THE STAR FORMATION NEWSLETTER

An electronic publication dedicated to early stellar evolution and molecular clouds

No. 29 — 11 Jan 1995 Editor: Bo Reipurth (reipurth@eso.org)

Abstracts of recently accepted papers

The jet-driven molecular outflow in L 1448. CO and continuum synthesis images

R. Bachiller[1], S. Guilloteau[2], A. Dutrey[2], P. Planesas[1], and J. Martın-Pintado[1]

[1] Centro Astronómico de Yebes, Apartado 148, E-19080 Guadalajara, Spain
[2] Institut de Radio Astronomie Millimétrique, 300 rue de la Piscine, F-38406 Saint Martin d'Hères, France

E-mail contact: bachiller@cay.es

The central region of the L 1448 molecular outflow has been mapped in the CO J=1–0 line, and in the λ 2.6 mm continuum, with angular resolution of 3"×2.5" ($\sim$ 4 10^{-3} pc at the distance of L 1448, 300 pc). In the mapped area, there are two partially overlapping outflows emerging from two different continuum sources (L 1448/IRS3 and L 1448-mm).

The continuum maps are used to study the nature of the two exciting sources. The strong mm peak around L 1448/IRS3 is coincident in position with the VLA cm source L 1448N(B), and it likely is the source driving the outflow in the northern region. L 1448-mm is at the origin of the main outflow. The spectral energy distributions confirm that both sources (L 1448-mm and IRS3) are among the youngest known protostellar candidates ("Class 0" sources)

New details on the structure of the L 1448-mm outflow are revealed by the CO observations. Weak line emission at extremely-high velocities is detected along the jet which is at the axis of the outflow. Such emission is associated with the molecular bullets detected with single-dish telescopes. The jet is inclined at PA –21°, and its actual jet speed is in excess of 200km s^{-1}.

Limb-brightened cavities are detected at low CO velocities. The cavities have a biconical morphology, suggesting that a bipolar nebula is forming. The formation of the cavity is well explained in the frame of models for jet-driven bipolar outflows, where the jet entrains ambient molecular material through the propagation of large bow-shocks which are able to disturb the ambient gas at long transverse distances from the jet axis. A comparison of the CO data with H_2 images at 2.12 μm provides further support to this scenario.

The blueshifted lobe of the L 1448-mm outflow exhibits a continuous bending that can be explained as a result of direct collision of the two outflows in L 1448.

Accepted by Astron. Astrophys.

The Flying Ghost Nebula: A remarkable Circumstellar Disk

M.-H. Boulard[1], E. Caux[1], J.-L. Monin[2], D. Nadeau[3], & N. Rowlands[3]

[1] Centre d'Etude Spatiale des Rayonnements, BP 4346, 31029 Toulouse Cedex, France
[2] Laboratoire d'Astrophysique, Observ. de Grenoble, Univ. Joseph Fourier, BP 53X, 38041 Grenoble Cedex, France
[3] Département de Physique, Université de Montréal et Observatoire du Mont Mégantic, C.P. 6128, Succ. A. Montréal, Québec, Canada, H3C 3J7

We present high resolution images in the photometric bands V, R, I, J, H & K of a remarkable bipolar nebula we named the "Flying Ghost Nebula" (FGN) from both its optical shape and its lack of detection by the IRAS satellite. We interpret these images in term of a central young bright star of intermediate mass surrounded by a circumstellar disk seen almost perfectly edge-on. We find that the central object is a 4 $M_\odot$ B star and the size and mass of its

circumstellar disk are respectively of the order of 1500 AU and 0.03 $M_\odot$. The Flying Ghost Nebula could be a rare example of an intermediate mass star formed from a flattened structure not yet dissipated.

Accepted by Astronomy and Astrophysics

Infrared CO emission from young stars: accretion disks and neutral winds

C. J. Chandler[1,2], J. E. Carlstrom[1] and N. Z. Scoville[1]

[1] Owens Valley Radio Observatory 105-24, Caltech, Pasadena, CA 91125, USA
[2] Present address: NRAO, P.O. Box O, Socorro, NM 87801, USA

We have modelled the emission in the first overtone rotation-vibration bands of CO from accretion disks and neutral winds. We compare our models with high-resolution spectra of five objects: DG Tau, SVS13, WL16, NGC2024 IRS2 and S106 IRS4. The emission from accretion disks with accretion rates of $\sim 10^{-8}$ – 10^{-7} $M_\odot$ yr^{-1} successfully reproduce the fluxes, the profiles, and the optical depths of the observed spectra. We also find for several objects that the data are best reproduced by the disk model, with higher K-band extinctions to the central star than those measured by other methods. A simple wind model can also account for the flux and line profile in a number of cases, but fails to reproduce the high optical depth obtained by fitting low-resolution data. Furthermore, unreasonably high mass-loss rates are needed to reproduce the flux. However, if there are sources of heating in the wind preventing it from cooling adiabatically, the CO emission region is larger and lower mass-loss rates may be accommodated.

Accepted by The Astrophysical Journal

Magnetically modulated accretion in T Tauri stars

C.J. Clarke[1], P.J. Armitage[2], K.W. Smith[2] and J.E. Pringle[2]

[1] School of Mathematical Sciences, Queen Mary & Westfield College, Mile End Road, London, E1 4NS, UK
[2] Institute of Astronomy, Madingley Road, Cambridge, CB3 0HA, UK

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

We examine how accretion on to T Tauri stars may be modulated by a time-dependent 'magnetic gate' where the inner edge of the accretion disc is disrupted by a varying stellar field. We show that magnetic field variations on time-scales $\ll 10^5$ yr can modulate the accretion flow, thus providing a possible mechanism both for the marked photometric variability of T Tauri stars and for the possible conversion of T Tauri stars between classical and weak line status. We thus suggest that archival data relating to the spectrophotometric variability of T Tauri stars may provide an indirect record of magnetic activity cycles in low-mass pre-main-sequence stars.

