THE STAR FORMATION NEWSLETTER

An electronic publication dedicated to early stellar evolution and molecular clouds

No. 167 — 21 September 2006 Editor: Bo Reipurth (reipurth@ifa.hawaii.edu)

Abstracts of recently accepted papers

Formation and structure of the three Neptune-mass planets system around HD69830

Y. Alibert[1], I. Baraffe[2], W. Benz[1], G. Chabrier[2], C. Mordasini[1], C. Lovis[3], M. Mayor[3], F. Pepe[3], F. Bouchy[4], D. Queloz[3] and S. Udry[3]

[1] Physikalisches Insitut, University of Bern, Sidlerstrasse 5, 3012 Bern, Switzerland
[2] CRAL, École Normale Supérieure, 46 allée d'Italie, 69007 Lyon, France
[3] Observatoire de Genéve 51 Ch. des Maillettes, 1290 Sauverny, Switzerland
[4] Institut d'Astrophysique de Paris, 98bis Bd Arago, 75014 Paris, France

E-mail contact: yann.alibert@space.unibe.ch

Since the discovery of the first giant planet outside the solar system in 1995 (Mayor & Queloz 1995, Nature, 378, 355), more than 180 extrasolar planets have been discovered. With improving detection capabilities, a new class of planets with masses 5-20 times larger than the Earth, at close distance from their parent star is rapidly emerging. Recently, the first system of three Neptune-mass planets has been discovered around the solar type star HD 69830 (Lovis et al. 2006, Nature, 441, 305). Here, we present and discuss a possible formation scenario for this planetary system based on a consistent coupling between the extended core accretion model and evolutionary models (Alibert et al. 2005a, A&A, 434, 343; Baraffe et al. 2004, A&A, 419, L13; Baraffe et al. 2006, A&A, 450, 1221). We show that the innermost planet formed from an embryo having started inside the iceline is composed essentially of a rocky core surrounded by a tiny gaseous envelope. The two outermost planets started their formation beyond the iceline and, as a consequence, accrete a substantial amount of water ice during their formation. We calculate the present day thermodynamical conditions inside these two latter planets and show that they are made of a rocky core surrounded by a shell of fluid water and a gaseous envelope.

Published by Astronomy & Astrophysics (Vol. 455, p. L25)

Spitzer/MIPS 24 micron Detection of Photoevaporating Protoplanetary Disks

Zoltan Balog[1,2], George H. Rieke[1], Kate Y. L. Su[1], James Muzerolle[1] and Erick T. Young[1]

[1] Steward Observatory Univ. of Arizona 933. N. Cherry Av.,Tucson AZ 85704 USA
[2] on leave from Dept of Optics Univ. of Szeged Dom ter 9. Szeged, H-6720, Hungary

E-mail contact: zbalog@as.arizona.edu

We present 24 micron images of three protoplanetary disks being photoevaporated around high mass O type stars. These objects have "cometary" structure where the dust pulled away from the disk by the photoevaporating flow is forced away from the O star by photon pressure on the dust and heating and ionization of the gas. Models of the 24 micron and 8 micron brightness profiles agree with this hypothesis. These models show that the mass-loss rate needed to sustain such a configuration is in agreement with or somewhat less than the theoretical predictions for the photoevaporation process.

Accepted by The Astrophysical Journal Letters

http://arxiv.org/list/astro-ph/0608630

On the age of the TW Hydrae Association and 2M1207334−393254

David Barrado y Navascués[1]

[1] Laboratorio de Astrofísica Espacial y Física Fundamental, LAEFF-INTA, P.O. Box 50727, E-28080 Madrid, SPAIN

E-mail contact: barrado@laeff.inta.es

We have estimated the age of the young moving group TW Hydrae Association, a cohort of a few dozen stars and brown dwarfs located near the Sun which share the same kinematic properties and, presumably, the same origin and age. The chronology has been determined by analyzing different properties (magnitudes, colors, activity, lithium) of its members and comparing them with several well-known star forming regions and open clusters, as well as theoretical models. In addition, by using medium-resolution optical spectra of two M8 members of the association (2M1139 and 2M1207 –an accreting brown dwarf with a planetary mass companion), we have derived spectral types and measured Hα and lithium equivalent widths. We have also estimated their effective temperature and gravity, which were used to produce an independent age estimation for these two brown dwarfs. We have also collected spectra of 2M1315, a candidate member with a L5 spectral type and measured its Hα equivalent width. Our age estimate for the association, 10^{+10}_{-7} Myr, agrees with previous values cited in the literature. In the case of the two brown dwarfs, we have derived an age of 15^{+15}_{-10} Myr, which also agree with our estimate for the whole group. We compared our results with recent articles published on the same subject using other techniques, and discuss the limits of the age-dating techniques.

Accepted by Astronomy & Astrophysics

http://xxx.unizar.es/abs/astro-ph/0608478

Formation of Narrow Dust Rings in Circumstellar Debris Disks

Gurtina Besla[1,2] **and Yanqin Wu**[2]

[1] Harvard-Smithsonian Center for Astrophysics, 60 Garden St., Cambridge, MA 02139, USA
[2] Department of Astronomy & Astrophysics, University of Toronto, 50 St. George St., Toronto, ON, M5S 3H4, Canada

E-mail contact: gbesla@cfa.harvard.edu, wu@astro.utoronto.ca

Narrow dust rings observed around some young stars (e.g., HR 4796A) need to be confined. We present a possible explanation for the formation and confinement of such rings in optically thin circumstellar disks, without invoking shepherding planets. If an enhancement of dust grains (e.g., due to a catastrophic collision) occurs somewhere in the disk, photoelectric emission from the grains can heat the gas to temperatures well above that of the dust. The gas orbits with super(sub)-Keplerian speeds inward (outward) of the associated pressure maximum. This tends to concentrate the grains into a narrow region. The rise in dust density leads to further heating and a stronger concentration of grains. A narrow dust ring forms as a result of this instability. We show that this mechanism not only operates around early-type stars that have high UV fluxes, but also around stars with spectral types as late as K. This implies that this process is generic and may have occurred during the lifetime of each circumstellar disk. We examine the stringent upper-limit on the H_2 column density in the HR 4796A disk and find it to be compatible with the presence of a significant amount of hydrogen gas in the disk. We also compute the OI and CII infrared line fluxes expected from various debris disks and show that these will be easily detectable by the upcoming Herschel mission. Herschel will be instrumental in detecting and characterizing gas in these disks.

Accepted by Astrophys. J.

Modeling of PMS Ae/Fe stars using UV spectra

P. F. C. Blondel[1,2] **and H. R. E. Tjin A Djie**[1]

[1] Astronomical Institute “Anton Pannekoek”, University of Amsterdam, Kruislaan 403, 1098 SJ Amsterdam, The Netherlands
[2] SARA, Kruislaan 415, 1098 SJ Amsterdam, The Netherlands

E-mail contact: blondel@sara.nl

Context. Spectral classification of AeFe stars, based on visual observations, may lead to ambiguous conclusions.

Aims. We aim to reduce these ambiguities by using UV spectra for the classification of these stars, because the rise of the continuum in the UV is highly sensitive to the stellar spectral type of A/F-type stars.

Methods. We analyse the low-resolution UV spectra in terms of a 3-component model, that consists of spectra of a central star, of an optically-thick accretion disc, and of a boundary-layer between the disc and star. The disc-component was calculated as a juxtaposition of Planck spectra, while the 2 other components were simulated by the low-resolution UV spectra of well-classified standard stars (taken from the IUE spectral atlases). The hot boundary-layer shows strong similarities to the spectra of late-B type supergiants (see Appendix A).

Results. We modeled the low-resolution UV spectra of 37 AeFe stars. Each spectral match provides 8 model parameters: spectral type and luminosity-class of photosphere and boundary-layer, temperature and width of the boundary-layer, disc-inclination and circumstellar extinction. From the results of these analyses, combined with available theoretical PMS evolutionary tracks, we could estimate their masses and ages and derive their mass-accretion rates. For a number of analysed PMS stars we calculated the corresponding SEDs and compared these with the observed SEDs.

Conclusions. All stars (except βPic) show indications of accretion, that affect the resulting spectral type of the stellar photosphere. Formerly this led to ambiguities in classificaton of PMS stars as the boundary-layer was not taken into consideration. We give evidence for an increase of the mass-accretion rate with stellar mass and for a decreases of this rate with stellar age.

Published by Astronomy & Astrophysics (Vol. 456, p. 1045)

The Spitzer c2d Survey of Nearby Dense Cores: II: Discovery of a Low Luminosity Object in the "Evolved Starless Core" L1521F

Tyler L. Bourke[1], Philip C. Myers[1], Neal J. Evans II[2], Michael M. Dunham[2], Jens Kauffmann[3], Yancy Shirley[4], Antonio Crapsi[5], Chadwick H. Young[6], Tracy L. Huard[1], Timothy Y. Brooke[7], Nicholas Chapman[8], Lucas Cieza[2], Chang-Won Lee[9], Peter Teuben[8] and Zahed Wahhaj[10]

[1] Harvard-Smithsonian Center for Astrophysics
[2] Universty of Texas at Austin
[3] Max-Planck-Institut für Radioastronomie
[4] Steward Observatory, University of Arizona
[5] Leiden Observatory
[6] Nicholls State University
[7] California Institute of Technology
[8] University of Maryland
[9] Korea Astronomy & Space Science Institute
[1]0 Northern Arizona University

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

We present Spitzer Space Telescope observations of the "evolved starless core" L1521F which reveal the presence of a very low luminosity object (L <0.07 $L_{\odot}$). The object, L1521F-IRS, is directly detected at mid-infrared wavelengths (>5 μm) but only in scattered light at shorter infrared wavelengths, showing a bipolar nebula oriented east-west which is probably tracing an outflow cavity. The nebula strongly suggests that L1521F-IRS is embedded in the L1521F core. Thus L1521F-IRS is similar to the recently discovered L1014-IRS and the previously known IRAM 04191 in its substellar luminosity and dense core environment. However these objects differ significantly in their core density, core chemistry, and outflow properties, and some may be destined to be brown dwarfs rather than stars.

Accepted by ApJ Letters

astro-ph/0608148

Deficit of wide binaries in the eta Chamaeleontis young cluster

Alexis Brandeker[1,2], Ray Jayawardhana[1], Parandis Khavari[1], Karl E. Haisch, Jr.[3] and Diego Mardones[4]

[1] University of Toronto
[2] Stockholm Observatory
[3] Utah Valley State College
[4] Universidad de Chile

E-mail contact: brandeker@astro.utoronto.ca

We have carried out a sensitive high-resolution imaging survey of stars in the young (6–8 Myr), nearby (97 pc) compact cluster around η Chamaeleontis to search for stellar and sub-stellar companions. Given its youth and proximity, any sub-stellar companions are expected to be luminous, especially in the near infrared, and thus easier to detect next to their parent stars. Here, we present VLT/NACO adaptive optics imaging with companion detection limits for 17 η Cha cluster members, and follow-up VLT/ISAAC near-infrared spectroscopy for companion candidates. The widest binary detected is $\sim$0.″2, corresponding to the projected separation 20 AU, despite our survey being sensitive down to sub-stellar companions outside 0.″3, and planetary mass objects outside 0.″5. This implies that the stellar companion probability outside 0.″3 and the brown dwarf companion probability outside 0.″5 are less than 0.16 with 95 % confidence. We compare the wide binary frequency of η Cha to that of the similarly aged TW Hydrae association, and estimate the statistical likelihood that the wide binary probability is equal in both groups to be $< 2 \times 10^{-4}$. Even though the η Cha cluster is relatively dense, stellar encounters in its present configuration cannot account for the relative deficit of wide binaries. We thus conclude that the difference in wide binary probability in these two groups provides strong evidence for multiplicity properties being dependent on environment. In two appendices we derive the projected separation probability distribution for binaries, used to constrain physical separations from observed projected separations, and summarize statistical tools useful for multiplicity studies.

Accepted by ApJ

http://arxiv.org/abs/astro-ph/0608352

Embedded star clusters and the formation of the Oort Cloud

R. Brasser[1,2], M.J. Duncan[3] and H.F. Levison[4]

[1] Department of Physics, Engineering Physics and Astronomy, Queen's University, Kingston, ON, Canada
[2] Canadian Institute for Theoretical Astrophysics, Toronto, ON, Canada
[3] Department of Physics, Engineering Physics and Astronomy, Queen's University, Kingston, ON, Canada
[4] SouthWest Research Institute, 1050 Walnut Street, Boulder, CO 80302, USA

E-mail contact: brasser_astro@yahoo.com

Observations suggest most stars originate in clusters embedded in giant molecular clouds [Lada, C.J., Lada, E.A., 2003. Annu. Rev. Astron. Astrophys. 41, 57115]. Our Solar System likely spent 15 Myrs in such regions just after it formed. Thus the Oort Cloud (OC) possibly retains evidence of the Sun's early dynamical history and of the stellar and tidal influence of the cluster. Indeed, the newly found objects (90377) Sedna and 2000 CR105 may have been put on their present orbits by such processes [Morbidelli, A., Levison, H.F., 2004. Astron. J. 128, 25642576]. Results are presented here of numerical simulations of the orbital evolution of comets subject to the influence of the Sun, Jupiter and Saturn (with their current masses on orbits appropriate to the period before the Late Heavy Bombardment (LHB) [Tsiganis, K., Gomes, R., Morbidelli, A., Levison, H.F., 2005. Nature 435, 459461]), passing stars and tidal force associated with the gas and stars of an embedded star cluster. The cluster was taken to be a Plummer model with 200-400 stars, with a range of initial central densities. The Sun's orbit was integrated in the cluster potential together with Jupiter and Saturn and the test particles. Stellar encounters were incorporated by directly integrating the effects of stars passing within a sphere centred on the Sun of radius equal to the Plummer radius for low-density clusters and half a Plummer radius for high-density clusters. The gravitational influence of the gas was modeled using the tidal force of the cluster potential. For a given solar orbit, the mean density, $\langle\rho\rangle$, was computed by orbit-averaging the density of material encountered. This parameter proved to be a good measure for predicting the properties of the OC. On average 2-18% of our initial sample of comets end up in the OC after 1-3 Myr. A comet is defined to be part of the OC if it is bound and has q > 35 AU. Our models show that the median distance of an object in the OC scales approximately as $\langle\rho\rangle^{-1/2}$ when $\langle\rho\rangle \gtrsim 10\ M_\odot pc^{-3}$. Our models easily produce objects on orbits like that of (90377) Sedna [Brown, M.E., Trujillo, C., Rabinowitz, D., 2004. Astrophys. J. 617, 645649] within $\sim$ 1 Myr in cases where the mean density is $10^3 M_\odot pc^{-3}$ or higher; one needs mean densities of order $10^4 M_\odot pc^{-3}$ to create objects like 2000 CR_{105} by this mechanism, which are reasonable (see, e.g., Guthermuth, R.A., Megeath, S.T., Pipher, J.L., Williams, J.P., Allen, L.E., Myers, P.C., Raines, S.N., 2005. Astrophys. J. 632, 397420). Thus the latter object may also be part of the OC. Close stellar passages can stir the primordial Kuiper Belt to sufficiently high eccentricities ($e \gtrsim$ 0.05; Kenyon, S.J., Bromley, B.C., 2002. Astron. J. 123, 17571775) that collisions become destructive. From the simulations performed it is determined that there is a 50% or better chance to stir the primordial Kuiper Belt

to eccentricities $e \geq 0.05$ at 50 AU when $\langle\rho\rangle \gtrsim 10^5 M_\odot pc^{-3}$. The orbit of the new object 2003 UB313 [Brown, M.E., Trujillo, C.A., Rabinowitz, D.L., 2005. Astrophys. J. 635, L97L100] is only reproduced for mean cluster densities of the order of $10^5 M_\odot pc^{-3}$, but in the simulations it could not come to be on its current orbit by this mechanism without disrupting the formation of bodies in the primordial Kuiper Belt down to 20 AU. It is therefore improbable that the latter object is created by this mechanism.

Published by Icarus (Vol. 184, p. 59)

Evidence for Mass-dependent Circumstellar Disk Evolution in the 5 Myr-old Upper Scorpius OB Association

John M. Carpenter[1], Eric E. Mamajek[2], Lynne A. Hillenbrand[1] and Michael R. Meyer[3]

[1] California Institute of Technology, Department of Astronomy, MC 105-24, Pasadena, CA 91125, USA
[2] Harvard-Smithsonian Center for Astrophysics, 60 Garden St., MS-42, Cambridge, MA 02138, USA
[3] Steward Observatory, The University of Arizona, 933 North Cherry Ave., Tucson, AZ 85721, USA

E-mail contact: jmc@astro.caltech.edu

We present 4.5, 8, and 16μm photometry from the *Spitzer Space Telescope* for 204 stars in the Upper Scorpius OB Association. The data are used to investigate the frequency and properties of circumstellar disks around stars with masses between $\sim$0.1 and 20 M$_\odot$ at an age of $\sim$5 Myr. We identify 35 stars that have emission at 8μm or 16μm in excess of the stellar photosphere. The lower mass stars ($\sim$0.1-1.2 M$_\odot$) appear surrounded by primordial optically thick disks based on the excess emission characteristics. Stars more massive than $\sim$1.8 M$_\odot$ have lower fractional excess luminosities suggesting that the inner $\sim$10 AU of the disk has been largely depleted of primordial material. None of the G and F stars ($\sim$1.2-1.8 M$_\odot$) in our sample have an infrared excess at wavelengths $\leq$16μm. These results indicate that the mechanisms for dispersing primordial optically thick disks operate less efficiently on average for low mass stars, and that longer time scales are available for the buildup of planetary systems in the terrestrial zone for stars with masses $\lesssim$1 M$_\odot$.

Accepted by ApJ Letters

http://arxiv.org/abs/astro-ph/0609372

Spitzer IRS Spectroscopy of IRAS-discovered Debris Disks

C. H. Chen[1], B. A. Sargent[2], C. Bohac[2], K. H. Kim[2], E. Leibensperger[3], M. Jura[4], J. Najita[1], W. J. Forrest[2], D. M. Watson[2], G. C. Sloan[5], and L. D. Keller[3]

[1] NOAO, 950 North Cherry Avenue, Tucson, AZ 85719, USA
[2] Department of Physics and Astronomy, University of Rochester, Rochester, NY 14627, USA
[3] Department of Physics, Ithaca College, Ithaca, NY 14850, USA
[4] Department of Physics and Astronomy, University of California, Los Angeles, CA 90095-1562, USA
[5] Center for Radiophysics and Space Research, Cornell University, Ithaca, NY 14853-6801, USA

E-mail contact: cchen@noao.edu

We have obtained Spitzer Space Telescope Infrared Spectrograph (IRS) 5.5-35μm spectra of 59 main-sequence stars that possess IRAS 60μm excess. The spectra of five objects possess spectral features that are well-modeled using micron-sized grains and silicates with crystalline mass fractions 0%-80%, consistent with T Tauri and Herbig AeBe stars. With the exception of ηCrv, these objects are young with ages $\leq$ 50 Myr. Our fits require the presence of a cool blackbody continuum, T_{gr} = 80-200 K, in addition to hot, amorphous, and crystalline silicates, T_{gr} = 290-600 K, suggesting that multiple parent body belts are present in some debris disks, analogous to the asteroid and Kuiper belts in our solar system. The spectra for the majority of objects are featureless, suggesting that the emitting grains probably have radii a $>$ 10μm. We have modeled the excess continua using a continuous disk with a uniform surface density distribution, expected if Poynting-Robertson and stellar wind drag are the dominant grain removal processes, and using a single-temperature blackbody, expected if the dust is located in a narrow ring around the star. The IRS spectra of many objects are better modeled with a single-temperature blackbody, suggesting that the disks possess inner holes. The distribution of grain temperatures, based on our blackbody fits, peaks at T_{gr} = 110-120 K. Since the timescale for ice sublimation of micron-sized grains with T_{gr} $>$ 110 K is a fraction of a Myr, the lack of warmer

material may be explained if the grains are icy. If planets dynamically clear the central portions of debris disks, then the frequency of planets around other stars is probably high. We estimate that the majority of debris disk systems possess parent body masses, $M_{PB} < 1 M_{\oplus}$. The low inferred parent body masses suggest that planet formation is an efficient process.

Published by The Astrophysical Journal Supplement Series (Vol. 166, p. 351)

New results of magnetic field measurements in BP Tau

G.A. Chuntonov[1], D.A. Smirnov[2] and S.A. Lamzin[2]

[1] Special Astrophysical Observatory, Nizhnij Arkhyz, 357147, Russia
[2] Sternberg Astronomical Institute, Moscow, V-234, 119992, Russia

E-mail contact: danila@sai.msu.ru

We present results of measurements of longitudinal component of magnetic field $B_{\|}$ of CTTS BP Tau in the HeI 5876 emission line formation region, i.e. in the accretion flow near stellar surface. The derived values ($B_{\|} \simeq 1.7$ kG and $\simeq 1.0$ kG in 2000 and 2001 yrs respectively) are in agreement with previous measurements of other authors. At the same time we found that values of BP Tau's polar magnetic field strength B_p and the angle between rotation and magnetic axes β derived by Symington et al. (2005) are not reliable.

We concluded that with existing data it is impossible to decide if magnetic field of the star is stationary or/and has dipol or more complicated configuration. Nevertheless we argue that (at least in HeI 5876 line formation region) magnetic field is not stationary and could change its structure with timescale as short as some hours. Possible reasons of these relatively quick variations of magnetic field could be nonstationary events in small-scale active regions at stellar surface and/or reconnection of magnetospheric large-scale field lines twisted due to stellar rotation. We suppose that just nonregular reconfiguration of stellar magnetic field is the reason of a luck of strictly periodical variations of brightness and emission line profiles of BP Tau.

Accepted by Astronomy Letters

Protoplanet Dynamics in a shear-dominated disk

Benjamin F. Collins[1] and Re'em Sari[2]

[1] California Institute of Technology, MC 130-33, Pasadena, CA 91125, USA

E-mail contact: bfc@tapir.caltech.edu

The velocity dispersion, or eccentricity distribution, of protoplanets interacting with planetesimals is set by a balance between dynamical friction and viscous stirring. We calculate analytically the eccentricity distribution function of protoplanets embedded in a cold, shear-dominated planetesimal swarm. We find a distinctly non-Rayleigh distribution with a simple analytical form. The peak of the distribution lies much lower than the rms value, indicating that while most of the bodies have similarly small eccentricities, a small subset of the population contains most of the thermal energy. We also measure the shear-dominated eccentricity distribution using numerical simulations. The numerical code treats each protoplanet explicitly and adds an additional force term to each body to represent the dynamical friction of the planetesimals. Without fitting any parameters, the eccentricity distribution of protoplanets in the N-body simulation agrees with the analytical results. This distribution function provides a useful tool for testing hybrid numerical simulations of late-stage planet formation.

Published by The Astronomical Journal (Vol. 132, p. 1316)

A small jet in Chamaeleon I powered by a low luminosity source

F. Comerón[1] and B. Reipurth[2]

[1] European Southern Observatory, Karl-Schwarzschild-Strasse 2, D-85748 Garching bei München, Germany
[2] Institute for Astronomy, University of Hawaii, 640 N. Aohoku Place, Hilo, HI 96720, USA

E-mail contact: fcomeron@eso.org

We report the discovery of a small bipolar Herbig-Haro jet, HH 872, powered by the low-luminosity source ESO-Hα 574 in Chamaeleon I. The end-to-end projected size of the jet in [SII] images is only 3,150 AU. Infrared images marginally resolve the central source showing a structure elongated perpendicularly to the jet axis, possibly a disk seen at a large angle with respect to the plane of the sky. The brightest feature of the jet, peaking at a distance of $1''6$ from the central source, is likely to result from enhanced outflow activity in the last decade.

Accepted by Astron. & Astrophys. (Letters)

http://www.eso.org/∼fcomeron/eso-halpha_574.pdf

Infrared Nebulae Around Young Stellar Objects

Michael Connelley[1], Bo Reipurth[1] and Alan Tokunaga[2]

[1] University of Hawai'i Institute for Astronomy, 640 A'ohoku Pl., Hilo, HI 96720, USA
[2] University of Hawai'i Institute for Astronomy, 2680 Woodlawn Dr., Honolulu, HI 96822, USA

E-mail contact: msc@ifa.hawaii.edu

We present a K-band atlas of 106 reflection nebulae, 41 of which are new discoveries. We observed these nebulae with the UH 2.2 m telescope in the course of an imaging survey of 197 objects that were selected to be nearby young Class I sources. K-band images and flux calibrated surface brightness contour plots of each nebula are presented. We found that the near-IR luminosities and physical sizes of the nebulae increase with the bolometric luminosity of the illuminating sources. Only 22 nebulae, about 10% of these candidate Class I sources, have indications of shocked H_2 emission. The great variety of nebulae that we observed prevented us from classifying them based on morphology. However, we note that as the spectral index decreases, the central star is more frequently visible at K-band and the flux from the central star tends to be dominant over the flux from the nebula. For objects that have a higher spectral index, most of the K-band flux is from the reflection nebula, and the central star is less frequently visible. The nebula around IRAS 05450+0019 has a unique morphology, and we speculate that it may be an example of a disk shadow being projected into the surrounding cloud. We present J, H, and K-band images of this object with surface brightness contours, as well as its SED from 1.2 μm to 100 μm.

