

# THE STAR FORMATION NEWSLETTER

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

No. 99 — 8 January 2001

Editor: Bo Reipurth (reipurth@casa.colorado.edu)

## *Abstracts of recently accepted papers*

### **Molecular Evolution in Collapsing Prestellar Cores**

**Y. Aikawa<sup>1</sup>, N. Ohashi<sup>2</sup>, S. Inutsuka<sup>3</sup>, E. Herbst<sup>4</sup> & S. Takakuwa<sup>2</sup>**

<sup>1</sup> Department of Earth and Planetary Sciences, Faculty of Science, Kobe University, Kobe 657-8501, Japan

<sup>2</sup> Academia Sinica Institute of Astronomy and Astrophysics, P.O. Box 1-87, Nankang, Taipei 115, Taiwan

<sup>3</sup> National Astronomical Observatory of Japan, Mitaka, Tokyo 181-8588, Japan

<sup>4</sup> Departments of Physics and Astronomy, The Ohio State University, Columbus, OH 43210, USA

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

We have investigated the evolution and distribution of molecules in collapsing prestellar cores via numerical chemical models, adopting the Larson-Penston solution and its delayed analogues to study collapse. Molecular abundances and distributions in a collapsing core are determined by the balance among the dynamical, chemical and adsorption time scales. When the central density  $n_{\text{H}}$  of a prestellar core with the Larson-Penston flow rises to  $3 \times 10^6 \text{ cm}^{-3}$ , the CCS and CO column densities are calculated to show central holes of radius 7000 AU and 4000 AU, respectively, while the column density of  $\text{N}_2\text{H}^+$  is centrally peaked. These predictions are consistent with observations of L1544. If the dynamical time scale of the core is larger than that of the Larson-Penston solution owing to magnetic fields, rotation, or turbulence, the column densities of CO and CCS are smaller, and their holes are larger than in the Larson-Penston core with the same central gas density. On the other hand,  $\text{N}_2\text{H}^+$  and  $\text{NH}_3$  are more abundant in the more slowly collapsing core. Therefore, molecular distributions can probe the collapse time scale of prestellar cores. Deuterium fractionation has also been studied via numerical calculations. The deuterium fraction in molecules increases as a core evolves and molecular depletion onto grains proceeds. When the central density of the core is  $n_{\text{H}} = 3 \times 10^6 \text{ cm}^{-3}$ , the ratio  $\text{DCO}^+/\text{HCO}^+$  at the center is in the range 0.06-0.27, depending on the collapse time scale and adsorption energy; this range is in reasonable agreement with the observed value in L1544.

Accepted by Ap. J.

[http://nova.planet.sci.kobe-u.ac.jp/~aikawa/paper\\_list.html](http://nova.planet.sci.kobe-u.ac.jp/~aikawa/paper_list.html)

### **Linear Analysis of the Hall Effect in Protostellar Disks**

**Steven A. Balbus<sup>1</sup> and Caroline Terquem<sup>2,3</sup>**

<sup>1</sup> Virginia Institute of Theoretical Astronomy, Department of Astronomy, University of Virginia, Charlottesville, VA 22903-0818, USA

<sup>2</sup> Institut d'Astrophysique de Paris, 98 bis Blvd. Arago, 74014 Paris, France

<sup>3</sup> Université Denis Diderot–Paris VII, 2 Place Jussieu, 75251 Paris Cedex 5, France

E-mail contact: sb@virginia.edu, terquem@iap.fr

The effects of Hall electromotive forces (HEMFs) on the linear stability of protostellar disks are examined. Earlier work on this topic focused on axial field and perturbation wavenumber geometry. Here we treat the problem more generally. Both axisymmetric and nonaxisymmetric cases are treated. Though seldom explicitly included in calculations, HEMFs appear to be important whenever Ohmic dissipation is. They allow for the appearance of electron whistler waves, and since these have right-handed polarization, a helicity factor is also introduced into the stability problem. This factor is the product of the components of the angular velocity and magnetic field along the perturbation wavenumber, and

it is destabilizing when negative. An important finding of our more general calculation is that unless the field and angular velocity are exactly aligned, it is always possible to find destabilizing wavenumbers. HEMFs can destabilize any differential rotation law, even those with angular velocity increasing outward. Regardless of the sign of the angular velocity gradient, the maximum growth rate is always given in magnitude by the local Oort A value of the disk, as in the standard magnetorotational instability. The role of Hall EMFs may prove crucial to understanding how turbulence is maintained in the “low state” of eruptive disk systems.

Accepted by Astrophysical Journal

Preprint available at <http://www.iap.fr/users/terquem/index.html>

## Constraints on Stirring and Dissipation of MHD Turbulence in Molecular Clouds

Shantanu Basu<sup>1</sup> and Chigurupati Murali<sup>2</sup>

<sup>1</sup> Department of Physics and Astronomy, University of Western Ontario, London, Ontario N6A 3K7, Canada

<sup>2</sup> Department of Astronomy, University of Massachusetts, Amherst, MA 01003-4525, USA

E-mail contact: [basu@astro.uwo.ca](mailto:basu@astro.uwo.ca)

We discuss constraints on the rates of stirring and dissipation of MHD turbulence in molecular clouds. Recent MHD simulations suggest that turbulence in clouds decays rapidly, thus providing a significant source of energy input, particularly if driven at small scales, by, for example, bipolar outflows. We quantify the heating rates by combining the linewidth-size relations, which describe global cloud properties, with numerically determined dissipation rates. We argue that, if cloud turbulence is driven on small internal scales, the <sup>12</sup>CO flux (enhanced by emission from weakly supersonic shocks) will be much larger than observed; this, in turn, would imply excitation temperatures significantly above observed values. We reach two conclusions: (1) small-scale driving by bipolar outflows cannot possibly account for cloud support and yield long-lived clouds, unless the published MHD dissipation rates are seriously overestimated; (2) driving on large scales (comparable to the cloud size) is much more viable from an energetic standpoint, and if the actual net dissipation rate is only slightly lower than what current MHD simulations estimate, then the observationally inferred lifetimes and apparent virial equilibrium of molecular clouds can be explained.

Accepted by ApJ (2001 April 10 issue)

Preprint available at <http://www.astro.uwo.ca/~basu/pub.html>

## Radio Spectral Indices of the Powering Sources of Outflows

Maria T. Beltrán<sup>1,2</sup>, Robert Estalella<sup>2</sup>, Guillem Anglada<sup>3</sup> Luis F. Rodríguez<sup>4</sup> and José M. Torrelles<sup>5</sup>

<sup>1</sup> Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA

<sup>2</sup> Departament d’Astronomia i Meteorologia, Universitat de Barcelona, Av. Diagonal 647, E-08028 Barcelona, Spain

<sup>3</sup> Instituto de Astrofísica de Andalucía, CSIC, Camino Bajo de Huétor 24, E-18008 Granada, Spain

<sup>4</sup> Instituto de Astronomía, UNAM, Apdo. Postal 72-3 (Xangari), 58089 Morelia, Michoacán, Mexico

<sup>5</sup> Institut d’Estudis Espacials de Catalunya (IEEC/CSIC) and Instituto de Ciencias del Espacio (CSIC), Edifici Nexus, Gran Capità 2-4, E-08034 Barcelona, Spain

E-mail contact: [mbeltran@cfa.harvard.edu](mailto:mbeltran@cfa.harvard.edu), [robert.estalella@am.ub.es](mailto:robert.estalella@am.ub.es)

Eight regions containing molecular or HH outflows (Mon R2E, S287, L1654, L483, PV Cephei, L1203, L1251A, and CB 247) have been observed with the VLA at 6 cm, and a total of 55 sources have been detected above a 5  $\sigma$  level. By combining our observations at 6 cm with previous data obtained at 3.6 cm, we estimate the spectral indices of the sources in the fields. For 32 of the sources we discriminate the sign of the spectral index and thus, we obtain information about the nature of the emission.

For seven outflows (Mon R2E, S287-B, L1654, L483, PV Cephei, L1203, and L1251A) we found at least a central source with an spectral index consistent with thermal free-free emission from thermal radio jets. Multiple sources, separated  $\sim 10''$ , are found near the center of the Mon R2E, S287-B, L1654, and L1251A outflows. In the case of S287-B we found two sources that are valid candidates to drive the S287-B molecular outflow, and could be related to the outflow excitation.

Under the assumption that the observed emission arises from thermal radio jets, we discuss the mechanism responsible

for the ionization and the constraints that introduces on their physical parameters, and we estimate that the flow of ionized material has to originate at a few AU from the exciting star. Most of the remaining, non-central, sources are characterized by negative spectral indices ( $\alpha < -0.1$ ), and are probably non-thermal background objects unrelated to the studied star-forming regions.

Accepted by Astron. Journal (March 2001 issue)

Preprint available at <http://www.am.ub.es/~robert/ISMpub.html>

## Helium Emission from Classical T Tauri stars: Dual Origin in Magnetospheric Infall and Hot Wind

Georgina Beristain<sup>1</sup>, Suzan Edwards<sup>2</sup> and John Kwan<sup>1</sup>

<sup>1</sup> Astronomy Department, University of Massachusetts, Amherst, Massachusetts 01003, USA

<sup>2</sup> Astronomy Department, Smith College, Massachusetts 01063, USA

E-mail contact: [sedwards@smith.edu](mailto:sedwards@smith.edu), [kwana@astro.umass.edu](mailto:kwana@astro.umass.edu)

High resolution emission line profiles of He I and He II in 31 classical T Tauri stars are analyzed with the aim of probing the environs of the star-disk interface in accreting low mass young stars. The diagnostic power of the helium lines lies in their high excitation potentials, which restrict their formation to a region either of high temperature or close proximity to a source of ionizing radiation. The He I profiles are decomposed into kinematic components that support the paradigm of magnetically controlled accretion from the disk onto the stellar surface but also require a significant contribution from a hot wind.