Accepted by MNRAS

The nature of massive protostellar candidates: A search for water masers towards color-selected IRAS candidates.

Claudio Codella[1] and Francesco Palla[2]

[1] Dipartimento di Astronomia e Scienza dello Spazio, Università di Firenze, Largo E. Fermi, 5, 50125 Firenze, Italy
[2] Osservatorio Astrofisico di Arcetri, Largo E. Fermi, 5, 50125 Firenze, Italy

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

A search for water maser emission at 22.2 GHz has been performed towards 160 IRAS sources selected using the Wood & Churchwell color criteria to identify high-mass star forming regions. The aim of the survey is to verify the existence of a substantial variation of the maser detection rate within the Wood & Churchwell sample, and to estimate its possible contamination due to spurious sources. Out of the whole sample, water maser emission was found in 11 sources, 2 of which being new detections. The success rate of the survey is very low: 7%. We find a strong dependence of the maser occurrence on the IRAS flux density at 60 μm: the rate drops from ∼24% for sources brighter than 100 Jy to ∼1% for weaker sources.

These results, combined with those found in previous surveys, indicate that it is very unlikely that the population of weak IRAS sources with shallow far-infrared continuum spectra is associated with high-mass star forming regions.

Since these sources account for about half of the total number of the IRAS PS located inside the Wood & Churchwell color box, we believe that the predicted population of OB-type stars may have been overestimated by a factor up to 50%.

Accepted by Astron. Astrophys.

Activity on young stars

G.F. Gahm, K. Lodén, E. Gullbring, D. Hartstein

Stockholm Observatory, S-133 36 Saltsjöbaden, Sweden

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

Simultaneous photometry and spectroscopy were made of 6 young stars during two observing periods mainly to study short-term variability on time-scales from minutes to a few hours. The material includes two classical T Tauri stars (CTTS): SY Ori and VW Cha; three T Tauri stars with weak emission line spectra (WTTS): San 1, SZ Cha and ADA 481 and one post-T Tauri candidate: HD 70309B. Both UBV and Strömgren photometry was made. In the visible spectral region we resolved rapid fluctuations - *events* - with total amplitudes of about 5 % (0.05 magnitudes). In the ultraviolet, the corresponding limit of detection was usually $\leq$ 10 %. On the basis of totally about 100 hours of monitoring we conclude that the normal state of these stars is that they are completely constant in brightness or that they vary only slowly with small amplitudes over several hours. Only a few percent of the time, on the average, is a given star caught at brightness changes $\geq$0.2 mag. during one night. No event reached a total amplitude of $\geq$0.3 mag. VW Cha is the most active star, but no events were seen on SY Ori and HD 70309B. This confirms earlier indications that powerful "flaring" on T Tauri stars is not frequent.

We make a detailed study of all events and find two types of slow events, usually with d(U or u)/dt $\leq$ 0.1 mag. hour^{-1}. One is caused by changes in the continuous emission (the veiling) superimposed on the stellar photospheric spectrum and operates mainly on VW Cha. These events have nothing to do with stellar surface flares of the type observed on flare stars and we suggest that they originate from inhomogeneous mass accretion from a circumstellar disk to the stellar surface. The time-scales support models with magnetically controlled accretion along the stellar dipole field to rings or spots at the stellar surface. The other type of event appears to originate from relatively rapid changes in the opacity of circumstellar dust in the line-of-sight to the star. This effect dominates on SZ Cha, a WTTS surrounded by a substantial dust reservoir.

Also for the rapid events we distinguish two types. On two WTTS we detected a few flare-like events produced by a sudden increase in emission in the Balmer continuum and the Balmer lines and no detectable change of the continuum long-ward of the Balmer jump. With only UBV photometry the Balmer flares could erronously been interpreted as very hot blackbody radiators. We suggest that these events are genuine surface flares with total energies of 10^{33} to 10^{34} erg, and discuss the implication of energy supply. On ADA 481 we detected 2 flare-like events in white light. If these are due to the ignition of a source of blackbody radiation, the inferred temperature of the flare is low compared to what is normally observed for flare stars.

Even though the events are rare and have small total amplitudes in UV, they are extremely powerful, with the same total energies as the largest flares seen on flare stars. The flare stars may show much larger changes in UV, but the difference comes from the lower contrast of the flares on the TTS. If all TTS have surface magnetic activity similar to the flare stars, only the radii being larger, then we conclude that the frequency distribution of the flare-like events on WTTS are similar to flare stars in the field, but much higher than for the dwarfs in the Pleiadees. No flare-like event was seen on the CTTS and we discuss possible implications.

For the long-term changes (over days) we conclude that very dark spots on the rotating surfaces of SY Ori and San 1 dominates, while VW Cha varies because of variable veiling, but with an uncertain period. For SZ Cha variable circumstellar extinction operates, also in phase with the hydrogen line absorption. The situation for ADA 481 is still unclear. HD 70309B did not vary.

Accepted by Astron. Astrophys.

The Line Profile Variability of SU Aur

Christopher M. Johns[1,2] **and Gibor Basri**[1]

[1] Astronomy Department, University of California, Berkeley, CA 94720, USA
[2] McDonald Observatory, University of Texas, Austin, TX 78712, USA

We analyze approximately one hundred echelle spectra of the T Tauri star SU Aur. The photospheric lines appear unveiled and show little variability. We find evidence for periodic intensity variations in the blue wing of Hβ between $-170 < v < -110$ km s^{-1} from line center with a period of approximately 3 days, the rotation period of the star. Both the period and velocity are the same as previously reported for Hα in SU Aur. Furthermore, evidence for unsteady accretion is found in the presence of a variable red displaced absorption feature with a velocity of $v \sim +100$ km s^{-1} in Hβ. This feature is also periodic at 3 days (unlike in Hα). Several spectra indicate simultaneous mass inflow and outflow. The Ca II infrared and He I 5876 lines show modest variability and imply that the structure of the chromosphere on SU Aur is very different than solar plage regions. Variations of the Ca II lines and the He I line are well correlated with each other, but only poorly correlated with Balmer line variability.