Accepted by The Astronomical Journal

A VLT/NACO Survey for Triple and Quadruple Systems among Visual Pre-Main Sequence Binaries

S. Correia[1], H. Zinnecker[1], Th. Ratzka[2] and M.F Sterzik[3]

[1] Astrophysikalisches Institut Potsdam, An der Sternwarte 16, D-14482 Potsdam, Germany
[2] Max-Planck-Institut für Astronomie, Königstuhl 17, D-69117 Heidelberg, Germany
[3] European Southern Observatory, Casilla 19001, Santiago 19, Chile

E-mail contact: scorreia@aip.de

This paper describes a systematic search for high-order multiplicity among wide visual Pre-Main Sequence (PMS) binaries. We conducted an Adaptive Optics survey of a sample of 58 PMS wide binaries from various star-forming regions, which include 52 T Tauri systems with mostly K- and M-type primaries, with the NIR instrument NACO at the VLT. Of these 52 systems, 7 are found to be triple (2 new) and 7 quadruple (1 new). The new close companions are most likely physically bound based on their probability of chance projection and, for some of them, on their position on a color-color diagram. The corresponding degree of multiplicity among wide binaries (number of triples and quadruples divided by the number of systems) is 26.9 ±7.2% in the projected separation range $\sim 0''.07$-$12''$, with the largest contribution from the Taurus-Auriga cloud. We also found that this degree of multiplicity is twice in Taurus compared to Ophiuchus and Chamaeleon for which the same number of sources are present in our sample. Considering a restricted sample composed of systems at distance 140-190 pc, the degree of multiplicity is 26.8 ±8.1%, in the separation range 10/14 AU - 1700/2300 AU (30 binaries, 5 triples, 6 quadruples). The observed frequency agrees with results from previous multiplicity surveys within the uncertainties, although a significant overabundance of quadruple systems compared to triple systems is apparent. Tentatively including the spectroscopic pairs in our restricted sample and comparing the multiplicity fractions to those measured for solar-type main-sequence stars in the solar neighborhood leads to the conclusion that both the ratio of triples to binaries and the ratio of quadruples to

triples seems to be in excess among young stars. Most of the current numerical simulations of multiple star formation, and especially smoothed particles hydrodynamics simulations, over-predict the fraction of high-order multiplicity when compared to our results. The circumstellar properties around the individual components of our high-order multiple systems tend to favor mixed systems (i.e. systems including components of wTTS and cTTS type), which is in general agreement with previous studies of disks in binaries, with the exception of Taurus, where we find a preponderance of similar type of components among the multiples studied.

Accepted by Astronomy & Astrophysics

astro-ph/0608674

Neon Abundances in B Stars of the Orion Association: Solving the Solar Model Problem?

Katia Cunha[1], Ivan Hubeny[2], and Thierry Lanz[3]

[1] National Optical Astronomy Observatory, P.O. Box 26732, Tucson, AZ 85726, USA
[2] Steward Observatory, University of Arizona, Tucson, AZ 85712, USA
[3] Department of Astronomy, University of Maryland, College Park, MD 20742, USA

E-mail contact: kcunha@noao.edu

We report on non-LTE Ne abundances for a sample of B-type stellar members of the Orion association. The abundances were derived by means of non-LTE fully metal-blanketed model atmospheres and extensive model atoms with updated atomic data. We find that these young stars have a very homogeneous abundance of A(Ne) = 8.11 ± 0.04. This abundance is higher by ∼0.3 dex than the currently adopted solar value, A(Ne) = 7.84, which is derived from lines produced in the corona and active regions. The general agreement between the abundances of C, N, and O derived for B stars with the solar abundances of these elements derived from three-dimensional hydrodynamical models atmospheres strongly suggests that the abundance patterns of the light elements in the Sun and B stars are broadly similar. If this hypothesis is true, then the Ne abundance derived here will help to reconcile solar models with helioseismological observations.

Published by The Astrophysical Journal Letters (Vol. 647, p. L143)

The Excitation of N_2H^+ in Interstellar Molecular Clouds. I. Models

F. Daniel[1,2], J. Cernicharo[1], and M.-L. Dubernet[2]

[1] Department of Molecular and Infrared Astrophysics (DAMIR), Consejo Superior de Investigaciones Científicas (CSIC), C/ Serrano 121, 28006 Madrid, Spain
[2] Observatoire de Paris-Meudon, LERMA UMR CNRS 8112, 5, Place Jules Janssen, F-92195 Meudon Cedex, France

E-mail contact: daniel@damir.iem.csic.es

We present large velocity gradient (LVG) and nonlocal radiative transfer calculations involving the rotational and hyperfine structure of the spectrum of N_2H^+, with collisional rate coefficients recently derived by us. The goal of this study is to check the validity of the assumptions made to treat the hyperfine structure and to study the physical mechanisms leading to the observed hyperfine anomalies. We find that the usual hypothesis of identical excitation temperatures for all hyperfine components of the J = 1-0 transition is not correct within the range of densities existing in cold dense cores, i.e., a few $10^4 < n(H_2) <$ a few 10^6 cm^{-3}. This is due to different radiative trapping effects in the hyperfine components. Moreover, within this range of densities and considering the typical abundance of N_2H^+, the total opacity of rotational lines has to be derived taking into account the hyperfine structure. The error made when only considering the rotational energy structure can be as large as 100%. Using nonlocal models, we find that, due to saturation, hyperfine anomalies appear as soon as the total opacity of the J = 1-0 transition becomes larger than $\simeq$ 20. Radiative scattering in less dense regions enhances these anomalies and particularly induces a differential increase of the excitation temperatures of the hyperfine components. This process is more effective for the transitions with the highest opacities for which emerging intensities are also reduced by self-absorption effects. These effects are not as critical as in HCO^+ or HCN, but should be taken into account when interpreting the spatial extent of the N_2H^+ emission in dark clouds.

Published by The Astrophysical Journal (Vol. 648, p. 461)

Evolution of Giant Planets in Eccentric Disks

Gennaro D'Angelo[1,3]**, Stephen H. Lubow**[2] **and Matthew R. Bate**[3]

[1] NASA-ARC, Space Science and Astrobiology Division, MS 245-3, Moffett Field, CA 94035, USA
[2] Space Telescope Science Institute, 3700 San Martin Drive, Baltimore, MD 21218, USA
[3] School of Physics, University of Exeter, Stocker Road, Exeter EX4 4QL, UK

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

We investigate the interaction between a giant planet and a viscous circumstellar disk by means of high-resolution, two-dimensional hydrodynamical simulations. We consider planet masses that range from 1 to 3 Jupiter masses (M_J) and initial orbital eccentricities that range from 0 to 0.4. We find that a planet can cause eccentricity growth in a disk region adjacent to the planet's orbit, even if the planet's orbit is circular. Disk-planet interactions lead to growth in a planet's orbital eccentricity. The orbital eccentricities of a $2\,M_J$ and a $3\,M_J$ planet increase from 0 to 0.11 within about 3000 orbits. Over a similar time period, the orbital eccentricity of a $1\,M_J$ planet grows from 0 to 0.02. For a case of a $1\,M_J$ planet with an initial eccentricity of 0.01, the orbital eccentricity grows to 0.09 over 4000 orbits. Radial migration is directed inwards, but slows considerably as a planet's orbit becomes eccentric. If a planet's orbital eccentricity becomes sufficiently large, $e \gtrsim 0.2$, migration can reverse and so be directed outwards. The accretion rate towards a planet depends on both the disk and the planet orbital eccentricity and is pulsed over the orbital period. Planet mass growth rates increase with planet orbital eccentricity. For $e \sim 0.2$ the mass growth rate of a planet increases by $\sim 30\%$ above the value for $e = 0$. For $e \gtrsim 0.1$, most of the accretion within the planet's Roche lobe occurs when the planet is near the apocenter. Similar accretion modulation occurs for flow at the inner disk boundary which represents accretion toward the star.

Accepted by The Astrophysical Journal (v652 n2 December 1, 2006 issue)

http://arxiv.org/abs/astro-ph/0608355

High-resolution observations of water masers in Bok globules

Itziar de Gregorio-Monsalvo[1]**, José F. Gómez**[2]**, Olga Suárez**[1]**, Thomas B. H. Kuiper**[3]**, Guillem Anglada**[2]**, Nimesh A. Patel**[4] **and José M. Torrelles**[5]

[1] Laboratorio de Astrofísica Espacial y Física Fundamental (INTA), Apartado 50727, E-28080 Madrid, Spain
[2] Instituto de Astrofísica de Andalucía (CSIC), Apartado 3004, E-18080 Granada, Spain
[3] Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, CA 91109, USA
[4] Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA
[5] Instituto de Ciencias del Espacio (CSIC) and Institut d'Estudis Espacials de Catalunya, Facultat de Física, Planta 7, Universitat de Barcelona, Av. Diagonal 647, E-08028 Barcelona, Spain

E-mail contact: itziar@laeff.inta.es

We present Very Large Array observations at 1.3 cm of several water maser detections obtained by previous single-dish studies of Bok globules in the Clemens & Barvainis (1988; CB) catalog. We report water maser emission in CB 3 (CB3-mm), CB 54 (IRAS 07020−1618), CB 101 (IRAS 17503−0833), and CB 232 (IRAS 21352+4307), and non-detection towards CB 65 (IRAS 16277−2332) and CB 205 (IRAS 19433+2743). These are the first reported interferometric observations of water masers in Bok globules of the CB catalog. We also present single-dish observations of millimeter and centimeter spectral lines towards CB 101 (IRAS 17503−0833) and CB 65 (IRAS 16277−2332). All the maser emission seems to be associated with star forming regions hosting bipolar molecular outflows, except IRAS 17503−0833 in CB 101, which we suggest to be a possible Mira evolved star, and IRAS 16277−2332 in CB 65, of unknown nature. We have used the precise position of the maser emission to derive information about the powering source of the masers. By analyzing the spatio-kinematical distribution of the water masers, we confirm the millimeter source CB 3-mm as the most likely powering source of the CB 3 masers. We propose the near-IR source CB 232 YC1-I as the best candidate for pumping the maser emission observed in CB 232, while in CB 54, we suggest that the pumping source of the masers could be located at the position of an elongated feature observed in near-infrared maps.

Accepted by The Astronomical Jounal

http://arxiv.org/abs/astro-ph/0608667

Collimation of astrophysical jets – the role of the accretion disk magnetic field distribution

Christian Fendt[1]

[1] Max Planck Institute for Astronomy, Königstuhl 17, D-69117 Heidelberg, Germany

E-mail contact: fendt@mpia.de

We have applied axisymmetric magnetohydrodynamic (MHD) simulations in order to investigate the impact of the accretion disk magnetic flux profile on the collimation of jets. Using the ZEUS-3D code modified for magnetic diffusivity, our simulations evolve from an initial state in hydrostatic equilibrium and a force-free magnetic field configuration. Considering a power law for the disk poloidal magnetic field profile $B_{\rm p} \sim r^{-\mu}$ and for the density profile of the disk wind $\rho \sim r^{-\mu_\rho}$, we have performed a systematic parameter study over a wide range of parameters μ and μ_ρ. We apply a toy parameterization for the magnetic diffusivity derived from the internal turbulent Alfvénic pressure. We find that the degree of collimation (quantified by the ratio of mass flow rates in axial and lateral direction) decreases for a steeper disk magnetic field profile (increasing μ). Varying the total magnetic flux does not change the degree of jet collimation substantially, it only affects the time scale of outflow evolution and the terminal jet speed. As our major result we find a general relation between the collimation degree with the disk wind magnetization power law exponent. Outflows with high degree of collimation resulting from a flat disk magnetic field profile tend to be unsteady, producing axially propagating knots as discussed earlier in the literature. Depending slightly on the inflow density profile this unsteady behavior sets in for $\mu < 0.4$. We also performed simulations of jet formation with artificially enhanced decay of the toroidal magnetic field component in order to investigate the idea of a purely "poloidal collimation" previously discussed in the literature. These outflows remain only weakly collimated and propagate with lower velocity. Thanks to our large numerical grid size (about 7×14 AU for protostars), we may apply our results to recently observed hints of jet rotation (DG Tau) indicating a relatively flat disk magnetic field profile, $\mu \simeq 0.5$. In general, our results are applicable to both stellar and extragalactic sources of MHD jets.

Accepted by Astrophysical Journal

http://www.mpia-hd.mpg.de/homes/fendt/publications.html

A Keplerian gaseous disk around the B0 star R Mon

A. Fuente[1]**, T. Alonso-Albi**[1]**, R. Bachiller**[1]**, A. Natta**[2]**, L. Testi**[2]**, R. Neri**[3] **and P. Planesas**[1]

[1] Observatorio Astronómico Nacional (OAN), Apdo. 112, E-28803 Alcalá de Henares (Madrid), Spain
[2] INAF-Osservatorio Astrofisico de Arcetri, Largo Enrico Fermi 5, I-50125 Firenze, Italy
[3] Institute de Radioastronomie Millimétrique, 300 rue de la Piscine, 38406 St Martin d'Heres Cedex, France

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

We present high-angular resolution observations of the circumstellar disk around the massive Herbig Be star R Mon (M_*~8 $M_\odot$) in the continuum at 2.7mm and 1.3mm and the ^{12}CO 1→0 and 2→1 rotational lines. Based on the new 1.3mm continuum image we estimate a disk mass (gas+dust) of 0.007 $M_\odot$ and an outer radius of <150 AU. Our CO images are consistent with the existence of *a Keplerian rotating gaseous disk around this star*. Up to our knowledge, this is the most clear evidence for the existence of Keplerian disks around massive stars reported thus far. The mass and physical characteristics of this disk are similar to those of the more evolved T Tauri stars and indicate a shorter timescale for the evolution and dispersal of circumstellar disks around massive stars which lose most of their mass before the star becomes visible.

Accepted by Astrophysical Journal Letters

gr-qc/0608088

Kinematics of NGC 2264: Signs of Cluster Formation

Gábor Fürész[1,2,3]**, Lee W. Hartmann**[4]**, Andrew H. Szentgyorgyi**[1]**, Naomi A. Ridge**[2]**, Luisa Rebull**[5]**, John Stauffer**[5]**, David W. Latham**[1]**, Maureen A. Conroy**[1]**, Daniel G. Fabricant**[1]**, and John Roll**[1]

[1] Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA
[2] Most of this work was done while G. F. was a research fellow of the Konkoly Observatory of the Hungarian Academy

of Sciences, P.O. Box 67, H-1525 Budapest, Hungary
[3] University of Szeged, Department of Experimental Physics, Dom ter 9, H-6723 Szeged, Hungary
[4] Astronomy Department, University of Michigan, 500 Church Street, 830 Dennison Building, Ann Arbor, MI 48109, USA
[5] Spitzer Science Center, MS 220-06, California Institute of Technology, USA

We present results from 1078 high-resolution spectra of 990 stars in the young open cluster NGC 2264, obtained with the Hectochelle multiobject echelle spectrograph on the 6.5 m MMT. We confirm 471 stars as members on the basis of their radial velocity and/or Hα emission. The radial velocity distribution of cluster members is non-Gaussian, with a dispersion of $\sigma \approx 3.5$ km s^{-1}. We find a substantial north-south velocity gradient and spatially coherent structure in the radial velocity distribution, similar to that seen in the molecular gas in the region. Our results suggest that there are at least three distinguishable subclusters in NGC 2264, correlated with similar structure seen in ^{13}CO emission, which is likely to be a remnant of initial structure in this very young cluster. We propose that this substructure is the result of gravitational amplification of initial inhomogeneities during overall collapse to a filamentary distribution of gas and stars, as found in simulations by Burkert & Hartmann (2004).

Published by The Astrophysical Journal(Vol. 648, p. 1090)

The Initial Conditions for Gravitational Collapse of a Core: An Extremely Young Low-Mass Class 0 Protostar GF 9-2

Ray S. Furuya[1], Yoshimi Kitamura[2] and Hiroko Shinnaga[3]

[1] Division of Physics, Mathematics, and Astronomy, California Institute of Technology,
Present address: Subaru Telecope, National Astronomical Observatory of Japan, 650 North A'ohoku Place, Hilo, HI 96720, U.S.A.
[2] Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency 3-1-1 Yoshinodai, Sagamihara, Kanagawa 229-8510, Japan
[3] Caltech Submillimeter Observatory, California Institute of Technology, 111 Nowelo Street, Hilo, HI 96720, U.S.A.

E-mail contact: rsf@subaru.naoj.org

We present a study of the natal core harboring the class 0 protostar GF 9-2 (bolometric luminosity $\simeq 0.3\ L_{\odot}$, bolometric temperature $\lesssim 20$ K; Wiesmeyer et al.) in the filamentary dark cloud GF 9 (distance = 200 pc) using the Nobeyama 45 m, CSO 10.4 m telescopes, and the OVRO mm-array. GF 9-2 stands unique in the sense that it shows H_2O maser emission (Furuya et al.), a clear signpost of protostar formation, whereas it does not have a high-velocity large-scale molecular outflow evidenced by our deep search for ^{12}CO wing emission. These facts indicate that GF 9-2 core is early enough after star formation so that it still retains some information of initial conditions for collapse. Our 350 μm dust continuum emission image revealed the presence of a protostellar envelope with an extent of $\simeq$ 5400 AU in the center of a molecular core $\simeq$ 0.08 pc in size. The mass of the envelope is $\simeq 0.6\ M_{\odot}$ from the 350 μm flux density, while LTE mass of the core is $\simeq 3\ M_{\odot}$ from N_2H^+, $H^{13}CO^+$, CCS, and NH_3 line observations. Combining visibility data from the OVRO mm-array and the 45 m telescope, we found that the core has a radial density profile of $\rho(r) \propto r^{-2}$ for $0.003 \lesssim r/\mathrm{pc} \lesssim 0.08$ region. Molecular line data analysis revealed that the velocity width of the core gas increases inward, while the outermost region maintains a velocity dispersion of a few times of the ambient sound speed. The broadened velocity width can be interpreted as infall. Thus, the collapse in GF 9-2 is likely to be described by an extension of the Larson-Penston solution for the period after formation of a central star. We derived the current mass accretion rate of $\simeq 3 \times 10^{-5}\ M_{\odot}$ year^{-1} from infall velocity of $\simeq 0.3$ km s^{-1} at $r \simeq 7000$ AU. Furthermore, we found evidence that a protobinary is being formed at the core center. All results suggest that GF 9-2 core has been undergoing gravitational collapse for $\lesssim$ 5000 years since the formation of central protostar(s), and that the unstable state initiated the collapse $\simeq 2 \times 10^5$ years (the free-fall time) ago.

Accepted by ApJ

Preprint is available from http://subarutelescope.org/staff/rsf/publication.html

Accretion Rates in Herbig Ae stars

R. Garcia Lopez [1,2], A. Natta [1], L. Testi [1], E. Habart [1,3]

[1] INAF - Osservatorio Astrofisico di Arcetri, Largo Fermi 5, 50125 Firenze, Italy
[2] Università degli Studi di Roma "Tor Vergata" - Dipartimento di Fisica, via della Ricerca Scientifica 1, 00133 Roma, Italy
[3] Université Paris-Sud, 91405 Orsay, France

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

Accretion rates from disks around pre-main sequence stars are of importance for our understanding of planetary formation and disk evolution. We provide in this paper estimates of the mass accretion rates in the disks around a large sample of Herbig Ae stars. We obtained medium resolution 2 μm spectra and used the results to compute values of $\dot{M}_{acc}$ from the measured luminosity of the Br_γ emission line, using a well established correlation between $L(Br_\gamma)$ and the accretion luminosity L_{acc}. We find that 80% of the stars, all of which have evidence of an associated circumstellar disk, are accreting matter, with rates $3\times10^{-9} \lesssim \dot{M}_{acc} \lesssim 10^{-6}$ $M_\odot$/yr; for 7 objects, 6 of which are located on the ZAMS in the HR diagram, we do not detect any line emission. Few HAe stars (25%) have $\dot{M}_{acc} > 10^{-7}$ $M_\odot$/yr. In most HAe stars the accretion rate is sufficiently low that the gas in the inner disk, inside the dust evaporation radius, is optically thin and does not prevent the formation of a puffed-up rim, where dust is directly exposed to the stellar radiation. When compared to the $\dot{M}_{acc}$ values found for lower-mass stars in the star forming regions Taurus and Ophiuchus, HAe stars have on average higher accretion rates than solar-mass stars; however, there is a lack of very stron g accretors among them, probably due to the fact that they are on average older.

Accepted by A&A

http://it.arXiv.org/astro-ph/0609032

Accretion in ρ Ophiuchi brown dwarfs: infrared hydrogen line ratios

T. Gatti[1,2], L. Testi[2], A. Natta[2], S. Randich[2] and J. Muzerolle[3]

[1] Dipartimento di Astronomia, Universita' di Firenze, Largo E. Fermi 5, Firenze, Italy
[2] INAF-Osservatorio Astrofisico di Arcetri, Largo E. Fermi 5, Firenze, Italy
[3] Steward Observatory, University of Arizona, USA

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

Mass accretion rate determinations are fundamental for an understanding of the evolution of pre-main sequence star circumstellar disks. Magnetospheric accretion models are used to derive values of the mass accretion rates in objects of very different properties, from brown dwarfs to intermediate-mass stars; we test the validity of these models in the brown dwarf regime, where the stellar mass and luminosity, as well as the mass accretion rate, are much lower than in T Tauri stars. We have measured simultaneously two infrared hydrogen lines, Pa_β and Br_γ, in a sample of 16 objects in the star-forming region ρ-Oph. The sample inc ludes 7 very low mass objects and brown dwarfs and 9 T Tauri stars. Brown dwarfs where both lines are detected have a ratio $Pa_\beta/Br_\gamma$of ~ 2. Larger values, $\gtrsim$3.5, are only found among the T Tauri stars. The low line ratios in brown dwarfs indicate that the lines cannot originate in the column of gas accreting from the disk onto the star along the magnetic field lines, and we suggest that they form instead in the shocked photosphere, heated to temperatures of $\sim$ 3500 K. If so, in analogy to veiling estimates in T Tauri stars, the hydrogen infrared line fluxes may provide a reliable measure of the accretion rate in brown dwarfs.

Accepted by A&A

http://arxiv.org/abs/astro-ph/0609291

C2D Spitzer-IRS spectra of disks around T Tauri stars II. PAH emission features

V.C. Geers[1], J.-C. Augereau[1,2], K.M. Pontoppidan[1,3], C.P. Dullemond[4], R. Visser[1], J.E. Kessler-Silacci[5], N.J. Evans II[5], E.F. van Dishoeck[1], G.A. Blake[3], A.C.A. Boogert[6], J.M. Brown[3], F. Lahuis[1,7] and B.M. Merín[1]

[1] Leiden Observatory, P.O. Box 9513, 2300RA Leiden, The Netherlands
[2] Laboratoire d'Astrophysique de l'Observatoire de Grenoble, B.P.53, 38041 Grenoble Cedex 9, France

[3] Division of GPS, Mail Code 150-21, California Institute of Technology, Pasadena, CA91125, USA
[4] Max-Planck-Institut für Astronomie, Koenigstuhl 17, 69117 Heidelberg, Germany
[5] Department of Astronomy, University of Texas, 1 University Station C1400, Austin, TX78712-0259, USA
[6] Division of PMA, Mail Code 105-24, California Institute of Technology, Pasadena, CA91125, USA
[7] SRON, P.O. BOX 800, 9700AV Groningen, The Netherlands

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

Aims: We search for Polycyclic Aromatic Hydrocarbon (PAH) features towards young low-mass (T Tauri) stars and compare them with surveys of intermediate mass (Herbig Ae/Be) stars. The presence and strength of the PAH features are interpreted with disk radiative transfer models exploring the PAH feature dependence on the incident UV radiation, PAH abundance and disk parameters.

Methods: Spitzer Space Telescope 5–35 μm spectra of 54 pre-main sequence stars with disks were obtained, consisting of 38 T Tauri, 7 Herbig Ae/Be and 9 stars with unknown spectral type.

Results: Compact PAH emission is detected towards at least 8 sources of which 5 are Herbig Ae/Be stars. The 11.2 μm PAH feature is detected in all of these sources, as is the 6.2 μm PAH feature for the 4 sources for which short wavelength data are available. However, the 7.7 and 8.6 μm features appear strongly in only 1 of these 4 sources. Based on the 11.2 μm feature, PAH emission is observed towards at least 3 T Tauri stars, with 14 tentative detections, resulting in a lower limit to the PAH detection rate of 8 %. The lowest mass source with PAH emission in our sample is T Cha with a spectral type G8. All 4 sources in our sample with evidence for dust holes in their inner disk show PAH emission, increasing the feature/continuum ratio. Typical 11.2 μm line intensities are an order of magnitude lower than those observed for the more massive Herbig Ae/Be stars. Measured line fluxes indicate PAH abundances that are factors of 10–100 lower than standard interstellar values. Conversely, PAH features from disks exposed to stars with $T_{\rm eff} \leq 4200$ K without enhanced UV are predicted to be below the current detection limit, even for high PAH abundances. Disk modeling shows that the 6.2 and 11.2 μm features are the best PAH tracers for T Tauri stars, whereas the 7.7 and 8.6 μm bands have low feature over continuum ratios due to the strongly rising silicate emission.

