

THE STAR FORMATION NEWSLETTER

An electronic publication dedicated to early stellar evolution and molecular clouds

No. 152 — 21 June 2005

Editor: Bo Reipurth (reipurth@ifa.hawaii.edu)

Abstracts of recently accepted papers

Orbits in Extended Mass Distributions: General Results and the Spirographic Approximation

Fred C. Adams¹ and Anthony M. Bloch²

¹ Michigan Center for Theoretical Physics, University of Michigan, Ann Arbor, MI 48109, USA

² Department of Mathematics, University of Michigan, Ann Arbor, MI 48109, USA

E-mail contact: fca@umich.edu

This paper explores orbits in extended mass distributions and develops an analytic approximation scheme based on epicycloids (spirograph patterns). We focus on the Hernquist potential, which provides a good model for many astrophysical systems, including elliptical galaxies (with an $R^{1/4}$ law), dark matter halos (where N-body simulations indicate a nearly universal density profile), and young embedded star clusters (with gas density $\rho \sim \xi^{-1}$). For a given potential, one can readily calculate orbital solutions as a function of energy and angular momentum using numerical methods. In contrast, this paper presents a number of analytic results for the Hernquist potential and proves a series of general constraints showing that orbits have similar properties for any extended mass distribution. We discuss circular orbits, radial orbits, zero energy orbits, different definitions of eccentricity, analogs of Kepler's law, the definition of orbital elements, and the relation of these orbits to spirograph patterns (epicycloids). Over a large portion of parameter space, the orbits can be adequately described (with accuracy better than 10%) using the parametric equations of epicycloids, thereby providing an analytic description of the orbits. As one application of this formal development, we find a solution for the orbit of the Large Magellanic Cloud in the potential of our Galaxy. NOTE: For *The Star Formation Newsletter*, the main applications of these orbits are for forming star clusters.

Accepted by The Astrophysical Journal

astro-ph/0504661

H₂ Pure Rotational Lines in the Orion Bar

K. N. Allers¹, D. T. Jaffe¹, J. H. Lacy¹, B. T. Draine² and M. J. Richter³

¹ Department of Astronomy, University of Texas at Austin, Austin, TX 78712-0259, USA

² Princeton University Observatory, Peyton Hall, Princeton, NJ 08544, USA

³ Department of Physics, University of California, Davis, 1 Shields Avenue, Davis, CA 95616, USA

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

Photodissociation regions, where UV radiation dominates the energetics and chemistry of the neutral gas, contain most of the mass in the dense interstellar medium of our galaxy. Observations of H₂ rotational and ro-vibrational lines reveal that PDRs contain unexpectedly large amounts of very warm (400-700 K) molecular gas. Theoretical models have difficulty explaining the existence of so much warm gas. Possible problems include errors in the heating and cooling functions or in the formation rate for H₂. To date, observations of H₂ rotational lines smear out the structure of the PDR. Only by resolving the hottest layers of H₂ can one test the predictions and assumptions of current models.

Using the Texas Echelon Cross Echelle Spectrograph (TEXES) we mapped emission in the H₂ $v = 0-0$ S(1) and S(2) lines toward the Orion Bar PDR at 2" resolution. We also observed H₂ $v = 0-0$ S(4) at selected points toward the front

of the PDR. Our maps cover a 12" by 40" region of the bar where H₂ ro-vibrational lines are bright. The distributions of H₂ 0-0 S(1), 0-0 S(2), and 1-0 S(1) line emission agree in remarkable detail.

The high spatial resolution (0.002 pc) of our observations allows us to probe the distribution of warm gas in the Orion Bar to a distance approaching the scale length for FUV photon absorption. We use these new observational results to set parameters for the PDR models described in a companion paper (Draine et al. 2005, in prep). The best-fit model can account for the separation of the H₂ emission from the ionization front and the intensities of the ground state rotational lines as well as the 1-0 S(1) and 2-1 S(1) lines. This model requires significant adjustments to the commonly used values for the dust UV attenuation cross section and the photoelectric heating rate.

Accepted by ApJ

<http://xxx.lanl.gov/abs/astro-ph/0506003>

The Structure of Magnetocentrifugal Winds: I. Steady Mass Loading

Jeffrey M. Anderson¹, Zhi-Yun Li¹, Ruben Krasnopolsky² and Roger D. Blandford³

¹ Department of Astronomy, University of Virginia, P.O. Box 3818, Charlottesville, VA 22903, USA

² Center for Theoretical Astrophysics, University of Illinois at Urbana-Champaign, Loomis Laboratory, 1110 West Green Street, Urbana, IL 61801, USA

³ SLAC, M/S 75, 2575 Sandhill Road, Menlo Park, CA 94025, USA

E-mail contact: jma2u@virginia.edu

We present the results of a series of time-dependent numerical simulations of cold, magnetocentrifugally launched winds from accretion disks. The goal of this study is to determine how the mass loading from the disk affects the structure and dynamics of the wind for a given distribution of magnetic field. Our simulations span four and half decades of mass loading; in the context of a disk with a launching region from 0.1 AU to 1.0 AU around a 1 M_⊙ star and a field strength of about 20 G at the inner disk edge, this amounts to mass loss rates of $1 \times 10^{-9} - 3 \times 10^{-5} M_{\odot} \text{ yr}^{-1}$ from each side of the disk. We find that, as expected intuitively, the degree of collimation of the wind increases with mass loading; however even the “lightest” wind simulated is significantly collimated compared with the force-free magnetic configuration of the same magnetic flux distribution at the launching surface, which becomes radial at large distances. The implication is that for flows from young stellar objects a radial field approximation is inappropriate. Surprisingly, the terminal velocity of the wind and the magnetic lever arm are still well-described by the analytical solutions for a radial field geometry. We also find that the isodensity contours and Alfvén surface are approximately self-similar in mass loading. The wind becomes unsteady above some critical mass loading rate. The exact value of the critical rate depends on the (small) velocity with which we inject the material into the wind. For a small enough injection speed, we are able to obtain the first examples of a class of heavily-loaded magnetocentrifugal winds with magnetic fields completely dominated by the toroidal component all the way to the launching surface. The stability of such toroidally dominated winds in 3D will be the subject of a future investigation.

Accepted by ApJ

<http://xxx.lanl.gov/abs/astro-ph/0410704>

Circumstellar Dust Disks in Taurus-Auriga: The Submillimeter Perspective

Sean M. Andrews¹ and Jonathan P. Williams¹

¹ University of Hawaii Institute for Astronomy, Honolulu, HI 96822, USA

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

We present a sensitive, multiwavelength submillimeter continuum survey of 153 young stellar objects in the Taurus-Auriga star formation region. The submillimeter detection rate is 61% to a completeness limit of ~ 10 mJy ($3\text{-}\sigma$) at $850 \mu\text{m}$. The inferred circumstellar disk masses are log-normally distributed with a mean mass of $\sim 5 \times 10^{-3} M_{\odot}$ and a large dispersion (0.5 dex). Roughly one third of the submillimeter sources have disk masses larger than the minimal nebula from which the solar system formed. The median disk to star mass ratio is 0.5%. The empirical behavior of the submillimeter continuum is best described as $F_{\nu} \propto \nu^{2.0 \pm 0.5}$ between $350 \mu\text{m}$ and 1.3 mm, which we argue is due to the combined effects of the fraction of optically thick emission and a flatter frequency behavior of the opacity

compared to the interstellar medium. This latter effect could be due to a substantial population of large dust grains, which presumably would have grown through collisional agglomeration. In this sample, the only stellar property that is correlated with the outer disk is the presence of a companion. We find evidence for significant decreases in submillimeter flux densities, disk masses, and submillimeter continuum slopes along the canonical infrared spectral energy distribution evolution sequence for young stellar objects. The fraction of objects detected in the submillimeter is essentially identical to the fraction with excess near-infrared emission, suggesting that dust in the inner and outer disk are removed nearly simultaneously.

Accepted by Astrophysical Journal

preprint available on astro-ph/0506187

XMM-Newton spectroscopy of the metal depleted T Tauri star TWA 5

C. Argiroffi¹, A. Maggio², G. Peres¹, B. Stelzer^{1,2} and R. Neuhauser³

¹ Dipartimento di Scienze Fisiche ed Astronomiche, Sezione di Astronomia, Università di Palermo, Piazza del Parlamento 1, 90134 Palermo, Italy

² INAF - Osservatorio Astronomico di Palermo, Piazza del Parlamento 1, 90134 Palermo, Italy

³ Astrophysikalisches Institut und Universitäts-Sternwarte, Schillergässchen 2-3, D-07745 Jena, Germany

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

We present results of X-ray spectroscopy for TWA 5, a member of the young TW Hydrae association, observed with *XMM-Newton*. TWA 5 is a multiple system which shows H α emission, a signature typical of classical T Tauri stars, but no infrared excess. From the analysis of the RGS and EPIC spectra, we have derived the emission measure distribution vs. temperature of the X-ray emitting plasma, its abundances, and the electron density. The characteristic temperature and density of the plasma suggest a corona similar to that of weak-line T Tauri stars and active late-type main sequence stars. TWA 5 also shows low iron abundance (~ 0.1 times the solar photospheric one) and a pattern of increasing abundances for elements with increasing first ionization potential reminiscent of the inverse FIP effect observed in highly active stars. The especially high ratio Ne/Fe ~ 10 is similar to that of the classical T Tauri star TW Hya, where the accreting material has been held responsible for the X-ray emission. We discuss the possible role of an accretion process in this scenario. Since all T Tauri stars in the TW Hydrae association studied so far have very high Ne/Fe ratios, we also propose that environmental conditions may cause this effect.

Accepted by Astronomy and Astrophysics

<http://www.astropa.unipa.it/Library/preprint.html>

Magnetic field in Cepheus A as deduced from OH maser polarimetric observations

A. Bartkiewicz¹, M. Szymczak¹, R.J. Cohen² and A.M.S. Richards²

¹ Toruń Centre for Astronomy, Nicolaus Copernicus University, Gagarina 11, 87-100 Toruń, Poland

² Jodrell Bank Observatory, University of Manchester, Macclesfield, Cheshire SK11 9DL, UK

E-mail contact: annan@astro.uni.torun.pl

We present the results of MERLIN polarization mapping of OH masers at 1665 and 1667 MHz towards the Cepheus A star-forming region. The maser emission is spread over a region of 6 arcsec by 10 arcsec, twice the extent previously detected. In contrast to the 22-GHz water masers, the OH masers associated with HII regions show neither clear velocity gradients nor regular structures. We identified ten Zeeman pairs which imply a magnetic field strength along the line-of-sight from -17.3 to $+12.7$ mG. The magnetic field is organised on the arcsecond scale, pointing towards us in the west and away from us in the east side. The linearly polarized components, detected for the first time, show regularities in the polarization position angles depending on their position. The electric vectors of OH masers observed towards the outer parts of HII regions are consistent with the interstellar magnetic field orientation, while those seen towards the centres of HII regions are parallel to the radio-jets. A Zeeman quartet inside a southern HII region has now been monitored for 25 years; we confirm that the magnetic field decays monotonically over that period.

Accepted by MNRAS

Preprint available at <http://arxiv.org/abs/astro-ph/0505374>

VLT K-band spectroscopy of massive stars deeply embedded in IRAS sources with UCHII colours.

A. Bik^{1,2}, L. Kaper², M.M. Hanson³ and M. Smits²

¹ European Southern Observatory, Karl-Schwarzschild Strasse 2, Garching-bei-München, D-85748, Germany

² Astronomical Institute “Anton Pannekoek”, University of Amsterdam, Kruislaan 403, 1098 SJ Amsterdam The Netherlands

³ University of Cincinnati, Cincinnati, OH 45221-0011, U.S.A.

