compare the X-ray properties of the young stars in NGC1333 to those in IC348. We find no evidence for a significant change of the X-ray luminosity function during the first few million years in the life of the pre main sequence stars.

Accepted by Astronomy & Astrophysics

http://www.astro.uni-wuerzburg.de/∼preib/1333.html

Detection of young stellar objects with ISO

L. Testi[1,6], M. Felli[2], A. Omont[3], M. Pérault[4], P. Séguin[4], G. Comoretto[2] and G. Gilmore[5]

[1] Dipartimento di Astronomia, Università degli Studi di Firenze, Largo E. Fermi 5, I-50125 Firenze, Italy
[2] Osservatorio Astrofisico di Arcetri, Largo E. Fermi 5, I-50125 Firenze, Italy
[3] Istitut d'Astrophysique de Paris, CNRS, 98bis Boulvard Arago, F-75014 Paris, France
[4] Laboratoire de Radioastronomie Millimétrique, ENS, 24 rue Lhomond, F-75005 Paris, France
[5] Istitute of Astronomy, University of Cambridge, Madingley road, CB3 OHA Cambridge, United Kingdom
[6] visiting astronomer: Istitut d'Astrophysique de Paris, CNRS, 98bis Boulvard Arago, F-75014 Paris, France

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

Preliminary 15 μm results obtained with ISOCAM are compared with deep K-band and H_2O maser observations of a 0.244 sq.deg. field in the galactic plane at l=+45 deg. A new maser source is found to be associated with the infrared source with the largest colour index, (m_K-$m_{15\mu m}$) ≥ 10, most probably a young star in its earliest evolutionary phase. Other three objects with (m_K-m_{15um}) ≥ 9, probably young stars, are also found in the observed region.

Accepted by Astronomy & Astrophysics (Letters)

http://www.arcetri.astro.it/∼testi/preprints.html

Chemical and Physical Gradients Along the OMC-1 Ridge

Hans Ungerechts[1,2], Edwin A. Bergin[1,3], Paul F. Goldsmith[4], William M. Irvine[1], Ronald L. Snell[1], and F. Peter Schloerb[1]

[1] Five College Radio Astronomy Observatory, Department of Physics and Astronomy, University of Massachusetts, Amherst, MA 01003, USA
[2] Current address: IRAM, Avenida Divina Pastora, 7-NC, E-18012 Granada, Spain
[3] Current address: Harvard-Smithsonian Center for Astrophysics MS-66, 60 Garden Street, Cambridge, MA 02138-1596, USA
[4] National Astronomy and Ionosphere Center, Department of Astronomy, Cornell University, Ithaca, NY 14853-6801, USA

We present a survey of the distribution of 20 chemical and isotopic molecular species along the central ridge of the Orion molecular cloud from $6'$ north to $6'$ south of BN-KL observed with the QUARRY focal plane array on the FCRAO 14m telescope, which provides an angular resolution of $\sim 50''$ in the 3mm wavelength region. We use standard tools of multivariate analysis for a systematic investigation of the similarities and differences among the maps of integrated intensities of the 32 lines observed. The maps fall in three broad classes: first, those strongly peaked toward BN-KL; second, those having rather flat distributions along the ridge; and third, those with a clear north-south gradient or contrast. We identify 6 positions or regions where we calculate relative abundances. Line velocities and linewidths indicate that the optically thin lines generally trace the same volume of dense gas, except in the molecular bar, where $C^{18}O$, $C^{34}S$, $H^{13}CO^+$, CN, C_2H, SO, and C_3H_2 have velocities characteristic of the bar itself, whereas the emission from other detected species is dominated by the background cloud. The strongest abundance variations in our data

are the well-known enhancements seen in HCN, CH_3OH, HC_3N, and SO toward BN-KL and, less strongly, toward 1.3′S.

The principal result of this study is that along the extended quiescent ridge the chemical abundances, within factors of 3–4, exhibit an impressive degree of uniformity. The northern part of the ridge has a chemistry closest to that found in quiescent dense clouds. While temperature and density are similar around the northern radical-ion peak near 3.5′N and in the southern core near 4.2′S, some abundances, in particular those of the ions HCO^+ and N_2H^+, are significantly lower toward 4.2′S. The areas near 4.2′S and the molecular bar itself around (1.7′E, 2.4′S) stand out with peculiar and similar properties—probably caused by stronger UV fields penetrating deeper into the clumpy molecular gas. This leads to higher electron abundances and thereby reduced abundances of the ions as well as a lack of complex molecules.