A *narrow component*, seen in 28/31 stars, is characterized by relatively uniform line widths and centroid velocities among all the helium lines. Our analysis supports previous conclusions that this feature is consistent with formation in the decelerating post-shock gas at the magnetosphere footpoint. A *broad component*, seen in 22/31 stars, displays a diversity of kinematic properties. Our analysis suggests that in many stars the He I broad component is itself composite. At one extreme are stars where the broad component is redshifted in excess of  $8 \text{ km s}^{-1}$ , as would occur if helium emission arises primarily from polar angles  $< 54.7^\circ$  in the funnel flow. At the other extreme are stars where the broad component is blueshifted in excess of  $-30 \text{ km s}^{-1}$ , requiring an origin in outflowing gas. The additional occurrence of maximum blue wing velocities exceeding  $-200 \text{ km s}^{-1}$  in 14 stars leads us to argue that hot winds are present in about half of our sample.

The relation between the narrow component and the optical veiling differs between the stars with or without a hot helium wind, suggesting that when the hot wind is present the luminosity and temperature of the accretion shock are reduced. A comparison of broad component helium emission with standard outflow indicators leads us to suggest that there are two sources of inner wind in T Tauri accretion disk systems— one a hot polar/coronal wind that prevails in stars with high veiling and the other a more widespread cool disk wind that is likely launched at the magnetosphere/disk boundary.

Accepted by Astrophysical Journal

preprints available at <http://earth.ast.smith.edu/preprint/>

## Competitive accretion in embedded stellar clusters

Ian A. Bonnell<sup>1</sup>, M. R. Bate<sup>2</sup>, C. J. Clarke<sup>2</sup> and J. E. Pringle<sup>2</sup>

<sup>1</sup> School of Physics and Astronomy, University of St Andrews, North Haugh, St Andrews, Fife, KY16 9SS, UK

<sup>2</sup> Institute of Astronomy, Madingley Road, Cambridge, CB3 0HA, UK

E-mail contact: [iab1@st-andrews.ac.uk](mailto:iab1@st-andrews.ac.uk)

We investigate the physics of gas accretion in young stellar clusters. Accretion in clusters is a dynamic phenomenon as both the stars and the gas respond to the same gravitational potential. Accretion rates are highly non-uniform with stars nearer the centre of the cluster, where gas densities are higher, accreting more than others. This competitive accretion naturally results in both initial mass segregation and a spectrum of stellar masses. Accretion in gas-dominated clusters is well modelled using a tidal-lobe radius instead of the commonly used Bondi-Hoyle accretion radius. This works as both the stellar and gas velocities are under the influence of the same gravitational potential and are thus

comparable. The low relative velocity that results means that  $R_{\text{tidal}} < R_{\text{BH}}$  in these systems. In contrast, when the stars dominate the potential and are virialised,  $R_{\text{BH}} < R_{\text{tidal}}$  and Bondi-Hoyle accretion is a better fit to the accretion rates.

Accepted by MNRAS

<http://star-www.st-and.ac.uk/astronomy>

## Accretion in stellar clusters and the IMF

Ian A. Bonnell<sup>1</sup>, C. J. Clarke<sup>2</sup>, M. R. Bate<sup>2</sup> and J. E. Pringle<sup>2</sup>

<sup>1</sup> School of Physics and Astronomy, University of St Andrews, North Haugh, St Andrews, Fife, KY16 9SS, UK

<sup>2</sup> Institute of Astronomy, Madingley Road, Cambridge CB3 0HA, UK

E-mail contact: [iab1@st-andrews.ac.uk](mailto:iab1@st-andrews.ac.uk)

We present a simple physical mechanism that can account for the observed stellar mass spectrum for masses  $M_* \gtrsim 0.5M_{\odot}$ . The model depends solely on the competitive accretion that occurs in stellar clusters where each star's accretion rate depends on the local gas density and the square of the accretion radius. In a stellar cluster, there are two different regimes depending on whether the gas or the stars dominate the gravitational potential. When the cluster is dominated by cold gas, the accretion radius is given by a tidal-lobe radius. This occurs as the cluster collapses towards a  $\rho \propto R^{-2}$  distribution. Accretion in this regime results in a mass spectrum with an asymptotic limit of  $\gamma = -3/2$  (where Salpeter is  $\gamma = -2.35$ ). Once the stars dominate the potential and are virialised, which occurs first in the cluster core, the accretion radius is the Bondi-Hoyle radius. The resultant mass spectrum has an asymptotic limit of  $\gamma = -2$  with slightly steeper slopes ( $\gamma \approx -2.5$ ) if the stars are already mass-segregated. Simulations of accretion onto clusters containing 1000 stars show that as expected, the low-mass stars accumulate the majority of their masses during the gas dominated phase whereas the high-mass stars accumulate the majority of their mass during the stellar dominated phase. This results in a mass spectrum with a relatively shallow  $\gamma \approx 3/2$  power-law for low-mass stars and a steeper, power-law for high-mass stars  $-2.5 \lesssim \gamma \leq -2$ . This competitive accretion model also results in a mass segregated cluster.

Accepted by MNRAS

<http://star-www.st-and.ac.uk/astronomy>

## The CIDA-QUEST Large Scale Survey of Orion OB1: Evidence for rapid disk dissipation in a dispersed stellar population

César Briceño<sup>1</sup>, A. Katherina Vivas<sup>2</sup>, Nuria Calvet<sup>3,1</sup>, Lee Hartmann<sup>3</sup>, Ricardo Pacheco<sup>1,5</sup>, David Herrera<sup>1</sup>, Lysett Romero<sup>1</sup>, Perry Berlind<sup>3</sup>, Gerardo Sánchez<sup>1</sup>, Jeffrey A. Snyder<sup>4,2</sup> and Peter Andrews<sup>4</sup>

<sup>1</sup> Centro de Investigaciones de Astronomía, Apartado Postal 264, Mérida 5101-A, Venezuela

<sup>2</sup> Astronomy Department, Yale University, P.O. Box 208101, New Haven, CT 06520-8101, USA

<sup>3</sup> Smithsonian Astrophysical Observatory, Mail Stop 42, 160 Concord Av., Cambridge, MA 02138, USA

<sup>4</sup> Physics Department, Yale University, P.O. Box 208121, New Haven, CT 06520-8121, USA

<sup>5</sup> Departamento de Física, Universidad de los Andes, Conjunto La Hechicera, Edif. "A", Mérida 5101, Venezuela

E-mail contact: [briceno@cida.ve](mailto:briceno@cida.ve)

We are conducting a large scale, multiepoch, optical photometric survey covering  $\sim 120$  square degrees to identify the young low mass stars in the Orion OB1 association. We present results for a 34 square degree area. Using photometric variability as our main selection criterion, as well as follow-up spectroscopy, we have confirmed 168 previously unidentified pre-main sequence  $\sim 0.6 - 0.9 M_{\text{odot}}$  stars, with ages  $\sim 1 - 3$  million yr (Ori OB1b) and  $\sim 3 - 10$  million yr (Ori OB1a). The low mass stars are spatially coincident with the high mass ( $\gtrsim 3 M_{\text{odot}}$ ) members of the associations. Indicators of disk accretion such as H $\alpha$  emission and near-infrared emission from dusty disks fall sharply from Ori 1b to Ori 1a, indicating that the time scale for disk dissipation and possibly the onset of planet formation is a few million years.

Accepted by Science

## VLA HI Zeeman Observations Toward the W49 Complex

C. L. Brogan<sup>1</sup>, and T. H. Troland<sup>2</sup>

<sup>1</sup> National Radio Astronomy Observatory, P.O. Box 0, Socorro, NM, 87801, USA

<sup>2</sup> University of Kentucky, 177 Chem-Phys Bldg, Lexington, KY 40506-0055, USA

E-mail contact: cbrogan@aoc.nrao.edu

We report VLA HI Zeeman observations toward the W49A star-forming region and the SNR W49B. Line of sight magnetic fields ( $B_{los}$ ) of 60 to 300  $\mu\text{G}$  at 25" resolution were detected toward W49A at velocities of  $\sim 4 \text{ km s}^{-1}$  and  $\sim 7 \text{ km s}^{-1}$ . The  $B_{los}$  values measured toward W49A show a significant *increase in field strength with higher resolution* especially for the  $\sim 4 \text{ km s}^{-1}$  HI component. The HI gas in the velocity range  $-5$  to  $25 \text{ km s}^{-1}$  toward W49A shows good agreement both kinematically and spatially with molecular emission intrinsically associated with W49A. Based on comparisons with molecular data toward W49A, we suggest that the  $\sim 4 \text{ km s}^{-1}$  HI component is directly associated with the northern part of the H II region ring, while the  $\sim 7 \text{ km s}^{-1}$  HI component seems to originate in a lower density halo surrounding W49A. We estimate that the W49A North core is significantly subvirial ( $2T/|W| \sim 0.2$ ), and that the total kinetic + magnetic energies amount to less than 1/3 of the total W49A North gravitational energy. These magnetic field results suggest that W49A North is unstable to overall gravitational collapse in agreement with evidence that the halo is collapsing onto the W49A North ring of H II regions.

The majority of the HI column density toward W49B comes from Sagittarius Arm clouds along the line of sight at  $\sim 40 \text{ km s}^{-1}$  and  $\sim 60 \text{ km s}^{-1}$ . No significant magnetic fields were detected toward W49B. Comparison of the spectral distribution of HI gas toward W49A and W49B suggests that evidence placing W49B 3 kpc closer to the sun (i.e. at 8 kpc) than W49A is quite weak. Although we cannot place W49B at the same distance as W49A, we find the morphology of a  $\sim 5 \text{ km s}^{-1}$  HI component toward the southern edge of W49B suggestive of an interaction.