E-mail contact: abik@eso.org

We have obtained high resolution ($R = 10,000$) K -band spectra of candidate young massive stars deeply embedded in (ultra-) compact HII regions (UCHIIs). These objects were selected from a near-infrared survey of 44 fields centered on IRAS sources with UCHII colours. Often, the near-infrared counterpart of the IRAS source is a young embedded cluster hosting massive stars. In these clusters, three types of objects are identified. The first type (38 objects) consists of “naked” OB stars whose K -band spectra are dominated by photospheric emission. We classify the K -band spectra of the OB-type cluster members using near-infrared classification criteria. A few of them have a very early (O3-O4 V) spectral type, consistent with a young age of the embedded clusters. The spectral classification provides an important constraint on the distance to the embedded cluster. The ionising power of the population thus derived is compared to the information obtained from the infrared and radio flux of these sources. In most cases these two different determinations of the ionising flux are consistent, from which we conclude that we have identified the ionising star(s) in about 50 % of the embedded clusters. The second type (7 objects) are point sources associated with UCHII radio emission, that exhibit nebular emission lines in the near-infrared. Six of the objects in this group produce HeI emission indicative of an embedded O-type star. These objects are more embedded than the OB stars and probably do not dominate the infrared flux as measured by IRAS. They may emit the bulk of their reprocessed UV radiation at mm wavelengths. The third type (20 objects) is characterised by broad (100–200 km s⁻¹) Br γ emission and no photospheric absorption profiles. In a forthcoming paper we show that these objects are massive YSO candidates surrounded by dense circumstellar disks.

Accepted by Astronomy and Astrophysics

<http://www.eso.org/~abik/publications.html> (or astro-ph/0505293)

Spitzer Observations of CO₂ Ice Towards Field Stars in the Taurus Molecular Cloud

Edwin A. Bergin¹, Gary J. Melnick², Perry A. Gerakines³, David A. Neufeld⁴, Douglas C.B. Whittet⁵

¹University of Michigan, 825 Dennison Building, 500 Church Street., Ann Arbor, MI 48109-1090, USA

²Harvard-Smithsonian Center for Astrophysics, 60 Garden St., Cambridge, MA 02138, USA

³Astro- and Solar-System Physics Program, Department of Physics, University of Alabama at Birmingham, 1300 University Blvd, CH 310, Birmingham, AL 35294-1170, USA

⁴Department of Physics and Astronomy, The Johns Hopkins University, 3400 North Charles Street, Baltimore, MD 21218, USA

⁵Department of Physics, Applied Physics, and Astronomy, and New York Center for Studies on the Origins of Life, Rensselaer Polytechnic Institute, Troy, NY 12180, USA

E-mail contact: ebergin@umich.edu

We present the first *Spitzer* Infrared Spectrograph observations of the 15.2 μm bending mode of CO₂ ice towards field stars behind a quiescent dark cloud. CO₂ ice is detected towards 2 field stars (Elias 16, Elias 3) and a single protostar (HL Tau) with an abundance of $\sim 15 - 20\%$ relative to water ice. CO₂ ice is not detected towards the source with lowest extinction in our sample, Tamura 17 ($A_V = 3.9^m$). A comparison of the Elias 16 spectrum with laboratory data demonstrates that the majority of CO₂ ice is embedded in a polar H₂O-rich ice component, with $\sim 15\%$ of CO₂ residing in an apolar H₂O-poor mantle. This is the first detection of apolar CO₂ towards a field star. We find that the CO₂ extinction threshold is $A_V = 4^m \pm 1^m$, comparable to the threshold for water ice, but significantly less than the threshold for CO ice, the likely precursor of CO₂. Our results confirm CO₂ ice forms in tandem with H₂O ice along quiescent lines of sight. This argues for CO₂ ice formation via a mechanism similar to that responsible for H₂O ice formation, viz. simple catalytic reactions on grain surfaces.

Accepted by Astrophysical Journal *Letters*

Deuterated H_3^+ in proto-planetary disks

Cecilia Ceccarelli¹ & Carsten Dominik²

¹ Laboratoire d'Astrophysique, Observatoire de Grenoble - BP 53, F-38041 Grenoble cedex 09, France

² Sterrenkundig Instituut "Anton Pannekoek", Kruislaan 403, NL-1098SJ Amsterdam, The Netherlands

E-mail contact: Cecilia.Ceccarelli@obs.ujf-grenoble.fr

Probing the gas and dust in proto-planetary disks is central for understanding the process of planet formation. In disks surrounding solar type protostars, the bulk of the disk mass resides in the outer midplane, which is cold (≤ 20 K), dense ($\geq 10^7$ cm⁻³) and depleted of CO. Observing the disk midplane has proved, therefore, to be a formidable challenge. Ceccarelli et al. (2004) detected H_2D^+ emission in a proto-planetary disk and claimed that it probes the midplane gas. Indeed, since all heavy-elements bearing molecules condense out onto the grain mantles, the most abundant ions in the disk midplane are predicted to be H_3^+ and its isotopomers. In this article, we carry out a theoretical study of the chemical structure of the outer midplane of proto-planetary disks. Using a self-consistent physical model for the flaring disk structure, we compute the abundances of H_3^+ and its deuterated forms across the disk midplane. We also provide the average column densities across the disk of H_3^+ , H_2D^+ , HD_2^+ and D_3^+ , and line intensities of the ground transitions of the ortho and para forms of H_2D^+ and HD_2^+ respectively. We discuss how the results depend on the cosmic ray ionization rate, dust-to-gas ratio and average grain radius, and general stellar/disk parameters. An important factor is the poorly understood freeze-out of N_2 molecules onto grains, which we investigate in depth. We finally summarize the diagnostic values of observations of the H_3^+ isotopomers.

Accepted by Astronomy & Astrophysics

astro-ph/0506254

Far-IR SEDs of Embedded Protostars and Dusty Galaxies: I. Theory for Spherical Sources

Sukanya Chakrabarti¹ and Christopher F. McKee¹

¹ University of CA, Berkeley, USA

E-mail contact: sukanya@astro.berkeley.edu

We present analytic radiative transfer solutions for the spectra of unresolved, spherically symmetric, centrally heated, dusty sources. We find that the dust thermal spectrum possesses scaling relations that provide a natural classification for a broad range of sources, from low-mass protostars to dusty galaxies. In particular, we find that, given our assumptions, spectral energy distributions (SEDs) can be characterized by two distance-independent parameters, the luminosity-to-mass ratio, L/M , and the surface density, Σ , for a set of two functions, namely, the density profile and the opacity curve. The goal is to use SEDs as a diagnostic tool in inferring the large-scale physical conditions in protostellar and extragalactic sources, and ultimately, evolutionary parameters. Our approach obviates the need to use SED templates in the millimeter to far-infrared region of the spectrum; this is a common practice in the extragalactic community that relies on observed correlations established at low redshift that may not necessarily extend to high redshift. Further, we demarcate the limited region of parameter space in which density profiles can be inferred from the SED, which is of particular import in the protostellar community as competing theories of star formation are characterized by different density profiles. The functionality of our model is unique in that it provides for a self-consistent analytic solution that we have validated by comparison with a well-tested radiative transfer code (DUSTY) to find excellent agreement with numerical results over a parameter space that spans low-mass protostars to ultra-luminous infrared galaxies (ULIRGS).

Accepted by Astrophysical Journal

IRAS 16293–2422: proper motions, jet precession, the hot core, and the unambiguous detection of infall

Claire J. Chandler¹, Crystal L. Brogan², Yancy L. Shirley¹, and Laurent Loinard³

¹ National Radio Astronomy Observatory, PO Box O, Socorro, NM 87801, USA

² University of Hawaii, Institute for Astronomy, 640 North A'ohoku Place, Hilo, HI 96720, USA

³ Centro de Radioastronomía y Astrofísica, Universidad Nacional Autónoma de México, Apdo Postal 72–3 (Xangari), 58089 Morelia, Michoacán, México

E-mail contact: cchandle@nrao.edu

We present high spatial resolution observations of the multiple protostellar system IRAS 16293–2422 using the Submillimeter Array (SMA) at 300 GHz, and the Very Large Array (VLA) at frequencies from 1.5 to 43 GHz. This source was already known to be a binary system with its main components, A and B, separated by $\sim 5''$. The new SMA data now separate source A into two submillimeter continuum components, which we denote Aa and Ab. The strongest of these, Aa, peaks between the centimeter radio sources A1 and A2, but the resolution of the current submillimeter data is insufficient to distinguish whether this is a separate source or the centroid of submillimeter dust emission associated with A1 and A2. Archival VLA data spanning 18 years show proper motion of sources A and B of 17 mas yr^{-1} , associated with the motion of the ρ Ophiuchi cloud. We also find, however, significant relative motion between the centimeter sources A1 and A2 which excludes the possibility that these two sources are gravitationally bound unless A1 is in a highly eccentric orbit and is observed at periastron, the probability of which is low. A2 remains stationary relative to source B, and we identify it as the protostar which drives the large-scale NE–SW CO outflow. A1 is shock-ionized gas which traces the location of the interaction between a precessing jet and nearby dense gas. This jet probably drives the large-scale E–W outflow, and indeed its motion is consistent with the wide opening angle of this flow. The origin of this jet must be located close to A2, and may be the submillimeter continuum source Aa. Thus source A is now shown to comprise three (proto)stellar components within $1''$. Source B, on the other hand, is single, exhibits optically-thick dust emission even at 8 GHz, has a high luminosity, and yet shows no sign of outflow. It is probably very young, and may not even have begun a phase of mass loss yet.

The SMA spectrum of IRAS 16293–2422 reports the first astronomical identification of many lines of organic and other molecules at 300 and 310 GHz. The species detected are typical of hot cores, the emission from which is mainly associated with source A. The abundances of second generation species, especially of sulphur-bearing molecules, are significantly higher than predicted by chemical models for this source to date, and we suggest that shocks are probably needed to explain these enhancements. The peaks in the integrated emission from molecules having high rotation temperatures coincide with the centimeter source A1, also highlighting the key role of shocks in explaining the nature of hot cores. Finally, we use the high brightness temperature of the submillimeter dust emission from source B to demonstrate the unambiguous detection of infall by observing redshifted SO (7_7-6_6) absorption against the emission from its dust disk.

Accepted by ApJ

Preprint available at <http://arxiv.org/abs/astro-ph/0506435>

Variability of the NGC 1333 IRAS 4A Outflow: Silicon Monoxide Observations

Minho Choi¹

¹ Taeduk Radio Astronomy Observatory, Korea Astronomy and Space Science Institute, Hwaam 61-1, Yuseong, Daejeon 305-348, Korea

E-mail contact: minho@trao.re.kr

The NGC 1333 IRAS 4A region was observed in the SiO $v = 0 J = 1 \rightarrow 0$ line with an angular resolution of about $2''$. The SiO map revealed highly collimated outflows consisting of compact emission peaks. The map shows at least two outflows: the main bipolar outflow in the northeast-southwest direction and a shorter one toward the south. The main outflow displays a sharp bend in the middle of the northeastern lobe. The existence of a dense molecular cloud core just north of the bend suggests that the outflow may have been deflected as a result of jet-core collision. This explanation is also supported by the asymmetric morphology of the bipolar outflow, the good collimation and complicated kinematics of the deflected flow, the low-velocity emission from the molecular gas near the bend, and the enhancement of SiO emission in the deflected flow. The projected deflection angle is about 34° , and a significant

fraction of the kinetic energy of the outflow may have been transferred to the ambient cloud through the collision process. Since the main outflow is highly collimated, it was possible to identify the driving source. The longer main outflow is probably driven by IRAS 4A2, the secondary member of the protobinary system, and the shorter southern outflow by A1, the primary. Possible explanations for this anti-correlation between outflow and accretion include a delay of the onset of outflow activity in A1 and a reversal of accretion rates between binary components.

Accepted by ApJ

Preprint: <http://www.trao.re.kr/~minho/Publications.html>

Is G84.0+0.8 a high mass star formation site near the edge of the Pelican nebula?