Accepted by Astronomy & Astrophysics

http://arXiv.org/abs/astro-ph/0609157

X-ray Study of Triggered Star Formation and Protostars in IC 1396N

K.V. Getman[1], E.D. Feigelson[1], G. Garmire[1], P. Broos[1] and J. Wang[1]

[1] Pennsylvania State University, University Park, PA 16803, USA

E-mail contact: gkosta@astro.psu.edu

The IC 1396N cometary globule within the large nearby HII region IC 1396 has been observed with the ACIS detector on board the *Chandra* X-ray Observatory. We detect 117 X-ray sources, of which $\sim 50-60$ are likely members of the young open cluster Trumpler 37 dispersed throughout the HII region, and 25 are associated with young stars formed within the globule. Spitzer/2MASS photometry shows the X-ray population is very young: 3 older Class III stars, 16 classical T Tauri stars, 6 protostars including a Class 0/I system. We infer a total T Tauri population of ~ 30 stars in the globule, including the undetected population, with a star formation efficiency of 1-4%. An elongated source spatial distribution with an age gradient oriented towards the exciting star is discovered in the X-ray population of IC 1396N, supporting similar findings in other cometary globules. The geometric and age distribution is consistent with the RDI model for triggered star formation in CGs by HII region shocks. The inferred velocity of the shock front propagating into the globule is ~ 0.6 km/s. The large number of X-ray-luminous protostars in the globule suggests either an unusually high ratio of Class I/0 vs. Class II/III stars, or a non-standard IMF favoring higher mass stars by the triggering process. The Chandra source associated with the luminous Class 0/I protostar IRAS 21391+5802 is one of the youngest stars ever detected in the X-ray band. We also establish for the first time that the X-ray absorption in protostars arises from the local infalling envelopes rather than ambient molecular cloud material.

Accepted by Astrophysical Journal

http://arxiv.org/abs/astro-ph/0607006

Magnetic Fields in the Formation of Sun-Like Stars

Josep M. Girart[1], Ramprasad Rao[2,3] and Daniel P. Marrone[2]

[1] Institut de Cincies de l'Espai (CSIC- IEEC)
[2] Harvard-Smithsonian Center for Astrophysics
[3] Academia Sinica, Institute of Astronomy and Astrophysics

E-mail contact: girart@ieec.cat

We report high-angular-resolution measurements of polarized dust emission toward the low-mass protostellar system NGC 1333 IRAS 4A. We show that in this system the observed magnetic field morphology is in agreement with the standard theoretical models of the formation of Sun-like stars in magnetized molecular clouds at scales of a few hundred astronomical units; gravity has overcome magnetic support, and the magnetic field traces a clear hourglass shape. The magnetic field is substantially more important than turbulence in the evolution of the system, and the initial misalignment of the magnetic and spin axes may have been important in the formation of the binary system.

Published by Science, Volume 313, Issue 5788, pp. 812-814 (2006)

astro-ph/0609177

X-ray emission from T Tauri stars in the Lupus 3 star-forming region

P. Gondoin

[1] European Space Agency, ESTEC - Postbus 299, 2200 AG Noordwijk, The Netherlands

E-mail contact: pgondoin@rssd.esa.int

*A*ims. In this paper, I present analysis results of an *XMM-Newton* observation of the Lupus 3 region that contains a high proportion of young low mass (M < 0.3 $M_\odot$) T Tauri stars in the Lupus star-forming complex.

*M*ethods. The detection of X-ray sources in 0.5 to 4.5 keV images of the Lupus 3 core was performed using the standard source detection method of the *XMM-Newton* Science Analysis Software. The detected sources were correlated with a list of Herbig-Haro objects and H $_\alpha$ emission stars that contains mainly classical T Tauri stars, with a catalogue of weak-line T Tauri Stars and with a recent list of new low-mass members of the Lupus 3 dark cloud found in a visible-light spectroscopic survey at the center of the Lupus 3 star-forming core. The light curves and spectra of the brightest X-ray sources with known T Tauri star counterparts were analysed.

*R*esults. One hundred and two X-ray sources were detected in the 30' diameter field-of-view of the EPIC cameras, of which 25 have visible or near-IR counterparts that are known as pre-main sequence stars. Their X-ray luminosity ranges from 3 $\times 10^{28}$ to 3 $\times 10^{30}$ erg s^{-1}. Two of these objects with mass estimates lower than 0.075 $M_\odot$ have an X-ray luminosity of about 4-7 $\times 10^{28}$ erg s^{-1}, comparable with that of flaring young brown dwarfs. A linear correlation is found between the X-ray luminosity and the mass or volume of the stars that is qualitatively expected from some models of distributed turbulent dynamos. The EPIC spectra of the X-ray brightest sources can be fitted using optically thin plasma emission models with two components at temperatures in the ranges 3-9 $\times 10^6$ K and 1-50 $\times 10^7$ K, respectively. The large emission measure of hot plasma may be caused by disruptions of magnetic fields associated with an intense flaring activity, while the X-ray emission from the "cool" plasma components may result from solar-type active regions. The emission measures of the plasma components are of the order of 10^{52} cm^{-3}, typical of the values expected from coronal plasmas in T Tauri stars, post-T Tauri stars, and active late-type dwarfs in close binary systems. One property of the X-ray brightest stars in Lupus 3 that seems common among pre-main sequence stars is the low abundance of Fe.

Published by Astronomy & Astrophysics (Vol. 454, p. 595)

X-ray emission from the young brown dwarfs of the Taurus Molecular Cloud

N. Grosso[1], K.R. Briggs[2], M. Güdel[2], S. Guieu[1], E. Franciosini[3], F. Palla[4], C. Dougados[1], J.-L. Monin[1], F. Ménard[1], J. Bouvier[1], M. Audard[6] and A. Telleschi[2]

[1] Laboratoire d'Astrophysique de Grenoble, Université Joseph-Fourier,F-38041 Grenoble cedex 9, France
[2] Paul Scherrer Institut, 5232 Villigen und Würenlingen, Switzerland
[3] INAF - Osservatorio Astronomico di Palermo, Piazza del Parlamento 1, I-90134 Palermo, Italy

[4] INAF - Osservatorio Astrofisico di Arcetri, Largo Enrico Fermi 5, I-50125 Firenze, Italy
[5] Institut Universitaire de France
[6] Columbia Astrophysics Laboratory, Columbia University, 550 West 120th Street, New York, NY 10027, USA

E-mail contact: Nicolas.Grosso@obs.ujf-grenoble.fr

Aims. We report the X-ray properties of young ($\sim$3 Myr) *bona fide* brown dwarfs of the Taurus Molecular Cloud (TMC).
Methods. The *XMM-Newton Extended Survey of the TMC* (XEST) is a large program designed to systematically investigate the X-ray properties of young stellar/substellar objects in the TMC. In particular, the area surveyed by 15 *XMM-Newton* pointings (of which three are archival observations), supplemented with one archival *Chandra* observation, allows us to study 17 brown dwarfs with M spectral types.
Results. Half of this sample (9 out of 17 brown dwarfs) is detected; 7 brown dwarfs are detected here for the first time in X-rays. We observed a flare from one brown dwarf. We confirm several previous findings on brown dwarf X-ray activity: a log-log relation between X-ray and bolometric luminosity for stars (with $L_* \leq 10\,L_\odot$) and brown dwarfs detected in X-rays, which is consistent with a mean X-ray fractional luminosity $<\log(L_X/L_*)> = -3.5 \pm 0.4$; for the XEST brown dwarfs, the median of $\log(L_X/L_*)$ (including upper limits) is -4.0; a shallow log-log relation between X-ray fractional luminosity and mass; a log-log relation between X-ray fractional luminosity and effective temperature; a log-log relation between X-ray surface flux and effective temperature. We find no significant log-log correlation between the X-ray fractional luminosity and $EW(\mathrm{H}\alpha)$. Accreting and nonaccreting brown dwarfs have a similar X-ray fractional luminosity. The median X-ray fractional luminosity of nonaccreting brown dwarfs is about 4 times lower than the mean saturation value for rapidly rotating low-mass field stars. Our TMC brown dwarfs have higher X-ray fractional luminosity than brown dwarfs in the *Chandra Orion Ultradeep Project.*
Conclusions. The X-ray fractional luminosity declines from low-mass stars to M-type brown dwarfs, and as a sample, the brown dwarfs are less efficient X-ray emitters than low-mass stars. We thus conclude that while the brown dwarf atmospheres observed here are mostly warm enough to sustain coronal activity, a trend is seen that may indicate its gradual decline due to the drop in photospheric ionization degree.

Accepted by A&A, to appear in a special section/issue dedicated to the XMM-Newton Extended Survey of the Taurus Molecular Cloud (XEST).

http://hal.ccsd.cnrs.fr/ccsd-00090499

A U-band survey of brown dwarfs in the Taurus Molecular Cloud with the XMM-Newton Optical/UV Monitor

N. Grosso[1], M. Audard[2], J. Bouvier[1], K. R. Briggs[3] and M. Güdel[3]

[1] Laboratoire d'Astrophysique de Grenoble, Université Joseph-Fourier, F-38041 Grenoble cedex 9, France
[2] Columbia Astrophysics Laboratory, Columbia University, 550 West 120th Street, New York, NY 10027, USA
[3] Paul Scherrer Institut, 5232 Villigen und Würenlingen, Switzerland

E-mail contact: Nicolas.Grosso@obs.ujf-grenoble.fr

Aims. We surveyed 13 young bona fide brown dwarfs of the Taurus molecular cloud in the U-band and looked for variable brown dwarfs.
Methods. During the XMM-Newton Extended Survey of the Taurus Molecular Cloud, a sample of young bona fide brown dwarfs were observed simultaneously in X-rays with XMM-Newton and in the U-band with the XMM-Newton Optical/UV Monitor (OM).
Results. We obtained upper limits to the U-band emission of 12 brown dwarfs (U¿19.6-20.5 mag), whereas 2MASS J04141188+2811535 was detected in the U-band. Remarkably, the magnitude of this brown dwarf increased regularly from U 19.5 mag at the beginning of the observation, peaked at U 18.4 mag 6 h later, and then decreased to U 18.65 mag in the next 2 h. The first OM U-band measurement is consistent with the quiescent level observed about one year later thanks to ground follow-up observations. This brown dwarf was not detected in X-rays by XMM-Newton during the OM observation.
Conclusions. We discuss the possible sources of U-band variability for this young brown dwarf – namely a magnetic flare, non-steady accretion onto the substellar surface, and rotational modulation of a hot spot – and favour the interpretation of this event as non-steady accretion where the disk accretion rate increased by about nearly a factor 3 in 6 hours.

Accepted by A&A, to appear in a special section/issue dedicated to the XMM-Newton Extended Survey of the Taurus Molecular Cloud (XEST).

http://hal.ccsd.cnrs.fr/ccsd-00090709

X-rays from jet-driving protostars and T Tauri stars

Manuel Guedel[1], Alessandra Telleschi[1], Marc Audard[2], Stephen L. Skinner[3], Kevin R. Briggs[1], Francesco Palla[4] and Catherine Dougados[5]

[1] Paul Scherrer Institut, Würenlingen and Villigen, CH-5232 Villigen PSI, Switzerland
[2] Columbia Astrophysics Laboratory, Mail Code 5247, 550 West 120th Street, New York, NY 10027, USA
[3] CASA, 389, University of Colorado, Boulder, CO 80309-0389, USA
[4] INAF - Osservatorio Astrofisico di Arcetri, Largo Enrico Fermi, 5, I-50125 Firenze, Italy
[5] Laboratoire d'Astrophysique de Grenoble, Université Joseph Fourier - CNRS, BP 53, F-38041 Grenoble Cedex, France

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

Aims: We study jet-driving protostars and T Tau stars to characterize their X-ray emission. We seek soft spectral components that may be due to shock emission, and search for soft, shock-induced emission displaced from the stellar position.
Methods: We study two stellar samples, the first consisting of lightly absorbed T Tau stars with strong jets, the other containing protostars with disks seen nearly edge-on. The former sample was observed in the *XMM-Newton Extended Survey of the Taurus Molecular Cloud* (XEST), while *Chandra* archival data provided observations of the latter.
Results: We confirm the previously identified peculiar spectrum of DG Tau A and find similar phenomenology in GV Tau and DP Tau, suggesting a new class of X-ray spectra. These consist of a lightly absorbed, very soft component and a strongly absorbed, very hard component. The latter is flaring while little variability is detected in the former. The absorption of the harder component is about an order of magnitude higher than expected from the optical extinction assuming a standard gas-to-dust mass ratio. For the absorbed protostars, only the hard, stellar X-ray component is found.
Conclusions: The flaring hard component represents active coronal emission. Its strong absorption is attributed to mass inflow from the accretion disk. The optical extinction is small because the dust has sublimated at larger distances. The little absorbed soft component cannot originate from the same location. Because the stars drive strong jets, we propose that the X-rays are generated in shocks in the jets. We find that for the three peculiar X-ray sources, the luminosity of the soft component roughly scales with the equivalent width of the [O I] λ 6300 line formed in the jets, and with the mass outflow rate. In the more strongly obscured protostars, the soft component is thus entirely absorbed, and only the hard, coronal component penetrates the envelope or the near-edge-on disk.

Accepted by Astronomy and Astrophysics, to appear in a special section/issue dedicated to the XMM-Newton Extended Survey of the Taurus Molecular Cloud (XEST).

http://www.issibern.ch/teams/Taurus/papers.html or http://www.astro.phys.ethz.ch/papers/guedel/guedel_p_nf.html

The XMM-Newton Extended Survey of the Taurus Molecular Cloud (XEST)

Manuel Guedel[1], Kevin R. Briggs[1], Kaspar Arzner[1], Marc Audard[2], Jerôme Bouvier[3], Eric D. Feigelson[4], Elena Franciosini[5], Adrian Glauser[1], Nicolas Grosso[3], Giusi Micela[5], Jean-Louis Monin[3], Thierry Montmerle[3], Deborah L. Padgett[6], Francesco Palla[7], Ignazio Pillitteri[8], Luisa Rebull[6], Luigi Scelsi[8], Bruno Silva[9,10], Stephen L. Skinner[11], Beate Stelzer[5] and Alessandra Telleschi[1]

[1] Paul Scherrer Institut, Würenlingen and Villigen, CH-5232 Villigen PSI, Switzerland
[2] Columbia Astrophysics Laboratory, Mail Code 5247, 550 West 120th Street, New York, NY 10027, USA
[3] Laboratoire d'Astrophysique de Grenoble, Université Joseph Fourier - CNRS, BP 53, F-38041 Grenoble Cedex, France
[4] Department of Astronomy & Astrophysics, Penn State University, 525 Davey Lab, University Park, PA 16802, USA
[5] INAF - Osservatorio Astronomico di Palermo, Piazza del Parlamento 1, I-90134 Palermo, Italy
[6] Spitzer Science Center, California Institute of Technology, Mail Code 220-6, Pasadena, CA 91125, USA
[7] INAF - Osservatorio Astrofisico di Arcetri, Largo Enrico Fermi, 5, I-50125 Firenze, Italy

[8] Dipartimento di Scienze Fisiche ed Astronomiche, Università di Palermo, Piazza del Parlamento 1, I-90134 Palermo, Italy
[9] Centro de Astrofísica da Universidade do Porto, Rua das Estrelas, 4150 Porto, Portugal
[1]0 Departamento de Matemática Aplicada, Faculdade de Ciêcias da Universidade do Porto, 4169 Porto, Portugal
[1]1 CASA, 389, University of Colorado, Boulder, CO 80309-0389, USA

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

Context: The Taurus Molecular Cloud (TMC) is the nearest large star-forming region, prototypical for the distributed mode of low-mass star formation. Pre-main sequence stars are luminous X-ray sources, probably mostly owing to magnetic energy release.
Aims: The *XMM-Newton Extended Survey of the Taurus Molecular Cloud* (XEST) presented in this paper surveys the most populated ≈5 square degrees of the TMC, using the *XMM-Newton* X-ray observatory to study the thermal structure, variability, and long-term evolution of hot plasma, to investigate the magnetic dynamo, and to search for new potential members of the association. Many targets are also studied in the optical, and high-resolution X-ray grating spectroscopy has been obtained for selected bright sources.
Methods: The X-ray spectra have been coherently analyzed with two different thermal models (2-component thermal model, and a continuous emission measure distribution model). We present overall correlations with fundamental stellar parameters that were derived from the previous literature. A few detections from *Chandra* observations have been added.
Results: The present overview paper introduces the project and provides the basic results from the X-ray analysis of all sources detected in the XEST survey. Comprehensive tables summarize the stellar properties of all targets surveyed. The survey goes deeper than previous X-ray surveys of Taurus by about an order of magnitude and for the first time systematically accesses very faint and strongly absorbed TMC objects. We find a detection rate of 85% and 98% for classical and weak-line T Tau stars (CTTS resp. WTTS), and identify about half of the surveyed protostars and brown dwarfs. Overall, 136 out of 169 surveyed stellar systems are detected. We describe an X-ray luminosity vs. mass correlation, discuss the distribution of X-ray-to-bolometric luminosity ratios, and show evidence for lower X-ray luminosities in CTTS compared to WTTS. Detailed analysis (e.g., variability, rotation-activity relations, influence of accretion on X-rays) will be discussed in a series of accompanying papers.

Accepted by Astronomy and Astrophysics, to appear in a special section/issue dedicated to the XMM-Newton Extended Survey of the Taurus Molecular Cloud (XEST).

http://www.issibern.ch/teams/Taurus/papers.html or http://www.astro.phys.ethz.ch/papers/guedel/guedel_p_nf.html

Mid-Infrared Observations of Class I/Flat-Spectrum Systems in Six Nearby Molecular Clouds

Karl E. Haisch Jr.[1], Mary Barsony[2], Michael E. Ressler[3] and Thomas P. Greene[4]

[1] Utah Valley State College, 800 W. University Pkwy., Orem, Utah 84058-5999, USA
[2] San Francisco State University, 1600 Holloway Drive, San Francisco, California 94132, USA
[3] Jet Propulsion Laboratory, Mail Stop 169-327, 4800 Oak Grove Drive, Pasadena, California 91109, USA
[4] NASA Ames Research Center, Mail Stop 245-6, Moffett Field, California 94035-1000, USA

E-mail contact: haischka@uvsc.edu

We have obtained new mid-infrared observations of 65 Class I/Flat-Spectrum (F.S.) objects in the Perseus, Taurus, Chamaeleon I and II, ρ Ophiuchi, and Serpens dark clouds. These objects represent a subset of the young stellar objects (YSOs) from our previous near-infrared multiplicity surveys. We detected 45/48 (94%) of the single sources, 16/16 (100%) of the primary components, and 12/16 (75%) of the secondary/triple components of the binary/multiple objects surveyed. One target, IRS 34, a 0.31 arcsec separation F.S. binary, remains unresolved at near-infrared wavelengths. The composite spectral energy distributions (SEDs) for all of our sample YSOs are either Class I or F.S., and, in 15/16 multiple systems, at least one of the individual components displays a Class I or F.S. spectral index. However, the occurrence of mixed pairings, such as F.S. with Class I, F.S. with Class II, and, in one case, an F.S. with a Class III (Cha I T33B), is suprisingly frequent. Such behavior is not consistent with that of multiple systems among T Tauri stars (TTS), where the companion of a classical TTS also tends to be a classical TTS, although other mixed pairings have been previously observed among Class II YSOs. Based on an analysis of the spectral indices of the individual binary components, there appears to be a higher proportion of mixed Class I/Flat-Spectrum systems (65-80%) than that of

mixed Classical/Weak Lined T Tauri systems (25-40%), demonstrating that the envelopes of Class I/Flat-Spectrum systems are rapidly evolving during this evolutionary phase. In general, the individual binary/multiple components suffer very similar extinctions, A_v, suggesting that most of the line-of-sight material is either in the foreground of the molecular cloud or circumbinary. We report the discovery of a steep spectral index secondary companion to ISO-Cha I 97, detected for the first time via our mid-infrared observations. In our previous near-infrared imaging survey of binary/multiple Class I and F.S.YSOs, ISO-Cha I 97 appeared to be single. With a spectral index of $\alpha \geq +3.9$, the secondary component of this system is a member of a rare class of very steep spectral index YSOs, those with $\alpha >$ +3. Only three such objects have previously been reported, all of which are either Class 0 or Class I.

Accepted by Astronomical Journal (December 2006 issue)

Preprints are available at astro-ph/0609235

Why Do T Tauri Disks Accrete?

Lee Hartmann[1], Paola D'Alessio[2], Nuria Calvet[1], and James Muzerolle[3]

[1] Department of Astronomy, 830 Dennison, University of Michigan, 500 Church Street, Ann Arbor, MI 48109, USA
[2] Centro de Radioastronomia y Astrofisica, UNAM, Apartado Postal 3-72 (Xangari), 58089 Morelia, Michoacan, Mexico
[3] Steward Observatory, University of Arizona, Tucson, AZ 85712, USA

E-mail contact: lhartm@umich.edu

Observations of T Tauri stars and young brown dwarfs suggest that the accretion rates of their disks scale strongly with the central stellar mass, approximately $\dot{M} \propto M_\star^2$. No dependence of accretion rate on stellar mass is predicted by the simplest version of the Gammie layered disk model, in which nonthermal ionization of upper disk layers allows accretion to occur via the magnetorotational instability. We show that a minor modification of Gammie's model to include heating by irradiation from the central star yields a modest dependence of $\dot{M}$ on the mass of the central star. A purely viscous disk model could provide a strong dependence of accretion rate on stellar mass if the initial disk radius (before much viscous evolution has occurred) has a strong dependence on stellar mass. However, it is far from clear that at least the most massive pre-main-sequence disks can be totally magnetically activated by X-rays or cosmic rays. We suggest that a combination of effects are responsible for the observed dependence, with the lowest mass stars having the lowest mass disks, which can be thoroughly magnetically active, while the higher mass stars have higher mass disks that have layered accretion and relatively inactive or "dead" central zones at some radii. In such dead zones, we suggest that gravitational instabilities may play a role in allowing accretion to proceed. In this connection, we emphasize the uncertainty in disk masses derived from dust emission and argue that T Tauri disk masses have been systematically underestimated by conventional analyses. Further study of accretion rates, especially in the lowest mass stars, would help to clarify the mechanisms of accretion in T Tauri stars.

Published by The Astrophysical Journal (Vol. 648, p. 484)

θ^1 Orionis E as a Spectroscopic Binary

G.H. Herbig [1] and R.F. Griffin [2]

[1] Institute for Astronomy, University of Hawaii, 2680 Woodlawn Drive, Honolulu, HI 96822, USA
[2] Cambridge Observatories, Madingley Road, Cambridge CB3 0HA, England, UK

E-mail contact: herbig@uhifa.hawaii.edu

θ^1 Ori E (θ^1E), the fifth brightest member of the Orion Nebula Trapezium, has been discovered to be a double-line spectroscopic binary. This paper describes the 1998–2006 Keck HIRES observations, the resulting spectroscopic orbit, and what can be inferred from the limited photometric information now available. The period is 9.89 days, and the components are essentially identical mid-G-type giants; their location in the H-R diagram and their possession of strong Li I λ6707 lines indicate that they are pre-main sequence members of the Orion Nebula Cluster (ONC), with masses of about 3–4 $M_\odot$. θ^1E is among the brightest X-ray sources in the ONC. It is variable in X-rays and is also a variable nonthermal radio cource, but it is uncertain whether the object is also optically variable.

Accepted by Astron. J. (vol. 132, no. 5, November 2006)

First Measurements of the Electron Density Enhancements Expected in C–shocks.

I. Jimenez-Serra[1], J. Martin-Pintado[1], S. Viti[2], S. Martin[3], A. Rodriguez-Franco[1,4], A. Faure[5] and J. Tennyson[2]

[1] Dpto. de Astrofisica Molecular e Infrarroja, Inst. CSIC, C/ Serrano 121, 28006 Madrid, Spain
[2] University College London, London WC1E 6BT, England, UK
[3] Instituto de Radioastronomia Milimetrica, Avda. Divina Pastora, Local 20, E-18012 Granada, Spain
[4] Escuela Universitaria de Optica, Departamento de Matematica Aplicada (Biomatematica), Universidad Complutense de Madrid, Avda. Arcos de Jalon s/n, E-28037 Madrid, Spain
[5] Laboratoire d'Astrophysique, Observatoire de Grenoble, BP 53, 38041 Grenoble Cedex 09, France

E-mail contact: izaskun@damir.iem.csic.es

Magnetic precursors of C–shocks accelerate, compress and heat molecular ions, modifying the kinematics and the physical conditions of the ion fluid with respect to the neutral one. Electron densities are also expected to be significantly enhanced in shock precursors. In this Letter, we present observations of strongly polar ion and neutral molecules such as SiO, $H^{13}CO^+$, $HN^{13}C$ and $H^{13}CN$, which reveal the electron density enhancements associated with the precursor of the young L1448–mm outflow. While in the ambient gas the excitation of the ions and neutrals is explained by collisional excitation by H_2 with a single density of $\sim10^5\,\mathrm{cm}^{-3}$, $H^{13}CO^+$ shows an over excitation in the shock precursor component that requires H_2 densities of a factor of $\geq$10 larger than those derived from the neutral species. This over excitation in $H^{13}CO^+$ can be explained if we consider an additional excitation by collisions with electrons and an electron density enhancement in the precursor stage by a factor of $\sim$500, i.e. a fractional ionization of 5×10^{-5}. These results show that multiline observations can be used to study the evolution of the ion and electron fluids at the first stages of the C–shock interaction.