Accepted by ApJ

<http://www.aoc.nrao.edu/cbrogan/publications.html>

## Evidence for Residual Material in Accretion Disk Gaps: CO Fundamental Emission from the T Tauri Spectroscopic Binary DQ Tau

John S. Carr<sup>1</sup>, Robert D. Mathieu<sup>2</sup> and Joan R. Najita<sup>3</sup>

<sup>1</sup> Naval Research Laboratory, Code 7213, Washington, DC 20375, USA

<sup>2</sup> Dept. of Astronomy, University of Wisconsin, Madison, WI 53706, USA

<sup>3</sup> National Optical Astronomy Observatories, 950 N. Cherry Ave., Tucson, AZ 85719, USA

E-mail contact: carr@mriga.nrl.navy.mil

We present the discovery of CO fundamental ro-vibrational emission from the classical T Tauri spectroscopic binary DQ Tau. The high-resolution infrared echelle spectra reveal emission lines from both the  $v=1$  and  $v=2$  vibrational levels with line widths of roughly  $70 \text{ km s}^{-1}$ . The average CO excitation temperature is approximately 1200 K. We model the spectra as arising from gas in Keplerian rotation about the center-of-mass of the binary. The disk model requires gas with an average surface density of  $5 \times 10^{-4} \text{ g cm}^{-2}$  that extends outward to  $0.5 \pm 0.1 \text{ AU}$  and inward to at least  $0.1 \text{ AU}$  from the center-of-mass. The radial extent for the emitting gas is close to the predicted size of the gap in the DQ Tau accretion disk that is expected to be dynamically cleared by the binary. We interpret these results, and previous modeling of DQ Tau's spectral energy distribution, as evidence for a small amount ( $\approx 10^{-10} M_{\odot}$ ) of diffuse material residing within the optically-thin disk gap. Thus dynamical clearing has not been completely efficient in the DQ Tau binary. We suggest that the material is associated with a flow from the circumbinary disk which feeds the ongoing accretion at the stellar surfaces.

Accepted by Astrophysical Journal

<http://xxx.lanl.gov/abs/astro-ph/0101059>

## The Deceleration of Giant Herbig-Haro Flows

Elisabete M. de Gouveia Dal Pino<sup>1</sup>

<sup>1</sup> Instituto Astronômico e Geofísico, Universidade de São Paulo, Av. Miguel Stéfano, 4200, São Paulo 04301-904, SP, Brazil

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

It has been recently discovered that spatially separated Herbig-Haro objects, once considered unrelated, are linked within a chain that may extend for parsecs in either direction of the embedded protostar forming a *giant Herbig-Haro jet*. Presently, several dozen of these giant flows have been detected and the best documented example, the HH 34 system, shows a systematic velocity decrease with distance on either side of the source. In this paper, we have modeled giant jets by performing fully three-dimensional simulations of overdense, radiatively cooling jets modulated with long-period ( $P \sim$  several hundred years) and large amplitude sinusoidal velocity variability at injection ( $\Delta v \sim$  mean jet flow velocity). Allowing them to travel over a distance well beyond the source, we have found that multiple travelling pulses develop and their velocity indeed falls off smoothly and systematically with distance. This deceleration is fastest if the jet is pressure-confined, in which case the falloff in velocity is roughly consistent with the observations. The deceleration occurs as momentum is transferred by gas expelled sideways from the traveling pulses.

The simulation of a pressure-confined, steady-state jet with similar initial conditions to those of the pulsed jet shows that the flow in this case experiences *acceleration*. This result is thus an additional indication that the primary source of deceleration in the giant flows *cannot* be attributed to braking of the jet head against the external medium.

Accepted by ApJ (vol. 541)

## The Spatial Distribution of the $\lambda$ Orionis Pre-Main-Sequence Population

Christopher J. Dolan and Robert D. Mathieu

Department of Astronomy, University of Wisconsin–Madison, 475 North Charter Street, Madison, WI 53706, USA

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

The  $\lambda$  Ori star-forming region presents a snapshot of a moderate-mass giant molecular cloud 1–2 Myr after cloud disruption by OB stars, with the OB stars, the low-mass stellar population, remnant molecular clouds, and the dispersed gas all still present. We have used optical photometry and multi-object spectroscopy for lithium absorption to identify 266 PMS stars in 8 degrees<sup>2</sup> of the region. We also present new Strömgren photometry for the massive stars, from which we derive a distance of 450 pc and a turnoff age of 6–7 Myr. Using these parameters and pre-main-sequence evolutionary models, we map the star-formation history of the low-mass stars. We find that low-mass star formation started throughout the region at about the same time as the birth of the massive stars, and thereafter the birth rate accelerated. Within the last 1–2 Myr star-formation ceased in the center of the star-forming region, near the concentration of OB stars, while it continues in dark clouds 20 pc away. We suggest that a supernova 1–2 Myr ago destroyed the molecular cloud core from which the OB stars formed, but did not terminate star formation in more distant reaches of the giant molecular cloud. We find no secure evidence for triggered or sequential star formation in the outer molecular clouds. The global star formation of the  $\lambda$  Ori region has generated the field IMF, but local star formation in sub-regions shows large deviations from the expected ratio of high- to low-mass stars.

Accepted by Astron. J.

<http://www.astro.wisc.edu/~dolan/thesis/>

## Laboratory and astrophysical detection of the hyperfine structure of the $J = 1 - 0$ rotational transition of $\text{HC}^{17}\text{O}^+$

L. Dore<sup>1</sup>, G. Cazzoli<sup>1</sup> and P. Caselli<sup>3</sup>

<sup>1</sup> Dipartimento di Chimica "G. Ciamician", Università di Bologna, via Selmi 2, I-40126 Bologna, Italy

<sup>2</sup> Osservatorio Astrofisico di Arcetri, Largo E. Fermi 5, I-50125 Firenze, Italy

E-mail contact: dore@ciam.unibo.it

The three hyperfine components of the  $J = 1 \leftarrow 0$  rotational transition of  $\text{HC}^{17}\text{O}^+$  have been resolved in laboratory leading to a value of the quadrupole coupling constant  $eQq$  of 4.595 MHz, which is far below the previous estimate of an upper limit of 12 MHz by Guélin et al. (1982). The  $\text{HC}^{17}\text{O}^+$  (1–0) spectrum has been observed toward the "molecular peak" of L1544 and analyzed on the basis of the laboratory hyperfine frequencies.

Accepted by A&A

<http://www.arcetri.astro.it/~starform/publ2000.htm>

## Fractal Structure in Galactic Star Fields

Bruce G. Elmegreen<sup>1</sup>, and Debra Meloy Elmegreen<sup>2</sup>

<sup>1</sup> IBM Research Division, T.J. Watson Research Center, P.O. Box 218, Yorktown Heights, NY 10598, USA

<sup>2</sup> Department of Physics and Astronomy, Vassar College, Poughkeepsie, NY 12604, USA

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

The fractal structure of star formation on large scales in disk galaxies is studied using the size distribution function of stellar aggregates in kpc-scale star fields. Archival HST images of 10 galaxies are Gaussian smoothed to define the aggregates, and a count of these aggregates versus smoothing scale gives the fractal dimension. Fractal and Poisson models confirm the procedure. The fractal dimension of star formation in all of the galaxies is  $\sim 2.3$ . This is the same as the fractal dimension of interstellar gas in the Milky Way and nearby galaxies, suggesting that star formation is a passive tracer of gas structure defined by self-gravity and turbulence. Dense clusters like the Pleiades form at the bottom of the hierarchy of structures, where the protostellar gas is densest. If most stars form in such clusters, then the fractal arises from the spatial distribution of their positions, giving dispersed star fields from continuous cluster disruption. Dense clusters should have an upper mass limit that increases with pressure, from  $\sim 10^3 M_{\odot}$  in regions like the Solar neighborhood to  $\sim 10^6 M_{\odot}$  in starbursts.

Accepted by Astron. J. March 2001, Vol 121

## Molecular Carbon Chains and Rings in TMC-1

David Fossé<sup>1,2</sup>, José Cernicharo<sup>1</sup>, Maryvonne Gerin<sup>2</sup>, and Pierre Cox<sup>3</sup>

<sup>1</sup> Depto Física Molecular, I.E.M., C.S.I.C., Serrano 121, E-28006 Madrid, Spain

<sup>2</sup> L.R.A., Observatoire de Paris & Ecole Normale Supérieure, 24 rue Lhomond, F-75231 Paris Cedex 05, France

<sup>3</sup> I.A.S., Université Paris-Sud, bâtiment 121, F-91405 Orsay, France

E-mail contact: David.Fosse@lra.ens.fr

We present mapping results in several rotational transitions of  $\text{HC}_3\text{N}$ ,  $\text{C}_6\text{H}$ , both cyclic and linear  $\text{C}_3\text{H}_2$  and  $\text{C}_3\text{H}$ , towards the cyanopolyne peak of the filamentary dense cloud TMC-1 using the IRAM 30m and MPIFR 100m telescopes. The spatial distribution of the cumulene carbon chain propadienyliene  $\text{H}_2\text{CCC}$  (hereafter  $l\text{-C}_3\text{H}_2$ ) is found to deviate significantly from the distributions of the cyclic isomer  $c\text{-C}_3\text{H}_2$ ,  $\text{HC}_3\text{N}$ , and  $\text{C}_6\text{H}$  which in turn look very similar. The cyclic over linear abundance ratio of  $\text{C}_3\text{H}_2$  increases by a factor of 3 across the filament, with a value of 28 at the cyanopolyne peak. This abundance ratio is an order of magnitude larger than the range (3 to 5) we observed in the diffuse interstellar medium. The cyclic over linear abundance ratio of  $\text{C}_3\text{H}$  also varies by  $\sim 2.5$  in TMC-1, reaching a maximum value (13) close to the cyanopolyne peak. These behaviors might be related to competitive processes between ion-neutral and neutral-neutral reactions for cyclic and linear species.