F. Comerón¹, A. Pasquali² and J. Torra³

¹ European Southern Observatory, Karl-Schwarzschild-Strasse 2, D-85748 Garching, Germany

² Institute of Astronomy, ETH Hoenggerberg, CH-8093 Zurich, Switzerland

³ Departament d'Astronomia i Meteorologia, Universitat de Barcelona, E-08028 Barcelona, Spain

E-mail contact: fcomeron@eso.org

We present visible and near-infrared observations of the G84.0+0.8 HII region, a bright compact knot projected within the boundaries of the W80 complex dominated by the North America and Pelican nebulae. The spectrum of the nebula indicates a temperature of the ionizing stellar spectrum $T_* \simeq 40,000 - 45,000$ K (corresponding to a O7-O5 star) and a density of the HII region $n \simeq 460 \text{ cm}^{-3}$, with a foreground extinction of $A_V \simeq 5.9$ mag. A comparison of narrow-band near-infrared images through the Br γ and the H₂ S(1) $v = 1 \rightarrow 0$ filters shows that G84.0+0.8 consists of a fan-shaped cavity in a molecular cloud at least partly bounded by a photodissociation region, filled with Br γ -emitting ionized gas, and with a compact cluster at the tip of the fan. The brightest star at the position of the cluster is found to be a late G-type interloper. While membership of G84.0+0.8 in the local arm is well established from existing radial velocity measurements of the ionized gas, we find that the ionizing flux estimated from the size and density of the nebula on the one hand, and the radio continuum properties of the nebula on the other hand, are well below the expected ionizing flux of a mid, or even late, O-type star. We consider the possibility that G84.0+0.8 might be externally ionized by a nearby mid-O star. Currently available observations do not definitely confirm or reject the membership of G84.0+0.8 in the W80 complex, although a larger distance seems favored by the available data. Nevertheless, we can firmly rule out the possibility that it represents a massive star forming site in that complex, as its appearance as a compact HII region containing an embedded cluster may lead one to think.

Accepted by Astronomy and Astrophysics

Preprints available from <http://www.eso.org/~fcomeron/g84.ps.gz>

The Young Cluster NGC 2362

S. E. Dahm¹

¹ Institute for Astronomy, University of Hawaii, 2680 Woodlawn Drive, Honolulu, HI 96822, USA

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

An H α emission survey of the young cluster NGC 2362 resulted in the detection of 130 H α emission stars in an 11' \times 11' field approximately centered upon the 4th magnitude O9Ib multiple star, τ CMa. The survey was carried out using the wide-field grism spectrograph (WFGS) on the University of Hawaii (UH) 2.2 meter telescope and the Gemini Multi-Object Spectrograph (GMOS) on Gemini North. Deep optical VR_cI_c (to $V \sim 23.0$) and near infrared (NIR) photometry (JHK) to $K \sim 16$ were obtained for several fields within the cluster. Spectra covering the 6000–8000Å region at a resolution of $R \sim 3000$ (adequate for the determination of Li I $\lambda 6708$ line strengths) were also acquired for ~ 200 PMS candidates with GMOS. Ages and masses for the H α emitters in NGC 2362 were inferred from the isochrones and evolutionary tracks of D'Antona & Mazzitelli (DM97) as well as Baraffe et al. (B98). An estimated cluster age of ~ 1.8 Myr follows from the models of DM97 and 3.5–5.0 Myr from those of B98. The fraction of the T Tauri star (TTS) population that is composed of weak-line emitters, $f(\text{WTTS})$, is 0.91, compared with 0.43 for the TTS population of NGC 2264. On the basis of W(H α) alone, the fraction of TTSs still undergoing accretion is 5–9%, comparable to the inner disk fraction determined from $JHKL$ -band excesses by Haisch, Lada, and Lada (12%). Approximately 15% of the PMS sample in this study exhibits possible NIR excess, having $E_{H-K} > 0.1$ mag. Given

the lack of NIR excess and strong H α emission from the majority of cluster members, it is inferred that the inner disk regions of the TTS population have dissipated significantly. The mean level of chromospheric activity among the WTTS population of NGC 2362 is $\log(L_{H\alpha}/L_{bol}) = -3.65$, significantly greater than that of the low-mass population of the 600 Myr old Hyades cluster, $\log(L_{H\alpha}/L_{bol}) = -3.90$. The total mass of the H α emitters and the OB stellar population of NGC 2362 define a lower limit for the cluster mass of $\sim 300 M_{\odot}$. Allowance for A and F-type stars still on the radiative track, multiplicity, outlying members, and the low-mass population lying below the completeness limit of the H α emission survey increases this lower limit to well over $500 M_{\odot}$. The derived relaxation, disruption, and evaporation timescales for the cluster imply that NGC 2362 will likely survive beyond the age of the Pleiades, but statistics of galactic cluster lifetimes favor its disruption well before the age of the Hyades.

Accepted by Astronomical Journal

X-ray Diagnostics of Grain Depletion in Matter Accreting onto T Tauri Stars

Jeremy J. Drake¹, Paola Testa² and Lee Hartmann¹

¹ Smithsonian Astrophysical Observatory, MS-3, 60 Garden Street, Cambridge, MA 02138, USA

² Kavli Institute for Astrophysics and Space Research, Massachusetts Institute of Technology, 70 Vassar Street, Cambridge, MA 02139, USA

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

Recent analysis of high resolution *Chandra* X-ray spectra has shown that the Ne/O abundance ratio is remarkably constant in stellar coronae. Based on this result, we point out the utility of the Ne/O ratio as a discriminant for accretion-related X-rays from T Tauri stars, and for probing the measure of grain-depletion of the accreting material in the inner disk. We apply the Ne/O diagnostic to the classical T Tauri stars BP Tau and TW Hya—the two stars found to date whose X-ray emission appears to originate, at least in part, from accretion activity. We show that TW Hya appears to be accreting material which is significantly depleted in O relative to Ne. In contrast, BP Tau has an Ne/O abundance ratio consistent with that observed for post-T Tauri stars. We interpret this result in terms of the different ages and evolutionary states of the circumstellar disks of these stars. In the young BP Tau disk (age ~ 0.6 Myr) dust is still present near the disk corotation radius and can be ionized and accreted, re-releasing elements depleted onto grains. In the more evolved TW Hya disk (age ~ 10 Myr), evidence points to ongoing coagulation of grains into much larger bodies, and possibly planets, that can resist the drag of inward-migrating gas, and accreting gas is consequently depleted of grain-forming elements.

Accepted by ApJ Letters

VLA 3.5 cm continuum sources in the Serpens cloud core

C. Eiroa¹, J.M. Torrelles², S. Curiel³ and A.A. Djupvik⁴

¹ Dpto. Física Teórica, C-XI, Facultad de Ciencias, Universidad Autónoma de Madrid, Cantoblanco, 28049 Madrid, Spain

² Instituto de Ciencias del Espacio (CSIC) and Institut d'Estudis Espacials de Catalunya, C/ Gran Capitá 2-4, 08034 Barcelona, Spain

³ Instituto de Astronomía, UNAM, Apdo. Postal 70-264, 04510 México D.F., México and Harvard-Smithsonian Center for Astrophysics, 60 Garden St, Cambridge, MA02138, USA

⁴ Nordic Optical Telescope, Apdo. 474, 38700 Santa Cruz de La Palma

E-mail contact: carlos.eiroa@uam.es

We present VLA 3.5 cm continuum observations of the Serpens cloud core. 22 radio continuum sources are detected. 16 out of the 22 cm sources are suggested to be associated with young stellar objects (Class 0, Class I, flat-spectrum, and Class II) of the young Serpens cluster. The rest of the VLA sources plausibly are background objects. Most of the Serpens cm sources likely represent thermal radio jets; on the other hand, the radio continuum emission of some sources could be due to a gyrosynchrotron mechanism arising from coronally active young stars. The Serpens VLA sources are spatially distributed into two groups; one of them located towards the NW clump of the Serpens core, where only Class 0 and Class I protostars are found to present cm emission, and a second group located towards the SE clump, where radio continuum sources are associated with objects in evolutionary classes from Class 0 to Class II.

This subgrouping is similar to that found in the near IR, mid-IR and mm wavelength regimes.

Accepted by Astronomical journal

<http://arxiv.org/abs/astro-ph/0506054>

Mass loss at the lowest stellar masses

M. Fernández^{1,2} and F. Comerón³

¹ Max-Planck-Institut für Astronomie, Königstuhl 17, D-69117 Heidelberg, Germany

² Instituto de Astrofísica de Andalucía, CSIC, Camino Bajo de Huétor 50, E-18008 Granada, Spain

³ European Southern Observatory, Karl-Schwarzschild-Strasse 2, D-85748 Garching, Germany

E-mail contact: matilde@mpia-hd.mpg.de

We report the discovery of a jet in a [SII] image of Par-Lup3-4, a remarkable M5-type pre-main sequence object in the Lupus 3 star-forming cloud. The spectrum of this star is dominated by the emission lines commonly interpreted as tracers of accretion and outflows. Par-Lup3-4 is therefore at the very low-mass end of the exciting sources of jets. High resolution spectroscopy shows that the [SII] line profile is double-peaked, implying that the low excitation jet is seen at a small angle (probably $\geq 8^\circ$) with respect to the plane of the sky. The width of the H_α line suggests a dominating contribution from the accretion columns and from the shocks on the stellar surface. Unresolved H_α emission coming from an object located at 4.2" from Par-Lup3-4 is detected at a position angle $\sim 30^\circ$ or $\sim 210^\circ$, with no counterpart seen either in visible or infrared images.

We also confirm previous evidence of strong mass loss from the very low mass star LS-RCrA 1, with spectral type M6.5 or later. All its forbidden lines are blueshifted with respect to the local standard of rest (LSR) of the molecular cloud at a position very close to the object and the line profile of the [OI] lines is clearly asymmetric. Thus, the receding jet could be hidden by a disk which is not seen edge-on.

If an edge-on disk does not surround Par-Lup3-4 or LS-RCrA 1, an alternative explanation, possibly based on the effects of mass accretion, is required to account for their unusually low luminosities.

Accepted by Astronomy & Astrophysics

Preprint available at http://www.iaa.es/~matilde/jet_vlms_12.ps.gz

The effect of the Coriolis force on Kelvin-Helmholtz-driven mixing in protoplanetary disks.

Gilberto C. Gomez¹ and Eve C. Ostriker¹

¹ Astronomy Department, University of Maryland, College Park MD 20742, USA

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

We study the stability of proto-planetary disks with vertical velocity gradients in their equilibrium rotation rates; such gradients are expected to develop when dust settles into the midplane. Using a linear stability analysis of a simple three-layer model, we show that the onset of instability occurs at a larger value of the Richardson number, and therefore for a thicker layer, when the effects of Coriolis forces are included. This analysis also shows that even-symmetry (midplane-crossing) modes develop faster than odd-symmetry ones. These conclusions are corroborated by a large number of nonlinear numerical simulations with two different parameterized prescriptions for the initial (continuous) dust distributions. Based on these numerical experiments, the Richardson number required for marginal stability is more than an order of magnitude larger than the traditional 1/4 value. The dominant modes that grow have horizontal wavelengths of several initial dust scale heights, and in nonlinear stages mix solids fairly homogeneously over a comparable vertical range. We conclude that gravitational instability may be more difficult to achieve than previously thought, and that the vertical distribution of matter within the dust layer is likely globally, rather than locally, determined.

Accepted by Astrophysical Journal

<http://www.astro.umd.edu/~gomez/publica/khdisk.pdf>

Limits on the primordial stellar multiplicity

Simon P Goodwin¹ and Pavel Kroupa²

¹ School of Physics & Astronomy, Cardiff University, 5 The Parade, Cardiff, CF24 3YB, UK

² Sternwarte, Universität Bonn, Auf dem Hügel 71, D 53121, Bonn, Germany

E-mail contact: Simon.Goodwin@astro.cf.ac.uk

Most stars - especially young stars - are observed to be in multiple systems. Dynamical evolution is unable to pair stars efficiently, which leads to the conclusion that star-forming cores must usually fragment into ≥ 2 stars. However, the dynamical decay of systems with ≥ 3 or 4 stars would result in a large single-star population that is not seen in the young stellar population. Additionally, ejections would produce a significant population of close binaries that are not observed. This leads to a strong constraint on star formation theories that cores must typically produce only 2 or 3 stars. This conclusion is in sharp disagreement with the results of currently available numerical simulations that follow the fragmentation of molecular cores and typically predict the formation of 5–10 seeds per core. In addition, open cluster remnants may account for the majority of observed highly hierarchical higher-order multiple systems in the field.

Accepted by A&A

<http://www.astro.cf.ac.uk/pub/Simon.Goodwin/2654.pdf>

Evidence for an X-Ray Jet in DG Tauri A?