Accepted by The Astrophysical Journal Letters

http://arxiv.org/abs/astro-ph/0609538

How Hot is the Wind from TW Hydrae?

Christopher M. Johns-Krull[1] and Gregory J. Herczeg[2]

[1] Department of Physics and Astronomy, Rice University, 6100 Main St. MS-108, Houston, TX 77005, USA
[2] California Institute of Technology, MC105-24, 1200 East California Blvd., Pasadena, CA 91125, USA

E-mail contact: cmj@rice.edu

It has recently been suggested that the winds from Classical T Tauri stars in general, and the wind from TW Hya in particular, reaches temperatures of at least 300,000 K while maintaing a mass loss rate of $\sim 10^{-11}$ $M_\odot yr^{-1}$ or larger. If confirmed, this would place strong new requirements on wind launching and heating models. We therefore re-examine spectra from the Space Telescope Imaging Spectrograph aboard the Hubble Space Telescope and spectra from the Far Ultraviolet Spectroscopic Explorer satellite in an effort to better constrain the maximum temperature in the wind of TW Hya. We find clear evidence for a wind in the C II doublet at 1037 Å and in the C II multiplet at 1335 Å. We find no wind absorption in the C IV 1550 Å doublet observed at the same time as the C II 1335 Å line or in observations of O VI observed simultaneously with the C II 1037 Å line. The presence or absence of C III wind absorption is ambiguous. The clear lack of a wind in the C IV line argues that the wind from TW Hya does not reach the 100,000 K characteristic formation temperature of this line. We therefore argue that the available evidence suggests that the wind from TW Hya, and probably all classical T Tauri stars, reaches a maximum temperature in the range of 10,000 – 30,000 K.

Accepted by The Astrophysical Journal

http://arxiv.org/abs/astro-ph/0609239

Diffusive Migration of Low-Mass Protoplanets in Turbulent Disks

Eric T. Johnson[1], Jeremy Goodman[1], and Kristen Menou[2]

[1] Department of Astrophysical Sciences, Princeton University, Princeton, NJ 08544,USA
[2] Department of Astronomy, Columbia University, 550 West 120th Street, New York, NY 10027, USA

Torque fluctuations due to magnetorotational turbulence in protoplanetary disks may greatly influence the migration patterns and survival probabilities of nascent planets. Provided that the turbulence is a stationary stochastic process with finite amplitude and correlation time, the resulting diffusive migration can be described with a Fokker-Planck equation, which we reduce to an advection-diffusion equation. We calibrate the coefficients with existing turbulent-disk simulations and mean-migration estimates and solve the equation both analytically and numerically. Diffusion tends to dominate over advection for planets of low mass and those in the outer regions of protoplanetary disks, whether they are described by the minimum mass solar nebula (MMSN) or by T Tauri alpha disks. Diffusion systematically reduces the lifetime of most planets, yet it allows a declining fraction of them to survive for extended periods of time at large radii. Mean planet lifetimes can even be formally infinite (e.g., in an infinite steady MMSN), although median lifetimes are always finite. Surviving planets may linger near specific radii where the combined effects of advection and diffusion are minimized or at large radii, depending on model specifics. The stochastic nature of migration in turbulent disks challenges deterministic planet formation scenarios and suggests instead that a wide variety of planetary outcomes are possible from similar initial conditions. This would contribute to the diversity of (extrasolar) planetary systems.

Published by The Astrophysical Journal (Vol. 647, p. 1413)

Large Area Mapping at 850 Microns. V. Analysis of the Clump Distribution in the Orion A South Molecular Cloud

Doug Johnstone[1,2] and John Bally[3]

[1] National Research Council Canada, Herzberg Institute of Astrophysics, 5071 West Saanich Rd, Victoria, BC, V9E 2E7, Canada

[2] Department of Physics & Astronomy, University of Victoria, Victoria, BC, V8P 1A1, Canada

[3] Center for Astrophysics and Space Astronomy and Department of Astrophysical and Planetary Sciences, University of Colorado, Boulder, CO 80309

E-mail contact: doug.johnstone@nrc-cnrc.gc.ca

We present results from a 2300 arcmin^2 survey of the Orion A molecular cloud at 450 and 850 μm using the Submillimetre Common-User Bolometer Array (SCUBA) on the James Clerk Maxwell Telescope. The region mapped lies directly south of the OMC1 cloud core and includes OMC4, OMC5, HH1/2, HH34, and L1641N. We identify 71 independent clumps in the 850 μm map and compute size, flux, and degree of central concentration in each. Comparison with isothermal, pressure-confined, self-gravitating Bonnor-Ebert spheres implies that the clumps have internal temperatures $T_d \sim 22 \pm 5\,\mathrm{K}$ and surface pressures $\log(k^{-1}\,P\,\mathrm{cm}^{-3}\,\mathrm{K}) = 6.0 \pm 0.2$. The clump masses span the range $0.3 - 22\,M_\odot$ assuming a dust temperature $T_d \sim 20\,\mathrm{K}$ and a dust emissivity $\kappa_{850} = 0.02\,\mathrm{cm}^2\,\mathrm{g}^{-1}$. The distribution of clump masses is well characterized by a power-law $N(M) \propto M^{-\alpha}$ with $\alpha = 2.0 \pm 0.5$ for $M > 3.0\,M_\odot$, indicating a clump mass function steeper than the stellar Initial Mass Function. Significant incompleteness makes determination of the slope at lower masses difficult. A comparison of the submillimeter emission map with an H_2 2.122 μm survey of the same region is performed. Several new Class 0 sources are revealed and a correlation is found between both the column density and degree of concentration of the submillimeter sources and the likelihood of coincident H_2 shock emission.

Accepted by Astrophysical Journal

http://lanl.arxiv.org/abs/astro-ph/0609171 (astro-ph)

V1647 Orionis: The X-Ray Evolution of a PreMain-Sequence Accretion Burst

Joel H. Kastner[1], Michael Richmond[1], Nicolas Grosso[2], David A. Weintraub[3], Theodore Simon[4], Arne Henden[5], Kenji Hamaguchi[6], Adam Frank[7], and Hideki Ozawa[8]

[1] Rochester Institute of Technology, 54 Lomb Memorial Drive, Rochester, NY 14623, USA

[2] Laboratoire d'Astrophysique de Grenoble, Universitoseph-Fourier, Grenoble 38041, France.

[3] Vanderbilt University, Nashville, TN 37235, USA

[4] Institute for Astronomy, Honolulu, HI 96822, USA

[5] US Naval Observatory, Flagstaff Station, P.O. Box 1149, Flagstaff, AZ 86002-1149, USA

[6] NASA Goddard Space Flight Center, Greenbelt, MD 20771; and Universities Space Research Association, 10211 Wincopin Circle, Suite 500, Columbia, MD 21044, USA

[7] Department of Physics and Astronomy, University of Rochester, Rochester, NY 14627-0171, USA
[8] Department of Earth and Space Science, Graduate School of Science, Osaka University, Osaka 560-0043, Japan

E-mail contact: jhk@cis.rit.edu

We present Chandra X-Ray Observatory monitoring observations of the recent accretion outburst displayed by the premain-sequence (pre-MS) star V1647 Ori. The X-ray observations were obtained over a period beginning prior to outburst onset in late 2003 and continuing through its apparent cessation in late 2005, and demonstrate that the mean flux of the spatially coincident X-ray source closely tracked the near-infrared luminosity of V1647 Ori throughout its eruption. We find negligible likelihood that the correspondence between X-ray and infrared light curves over this period was the result of multiple X-ray flares unrelated to the accretion burst. The recent Chandra data confirm that the X-ray spectrum of V1647 Ori hardened during outburst, relative both to its preoutburst state and to the X-ray spectra of nearby pre-MS stars in the L1630 cloud. We conclude that the observed changes in the X-ray emission from V1647 Ori over the course of its 2003-2005 eruption were generated by a sudden increase and subsequent decline in its accretion rate. These results for V1647 Ori indicate that the flux of hard X-ray emission from erupting low-mass, pre-MS stars, and the duration and intensity of such eruptions, reflect the degree to which star-disk magnetic fields are reorganized before and during major accretion events.

Published by The Astrophysical Journal Letters (Vol. 648, p. L43)

The Possibly Remnant Massive Outflow in G5.89-0.39. I. Observations and Initial Magnetohydrodynamic Simulations

P. D. Klaassen[1,3], R. Plume[1], R. Ouyed[1], A. M. von Benda-Beckmann[1,4], and J. Di Francesco[2,5]

[1] Department of Physics and Astronomy, University of Calgary, Calgary, AB, Canada
[2] National Research Council Canada, Herzberg Institute of Astrophysics, Victoria, BC, Canada
[3] Current address: McMaster University, Hamilton, ON, Canada
[4] Current address: Astrophysical Institute Potsdam, Potsdam, Germany
[5] Also at University of Calgary

E-mail contact: pamela@ism.ucalgary.ca

We have obtained maps of the large-scale outflow associated with the UC H II region G5.89-0.39 in CO and ^{13}CO (J = 3-2), SiO (J = 8-7, J = 5-4), SO_2 (J = $13_{2,12}$-$13_{1,13}$)^{13}, and $H^{13}CO^+$(J = 4-3). From these maps we have been able to determine the mass (3.3 $M_\odot$), momentum (96 $M_\odot$ km s^{-1}), energy (3.5×10^{46} ergs), mechanical luminosity (141 $L_\odot$), and mass-loss rate ($\sim 1 \times 10^{-3}$ $M_\odot$ yr^{-1}) in the large-scale outflow. The observationally derived parameters were used to guide three-dimensional magnetohydrodynamic models of the jet-entrained outflow. Through the combination of observations and simulations, we suggest that the large-scale outflow may be inclined by approximately 45° to the line of sight, and that the jet entraining the observed molecular outflow may have been active for as little as 1000 years, half the kinematic age of the outflow.

Published by The Astrophysical Journal (Vol. 648, p. 1079)

The Global Evolution of Giant Molecular Clouds. I: Model Formulation and Quasi-Equilibrium Behavior

Mark R. Krumholz[1], Christopher D. Matzner[2] and Christopher F. McKee[3]

[1] Department of Astrophysical Sciences, Princeton University, Princeton, NJ 08544-1001, USA
[2] Department of Astronomy, University of Toronto, Toronto, ON M5S 3H8, Canada
[3] Departments of Physics and Astronomy, University of California, Berkeley, CA 94720-7304, USA

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

We present semi-analytic dynamical models for giant molecular clouds evolving under the influence of HII regions launched by newborn star clusters. In contrast to previous work, we neither assume that clouds are in virial or energetic equilibrium, nor do we ignore the effects of star formation feedback. The clouds, which we treat as spherical, can expand and contract homologously. Photoionization drives mass ejection; the recoil of cloud material both stirs turbulent motions and leads to an effective confining pressure. The balance between these effects and the decay of turbulent motions through isothermal shocks determines clouds' dynamical and energetic evolution. We find that for realistic values of the rates of turbulent dissipation, photoevaporation, and energy injection by HII regions, the massive clouds where most molecular gas in the Galaxy resides live for a few crossing times, in good agreement with recent observational estimates that large clouds in local group galaxies survive roughly $20-30$ Myr. During this time clouds remain close to equilibrium, with virial parameters of $1-3$ and column densities near 10^{22} H atoms cm^{-2}, also in agreement with observed cloud properties. Over their lives they convert $5-10\%$ of their mass into stars, after which point most clouds are destroyed when a large HII region unbinds them. In contrast, small clouds like those found in the solar neighborhood only survive ~ 1 crossing time before being destroyed.

Accepted by ApJ

http://arxiv.org/abs/astro-ph/0608471

Slow Star Formation in Dense Gas: Evidence and Implications

Mark R. Krumholz[1] and Jonathan C. Tan[2]

[1] Department of Astrophysical Sciences, Princeton University, Princeton, NJ 08544-1001, USA
[2] Department of Astronomy, University of Florida, Gainesville, FL 32611, USA

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

It has been known for more than 30 years that star formation in giant molecular clouds (GMCs) is slow, in the sense that only $\sim 1\%$ of the gas forms stars every free-fall time. This result is entirely independent of any particular model of molecular cloud lifetime or evolution. Here we survey observational data on higher density objects in the interstellar medium, including infrared dark clouds and dense molecular clumps, to determine if these objects form stars slowly like GMCs, or rapidly, converting a significant fraction of their mass into stars in one free-fall time. We find no evidence for a transition from slow to rapid star formation in structures covering three orders of magnitude in density. This has important implications for models of star formation, since competing models make differing predictions for the characteristic density at which star formation should transition from slow to rapid. The data are inconsistent with models that predict that star clusters form rapidly and in free-fall collapse. Magnetic- and turbulence-regulated star formation models can reproduce the observations qualitatively, and the turbulence-regulated star formation model of Krumholz & McKee quantitatively reproduces the infrared-HCN luminosity correlation recently reported by Gao & Solomon. Slow star formation also implies that the process of star cluster formation cannot be one of global collapse, but must instead proceed over many free-fall times. This suggests that turbulence in star-forming clumps must be driven, and that the competitive accretion mechanism does not operate in typical cluster-forming molecular clumps.

Accepted by ApJ

http://xxx.lanl.gov/abs/astro-ph/0606277

Mid-IR Observations of T Tauri stars: Probing the Star-Disk Connection in Rotational Evolution

Praveen Kundurthy[1], Michael R. Meyer[1], Massimo Robberto[2], Steven V.W. Beckwith[2] and Tom Herbst[3]

[1] Steward Observatory, The University of Arizona, Tucson, AZ 85721
[2] Space Telescope Science Institute, Baltimore, MD 21218
[3] Max-Planck-Institut für Astronomie, Heidelberg D-69117, Germany

E-mail contact: pkundurthy@as.arizona.edu, mmeyer@as.arizona.edu

We present mid-IR N-band ($\lambda_{eff} = 10.2\mu$m) photometry of a carefully selected sample of T Tauri stars thought to be single from the Taurus-Auriga molecular cloud. Infrared excesses in these stars are generally attributed to circumstellar dust-disks. Combining observations at 2.16μm (K$_s$-band) and 10.2μm (N-band) we probe a region in the circumstellar dust-disk from a few stellar radii through the terrestrial planet zone (0.02-1.0AU). By analyzing the distribution of the $(K_s - N)$ color index with respect to previously measured photometric rotation periods we investigate what role circumstellar disks play in the rotational evolution of the central star. The resulting positive correlation between these two variables is consistent with the notion that a star-disk interaction facilitates the regulation of angular momentum during the T Tauri stage. We also demonstrate, how including non-single stars in such an analysis will *weaken* any correlation in the relation between $(K_s - N)$ color and period. To further understand disk properties we also present

SEDs for a few objects with new ground based M-band ($\lambda_{eff} = 4.8\mu$m) and Q-band ($\lambda_{eff} = 20\mu$m) data and compare them to a geometrically thin, optically-thick disk model.

Accepted by The Astronomical Journal

Radial and rotational velocities of young brown dwarfs and very low-mass stars in the Upper Scorpius OB association and the ρ Ophiuchi cloud core

Ryuichi Kurosawa[1], Tim J. Harries[1] and S. P. Littlefair[2]

[1] School of Physics, University of Exeter, Stocker Road, Exeter EX4 4QL, UK
[2] Department of Physics and Astronomy, University of Sheffield, Sheffield S3 7RH, UK

E-mail contact: rk@astro.ex.ac.uk

We present the results of a radial velocity (RV) survey of 14 brown dwarfs (BDs) and very low-mass (VLM) stars in the Upper Scorpius OB association (UScoOB) and 3 BD candidates in the ρ Ophiuchi dark cloud core. We obtained high-resolution echelle spectra at the Very Large Telescope using Ultraviolet and Visual Echelle Spectrograph (UVES) at two different epochs for each object, and measured the shifts in their RVs to identify candidates for binary/multiple systems in the sample. The average time separation of the RV measurements is 21.6 d, and our survey is sensitive to the binaries with separation < 0.1 au. We found that 4 out of 17 objects (or 24^{+16}_{-13} per cent by fraction) show a significant RV change in 4–33 d time scale, and are considered as binary/multiple 'candidates.' We found no double-lined spectroscopic binaries in our sample, based on the shape of cross-correlation curves. The RV dispersion of the objects in UScoOB is found to be very similar to that of the BD and VLM stars in Chamaeleon I (Cha I). We also found the distribution of the mean rotational velocities ($v \sin i$) of the UScoOB objects is similar to that of the Cha I, but the dispersion of $v \sin i$ is much larger than that of the Cha I objects.

Accepted by MNRAS

http://arxiv.org/abs/astro-ph/0609053

Two Bipolar Outflows and Magnetic Fields in a Multiple Protostar System, L1448 IRS3

Woojin Kwon[1], Leslie W. Looney[1], Richard M. Crutcher[1,2] and Jason M. Kirk[3]

[1] Department of Astronomy, University of Illinois at Urbana-Champaign, 1002 W. Green St., Urbana, IL 61801, USA
[2] National Center for Supercomputing Applications, USA
[3] School of Physics and Astronomy, Cardiff University, Queens Buildings, The Parade, Cardiff CF24 3AA, UK

E-mail contact: wkwon@astro.uiuc.edu

We performed spectral line observations of CO $J = 2 \rightarrow 1$, ^{13}CO $J = 1 \rightarrow 0$, and C^{18}O $J = 1 \rightarrow 0$ and polarimetric observations in the $\lambda = 1.3$ mm continuum and CO $J = 2 \rightarrow 1$ toward a multiple protostar system, L1448 IRS 3, in the Perseus molecular complex at a distance of ~ 250 pc, using the BIMA array. In the $\lambda = 1.3$ mm continuum, two sources (IRS 3A and 3B) were clearly detected with estimated envelope masses of 0.21 and 1.15 M$_\odot$, and one source (IRS 3C) was marginally detected with an upper mass limit of 0.03 M$_\odot$. In CO $J = 2 \rightarrow 1$, we revealed two outflows originating from IRS 3A and 3B. The masses, mean number densities, momentums, and kinetic energies of outflow lobes were estimated. Based on those estimates and outflow features, we concluded that the two outflows are interacting and that the IRS 3A outflow is nearly perpendicular to the line of sight. In addition, we estimated the velocity, inclination, and opening of the IRS 3B outflow using Bayesian statistics. When the opening angle is $\sim 20°$, we constrain the velocity to ~ 45 km s^{-1} and the inclination angle to $\sim 57°$. Linear polarization was detected in both the $\lambda = 1.3$ mm continuum and CO $J = 2 \rightarrow 1$. The linear polarization in the continuum shows a magnetic field at the central source (IRS 3B) perpendicular to the outflow direction, and the linear polarization in the CO $J = 2 \rightarrow 1$ was detected in the outflow regions, parallel or perpendicular to the outflow direction. Moreover, we comprehensively discuss whether the binary system of IRS 3A and 3B is gravitationally bound, based on the velocity differences detected in ^{13}CO $J = 1 \rightarrow 0$ and C^{18}O $J = 1 \rightarrow 0$ observations and on the outflow features. The specific angular momentum of the system was estimated as $\sim 3 \times 10^{20}$ cm^2 s^{-1}, comparable to the values obtained from previous studies on binaries and molecular clouds in Taurus.

Accepted by Astrophysical Journal

http://www.arxiv.org/abs/astro-ph/0609176

Non-gray rotating stellar models and the evolutionary history of the Orion Nebular Cluster

N. R. Landin[1,2], P. Ventura[2], F. D'Antona[2], L. T. S. Mendes[1,3] and L. P. R. Vaz[1]

[1] Depto. de Física, Universidade Federal de Minas Gerais, CP 702, 30161-970 Belo Horizonte, MG, Brazil
[2] Osservatorio Astronomico di Roma, via Frascati 33, 00040 MontePorzio Catone, Italy
[3] Depto. de Engenharia Eletrônica, Universidade Federal de Minas Gerais, CP 702, 30161-970 Belo Horizonte, MG, Brazil

E-mail contact: nlandin@fisica.ufmg.br

Context. Rotational evolution in the pre-main sequence is described with new sets of pre-MS evolutionary tracks including rotation, non-gray boundary conditions (BCs) and either low (LCE) or high convection efficiency (HCE).

Aims. Using observational data and our theoretical predictions, we aim at constraining (1) the differences obtained for the rotational evolution of stars within the ONC by means of these different sets of new models; (2) the initial angular momentum of low mass stars, by means of their templates in the ONC.

Methods. We discuss the reliability of current stellar models for the pre-MS. While the 2D radiation hydrodynamic simulations predict HCE in pre-MS, semi-empirical calibrations either seem to require that convection is less efficient in pre-MS than in the following MS phase (lithium depletion) or are still contradictory (binary masses). We derive stellar masses and ages for the ONC by using both LCE and HCE.

Results. The resulting mass distribution for the bulk of the ONC population is in the range 0.2-0.4 $M_\odot$ for our new non-gray models and, as in previous analyse, in the range 0.1-0.3 $M_\odot$ for models having gray BCs. In agreement with Herbst et al. (2002) we find that a large percentage ($\sim$70%) of low-mass stars (M $\lesssim$ 0.5 $M_\odot$ for LCE; M $\lesssim$ 0.35 $M_\odot$ for HCE) in the ONC appears to be fast rotators (P<4 days). Three possibilities are open: 1) $\sim$70% of the ONC low mass stars lose their disk at early evolutionary phases; 2) their "locking period" is shorter; 3) the period evolution is linked to a different morphology of the magnetic fields of the two groups of stars. We also estimate the range of initial angular momentum consistent with the observed periods.

Conclusions. The comparisons made indicate that a second parameter is needed to describe convection in the pre-MS, possibly related to the structural effect of a dynamo magnetic field.

Published by Astronomy & Astrophysics (Vol. 456, p. 269)

Anatomy of HH 111 from CO observations : a bow shock driven molecular outflow

B. Lefloch[1], J. Cernicharo[2], B. Reipurth[3], J.R. Pardo[2] and R. Neri[4]

[1] Laboratoire d'Astrophysique de l'Observatoire de Grenoble, BP 53, 38041 Grenoble cedex, France
[2] DAMIR, IEM, Dpto Fisica Molecular, Serrano 123, 28006 Madrid, Spain
[3] Institute for Astronomy, University of Hawaii, 640 N. Aohoku Place, Hilo, HI 96720 , USA
[4] IRAM, Domaine Universitaire, 300 rue de la Piscine, 38406 St Martin d'Heres, France

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

We present single-dish and interferometric millimeter line observations of the HH 111 outflow and its driving source. The physical conditions of the protostellar core have been determined from the emission of the millimeter line emission of CO and its isotopomers and CS with the IRAM 30m telescope, and the CO $J = 7 \rightarrow 6$ line with the Caltech Submm Observatory. The molecular gas emission reveals a small condensation of cold (T $= 20 - 25$ K) and dense gas ($n(\mathrm{H_2}) = 3 \times 10^5\,\mathrm{cm^{-3}}$). The low-velocity outflowing gas has been mapped with the IRAM Plateau de Bure interferometer. The cold gas is distributed in a hollow cylinder surrounding the optical jet. The formation of this cavity and its kinematics are well accounted for in the frame of outflow gas entrainment by jet bow shocks. Evidence of gas acceleration is found along the cavity walls, correlated with the presence of optical bow shocks. The cavity has been expanding with a mean velocity of $4\,\mathrm{km\,s^{-1}}$ on a timescale of 8700 yr, similar to the dynamical age of the optical jet. The separation of the inner walls reaches 8" $-$ 10", which matches the transverse size of the wings in the bow shock. CSO observations of the $J = 7 \rightarrow 6$ line show evidence of a high-velocity and hot gas component (T $= 300 - 1000$ K) with a low filling factor. This emission probably arises from shocked molecular gas in the jet. Observations of the $^3\mathrm{P}_2 - ^3\mathrm{P}_1$ [CI] line are consistent with C-type non-dissociative shocks. Mapping of the high-velocity molecular bullets B1-B3, located beyond the optical jet, with the IRAM PdBI reveals small structures of 3" $\times$ 7" flattened perpendicular

to the flow direction. They are made of cold (T $\sim 30\,$K), moderate density gas (n(H_2) $= (0.5 - 1.0) \times 10^4\,\mathrm{cm}^{-3}$). We find evidence that the bullets are expanding into the low-density surrounding medium. Their properties are consistent with their being shocked gas knots resulting from past time-variable ejections in the jet.

Accepted by Astrophysical Journal

ArXiv Astrophysics e-prints ; arXiv:astro-ph/0609567

APEX 1 mm line survey of the Orion Bar

S. Leurini[1], R. Rolffs[1], S. Thorwirth[1], B. Parise[1], P. Schilke[1], C. Comito[1], F. Wyrowski[1], R. Güsten[1], P. Bergman[2], K. M. Menten[1] and L.-Å. Nyman[2]

[1] Max-Planck-Institut für Radioastronomie, Auf dem Hügel 69, 53121 Bonn, Germany
[2] European Southern Observatory, Casilla 19001, Santiago, Chile

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

Context. Unbiased molecular line surveys are a powerful tool for analyzing the physical and chemical parameters of astronomical objects and are the only means for obtaining a complete view of the molecular inventory for a given source. The present work stands for the first such investigation of a photon-dominated region.

Aims. The first results of an ongoing millimeter-wave survey obtained towards the Orion Bar are reported.

Methods. The APEX telescope in combination with the APEX-2A facility receiver was employed in this investigation.