Accepted by ApJ

<http://arXiv.org/archive/astro-ph>

## Disks and outflows around intermediate-mass stars and protostars

A. Fuente<sup>1</sup>, R. Neri<sup>2</sup>, J. Martín-Pintado<sup>1</sup>, R. Bachiller<sup>1</sup>, A. Rodríguez-Franco<sup>1</sup>, F. Palla<sup>3</sup>

<sup>1</sup> Observatorio Astronómico Nacional (IGN), Campus Universitario, Apdo. 1143, E-28800 Alcalá de Henares (Madrid), Spain

<sup>2</sup> Institut de Radioastronomie Millimétrique (IRAM), 300 rue de la Piscine, Domaine Universitaire, F-38406 St Martin d'Hères Cedex, France

<sup>3</sup> Osservatorio Astrofisico di Arcetri, Largo Enrico Fermi, 5 I-50125 Firenze, Italy

E-mail contact: fuente@oan.es

In order to study the existence and evolution of circumstellar disks around intermediate-mass stars ( $M_{*} \geq 3 M_{\odot}$ ), we have obtained single-dish and interferometric continuum images at 2.6mm and 1.3mm of the intermediate-mass protostar NGC 7129 FIRS 2 and of the Herbig Be stars LkH $\alpha$  234 and HD 200775. These objects are representative of the different stages of the pre-main sequence evolution with ages ranging from a few  $10^3$  to  $8 \times 10^6$  years. Single-dish and interferometric observations of the outflows associated with these sources are also presented.

In NGC 7129 FIRS 2, two millimeter sources are required to fit the interferometric 1.3mm continuum emission. Only the most intense of these millimeter objects, FIRS 2 - MM1, seems to be associated with the CO outflow. The second and weaker source, FIRS 2 - MM2, does not present any sign of stellar activity. The single-dish map of the CO outflow presents an unusual morphology with the blue and red lobes separated by an angle of 82deg. The CO J=1→0 interferometric image shows that this unusual morphology is the result of the superposition of two outflows, one of them associated with FIRS 2 - MM1 (the blue lobe in the single-dish map) and the other (the red lobe) with a new infrared source (FIRS 2 - IR) which is not detected in the millimeter continuum images.

The interferometric 1.3mm continuum image of NGC 7129 FIRS 1 reveals that LkH $\alpha$  234 is a member of a cluster of embedded objects. Two millimeter clumps are detected in this far-infrared source. The strongest is spatially coincident with the mid-infrared companion of LkH  $\alpha$  234, IRS 6. A new millimeter clump, FIRS 1 - MM1, is detected at an offset (-3.23'', 3.0'') from LkH $\alpha$  234. We have not detected any compact source towards LkH $\alpha$  234 with a limit for the mass of a circumstellar disk,  $M_D < 0.1 M_\odot$ . The comparison of the interferometric CO J=1→0 and continuum images reveals that IRS 6 very likely drives the energetic molecular outflow detected towards NGC 7129 FIRS 1 and the [SII] jet. The extremely young object FIRS 1 - MM1 (it has not been detected in the near- and mid-infrared) turns out to be the driving source of the H $_2$  jet. There is no evidence for the existence of a bipolar outflow associated with LkH $\alpha$  234.

We have not detected 1.3mm continuum emission towards HD 200775. Our observations imply a 3- $\sigma$  upper limit of  $< 0.002 M_\odot$  for the mass of a circumstellar disk. This is the lowest upper limit obtained so far in a Herbig Be star.

Thus our observations provide new important information on three protostars (IRS 6, FIRS 1 - MM1 and FIRS 2 - MM1), one infrared star (FIRS 2 - IR) and two Herbig Be stars. The luminosities of the protostars are consistent with being intermediate-mass objects ( $M_* \sim 3.5 - 4.5 M_\odot$ ). They are surrounded by thick envelopes with masses ranging between  $\sim 2 - 3.5 M_\odot$  and drive energetic outflows.

Circumstellar disks and bipolar outflows are not detected toward the Herbig Be stars. We have obtained an upper limit for the disk/stellar mass ratio,  $M_D/M_*$ , of  $< 0.02$  in LkH $\alpha$  234 and of  $< 0.0002$  in HD 200775. Our limit in HD 200775 implies that in evolved Herbig Be stars the  $M_D/M_*$  ratio is more than two orders of magnitude lower than in T Tauri and Herbig Ae stars. We propose that in massive stars ( $M_* \geq 5 M_\odot$ ) both the dispersal of the outer disk and the energetic mass-loss, occur early in the stellar evolution before the star becomes visible. Some mechanisms for the dispersal of the outer disk are discussed.

Accepted by Astronomy & Astrophysics

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

## Circumstellar medium around close southern PMS binaries. New results with the ESO ADONIS + COMIC/SHARP infrared system

H. Geoffroy<sup>1,3</sup> and J.-L. Monin<sup>1,2</sup>

<sup>1</sup> Laboratoire d'Astrophysique, Observatoire de Grenoble, Université Joseph Fourier, BP 53, 38041 Grenoble Cedex, France <sup>2</sup> Institut Universitaire de France

<sup>3</sup> CNES, 18 Av. E. Belin, 31400 Toulouse, France

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

We have started a series of high angular resolution observations of close southern pre Main-Sequence (PMS) binary systems in order to study their respective photometry from 1 to 5 $\mu$ m. For most of the binaries of our sample, we present the first near infrared (NIR) measurements longward of 3 $\mu$ m on both components. From these measurements we characterize the stellar Spectral Energy Distribution (SED) of the primary and its companion, adjust standard photospheres to estimate their luminosities & temperatures, hence masses & ages through the use of an HR Diagram. At the same time, we study the presence of circumstellar material around our PMS targets, in order to assess how the eventually leftover material is distributed after contraction. We find the same proportion of mixed systems (W/C TTS) as in the overall southern clouds; all the W/W TTS systems appear in close ( $< 60$  AU) binaries ; apart from one of the most separated binaries, all the objects appear coeval; the mass ratio increases in mixed systems.

Accepted by Astronomy and Astrophysics

<http://www-laog.obs.ujf-grenoble.fr/activites/starform/formation.html>



## A Mid-Infrared Study of the Young Stellar Population in the NGC 2024 Cluster

Karl E. Haisch Jr.<sup>1</sup>, Elizabeth A. Lada<sup>1</sup>, Robert K. Piña,<sup>1</sup> Charles M. Telesco<sup>1</sup> and Charles J. Lada<sup>2</sup>

<sup>1</sup> University of Florida, Dept. of Astronomy, 211 SSRB, Gainesville, Florida 32611, USA

<sup>2</sup> Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, Massachusetts 02138, USA

E-mail contact: haisch@astro.ufl.edu

We present the results of the first broadband  $N$  ( $10.8 \mu\text{m}$ ) survey of the NGC 2024 cluster. The mid-infrared data were combined with our previously published  $JHKL$  photometry in order to construct spectral energy distributions (SEDs) for all detected sources. The main scientific goals were to investigate the nature of the young stellar objects (YSOs) in the cluster, and to examine the efficiency of detecting circumstellar disk sources from near-infrared  $JHKL$  color-color diagrams. Out of 59 sources surveyed having  $K$  band ( $2.2 \mu\text{m}$ ) magnitudes  $m_K \leq 10.5$ , we detected 35 ( $\sim 59\%$ ) at  $10 \mu\text{m}$ . Combining these detections, and upper limits for the nondetections, with existing  $JHKL$  data, we identify 1 Class I, 6 flat spectrum, 28 Class II and 5 Class III sources. We find a circumstellar disk fraction for NGC 2024 of  $\sim 85\% \pm 15\%$ , which confirms earlier published suggestions that the majority, if not all, of the stars in the NGC 2024 cluster formed with disks, and these disks still exist at the present time. In addition, all but one of the disk sources identified in our survey lie in the infrared excess region of the  $JHKL$  color-color diagram for the NGC 2024 cluster. This demonstrates that  $JHKL$  color-color diagrams are extremely efficient in identifying YSOs with circumstellar disks. Of the 14 sources in our survey with  $K - L$  colors suggestive of protostellar objects,  $\sim 29\%$  are protostellar in nature, while  $\sim 7\%$  are true Class I sources. This may be due to extinction producing very red  $K - L$  colors in Class II YSOs, thus making them appear similar in color to protostars. This suggests caution must be applied when estimating the sizes and lifetimes of protostellar populations within star forming regions based on  $K - L$  colors alone. A comparison of the ratio of (Class I + flat spectrum)/(Class II + Class III) sources in NGC 2024,  $\rho$  Oph, and Taurus-Auriga indicates that NGC 2024 and  $\rho$  Oph have similar ages, while Taurus-Auriga is an older region of star formation, consistent with published T Tauri star ages in each region. Finally, we calculate the luminosities of the Class II sources in NGC 2024,  $\rho$  Oph and Taurus and discuss the results.

Accepted by Astron. J.

Preprints available from astro-ph/0012482

## The $\eta$ Chamaeleontis cluster: photometric study of the *ROSAT*-detected weak-lined T Tauri stars

Warrick A. Lawson<sup>1</sup>, Lisa A. Crause<sup>2</sup>, Eric E. Mamajek<sup>3</sup> and Eric D. Feigelson<sup>4</sup>

<sup>1</sup> School of Physics, University College UNSW, Australian Defence Force Academy, Canberra ACT 2600, Australia

<sup>2</sup> Department of Astronomy, University of Cape Town, Private Bag, Rondebosch 7700, South Africa

<sup>3</sup> Steward Observatory, University of Arizona, 933 N Cherry Avenue, Tucson AZ 85721, USA

<sup>4</sup> Department of Astronomy and Astrophysics, Pennsylvania State University, University Park PA 16802, USA

E-mail contact: wal@ph.adfa.edu.au

We present the results of a photometric study of X-ray-active weak-lined T Tauri (WTT) stars in the  $\eta$  Chamaeleontis star cluster. Multi-epoch  $V$ -band photometric monitoring during 1999 and 2000 of the 10 X-ray-active WTT stars found that all were variable in one or both years, with periods ascribed to rotational modulation of starspots. Comparison between the rotational and X-ray properties of these objects indicates the saturation level,  $\log(L_X/L_{\text{bol}}) \approx -3$ , observed in other studies of X-ray-active pre-main-sequence stars, persists in the  $\eta$  Cha stars from the slow- to the fast-rotator regimes. Cousins  $VRI$  photometry of the WTT stars has enabled us to further investigate the photometric properties of these stars. The stars appear sufficiently coeval to distinguish near-equal-mass binaries within the sample. A new Hertzsprung-Russell diagram for these objects suggests ages of 4 – 9 Myr for M-type RECX primaries using the tracks of D’Antona & Mazzitelli.