We use spherically symmetric radiative transfer codes to calculate line profiles for SU Aur. The equations of statistical equilibrium are solved using the general purpose program CLOUDY. By simultaneously fitting the Balmer lines in SU Aur, we determine to what extent these lines can be produced in a spherically symmetric wind and constrain the parameters of this wind. We find that large turbulent velocities are required at the base of such a wind, where the bulk of the emission is produced. The steady absorption feature seen at $v \approx -50$km s^{-1} must form in the outer portions of the stellar wind, implying a terminal velocity of the wind much below the stellar escape velocity. The mass loss rate is determined to be about 4.5×10^{-9} M$_\odot$ yr^{-1}.

Accepted by Astrophys. J. Supp.

Ammonia Observations of NGC 6334 I(N)

T. B. H. Kuiper[1], **W. L. Peters, III**[2], **J. R. Forster**[3], **F. F. Gardner**[3], **and J. B. Whiteoak**[3]

[1] Jet Propulsion Laboratory 169-506, California Institute of Technology, Pasadena, CA 91109, USA.
[2] Steward Observatory, Univ. of Arizona, Tucson, AZ 85721, USA.
[3] Australia Telescope National Facility, Commonwealth Scientific and Industrial Research Organization, P.O. Box 76, Epping, NSW 2121, Australia.

E-mail contact: Kuiper@JPL.NASA.gov

Coincident with the far-infrared source NGC 6334 I(N) and water maser source E is a massive dense cloud which has the most intense ammonia (1,1) emission of any known interstellar cloud. We have mapped the (3,3) emission and find the cloud is extended 0.8 pc in the direction parallel to the Galactic plane, and 0.5 pc perpendicular to it. It has a velocity gradient of 1 km s^{-1} pc^{-1} perpendicular to the Galactic plane. The gas kinetic temperature is about 30 K and the density is greater than 10^6 cm^{-3}. The mass of the cloud is about 3000 M$_\odot$, three times greater than previously estimated. The para-ammonia column density is 6-8 $\times 10^{15}$ cm^{-2}. An ammonia abundance of 0.5-1.5 $\times 10^{-8}$ is inferred, where the larger number assumes an early time ortho/para ratio. This suggests either a cloud age of less than $\sim 10^6$ yr, or substantial depletion of ammonia.

Accepted by Astroph. J., June 20, 1995 issue

On the mass and the gas-to-dust ratio of the ρ Ophiuchi cloud core

R. Liseau[1,2], **D. Lorenzetti**[2], **S. Molinari**[2], **B. Nisini**[2], **P. Saraceno**[2] **and L. Spinoglio**[2]

[1] Stockholm Observatory, S-133 36, Saltsjöbaden, Sweden
[2] CNR-Istituto di Fisica dello Spazio Interplanetario, Casella Postale 27, I-00044 Frascati (Rome), Italy

E-mail contact: rene@astro.su

We have mapped the ρ Oph main cloud (L 1688) in the J = 2 − 1 transition of CS with the Nagoya 4m millimetre-wave telescope. The overall morphology of the cloud is similar to that mapped in C^{18}O, but the high density regions ρ Oph A and B are more evident in CS. Depending on the adopted model for the CS excitation, these observations lead to estimated cloud masses 540 M$_\odot$ (LTE) or 2500 M$_\odot$ (NLTE) for a value of the CS abundance equal to 10^{-9}. We find,

in particular, that the assumption of LTE is inadequate and that the mass of the ρ Oph main cloud may previously have been underestimated by at least a factor of three. This does also imply that the previously determined high star formation efficiency of the cloud would have to be revised downwards accordingly. From IRAS observations we determine the mass of the dust emitting at 60 μm to be at least 5.5 $M_\odot$. Average mass ratios of the gas-to-dust are thus found to be 100 or 450. Detailed comparison of the CS and IRAS images reveals, however, that average values are rarely, if ever, found on local scales of order 0.15 pc.

Accepted by Astron. Astrophys.

Very Hot Ionized Material in Sagittarius B2 F

David M. Mehringer[1], C. G. De Pree[2], Ralph A. Gaume[3], W. M. Goss[2] and Mark J. Claussen[2]

[1] University of Illinois, Astronomy Department, 1002 W. Green St., Urbana, IL 61801, USA
[2] National Radio Astronomy Observatory, Box O, Socorro, NM 87801, USA
[3] U. S. Naval Observatory, 3450 Massachusettes Ave., NW, Washington, DC 20392-5420, USA

E-mail contact: dmehring@sirius.astro.uiuc.edu

VLA 20 cm continuum observations ($2'' \times 1''$ resolution) of the Sgr B2 star forming region have been carried out. The peak intensity, which occurs at the location of the Sgr B2 F complex of H II regions, corresponds to a brightness temperature of 23,000 K. The continuum spectrum appears to be thermal; thus the brightness temperature provides a lower limit to the electron temperature. The H66α recombination lines (ν = 22.4 GHz) in this region also suggest that the temperature is high. The LTE electron temperature derived from the H66α data is 19,600 K. It is unclear what the heating mechanism is, although a highly non-equilibrium situation which occurs at the edge of the expanding ionization front might be responsible.

Accepted by The Astrophysical Journal (Letters)

A Submillimetre Continuum Study of S140/L1204: The Detection of Three New Submillimetre Sources and a Self-consistent Model for the Region

Nigel R. Minchin[1], Derek Ward-Thompson[2] and Glenn J. White[1]

[1] Department of Physics, Queen Mary and Westfield College, Univ. of London, Mile End Road, London E1 3NS, U.K.
[2] Royal Observatory, Blackford Hill, Edinburgh EH9 3HJ, U.K.