Results. We derived the physical parameters of the gas through LVG analyses of the methanol and formaldehyde data. Information on the sulfur and deuterium chemistry of photon-dominated regions is obtained from detections of several sulfur-bearing molecules and DCN.

Published by Astronomy & Astrophysics (Vol. 454, p. L47)

The high velocity outflow in NGC 6334 I

S. Leurini, P. Schilke, B. Parise, F. Wyrowski, R. Güsten and S. Philipp

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

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

Aims. We observed the high velocity outflow originating from NGC 6334 I in several CO transitions with the APEX telescope, with the goal of deriving the physical parameters of the gas.

Methods. Using an LVG analysis, we studied line ratios between the CO(3-2), CO(4-3), and CO(7-6) data as a function of the density and of the kinetic temperature of the gas. An upper limit on the CO column density is derived by comparison with ^{13}CO data.

Results. We constrained the temperature to be higher than 50 K and the H_2 density to values higher than $n \sim 10^4$ cm^{-3} towards the peak position in the red lobe, while T $>$ 15 K and $n > 10^3$ cm^{-3} are derived towards the peak position in the blue lobe. The physical parameters of the outflow, its mass and its energetics, have been computed using the temperatures derived from this analysis.

Conclusions. We conclude that high kinetic temperatures are present in the outflow and traced by high excitation CO lines. Observations of high-J CO lines are thus needed to infer reliable values of the kinetic temperatures and of the other physical parameters in outflows.

Published by Astronomy & Astrophysics (Vol. 454, p. L83)

Results of SPARO 2003: Mapping Magnetic Fields in Giant Molecular Clouds

H. Li[1], G. S. Griffin[1], M. Krejny[1], G. Novak[1], R. F. Loewenstein[2], M. G. Newcomb[2], P. G. Calisse[3], and D. T. Chuss[4]

[1] Department of Physics and Astronomy, Northwestern University, 2131 Sheridan Road, Evanston, IL 60208, USA
[2] Yerkes Observatory, 373 West Geneva Street, Williams Bay, WI 53191, USA
[3] School of Physics and Astronomy, Cardiff University, Wales, P.O. Box 913, Cardiff CF24 3YB, UK
[4] NASA Goddard Space Flight Center, Laboratory for High Energy Astrophysics, Code 662, Greenbelt, MD 20771, USA

E-mail contact: h-li5@northwestern.edu

We present results from the Austral Winter 2003 observing campaign of SPARO, a 450 μm polarimeter used with a 2 m telescope at the South Pole. We mapped large-scale magnetic fields in four GMCs in the Galactic disk: NGC 6334, the Carina Nebula, G333.6-0.2, and G331.5-0.1. We find a statistically significant correlation of the inferred field directions with the orientation of the Galactic plane. Specifically, three of the four GMCs (NGC 6334 is the exception) have mean field directions that are within 15° of the plane. The simplest interpretation is that the field direction tends to be preserved during the process of GMC formation. We have also carried out an analysis of published optical polarimetry data. For the closest of the SPARO GMCs, NGC 6334, we can compare the field direction in the cloud as measured by SPARO with the field direction in a larger region surrounding the cloud, as determined from optical polarimetry. For purposes of comparison, we also use optical polarimetry to determine field directions for 9-10 other regions of similar size. We find that the region surrounding NGC 6334 is an outlier in the distribution of field directions determined from optical polarimetry, just as the NGC 6334 cloud is an outlier in the distribution of cloud field directions determined by SPARO. In both cases the field direction corresponding to NGC 6334 is rotated away from the direction of the plane by a large angle. This finding is consistent with our suggestion that field direction tends to be preserved during GMC formation. Finally, by comparing the disorder in our magnetic field maps with the disorder seen in magnetic field maps derived from MHD turbulence simulations, we conclude that the magnetic energy density in our clouds is comparable to the turbulent energy density.

Published by The Astrophysical Journal (Vol. 648, p. 340)

Properties and Formation of the Multiple Protostellar System L1551 IRS5

Jeremy Lim[1] and Shigehisa Takakuwa[2]

[1] Institute of Astronomy & Astrophysics, Academia Sinica, PO Box 23-141, Taipei 106, Taiwan
[2] National Astronomical Observatory of Japan, ALMA Project Office, Osawa 2-21-1, Mitaka, Tokyo, 181-8588, Japan

E-mail contact: jlim@asiaa.sinica.edu.tw

We present an observation of the protostellar system L1551 IRS5 at 7 mm with an angular resolution as high as $\sim 0\farcs04$ (5 AU at a distance of ∼140 pc). Our observation is sensitive to both free-free emission from ionized gas in outflows, as well as thermal emission from dust in circumstellar disks. We confirm that L1551 IRS5 comprises two components oriented approximately north-south with a projected separation of 47 AU. In addition, we discover a third component lying 13 AU in projection to the south-east of the northern component, making L1551 IRS5 a triple protostellar system. The two main components each comprise a circumstellar dust disk together with a bipolar ionized jet. The disks have dimensions of just ∼17 AU, and their jets are collimated within a radial distance of $\lesssim$3 AU from the central protostars. The third component is most probably another circumstellar dust disk, which has an even smaller dimension of ∼9 AU. All three circumstellar disks have relatively high brightness temperatures of 100-200 K, indicating that they, and/or their protostellar components, are actively accreting.

We collect all available measurements to make the most accurate determination yet of the relative proper motion of the two main components. The annual change in separation is $\mu_{\rm sep} = +2.5 \pm 0.5$ mas yr^{-1} towards a position angle of $v_{\rm pa} = 129° \pm 11°$ as measured from the southern relative to the northern component. We show that this relative proper motion is consistent with a circular coplanar orbit, which would imply a true orbital separation of ∼50 AU, an orbital period of ∼380 yrs, and total mass for the two main components of ∼0.9 $M_\odot$. We argue that these components likely have comparable masses, and measured (minimum) disk sizes that are somewhat smaller than their predicted gravitationally-truncated sizes of ∼26 AU. We also show, based on the predicted maximum disks and minimum circumbinary gap sizes, that any non-circular coplanar orbit is constrained to an eccentricity $\lesssim$ 0.3. We

make a crude estimate for the mass of the third component of $\sim$0.1 $M_\odot$, and a minimum orbital separation from the northern component of $\sim$23 AU.

The disks of the two main components are accurately aligned with each other, as well as with their surrounding pseudodisk of molecular gas and dust. Furthermore, the clockwise orbital motion of these components resembles the rotational motion of the surrounding pseudodisk. Together with their relatively small orbital eccentricity (if in a coplanar orbit), these attributes constitute a smoking gun for the formation of the two main components via fragmentation in the central region of their parent pseudodisk. By contrast, the disk of the third component is significantly misaligned with respect to the disks of the two main components, as well as the surrounding pseudodisk. The origin of the third component is not clear (fragmentation or capture), but could be resolved with future measurements of its relative proper motion.

Accepted by The Astrophysical Journal

Radioactive Probes of the Supernova-Contaminated Solar Nebula: Evidence that the Sun was Born in a Cluster

Leslie W. Looney[1], John J. Tobin[1] and Brian D. Fields[1]

[1] University of Illinois at Urbana-Champaign

E-mail contact: lwl@uiuc.edu

We use a simple model for radioisotopic enrichment of the protosolar nebula by injection from a nearby supernova, based on the inverse square law for ejecta dispersion. In that case, the presolar radioisotopes abundances (i.e., in solar masses) demand a nearby supernova: its distance D can be no larger than $D/R_{\rm SS} \leq 66$ times the size $R_{\rm SS}$ of the protosolar nebula, at a 90% confidence level, assuming 1 $M_\odot$ of protosolar material. The relevant size and mass of the nebula depends on its state of evolution at the time of radioactivity injection. Nonetheless, this suggests that a collection of low-mass stars, including our sun, formed in a group or cluster with a high-mass star that ended its life as a supernova while our sun was still a protostar, a starless core, or perhaps a diffuse cloud. Using recent observations of protostars to estimate the size of the protosolar nebula at various stages constrains the distance of the supernova to $D \sim 0.02$ pc to 1.6 pc. The supernova distance limit is consistent with the scales of low-mass star formation around one or more massive stars, but it is closer than expected were the sun formed in an isolated, solitary state. Consequently, if *any* presolar radioactivities originated via supernova injection, we must conclude that our sun was probably a member of such a group or cluster that has since dispersed, and thus that solar system formation should be understood in this context.

Accepted by ApJ

http://arXiv.org/abs/astro-ph/0608411

A Survey for New Members of Taurus with the Spitzer Space Telescope

K. L. Luhman[1], B. A. Whitney[2], M. R. Meade[3], B. L. Babler[3], R. Indebetouw[4], S. Bracker[3], and E. B. Churchwell[3]

[1] Department of Astronomy and Astrophysics, 525 Davey Laboratory, Pennsylvania State University, University Park, PA 16802, USA
[2] Space Science Institute, 4750 Walnut Street, Suite 205, Boulder, CO 80301, USA
[3] Department of Astronomy, University of Wisconsin, 475 North Charter Street, Madison, WI 53706, USA
[4] Department of Astronomy, University of Virginia, P.O. Box 3818, Charlottesville, VA 22903-0818, USA

E-mail contact: kluhman@astro.psu.edu

We present the results of a search for new members of the Taurus star-forming region using the Infrared Array Camera (IRAC) aboard the Spitzer Space Telescope. With IRAC images of 29.7 deg^2 of Taurus at 3.6, 4.5, 5.8, and 8.0 μm, we have identified sources with red mid-infrared colors indicative of disk-bearing objects and have obtained optical and infrared spectra of 23 of these candidate members. Through this work, we have discovered 13 new members of Taurus, two of which have spectral types later than M6 and thus are likely to be brown dwarfs, according to the theoretical evolutionary models of Chabrier & Baraffe. This survey indicates that the previous census of Taurus has a completeness of 80% for members with disks. The new members that we have found do not significantly modify the

previously measured distributions of Taurus members as a function of position, mass, and extinction. For instance, we find no evidence for a population of highly reddened brown dwarfs ($A_K \sim 2$) that has been missed by previous optical and near-infrared surveys, which suggests that brown dwarf disks are not significantly more flared than disks around stars. In addition to the new members, we also present IRAC photometry for the 149 previously known members that appear within this survey, which includes 27 objects later than M6.

Published by The Astrophysical Journal (Vol. 647, p. 1180)

Outflows driven by Giant Protoplanets

Masahiro N. Machida[1], Shu-ichiro Inutsuka[1] and Tomoaki Matsumoto[2]

[1] Department of Physics, Graduate School of Science, Kyoto University, Sakyo-ku, Kyoto 606-8502, Japan
[2] Faculty of Humanity and Environment, Hosei University, Fujimi, Chiyoda-ku, Tokyo 102-8160, Japan

E-mail contact: machidam@scphys.kyoto-u.ac.jp

We investigate outflows driven by a giant protoplanet using three-dimensional MHD nested grid simulations. We consider a local region around the protoplanet in the protoplanetary disk, and calculate three models: unmagnetized disk model, magnetized disk model having magnetic field azimuthally parallel to the disk, and magnetic field perpendicular to the disk. Outflows with velocities, at least, $\sim$10 km s^{-1} are driven by the protoplanets in both magnetized disk models, while outflow does not appear in unmagnetized disk model. Tube-like outflows along the azimuthal direction of the protoplanetary disk appear in the model with magnetic field being parallel to the disk. In this model, the magnetically dominated regions (i.e., density gap) are clearly contrasted from other regions and spiral waves appear near the protoplanet. On the other hand, in the model with magnetic field being perpendicular to the disk, outflows are driven by a protoplanet with cone-like structure just as seen in the outflow driven by a protostar. Magnetic field lines are strongly twisted near the protoplanet and the outflows have well-collimated structures in this model. These outflows can be landmarks for searching exo-protoplanets in their formation stages. Our results indicate that the accretion rate onto the protoplanet tend to have a larger value than that expected from previous hydrodynamical calculations, since a fraction of the angular momentum of circum-planetary disk is removed by outflows, enhanced non-axisymmetric patterns caused by magnetic field, and magnetic braking. Possible implications for observation are also briefly discussed.

Accepted by The Astrophysical Journal Letters

http://arxiv.org/abs/astro-ph/0604594

A New Nearby Candidate Star Cluster in Ophiuchus at d $\simeq$ 170 pc

Eric Mamajek[1]

[1] Harvard-Smithsonian Center for Astrophysics, 60 Garden St., MS-42, Cambridge, MA 02138, USA

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

The recent discoveries of nearby star clusters and associations within a few hundred pc of the Sun, as well as the order of magnitude difference in the formation rates of the embedded and open cluster populations, suggests that additional poor stellar groups are likely to be found at surprisingly close distances to the Sun. Here I describe a new nearby stellar aggregate found by virtue of the parallel proper motions, similar trigonometric parallaxes, and consistent color-magnitude distribution of its early-type members. The 120 Myr-old group lies in Ophiuchus at $d \simeq$ 170 pc, with its most massive member being the 4th-magnitude post-MS B8II-III star μ Oph. The group may have escaped previous notice due to its non-negligible extinction ($A_V \simeq 0.9$ mag). If the group was born with a normal initial mass function, and the nine B- and A-type systems represent a complete system of intermediate-mass stars, then the original population was probably of order $\sim$200 systems. The age and space motion of the new cluster are very similar to those of the Pleiades, α Per cluster, and AB Dor Moving Group, suggesting that these aggregates may have formed in the same star-forming complex some $\sim 10^8$ yr ago.

Accepted by Astronomical Journal

http://xxx.lanl.gov/abs/astro-ph/0609064

Evolution of emission line activity in intermediate mass young stars

P. Manoj[1], H. C. Bhatt[2], G. Maheswar[3] and S. Muneer[2]

[1] Academia Sinica, Institute of Astronomy and Astrophysics, Taipei 10617, Taiwan
[2] Indian Institute of Astrophysics, II Block, Koramangala, Bangalore 560034, India
[3] Aryabhatta Research Institute of Observational Sciences (ARIES), Manora Peak, Nainital 263 129, India

E-mail contact: manoj@asiaa.sinica.edu.tw

We present optical spectra of 45 intermediate mass Herbig Ae/Be stars. Together with the multi-epoch spectroscopic and photometric data compiled for a large sample of these stars and ages estimated for individual stars by using pre-main sequence evolutionary tracks, we have studied the evolution of emission line activity in them. We find that, on average, the Hα emission line strength decreases with increasing stellar age in HAeBe stars, indicating that the accretion activity gradually declines during the PMS phase. This would hint at a relatively long-lived (a few Myr) process being responsible for the cessation of accretion in Herbig Ae/Be stars. We also find that the accretion activity in these stars drops substantially by $\sim$ 3 Myr. This is comparable to the timescale in which most intermediate mass stars are thought to lose their inner disks, suggesting that inner disks in intermediate mass stars are dissipated rapidly after the accretion activity has fallen below a certain level. We, further find a relatively tight correlation between strength of the emission line and near-infrared excess due to inner disks in HAeBe stars, indicating that the disks around Herbig Ae/Be stars cannot be entirely passive. We suggest that this correlation can be understood within the frame work of the puffed-up inner rim disk models if the radiation from the accretion shock is also responsible for the disk heating.

Accepted by Astrophysical Journal

http://xxx.lanl.gov/abs/astro-ph/0608541

Mid-Infrared Imaging of the Herbig Ae Star AB Aurigae: Extended Emission on Several Scales

N. Marinas[1], C. M. Telesco[1], R. S. Fisher[2], C. Packham[1] and J. T. Radomski[3]

[1] Astronomy Department, University of Florida, Gainesville, FL 32611
[2] Gemini ObservatoryNorthern Operations Center, Hilo, Hawaii 96720
[3] Gemini Observatory Southern Operations Center, La Serena, Chile

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

We present high sensitivity sub-arcsecond resolution images of the Herbig Ae star AB Aurigae at 11.6 and 18.5 μm taken with Michelle on Gemini North. Bright extended dust emission close to the star is resolved at both wavelengths, with quadratically subtracted FWHM of 17$\pm$4 AU at 11.6 μm and 22$\pm$5 AU at 18.5 μm. Additional, fainter emission is detected out to a radius of 280 AU at 11.6 μm and 350 AU at 18.5 μm down to the sensitivity limit of the observations. The latter value is identical to the measured size of the millimeter-continuum disk, but much smaller than the CO disk. Assuming moderately absorbing material, we find that larger particles ($\sim$ 1 μm) dominate the mid-IR emission in the inner ($<$ 100 AU) regions of the disk, and smaller particles ($<$ 0.3 μm) dominate in the outer regions of the disk. A model of a nearly face-on passive flared disk with an inner rim accounts well for our observations.

Accepted by ApJ

http://arxiv.org/abs/astro-ph/0609119

On the effect of overshooting as predicted by the modelling of the pre-main-sequence evolution of a 2 $M_\odot$ star

João P. Marques[1,2,3], Mário J. P. F. G. Monteiro[1,3], João Fernandes[2,4]

[1] Centro de Astrofísica da Universidade do Porto, Rua das Estrelas, 4150-762 Porto, Portugal
[2] Grupo de Astrofísica da Universidade de Coimbra, Observatório Astronômico da Universidade de Coimbra, Santa Clara, Coimbra, Portugal
[3] Departamento de Matemática Aplicada, Faculdade de Ciências da Universidade do Porto, Portuga l
[4] Departamento de Matemática, Faculdade de Ciências e Tecnologia da Universidade de Coimbra, Portugal

E-mail contact: mjm@astro.up.pt

We discuss the effects of convective overshooting in the pre-main-sequence (PMS) evolution of intermediate-mass stars, by analysing in detail the early evolution towards the main sequence of a 2 $M_\odot$ stellar model. These effects can be extremely important in the end of the PMS, when the abundances in CNO elements approach the equilibrium in the centre. We provide a possible physical explanation on why a moderate amount of overshooting produces, as the star approaches the zero-age main-sequence, an extra loop in the evolutionary tracks on the HertzsprungRussell diagram.

An interesting feature is that there is a very well defined amount of overshooting (for a given stellar mass and chemical composition) beyond which a loop is produced. For smaller amounts of overshooting such a loop does not take place and the evolutionary tracks are similar to those found in the literature. The amount of overshooting needed to produce the loop decreases with stellar mass.

We discuss the underlining physical reasons for the behaviour predicted by the evolution models and argue that it provides a crucial observational test for convective overshooting in the core of intermediate-mass stars.

Published by The Monthly Notices of the Royal Astronomical Society (Vol. 371, p. 293)

The rotating envelope and precessing outflow of the young stellar object Barnard 1c

Brenda Matthews[1], Michiel Hogerheijde[2], Jes Jorgensen[3] and Edwin Bergin[4]

[1] Herzberg Institute of Astrophysics, National Research Council of Canada, 5071 West Saanich Road, Victoria, BC, V9E 2E7, Canada
[2] Leiden Observatory, P.O. Box 9513, 2300 RA, Leiden, The Netherlands
[3] Harvard-Smithsonian Center for Astrophysics, 60 Garden Street MS42, Cambridge, MA, 02138, USA
[4] Department of Astronomy, University of Michigan, 825 Dennison Building, 500 Church Street, Ann Arbor, MI 48109, USA

E-mail contact: brenda.matthews@nrc-cnrc.gc.ca

We investigate the structure of the core surrounding the recently identified deeply embedded young stellar object Barnard 1c which has an unusual polarization pattern as traced in submillimeter dust emission. Barnard 1c lies within the Perseus molecular cloud at a distance of 250 pc. It is a deeply embedded core of 2.4 $M_\odot$ (Kirk et al.) and a luminosity of $4 \pm 2 L_\odot$. Observations (and resolutions) of ^{12}CO $J = 1-0$ ($9.2'' \times 5.9''$), ^{13}CO $J = 1-0$ and $C^{18}O$ $J = 1-0$ ($14.3'' \times 6.7''$), HCO^+ $J = 1-0$ ($7.6'' \times 5.8''$), and N_2H^+ $J = 1-0$ ($5.9'' \times 4.6''$) were obtained with the Berkeley-Illinois-Maryland Association array, together with the continuum at 3.3 mm ($6.4'' \times 4.9''$) and 2.7 mm ($9.5'' \times 6.3''$). The field of view of the BIMA array antennas at 3 mm is $2.1'$. Single-dish measurements of N_2H^+ $J = 1-0$ and HCO^+ $J = 1-0$ with FCRAO reveal the larger scale emission in these lines with resolutions of $57.5''$ and $60.5''$, respectively. The ^{12}CO and HCO^+ emission traces the outflow extending over the full field of view, which coincides in detail with the S-shaped jet recently found in Spitzer IRAC imaging. The N_2H^+ emission, which anticorrelates spatially with the $C^{18}O$ $J = 1-0$ emission, originates from a rotating envelope with effective radius ~ 2400 AU and mass $2.1-2.9$ $M_\odot$, as derived from the 3.3 mm continuum emission. N_2H^+ emission is absent from a 600 AU diameter region around the young star, offset from the continuum peak. The remaining N_2H^+ emission may lie in a coherent torus of dense material. With its outflow and rotating envelope, B1c closely resembles the previously studied object L483-mm, and we conclude that it is a protostar in an early stage of evolution, i.e., Class 0 or in transition between Class 0 and Class I. We hypothesize that heating by the outflow and star has desorbed CO from grains which has destroyed N_2H^+ in the inner region and surmise that the presence of grains without ice mantles in this warm inner region can explain the unusual polarization signature from B1c.

Accepted by The Astrophysical Journal

http://astrowww.phys.uvic.ca/~brenda/preprints.html

SiO and CH_3CCH abundances and dust emission in high-mass star-forming cores

O. Miettinen[1], J. Harju[1], L. K. Haikala[1] and C. Pomrén[1]

[1] Observatory, P.O. Box 14, FI-00014 University of Helsinki, Finland

E-mail contact: osmietti@astro.helsinki.fi

Aims. The main goal of the present study is to determine the fractional SiO abundance in high-mass star-forming cores, and to investigate its dependence on the physical conditions. In this way we wish to provide constraints on the chemistry models concerning the formation of SiO in the gas phase or via grain mantle evaporation. The work addresses also CH_3CCH chemistry as the kinetic temperature is determined using this molecule.

Methods. We estimate the physical conditions of 15 high-mass star-forming cores and derive the fractional SiO and CH_3CCH abundances in them by using spectral line and dust continuum observations with the SEST.

Results. The kinetic temperatures as derived from CH_3CCH range from 25 to 39 K, the average being 33 K. The average gas density in the cores is $4.5 \cdot 10^6$ cm^{-3}. The SiO emission regions are extended and typically half of the integrated line emission comes from the velocity range traced out by CH_3CCH emission. The upper limit of SiO abundance in this 'quiescent' gas component is $\sim 10^{-10}$. The average CH_3CCH abundance is about $7 \cdot 10^{-9}$. It shows a shallow, positive correlation with the temperature, whereas SiO shows the opposite tendency.

Conclusions. We suggest that the high CH_3CCH abundance and its possible increase when the clouds get warmer is related to the intensified desorption of the chemical precursors of the molecule from grain surfaces. In contrast, the observed tendency of SiO does not support the idea that the evaporation of Si-containing species from the grain mantles would be important, and it contradicts with the models where neutral reactions with activation barriers dominate the SiO production. A possible explanation for the decrease is that warmer cores represent more evolved stages of core evolution with fewer high-velocity shocks and thus less efficient SiO replenishment.

Accepted by Astronomy and Astrophysics

astro-ph/0609026

Molecular Line Emission from Gravitationally Unstable Protoplanetary Disks

Desika Narayanan[1], Craig A. Kulesa[1], Alan Boss[2], and Christopher K. Walker[1]

[1] Steward Observatory, University of Arizona, 933 North Cherry Avenue, Tucson, AZ 85721, USA

[2] Department of Terrestrial Magnetism, Carnegie Institution of Washington, 5241 Broad Branch Road, NW, Washington, DC 20015-1305, USA

E-mail contact: dnarayanan@as.arizona.edu

In the era of high-resolution submillimeter interferometers, it will soon be possible to observe the neutral circumstellar medium directly involved in gas giant planet (GGP) formation at physical scales previously unattainable. In order to explore possible signatures of GGP formation via disk instabilities, we have combined a three-dimensional (3D), nonlocal thermodynamic equilibrium (LTE) radiative transfer code with a 3D, finite differences hydrodynamical code to model molecular emission lines from the vicinity of a $1.4M_J$ self-gravitating proto-GGP. Here we explore the properties of rotational transitions of the commonly observed dense gas tracer, HCO^+. Our main results are as follows: (1) Very high lying HCO^+ transitions (e.g., HCO^+ J = 7-6) can trace dense clumps around circumstellar disks. Depending on the molecular abundance, the proto-GGP may be directly imageable by the Atacama Large Millimeter Array (ALMA). (2) HCO^+ emission lines are heavily self-absorbed through the proto-GGP's dense molecular core. This signature is nearly ubiquitous and only weakly dependent on assumed HCO^+ abundances. The self-absorption features are most pronounced at higher angular resolutions. Dense clumps that are not self-gravitating only show minor self-absorption features. (3) Line temperatures are highest through the proto-GGP at all assumed abundances and inclination angles. Conversely, due to self-absorption in the line, the velocity-integrated intensity may not be. High angular resolution interferometers such as the Submillimeter Array (SMA) and ALMA may be able to differentiate between competing theories of GGP formation.