Accepted by MNRAS

# On the Similarity of FU Orionis Stars to Class I Protostars: Evidence from the Submillimeter

Göran Sandell<sup>1,2</sup>, David A. Weintraub<sup>3</sup>

<sup>1</sup> National Radio Astronomy Observatory, P.O. Box 2, Green Bank, West Virginia 24944, U.S.A.

<sup>2</sup> Current address: USRA, NASA Ames Research Center, MS 144-2, Moffett Field, CA 94035, U.S.A.

<sup>3</sup> Department of Physics & Astronomy, Vanderbilt University, P.O. Box 1807 Station B, Nashville, TN 37235, U.S.A.

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

On the basis of analysis of new submillimeter maps of a sample of most known FU Orionis stars, we confirm that these stars are extremely young, more similar to Class I protostars than to Class II T Tauri stars. The submillimeter maps reveal that FU Orionis stars have accretion disks that are larger and contain an order of magnitude more mass than those of T Tauri stars but are comparable in mass to those seen around Class I sources. The disks around the FU Orionis stars are sufficiently massive to act as reservoirs of material for replenishing the mass of the disks after eruptions, in which large amounts of material are believed to fall onto the underlying stars. We have identified a number of FU Orionis stars that are surrounded by extended cloud emission and in several cases we find nearby submillimeter sources that have no optical or near-infrared counterparts. These sources most likely are young protostellar Class I or Class 0 sources. In at least in one case, V 1735 Cyg, the dominant submillimeter source is the protostar, not the optically visible FU Orionis star.

Accepted by Astrophysical Journal Supplement

## Destruction of protoplanetary disks in the Orion Nebula Cluster

Aylwyn Scally<sup>1</sup> and Cathie Clarke<sup>1</sup>

<sup>1</sup> Institute of Astronomy, Madingley Road, Cambridge CB3 0HA, England

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

We use numerical  $N$ -body simulations of the Orion Nebula Cluster (ONC) to investigate the destruction of protoplanetary disks by close stellar encounters and UV radiation from massive stars. The simulations model a cluster of 4000 stars, and we consider separately cases in which the disks have fixed radii of 100 AU and 10 AU. In the former case, depending on a star's position and orbit in the cluster over  $10^7$  years, UV photoevaporation removes at least  $0.01 M_{\odot}$  from its disk, and can remove up to  $1 M_{\odot}$ . We find no dynamical models of the ONC consistent with the suggestion of Störzer and Hollenbach (1999) that the observed distribution and abundance of proplyds could be explained by a population of stars on radial orbits which spend relatively little time near  $\theta^1$ C Ori (the most massive star in the ONC). Instead the observations require either massive disks (e.g. a typical initial disk mass of  $0.4 M_{\odot}$ ) or a very recent birth for  $\theta^1$ C Ori. When we consider the photoevaporation of the inner 10 AU of disks in the ONC, we find that planet formation would be hardly affected. Outside that region, planets would be prevented from forming in about half the systems, unless either the initial disk masses were very high (e.g.  $0.4 M_{\odot}$ ) or they formed quickly (in less than  $\sim 2$  Myr) and  $\theta^1$ C Ori has only very recently appeared.

We also present statistics on the distribution of minimum stellar encounter separations. This peaks at 1000 AU, with only about 4 per cent of stars having had an encounter closer than 100 AU at the cluster's present age, and less than 10 per cent after  $10^7$  years. We conclude that stellar encounters are unlikely to play a significant role in destroying protoplanetary disks. In the absence of any disruption mechanism other than those considered here, we would thus predict planetary systems like our own to be common amongst stars forming in ONC-like environments.

Also, although almost all stars will have experienced an encounter at the radius of the Oort cloud in our own system, this only places a firm constraint on the possible birthplace of the Sun if the Oort cloud formed in situ, rather than through the secular ejection of matter from the planetary zone.

Accepted by Mon. Not. R. Astron. Soc.

## Chandra Observations of Variable Embedded X-ray sources in Orion. Paper I: Resolving the Orion Trapezium

N.S. Schulz<sup>1</sup>, C. Canizares<sup>1</sup>, D. Huenemoerde<sup>1</sup>, J.H. Kastner<sup>2</sup>, S.C. Taylor<sup>1</sup> and E.J. Bergstrom<sup>2</sup>

<sup>1</sup> Center for Space Research, Massachusetts Institute of Technology, Cambridge MA02139, USA

<sup>2</sup> Chester F. Carlson Center for Imaging Science, Rochester Institute of Technology, Rochester NY 14623, USA

E-mail contact: nss@space.mit.edu

We used the High Energy Transmission Grating Spectrometer (HETGS) onboard the Chandra X-ray Observatory to perform two observations, separated by three weeks, of the Orion Trapezium region. The zeroth order images on the Advanced CCD Imaging Spectrometer (ACIS) provide spatial resolution of 0.5" and moderate energy resolution. Within a 160"x140" region around the Orion Trapezium we resolve 111 X-ray sources with luminosities between  $7 \times 10^{28}$  erg/sec and  $2 \times 10^{32}$  erg/sec. We do not detect any diffuse emission. All but six sources are identified. From spectral fits of the three brightest stars in the Trapezium we determine the line of sight column density to be  $N_H = 1.93 \pm 0.29 \times 10^{21} \text{ cm}^{-2}$ . Many sources appear much more heavily absorbed, with  $N_H$  in the range of  $10^{22}$  to  $10^{23} \text{ cm}^{-2}$ . A large fraction of sources also show excursions in luminosity by more than a factor 5 on timescales  $>50$  ks; many are only detected in one of the observations.

The main objective of this paper is to study the Orion Trapezium and its close vicinity. All five Trapezium stars are bright in X-rays, with  $\theta^1$  Ori C accounting for about 60% of the total luminosity of the Trapezium. The CCD spectra of the three very early type members can be fit with a two-temperature thermal spectrum with a soft component of  $kT \sim 0.8$  keV and a hard component of  $kT \sim 2$  to 3 keV.  $\theta^1$  Ori B is an order of magnitude fainter than  $\theta^1$  Ori E and shows only a hard spectrum of  $kT \sim 3$  keV.  $\theta^1$  Ori D is another order of magnitude fainter than  $\theta^1$  Ori B, with only a  $kT \sim 0.7$  keV component. We discuss these results in the context of stellar wind models.

We detect eight additional, mostly variable X-ray sources in the close vicinity of the Trapezium. They are identified with thermal and non-thermal radio sources, as well as infrared and optical stars. Five of these X-rays sources are identified with proplyds and we argue that the X-ray emission originates from class I, II and III protostars at the cores of the proplyds.

Accepted by the Astrophysical Journal

preprint on: <http://space.mit.edu/nss/orion/orion.html>

## Free floating planets in stellar clusters?

Kester W. Smith<sup>1,2</sup> & Ian A. Bonnell<sup>3</sup>

<sup>1</sup> Institute of Astronomy, ETHZ, Zürich CH-8092, Switzerland.

<sup>2</sup> Paul Scherrer Institut, CH-5232 PSI-Villigen, Switzerland.

<sup>3</sup> School of Physics and Astronomy, University of St Andrews, North Haugh, St Andrews, Fife, KY16 9SS, Scotland

E-mail contact: kester@astro.phys.ethz.ch

We have simulated encounters between planetary systems and single stars in various clustered environments. This allows us to estimate the fraction of systems liberated, the velocity distribution of the liberated planets, and the separation and eccentricity distributions of the surviving bound systems. Our results indicate that, for an initial distribution of orbits that is flat in log space and extends out to 50AU, 50% of the available planets can be liberated in a globular cluster, 25% in an open cluster, and less than 10% in a young cluster. These fractions are reduced to 25%, 12% and 2% if the initial population extends only to 20AU. Furthermore, these free-floating planets can be retained for longer than a crossing time only in a massive globular cluster. It is therefore difficult to see how planets, which by definition form in a disc around a young star, could be subsequently liberated to form a significant population of free floating substellar objects in a cluster.

To appear in MNRAS

Available at [http://www.astro.phys.ethz.ch/papers/smith/smith\\_p\\_m.html](http://www.astro.phys.ethz.ch/papers/smith/smith_p_m.html)

## The Abundance and Emission of H<sub>2</sub>O and O<sub>2</sub> in Clumpy Molecular clouds

Marco Spaans<sup>1</sup> and Ewine F. van Dishoeck<sup>2</sup>

<sup>1</sup> Kapteyn Institute, P.O. Box 800, 9700 AV Groningen, The Netherlands

<sup>2</sup> Leiden Observatory, P.O. Box 9513, 2300 RA Leiden, The Netherlands

E-mail contact: spaans@astro.rug.nl

Recent observations with the *Submillimeter Wave Astronomy Satellite* indicate abundances of gaseous H<sub>2</sub>O and O<sub>2</sub> in dense molecular clouds which are significantly lower than found in standard homogeneous chemistry models. We present here results for the thermal and chemical balance of inhomogeneous molecular clouds exposed to ultraviolet radiation in which the abundances of H<sub>2</sub>O and O<sub>2</sub> are computed for various density distributions, radiation field strengths and geometries. It is found that an inhomogeneous density distribution lowers the column densities of H<sub>2</sub>O and O<sub>2</sub> compared to the homogeneous case by more than an order of magnitude at the same  $A_V$ . O<sub>2</sub> is particularly sensitive to the penetrating ultraviolet radiation, more so than H<sub>2</sub>O. The S 140 and  $\rho$  Oph clouds are studied as relevant test cases of star-forming and quiescent regions. The SWAS results of S 140 can be accommodated naturally in a clumpy model with mean density of  $2 \times 10^3 \text{ cm}^{-3}$  and enhancement  $I_{UV} = 140$  compared with the average interstellar radiation field, in agreement with observations of [C I] and <sup>(13)</sup>CO of this cloud. Additional radiative transfer computations suggest that this diffuse H<sub>2</sub>O component is warm,  $\sim 60 - 90 \text{ K}$ , and can account for the bulk of the  $1_{10} - 1_{01}$  line emission observed by SWAS. The  $\rho$  Oph model yields consistent O<sub>2</sub> abundances but too much H<sub>2</sub>O, even for [C]/[O]=0.94, if  $I_{UV} < 10$  respectively  $< 40$  for a mean density of  $10^3$  respectively  $10^4 \text{ cm}^{-3}$ . It is concluded that enhanced photodissociation in clumpy regions can explain the low H<sub>2</sub>O and O<sub>2</sub> abundances and emissivities found in the large SWAS beam for extended molecular clouds, but that additional freeze-out of oxygen onto grains is needed in dense cold cores.