E-mail contact: nrm@starlink.qmw.ac.uk

We present submillimetre continuum observations of the L1204/S140 complex in broad bands centred at 450, 800 and 1100μm. The morphology of the region is similar at all three wavelengths, with the emitting region compact, about 90 arcsec in diameter, and centrally peaked around the cloud core. Three new submillimetre continuum sources are observed which are not coincident with any previously known near or mid-infrared sources. We designate the sources S140-SMM1–3. SMM1 is roughly coincident with a previously known NH_3 clump and 2.7mm source, and near-ir reflection nebulosity from the surface of SMM2 has previously been seen. The three submillimetre continuum sources may be protostellar in nature, although it is not possible to determine whether they are gravitationally bound, since virial mass estimates are disrupted by the presence of an energetic bipolar outflow. For this reason, earlier claims that the 2.7mm source in SMM1 is collapsing appear somewhat premature. The observation that SMM1 and SMM2 lie either side of the infrared sources, in a line roughly perpendicular to the direction of the bipolar outflow, imply they may be the remnants of a large-scale disk.

Comparison of the continuum emission with previous high resolution CS, NH_3 and CI observations provides evidence that, for the first time, demonstrates the PDR and outflow are intimately linked. The only scenario that is able to explain all of the available molecular and atomic emission line data and our submillimetre continuum data, is one in which the outflow has expanded towards the edge of the molecular cloud and the edge of the blueshifted outflow lobe is now bounded by the expanding HII region. The NH_3 and continuum emission emanate from the inner edge of the outflow lobe, shielded from the external UV field.

A plot of the 800μm flux against N($C^{18}O$) implies that the dust/gas mass ratio is close to the canonical value ($\sim$1%) at the lower end of the observed extinction range ($A_v \leq 70$), but for the highest observed extinctions (A_v =70–100) the continuum flux density increases rapidly, implying a higher dust/gas mass ratio is appropriate ($\sim$2-5%), possibly

indicating freeze-out of gas onto dust grains.

Accepted by Astron. & Astrophys.

Fragmentation of Filamentary Molecular Clouds with Longitudinal Magnetic Fields: Formation of Disks and their Collapse

Fumitaka Nakamura[1], Tomoyuki Hanawa[1] and Takenori Nakano[2]

[1] Department of Astrophysics, School of Science, Nagoya University, Chikusa-ku, Nagoya 464-01, Japan
[2] Nobeyama Radio Observatory, Nobeyama, Minamisaku, Nagano 384-13, Japan

We followed fragmentation of magnetized filamentary clouds and formation of disks with numerical simulations and semi-analytical approach. The two-dimensional magnetohydrodynamical simulations showed that a filamentary cloud with longitudinal magnetic fields fragments to form geometrically thin disks perpendicular to the magnetic field. Each disk contracts dynamically toward the symmetry axis keeping quasi-static equilibrium in the direction parallel to the axis. We followed the late-stage evolution of the disk with a one-dimensional numerical simulation assuming that the disk is infinitesimally thin, and found that the disk approaches a state in which the surface density is inversely proportional to the distance from the center, suggesting the existence of a similarity solution. With some simplification we obtained numerically some similarity solutions for the one-dimensional dynamically contracting disks.

Accepted by Astrophys. J.

Discovering new weak-line T Tauri stars in Taurus–Auriga with the ROSAT All-Sky Survey

R. Neuhäuser[1], M.F. Sterzik[1], J.H.M.M. Schmitt[1], R. Wichmann[2], and J. Krautter[2]

[1] Max-Planck-Institut für Extraterrestrische Physik, D–85740 Garching, Germany
[2] Landessternwarte Königstuhl, D–69117 Heidelberg, Germany

We analyse ROSAT All-Sky Survey (RASS) observations of a $\sim 10^3$ deg^2 area including the Taurus–Auriga star forming region and its surroundings. The sample of low-mass pre-main sequence stars detected with the spatially complete flux-limited RASS consists mainly of weak-emission line T Tauri stars (WTTS). Two thirds of all RASS X-ray sources cannot be identified with known stellar or extragalactic counterparts. Based on the fraction of spectroscopically identified WTTS among a sample of previously unidentified RASS sources, we extrapolate a lower limit for the total number of WTTS in and around Taurus–Auriga: WTTS outnumber classical TTS by at least a factor of 8. A selection criterion for WTTS candidates is established based on the low-resolution X-ray spectra of identified WTTS. We achive a selection reliability of 54%.

Accepted by A.&A. (preprints are available from Ralph Neuhäuser, Internet: rne@hpth03.mpe-garching.mpg.de)

On the 21 μm feature in HII regions

René D. Oudmaijer[1] and Dolf de Winter[2]

[1] Kapteyn Astronomical Institute, P.O.Box 800, 9700 AV Groningen, The Netherlands
[2] Astronomical Institute 'Anton Pannekoek', Univ. of Amsterdam, Kruislaan 403, 1098 SJ Amsterdam, The Netherlands
E-mail contact: oudmayer@astro.rug.nl

It has recently become possible to reduce all raw IRAS Low Resolution Spectrograph (LRS) data in an interactive way. In this paper several problems concerning the reduction of data of extended objects are addressed. We investigated the presence of the 21 μm emission feature in HII regions as reported by Cox (1990). A careful re-analysis of the IRAS data shows that the feature can well be explained by an artefact of the data reduction since the objects are extended at IRAS wavelengths. The extent of the objects leads to an underestimate of the point source flux density and a decrease of the LRS spectrum at the wavelength edges.

Accepted by Astron. & Astroph. (Letters)

On the dynamics of tilted discs around young stars

John C.B. Papaloizou and Caroline Terquem

Astronomy Unit, School of Mathematical Sciences, Queen Mary and Westfield College, University of London, Mile End Road, London E1 4NS, U.K.