Published by The Astrophysical Journal (Vol. 647, p. 1426)

Numerical requirements for simulations of self gravitating and non-self gravitating disks

Andrew F. Nelson[1]

[1] LANL X2 MS T087, Los Alamos NM, 87545, USA

E-mail contact: andy.nelson@lanl.gov

We define three requirements for accurate simulations that attempt to model circumstellar disks and the formation

of collapsed objects (e.g. planets) within them. First, we define a resolution requirement based on the wavelength for neutral stability of self gravitating waves in the disk, where a Jeans analysis does not apply. For particle based or grid based simulations, this criterion takes the form, respectively, of a minimum number of particles per critical ('Toomre') mass or maximum value of a 'Toomre number', $T = \delta x/\lambda_T$, where the wavelength, λ_T, is the wavelength for neutral stability for waves in disks. The requirements are analogues of the conditions for cloud collapse simulations as discussed in Bate & Burkert (1997) and Truelove et al. (1997), where the required minimum resolution was shown to be twice the number of neighbors per Jeans mass or 4-5 times the local Jeans wavelength, λ_J, for particle or grid simulations, respectively.

We apply our criterion to particle simulations of disk evolution and find that in order to prevent numerically induced fragmentation of the disk, the Toomre mass must be resolved by a minimum of six times the average number of neighbor particles used. We investigate the origin of the apparent discrepancy between the number of particles required by the cloud and disk fragmentation criteria and find that it is due largely to ambiguities in the definition of the Jeans mass, as used by different authors. We reconcile the various definitions, and when an identical definition of the Jeans mass is used, the condition that $J \lesssim 1/4$ in the Truelove condition is equivalent to requiring about 10-12 times the average number of neighbor particles per Jeans mass in an SPH simulation, reducing the difference between simulations of disks and clouds to about two. While the numbers of particles per critical mass are similar for both the Jeans and Toomre formalisms, the Toomre requirement is more restrictive than the Jeans requirement when the local value of the Toomre stability parameter Q falls below about one half.

Second, we require that particle based simulations with self gravity use a variable gravitational softening, in order to avoid inducing fragmentation by an inappropriate choice of softening length. We show that using a fixed gravitational softening length for all particles can lead either to artificial suppression or enhancement of structure (including fragmentation) in a given disk, or both in different locations of the same disk, depending on the value chosen for the softening length. Unphysical behavior can occur whether or not the system is properly resolved by the new Toomre criterion.

Third, we require that three dimensional SPH simulations resolve the vertical structure with at least ~ 4 particle smoothing lengths per scale height at the disk midplane, a value which implies a substantially larger number per vertical column because the disk itself extends over many scale heights. We suggest that a similar criterion applies to grid based simulations. We demonstrate that failure to meet this criterion leads to underestimates in the midplane density of up to 30–50% at resolutions common in the literature. As a direct consequence, gas pressures will be dramatically underestimated and simulations of self gravitating systems may artificially and erroneously inflate the likelihood of fragmentation. We outline an additional condition on the vertical resolution in simulations that include radiative transfer in order to ensure a correct description of the cooling, specifically that the temperature structure near the disk photosphere must be well resolved. As an example, we demonstrate that for an isentropic vertical structure, the criterion translates to resolution comparable to $H/20$ near the disk photosphere, to avoid serious errors in transfer rates of thermal energy in and out of the disk.

Finally, we discuss results in the literature that purport to form collapsed objects and conclude that many are likely to have violated one or more of our criteria, and have therefore made incorrect conclusions regarding the likelihood for fragmentation and planet formation.

Accepted by MNRAS

Available on astro-ph/0609493

Massive Young Stellar Objects in the Large Magellanic Cloud: water masers and ESO-VLT 3−4 μm spectroscopy

J. M. Oliveira[1], J.Th. van Loon[1], S. Stanimirovic[2] and A.A. Zijlstra[3]

[1] School of Physical & Geographical Sciences, Lennard-Jones Laboratories, Keele University, Staffordshire ST5 5BG, UK
[2] Radio Astronomy Lab, University of California at Berkeley, 601 Campbell Hall, Berkeley CA 94720, USA
[3] Department of Physics and Astronomy, University of Manchester, Sackville Street, P.O.Box 88, Manchester M60 1QD, UK

E-mail contact: joana@astro.keele.ac.uk

We investigate the conditions of star formation in the Large Magellanic Cloud. We have conducted a survey for water maser emission arising from massive young stellar objects in the 30 Doradus region (N 157) and several other H II regions in the Large Magellanic Cloud (N 105A, N 113 and N 160A). We have identified a new maser source in 30 Dor at the systemic velocity of the LMC. We have obtained 3−4 μm spectra, with the ESO Very Large Telescope, of two candidate young stellar objects. N 105A IRS1 shows H recombination line emission and its Spectral Energy Distribution (SED) and mid-infrared colours are consistent with a massive young star ionising the molecular cloud. N 157B IRS1 is identified as an embedded young object, based on its SED and a tentative detection of water ice. The data on these four H II regions are combined with mid-infrared archival images from the Spitzer Space Telescope to study the location and nature of the embedded massive young stellar objects and signatures of stellar feedback. Our analysis of 30 Dor, N 113 and N 160A confirms the picture that the feedback from the massive O and B-type stars, which creates the H II regions, also triggers further star formation on the interfaces of the ionised gas and the surrounding molecular cloud. Although in the dense cloud N 105A star formation seems to occur without evidence of massive star feedback, the general conditions in the LMC seem favourable for sequential star formation as a result of feedback. In an appendix we present water maser observations of the galactic red giants R Doradus and W Hydrae.

Accepted by MNRAS

http://www.astro.keele.ac.uk/~jacco/papers/SF_LMC_2006.pdf

Eolian Erosion of Dusty Bodies in Protoplanetary Disks

Georgi B. Paraskov, Gerhard Wurm, and Oliver Krauss

[1] Institute of Planetology, Wilhelm-Klemm-Strasse 10, D-48149 Münster, Germany

E-mail contact: paraskov@uni-muenster.de

We discuss the possibility of the erosion of dusty bodies in protoplanetary disks by a subsonic laminar gas flow. Our analysis is based on wind tunnel experiments on centimeter-size dust targets in an air gas flow of 63 m s^{-1} at static gas pressures between 0.1 and 4.5 mbar. We compare the results to numerical calculations of gas flow through porous bodies and the resulting drag force on dust aggregates at the surface. Our studies imply that a dusty body can be efficiently eroded if the dynamic gas pressure of the surface flow exceeds gravity and/or cohesion. In protoplanetary disks, we find that objects on circular orbits might be relatively safe against erosion in a laminar gas flow even in a dense disk. However, if a body is stirred up to an eccentric orbit, its motion relative to the gas increases. Such objects can be significantly eroded if they consist of dust. As an extreme, a 100 m body with the rather low eccentricity of an Earth orbit might be eroded in a single orbit. This effect leads to a bias for planetesimals in low-eccentricity orbits, as objects with large eccentricities are destroyed more easily. Erosion of bodies in high-eccentricity orbits, and reaccretion of the dust aggregates by low-eccentricity planetesimals, might provide a special growth mode of planetesimals and protoplanets.

Published by The Astrophysical Journal (Vol. 648, p. 1219)

Plateau de Bure Interferometer Observations of the Disk and Outflow of HH 30

J. Pety[1,2], F. Gueth[1], S. Guilloteau[3] and A. Dutrey[3]

[1] IRAM, 300 rue de la Piscine, 38400 Saint Martin d'Hères, France
[2] LERMA, UMR 8112, CNRS, Observatoire de Paris, 61 av. de l'Observatoire, 75014, Paris, France
[3] L3AB, UMR 5804, Observatoire de Bordeaux, 2 rue de l'Observatoire, 33270 Floirac, France

E-mail contact: pety@iram.fr

HH 30 is a well-known Pre-Main-Sequence star in Taurus. HST observations have revealed a flared, edge-on disk driving a highly-collimated optical jet, making this object a case study for the disk-jet-outflow paradigm. We obtained high angular resolution (about 1″) observations of the dust continuum at 2.7 and 1.3 mm, and of the ^{12}CO J=2–1, ^{13}CO J=2–1 & J=1–0, C^{18}O J=1–0 emissions around HH 30. A standard disk model is used to fit the ^{13}CO J=2–1 uv-plane visibilities and derive the disk properties, and the stellar mass. It results that HH 30 is a low mass TTauri of spectral type around M1 and age 1 to 4 Myrs, surrounded by a medium size Keplerian disk, of mass around $4\,10^{-3}\,M_\odot$ and outer radius 420 AU. The disk rotation vector points toward the North-Eastern jet. Using a distance of 140 pc, we deduce a stellar mass of $0.45\,M_\odot$. Moreover, a highly asymmetric outflow originates from the inner parts of the

disk. It presents to first order a conical morphology with a 30° half opening angle and a constant ($12\,\mathrm{km\,s^{-1}}$) radial velocity field. Outflow rotation was searched for but not found. These observations do not enable to assign the origin of the molecular outflow to entrainment by the optical jet or to a disk wind. In the latter case, the upper limit of the outflow rotation velocity ($1\,\mathrm{km\,s^{-1}}$ at 200 AU) implies an origin in the inner 15 AU of the disk.

Accepted by A&A

URL: astro-ph/0608218

High Resolution Imaging of Molecular Outflows in Massive Young Stars

Keping Qiu[1,2], Qizhou Zhang[1], Henrik Beuther[3] and Ji Yang[4]

[1] Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA
[2] Department of Astronomy, Nanjing University, Nanjing 210093, China
[3] Max-Planck-Institute for Astronomy, Königstuhl 17, 69117 Heidelberg, Germany
[4] Purple Mountain Observatory, Chinese Academy of Sciences, Nanjing 210008, China

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

We present high angular resolution observations toward two massive star forming regions IRAS 18264-1152 and IRAS 23151+5912 with the Plateau de Bure Interferometer (PdBI) in the SiO (J=2-1) and $H^{13}CO^+$ (J=1-0) lines and at 1.3 mm and 3.4 mm continuum, and with the Very Large Array (VLA) in the NH_3 (J,K)=(1,1), (2,2) lines. The NH_3 (1,1) and (2,2) emission is detected toward IRAS 18264-1152 only. For IRAS 18264-1152, the SiO observations reveal at least two quasi-perpendicular outflows with high collimation factors, and the most dominant feature is a redshifted jet-like outflow with very high velocities up to about $\Delta v = 60$ kms^{-1} with respect to the systemic velocity. The very-high-velocity component ($\Delta v = 22 - 60$ kms^{-1}) of this outflow is spatially offset from its high-velocity ($\Delta v = 3 - 21$ kms^{-1}) component. The SiO line profiles and position-velocity characteristics of these two components suggest that this outflow can be driven by an underlying precessing jet. For IRAS 23151+5912, the bipolar but mainly blueshifted SiO outflow coincides with the inner parts of the single-dish CO outflow. In particular the quasi-parabolic shape of the blueshifted outflow coincides with the near-infrared nebulosity and is consistent with entrainment of the gas by an underlying wide-angle wind. The analysis of the molecular outflow data of the two luminous sources further support high-mass stars forming via a disk-mediated accretion process similar to low-mass stars.

Accepted by The Astrophysical Journal

astro-ph/0609285

Atmospheres of Protoplanetary Cores: Critical Mass for Nucleated Instability

Roman R. Rafikov[1]

[1] Institute for Advanced Study, Einstein Drive, Princeton, NJ 08540, USA

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

We systematically study quasi-static atmospheres of accreting protoplanetary cores for different opacity behaviors and realistic planetesimal accretion rates in various parts of the protoplanetary nebula. We demonstrate that there are two important classes of atmospheres: (1) those having an outer convective zone that smoothly merges with the surrounding nebular gas, and (2) those possessing an almost isothermal outer radiative region that effectively decouples the atmospheric interior from the nebula. The type of atmosphere accumulating around a given core depends on the core mass, nebular parameters, and accretion luminosity of the core. Cores in the inner parts of the protoplanetary disk (within roughly 0.3 AU from the Sun) have large luminosities resulting in atmospheres of the first type, while cores in the giant planet region (beyond several AU) have small accretion luminosities and always accumulate massive atmospheres of the second type. The critical core mass needed for the nucleated instability to commence is found to vary considerably as a function of distance from the Sun. This mass is 5-20 $M_\oplus$ at 0.1-1 AU, which is too large to permit the formation of "hot Jupiters" by nucleated instability around the cores that have grown in situ. In the region of giant planets the critical core mass depends on the gas opacity and planetesimal accretion rate but is insensitive to the nebular temperature or density provided that the opacity in the outer radiative region does not depend on the gas density (e.g., dust opacity). The critical mass in the region of giant planets can be as high as 20-60 $M_\oplus$ (for an opacity of 0.1 cm^2 g^{-1}) if planetesimal accretion is fast enough for protoplanetary cores to form prior to the nebular

gas dissipation.

Published by The Astrophysical Journal (Vol. 648, p. 666)

Exotic Earths: Forming Habitable Worlds with Giant Planet Migration

Sean N. Raymond[1,4], Avi M. Mandell[2,3,4] and Steinn Sigurdsson[2,4]

[1] LASP, University of Colorado, Boulder
[2] Penn State University, State College, PA
[3] NASA Goddard Space Flight Center
[4] Member of NASA Astrobiology Institute

E-mail contact: raymond@lasp.colorado.edu

Close-in giant planets (e.g. "Hot Jupiters") are thought to form far from their host stars and migrate inward, through the terrestrial planet zone, via torques with a massive gaseous disk. Here we simulate terrestrial planet growth during and after giant planet migration. Several-Earth mass planets also form interior to the migrating Jovian planet, analogous to recently-discovered "Hot Earths". Very water-rich, Earth-mass planets form from surviving material outside the giant planet's orbit, often in the Habitable Zone and with low orbital eccentricities. More than a third of the known systems of giant planets may harbor Earth-like planets.

Published in Science (313, 1413)

http://lasp.colorado.edu/~raymond/RMS-pre.pdf

An Association in the Aquila Star-forming Region: High-Resolution Infrared Spectroscopy of T Tauri Stars

E. L. Rice[1], L. Prato[2], and I. S. McLean[1]

[1] Department of Physics and Astronomy, UCLA, Los Angeles, CA 90095, USA
[2] Lowell Observatory, 1400 West Mars Hill Road, Flagstaff, AZ 86001, USA

E-mail contact: erice@astro.ucla.edu

We present the properties of a group of young stars associated with the well-studied T Tauri star system AS 353, located in the Aquila star-forming region. The association is identified using radial velocity measurements of sample objects selected from the Herbig and Bell Catalog based on their spatial proximity to AS 353. Radial velocities of nine objects were measured from multiepoch high-resolution (R$\sim$30,000) H-band spectra obtained with NIRSPEC on Keck II. High-resolution K-band spectra were also obtained for most of the sample objects. Spectral types and rotational velocities are determined for all objects in the sample. The multiepoch H-band spectra were examined for radial velocity variations to detect possible spectroscopic binaries. Eight of the nine objects have radial velocities that are consistent within the 1 σ scatter of the sample. From their mean of -8 km s^{-1}, these eight objects have a standard deviation of 2 km s^{-1}, which suggests that the sample stars are related. The ninth object shows significant radial velocity variations between epochs, characteristic of a spectroscopic binary. The overall multiplicity of the sample is high; we observed 13 stars in seven systems, identifying three new candidate binary components in this project. Many of the spectra reveal hydrogen emission lines typical of strong accretion processes, indicating that most of these objects harbor circumstellar disks and are less than a few million years old. Based on previous estimates, we adopt a distance of 200 $\pm$ 30 pc to the young stars in Aquila in order to calculate luminosities and place the stars on an H-R diagram. We discuss possible interpretations of the enigmatic pure emission line spectrum of HBC 684. This work represents the highest spectral resolution infrared observations to date of these intriguing, nearby young stars.

Published by The Astrophysical Journal (Vol. 647, p. 432)

Interpreting Spectral Energy Distributions from Young Stellar Objects. I. A grid of 200,000 YSO model SEDs.

Thomas P. Robitaille[1], Barbara A. Whitney[2], Remy Indebetouw[3], Kenneth Wood[1] and Pia Denzmore[4]

[1] SUPA, School of Physics and Astronomy, University of St Andrews, St Andrews, Fife, KY16 9SS, UK

[2] Space Science Institute, 4750 Walnut St. Suite 205, Boulder, CO 80301, USA
[3] University of Virginia, Astronomy Dept., P.O. Box 3818, Charlottesville, VA, 22903-0818, USA
[4] Physics and Astronomy Department, Rice University, Houston, TX, USA

E-mail contact: tr9@st-andrews.ac.uk

We present a grid of radiation transfer models of axisymmetric young stellar objects (YSOs), covering a wide range of stellar masses (from 0.1 $M_\odot$ to 50 $M_\odot$) and evolutionary stages (from the early envelope infall stage to the late disk-only stage). The grid consists of 20,000 YSO models, with spectral energy distributions (SEDs) and polarization spectra computed at ten viewing angles for each model, resulting in a total of 200,000 SEDs. We made a careful assessment of the theoretical and observational constraints on the physical conditions of disks and envelopes in YSOs, and have attempted to fully span the corresponding regions in parameter space. These models are publicly available on a dedicated WWW server (http://www.astro.wisc.edu/protostars). In this paper we summarize the main features of our models, as well as the range of parameters explored. Having a large grid covering reasonable regions of parameter space allows us to shed light on many trends in near- and mid-IR observations of YSOs (such as changes in the spectral indices and colors of their SEDs), linking them with physical parameters (such as disk and infalling envelope parameters). In particular we examine the dependence of the spectral indices of the model SEDs on envelope accretion rate and disk mass. In addition, we show variations of spectral indices with stellar temperature, disk inner radius, and disk flaring power for a subset of disk-only models. We also examine how changing the wavelength range of data used to calculate spectral indices affects their values. We show sample color-color plots of the entire grid as well as simulated clusters at various distances with typical *Spitzer Space Telescope* sensitivities. We find that young embedded sources generally occupy a large region of color-color space due to inclination and stellar temperature effects. Disk sources occupy a smaller region of color-color space, but overlap substantially with the region occupied by embedded sources, especially in the near- and mid-IR. We identify regions in color-color space where our models indicate that only sources at a given evolutionary stage should lie. We find that while near-IR (such as JHK) and mid-IR (such as IRAC) fluxes are useful in discriminating between stars and YSOs, and are useful for identifying very young sources, the addition of longer wavelength data such as MIPS 24 μm is extremely valuable for determining the evolutionary stage of YSOs.

Accepted by The Astrophysical Journal Supplement Series

http://www.astro.wisc.edu/protostars

An XMM-Newton view of the young open cluster NGC 6231: I. The Catalogue

H. Sana[1], E. Gosset[1], G. Rauw[1], H. Sung[2] and J.-M. Vreux[1]

[1] Institut d'Astrophysique et de Géophysique, University of Liège, Allée du 6 Aoüt 17, Bât. B5c, 4000 Liège, Belgium
[2] Department of Astronomy and Space Science, Sejong University, Kunja-dong 98, Kwangjin-gu, Seoul 143-747, Korea

E-mail contact: sana@astro.ulg.ac.be

This paper is the first of a series dedicated to the X-ray properties of the young open cluster NGC 6231. Our data set relies on an XMM-Newton campaign of a nominal duration of 180 ks and reveals that NGC 6231 is very rich in the X-ray domain too. Indeed, 610 X-ray sources are detected in the present field of view, centered on the cluster core. The limiting sensitivity of our survey is approximately 6 $\times 10^{-15}$ erg cm^{-2} s^{-1} but clearly depends on the location in the field of view and on the source spectrum. Using different existing catalogues, over 85% of the X-ray sources could be associated with at least one optical and/or infrared counterpart within a limited cross-correlation radius of 3" at maximum. The surface density distribution of the X-ray sources presents a slight N-S elongation. Once corrected for the spatial sensitivity variation of the EPIC instruments, the radial profile of the source surface density is well described by a King profile with a central density of about 8 sources per arcmin^2 and a core radius close to 3.1 arcmin. The distribution of the X-ray sources seems closely related to the optical source distribution. The expected number of foreground and background sources should represent about 9% of the detected sources, thus strongly suggesting that most of the observed X-ray emitters are physically belonging to NGC 6231. Finally, beside a few bright but soft objects - corresponding to the early-type stars of the cluster - most of the sources are relatively faint ($\sim 5 \times 10^{-15}$ erg cm^{-2} s^{-1}) with an energy distribution peaked around 1.0-2.0 keV.

Published by Astronomy & Astrophysics (Vol. 454, p. 1047)

New pre-main sequence candidates in the Taurus-Auriga star forming region

L. Scelsi[1], A. Maggio[2], G. Micela[2], I. Pillitteri[2], B. Stelzer[2], K. Briggs[3], M. Güdel[3], N. Grosso[4], M. Audard[5] and F. Palla[6]

[1] Dipartimento di Scienze Fisiche ed Astronomiche, Sezione di Astronomia, Università di Palermo, Piazza del Parlamento 1, I-90134 Palermo, Italy
[2] INAF - Osservatorio Astronomico di Palermo, Piazza del Parlamento 1, I-90134 Palermo, Italy
[3] Paul Scherrer Institut, Würenlingen and Villigen, CH-5232 Villigen PSI, Switzerland
[4] Laboratoire d'Astrophysique de Grenoble, Université Joseph-Fourier, 414, rue de la Piscine, F-38041 Grenoble Cedex, France
[5] Columbia Astrophysics Laboratory, Mail Code 5247, 550 West 120th Street, New York, NY 10027, USA
[6] INAF - Osservatorio Astrofisico di Arcetri, Largo E. Fermi 5, I-50125 Firenze, Italy

E-mail contact: scelsi@astropa.unipa.it

We have studied the X-ray source population of the Taurus Molecular Cloud (TMC) to search for new members of the Taurus-Auriga star forming region. Candidate members have been selected among the X-ray sources detected in 24 fields of the XMM-*Newton* Extended Survey of the Taurus Molecular Cloud, having an IR counterpart in the 2MASS catalog, based on color-magnitude and color-color diagrams. Their X-ray spectral properties have been compared with those of known members and other X-ray sources in the same fields but without a NIR counterpart. A search for flare-like variability in the time series of all new candidates and the analysis of the X-ray spectra of the brightest candidates have been used to identify sources with a high probability of membership. We have found that 347 of 1909 detected X-ray sources have an infrared counterpart in the 2MASS catalogue. Among them, we have selected 57 sources that are consistent with being new pre-main sequence star candidates at the distance of the Taurus-Auriga star forming region; the X-ray spectral properties of this sample are, on the whole, similar to the properties of known TMC members and different from those of X-ray sources without an IR counterpart, most of which are likely to be of extragalactic origin. For 12 such candidates, the likelihood of membership is very high, based on the relatively high plasma temperatures derived from their X-ray spectra and/or the observation of powerful flares in their light curves.

Accepted by A&A, to appear in a special section/issue dedicated to the XMM-Newton Extended Survey of the Taurus Molecular Cloud (XEST).

http://www.issibern.ch/teams/Taurus/papers.html

Dynamical Mass Estimates for Incomplete Orbits: Young Multiple Stars in Taurus and Ophiuchus

G. H. Schaefer[1,2], M. Simon[2], T. L. Beck[3], E. Nelan[1] and L. Prato[4]

[1] Space Telescope Science Institute, 3700 San Martin Drive, Baltimore, MD 21218, USA
[2] Department of Physics and Astronomy, SUNY Stony Brook, Stony Brook, NY 11794-3800, USA
[3] Gemini Observatory, 670 North A'ohoku Place, Hilo, HI 96720, USA
[4] Lowell Observatory, 1400 West Mars Hill Road, Flagstaff, AZ 86001, USA

E-mail contact: gschaefer@stsci.edu

We present recent measurements of the orbital motion in the binaries, DF Tau and ZZ Tau, and in the triples, Elias 12, T Tau, and V853 Oph. We observed these systems with the Fine Guidance Sensors on the *Hubble Space Telescope* and with adaptive optics imaging at the W. M. Keck and Gemini North Observatories. Based on our measurements and those presented in the literature, we perform preliminary orbital analyses for DF Tau, ZZ Tau, Elias 12 Na-Nb, and T Tau Sa-Sb. Because the orbital coverage in most of these systems does not yet span a sufficient portion of the orbit, we are not able to find definitive orbit solutions. By using a Monte Carlo search technique, we explored the orbital parameter space allowed by the current set of data available for each binary. We constructed weighted distributions for the total mass of the binaries derived from a large sample of possible orbits that fit the data. These mass distributions show that the total mass is already well-defined. We compute total mass estimates of $0.78^{+0.25}_{-0.15} M_\odot$, $0.66^{+0.15}_{-0.11} M_\odot$, $1.13^{+0.36}_{-0.09} M_\odot$, and $4.13^{+1.58}_{-0.97} M_\odot$ for DF Tau, ZZ Tau, Elias 12 Na-Nb, and T Tau Sa-Sb respectively, using a distance of 140 pc. For Elias 12 Na-Nb, where the orbital coverage spans $\sim 164°$, we compute a preliminary orbit solution with a period of $\sim$ 9-12 years. By including an earlier lunar occultation measurement, we also find a likely orbit solution for ZZ Tau, with a period of $\sim$ 32 years. With additional measurements to continue mapping

the orbits, the derived dynamical masses will be useful in constraining the theoretical tracks of pre-main sequence evolution.