M. Güdel¹, S. L. Skinner², K. R. Briggs¹, M. Audard³, K. Arzner¹, and A. Telleschi¹

¹ Paul Scherrer Institut, Würenlingen and Villigen, CH-5232 Villigen PSI, Switzerland

² Center for Astrophysics and Space Astronomy, University of Colorado, Boulder, CO 80309-0389, USA

³ Columbia Astrophysics Laboratory, Columbia University, 550 West 120th Street, New York, NY 10027, US

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

We present evidence for an X-ray jet in the T Tau star DG Tau A based on *Chandra* ACIS data. DG Tau A, a jet-driving classical T Tau star with a flat infrared spectrum, reveals an unusual X-ray spectrum that requires two thermal components with different intervening absorption column densities. The softer component shows a low temperature of $T \approx 2.9$ MK, and its absorption is compatible with the stellar optical extinction (hydrogen column density $N_{\text{H}} \approx 5 \times 10^{21} \text{ cm}^{-2}$). In contrast, the harder component reveals a temperature (22 MK) characteristic of active T Tau stars but its emission is more strongly absorbed ($N_{\text{H}} \approx 2.8 \times 10^{22} \text{ cm}^{-2}$). Furthermore, the high-resolution ACIS-S image reveals a weak excess of soft (0.5 – 2 keV) counts at distances of 2–4'' from the star precisely along the optical jet, with a suggestive concentration at 4'' where a bow-shock-like structure has previously been identified in optical line observations. The energy distribution of these photons is similar to those of the stellar soft component. We interpret the soft spectral component as originating from shocks at the base of the jet, with shock heating continuing out to a distance of at least 500 AU along the jet, whereas the hard component is most likely coronal/magnetospheric as in other young stellar systems.

Accepted by *Astrophys. J.* (626, L53)

WWW: http://www.astro.phys.ethz.ch/papers/guedel/guedel_p_nf.html

Constraints on Inner Disk Evolution Timescales: A Disk Census of the eta Chamaeleontis Young Cluster

Karl E. Haisch Jr.¹, Ray Jayawardhana² and João Alves³

¹ Physics Department, Utah Valley State College, Orem, UT 84058-5999, U.S.A.

² Department of Astronomy & Astrophysics, University of Toronto, Toronto, Ontario M5S 3H8, Canada

³ European Southern Observatory, D-85748 Garching, Germany

E-mail contact: Karl.Haisch@uvsc.edu

We present new L' -band ($3.8\mu\text{m}$) observations of stars in the nearby (~ 97 pc) young (~ 6 Myr) compact cluster around η Chamaeleontis, obtained with the European Southern Observatory's Very Large Telescope in Paranal, Chile. Our

data, combined with J, H, K_s photometry from the 2-Micron All Sky Survey, reveal that only two of the 12 members surveyed harbor L' -band excesses consistent with optically thick inner disks; both are also likely accretors. Intriguingly, two other stars with possible evidence for on-going accretion, albeit at very low rates, do not show significant infrared excess: this may imply substantial grain growth and/or partial clearing of the inner disk region, as expected in planet formation scenarios. Our findings suggest that η Cha stars are in an epoch when disks are rapidly evolving, perhaps due to processes related to planet building, and provide further constraints on inner disk lifetimes.

Accepted by Astrophysical Journal Letters

<http://arxiv.org/abs/astro-ph/0506352>

The Disappearing Act of KH 15D: Photometric Results from 1995 to 2004

Catrina M. Hamilton¹, William Herbst², Frederick J. Vrba³, Mansur A. Ibrahimov⁴, Reinhard Mundt and Coryn A. L. Bailer-Jones⁵, Alexei V. Filippenko and Weidong Li⁶, Victor J.S. Bejar⁷, Peter Abraham, Maria Kun, Attila Moor, Jozsef Benko and Szilard Csizmadia⁸ and Darren L. DePoy, Richard W. Pogge, and Jennifer L. Marshall⁹

¹ Mount Holyoke College, Astronomy Department, 50 College St., South Hadley, MA 01075, USA

² Astronomy Department, Wesleyan University, Middletown, CT 06459, USA

³ US Naval Observatory, Flagstaff Station, Box 1149, Flagstaff, AZ, 86002-1149, USA

⁴ Ulugh Beg Astronomical Institute of the Uzbek Academy of Sciences, Astronomicheskaya 33, 700052 Tashkent, Uzbekistan

⁵ Max-Planck-Intitut fur Astronomie, Konigstuhl 17, D-69117, Heidelberg, Germany

⁶ Department of Astronomy, University of California, Berkeley, CA 94720-3411, USA

⁷ GTC Project. Instituto de Astrofisica de Canarias, IAC. E-38200. La Laguna, Tenerife, Spain

⁸ Konkoly Observatory, H-1525, P.O. Box 67, Budapest, Hungary

⁹ Department of Astronomy, Ohio State University, Columbus, OH 43210-1106, USA

E-mail contact: chamilton@MtHolyoke.edu

We present results from the most recent (2002–2004) observing campaigns of the eclipsing system KH 15D, in addition to re-reduced data obtained at Van Vleck Observatory (VVO) between 1995 and 2000. Phasing nine years of photometric data shows substantial evolution in the width and depth of the eclipses. The most recent data indicate that the eclipses are now approximately 24 days in length, or half the orbital period. These results are interpreted and discussed in the context of the recent models for this system put forward by Winn et al. (2004) and Chiang & Murray-Clay (2004). A periodogram of the entire data set yields a highly significant peak at 48.37 ± 0.01 days, which is in accord with the spectroscopic period of 48.38 ± 0.01 days determined by Johnson et al. (2004). Another significant peak, at 9.6 days, was found in the periodogram of the out-of-eclipse data at two different epochs. We interpret this as the rotation period of the visible star and argue that it may be tidally locked in pseudosynchronism with its orbital motion. If so, application of Hut’s (1981) theory implies that the eccentricity of the orbit is $e = 0.65 \pm 0.01$. Analysis of the UVES/VLT spectra obtained by Hamilton et al. (2003) shows that the $v \sin(i)$ of the visible star in this system is $6.9 \pm 0.3 \text{ km s}^{-1}$. Using this value of $v \sin(i)$ and the measured rotation period of the star, we calculate the lower limit on the radius to be $R = (1.3 \pm 0.1) R_{\odot}$, which concurs with the value obtained by Hamilton et al. (2001) from its luminosity and effective temperature. Here we assume that $i = 90^{\circ}$ since it is likely that the spin and orbital angular momenta vectors are nearly aligned. One unusually bright data point obtained in the 1995/1996 observing season at VVO is interpreted as the point in time when the currently hidden star (B) made its last appearance. Based on this datum, we show that star B is 0.46 ± 0.03 mag brighter than the currently visible star A, which is entirely consistent with the historical light curve (Johnson et al. 2005). Finally, well-sampled V_J and I_J data obtained at the CTIO/Yale 1-m telescope during 2001/2002 show an entirely new feature: the system becomes bluer by a small but significant amount in very steady fashion as it enters eclipse and shows an analogous reddening as it emerges from eclipse. This suggests an extended zone of hot gas located close to, but above, the photosphere of the currently visible star. The persistence of the bluing of the light curve shows that its length scale is comparable to a stellar radius.

Accepted by Astronomical Journal

IRAC Observations of Taurus Pre-Main Sequence Stars

Lee Hartmann¹, S.T. Megeath¹, Lori Allen¹, Kevin Luhman¹, Nuria Calvet¹, Paola D’Alessio², Ramiro Franco-Hernandez² and Giovanni Fazio¹

¹ Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138 USA

² Centro de Radioastronomia y Astrofisica, Ap. P. 72-3 (Xangari) 58089 Morelia, Michoacan, Mexico

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

We present infrared photometry obtained with the IRAC camera on the *Spitzer* Space Telescope of a sample of 82 pre-main sequence stars and brown dwarfs in the Taurus star-forming region. We find a clear separation in some IRAC color-color diagrams between objects with and without disks. A few “transition” objects are noted, which correspond to systems in which the inner disk has been evacuated of small dust. Separating pure disk systems from objects with remnant protostellar envelopes is more difficult at IRAC wavelengths, especially for objects with infall at low rates and large angular momenta. Our results generally confirm the IRAC color classification scheme used in previous papers by Allen et al. and Megeath et al. to distinguish between protostars, T Tauri stars with disks, and young stars without (inner) disks. The observed IRAC colors are in good agreement with recent improved disk models, and in general accord with models for protostellar envelopes derived from analyzing a larger wavelength region. We also comment on a few Taurus objects of special interest. Our results should be useful for interpreting IRAC results in other, less well-studied star-forming regions.

Accepted by Astrophysical Journal

<http://cfa-www.harvard.edu/cfa/youngstars/publications.html>

X-ray Emission from the Weak-lined T Tauri Binary System KH 15D

William Herbst¹ and Edward C. Moran¹

¹ Astronomy Department, Wesleyan University, Middletown, CT 06459, USA

E-mail contact: wherbst@wesleyan.edu

The unique eclipsing, weak-lined T Tauri star KH 15D has been detected as an X-ray source in a 95.7 ks exposure from the *Chandra X-ray Observatory* archives. A maximum X-ray luminosity of 1.5×10^{29} erg s⁻¹ is derived in the 0.5–8 keV band, corresponding to $L_X/L_{\text{bol}} = 7.5 \times 10^{-5}$. Comparison with samples of stars of similar effective temperature in NGC 2264 and in the Orion Nebula Cluster shows that this is about an order of magnitude low for a typical star of its mass and age. We argue that the relatively low luminosity cannot be attributed to absorption along the line of sight but implies a real deficiency in X-ray production. Possible causes for this are considered in the context of a recently proposed eccentric binary model for KH 15D. In particular, we note that the visible component rotates rather slowly for a weak-lined T Tauri star and has possibly been pseudosynchronized by tidal interaction with the primary near periastron.

Accepted by Astrophys. J.

Available at: astro-ph/0506167

Velocity field and star formation in the Horsehead nebula

P. Hily-Blant¹, D. Teyssier^{2,3}, S. Philipp⁴ and R. Guesten⁴

¹ Institut de Radio Astronomie Millimetrique (IRAM), France

² Space Research Organization, Netherlands

³ Departamento de Astrofisica Molecular e Infrarroja, Spain

⁴ Max-Planck-Institut fur Radioastronomie, Germany

E-mail contact: hilyblan@iram.fr

Using large scale maps in C¹⁸O(2 – 1) and in the continuum at 1.2mm obtained at the IRAM-30m antenna with the Heterodyne Receiver Array (HERA) and MAMBO2, we investigated the morphology and the velocity field probed in the inner layers of the Horsehead nebula. The data reveal a non-self-gravitating ($m/m_{\text{vir}} \approx 0.3$) filament of dust and gas (the “neck”, diametre = 0.15 – 0.30 pc) connecting the Horsehead western ridge, a Photon-Dominated Region

illuminated by σ Ori, to its parental cloud L1630. Several dense cores are embedded in the ridge and the neck. One of these cores appears particularly peaked in the 1.2 mm continuum map and corresponds to a feature seen in absorption on ISO maps around $7\ \mu\text{m}$. Its C^{18}O emission drops at the continuum peak, suggestive of molecular depletion onto cold grains. The channel maps of the Horsehead exhibit an overall north-east velocity gradient whose orientation swivels east-west, showing a somewhat more complex structure than was recently reported by Pound et al 2003 using BIMA CO(1–0) mapping. In both the neck and the western ridge, the material is rotating around an axis extending from the PDR to L1630 (angular velocity = $1.5 - 4.0\ \text{km s}^{-1}$). Moreover, velocity gradients along the filament appear to change sign regularly ($3\ \text{km s}^{-1}\ \text{pc}^{-1}$, period= $0.30\ \text{pc}$) at the locations of embedded integrated intensity peaks. The nodes of this oscillation are at the same velocity. Similar transverse cuts across the filament show a sharp variation of the angular velocity in the area of the main dense core. The data also suggest that differential rotation is occurring in parts of the filament. We present a new scenario for the formation and evolution of the nebula and discuss dense core formation inside the filament.