E-mail contact: J.C.B.Papaloizou@qmw.ac.uk, C.Terquem@qmw.ac.uk

Tidal perturbation of a circumstellar disc by a companion on an inclined circular orbit in a binary system of T Tauri stars is studied. The two stars have comparable masses and we suppose that the separation of the system is large enough compared to the radius of the disc to allow a linear analysis. In this paper we concentrate on the tidally induced angular momentum transport in the disc arising from ($m = 1$) bending waves that are excited by potential perturbations with odd symmetry with respect to reflection in the disc midplane. These are of interest because they have a long wavelength which may in some cases be a significant fraction of the radius. Then propagation to the inner regions of the disc is facilitated. We calculate the response of the disc to tidal perturbations with both zero and non-zero perturbing frequencies. We expect the response to the zero frequency term to be an approximate rigid body precession if the sound crossing time turns out to be short compared to the precession period. The response to the non-zero frequencies are long wavelength waves excited at the outer edge of the disc and which propagate inwards transporting negative angular momentum with, in the inviscid case, an associated conserved wave action. Such conservation implies that the wave amplitude increases as it propagates inwards until nonlinear effects become important and cause the wave to damp. Because the perturber rotates external to, and more slowly than, the disc, on dissipation of the wave, angular momentum is transfered from the disc to the companion, increasing the accretion rate onto the central star. If nonlinear dissipation can produce a slowly decreasing wave action as the disc centre is approached, it is possible that tidal effects could induce an accretion rate which is on the order of typical accretion rates in classical T Tauri stars (namely between 10^{-9} and 10^{-7} $M_\odot$/yr).

As long as the response of the disc is wavelike, the wave angular momentum flux induced in our model discs tends to increase with increasing separation of the binary system. This is at least in part due to the fact that the response of the disc has an increasing wavelength with increasing separation.

The torque exerted by the perturber on the disc leads to the evolution of the relative inclination of the disc and the orbital planes, but not necessary towards coplanarity. In some cases, the only stable equilibrium position of the system does not correspond to coplanarity. The time-scale for this evolution is on the order of magnitude of the time needed by tidal effects to remove the angular momentum content of the disc.

We conclude that when the orbit is highly inclined in respect to the disc, tidal effets may play a significant role in the accretion process in the circumprimary disc.

Accepted by M.N.R.A.S.

Infrared Spectroscopy of Herbig-Haro Objects

Richard D. Schwartz[1], A.S.B. Schultz[2], Martin Cohen[3], and Peredur M. Williams[4]

[1] Dept. of Physics & Astronomy, Univ. of Missouri-St. Louis, 8001 Natural Bridge Road, St. Louis, MO 63121, USA
[2] MS 245-6, NASA Ames Research Lab, Moffett Field, CA 94035-1000, USA
[3] Radioastronomy Laboratory, 601 Campbell Hall, University of California, Berkeley, CA 94720, USA
[4] Royal Observatory, Blackford Hill, Edinburgh EH9 3HJ, Scotland

We report near-infrared spectrophotometry of H_2 emission in a set of low-excitation Herbig-Haro Objects for which optical emission line fluxes are available. In most objects, the H_2 line ratio 2-1 S(3)/ 1-0 S(1) is consistent with collisional excitation in low-velocity shocks, with no indication of a fluorescence component. The excitation plot for HH 43 shows definite curvature, with a nonlinear (logarithmic) best fit suggesting that the higher excitation lines are created in the hottest postshock gas. This curvature of the excitation plot is akin to that seen in HH 91A and the OMC, where it has been taken as evidence of non-dissociative J-shocks. In general, the 1-0 S(1) flux appears to be comparable to the Hα flux. The implications of this are discussed with respect to the nature of the shocks which produce the optical and H_2 emission.

Accepted by The Astrophysical Journal (scheduled for the June 10, 1995 issue)

L1780: a cometary globule associated with Loop I?

L.V. Tóth[1,2] L.K. Haikala[1,2] T. Liljeström[1] K. Mattila[1]

[1] Department of Astronomy of the Loránd Eötvös University, Ludovika tér 2., H-1083 Budapest, Hungary
[2] Helsinki University Observatory, P.O. Box 14, FIN-00014 University of Helsinki, Finland
[3] I. Physikalisches Institut, Universität zu Köln, 50937 Köln, Germany

^{12}CO, ^{13}CO and C^{18}O J = 1 $\rightarrow$ 0 observations of the L1778/L1780 high latitude ($b = 36^{o}.7$) dark cloud have been carried out using the Gornergrat 3m and SEST 15m telescopes. The observations revealed a cometary cloud structure: a dense core asymmetrically surrounded by a diffuse outer layer. The mass of the cloud calculated from the CO observations is 21.6M$_{\odot}$. The compact ^{13}CO core has a mass of 8.3M$_{\odot}$ and is found to be in virial equilibrium. The CO data have been compared to previous optical, H I, and IRAS observations. We suggest that the structure and the morphology of L1780 have been influenced by two large scale environmental effects: (1) the asymmetric interstellar UV radiation field and (2) a shock front, both caused by the high mass stars of the Sco – Cen OB association.

Accepted by Astron. & Astrophys.