Accepted by Astronomical Journal

http://arxiv.org/abs/astro-ph/0609203

Submillimeter spectroscopy of southern hot cores: NGC 6334(I) and G327.3-0.6

P. Schilke[1], C. Comito[1], S. Thorwirth[1], F. Wyrowski[1], K. M. Menten[1], R. Güsten[1], P. Bergman[2] and L.-Å. Nyman[2]

[1] Max-Planck-Institut für Radioastronomie, Auf dem Hügel 69, 53121 Bonn, Germany
[2] European Southern Observatory, Alonso de Cordova 3107, Vitacura, Casilla 19001, Santiago, Chile

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

Context. High-mass star-forming regions are known to have a rich molecular spectrum from many species. Some of the very highly excited lines are emitted from very hot and dense gas close to the central object(s).
Aims. The physics and chemistry of the inner cores of two high mass star forming regions, NGC 6334(I) and G327.3-0.6, shall be characterized.
Methods. Submillimeter line surveys with the APEX telescope provide spectra which sample many molecular lines at high excitation stages.
Results. Partial spectral surveys were obtained, the lines were identified, physical parameters were determined through fitting of the spectra.
Conclusions. Both sources show similar spectra that are comparable to that of the only other high mass star forming region ever surveyed in this frequency range, Orion-KL, but with an even higher line density. Evidence for very compact, very hot sources is found.

Published by Astronomy & Astrophysics (Vol. 454, p. L41)

Spitzer 24 Micron Observations of Open Cluster IC 2391 and Debris Disk Evolution of FGK Stars

Nick Siegler[1], James Muzerolle[1], Erick T. Young[1], George H. Rieke[1], Eric E. Mamajek[2], David E. Trilling[1], Nadya Gorlova[1] and Kate Y. L. Su[1]

[1] Steward Observatory, University of Arizona
[2] Harvard-Smithsonian Center for Astrophysics

E-mail contact: nsiegler@as.arizona.edu

We present 24 μm *Spitzer*/MIPS photometric observations of the ~ 50 Myr open cluster IC 2391. Thirty-four cluster members ranging in spectral type from B3-M5 were observed in the central square degree of the cluster. Excesses indicative of debris disks were discovered around 1 A star, 6 FGK stars, and possibly 1 M dwarf. For the cluster members observed to their photospheric limit, we find a debris disk frequency of 10^{+17}_{-3}% for B-A stars and 31^{+13}_{-9}% for FGK stars using a 15% relative excess threshold. Relative to a model of decaying excess frequency, the frequency of debris disks around A-type stars appears marginally low for the cluster's age while that of FGK stars appears consistent. Scenarios that may qualitatively explain this result are examined. We conclude that planetesimal activity in the terrestrial region of FGK stars is common in the first ~ 50 Myr and decays on timescales of ~ 100 Myr. Despite luminosity differences, debris disk evolution does not appear to depend strongly on stellar mass.

Accepted by The Astrophysical Journal

http://xxx.lanl.gov/PS_cache/astro-ph/pdf/0609/0609141.pdf

On the first generation of stars

Joseph Silk[1] and Mathieu Langer[1]

[1] Astrophysics, University of Oxford, Denys Wilkinson Building, Keble Road, Oxford OX1 3RH, UK

E-mail contact: silk@astro.ox.ac.uk

We argue that the first stars may have spanned the conventional mass range rather than be identified with the very massive objects ($\sim$ 100-10^3 $M_\odot$) favoured by numerical simulations. Specifically, we find that magnetic field generation processes acting in the first protostellar systems suffice to produce fields that exceed the threshold for magneto-rotational instability (MRI) to operate, and thereby allow the MRI dynamo to generate equipartition-amplitude magnetic fields on protostellar mass scales below $\sim$ 50 $M_\odot$. Such fields allow primordial star formation to occur at essentially any metallicity by regulating angular momentum transfer, fragmentation, accretion and feedback in much the same way as occurs in conventional molecular clouds.

Published by The Monthly Notices of the Royal Astronomical Society (Vol. 371, p. 444)

Near-IR Synthetic Images of Protostellar Disks and Envelopes

D.P. Stark[1], B.A. Whitney[2], K. Stassun[3] and K. Wood[4]

[1] Department of Astronomy, California Institute of Technology, MC 105-24, 1200 E. California Blvd, Pasadena, CA 91125

[2] Space Science Institute, 4750 Walnut St., Suite 205, Boulder, CO 80301

[3] Physics & Astronomy Department, Vanderbilt University, VU Station B 1807, Nashville, TN, 3735

[4] School of Physics & Astronomy, University of St. Andrews, North Haugh, St. Andrews, Fife, KY169AD

E-mail contact: dps@astro.caltech.edu

We present a grid of near-infrared (IR) synthetic images of pre-main sequence stars at different stages of evolution, which we simulate by varying envelope mass, disk radius and mass, and outflow cavity shape. Our aim is to determine how variations in physical properties of young stellar objects (e.g. mass infall rate, disk size) affect their observed colors and morphology, and use this information to highlight observable differences between different evolutionary states. We show that the near-IR colors are a function of envelope mass infall rate and inclination; hence both parameters must be constrained if colors are to be used to infer a source's true evolutionary state. Sources with more opaque envelopes have redder diffuse colors, because the scattered light suffers reddening as it propagates through the envelope. Somewhat counterintuitively, colors are reddest at intermediate inclinations ($i \sim 45-70°$) and then become bluer edge-on, where light is ∼100% scattered. Thus a source with relatively blue colors could be an evolved source or a younger source oriented edge-on. Importantly, we find that at inclinations where scattered light dominates, it is erroneous to derive extinction A_V from observed colors; fully half of all objects will underestimate A_V by at least an order of magnitude.

Our grid allows us to identify morphological features that are useful for determining the evolutionary state and circumstellar disk size of an observed source. For example, a flared disk embedded in a low mass envelope can shadow large regions in the equatorial plane; the size of the disk can be estimated from the inner edge of this shadow.

We use our models to interpret six protostellar sources in the Taurus-Auriga molecular cloud observed with HST NICMOS. Of the six young stellar objects modeled in this paper, five require an infalling envelope to match the colors and should thus be classified as young embedded sources. The remaining source, Haro 6-5B, is a disk source, having already dispersed its envelope.

Accepted by The Astrophysical Journal

http://www.astro.caltech.edu/ dps/nicmod/

A statistical analysis of X-ray variability in pre-main sequence objects of the Taurus Molecular Cloud

B. Stelzer[1], E. Flaccomio[1], K. Briggs[2], G. Micela[1], L. Scelsi[3], M. Audard[4], I. Pillitteri[1,3] and M. Güdel[2]

[1] INAF - Osservatorio Astronomico di Palermo, Piazza del Parlamento 1, I-90134 Palermo, Italy

[2] Paul Scherrer Institut, Würenlingen and Villigen, CH-5232 Villigen PSI, Switzerland

[3] Dipartimento di Scienze Fisiche ed Astronomiche, Sezione di Astronomia, Università di Palermo, Piazza del Parlamento 1, I-90134 Palermo, Italy

[4] Columbia Astrophysics Laboratory, Mail Code 5247, 550 West 120th Street, New York, NY 10027, USA

E-mail contact: stelzer@astropa.unipa.it

This work is part of a systematic X-ray survey of the Taurus star forming complex with XMM-Newton. We study the time series of all X-ray sources associated with Taurus members, to statistically characterize their X-ray variability, and compare the results to those for pre-main sequence stars in the Orion Nebula Cluster and to expectations arising from a model where all the X-ray emission is the result of a large number of stochastically occurring flares. The analysis of the lightcurves is based on a maximum likelihood algorithm that segments the time series in intervals of constant signal without the need of binning. Flares are defined with criteria that take into account the amplitude and the derivative of the segmented lightcurves. Variability statistics are evaluated for different classes of pre-main sequence stars (protostars, cTTS, wTTS, brown dwarfs), and for different spectral type ranges. Flare frequency and energy distribution are computed. We find that roughly half of the detected X-ray sources show variability above our sensitivity limit, and in $\sim 26\,\%$ of the cases this variability is recognized as flares. Variability is more frequently detected at hard than at soft energies. The variability statistics of cTTS and wTTS are undistinguishable, suggesting a common (coronal) origin for their X-ray emission. The frequency of large flares ($E > 10^{35}$ erg) on Taurus members is 1 event per star in 800 ksec. The typical duration of these flares – probably biased by the finite observing time – is about 10 ksec. We have for the first time applied a rigorous maximum likelihood method in the analysis of the number distribution of flare energies on pre-main sequence stars. In its differential form this distribution follows a power-law with index $\alpha = 2.4 \pm 0.5$, in the range typically observed on late-type stars and the Sun. The signature of the X-ray variability in the pre-main sequence stars in Taurus and Orion provides twofold support for coronal heating by flares: (i) The correlation between the maximum variability amplitude and the minimum emission level indicates that both flare and quiescent emission are closely related to the coronal heating process. (ii) The power-law index α derived for the flare energy distribution is large enough to explain the heating of stellar coronae by nano-flares ($\alpha > 2$), albeit associated with a rather large uncertainty that leaves some doubt on this conclusion.

Accepted by A&A, to appear in a Special Section/Issue dedicated to the XMM-Newton Extended Survey of the Taurus Molecular Cloud (XEST)

For preprints via ftp or WWW: `http://www.astropa.unipa.it/~stelzer/publications.html`

Dust Dynamics, Surface Brightness Profiles, and Thermal Spectra of Debris Disks: The Case of AU Microscopii

Linda E. Strubbe[1] and Eugene I. Chiang[1]

[1] Center for Integrative Planetary Sciences, Astronomy Department, University of California at Berkeley, Berkeley, CA 94720, USA

E-mail contact: linda@astron.berkeley.edu

AU Microscopii is a 12 Myr old M dwarf that harbors an optically thin, edge-on disk of dust. The scattered light surface brightness falls with projected distance b from the star as $b^{-\alpha}$; within b = 43 AU, $\alpha \approx$ 1-2, while outside 43 AU, $\alpha \approx$ 4-5. We devise a theory to explain this profile. At a stellocentric distance r = r_{BR} = 43 AU, we posit a ring of parent bodies on circular orbits: the "birth ring," wherein micron-sized grains are born from the collisional attrition of parent bodies. The "inner disk" at r < r_{BR} contains grains that migrate inward by corpuscular and Poynting-Robertson (CPR) drag. The "outer disk" at r > r_{BR} comprises grains just large enough to remain bound to the star, on orbits rendered highly eccentric by stellar wind and radiation pressure. How the vertical optical depth $\tau_\perp$ scales with r depends on the fraction of grains that migrate inward by CPR drag without suffering a collision. If this fraction is large, the inner disk and birth ring share the same optical depth, and $\tau_\perp \approx r^{-5/2}$ in the outer disk. By contrast, under collision-dominated conditions, the inner disk is empty, and $\tau_\perp \approx r^{-3/2}$ outside. These scaling relations, which we derive analytically and confirm numerically, are robust against uncertainties in the grain size distribution. By simultaneously modeling the surface brightness and thermal spectrum, we break model degeneracies to establish that the AU Mic system is collision dominated and that its narrow birth ring contains a lunar mass of decimeter-sized bodies. The inner disk is devoid of micron-sized grains; the surface brightness at b $\lesssim$ 43 AU arises from light forward scattered by the birth ring. Inside b = 43 AU, the disk's V - H color should not vary with b; outside, the disk must become bluer as ever smaller grains are probed.

Published by The Astrophysical Journal (Vol. 648, p. 652)

Tracing high energy radiation with molecular lines near deeply embedded protostars

P. Stäuber[1], A.O. Benz[1], J.K. Jorgensen[2], E.F. van Dishoeck[3], S.D. Doty[4] and F.F.S. van der Tak[5]

[1] Institute of Astronomy, ETH Zurich, CH-8092 Zurich, Switzerland
[2] Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, USA
[3] Sterrewacht Leiden, PO Box 9513, 2300 RA Leiden, The Netherlands
[4] Department of Physics and Astronomy, Denison University, Granville, OH 43023, USA
[5] SRON National Institute for Space Research, Landleven 12, 9747 AD Groningen, The Netherlands

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

Submillimeter lines of CN, NO, CO+ and SO+, and upper limits on SH+ and N2O are observed with the James Clerk Maxwell Telescope in two high-mass and up to nine low-mass young stellar objects. Constant fractional abundances derived from radiative transfer modeling of the line strengths are x(CN) $\sim$ a few x$10^{(-11)}$-$10^{(-8)}$, x(NO) $\sim 10^{(-9)}$-$10^{(-8)}$ and x(CO+) $\sim 10^{(-12)}$-$10^{(-10)}$. SO+ has abundances of a few x$10^{(-11)}$ in the high-mass objects and upper limits of $\sim 10^{(-12)}$-$10^{(-11)}$ in the low-mass sources. All abundances are up to 1-2 orders of magnitude higher if the molecular emission is assumed to originate mainly from the inner region (< 1000 AU) from the envelope. However, the CN abundances are well-fit with constant fractional abundances. The observed CN and SO+ abundances can be explained by the influence of a central X-ray source. The observed CO+ emission towards high-mass objects is best interpreted by a far ultraviolet (FUV) field irradiating the outflow walls on scales comparable to the observing beam. Chemical models show, however, that FUV fields efficiently produce CO+ only for T > 300 K. The CO+ emission in low-mass objects is therefore thought to trace an X-ray enhanced region close to the protostar (r < 500 AU). Gas-phase chemical models produce more NO compared to observations, suggesting that NO is frozen out in the cooler outer part of the envelope. It is concluded, that the observed CN, CO+ and SO+ abundances can only be explained with either enhanced X-rays or FUV fields from the central source. High-mass sources are predicted to have low opacity regions that allow the FUV photons to reach large distances from the central source. X-rays are suggested to be more effective than FUV fields in the low-mass sources. The observed abundances imply X-ray fluxes for the Class 0 objects at similar levels as observed from Class I protostars with Lx $\sim 10^{29}$-10^{31} erg s$^{(-1)}$.

Accepted by A&A

http://arxiv.org/abs/astro-ph/0608393

Diamonds and PAHs in the Circumstellar Environment of the Herbig Ae/Be Star Elias 1

R. Topalovic[1], J. Russell[1], J. McCombie[1], T.H. Kerr[2] and P.J. Sarre[1]

[1] School of Chemistry, The University of Nottingham, University Park, Nottingham NG7 2RD, UK
[2] UKIRT, Joint Astronomy Centre, 660 N. A'ohoku Place, University Park, Hilo, Hawaii, USA

E-mail contact: Peter.Sarre@Nottingham.ac.uk

We report long-slit spectroscopic observations of the Herbig Ae/Be star Elias 1 in the 3.2 - 3.6 μm region covering the C-H stretch emission features of hydrogen-terminated diamonds and PAHs. The data were recorded at UKIRT using UIST and yield information on the profiles and intensities of the bands as a function of offset along the N-S and E-W axes centred on the close binary. The diamond and nearby IR continuum emission arises from a symmetrical inner core region ($\leq 0.34''$ or 48 AU). The 3.3 μm PAH emission is extended along the E-W axis up to *c.* 100 AU each side of the star. This result supports a suggestion of Haas, Leinert & Richichi of an E-W oriented bipolar nebula in Elias 1.

Accepted by MNRAS

http://arxiv.org/abs/astro-ph/0608334

Search for Associations Containing Young stars (SACY) I. Sample & Searching Method

Carlos A. O. Torres[1], Germano R. Quast[1], Licio da Silva[2], Ramiro de la Reza[2], Claudio H. F. Melo[3,4] and Michael Sterzik[3]

[1] Laboratório Nacional de Astrofísica/MCT, Rua Estados Unidos 154, 37504-364 Itajubá, Brazil
[2] Observatório Nacional/MCT, 20921-400 Rio de Janeiro, Brazil
[3] European Southern Observatory, Casilla 19001, Santiago 19, Chile

[4] Departamento de Astronomía, Universidad de Chile, Casilla 36-D, Santiago, Chile

E-mail contact: beto@lna.br

We report results from a high-resolution optical spectroscopic survey aimed to search for nearby young associations and young stars among optical counterparts of ROSAT All-Sky Survey X-ray sources in the Southern Hemisphere. We selected 1953 late-type ($B - V \geq 0.6$), potentially young, optical counterparts out of a total of 9574 1RXS sources for follow-up observations. At least one high-resolution spectrum was obtained for each of 1511 targets. This paper is the first in a series presenting the results of the SACY survey. Here we describe our sample and our observations. We describe a convergence method in the (UVW) velocity space to find associations. As an example, we discuss the validity of this method in the framework of the β Pic Association.

Accepted by Astronomy and Astrophysics

http://arxiv.org/abs/astro-ph/0609258

Interferometric Observations Toward the High-mass YSO IRAS 23139+5939: Radio Continuum and Water Maser Emission

M.A. Trinidad[1], S. Curiel[2], J.M. Torrelles[3], L.F. Rodríguez[4] and N. Patel[5]

[1] Departamento de Astronomía, Universidad de Guanajuato,Apdo. Postal 144, Guanajuato, Gto. 36240, México
[2] Instituto de Astronomía, UNAM, Apdo. Postal 70-264, D.F.04510, México
[3] Instituto de Ciencias del Espacio (CSIC) and Institut d'Estudis Espacials de Catalunya, Facultat de Física, Planta 7a, Universitat de Barcelona, Av. Diagonal 647, 08028 Barcelona, Spain
[4] Centro de Radioastronomía y Astrofísica, (UNAM),Apdo. Postal 3-72 (Xangari) 58089 Morelia, Michoacán, México
[5] Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA

E-mail contact: trinidad@astro.ugto.mx

We present simultaneous interferometric observations of continuum (3.5 and 1.3 cm) and water maser line emission (1.3 cm) carried out with the A-configuration of the Very Large Array (VLA) toward the high-mass object IRAS 23139+5939. We detected two radio continuum sources at 3.5 cm separated by $\sim 0\farcs5$ ($\sim$ 2400 AU), I23139 and I23139S, the latter being a new detection. I23139 is also detected at 1.3 cm. We also detected a cluster of water masers toward these two VLA sources, obtaining an accuracy of the order of $\sim$ 10 milliarcseconds (mas) in the relative positions between the radio continuum emission and the H_2O masers. In addition, based on the observed continuum flux density and the spectral index, we suggest that I23139 is a thermal radio jet associated with a high-mass YSO. This jet appears to be the best candidate for the driving source of the more spatially extended molecular outflow observed in the region. On the other hand, based on the spatio-kinematical distribution of the water masers, together with the continuum emission information, we speculate that I23139S is also a jet source powering some of the masers detected in the region.

Accepted by Astron. J.

Class I methanol masers in the outflow of IRAS 16547-4247

M.A. Voronkov[1,2], K.J. Brooks[1], A.M. Sobolev[3], S.P. Ellingsen[4], A.B. Ostrovskii[3] and J.L. Caswell[1]

[1] Australia Telescope National Facility CSIRO, PO Box 76, Epping, NSW 1710, Australia
[2] Astro Space Centre, Profsouznaya st. 84/32, 117997 Moscow, Russia
[3] Ural State University, Lenin ave. 51, 620083 Ekaterinburg, Russia
[4] School of Mathematics and Physics, University of Tasmania, GPO Box 252-37, Hobart, Tasmania 7000, Australia

E-mail contact: Maxim.Voronkov@csiro.au

The Australia Telescope Compact Array (ATCA) has been used to image class I methanol masers at 9.9, 25 (a series from J=2 to J=9), 84, 95 and 104 GHz located in the vicinity of IRAS 16547-4247 (G343.12-0.06), a luminous young stellar object known to harbour a radio jet. The detected maser emission consists of a cluster of 6 spots spread over an area of 30 arcsec. Five spots were detected in only the 84- and 95-GHz transitions (for two spots the 84-GHz detection is marginal), while the sixth spot shows activity in all 12 observed transitions. We report the first interferometric observations of the rare 9.9- and 104-GHz masers. It is shown that the spectra contain a very narrow spike (< 0.03 km s^{-1}) and the brightness temperature in these two transitions exceeds 5.3×10^7 and 2.0×10^4 K, respectively. The three most southern maser spots show a clear association with the shocked gas traced by the H_2 2.12 μm emission associated with the radio jet and their velocities are close to that of the molecular core within which the jet is embedded. This fact supports the idea that the class I masers reside in the interface regions of outflows. Comparison with OH masers and infrared data reveals a potential discrepancy in the expected evolutionary state. The presence of the OH masers usually means that the source is evolved, but the infrared data suggest otherwise. The lack of any class II methanol maser emission at 6.7 GHz in the source raises an additional question, is this source too young or too old to have a 6.7 GHz maser? We argue that both cases are possible and suggest that the evolutionary stage where the class I masers are active, may last longer and start earlier than when the class II masers are active. However, it is currently not possible to reveal the exact evolutionary status of IRAS 16547-4247.

Accepted by MNRAS

astro-ph/0609222

Water Masers Associated with Infrared Dark Cloud Cores

Yang Wang[1,2], Qizhou Zhang[2], Jill M. Rathborne[3], James Jackson[3] and Yuefang Wu[1]

[1] Astronomy Department and CAS-PKU Joint Beijing Astrophysics Center, Peking University, Beijing 100871, P.R. China

[2] Harvard-Smithsonian Center for Astrophysics, Cambridge, MA 02138, U.S.A.

[3] Institute for Astrophysical Research, Boston University, Boston, MA 02215, U.S.A.

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

We present a survey of the $6_{16} - 5_{23}$ H_2O maser transition toward a sample of 140 compact cores in Infrared Dark Clouds using the Very Large Array. Strong (> 1 Jy) H_2O maser emission was found associated with 17 cores, indicative of star formation in these cores. We infer that the cores with H_2O masers have embedded protostars. Cores associated with maser emission have masses of 12 to 2×10^3 $M_\odot$, similar to the mass range in the entire sample. The H_2O maser detection rate (12%) toward the compact, cold cores is much lower than that toward high-mass protostellar objects and UCHII regions. The detection rate of H_2O masers is significantly higher for higher-mass cores than for lower-mass cores. We suggest that some of the most massive Infrared Dark Cloud cores without H_2O maser emission are at an evolutionary stage earlier than the protostellar phases. They are prime candidates for high-mass starless cores.

Accepted by ApJ Letters

VLA NH_3 Observations of Regions of Massive Star Formation in Protostellar Cores

Y. Wang[1,2], Y. Wu[1], Q. Zhang[2], R. -Q. Mao[3] and M. Miller[4]

[1] Astronomy Department and CAS-PKU Joint Beijing Astrophysics Center, Peking University, Beijing 100871, P.R. China

[2] Harvard-Smithsonian Center for Astrophysics, Cambridge, MA 02138, U.S.A.

[3] Purple Mountain Observatory, Chinese Academy of Sciences, Nanjing 210008, P.R. China

[4] I, Physics Institute, Koln Univ., Zulpicher St., D-50937, Koln, Germany

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

We found that these objects have hundreds of solar masses in dense gas with rotation temperatures from 8 to 27K. No 1.3 cm continuum emission is detected at an rms of $\sim$0.7 mJy in all sources except IRAS 18361-0627. We identified 60 clumps and determined their physical parameters (e.g. line width, rotation temperature, size, and mass). The clump masses range from 0.1 $M_\odot$ to 4800 $M_\odot$. The average size, line width and temperature are 0.1$\pm$0.06 pc, 1.3$\pm$0.4 km s^{-1} and 16$\pm$5 K, respectively. The discrepancy between NH_3 and (sub)mm continuum emission is found in IRAS 18196-1331. This phenomenon could occur as a result of NH_3 abundance variation affected by the UV illumination.

Accepted by A. & A.

The Dust Properties of Eight Debris Disk Candidates as Determined by Submillimeter Photometry

Jonathan Williams[1] **and Sean Andrews**[1]

[1] Institute for Astronomy, University of Hawaii, Honolulu, HI 96822

E-mail contact: jpw@ifa.hawaii.edu

The nature of far-infrared dust emission toward main sequence stars, whether interstellar or circumstellar, can be deduced from submillimeter photometry. We present JCMT/SCUBA flux measurements at 850 μm toward 8 stars with large photospheric excesses at 60–100 μm. 5 sources were detected at 3σ or greater significance and one was marginally detected at 2.5σ. The inferred dust masses and temperatures range from 0.033 to 0.24 $M_\oplus$ and $43-65$ K respectively. The frequency behavior of the opacity, $\tau_\nu \propto \nu^\beta$, is relatively shallow, $\beta < 1$. These dust properties are characteristic of circumstellar material, most likely the debris from planetesimal collisions. The 2 non-detections have lower temperatures, $35-38$ K, and steeper opacity indices, $\beta > 1.5$, that are more typical of interstellar cirrus. The confirmed disks all have inferred diameters $> 2''$ most lie near the upper envelope of the debris disk mass distribution, and 4 are bright enough to be feasible for high resolution imaging.