Accepted by A&A

Grain Evolution across the Shocks in the L1448–mm Outflow

I. Jiménez–Serra¹, J. Martín–Pintado¹, A. Rodríguez–Franco^{1,2} and S. Martín³

¹ Dpto. de Astrofísica Molecular e Infrarroja (IEM-CSIC), C/ Serrano 121, 28006 Madrid, Spain

² Escuela Universitaria de Óptica (UCM), Avda. Arcos de Jalón s/n, E-28037 Madrid, Spain

³ IRAM, Avda. Divina Pastora, Local 20, E-18012 Granada, Spain

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

The recent detection of the shock–precursors toward the very young L1448–mm outflow offers the possibility to study the grain chemistry during the first stages of the shock evolution, constraining the molecules ejected from grains and the species formed in gas phase. Observations of key molecules in the grain chemistry like SiO, CH_3OH , SO, CS, H_2S , OCS, and SO_2 toward this outflow are presented. The line profiles and the derived abundances show three distinct velocity regimes that trace the shock evolution: the preshock, the shock–precursor and the postshock gas. The SiO, CH_3OH , SO, and CS abundances are enhanced with respect to the quiescent gas by one order of magnitude in the shock–precursor component, and by three orders of magnitude in the postshock gas. The derived SiO and CH_3OH abundances are consistent with the recent ejection of these molecules from grains. Since H_2S is only enhanced in the shock–precursor component, and OCS and SO_2 are undetected, SO and CS are the most abundant sulfur–bearing species in the grain mantles of L1448–mm. The ejection of mainly SO and CS rather than H_2S or OCS from grains, suggests that the sulfur chemistry will depend on the chemical “history” of the grain mantles in outflows and hot cores.

Accepted by Astrophysical Journal Letters

<http://arxiv.org/abs/astro-ph/0506408>

Formation and Evolution of Planetary Systems: Cold Outer Disks Associated with Sun-like stars

Jinyoung Serena Kim¹, Dean C. Hines², Dana E. Backman³, Lynne A. Hillenbrand⁴, Michael R. Meyer¹, Jens Rodmann⁵, Amaya Moro-Martín⁶, John M. Carpenter⁴, Murray D. Silverstone¹, Jeroen Bouwman⁵, Eric E. Mamajek⁷, Sebastian Wolf⁴, Renu Malhotra⁸, Ilaria Pascucci¹, Joan Najita⁹, Deborah L. Padgett¹⁰, Thomas Henning⁵, Timothy Y. Brooke⁴, Martin Cohen¹¹, Stephen E. Strom⁹, Elizabeth B. Stobie¹, Charles W. Engelbracht¹, Karl D. Gordon¹, Karl Misselt¹, Jane E. Morrison¹, James Muzerolle¹, & Kate Y. L. Su¹

¹ Steward Observatory, The University of Arizona, 933 N. Cherry Ave., Tucson, AZ 85721-0065, USA

² Space Science Institute, 4750 Walnut Street, Suite 205, Boulder, CO

³ SOFIA, MS 211-3, NASA-Ames, Moffet Field, CA 94035-1000, USA

⁴ Astronomy, California Institute of Technology, Pasadena, CA 91125, USA

⁵ Max-Planck-Institut für Astronomie, D-69117, Heidelberg, Germany

⁶ Princeton University, Princeton, NJ 08540, USA

⁷ Harvard-Smithsonian Center for Astrophysics, 60 Garden St., MS-42 Cambridge, MA 02138, USA

⁸ Department of Planetary Sciences & Lunar and Planetary Laboratory, The University of Arizona, 1629 E. University Blvd., Tucson, AZ85721-0092, USA

⁹ National Optical Astronomy Observatory, 950 N. Cherry Ave., Tucson, AZ 85719, USA

¹⁰ Spitzer Science Center, California Institute of Technology, Pasadena, CA, 91125, USA

¹¹ Radio Astronomy, University of California, Berkeley, CA 94720, USA

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

We present the discovery of debris systems around three solar mass stars based upon observations performed with the *Spitzer Space Telescope* as part of a Legacy Science Program, “the Formation and Evolution of Planetary Systems” (FEPS). We also confirm the presence of debris around two other stars. All the stars exhibit infrared emission in excess of the expected photospheres in the 70 μm band, but are consistent with photospheric emission at $\leq 33 \mu\text{m}$. This restricts the maximum temperature of debris in equilibrium with the stellar radiation to $T < 70 \text{ K}$. We find that these sources are relatively old in the FEPS sample, in the age range 0.7 – 3 Gyr. Based on models of the spectral energy distributions, we suggest that these debris systems represent materials generated by collisions of planetesimal belts. We speculate on the nature of these systems through comparisons to our own Kuiper Belt, and on the likely planet(s) responsible for stirring the system and ultimately releasing dust through collisions. We further report observations of a nearby star HD 13974 ($d = 11 \text{ pc}$) that is indistinguishable from a bare photosphere at both 24 μm and 70 μm . The observations place strong upper limits on the presence of any cold dust in this nearby system ($L_{\text{IR}}/L_{\star} < 10^{-5.2}$).

Accepted by Astrophysical Journal

http://globule.as.arizona.edu/~serena/publications/JSK_cold_disks.ps

Photon dominated regions in the spiral arms of M83 and M51

C. Kramer¹, B. Mookerjee¹, E. Bayet², S. Garcia-Burillo³, M. Gerin², F.P. Israel⁴, J. Stutzki¹, and J.G.A. Wouterloot⁵

¹ KOSMA, I. Physikalisches Institut, Universität zu Köln, Zùlpicher Straße 77, 50937 Köln, Germany

² Radioastronomie Millimetrique: UMR 8540 du CNRS, Laboratoire de Physique de l’ENS, 24 Rue Lhomond, 75231 Paris cedex 05, France

³ Centro Astronomico de Yebes, IGN, E-19080 Guadalajara, Spain

⁴ Sterrewacht Leiden, P.O. Box 9513, 2300 RA Leiden, The Netherlands

⁵ Joint Astronomy Centre, 660 N. A’ohoku Place, Hilo, HI, USA

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

We present [CI] $^3\text{P}_1\text{--}^3\text{P}_0$ spectra at four spiral arm positions and the nuclei of the nearby galaxies M83 and M51 obtained at the JCMT. The spiral arm positions lie at galacto-centric distances of between 2 kpc and 6 kpc. This data is complemented with maps of CO 1–0, 2–1, and 3–2, and ISO/LWS far-infrared data of [CII] (158 μm), [OI] (63 μm), and [NII] (122 μm) allowing for the investigation of a complete set of all major gas cooling lines. From the intensity of the [NII] line, we estimate that between 15% and 30% of the observed [CII] emission originate from the dense ionized phase of the ISM. The analysis indicates that emission from the diffuse ionized medium is negligible. In combination with the FIR dust continuum, we find gas heating efficiencies below $\sim 0.21\%$ in the nuclei, and between 0.25 and 0.36% at the outer positions. Comparison with models of photon-dominated regions (PDRs) of Kaufman et al. (1999) with the standard ratios $[\text{OI}](63)/[\text{CII}]_{\text{PDR}}$ and $(\text{OI}(63)+[\text{CII}]_{\text{PDR}})$ vs. TIR, the total infrared intensity, yields two solutions. The physically most plausible solution exhibits slightly lower densities and higher FUV fields than found when using a full set of line ratios, $[\text{CII}]_{\text{PDR}}/[\text{CI}](1\text{--}0)$, $[\text{CI}](1\text{--}0)/\text{CO}(3\text{--}2)$, $\text{CO}(3\text{--}2)/\text{CO}(1\text{--}0)$, $[\text{CII}]/\text{CO}(3\text{--}2)$, and, $[\text{OI}](63)/[\text{CII}]_{\text{PDR}}$. The best fits to the latter ratios yield densities of 10^4 cm^{-3} and FUV fields of $\sim G_0 = 20\text{--}30$ times the average interstellar field without much variation. At the outer positions, the observed total infrared intensities are in perfect agreement with the derived best fitting FUV intensities. The ratio of the two intensities lies at 4–5 at the nuclei, indicating the presence of other mechanisms heating the dust. [CI] area filling factors lie below 2% at all positions, consistent with low volume filling factors of the emitting gas. The fit of the model to the line ratios improves significantly if we assume that [CI] stems from a larger region than CO 2–1. Improved modelling would need to address the filling factors of the various submm and FIR tracers, taking into consideration the presence of density gradients of the emitting gas by including cloud mass and size distributions within the beam.

Accepted by A&A

<http://www.ph1.uni-koeln.de/~kramer/>

Comparisons of an Evolutionary Chemical Model with Other Models

Jeong-Eun Lee¹, Neal J. Evans II¹ and Edwin A. Bergin²

¹ Department of Astronomy, The University of Texas at Austin, 1 University Station C1400, Austin, Texas 78712-0259

² Department of Astronomy, The University of Michigan, 825 Dennison Building Ann Arbor, Michigan 48109-1090

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

We compare an evolutionary chemical model with simple empirical models of the abundance and with static chemical models. We focus on the prediction of molecular line profiles that are commonly observed in low mass star forming cores. We show that empirical models can be used to constrain evaporation radii and infall radii using lines of some species. Species with more complex abundance profiles are not well represented by the empirical models. Static chemical models produce abundance profiles different from those obtained from an evolutionary calculation because static models do not account for the flow of matter inward from the outer regions. The resulting profiles of lines used to probe infall may differ substantially.

Accepted by ApJ

<http://arxiv.org/abs/astro-ph/0506086>

Collapse and Fragmentation of Rotating Magnetized Clouds. I. Magnetic Flux - Spin Relation

Masahiro N Machida¹, Tomoaki Matsumoto², Kohji Tomisaka³ and Tomoyuki Hanawa⁴

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

³ National Astronomical Observatory of Japan, Mitaka, Tokyo 181-8588, Japan

⁴ Center for Frontier Science, Chiba University, Yayoicho 1-33, Inageku, Chiba 263-8522, Japan

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

We discuss evolution of the magnetic flux density and angular velocity in a molecular cloud core, on the basis of three-dimensional numerical simulations, in which a rotating magnetized cloud fragments and collapses to form a very dense optically thick core of $> 5 \times 10^{10} \text{ cm}^{-3}$. As the density increases towards the formation of the optically thick core, the magnetic flux density and angular velocity converge towards a single relationship between the two quantities. If the core is magnetically dominated its magnetic flux density approaches $1.5(n/5 \times 10^{10} \text{ cm}^{-3})^{1/2} \text{ mG}$, while if the core is rotationally dominated the angular velocity approaches $2.57 \times 10^{-3} (n/5 \times 10^{10} \text{ cm}^{-3})^{1/2} \text{ yr}^{-1}$, where n is the density of the gas. We also find that the ratio of the angular velocity to the magnetic flux density remains nearly constant until the density exceeds $5 \times 10^{10} \text{ cm}^{-3}$. Fragmentation of the very dense core and emergence of outflows from fragments are shown in the subsequent paper.

Accepted by MNRAS

[astro-ph/0506439](http://arxiv.org/abs/astro-ph/0506439)

Collapse and Fragmentation of Rotating Magnetized Clouds. II. Binary Formation and Fragmentation of First Cores

Masahiro N Machida¹, Tomoaki Matsumoto², Tomoyuki Hanawa³ and Kohji Tomisaka⁴

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

³ Center for Frontier Science, Chiba University, Yayoicho 1-33, Inageku, Chiba 263-8522, Japan

⁴ National Astronomical Observatory of Japan, Mitaka, Tokyo 181-8588, Japan

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

Subsequent to Paper I, the evolution and fragmentation of a rotating magnetized cloud are studied with use of three-

dimensional MHD nested-grid simulations. After the isothermal runaway collapse, an adiabatic gas forms a protostellar first core at the center of the cloud. When the isothermal gas is stable for fragmentation in a contracting disk, the adiabatic core often breaks into several fragments. Conditions for fragmentation and binary formation are studied. All the cores which show fragmentations are geometrically thin, as the diameter-to-thickness ratio is larger than 3. Two patterns of fragmentation are found. (1) When a thin disk is supported by centrifugal force, the disk fragments through a ring configuration (ring fragmentation). This is realized in a fast rotating adiabatic core as $\Omega > 0.2\tau_{\text{ff}}^{-1}$, where Ω and τ_{ff} represent the angular rotation speed and the free-fall time of the core, respectively. (2) On the other hand, the disk is deformed to an elongated bar in the isothermal stage for a strongly magnetized or rapidly rotating cloud. The bar breaks into 2 - 4 fragments (bar fragmentation). Even if a disk is thin, the disk dominated by the magnetic force or thermal pressure is stable and forms a single compact body. In either ring or bar fragmentation mode, the fragments contract and a pair of outflows are ejected from the vicinities of the compact cores. The orbital angular momentum is larger than the spin angular momentum in the ring fragmentation. On the other hand, fragments often quickly merge in the bar fragmentation, since the orbital angular momentum is smaller than the spin angular momentum in this case. Comparison with observations is also shown.