To appear in Ap.J., June 10, 1997

Preprints available on the WWW in USA at http://cfa-www.harvard.edu/∼ebergin/
and in Europe at http://www.iram.es/Astronomy/paper.html

T Tauri stars and the Gould Belt near Lupus

R. Wichmann[1], M. Sterzik[2], J. Krautter[1], A. Metanomski[1,3], and W. Voges[2]

[1] Landessternwarte Königstuhl, D-69117 Heidelberg, Germany

[2] Max-Plank-Institut für Extraterrestrische Physik, D-85740 Garching, Germany

[3] European Southern Observatory, Casilla 19001, Santiago 19, Chile

E-mail contact: R.Wichmann@lsw.uni-heidelberg.de

We present results of a study to investigate the spatial distribution of X-ray active young stellar objects near the Lupus star forming region (SFR). In this SFR, a recent study has led to the discovery of some 130 new *weak-line T Tauri stars* (WTTS) dispersed over a large area of some 230 square degrees. However, the true extent of the spatial distribution of these stars could not be determined in this study.
We have selected from the ROSAT All-Sky-Survey candidate T Tauri stars within a narrow strip of 10^o width, located adjacent to the Lupus SFR, and oriented perpendicular to the galactic plane. Intermediate resolution spectroscopy was carried out to identify stellar objects with strong Li I λ6708 absorption, indicative of their youth, and 48 Li-rich stars were found within our study region.
The peak at $b \simeq 18^o$ in the spatial distribution of Li-rich stars within this strip corresponds well with the intersection of our study region with the Gould Belt, but is inconsistent with the assumption that these stars belong to a galactic ZAMS foreground population, which would be expected to be centered on the galactic midplane.
We conclude that the majority of recently discovered low-mass, X-ray active, Li-rich stars dispersed over large areas around Gould Belt SFRs are indeed WTTS with ages not exceeding that of the Gould Belt itself, i.e. below $5-6\times10^7$ years.

Accepted by Astron. Astrophys.

Herbig-Haro Objects in the ρ Ophiuchi Cloud

Bruce A. Wilking[1], Richard D. Schwartz[1], Tina M. Fanetti[1] and Eileen D. Friel[2]

[1] Department of Physics & Astronomy, University of Missouri-St. Louis, St. Louis, MO 63121, USA

[2] National Science Foundation, Division of Astronomical Sciences, 4201 Wilson Blvd., Arlington, VA 22230, USA

E-mail contact: brucew@newton.umsl.edu

Using deep, narrow-band images of the main ρ Oph dark cloud centered on the wavelengths of Hα and [S II], we present evidence for three new Herbig-Haro objects. This increases the total number in the cloud to five. In addition, positions for 5 candidate Herbig-Haro objects are given. Relatively high [S II]/Hα ratios indicate low excitation conditions for all of these nebulae. We list potential exciting stars for each Herbig-Haro object and candidate by identifying nearby young stellar objects with strong infrared excesses and/or millimeter continuum emission. The location of most of these nebulae near the cloud edges underscores the important role that extinction by dust plays in the ρ Oph cloud in masking the presence of Herbig-Haro objects. Among the newly identified Herbig-Haro objects is a jet-like string of emission nebulae emanating from the classical T Tauri star SR 4. [S II] emission is also found coincident with a knot

of strong molecular hydrogen emission associated with the highly-collimated VLA 1623 molecular outflow. Indeed, the low excitation nature of all of the objects in our study, coupled with the high extinction of the cloud, suggests that a deep survey for shocked molecular hydrogen at λ=2.122 μm would be the best way to search for evidence of strong winds from the large population of young stellar objects in the cloud.

Accepted by PASP

Preprints available on the WWW at http://newton.umsl.edu/~brucew

Millimeter Interferometry towards the ultra–compact HII region W3(OH)

F. Wyrowski[1], P. Hofner[2], P. Schilke[1], C.M. Walmsley[1,3], D.J. Wilner[4], J.E. Wink[5]

[1] I. Physikalisches Institut, Univ. zu Köln, Zülpicherstr. 77, D-50937 Köln. Germany
[2] Cornell University, NAIC, Arecibo Observatory, P.O. Box 995, Arecibo, P.R. 00613
[3] Osservatorio Astrofisico di Arcetri, Largo E.Fermi 5, I-50125 Firenze, Italy
[4] Harvard Smithsonian Center for Astrophysics , 60 Garden St., Cambridge, MA 02138, USA
[5] Insitut de Radioastronomie Millimétrique, Domaine Universitaire, F-38406 St-Martin-d'Hères, France

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

We used the IRAM Interferometer to map the J=1–0 and J=2–1 lines of $C^{17}O$ as well as the continuum at 112 and 225 GHz of the W3(OH) region. Towards the cluster of water masers W3(H_2O) we observed compact continuum emission at both frequencies with spectral index of 3.6 from hot dust emission. The $C^{17}O$ maps show more extended gas with the most massive molecular clump towards W3(H_2O) and none towards W3(OH) itself. We derive a peak column density of 5×10^{23} cm^{-2} at the H_2O maser position. Dust and line fluxes are both consistent with a mass of 10 $M_\odot$. Peaks of molecular line channel maps of $C^{17}O$, CH_3OH, and C_2H_5CN show an E–W orientation similar to the cluster of H_2O masers.