Confirmation of the Driving Source of the NGC2264G Bipolar Outflow:– a Class 0 Protostar

D. Ward-Thompson[1], C. Eiroa[2] and M. M. Casali[1]

[1] Royal Observatory, Blackford Hill, Edinburgh EH9 3HJ, UK
[2] Depto. Fisica Teórica C-XI, Universidad Autónoma de Madrid, E-28049 Madrid, Spain

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

Results are presented of a JCMT submillimetre continuum study of the recently discovered VLA source at the centre of the NGC2264G bipolar outflow, known as NGC2264G-VLA2, which is coincident with the source IRAS 06384+0958. Submillimetre flux densities are listed, and the IRAS Calibrated Reconstructed Detector Data are analysed. A 100-μm flux density, together with 12- and 25-μm upper limits are obtained for this source, which only has a 60-μm flux density listed in the Point Source Catalog. The spectral energy distribution of the source is discussed and various parameters derived. The circumstellar mass in a 0.07pc diameter region is found to be $\sim$2–4 M$_{\odot}$, a bolometric luminosity of $\sim$12 L$_{\odot}$ is derived, compared to a previous upper limit for the region of 4.5 L$_{\odot}$, from a survey which discounted this source as cirrus (Margulis et al. 1990), and a submillimetre luminosity of $\sim$0.3 L$_{\odot}$ is found. Thus the ratio of bolometric to submillimetre luminosity is $\sim$40, and the source is seen to be consistent with a deeply embedded Class 0 protostar. The ratio of outflow mechanical luminosity to driving source luminosity is calculated in the light of the new data.

Accepted by MNRAS

High resolution molecular line observations of the Serpens Nebula

Glenn J White[1] , Mark M. Casali [2] and Goeran Sandell [3]

[1] Physics Department, Queen Mary and Westfield College, The University of London, Mile End Road, London E1 4NS, England
[2] Royal Observatory, Blackford Hill, Edinburgh EH9 3HJ, Scotland
[3] Depto. de Fisica Teorica, Facultad de Ciencias, Univ. Autonoma de Madrid, Cantoblanco 28049 Madrid, Spain

E-mail contact: G.J.White@qmw.ac.uk

The Serpens Molecular cloud is a nearby low / intermediate mass star forming region that is in the final stages of forming a densely packed cluster of stars. Spectra and high angular resolution maps of the CO, ^{13}CO, C^{18}O and C^{17}O J=2-1 and CO J= 4-3 transitions were obtained to study the distribution of molecular gas near the cluster. These are supplemented with data on the J= 4-3 HCO^{+} line (to probe the denser gas), and 3P1 - 3P0 line of atomic carbon. The mass of the region is estimated to be 1450 M$_{\odot}$, implying that the star formation efficiency in the region to date has been 2.5 percent. Several molecular outflows are visible in the maps; some are associated with compact objects visible in millimetre and submillimetre wave continuum maps, as well as more widespread diffuse high velocity gas that extends over much of the nebula. The mass and energy of material in the high velocity gas are relatively small, 0.3 M$_{\odot}$ and 3 x 10^{45} erg s^{-1}, consistent with the characteristics of outflows seen towards low mass star-formation regions. The directions of the overlapping outflow lobes do not however show a clear alignment with the cloud's large

scale magnetic field as has been reported towards some other regions. The gas temperatures in the region are warmer (30 - 40 K) than typical for dark clouds, suggesting that the Serpens cluster has interacted with, and heated the gas. Estimates of the CO isotopomeric abundance ratios from these data may be strongly affected by opacity and radiative transfer effects. In a comparison of the LTE and LVG techniques, the disagreement between the derived column densities is discussed - with particular relevance to the higher rotational transitions.

Accepted by Astronomy and Astrophysics

A copy of the paper and figures is available on our Preprint Server via the World Wide Web at:
http://www.qmw.ac.uk/Astronomy.html, follow through to the Preprints section

CO, CI and 790 micron continuum observations of the Orion Molecular Cloud and Ionisation Bar

Glenn J White[1] **and Goeran Sandell** [2]

[1] Physics Department, Queen Mary and Westfield College, The University of London, Mile End Road, London E1 4NS, England
[2] Joint Astronomy Centre, 660 North A'ohoku Place, University Park, Hilo, Hawaii HI 96720, USA

E-mail contact: G.J.White@qmw.ac.uk

The spatial distributions of the $^3P_1$–$^3P_0$ atomic fine structure of carbon (CI), the CO J=4-3, the CO J=2-1 transitions of CO, ^{13}CO, C^{18}O and C^{17}O and the 790 μm continuum emission have been mapped towards the central region of the Orion molecular cloud (OMC1 cloud), and the Bright Bar ionisation front. The CO data are analysed in a consistent way, allowing the inter isotopomeric abundance ratios to be studied over a wide range of extinction values. The ^{13}CO lines are optically thick; the ^{13}CO abundance being enhanced because of strong isotopic fractionation near the Bright Bar, but less convincingly in the OMC1 cloud. The fractionation occurs mostly in the less opaque regions where N(^{13}CO) may be enhanced by up to one order of magnitude, relative to the more shielded parts. No isotope selective enhancement of the other CO isotopomers was seen; C^{18}O may in fact show a slight depletion in more exposed material. The C^{18}O and C^{17}O lines are optically thin, and correlated with the 790 μm dust continuum emission. The CI emission comes from hot optically thin gas; the abundance ratios of [CI]/[CO] are typically 0.05 - 0.3, with the larger ratios towards the northern section of the Orion ridge. The CI abundance ratios are also high along the edge of the Bright Bar which is adjacent to the HII region (and the Trapezium cluster which excites it), but decrease in the dense shielded material behind the Bar.