Accepted by MNRAS

astro-ph/0506440

Evaporation and condensation of HI clouds in thermally bistable interstellar media: semi-analytic description of isobaric dynamics of curved interfaces

Masahiro Nagashima¹, Hiroshi Koyama² and Shu-ichiro Inutsuka¹

¹ Department of Physics, Graduate School of Science, Kyoto University, Sakyo-ku, Kyoto 606-8502, Japan

² Department of Earth and Planetary Science, Kobe University, Kobe 657-8501, Japan

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

We analyse the evaporation and condensation of spherical and cylindrical HI clouds of the cold neutral medium surrounded by the warm neutral medium. Because the interstellar medium including those two phases is well described as a thermally bistable fluid, it is useful to apply pattern formation theories to the dynamics of the interface between the two phases. Assuming isobaric evolution of fluids and a simple polynomial form of the heat-loss function, we show the curvature effects of the interface. We find that approximate solutions for spherical clouds are in good agreement with numerically obtained solutions. We extend our analysis to general curved interfaces taking into account the curvature effects explicitly. We find that the curvature effects always stabilize curved interfaces under assumptions such as isobaric evolution we adopt in this Letter.

Accepted by MNRAS Letters

<http://arxiv.org/abs/astro-ph/0503137>

Quiescent Cores and the Efficiency of Turbulence-Accelerated, Magnetically Regulated Star Formation

Fumitaka Nakamura¹ and Zhi-Yun Li²

¹ Faculty of Education and Human Sciences, Niigata University, 8050 Ikarashi-2, Niigata 950-2181, Japan

² Astronomy Department, University of Virginia, P.O. Box 3818, Charlottesville, VA 22903, USA

E-mail contact: fnakamur@ed.niigata-u.ac.jp

The efficiency of star formation, defined as the ratio of the stellar to total (gas and stellar) mass, is observed to vary from a few percent in regions of dispersed star formation to about a third in cluster-forming cores. This difference may reflect the relative importance of magnetic fields and turbulence in controlling star formation. We investigate the interplay between (decaying) turbulence and magnetic fields using numerical simulations, in a sheet-like geometry. The geometry allows for an accurate and expedient treatment of ambipolar diffusion, a key ingredient for star formation. We demonstrate that star formation with an efficiency of a few percent can occur over several gravitational collapse times in moderately magnetically subcritical clouds that are supersonically turbulent. In turbulent clouds that are marginally magnetically supercritical, the star formation efficiency is higher, but can still be consistent with the values inferred for nearby embedded clusters. A phenomenological prescription for protostellar outflow is included in our

model to stop mass accretion after a star has obtained a given mass and to disperse away the remaining core material. Within a reasonable range of strength, the outflow does not affect the efficiency of star formation much and contributes little to turbulence replenishment in subcritical and marginally supercritical clouds. If not regulated by magnetic fields at all, star formation in a multi-Jeans mass cloud endowed with a strong initial turbulence proceeds rapidly, with the majority of cloud mass converted into stars in a gravitational collapse time in the absence of constant turbulence driving. The efficiency is formally higher than the values inferred for nearby cluster-forming cores, indicating that magnetic fields are dynamically important even for cluster formation.

In turbulent, magnetically subcritical clouds, the turbulence accelerates star formation by reducing the time for dense core formation. The dense cores produced in such clouds are predominantly quiescent. For example, 8 out of the 10 cores produced at the middle point of our standard simulation have subsonic internal motions. The cores tend to be moderately supercritical, and thus remain magnetically supported to a large extent. They contain a small fraction of the cloud mass, and have lifetimes ranging from $\sim 1.5 - 10$ times their local gravitational collapse time. Some of the cores collapse to form stars, while others disperse away without star formation, in agreement with previous work. All these factors, as well as core-outflow interaction, contribute to the low efficiency of the star formation in these clouds of dispersed star formation.

Accepted by ApJ

astro-ph/0502130

Large Confinement-Driven Spatial Variations in the Cosmic Ray Flux

Paolo Padoan¹ and John Scalo²

¹ Department of Physics, University of California, San Diego, CASS/UCSD 0424, 9500 Gilman Drive, La Jolla, CA 92093-0424, USA

² Department of Astronomy, University of Texas, Austin, TX 78712, USA

E-mail contact: ppadoan@ucsd.edu; parrot@astro.as.utexas.edu

The Galactic cosmic-ray (CR) flux is usually assumed to be relatively constant on scales less than a few hundred parsecs, while estimates of the CR ionization rate in diffuse ISM regions are larger than in molecular regions by factors of 10-50. We show that the observed CR variations can be understood in terms of self-confinement of low-energy CRs by resonant pitch-angle scattering with self-generated MHD waves in mostly neutral regions. The self-confinement yields a CR density proportional to the square root of the local ion density, and dropping sharply at densities above which damping of the waves allows the CRs to stream freely.

Accepted by The Astrophysical Journal

Preprint available at: <http://xxx.lanl.gov/abs/astro-ph/0503585>

Theoretical HDO emission from low-mass protostellar envelopes

Bérengère Parise¹, Cecilia Ceccarelli² and Sébastien Maret³

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

² Laboratoire d'Astrophysique, Observatoire de Grenoble - BP 53, F-38041 Grenoble cedex 09, France

³ Department of Astronomy, University of Michigan, 500 Church Street, Ann Arbor MI 48109-1042, USA

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

We present theoretical predictions of the rotational line emission of deuterated water in low-mass protostar collapsing envelopes. The model accounts for the density and temperature structure of the envelope, according the inside-out collapse framework. The deuterated water abundance profile is approximated by a step function, with a low value in the cold outer envelope and a higher value in the inner envelope where the grain mantles evaporate. The two abundances are the two main parameters of the modeling, along with the temperature at which the mantles evaporate. We report line flux predictions for a 30 and 5 L_{\odot} source luminosity respectively. We show that ground based observations are capable to constrain the three parameters of the model in the case of bright low-mass protostars ($L > 10 L_{\odot}$), and that no space based observations, like for example HSO observations, are required in this case. On the contrary, we show that the study of low-luminosity sources ($L < 10 L_{\odot}$), assuming the same HDO abundance profile, requires too much integration time to be carried out either with available ground-based telescopes or with the HIFI instrument on board

HSO. For these sources, only the large interferometer ALMA will allow to constrain the HDO abundance.

Accepted by Astronomy & Astrophysics

astro-ph/0506144

X-ray emission from young brown dwarfs in the Orion Nebula Cluster

Thomas Preibisch¹, Mark J. McCaughrean^{2,3}, Nicolas Grosso⁴, Eric D. Feigelson⁵, Ettore Flaccomio⁶, Konstantin Getman⁵, Lynne A. Hillenbrand⁷, Gwendolyn Meeus³, Giusi Micela⁶, Salvatore Sciortino⁶, Beate Stelzer^{6,8}

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

² University of Exeter, School of Physics, Stocker Road, Exeter EX4 4QL, Devon, UK

³ Astrophysikalisches Institut Potsdam, An der Sternwarte 16, D-14482 Potsdam, Germany

⁴ Laboratoire d'Astrophysique de Grenoble, Université Joseph-Fourier, F-38041 Grenoble cedex 9, France

⁵ Department of Astronomy & Astrophysics, Pennsylvania State University, University Park PA 16802

⁶ INAF, Osservatorio Astronomico di Palermo G. S. Vaiana, Piazza del Parlamento 1, I-90134 Palermo, Italy

⁷ Department of Astronomy, California Institute of Technology, Mail Code 105-24, Pasadena, CA 91125

⁸ Dipartimento di Scienze Fisiche ed Astronomiche, Università di Palermo, Piazza del Parlamento 1, I-90134 Palermo, Italy

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

We use the sensitive X-ray data from the *Chandra* Orion Ultradeep Project (COUP) to study the X-ray properties of 34 spectroscopically-identified brown dwarfs with near-infrared spectral types between M6 and M9 in the core of the Orion Nebula Cluster. Nine of the 34 objects are clearly detected as X-ray sources. The apparently low detection rate is in many cases related to the substantial extinction of these brown dwarfs; considering only the BDs with $A_V \leq 5$ mag, nearly half of the objects (7 out of 16) are detected in X-rays. Our 10-day long X-ray lightcurves of these objects exhibit strong variability, including numerous flares. While one of the objects was only detected during a short flare, a statistical analysis of the lightcurves provides evidence for continuous ('quiescent') emission in addition to flares for all other objects. Of these, the \sim M9 brown dwarf COUP 1255 = HC 212 is one of the coolest known objects with a clear detection of quiescent X-ray emission. The X-ray properties (spectra, fractional X-ray luminosities, flare rates) of these young brown dwarfs are similar to those of the low-mass stars in the ONC, and thus there is no evidence for changes in the magnetic activity around the stellar/substellar boundary, which lies at \sim M6 for ONC sources. Since the X-ray properties of the young brown dwarfs are also similar to those of M6–M9 field stars, the key to the magnetic activity in very cool objects seems to be the effective temperature, which determines the degree of ionization in the atmosphere.

Accepted by Astrophysical Journal Supplement (COUP Special Issue)

<http://www.mpifr-bonn.mpg.de/staff/tpreibis/coup-bd.html>

The evolution of X-ray emission in young stars

Thomas Preibisch¹ and Eric D. Feigelson²

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

² Department of Astronomy & Astrophysics, Pennsylvania State University, University Park PA 16802, USA

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

The evolution of magnetic activity in late-type stars is part of the intertwined rotation-age-activity relation which provides an empirical foundation to the theory of magnetic dynamos. We study the age-activity relation in the pre-main sequence (PMS) regime, for the first time using mass-stratified subsamples. The effort is based on the *Chandra* Orion Ultradeep Project (COUP) which provides very sensitive and homogenous X-ray data on a uniquely large sample of 481 optically well-characterized low-extinction low-mass members of the Orion Nebula Cluster, for which individual stellar masses and ages could be determined. More than 98 percent of the stars in this sample are detected as X-ray sources. Within the PMS phase for stellar ages in the range $\sim 0.1 - 10$ Myr, we establish a mild decay in activity with stellar age τ roughly as $L_X \propto \tau^{-1/3}$. On longer timescales, when the Orion stars are compared to main sequence stars, the X-ray luminosity decay law for stars in the $0.5 < M < 1.2 M_\odot$ mass range is more rapid with $L_X \propto \tau^{-0.75}$

over the wide range of ages $5 < \log \tau < 9.5$ yr. When the fractional X-ray luminosity L_X/L_{bol} and the X-ray surface flux are considered as activity indicators, the decay law index is similarly slow for the first 1 – 100 Myr but accelerates for older stars. The magnetic activity history for M stars with masses $0.1 < M < 0.4 M_\odot$ is distinctly different. Only a mild decrease in X-ray luminosity, and even a mild increase in L_X/L_{bol} and F_X , is seen over the 1 – 100 Myr range, though the X-ray emission does decay over long timescales on the main sequence. Together with COUP results on the absence of a rotation-activity relation in Orion stars, we find that the activity-age decay is strong across the entire history of solar-type stars but is not attributable to rotational deceleration during the early epochs. A combination of tachocline and distributed convective dynamos may be operative in young solar-type stars. The results for the lowest mass stars are most easily understood by the dominance of convective dynamos during both the PMS and main sequence phases.