Accepted by Astonomy & Astrophysics Letters

Preprints are available at http://www.ph1.uni-koeln.de/∼wyrowski

H_2 imaging of Sandqvist 136: shocked gas, jets, and knots

João Lin Yun[1], Dan Clemens[2], Miguel C. Moreira[1], & Nuno C. Santos[1]

[1]Departamento de Física, Universidade de Lisboa, Campo Grande, Ed. C1, 1700 Lisboa, Portugal
[2]Boston University, 725 Commonwealth Avenue, Boston, MA 02215, USA

We present a study of the morphological aspects of H_2 jets and knots seen towards the small dark cloud Sandqvist 136. Near-infrared images of this cloud in the J, H, K-bands, and in the 2.12 μm $v = 1 - 0$ S(1) molecular hydrogen line were obtained. The images reveal the presence of a near-infrared nebula with a conical shape. The location of the apex of the cone, in the K-band image, coincides with the position of an *IRAS* PSC source. This source, possibly a Class 0 young stellar object, is likely to be the illuminator of the nebula. The position and orientation of the conical nebula coincide with those of the blue-shifted lobe of the previously found molecular outflow associated with Sandqvist 136. Near-infrared jets and knots were found positionally associated with the high-velocity molecular outflow. The knots seem to be tracing the walls of a cavity excavated by the molecular outflow. Unlike most outflows commonly associated with Class 0 sources, the outflow associated with this source appears to be poorly collimated.

Accepted by *The Astrophysical Journal (Letters)*

A copy of this paper is available via the World Wide Web. Connect to http://delphi.cc.fc.ul.pt/papers/sand136

Dissertation Abstracts

Probing the Clumpy Nature of Molecular Clouds

Yong-Sun Park

Thesis work conducted at: Department of Astronomy, Seoul National University, Korea

Current address: Korea Astronomy Observatory, San36-1, Yusong-Gu, Taejon, 305-348, Korea

Electronic mail: yspark@hanul.issa.re.kr

Ph.D dissertation directed by: Seung-Soo, Hong

Ph.D degree awarded: February 1997

We investigated the excitation conditions and the line formation mechanism of molecular transitions in the clumpy structured clouds and the dense molecular cores. It is generally accepted that the clouds or cores are composed of many small clumps. However, have been done little model studies on the radiative transfer of molecular lines in such clumpy medium. This study is aimed at knowing how the emission lines are formed in the clumpy clouds and how they reflect the kinematics and structure of the clumps.

First we developed a three dimensional radiative transfer code by using the Monte Carlo method, and simulated the clumpy structure of the cloud as realistically as possible. It is found that the excitation conditions in the clumpy cloud are more uniform than those of the smoothly varying density structure. The tendency of uniformity is pronounced under the dominance of macroturbulent motion of the clumps. When the space between the clumps is left empty, the CO line profiles calculated in these conditions do not show the time long self-absorption features, and are compatible with the observed line characteristics. An inclusion of very dilute inter-clump matter results in a development of the self-absorption features or the flat tops to the line center. This suggests that a very large density contrast exists between the clump and inter-clump media. The tendency of the uniform excitation conditions is also noted for the CS transitions, if the dense cores are clumpy.

We applied our clumpy model to the NGC2071 dense core, for which multi-transitional observations of CS are available. The clumpy model fits the observations much better than the microturbulent one. It was found that the volume fraction occupied by the clumps is only 5% and the mean density gradient is steeper than that estimated by the previous study.

The first half of the thesis was already published in A&A, 300, 890 and in A&A, 312, 981.

Dynamical Collapse in Star Forming Cores

Qizhou Zhang

Department of Astronomy, Harvard University, USA

Current address: 60 Garden Street, Cambridge, MA 02138, USA

Electronic mail: qzhang@cfa.harvard.edu

Ph.D dissertation directed by: Paul T. P. Ho

Ph.D degree awarded: December, 1996

The observational evidence of molecular cloud collapse is rare partly due to confusion of coexisting processes such as molecular outflows. In this thesis, we studied a number of dense molecular cloud cores with centimeter- and millimeter-wave interferometers. Toward two infall candidates in the W51 region, we find consistent spectroscopic signatures of cloud collapse in molecular lines of NH_3, CS, CH_3CN, CH_3OCH_3 and $HCOOCH_3$. The optically thick lines show the inverse P-Cygni or double-peaked profiles with the blue-shifted components stronger than the red-shifted ones. The line asymmetries increase systematically toward transitions of larger optical depths or toward a transition synthesized with higher angular resolutions. These characteristics are in excellent agreement with the expected signatures from a centrally condensed infalling cloud.