Accepted by ApJ Letters

## Physical conditions and current massive star formation in NGC 3603

Mauricio Tapia<sup>1</sup>, Joaquín Bohigas<sup>1</sup>, Brenda Pérez<sup>1</sup>, Miguel Roth<sup>2</sup> and María Teresa Ruiz<sup>3</sup>

<sup>1</sup> Instituto de Astronomía, UNAM, Ensenada, Mexico

<sup>2</sup> Las Campanas Observatory, CIW, Chile

<sup>3</sup> Departamento de Astronomía, Universidad de Chile, Santiago, Chile

E-mail contact: mt@astrosen.unam.mx

New optical and near-infrared observations of the Galactic HII region NGC 3603 have been obtained in order to explore the interaction of the central starburst cluster HD 97950 with the remains of the molecular cloud and the formation of new generations of OB-type stars. Ample evidence for continuous stellar formation activity proceeding from north to south over the past three to six million years is presented. *K*-band excess is found in 50 objects, most of which are optically very faint ( $V > 18$ ) and are the youngest OB-type stars in the region. Nearly 80% is clustered or associated to signposts of recent star formation. Several sources are found near the tips of the ionization fronts produced by HD 97950. Some of these are young OB stars which have water masers in their vicinity and, in three cases, associated to isolated radio-continuum emission peaks. Near the centre of the active star formation region that is further away from HD 97950, the Irs 9 cluster, 12 OB-type stars (out of 16) with large excess emission beyond 2  $\mu\text{m}$  are found within a 15" radius. The most massive star of this new stellar generation in NGC 3603 is an O5 - O6 star. An ionization front lies just south of this very young cluster.

Accepted by Revista Mexicana de Astronomía y Astrofísica, Vol. 37 (April 2001)

Preprints available at <http://bufadora.astrosen.unam.mx/mt/preprints/n360300.ps>

## The Arcetri Catalog of H<sub>2</sub>O maser sources: Update 2000

R. Valdettaro<sup>1</sup>, F. Palla<sup>1</sup>, J. Brand<sup>2</sup>, R. Cesaroni<sup>1</sup>, G. Comoretto<sup>1</sup>, S. Di Franco<sup>3</sup>, M. Felli<sup>1</sup>, E. Natale<sup>4</sup>, F. Palagi<sup>4</sup>, D. Panella<sup>1</sup>, G. Tofani<sup>1</sup>

<sup>1</sup> Osservatorio Astrofisico di Arcetri, Largo E. Fermi 5, I-50125 Firenze, Italy

<sup>2</sup> Istituto di Radioastronomia CNR, Via Gobetti 101, I-40129 Bologna, Italy

<sup>3</sup> Dipartimento di Astronomia e Scienza dello Spazio, Largo E. Fermi 5, I-50125 Firenze, Italy

<sup>4</sup> CAISMI, C.N.R., Largo E. Fermi 5, I-50125 Firenze, Italy

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

We present a second update of the Arcetri Catalog of water masers (Comoretto et al., 1990; Brand et al. 1994). The present study reports the results of the observations carried out with the Medicina 32-m radiotelescope from January 1993 to April 2000 on a sample of 300 sources. This compilation consists of newly discovered maser sources that did

not appear in the previous Arcetri Catalogs and is made of: a) detections from the literature, and b) unpublished detections obtained with the Medicina antenna. Overall, 83 out of 300 sources were detected. The detection rate is low (28%) and we attribute this result to the inclusion in our survey of a rather large number of spurious maser detections that have appeared in one particular paper. The observational parameters are reported in tabular form for all the 300 sources and the spectra of the detected masers are presented.

We discuss the global properties of the complete Arcetri Catalog based on Comoretto et al. (1990), Brand et al. (1994) and the present observations, which now contains 1013 galactic water maser sources. Of these, 937 have an IRAS counterpart within 1 arcminute from the nominal position of the maser. We establish a classification scheme based on the IRAS flux densities which allows to distinguish between water masers associated with star forming regions and late-type stars. The Arcetri Catalog represents a useful data base for systematic studies of galactic water maser sources.

Accepted by Astron. & Astroph. Supp.

## **Herbig-Haro Objects HH 434-436: Part of a Giant Flow Driven by the Central Source A/B of IRAS 04325+2402?**

**Hongchi Wang<sup>1,2</sup>, Ji Yang<sup>1,2</sup>, Min Wang<sup>1,2</sup>, Licai Deng<sup>2,3,4</sup>, Jun Yan<sup>1,2</sup>, and Jiansheng Chen<sup>2,3,4</sup>**

<sup>1</sup> Purple Mountain Observatory, Academia Sinica, Nanjing 210008, PR China

<sup>2</sup> Chinese National Astronomical Observatories, Chinese Academy of Sciences, A20 Datun Road, Chaoyang District, Beijing 100012, PR China

<sup>3</sup> Beijing Astronomical Observatory, Chinese Academy of Sciences, Beijing 100012, PR China

<sup>4</sup> BAC: Chinese Academy of Sciences-Peking University Joint Beijing Astrophysical Center

E-mail contact: hcwang@pmo.ac.cn

While carrying out a wide-field survey of nearby star forming regions for Herbig-Haro (HH) objects we discovered 3 Herbig-Haro objects, HH 434-436, in a  $\sim 2' \times 2'$  ( $0.08 \times 0.08$  pc) region near L1536. HH 434 consists of 3 knots. HH 435 shows a bow shock shape and HH 436 is an elongated patch. Spectroscopic observations indicate that the excitation levels of HH 434-436 are different: HH 436 has a high excitation level while 434A has an intermediate and 435 has a low excitation level. The overall morphology of HH 434-436 shows a bow shock shape and suggests that HH 434-436 may be a single bow shock fragmented into separate knots. Near infrared observations of the region in the JHK' broad bands and H<sub>2</sub>  $v = 1-0$  S(1) narrow band were also carried out but no embedded source was detected. The overall bow shock of HH 434-436 points back towards an embedded multiple system IRAS 04325+2402. Moreover, from HST/NICMOS observations HH 434-436 are located on the expected outflow axis of the central source A/B of this multiple system. On the basis of these facts we propose that HH 434-436 may be driven by the central source A/B of IRAS 04325+2402, therefore, they are probably part of a giant HH flow which has a scale of 2.4 pc, although the possibility that HH 434-436 are three distinct flows can not be completely ruled out.

Accepted by Astron. J.

Preprint available at <http://jets.pmo.ac.cn/starfm/preprints.html>

*Dissertation Abstracts*

**The Young Population of the Lambda Orionis Star-Forming Region**

**Christopher Jon Dolan**

Thesis work conducted at: University of Wisconsin–Madison, USA

Current address: Department of Astronomy, University of Wisconsin–Madison, 475 North Charter Street, Madison, WI 53706

Electronic mail: [dolan@astro.wisc.edu](mailto:dolan@astro.wisc.edu)

Ph.D dissertation directed by: Robert D. Mathieu

Ph.D degree awarded: August 2000

To investigate the effect that massive stars have on low-mass star formation, we have conducted a detailed study of the young stellar population of the  $\lambda$  Orionis star-forming complex. To do this, we first surveyed the complex to enumerate the young stellar population, including both high- and low-mass stars. Measuring the ages and masses of these stars by photometric comparison with stellar evolution models, we have reconstructed the star-formation history and initial mass function of the region.

The stellar ages demonstrate that the current episode of star formation started gradually about 8–10 Myr ago, showing no signs of triggered or sequential star formation. The birth rate increased continuously until 1 Myr ago when a supernova exploded, cleared away the gas from which stars were forming in the center of the star-forming region. This terminated low-mass star formation within 15 pc of the massive stars while further away stars continue to form today.

Globally, the mass function resembles that of the field but it shows substantial local variation across the star-forming region, favoring massive stars in the center and low-mass stars elsewhere. However, we do not see strictly bimodal star formation, as the low-mass stellar density is highest in the same location as the OB stars.

We have discovered a marked lack of accretion disks (diagnosed by stellar H $\alpha$  emission) around the low-mass stars in the vicinity of the massive stars. We suspect that close encounters with OB stars or the supernova shock diminished the disks of those stars. Since the stars with or without accretion disks span all ages, we conclude that the absence of disks is the product of environment, not just evolution.

Thus we find that the star-forming environment near OB stars is detrimental to further formation. The massive stars may disperse the gas from which stars form and they may destroy the disks by which low-mass stars accrete that gas. Nonetheless, low-mass stars do form in great numbers both near to and far from their massive neighbors.