Accepted by Astrophysical Journal Supplement (COUP Special Issue)

<http://www.mpifr-bonn.mpg.de/staff/tpreibis/coup-evol.html>

Rapid Dissipation of Primordial Gas from the AU Microscopii Debris Disk

Aki Roberge¹, Alycia J. Weinberger¹, Seth Redfield² and Paul D. Feldman³

¹ Dept. of Terrestrial Magnetism, Carnegie Institution of Washington, 5241 Broad Branch Road, NW, Washington, DC, 20015, USA

² Harlan J. Smith Postdoctoral Fellow, McDonald Observatory, University of Texas at Austin, 1 University Station, C1400, Austin, TX, 78712, USA

³ Dept. of Physics & Astronomy, Johns Hopkins University, 3400 N. Charles St., Baltimore, MD, 21218, USA

E-mail contact: akir@dtm.ciw.edu

The disk around AU Microscopii, an M1 star in the β Pictoris Moving Group, is extraordinarily well-suited for comparison to the β Pic debris disk (type A5V). We use far-UV absorption spectroscopy of AU Mic to probe its edge-on disk for small amounts of H₂, the primary constituent of gas giant planets. Our conservative upper limit on the line-of-sight H₂ column density is $1.7 \times 10^{19} \text{ cm}^{-2}$, which is 18.5 times lower than the limit obtained from non-detection of sub-mm CO emission (Liu et al. 2004). In addition, there is a hint of H₂ absorption at a column density an order of magnitude or more below our upper limit. The H₂-to-dust ratio in the AU Mic disk is $< 6:1$, similar to that in the β Pic disk. This shows that the primordial gas has largely been dissipated in less than about 12 Myr for both disks, despite their very different stellar masses and luminosities. It is extremely difficult to form a giant planet around AU Mic with current core-accretion scenarios in such a short time.

Accepted by ApJ Letters

<http://xxx.lanl.gov/abs/astro-ph/0505302>

Proper Motions in Cepheus A

Luis F. Rodríguez¹, José M. Torrelles², Alejandro C. Raga³, Jorge Cantó⁴, Salvador Curiel⁴, and Guido Garay⁵

¹ Centro de Radioastronomía y Astrofísica, UNAM, Apdo. Postal 3-72 (Xangari), 58089 Morelia, Michoacán, México

² Instituto de Ciencias del Espacio, CSIC; and Institut d'Estudis Espacials de Catalunya, Edifici Nexus, Gran Capità, 2-4, E-08034 Barcelona, Spain

³ Instituto de Ciencias Nucleares, UNAM, Apartado Postal 70-543, 04510 México DF, México

⁴ Instituto de Astronomía, UNAM, Apdo. Postal 70-264, México, D. F., 04510 México

⁵ Departamento de Astronomía, Universidad de Chile, Casilla 36-D, Santiago, Chile

E-mail contact: l.rodriguez@astrosmo.unam.mx

We present an analysis of radio continuum observations made with the Very Large Array toward the region of massive star formation Cepheus A. The main purpose of this analysis is to search and study proper motions in the radio sources over the two decades of time covered by the observations. The four components of source W, located in Cep A West, clearly show westward proper motions in the range of 120 to 280 km s⁻¹. We believe that these components are being excited by the thermal jet Cep A HW3d, located to their east. Furthermore, we propose that after being deflected at the position of source W, the Cep A HW3d jet moves to the NW and produces the optical source GGD 37. The

source Cep A HW7 shows a complex pattern of proper motions for which we discuss several possible explanations.

Accepted by Revista Mexicana de Astronomía y Astrofísica

<http://www.astrosmo.unam.mx/~luisfr/publ.html>

X-ray emission from early-type stars in the Orion Nebula Cluster

B. Stelzer^{1,2}, **E. Flaccomio**², **T. Montmerle**³, **G. Micela**², **S. Sciortino**², **F. Favata**⁴, **T. Preibisch**⁵ and **E. D. Feigelson**⁶

¹ Dipartimento di Scienze Fisiche ed Astronomiche, 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 Laboratoire d'Astrophysique de Grenoble, Université Joseph-Fourier, F-38041 Grenoble, France

⁴ Astrophysics Division - Research and Science Support Department of ESA, ESTEC, Postbus 299, 2200 AG Noordwijk, The Netherlands

⁵ Max-Planck Institut für Radioastronomie, Auf dem Hügel 69, D-53121 Bonn, Germany

⁶ Department of Astronomy & Astrophysics, Pennsylvania State University, University Park PA 16802, USA

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

The X-ray properties of twenty ~ 1 Myr old O, B, and A stars of the Orion Trapezium are examined with data from the *Chandra* Orion Ultradeep Project (COUP). On the basis of simple theories for X-ray emission, we define two classes separated at spectral type B4: hotter stars have strong winds that may give rise to X-ray emission in small- or large-scale wind shocks, and cooler stars that should be X-ray dark due to their weaker winds and absence of outer convection zones where dynamos can generate magnetic fields. Emission by late-type magnetically active companions may be present in either class. Sixteen of the 20 stars are detected with a wide range of X-ray luminosities, $\log L_x [\text{erg s}^{-1}] \sim 29 - 33$ and X-ray efficiencies $\log (L_x/L_{\text{bol}}) \sim -4$ to -8 . Only two stars, θ^1 Ori D (B0.5) and NU Ori (B1), show exclusively the constant soft-spectrum emission at $\log (L_x/L_{\text{bol}}) \sim -7$ expected from the standard model involving many small shocks in an unmagnetized radiatively accelerated wind. Most of the other massive O7-B3 stars exhibit some combination of soft-spectrum wind emission, hard-spectrum flaring, and/or rotational modulation indicating large-scale inhomogeneity. Magnetic confinement of winds with large-scale shocks can be invoked to explain these phenomena. This is supported in some cases by non-thermal radio emission and/or chemical peculiarities, or direct detection of the magnetic field (θ^1 Ori C). Most of the stars in the weak-wind class exhibit X-ray flares and $\log L_x < 31 \text{ erg s}^{-1}$, consistent with magnetic activity from known or unseen low-mass companions. In most cases, the X-ray spectra can be interpreted in terms of a two-temperature plasma model with a soft component of 3–10 MK and a hard component up to 40 MK. All non-detections belong to the weak-wind class. A group of stars exhibit hybrid properties – flare-like behavior superimposed on a constant component with $\log L_x \sim 32 \text{ erg s}^{-1}$ – which suggest both magnetic activity and wind emission.

Accepted by ApJ Suppl., COUP Special Issue

NGC 146: A young open cluster with a Herbig Be star and intermediate mass pre-main sequence star

A. Subramaniam¹, **D.K. Sahu**², **R. Sagar**³ and **P. Vijitha**⁴

¹ Indian Institute of Astrophysics, II Block Koramangala, Bangalore 560 034

² CREST campus, Indian Institute of Astrophysics, Hosakote, Bangalore

³ Aryabhata Research Institute of Observational Studies (ARIES), Manora peak, Nainital - 263129, India

⁴ VS RTP student, Mother Theresa University, Kodaikanal

E-mail contact: purni@iiap.res.in

We present UBV CCD photometry and low-resolution spectra of stars in the field of the young open cluster NGC 146. UBV photometry of 434 stars were used to estimate the $E(B-V)$ reddening of 0.55 ± 0.04 mag and BV photometry of 976 stars were used to estimate a distance modulus of $(m-M)_0 = 12.7 \pm 0.2$ mag, corresponding to a distance of 3470_{-305}^{+335} pc. We estimated 10–16 Myr as the turn-off age for the upper main sequence of the cluster using isochrones and synthetic colour magnitude diagrams. We identified two B type stars with H_α in emission and located on the

MS using slit-less spectra. A higher resolution spectrum of the brighter Be star indicated the presence of a number of emission lines, with some lines showing the signature of gas infall. This star was found to be located in the region of Herbig Ae/Be stars in the (J–H) vs (H–K) colour-colour diagram. Thus, we identify this star as a Herbig Be star. On the other hand, 54 stars were found to show near infrared excess, of which 17 were found to be located in the region of Herbig Ae/Be stars and 18 stars were found to be located in the region of Be stars in the NIR colour-colour diagram. Thus NGC 146 is a young cluster with a large number of intermediate mass pre-main sequence stars. The turn-on age of the cluster is found to be ~ 3 Myr. Though NGC 146 shows an older turn off, the bulk of stars in this cluster seems to belong to the younger population of 3 Myr.

Accepted by A&A

astro-ph/0505314

From Dusty Filaments to Cores to Stars: An Infrared Extinction Study of Lupus 3

Paula S. Teixeira^{1,2,3}, Charles J. Lada¹ and João F. Alves⁴

¹ Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA, 02138, USA

² Departamento de Física da Faculdade de Ciências da Universidade de Lisboa, Portugal

³ Centro de Física Nuclear da Universidade de Lisboa, Portugal

⁴ European Southern Observatory, Karl-Schwarzschild-Strasse 2, D-85748 Garching bei München, Germany

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

We present deep near-infrared (NIR) observations of a dense region of the Lupus 3 cloud obtained with the European Southern Observatory's (ESO) New Technology Telescope (NTT) and Very Large Telescope (VLT). Using the near-infrared color excess (NICE) method we construct a detailed high angular resolution dust extinction map of the cloud. The dust extinction map reveals embedded globules, a dense filament, and a dense ring structure. We derive dust column densities and masses for the entire cloud and for the individual structures therein. We construct radial extinction profiles for the embedded globules and find a range of profile shapes from relatively shallow profiles for cores with low peak extinctions, to relatively steep profiles for cores with high extinction. Overall the profiles are similar to those of pressure truncated isothermal spheres of varying center-to-edge density contrast. We apply Bonnor-Ebert analysis to compare the density profiles of the embedded cores in a quantitative manner and derive physical parameters such as temperatures, central densities, and external pressures. We examine the stability of the cores and find that two cores are likely stable and two are likely unstable. One of these latter cores is known to harbor an active protostar. Finally, we discuss the relation between an emerging cluster in the Lupus 3 cloud and the ring structure identified in our extinction map. Assuming that the ring is the remnant of the core within which the cluster originally formed we estimate that a star formation efficiency of approximately 30% characterized the formation of the small cluster. Our observations of the Lupus 3 cloud suggest an intimate link between the structure of a dense core and its state of star forming activity. The dense cores in this cloud are found to span the entire range of evolution from a stable, starless core of modest central concentration, to an unstable, star-forming core which is highly centrally concentrated, to a significantly disrupted core from which a cluster of young stars is emerging.

Accepted by the Astrophysical Journal (tentative publication schedule ApJ 1 August 2005, v628, 2 issue)

Preprints can be found at <http://cfa-www.harvard.edu/~clada/preprints.html>

and <http://cfa-www.harvard.edu/~pteixeir/>

A 3-5 μm VLT spectroscopic survey of embedded young low mass stars II: Solid OCN⁻

F.A. van Broekhuizen¹, K.M. Pontoppidan², H.J. Fraser¹, and E.F. van Dishoeck^{1,2}

¹ Raymond and Beverly Sackler Laboratory for Astrophysics, Leiden Observatory, P.O. Box 9513, 2300 RA Leiden, The Netherlands

² Leiden Observatory, P.O. Box 9513, 2300 RA Leiden, The Netherlands

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

The 4.62 μm (2164.5 cm^{-1}) 'XCN' band has been detected in the *M*-band spectra of 34 deeply embedded young stellar objects (YSO's), observed with high signal-to-noise and high spectral resolution with the VLT-ISAAC spectrometer, providing the first opportunity to study the solid OCN⁻ abundance toward a large number of low-mass YSO's. It

is shown unequivocally that at least two components, centred at 2165.7 cm^{-1} (FWHM = 26 cm^{-1}) and 2175.4 cm^{-1} (FWHM = 15 cm^{-1}), underlie the XCN band. Only the 2165.7-component can be ascribed to OCN^- , embedded in a strongly hydrogen-bonding, and possibly thermally annealed, ice environment based on laboratory OCN^- spectra. In order to correct for the contribution of the 2175.4-component to the XCN band, a phenomenological decomposition into the 2165.7- and the 2175.4-components is used to fit the full band profile and derive the OCN^- abundance for each line-of-sight. The same analysis is performed for 5 high-mass YSO's taken from the ISO-SWS data archive. Inferred OCN^- abundances are $\leq 0.85\%$ toward low-mass YSO's and $\leq 1\%$ toward high-mass YSO's, except for W33 A. Abundances are found to vary by at least a factor of 10–20 and large source-to-source abundance variations are observed within the same star-forming cloud complex on scales down to 400 AU, indicating that the OCN^- formation mechanism is sensitive to local conditions. The inferred abundances allow quantitatively for photochemical formation of OCN^- , but the large abundance variations are not easily explained in this scenario unless local radiation sources or special geometries are invoked. Surface chemistry should therefore be considered as an alternative formation mechanism.