The infall motion at scales from 0.04 pc to 0.2 pc appears to be radial and remains nearly constant. The mass densities in the infall region increase inward and scale with radius as r^{-2}. The infall at the inner part ($\lesssim$ 0.04 pc) of the dense cores is accompanied by rotational motions which spin up as $\omega \propto r^{-1.2}$. The two infalling cores are embedded in an extended cloud which rotates in a different direction than the dense cores. It is likely that these dense cores are formed through fragmentation of the extended cloud. In this case, the rotational axis of the parental cloud may not be preserved during this process. Although the fragmentation may play important roles in core formation, it seems to be the collapse of individual cores that leads to the formation of OB stars.

We also studied two low mass regions, GSS30 and L1157, in which the dominant phenomenon turns out to be outflow motions. In the case of GSS30, we found an expanding core which is likely disrupted by the formation of stars. In L1157, we observed a powerful outflow from a very low luminosity (11 $L_\odot$) source which gives rise to heating and shocked emission in the cloud core.

New Jobs

POSTDOCTORAL POSITION
Centre for Astrophysics
University of Porto - Portugal

CAUP accepts candidates for **a post-doctoral position in Stellar Astrophysics**, namely in areas of circumstellar medium and young objects, stellar evolution and activity, and astro-tomography and inversion techniques. Priority will be given to candidates with experience in multi-wavelength observations.

The position is for one year with possible extension up to three years, and is expected to start in December 97. The deadline for applications is the **22nd of May**.

Applicants should forward curriculum vitae, list of publications, a brief description of past experience and of research interests and plans as well as the name/address of three referees.

Inquiries about the positions and CAUP can be directed to

Prof M.T.V.T. Lago (mtlago@astro.up.pt)

Centro de Astrofísica - UP

Rua do Campo Alegre 823

P-4150 Porto, PORTUGAL.

For more information see also "http://www.astro.up.pt/".

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/

New Books

Low Mass Star Formation - from Infall to Outflow

Edited by Alain Castets and Fabien Malbet

This book contains the more than 100 poster papers which were presented at IAU Symposium No. 182 *Herbig-Haro Flows and the Birth of Low Mass Stars*, which was held January 20 - 24, 1997 in Chamonix, France.

The book has now been placed on the web, from where you can download individual papers. The address is

http://laog.obs.ujf-grenoble.fr/meetings/iau182/posterbook

The Interplay between Massive Star formation, the ISM and Galaxy Evolution

edited by D. Kunth, B. Guiderdoni, M. Heydari-Malayeri and T.X. Thuan

Because of their large luminosities, massive stars are useful tracers of the current rate of massive star formation . Moreover they can do substantial damage to their surroundings, the interstellar medium (ISM) of galaxies,through their copious output of ultraviolet radiation, stellar winds and the fiery supernovae which result from their death. When large numbers of massive stars are gathered in one place, the collective energy input of the stars can produce shells, supershells , blowouts, galactic fountains, etc. This in turn affects the overall evolution of the galaxy where massive star formation is ongoing.

This book, which contains the proceedings of the 11th Astrophysics IAP meeting held from 3 to 8 July 1995 at the INSTITUT d'ASTROPHYSIQUE de PARIS, has for ambition to bring together 3 fields of research which have been in general discussed separately in the past, in spite of their intimate connections: massive star formation, their interaction with the surrounding ISM and galaxy evolution. Our ambition of bringing together researchers from these 3 fields was fraught with risks. The meeting could have degenerated into 3 separate sub-meetings with no real interdisciplinary exchanges. The meeting, as it went on, quickly dissipated our fears: more than 140 participants joined during a full week, the discussions were many and passionate, with a real spirit of learning from each other, vindicating our belief that real progress in the field can only be made with a multidisciplinary approach. That multidisciplinary spirit can be found in the review and poster papers found in this volume. The review papers discuss, among other topics, the latest findings on massive stars (including the high spatial resolution work with HST), superbubbles, superwinds, blowouts, galactic fountains, the large scale transport and mixing mechanisms in the ISM, the most recent models of the ISM, the IMF in starburst clusters, the star formation rate history in galaxies, and the latest models of galaxy formation and evolution. The book should be a valuable tool for any researcher seeking an unified view of the interplay between massive star formation, the ISM and galaxy evolution.

The book contains 656 pages, among which 10 color pages, and can be ordered from:

EDITIONS FRONTIERES
B.P. 33
91192 Gif-sur-Yvette Cedex
FRANCE

Tel: (33-1) 69 28 51 35
FAX: (33-1) 69 28 86 59

ISBN: 2-86332-194-3

Price: US$95 or FF 520