<http://www.astro.wisc.edu/~dolan/thesis/>

# Evidence for the Growth of Dust Grains around Protostars

Tracy L. Huard

Thesis work conducted at: Vanderbilt University, Nashville, TN, USA

Current address: Center for Astrophysics, 60 Garden St., Cambridge, MA 02138

Electronic mail: [thuard@cfa.harvard.edu](mailto:thuard@cfa.harvard.edu)

Ph.D dissertation directed by: David A. Weintraub

Ph.D degree awarded: December 2000

We have mapped the submillimeter emission from protostars that are forming within small molecular clouds known as Bok globules. From these maps, which reveal the spatial distribution of thermal dust emission around the protostars, we have partitioned the total observed flux into two components: flux from protostellar dust and flux from dust associated with the molecular cloud. Assuming that both the protostar and cloud emit as greybodies with dust opacities given by  $\kappa_\nu \propto \nu^\beta$ , we have constrained the values of the “emissivity index”  $\beta$  using our separate protostellar and cloud fluxes supplemented with previous flux observations at other wavelengths. Our analysis of the protostar B 335 SMM1, for which we have the best data, demonstrates that the likely range for the protostellar dust emissivity index is  $0.4 \lesssim \beta^p \lesssim 1.0$ , while the likely range for the cloud dust emissivity index is  $1.0 \lesssim \beta^c \lesssim 1.8$ . A similar analysis for two other protostars, CB 68 SMM1 and CB 230 SMM1, produce results consistent with those for B 335 SMM1.

We then show that the protostellar dust emissivities are less than and inconsistent with emissivities predicted by standard models for interstellar dust grains that include grains only as large as  $\sim 1 \mu\text{m}$ . The addition of larger grains is known to yield smaller emissivities. For this reason, we have constructed a protostellar dust model with grains composed of a presumed realistic mixture of constituents: amorphous carbon, silicates, and  $\text{H}_2\text{O}$ -ice. We demonstrate that, for such a protostellar dust population, a distribution of grain sizes following a power law in grain radius proportional to  $r^{-(3.6 \pm 0.3)}$  is most consistent with the protostellar dust emissivities determined in this study. Furthermore, we show that this protostellar dust population must include grains at least as large as  $\sim 200 \mu\text{m}$ , more than two orders of magnitude larger than standard interstellar grains.

Since protostars form by collapse of fragments of molecular clouds while molecular clouds, in turn, form from material within the diffuse interstellar medium, the observed protostellar dust must once have been dust associated with molecular clouds. Furthermore, this cloud dust was originally interstellar dust. Since the typical density of these environments increases from the diffuse interstellar medium to molecular clouds to protostars, dust grain growth may be facilitated by increased probability of coagulation of the smaller grains. In this scenario, we might expect to see a progression in the typical grain sizes, from submicron-sized interstellar grains to intermediate-sized cloud grains to perhaps millimeter-sized protostellar grains. These millimeter-sized protostellar grains would represent the seeds from which planetesimals and eventually planets might grow in the disks around protostars. Our analysis does not detect any difference in the sizes of interstellar and cloud dust grains, but this result may be due to a lack of sensitivity on the part of our method to distinguish these intermediate grains from the small interstellar grains. However, the results of our analysis for the protostars B 335 SMM1, CB 68 SMM1, and CB 230 SMM1, as described above, indicate that significant grain growth has occurred from interstellar grains to the dust grains surrounding these protostars. Given the abundance of extrasolar planets that have been detected recently, the findings of this study suggest that extensive dust grain growth likely occurs around protostars, in general.

<http://www.hep.vanderbilt.edu/~huard/index.html>

## *New Jobs*

### **Three Research Positions in Infrared Astronomy**

The Infrared Interferometry Group of the Max Planck Institute for Radioastronomy in Bonn (see <http://www.mpifr-bonn.mpg.de/div/ir-interferometry>) invites applications for **three postdoctoral positions** in the following fields:

- Star formation: multiplicity, disks, jets, and outflows of young stars.
- Late stages of stellar evolution: stellar surface structure and circumstellar dust shells (Mira stars, carbon stars, PPN, etc.).
- Active galactic nuclei: torus, jet, NLR, etc.
- Infrared long-baseline interferometry with the GI2T, IOTA, and VLT interferometer.

The successful applicants are expected to work primarily on the observation and interpretation of the above objects. Applicants should have a Ph.D. and observational or theoretical experience in one of the above fields. The appointment is initially for one year, and is renewable for up to five years. Interested scientists should email a letter of application with a summary of relevant experience and research interests, a curriculum vitae, a list of publications, and two letters of recommendation to

Prof. Gerd Weigelt  
Max Planck Institute for Radioastronomy  
Auf dem Huegel 69  
D-53121 Bonn  
Fax: +49 228 525 437  
Email: [weigelt@mpifr-bonn.mpg.de](mailto:weigelt@mpifr-bonn.mpg.de)

Review of applications will begin on 1. Feb. 2001 and continue until the positions are filled. The Max Planck Society is an equal opportunity employer.



**The University of New South Wales, Sydney, Australia**

**Department of Astrophysics**

**POSTDOCTORAL RESEARCH FELLOWSHIP**

**in Infrared and Millimetre Astronomy**

Applications are invited for a Research Associate position funded by the Australian Research Council, to work with Dr Michael Burton and Professor John Storey on hot molecular cores in star formation. The position is for a person with experience in one or more of the following research areas: (i) infrared astronomy, (ii) millimetre astronomy, (iii) star formation and (iv) the ISM. Experience in modelling line emission would also be an asset.

The position will initially be for one year with the possibility of renewal for a further two years, subject to satisfactory performance. Candidates must possess a PhD and show a demonstrated ability to pursue independent research in the relevant fields. The salary scale for this position will be in the range set by UNSW Academic Staff Salary Rates (Level A) according to the experience of the successful applicant.

Further details can be obtained from Dr. Burton (email: M.Burton@unsw.edu.au; tel: +61-2-9385-5618; fax: +61-2-9385-6060; URL: [www.phys.unsw.edu.au/astro.html](http://www.phys.unsw.edu.au/astro.html)). Applications should include a CV, a bibliography and a statement of research interests and plans. They should be sent to Dr. Burton at the School of Physics, University of New South Wales, Sydney, NSW 2052, Australia before March 1, 2001. Applicants should arrange for up to three letters of recommendation to arrive at the same address by this date.

The Department of Astrophysics at UNSW is a growing and active group, consisting of six academics, nine postdoctoral fellows and a dozen graduate students. We have excellent departmental computing facilities. Staff members regularly obtain time on national (AAO, ATNF, ANU 2.3m etc.), international (Gemini, NTT, WHT, UKIRT etc) and space-based (e.g. HST) observing facilities. We also operate the Automated Patrol Telescope (APT), the Mopra 22-m millimetre-wave Telescope at Siding Spring Observatory and a site testing observatory at the South Pole. We are located in Eastern Suburbs of Sydney, the Olympic city, close to both the city centre and the beaches.

Research activities in the Department include studies of high redshift galaxies, clusters of galaxies and quasars, cosmology, Antarctic astronomy, IR and MM astronomy, star formation and the interstellar medium. There are several major instrumentation projects underway, including astronomical site-testing and infrared astronomy in Antarctica, an infrared imaging Fabry-Perot (UNSWIRF), a mid-infrared camera (MANIAC). We have upgraded the Mopra radio telescope to a 22-m millimetre-wave telescope, making it the largest such telescope in the Southern Hemisphere and are developing an automated facility for rapid monitoring of gamma ray bursts using the Automated Patrol Telescope (APT).

## *New Books*

### **New Perspectives on the Interstellar Medium**

Editors **A.R. Taylor, T.L. Landecker, G. Joncas**

The interstellar medium of our Galaxy has multiple components, all of which cycle from one state to the other through the injection of energy from stars, addition of mass from stars, and large scale impacts of spiral shocks. Numerous new results impact our everchanging view of the processes in the interstellar medium, and this book, which forms the proceedings of a conference held at Naramata, British Columbia, Canada in August 1998, gives an up-to-date overview of our current knowledge.

The following is a partial list of the more extensive papers:

#### **Part 1. New Observations and Techniques**

*Radio Continuum Results from the Canadian Galactic Plane Survey* A.R. Taylor  
*The Canadian Galactic Plane Survey: Atomic Hydrogen Observations* L.A. Higgs  
*The 7C(G) Survey of the Galactic Plane at 151 MHz* D.A. Green  
*The Molonglo Galactic Plane Surveys* A.J. Green  
*The Molecular Gas Components of the Outer Galaxy* M.H. Heyer  
*Polarimetric Investigations of the Galactic Plane at GHz Frequencies* A.R. Duncan  
*High-resolution Mid-Infrared Images of the ISM from the MSX Satellite* M. Cohen  
*Interstellar Dust in the WIRE to PLANCK Era* P.G. Martin  
*The AAO/UKST H $\alpha$  Survey* Q.A. Parker et al.

#### **Part 2. Physical States and Phases**

*The Gaseous ISM: Observations with the Wisconsin H $\alpha$  Mapper* R.J. Reynolds et al.  
*Galactic Cosmic Rays and Magnetic Fields* N. Duric  
*Dust Emission and ISM Components* F. Boulanger

#### **Part 3. Processes and Interfaces**

*The Eridanus Superbubble in its Multiwavelength Glory* C. Heiles et al.  
*Cluster Formation and the ISM* R.E. Pudritz & J.D. Fiege

#### **Part 4. Disk-Halo Interaction**

*Disk-Halo Interactions in External Spiral Galaxies* M. Dahlem  
*Observations and Modeling of the Disk-Halo Interaction in Our Galaxy* M. Normandeau & S. Basu  
*The Interaction of the Disk with the Halo* M.-M. Mac Low  
*On the Distribution of Compact, Isolated High-Velocity Clouds Throughout the Local Group* W.B. Burton & R. Braun

#### **Part 5. Global Models**

*Large-Scale Model of the Interstellar Medium, with New Constraints on the Hot Gas Component* K.M. Ferriere  
*Interstellar Turbulence, Cloud Formation and Pressure Balance* E. Vázquez-Semadeni

#### **Part 6. Topology and Structure of the ISM**

*The Structure and Statistical Characterisation of HI Gas* G. Joncas & S. Mashchenko  
*Retrieval of Turbulent Velocity Field Statistics* M.H. Heyer & C. Brunt

#### **Part 7. Energy Injection**

*Mechanisms of Injection and Dissipation of Energy and their Relation to the Dynamics of the Interstellar Medium* A. Pouquet et al.  
*Supershells Formed by Stellar Winds and SNe from OB Associations: On the Nature of their Two-Component Kinematics* T.A. Lozinskaya

ISBN 1-886733-89-9 - published 1999 - 473 pages

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## **Stellar Clusters and Associations: Convection, Rotation, and Dynamos**

**Editors R. Pallavicini, G. Micela, S. Sciortino**

This book presents the proceedings of a conference held in Palermo, Italy on May 25-28, 1999, which was the second of three devoted to the topic "Stellar Clusters and Associations: Formation, Structure and Evolution of Low-Mass Stars".