Accepted by Astronomy and Astrophysics

A copy of the paper and figures is available on our Preprint Server via the internet
http://www.qmw.ac.uk/Astronomy.html, follow through to the Preprints section

Studies of dense molecular cores in regions of massive star formation. II. CS $J = 2 - 1$ survey of southern H_2O masers in the longitude range l = 260° – 310°

I. Zinchenko[1,2], **K. Mattila**[2], **M. Toriseva**[2]

[1] Institute of Applied Physics of the Russian Academy of Sciences, 46 Uljanov str., 603600 Nizhny Novgorod, Russia, e-mail: zin@appl.nnov.su
[2] Helsinki University Observatory, Tähtitorninmäki, P.O.Box 14, FIN-00014 University of Helsinki, Finland

We searched for the CS $J = 2 - 1$ emission towards 30 southern H_2O and OH masers with the SEST radio telescope (29 H_2O and H_2O/OH masers and 1 OH maser). We detected and mapped 24 CS emitting regions associated probably with 27 H_2O masers. The C^{34}S $J = 2-1$ and CO $J = 1-0$ lines were also observed at the grid positions closest to the CS peaks. Here we present the CS maps and the spectra at the peak positions along with the CO and C^{34}S spectra. We derive the C^{34}S column densities in the LTE approximation and discuss briefly the spatial and kinematic structure of the sources. The association with the IRAS point sources and small scale structure sources is examined. We estimate the kinematic distances to the cores and derive their sizes, masses and mean densities. The velocity differences between the masers and CS cores are analyzed. The CO and CS spectra towards several sources demonstrate deep absorption features. We argue that they can be due to extended low excitation foreground cloud(s).

Accepted by Astron. Astrophys.

Dissertation Abstracts

Long-slit spectroscopic investigations of the forbidden emission line regions of young stars

Gerhard A. Hirth

Thesis work conducted at: Max-Planck-Institut für Astronomie, Heidelberg, Germany

Current address: Max-Planck-Institut für Astronomie, Königstuhl 17, D-69117 Heidelberg, Germany

Electronic mail: hirth@mpia-hd.mpg.de

Ph.D dissertation directed by: Reinhard Mundt

Ph.D degree awarded: October 1994

Our poor knowledge about the physical properties of outflows from young stars (e.g. outflow velocity, collimation, excitation) on scales of a few 100 AU distance from the source was the reason for conducting a long-slit spectroscopic survey of the forbidden emission lines from 38 classical T Tauri stars in the optical. The forbidden emission lines which are thought to be excited by internal shocks in the outflowing gas are often the only diagnostic mean to investigate these outflows since these stars have no extended jet or Herbig-Haro objects.

More than half of the T Tauri stars of the survey are located within nearby star formation regions ($d \leq 200$ pc) and for 14 objects spatial information on the properties of the forbidden emission line regions have been obtained by taking long-slit spectra at four to six slit positions which allowed an approximate determination of the outflow direction.

As a surprising result of this survey all but one of these 14 T Tauri stars show spatially extended forbidden emission line regions. In most cases this is probably the result of a bipolar jet. The typical spatial extent in the outflow direction is of the order of 50 – 500 AU. The opening angles of the outflows derived from radial velocity and velocity dispersion data suggest values between 10 and 20 degrees at distances between a few 100 and 1000 AU and values up to 2 – 3 times higher at scales below 200 AU. *This means that extended and partially well collimated outflows are a typical property of presumably most of the classical T Tauri stars.*

Interestingly in 50% of all bipolar outflows from T Tauri stars and embedded sources the outflow velocity of the blueshifted and redshifted part differs about a factor of 1.4 to 2.6. Probably the flow is accelerated to intrinsically different velocities on opposite sides of the star. However, an asymmetric pressure and density distribution of the surrounding circumstellar matter could also cause similar effects.

A detailed study of the double-peaked profile of the forbidden emission lines gives strong evidence that the two velocity components originate in spatially different regions. The high-velocity component is probably formed in a well collimated jet whereas there are indications that the low-velocity component originates within a rotating line formation region presumably associated with a disk wind.

For seven young stars of the survey spectra of at least three epochs are available. From these observations and from data in the literature it was possible to show that temporal variations in the forbidden emission lines are probably a typical property of many T Tauri stars. Studying such variations gives an additional interesting diagnostic mean for these outflows. Due to the relatively small extent of the emission regions of some forbidden emission lines ($r \leq 30$ AU) and the high outflow velocities (≈ 200 km s^{-1}) it is in principle possible that strong variations in the emission properties of the outflows occur within a few months. Note that so far radial velocity studies along extended jets and Herbig-Haro objects provided information only on time scales of the order of 10 to 1000 years. In studying position-velocity maps obtained from spectra with epoch differences of a few months up to a few years significant changes in the forbidden emission line flux, radial velocity, velocity dispersion and in the spatial properties of the high- and low-velocity component have been observed in seven TTSs. The different temporal variation of the two velocity components gives additional support to the idea that the two components in the double-peaked profile of the forbidden emission lines are formed in two physically separated regions.

New Jobs

The University of New South Wales, Sydney, Australia

Department of Astrophysics

POSTDOCTORAL RESEARCH FELLOWSHIP

in Infrared Astronomy and Star Formation

Applications are invited for a Research Associate position funded by the Australian Research Council, to work with Dr Michael Burton on infrared astronomy. Experience is needed in one or more of the following research areas : (i) the excitation of molecular clouds; (ii) star formation; (iii) the interaction of supernova remnants with the interstellar medium; (iv) the Galactic centre; and (v) the interstellar medium in external galaxies. Experience in modeling IR line emission would 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. The salary scale ranges from A$34,953 to A$38,950, depending on qualifications and experience.

The Department of Astrophysics at UNSW is an active group with 6 faculty members and 9 post-graduate students. The group is playing a leading role in the development of the Antarctic Plateau for astronomy, and operate two site-testing experiments at the South Pole. A wide-field infrared Fabry-Perot (UNSWIRF) array camera is also being developed for the AAT. A network of workstations (Sun and Dec) and X-terminals are available for data analysis.

Further details can be obtained from Dr Burton (email: mgb@newt.phys.unsw.edu.au; tel : +61-2-385-5618), or via the www (URL http://www.phys.unsw.edu.au/home.html). Applications should include a CV, a bibliography, and a statement of research interests, and be sent to the School of Physics, University of New South Wales, Sydney, NSW 2052, Australia (FAX : +61-2-663-3420) before February 15, 1995. Applicants should arrange for up to three letters of recommendation to arrive by this date.