Accepted by Astrophysical Journal

http://xxx.lanl.gov/abs/astro-ph/0609122

Odin CO and ^{13}CO J=5-4 mapping of Orion KL - a step towards accurate water abundances

E. S. Wirström[1]**, P. Bergman**[1,2]**, A. O. H. Olofsson**[1]**, U. Frisk**[3]**, Å, Hjalmarson**[1]**, M. Olberg**[1]**, C. M. Persson**[1] **and Aa. Sandqvist**[4]

[1] Onsala Space Observatory, Chalmers University of Technology, 43992 Onsala, Sweden
[2] European Southern Observatory, Alonso de Cordova 3107, Vitacura, Casilla 19001, Santiago, Chile
[3] Swedish Space Corporation, PO Box 4207, 17104 Solna, Sweden
[4] Stockholm Observatory, SCFAB-AlbaNova, 10691 Stockholm, Sweden

E-mail contact: eva@oso.chalmers.se

Aims. The very high main beam efficiency (90%) of the telescope on the sub-millimetre wave satellite Odin, in combination with the small calibration errors in the absence of atmospheric attenuation, assures that observed line brightness temperatures are very accurately determined. Based on this, we attempt to determine the column density distribution of H_2, and the ortho-water abundance, in the Orion KL region.

Methods. We have, for the first time, mapped the ^{12}CO J=5-4 emission in a $7' \times 7'$ region covering Orion KL, observed simultaneously with a ^{13}CO J=5-4 map. Also presented are C^{18}O J=5-4 emission data at four different positions and a C^{17}O J=5-4 emission spectrum detected towards the Orion KL position. The Odin mapping was performed at 1' spacing (beam full width at half maximum 126" at 557 GHz).

Results. The CO J=5-4 narrow line emission from this region mainly arises in the warm, dense gas at the interface (the photon-dominated region) between the M42 Hii region and the Orion A molecular cloud, the Orion PDR. The ^{12}CO and ^{13}CO J=5-4 emission maps have been used to determine the column density distribution of H_2 gas across the Orion KL region. The results have been verified by comparing to column densities obtained using the decidedly optically thin C^{18}O emission as input to the RADEX radiative transfer code. We find H_2 column densities ranging from 5×10^{21} cm^{-2} at map edges to 7×10^{22} cm^{-2} at the molecular ridge. The mass of the gas in the mapped region is estimated to be 480 $M_\odot$, of which 320 $M_\odot$ is situated towards the molecular ridge. We estimate that about half of this mass belongs to the warm Orion PDR interface layer. Finally, based on data from the positions where C^{18}O J=5-4 has been observed, we estimate the ortho-water abundance in the Orion PDR layer to be $\geq 8 \times 10^{-8}$, higher than previously estimated.

Published by Astronomy & Astrophysics (Vol. 453, p. 979)

Spectropolarimetry of the Classical T Tauri Star TW Hydrae

Hao Yang[1], Christopher M. Johns-Krull[1] and Jeff A. Valenti[2]

[1] Department of Physics & Astronomy, Rice University, 6100 Main St., Houston,TX, 77005, USA
[2] Space Telescope Science Institute, 3700 San Martin Dr., Baltimore, MD,21210, USA

E-mail contact: haoyang@rice.edu

We present high resolution ($R \approx 60,000$) circular spectropolarimetry of the classical T Tauri star TW Hydrae. We analyze 12 photospheric absorption lines and measure the net longitudinal magnetic field for 6 consecutive nights. While no net polarization is detected the first five nights, a significant photospheric field of $B_z = 149 \pm 33$ G is found on the sixth night. To rule out spurious instrumental polarization, we apply the same analysis technique to several non-magnetic telluric lines, detecting no significant polarization. We further demonstrate the reality of this field detection by showing that the splitting between right and left polarized components in these 12 photospheric lines shows a linear trend with Landé g-factor times wavelength squared, as predicted by the Zeeman effect. However, this longitudinal field detection is still much lower than that which would result if a pure dipole magnetic geometry is responsible for the mean magnetic field strength of 2.6 kG previously reported for TW Hya. We also detect strong circular polarization in the He I 5876 Å and the Ca II 8498 Å emission lines, indicating a strong field in the line formation region of these features. The polarization of the Ca II line is substantially weaker than that of the He I line, which we interpret as due to a larger contribution to the Ca II line from chromospheric emission in which the polarization signals cancel. However, the presence of polarization in the Ca II line indicates that accretion shocks on Classical T Tauri stars do produce narrow emission features in the infrared triplet lines of Calcium.

Accepted by Astronomical Journal

http://arxiv.org/abs/astro-ph/0609289

First Evidence of a Precessing Jet Excavating a Protostellar Envelope

Jason E. Ybarra[1], Mary Barsony[1,2], Karl E. Haisch, Jr.[3]
Thomas H. Jarrett[4], Raghvendra Sahai[5], and Alycia J. Weinberger[6]

[1] Department of Physics and Astronomy, San Francisco State University,
1600 Holloway Avenue, San Francisco, CA 94132
[2] Space Science Institute, 4750 Walnut Street, Suite 205, Boulder, CO 80301
[3] Utah Valley State College, 800 West University Parkway, Orem, UT 84058
[4] Infrared Processing and Analysis Center, MS 100-22 Caltech, Pasadena, CA 91125
[5] Jet Propulsion Laboratory, MS 183-900, 4800 Oak Grove Drive, Pasadena, CA 91109
[6] Deparment of Terrestrial Magnetism, Carnegie Institution of Washington, Washington, DC 20015

mbarsony@stars.sfsu.edu

We present new, sensitive, near-infrared images of the Class I protostar, Elias 29, in the Ophiuchus cloud core. To explore the relationship between the infall envelope and the outflow, narrowband H_2 1−0 $S(1)$, Brγ, and K_{cont} filters were used to image the source with the Wide-Field Infrared Camera on the Hale 5m telescope and with Persson's Auxiliary Nasmyth Infrared Camera on the Baade 6.5 m telescope. The source appears as a bipolar, scattered light nebula, with a wide opening angle in all filters, as is typical for late-stage protostars. However, the pure H_2 emission-line images point to the presence of a heretofore undetected precessing jet. It is argued that high-velocity, narrow, precessing jets provide the mechanism for creating the observed wide-angled outflow cavity in this source.

Published by Ap. J. Letters. (Vol. 647, p. L159)

http://lanl.arxiv.org/abs/astro-ph/0608162

Silicon Monoxide Observations Reveal a Cluster of Hidden Compact Outflows in the OMC1 South Region

Luis A. Zapata[1,2], Paul T. P. Ho[2,3,4], Luis F. Rodríguez[1], C. R. O'Dell[5], Qizhou Zhang[2], and August Muench[2]

[1]Centro de Radioastronomía y Astrofísica, UNAM, Apdo. Postal 3-72 (Xangari), 58089 Morelia, Michoacán, México
[2]Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA

[3]Academia Sinica Institute of Astronomy and Astrophysics, Taipei, Taiwan
[4]Department of Physics, National Taiwan University, Taipei, Taiwan
[5]Department of Physics and Astronomy, Vanderbilt University, Box 1807-B, Nashville, TN 37235, USA

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

We present high angular resolution ($2\farcs8 \times 1\farcs7$) SiO J=5→4; $v = 0$ line observations of the OMC1S region in the Orion Nebula made using the Submillimeter Array (SMA). We detect for the first time a cluster of four compact bipolar and monopolar outflows that show high, moderate and low velocity gas and appear to be energized by millimeter and infrared sources associated with this region. The SiO molecular outflows are compact (< 3500 AU), and in most of the cases, they are located very close to their exciting sources. We thus propose that the SiO thermal emission is tracing the youngest and most highly excited parts of the outflows which cannot be detected by other molecules. Moreover, since the ambient cloud is weak in the SiO line emission, these observations can reveal flows that in other molecular transitions will be confused with the ambient velocity cloud emission. Analysis of their positional-velocity diagrams show that some components of these outflows may be driven by wide-angle winds very close to the exciting object. Finally, we find that some of these SiO outflows seem to be the base of powerful Herbig-Haro jets and large-scale molecular flows that emanate from a few arcseconds around this zone. In particular, we find a strongly excited SiO bipolar outflow with a P.A. of $\sim 100°$, that is likely energized by the luminous ($\sim 3 \times 10^3$ $L_\odot$) infrared protostar "B" and could be the base of the remarkable object HH269.

Accepted by *The Astrophysical Journal*

astro-ph/0608133

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), *Abstracts of recently accepted major reviews* (not standard conference contributions), *Dissertation Abstracts* (presenting abstracts of new Ph.D dissertations), *Meetings* (announcing meetings broadly of interest to the star and planet formation and early solar system community), *New Jobs* (advertising jobs specifically aimed towards persons within the areas of the Newsletter), and *Short Announcements* (where you can inform or request information from the community).

Latex macros for submitting abstracts and dissertation abstracts (by e-mail to reipurth@ifa.hawaii.edu) are appended to each issue of the newsletter. You can also submit via the Newsletter web interface at http://www2.ifa.hawaii.edu/star-formation/index.cfm
.

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

Dissertation Abstracts

3D Hydrodynamics Simulations of Gravitational Instabilities in Embedded Protoplanetary Disks

Kai Cai

Astronomy Department, Indiana University, USA

144 MapleHill Dr. Apt. 6, Richmond, KY 40475, USA

Address as of 1 Oct 2006: Department of Physics and Astronomy, McMaster University, Hamilton, ON L8S 4M1, Canada

Electronic mail: kai@astro.indiana.edu

Ph.D dissertation directed by: Richard H. Durisen

Ph.D degree awarded: August 2006

Planets are believed to form in the primordial disks of gas and dust around newborn stars. The discovery of giant planets outside our Solar System and new observations of protoplanetary disks pose new challenges to the current formation theories of giant planets. Fragmentation of the disks due to severe gravitational instabilities (GIs) caused by rapid cooling has been suggested as one of the major formation mechanisms for these gas giants. It is generally thought that the disks embedded in thick gaseous envelopes are more massive and smaller in size and thus are more susceptible to GIs. On the basis of Mejía's methods (2004 Ph.D. Dissertation, Indiana University), I developed a radiative scheme that incorporates the effect of envelope irradiation. 3D radiative hydrodynamics simulations for a disk of 0.07 Msun around a young star of 0.5 Msun using this scheme show that, the irradiation tends to suppress GIs and GIs become weaker in a protoplanetary disk with higher metallicity or larger grain size, due to higher disk opacity and therefore longer cooling times. The global mass transport induced by GIs seems to be dominated by the low-order modes and so displays a complex behaviour as the parameters vary. Preliminary results from a simulation of a massive embedded disk with physical characteristics similar to a disk in the embedded source L1551 IRS5 also suggest a long radiative cooling time. None of the simulations produce dense clumps, even with high resolution, arguing against direct formation of giant planets by disk instability. Efforts to understand the disagreement between these results and simulations by others are underway. In future simulations, we hope to include the effects of dust sedimentation and gas infall onto the disk from the envelope, to further explore the possibility of gravitational fragmentation in young embedded disks.

http://westworld.astro.indiana.edu/Publications/c06.html

Examining the Evolutionary Sequence of Massive Star Formation

Tracey Hill

The University of New South Wales

Leiden Observatory, PO BOX 9513, 2300 RA, Leiden, The Netherlands

Electronic mail: thill@strw.leidenuniv.nl

Ph.D dissertation directed by: Michael G. Burton

Ph.D degree awarded: July 2006

Massive stars form in the dense optically thick cores of molecular clouds throughout the Galaxy. They actively participate in the heating of these molecular clouds and also in enriching the interstellar medium with heavy elements. Stellar winds may contribute to change the original cloud structure by influencing nearby low mass star formation, or even by triggering the formation of new stars. Despite the fact that massive star formation is manifest throughout the Galaxy, the mechanisms involved in their formation are poorly understood. The coincidence of methanol masers and ultracompact (UC) HII regions with young massive stars, indicates their effectiveness in tracing the earliest stages of high-mass stellar evolution. This thesis concentrates on a multiwavelength study of massive star formation regions.

The cornerstone of this thesis is a (sub)millimetre study of methanol maser and UC HII sources associated with massive star formation regions. The 15 m Swedish ESO Submillimetre Telescope (SEST) and the 15 m James Clerk Maxwell Telescope (JCMT) were used to survey continuum emission at 1.2 mm and 450 & 850 μm, respectively. The 1.2-mm continuum emission observations were undertaken with the SEST IMaging Bolometer Array (SIMBA) toward star-forming complexes associated with methanol maser and/or radio continuum sources. This survey detected emission toward all of the methanol maser and UC HII regions targeted, and revealed evidence of a handful of these tracers lying within the fields mapped without millimetre continuum emission. Interestingly, the SIMBA survey also revealed evidence of sources devoid of traditional star formation tracers (methanol/OH maser, UC HII regions, *IRAS* sources), detected solely from their millimetre continuum emission. These 'mm-only' sources prompted a follow-up study with the JCMT. The 450 and 850μm observations of mm-only cores discovered in the SIMBA survey, utilised the Submillimetre Common User Bolometer Array (SCUBA) on the JCMT, which detected submillimetre continuum emission toward 97 per cent of sources targeted. The SCUBA instrument also resolved a number of SIMBA sources into multiple components, and found evidence of submillimetre sources devoid of SIMBA emission.

The (sub)millimetre data from the SIMBA and SCUBA surveys enabled study of the dust properties of the cores, and in particular the dust grain emissivity index β, which is of order 2 for the sample. Spectral energy distribution (SED) diagrams were drawn for the SIMBA sources, employing *MSX* and *IRAS* data where possible. Eight parameters are reported for each of the sources in the sample: luminosity, temperature, mass, H_2 number density (n_{H_2}), surface density (Σ), radius, distance and luminosity-to-mass ratio (L/M). These data show that the mm-only cores are of comparable mass to sources harbouring a methanol maser and/or radio continuum source, but are smaller, cooler, less luminous, with smaller luminosity-to-mass ratios, than these sources. This prompts the suggestion that the mm-only core is an example of the earliest stages of massive star formation prior to the onset of methanol maser emission.

The mm-only sample was identified as comprising two populations, which are distinguished by temperature. The cool-mm sources are distinct from the warm-mm sources as well as from those sources with a methanol maser and/or a radio continuum source for all parameters tested but for the mass and in some instances the radius. The warm-mm on the other hand are similar to those sources with a methanol maser site and/or an UC HII region for all parameters tested. The cool-mm sources are less luminous, with lower luminosity-to-mass ratios, as well as higher H_2 number and surface densities. This prompts hypotheses to be drawn regarding the nature of these two mm-only populations. The warm-mm sources are possible precursors to the methanol maser and are thus indicative of the earliest stages of massive star formation, whilst the cool-mm sources are possible examples of 'failed' cores that will remain starless. It is, however, not yet clear which of these mm-only populations are forming massive stars and further work to test these hypotheses is required.

http://www.strw.leidenuniv.nl/∼thill/thesis.pdf

An Ecological Case Study of Low-Mass Star Formation in Taurus

Jonathan Swift
UC Berkeley
601 Campbell Hall, University of California, Berkeley, CA 94720
Electronic mail: js@astro.berkeley.edu
Ph.D dissertation directed by: Wm. J. Welch
Ph.D degree awarded: May 2006

This thesis presents an extensive observational study of the Lynds dark cloud L1551 with the goal of understanding the past, present, and future star formation in the region. This is achieved by considering the connection between the diverse phenomena observed within the cloud and the cloud environment. Roughly $140\,M_\odot$ of total mass at $15\,K$ lies within a $0.9\,pc$ projected radius, and the dispersion in molecular line emission is close to what is expected from a virialized cloud.

Roughly 35 pre-main sequence stars comprise the L1551 association which has a spread in mass of ~ 0.1–$1.5\,M_\odot$ and a spread in age of more than 6 times the dynamical time of the present day cloud. The older stars are more spatially dispersed and may be slightly more massive than the recently formed stars.

A pre-stellar core discovered in L1551 is evidence that there will be at least one more star or stellar system to form in the cloud. This $\sim 2\,M_\odot$ cold core, named L1551-MC, is likely to collapse in $< 1\,$Myr. Asymmetric molecular line profiles toward L1551-MC suggest that it is building up mass via accretion and no sign of gravitational collapse is seen. L1551-MC also appears chemically young through the comparison of emission from several molecular species.

A high-resolution, wide-field mosaic of L1551 using the BIMA interferometer is combined with single-dish data to construct fully sampled maps in both $^{13}CO(1-0)$ and $C^{18}O(1-0)$. The ^{13}CO emission shows clear evidence for the destruction of the cloud by the embedded stars while the line wings trace the boundaries between outflows and ambient gas. The $C^{18}O$ emission is optically thin and is used to characterize the turbulence in L1551 which may be sustained by stellar feedback. No significant input of energy other than from young stars is seen.

The derived quantities in this thesis along with auxiliary information from the literature are used to construct a comprehensive picture of star formation in L1551. The timeline of events is inconsistent with purely dynamical models and is most consistent with a scenario where stellar feedback mediates star formation. Magnetic field measurements within L1551 are needed to quantify their role in the evolution of the cloud.

http://astro.berkeley.edu/∼js/thesis.pdf

Postdoctoral Research Associate in mm/submm techniques: Radiometric Phase Correction for ALMA

The Astrophysics Group of the Department of Physics, University of Cambridge, invites applications for a postdoctoral research associate to work on radiometric phase correction techniques, algorithms and software development for ALMA, the Atacama Large Millimetre Array. The Group conducts a broad programme of astrophysics research involving instrumentation, observation, theory and modelling. This post is funded by the European Union Framework 6 programme and ESO to further the group's leading role in the development of phase correction techniques for ALMA. The work will involve analysis of existing test data from our 183GHz radiometers, development of novel algorithms for optimal phase correction, and implementation of these algorithms within the ALMA software system. In addition, the postholder may assist with the specification and commissioning of the ALMA meteorological instruments required to support the radiometer system.

The appointment will be on the Research Associate scale (currently £23,457 - 30,607 per annum) at a level determined by skills and experience. Expenses for travel associated with the project are provided. The position is available immediately, and we hope the successful applicant will be able to start in the very near future.

Further information may be obtained from: Mrs Karen Scrivener, Astrophysics Group, Cavendish Laboratory, J J Thomson Avenue, Cambridge CB3 0HE, tel: (01223) 337294 (karen@mrao.cam.ac.uk); informal enquiries may be made to Dr John Richer (jsr@mrao.cam.ac.uk). Applications should contain a full CV and list of publications, together with the names and contact details of two referees, a brief summary of research interests, and a completed copy of the PD18 Cover Sheet (parts I and III only), available from http://www.admin.cam.ac.uk/offices/personnel/forms/pd18/

The University is committed to equality of opportunity.   Closing date: 30 September 2006

Postdoctoral Fellowship in (sub-)millimeter interferometry

A postdoctoral position will be available immediately at the Italian node of the European network of ALMA Regional Centres (ARCs). When ALMA is operational, the ARC-node will provide general user support and infrastructure for data analysis. In addition to carrying out a personal research program (ca. 50%), the postdoc is expected to help with the preparations for the ARC-node, prepare user support material, and will in particular be involved in the development and testing of ALMA-related software. We are looking for candidates with a Ph.D. in Astronomy, Physics, or Computer Science, and who are familiar with C/C++, while a background in millimetre or radio interferometry and an interest in (sub-) millimetre observations would be preferable. Fluency in English is required.

The postdoc will initially be for 1 year. A second year is possible, depending on performance and on the availability of funding. The gross salary will be Euro 25000 (ca. Euro 1600/month net).

Applicants should send a curriculum vitae, publication list, and a statement of research interests, to the Director at the postal address given below. The envelope should be marked "Postdoc ARC".

Italian law requires specific information to be supplied with applications, and the applicants are therefore advised to visit the URL http://www.ira.inaf.it/alma/documents/postdoc.html, and use the forms provided there.

Applicants should also arrange for two letters of recommendation to be sent to the same address, also marked "Postdoc ARC", or (letters only) to arcbo@ira.inaf.it.

The closing date for applications and letters of recommendation is 30 September 2006 (date of postmark). The successful candidate will have to start before 31 December 2006.

Postal address:

INAF - Istituto di Radioastronomia
Via P. Gobetti 101
40129 Bologna, Italy

Postdoctoral Research Position - Star and Planet Formation
University of Toronto

Applications are invited for a postdoctoral research position at the University of Toronto to start in 2007. The successful candidate will work with Prof. Ray Jayawardhana and his collaborators on observational and analytical studies of the formation of planets, brown dwarfs and stars, and will be encouraged to pursue independent research on related topics. On-going projects include adaptive optics imaging and radial velocity surveys for companions around young stars, mid-infrared and sub-millimeter studies of circumstellar disk evolution, and optical/infrared imaging and spectroscopy of young brown dwarfs and planetary mass objects using data from VLT, Subaru, Magellan, Spitzer, JCMT and other major observatories. The position is for two years, with extension to a third year possible, and comes with funds for research expenses. Applicants should send a curriculum vitae, a description of research interests and plans, a list of publications, and should arrange for three letters of recommendation to be sent directly to the above address. Applications received before 2006 November 15 will receive full consideration.

Submission address:

Prof. Ray Jayawardhana
Department of Astronomy and Astrophysics
University of Toronto
50 St. George Street
Toronto
ON M5S 3H4
Canada

Email Submission and Inquiries: rayjay@astro.utoronto.ca

URL: http://www.astro.utoronto.ca

Short Announcements

I'd like to introduce to the star formation community an on-line archive listing all known very low-mass binary systems and their parameters. The site is meant to provide data from published papers to help both theorists and observers remain current regarding the limits and trends of this interesting field. The Archive is an outgrowth from the PPV chapter on very low-mass stars and brown dwarf multiplicity studies (Burgasser et al. 2006). Columns can be sorted and the Archive can be readily downloaded as an ASCII or Excel format.

Please send any corrections, suggestions, and updates to Nick Siegler (nsiegler@as.arizona.edu).

http://paperclip.as.arizona.edu/~nsiegler/VLM_binaries/

Nick Siegler

New Books

Planet Formation

Theory, Observations, and Experiments

Edited by Hubert Klahr and Wolfgang Brandner

It is just over ten years since the first planet outside our solar system was detected. Since then, much work has focussed on understanding how extrasolar planets may form, and discovering the frequency of potentially habitable Earth-like planets. This volume addresses fundamental questions concerning the formation of planetary systems in general, and of our solar system in particular. Drawing from recent advances in observational, experimental, and theoretical research, it summarises our current understanding of the planet formation processes, and addresses major open questions and research issues. Chapters are written by leading experts in the field of planet formation and extrasolar planet studies. The book is based on a meeting held at Ringberg Castle in Bavaria, where experts gathered together to present and exchange their ideas and findings. It is a comprehensive resource for graduate students and researchers, and is written to be accessible to newcomers to the field.

The book contains the following 17 chapters:

13. From Hot Jupiters to Hot Neptunes ... and Below
Christophe Lovis, Michel Mayor, and Stéphane Udry

14. Disk-planet Interaction and Migration
Frederic Masset and Wilhelm Kley

15. The Brown Dwarf - Planet Relation
Matthew Bate

16. Exoplanet Detection Techniques - from Astronomy to Astrobiology
Wolfgang Brandner

17. Overview and Prospective in Theory and Observation of Planet Formation
Douglas Lin

ISBN 13-978-0-521-86015-4, hardbound, 302 pages, 2006

US$120

Cambridge Astrobiology – Cambridge University Press

http://www.cambridge.org/uk/catalogue/catalogue.asp?isbn=0521860156

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.

Meetings

First Announcement

IAU Symposium No. 243

Star-Disk Interaction in Young Stars

Grenoble, France, 21-25 May 2007

Rationale: Disk accretion and jet outflows are intimately associated with the formation of stars and planets. One central issue raised by recent observational studies is the origin of the physical connection between accretion and wind/jet processes. It has become clear that the physical connection takes place within 1 AU of the central star, in a region where the interaction between the star and the inner disk is still poorly understood. The conference is intended to review the observational constraints available on the physical processes thought to be at work at the star-disk interface, to confront the predictions of the latest numerical and analytical MHD models of star-disk-jet systems with observations, and to explore the consequences of these processes for stellar angular momentum evolution and inner disk structure.

Objectives: The aim of the conference is to gather astronomers from around the world to critically review the MHD processes which are thought to take place within 1 AU of young stellar objects. It will focus on the structure and variability of the inner magnetized disk, the magnetospheric cavity, and the jet launching region. Understanding the structure and evolution of the star-disk interaction region in young stars is critical to our understanding of the star and planetary system formation process.

Dedication: IAU Symposium "Star-disk interaction in young stars" is a tribute to Claude Bertouts pioneering contributions to our understanding of the physics of young stars. In a series of papers published in the late 80s, Bertout and collaborators demonstrated that the UV and IR excesses exhibited by many low mass young stars could be consistently accounted for by assuming the presence of an accretion disk. Disk models aimed at reproducing the spectral energy distribution of young stars additionally suggested truncated inner disks, and the study of photometric variability provided the first evidence for magnetically-channelled accretion onto the star. Nearly 20 years later, IAU Symposium 243 is intended to review our current understanding of the magnetopheric accretion/ejection process in young stars.

Scientific Organizing Committee: Silvia Alencar, Immo Appenzeller, Gibor Basri, Jerome Bouvier (chair), Sylvie Cabrit, Suzan Edwards, Moira Jardine, Rony Keppens, Oded Regev, Bo Reipurth, Kazunari Shibata

Local Organizing Committee: Silvia Alencar, Immo Appenzeller, Gibor Basri, Jerome Bouvier (chair), Sylvie Cabrit, Suzan Edwards, Moira Jardine, Rony Keppens, Oded Regev, Bo Reipurth, Kazunari Shibata

For a preliminary program and further details, see

http://www.iaus243.org