The book is divided into the following seven sections:

1. Stellar Structure and Evolution
2. Cluster Distances and Ages
3. IMF, Mass Segregation and Cluster Evolution
4. Lithium Abundances and Metallicities
5. Rotation and Angular Momentum Evolution
6. Magnetic Fields and Stellar Activity
7. New Technologies/Large-Scale Programs

Numerous articles in the book have interest for researchers in the star formation and young star community. Among the reviews with direct impact on pre-main sequence studies are the following:

*Convection and light element evolution from pre-main sequence to the upper asymptotic giant branch* F. D'Antona

*Cluster IMFs and mass segregation: dynamical effects* R. de la Fuente Marcos

*Early evolution of stellar clusters* I.A. Bonnell

*Lithium depletion in open clusters* R.D. Jeffries

*Age-dating open clusters with the lithium depletion boundary test* J. Stauffer

*Examining the case for regulation of pre-main-sequence rotation by circumstellar disks* K.G. Stassun et al

*Measurements of stellar magnetic fields* C.M. Johns-Krull & J.A. Valenti

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# **New Light on Dark Stars: Red Dwarfs, Low-Mass Stars, Brown Dwarfs**

**I. Neill Reid and Suzanne L. Hawley**

The low-mass end of the initial mass function has been an extremely active subject of research within the last few years, and with the recent discovery of numerous brown dwarfs and very-low-mass stars and the definition of the new spectral classes of L and T dwarfs, the topic has moved from the realm of pure theory to an active observational field. The pioneering book by Kumar opened up the study of the stellar/substellar mass boundary, and the timely appearance of this substantial monograph provides a sorely needed update on this exciting new field. The book gives an overview of our knowledge up to 1999/2000, with extensive references to the literature, at a level accessible to advanced undergraduate physics majors. It will form an excellent basis for a graduate course on brown dwarfs and other low-mass objects. Surely the book will also be frequently used as a reference book by many researchers in the field.

The book is divided into the following 11 sections:

1. Astronomical Concepts
2. Observational Properties of Low-Mass Dwarfs
3. The Structure, Formation and Evolution of Low-Mass Stars and Brown Dwarfs
4. The Photosphere
5. Stellar Activity
6. A Galactic Structure Primer
7. The Stellar Luminosity Function
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## *Meetings*

# Deuterium in the Universe

June 25-27, 2001

Observatoire de Meudon, France

**International Scientific Committee:** D. Gautier (chair), S. Burtles, J. Geiss, W.M. Irvine, T.J. Millar, T.C. Owen, F. Palla, P. Salati, A. Vidal-Madjar, E.F. van Dishoeck

**Local organisation Committee:** E. Roueff (chair), D. Bockele-Morvan, L. d'Hendecourt, R. Ferlet, M. Gerin, M. Lemoine, F. Robert, M. Signore

### **THE MEETING:**

The study of cosmic Deuterium is a fast expanding research topic of multidisciplinary nature. Deuterium and deuterated species are observed in a variety of astrophysical regions, from external galaxies to our own planetary atmosphere. Formed in the very first moments of the Universe and burned inside stars, deuterium is also subject to large fractionation effects. It is thus a powerful tracer of the dominant processes which govern the evolution of astrophysical objects and media, including the formation of the Universe up to that of our Solar System.

This 3-days meeting will cover most of topics related to deuterium studies, addressing the fundamental questions which arise from present observations and which will be answered by the coming new instrumentations. One day will be devoted for each of the following topics:

- Solar System
- The interstellar medium and star forming regions
- Nucleosynthesis and cosmology.

### **WEB SITE OF THE CONFERENCE:**

<http://wwwusr.obspm.fr/unicom/deuterium/textes/home.htm>

### **E-MAIL ADDRESS:**

deuterium.2001@obspm.fr

PRE-REGISTRATION BEFORE JANUARY 15, 2001 IS WELCOME !

## The Origins of Stars and Planets: The VLT View

ESO Auditorium, Garching bei München, 24–27 April 2001

Understanding how stars and planets form in the cold interiors of molecular clouds presents one of the most formidable challenges of modern astrophysics. Many important observational clues concerning this fundamental process have been amassed during the last two decades, almost all associated with major technological developments. Which scientific breakthroughs can we predict and plan to achieve with the new generation of 8-metre class telescopes combined with state-of-the-art instrumentation? This workshop will bring together the star and planet formation community to discuss the unique opportunities offered by the ESO Very Large Telescope, comprising the four 8-metre unit telescopes, VLTI, VST, VISTA, and their extensive array of UV, optical, and infrared instruments. An important goal of the workshop will be to characterise the needs of the community regarding future VLT instrumentation. We will also look forward to future complementary facilities with ESO involvement, in particular ALMA and OWL, and more broadly at other ground- and space-based observatories with likely important impact on the study of star and planet formation, including Gemini, Keck, LBT, HST, Chandra, XMM Newton, SIRTf, FIRST, and the NGST.

*Topics to be covered:*

- The structure of molecular clouds
- The physics of star formation: collapse, accretion, and outflows
- Chemical processes in star and planet formation
- Pre-main-sequence stellar evolution
- Origin and characterisation of the initial mass function in different environments
- Evolution of protoplanetary disks and the birth of planets
- The connection to the extragalactic domain

*Scientific Organizing Committee:*

J. Alves (co-chair), F. Bertoldi, F. Boulanger, C. Clarke, C. Cesarsky, E. van Dishoeck, F. Malbet, M. Mayor, R. Genzel, T. Henning, C. Lada, M. McCaughrean (co-chair), A. Moorwood, A. Natta, F. Paresce, B. Reipurth, M. Romaniello, & E. Tolstoy

*Local Organizing Committee:*

J. Alves (chair), M. Romaniello, & C. Stoffer

For more information and registration: <http://www.eso.org/starplanet2001>

**Closing date for registration is January 31st 2001, but as there are not many spaces remaining, please register as soon as possible to guarantee your participation in this meeting.**

2nd ANNOUNCEMENT

**Submillimeter Astronomy Science Workshop for  
Far Infrared and Submillimeter Telescope (FIRST)  
"Herschel/FIRST - A Vision of the Cool Universe"**

A Workshop will be held at Humphrey's Half Moon Inn on Shelter Island, San Diego, 11th to 13th February, 2001, to help inform the US astronomy community of the scientific opportunities available with the FIRST mission. The science workshop will be followed (14th - 16th of February, 2001) by the annual TeraHertz (THz) Technology Symposium (contact Imran Mehdi at [imran@merlin.jpl.nasa.gov](mailto:imran@merlin.jpl.nasa.gov)), where relevant technology will be discussed. Participants will be welcome to attend either or both components. A visit to Composite Optics Inc. will be arranged between the two meetings. Registration for the FIRST Science Workshop is required (see below), but is at no cost.

LIST OF INVITED SPEAKERS

M. Fall (STScI) - Theories of Galaxy Formation and Evolution; C. Steidel (Caltech) - Observations of Distant Galaxies (Optical); A. Blain (Cambridge) - Observations of Distant Galaxies (Submm); B. Draine (Princeton) - Physics of the ISM; E. Herbst (Ohio State) - Chemistry in Star Forming Regions; E. Lada (U. Florida) - Physics of Star Formation; J. Fischer (NRL) - CII in Galaxies; M. Gerin (ENS) - ISO Extragalactic Results; G. Blake (Caltech) - Line Surveys with FIRST; N. Scoville (Caltech) - ALMA Science - Extragalactic; N. Evans (U Texas) - ALMA and Galactic Studies; P. Solomon (Stony Brook) - Nearby Galaxies; P. Goldsmith (Cornell) - SWAS Science Results; G. Pilbratt (ESTEC) - Introduction to FIRST; A. Poglitsch (MPI, Garching) - Introduction to PACS; M. Werner (JPL) - Synergy with SIRTf; J. Davidson (NASA Ames) - SOFIA and FIRST; D. Neufeld (Johns Hopkins) - ISO Galactic Results; D. Wilner (CFA) - The SMA and FIRST; G. Pilbratt (ESTEC) - Introduction to FIRST; A. Poglitsch (MPI, Garching) - Introduction to PACS; J. Bock (JPL/Caltech) - Introduction to SPIRE; M. Harwit (Cornell) - Planck and FIRST; T. Phillips (Caltech) - Introduction to HIFI.

FIRST Mission "FIRST" is an ESA "Cornerstone Mission" in the Horizon 2000 program, consisting of a passively cooled 3.5m diameter telescope, operating in the 60-600 micron range at the L2 point. There are three instruments in the helium cooled focal plane:

SPIRE, a long wavelength (200 - 670 micron) camera and low resolution spectrometer;

PACS, a short wavelength (60 - 210 micron) camera and low resolution spectrometer; and

HIFI, a high resolution (heterodyne) spectrometer, operating from 450 - 1900 GHz.

Registration:

If you wish to attend, please register electronically. There is no registration fee planned for this workshop.

Contacts:

The organizing committee is T. Phillips (chair), P. Goldsmith, P. Harvey, M. Harwit, G. Helou, W. Langer, and G. Stringfellow.

Web-page: <http://spider.ipac.caltech.edu/staff/lmh/FIRST/workshop.html>

Registration forms, and any questions should be sent to [charmaine.d.mayes@jpl.nasa.gov](mailto:charmaine.d.mayes@jpl.nasa.gov)

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://casa.colorado.edu/reipurth> or at <http://www.eso.org/gen-fac/pubs/starform/> .

## 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.