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. You can either access it via the ESO Portal (http://http.hq.eso.org/eso-homepage.html) or directly in two ways: by issue number (http://http.hq.eso.org/star-form-newsl/star-form-list.html) or via a wais index (wais://http.hq.eso.org:2010/starform). 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/

Meetings

The 1995 Gordon Conference on "Origins of the Solar System" will take place in New Hampton, New Hampshire, USA, between Jun 18 and June 23, 1995. A formal announcement will appear in the February 3, 1995, issue of "Science".

The "Origins" Gordon Conference is held biannually. Astronomers and planetary scientists meet to discuss the wide variety of studies that contribute to understanding the origins of the solar system. The Gordon Conference format is designed to encourage presentation and lively discussion of the latest work in each field. Poster sessions are very much part of the format.

Further information may be obtained from Anneila Sargent, Astronomy Dept., Caltech 105-24, Pasadena, CA 91125 (afs@mmstar.caltech.edu)

1995 Gordon Research Conference on the Origins of Solar Systems

July 19 – 23, New Hampton School, New Hampton, NH

Chair: A. I. Sargent, Dept of Astronomy, Caltech 105-24, Pasadena CA 91125

Vice-Chair: J. F. Kerridge, Dept. of Chemistry, 0317, University of California, San Diego, CA 92093-0317

Session 1. Formation of Preplanetary Disks (Discussion leader: E. H. Levy)

(1) Opening remarks (2) A. Goodman, Molecular Cloud Collapse (3) A. Boss, Formation of the Protosolar Nebula

Session 2. Preplanetary Disks (Discussion Leader: C. J. Lada)

(1) D. N. C. Lin, Disk Kinematics (2) M. McCauchrean, Optical Observations of Proto-Planetary Disks

Session 3. Nucleosynthesis and chemical evolution (Discussion Leader: A. G. W. Cameron)

(1) D. D. Clayton, Cosmic Rays, Gamma Rays & Extinct Radioactivities in the Star-forming Cores of Molecular Clouds (2) G. A. Blake, Chemistry of Protoplanetary Disks (3) M. Busso, Nucleosynthetic Implications of Meteoritic Isotope Anomalies.

Session 4. Intersteller dust in the solar system (Discussion leader: D. S. Woolum)

(1) U. Ott, Sources of the Dust (2) D. E. Brownlee, Dust Properties

Session 5. Dust in Specific Environments (Discussion leader: S. P. Ruden)

(1) J. N. Cuzzi, Dust in the Nebular Environment (2) S. V. W. Beckwith, Dust In Protoplanetary Disks (3) B. Zuckerman, Vega-type Disks

Session 6. Effects of Secondary Objects (Discussion leader: C. Porco)

(1) A. M. Ghez, The effect of binaries (2) P. D. Nicholson, Planetary Rings

Session 7. Dissipating the Disks – Chronology (Discussion leader: J. J. Lissauer)

(1) P. Cassen, Chronology (theory) (2) Business meeting (3) S. E. Strom, Chronology (astronomical observations)

Session 8: Dissipating the Disks – cont'd (Discussion leader: J. A. Wood)

(1) G. W. Lugmair, Radiochronology of the solar nebula: I (2) F. A. Podosek, Radiochronology of the solar nebula: II

Session 9: Primitive Objects in the Outer Solar System (Discussion leader: M. J. Mumma)

(1) S. J. Weidenschilling, Accretion of comets (2) J. X. Luu, Objects in the Kuiper Belt (3) C. R. Chapman, Results from Comet Shomaker/Levy 9

New Books

The Nature and Evolutionary Status of Herbig Ae/Be Stars

Proceedings of the First International Meeting held in Amsterdam, 26–29 October, 1993

Volume 62, Astronomical Society of the Pacific, Conference Series

Edited by Pik Sin Thé, Mario R. Pérez, and Ed P.J. van den Heuvel

The book contains the invited reviews, contributed oral presentations and the poster papers presented at the Amsterdam meeting. This meeting was attended by 110 registered participants from 22 different countries. In this book, there are 95 articles distributed in 13 major sections. The following authors and titles are a sample of the invited reviews presented:

G.H. Herbig (Honorary Lecture): *The Ae/Be Stars*

I. Appenzeller: *Herbig Ae/Be Stars: The Interface Between Low-Mass and High-Mass Star Formation*

P.S. Thé: *The Photometric Behavior of Herbig Ae/Be Stars and Its Interpretation*

V.P. Grinin: *Polarimetric Activity of Herbig Ae/Be Stars*

C. Catala: *The Spectroscopic Variability of the Herbig Ae/Be Stars*

C.L. Imhoff: *Mg II and Clues to the Evolutionary Status of the Herbig Ae/Be Stars*

S.L. Skinner: *Radio Emission from Herbig Ae/Be Stars*

Ch. Leinert et al.: *Near-Infrared Speckle Observations of Herbig Stars*

N. Calvet et al.: *Infalling Envelopes in Herbig Ae/Be Stars*

R. Mundt & T.P. Ray: *Optical Outflows from Herbig Ae/Be Stars and other High Luminosity Young Stellar Objects*

H. Zinnecker & T. Preibisch: *ROSAT X-ray Observations of Herbig Ae/Be Stars*

S.N. Shore: *Massive Binary Systems Among the Herbig Ae/Be Stars*

M.R. Pérez: *Herbig Ae/Be Stars in Young Open Clusters*

J.A. Graham: *Interaction Between Herbig Ae/Be Stars and the Surrounding Medium*

F. Palla & S.W. Stahler: *The Formation and Evolution of Herbig Ae/Be Stars*

P.S. Thé: *Concluding Remarks*

456 pages (including indices), hardbound, ISBN 0-937707-81-2, 1994, US $ 40 (plus shipment)

Astronomical Society of the Pacific
CONFERENCE SERIES
390 Ashton Avenue
San Francisco, CA 94112-1722
(415)-337-1100