Accepted by A&A

GMOS-IFU spectroscopy of 167-317 (LV2) Proplyd in Orion

M. J. Vasconcelos^{1,2}, A. H. Cerqueira^{1,2}, H. Plana¹, A. C. Raga² and C. Morisset³

¹ LATO-UESC, Rodovia Ilheus-Itabuna, km. 16 - Ilheus - 45662-000 - Brasil

² ICN - UNAM, A. Postal 70-543, C. U. - D. F. - 04510 - Mexico

³ IAUNAM, A. Postal 70-264, C. U. - D. F. - 04510 - Mexico

E-mail contact: mjvasc@uesc.br

We present high spatial resolution spectroscopic observations of the proplyd 167-317 (LV2) near the Trapezium cluster in the Orion nebula, obtained during the System Verification run of the Gemini Multi Object Spectrograph (GMOS) Integral Field Unit (IFU) at the Gemini South Observatory. We have detected 38 forbidden and permitted emission lines associated with the proplyd and its redshifted jet. We have been able to detect three velocity components in the profiles of some of these lines: a peak with a $28\text{--}33\text{ km s}^{-1}$ systemic velocity that is associated with the photoevaporated proplyd flow, a highly redshifted component associated with a previously reported jet (which has receding velocities of about $80\text{--}120\text{ km s}^{-1}$ with respect to the systemic velocity and is spatially distributed to the southeast of the proplyd) and a less obvious, approaching structure, which may possibly be associated with a faint counter-jet with systemic velocity of $(-75 \pm 15)\text{ km s}^{-1}$. We find evidences that the redshifted jet has a variable velocity, with slow fluctuations as a function of the distance from the proplyd. We present several background subtracted, spatially distributed emission line maps and we use this information to obtain the dynamical characteristics over the observed field. Using a simple model and with the extinction corrected $\text{H}\alpha$ fluxes, we estimate the mass loss rate for both the proplyd photoevaporated flow and the redshifted microjet, obtaining $\dot{M}_{\text{proplyd}} = (6.2 \pm 0.6) \times 10^{-7}\text{ M}_{\odot}\text{ year}^{-1}$ and $\dot{M}_{\text{jet}} = (2.0 \pm 0.7) \times 10^{-8}\text{ M}_{\odot}\text{ year}^{-1}$, respectively.

Accepted by The Astronomical Journal

<http://arxiv.org/abs/astro-ph/0506315>

Optical Spectroscopy of the Surface Population of the Rho Ophiuchi Molecular Cloud: The First Wave of Star Formation

Bruce A. Wilking¹, Michael R. Meyer², John G. Robinson¹ and Thomas P. Greene³

¹ Department of Physics & Astronomy, Univ. of Missouri-St. Louis, St. Louis, MO 63121 USA

² Steward Observatory, The University of Arizona, Tucson, AZ, 85721, USA

³ NASA/Ames Research Center, M.S. 245-6, Moffett Field, CA 94035-1000, USA

E-mail contact: bwilking@umsl.edu

We present the results of optical spectroscopy of 139 stars obtained with the Hydra multi-object spectrograph. The objects extend over a 1.3 square degree area surrounding the main cloud of the ρ Oph complex. The objects were selected from narrowband images to have $\text{H}\alpha$ in emission. Using the presence of strong $\text{H}\alpha$ emission, lithium absorption, location in the Hertzsprung-Russell diagram, or previously reported x-ray emission, we were able to identify 88 objects as young stars associated with the cloud. Strong $\text{H}\alpha$ emission was confirmed in 39 objects with line widths consistent

with their origin in magnetospheric accretion columns. Two of the strongest emission-line objects are young, x-ray emitting brown dwarf candidates with M8 spectral types. Comparisons of the bolometric luminosities and effective temperatures with theoretical models suggest a median age for this population of 2.1 Myr which is significantly older than the ages derived for objects in the cloud core. It appears that these stars formed contemporaneously with low mass stars in the Upper Scorpius subgroup, likely triggered by massive stars in the Upper-Centaurus subgroup.

Accepted by Astronomical Journal

Discovery of a massive SCUBA core with both inflow and outflow motions

Y. Wu¹, M. Zhu², Y. Wei¹, D. Xu¹, Q. Zhang³ and J.D. Fiege⁴

¹ Astronomy Department, Peking University, Beijing 100871, China

² Joint Astronomy Centre/National Research Council of Canada, Herzberg Institute of Astrophysics, 5071 West Saanich Road, Victoria, BC V9E 2E7, Canada

³ Harvard-Smithsonian Center for Astrophysics, 60 garden Street, Cambridge, MA 02138, U.S.A.

⁴ Department of Physics & Astronomy, University of Manitoba, Winnipeg, Manitoba, R3T 2N2, Canada

E-mail contact: yfwu@bac.pku.edu.cn

We report the discovery of a massive SCUBA core with evidence of inflow and outflow motions. This core is detected by SCUBA at both 450 and 850 μm . Barely resolved by the telescope beam at 450 μm , it has a size of $10''$, corresponding to 0.28 pc at a distance of 5.7 kpc. The dust temperature is estimated to be ≤ 29 K, the total mass is $820 M_{\odot}$ and the average density is $1.1 \times 10^6 \text{ cm}^{-3}$ in a region with a radius of $5''$. Follow-up spectral line observations, including HCN (3–2), HCO⁺ (3–2), H¹³CO⁺ (3–2) and C¹⁷O (2–1) reveal a typical blue profile which indicates that this core is collapsing. The CO (3–2) line profile is as broad as 38 km/s, indicating outflow motions in this region. This core is approximately 1.5 pc away from the known HII region G25.4NW, but there are no obvious radio, IRAS, MSX or Spitzer sources associated with it. We suggest that this core is at a very early stage of massive star or cluster formation.

Accepted by Astrophysical Journal Letters

<http://arxiv.org/abs/astro-ph/0506226>

Spiral Structure when Setting up Pericentre Glow: Possible Giant Planets at Hundreds of AU in the HD141569 Disk

M. C. Wyatt¹

¹ UK Astronomy Technology Centre, Royal Observatory, Edinburgh EH9 3HJ, UK

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

This paper discusses the impact of introducing a planet on an eccentric orbit into a dynamically cold planetesimal disk. That planet's secular perturbations cause the orbits of the planetesimals to evolve in such a way that at any one time planetesimals at the same distance from the star have common pericentres and eccentricities. This causes the surface density distribution of an extended planetesimal disk to exhibit two spirals, one exterior the other interior to the planet's orbit. These two spirals unwind in different directions and their structure is described by just two parameters: the time since the planet was introduced relative to the characteristic secular timescale, $t_{sec(3:2)} = 0.651 \sqrt{a_{pl}^3 / M_{\star}} (M_{\star} / M_{pl})$; and the planet's eccentricity, e_{pl} . At late times the spirals become tightly wound and the offset centre of symmetry of the pericentre glow approximation is recovered. Comparison with spiral structure seen in the HD141569 disk shows that its spiral at 325 AU is similar to the structure that would be caused by introducing a planet into the disk 5 Myr ago with a mass in the range $0.2 - 2M_{Jup}$ orbiting at 235-250 AU with an eccentricity of 0.05-0.2; likewise a Saturn mass planet at 150 AU would cause structure like that seen at 200 AU. More definitive statements about any planets orbiting HD141569 from this model could be made once the effect of the binary companion on the disk is known (e.g., from knowledge of its orbit), and once the disk's structure has been better characterised down to 100 AU, including the location of the star within the disk. The relatively young age of this system (~ 5 Myr) means that if giant planets really do exist at hundreds of AU from HD141569, this provides a unique opportunity to set constraints on the mechanism by which those planets came to be at such large distances, especially since the structure of the disk

out of which those planets would have formed can be imaged.

Accepted by A&A

Preprint available at astro-ph/0506208

Also available (with movies) from <http://www.roe.ac.uk/~wyatt/>

Abstracts of papers in Nature and Science

Because of embargoes on preprints for Nature and Science, abstracts for these two journals will be accepted for papers that have already been published

A resolved outflow of matter from a brown dwarf

Emma T. Whelan¹, Thomas P. Ray¹, Francesca Bacciotti², Antonella Natta², Leonardo Testi² and Sofia Randich²

¹ Dublin Institute for Advanced Studies, School of Cosmic Physics, 5 Merrion Sq, D 2, Ireland

² Osservatorio Astrofisico di Arcetri, INAF, Largo E. Fermi 5, I-50125 Firenze, Italy

E-mail contact: ewhelan@cp.dias.ie

The birth of stars involves not only accretion but also, counter-intuitively, the expulsion of matter in the form of highly supersonic outflows. Although this phenomenon has been much studied in young stars, a fundamental question is whether it also occurs among newborn brown dwarfs. Recently evidence for accretion in young brown dwarfs has mounted and their spectra show forbidden emission lines that are suggestive of outflows. Here we report spectro-astrometric data that spatially resolve an outflow from the brown dwarf ρ -Oph 102. The forbidden emission line regions present in the spectra of this object are found to be displaced to a distance of $\sim 0.1''$ at a velocity of ~ -40 kms^{-1} . The outflow's characteristics appear similar to, but on a smaller scale than, outflows from normal young stars. This result suggests that the outflow mechanism is universal, and perhaps relevant even to the formation of planets.

Published in Nature, vol 435, p.652, 2 June 2005

Origin of the orbital architecture of the giant planets of the Solar System

K. Tsiganis¹, R. Gomes^{1,2}, A. Morbidelli¹ and H. F. Levison^{1,3}

¹ Observatoire de la Cote d'Azur, CNRS, BP 4229, 06304 Nice Cedex 4, France

² GEA/OV/UFRJ and ON/MCT, Ladeira do Pedro Antonio, 43-Centro 20.080-090, Rio de Janeiro, RJ, Brazil

³ Department of Space Studies, Southwest Research Institute, 1050 Walnut Street, Suite 400, Boulder, Colorado 80302, USA

Email contact: morby@obs-nice.fr

Planetary formation theories suggest that the giant planets formed on circular and coplanar orbits. The eccentricities of Jupiter, Saturn and Uranus, however, reach values of 6 per cent, 9 per cent and 8 per cent, respectively. In addition, the inclinations of the orbital planes of Saturn, Uranus and Neptune take maximum values of 2 degrees with respect to the mean orbital plane of Jupiter. Existing models for the excitation of the eccentricity of extrasolar giant planets have not been successfully applied to the Solar System. Here we show that a planetary system with initial quasi-circular, coplanar orbits would have evolved to the current orbital configuration, provided that Jupiter and Saturn crossed their 1:2 orbital resonance. We show that this resonance crossing could have occurred as the giant planets migrated owing to their interaction with a disk of planetesimals. Our model reproduces all the important characteristics of the giant planets' orbits, namely their final semimajor axes, eccentricities and mutual inclinations.

Published in Nature vol. 435, p.459, 26 May 2005

Dissertation Abstracts

Dust and Gas in Protoplanetary Discs

Dmitry Semenov

Astrophysical Institute and University Observatory, Friedrich Schiller University, Jena, Germany

Max Planck Institute for Astronomy, Koenigstuhl 17, 69117 Heidelberg, Germany

Electronic mail: semenov@mpia.de

Ph.D dissertation directed by: Thomas K. Henning

Ph.D degree awarded: May 2005

In this thesis, the following problems regarding the evolution of the gas and dust in protoplanetary discs are addressed.

In Chapter 1, I deal with the modelling of absorption and scattering of light by ensembles of dust grains having various sizes, composition, porosities, and shapes, and calculate frequency-dependent opacities. Using the latter quantities, the Rosseland and Planck mean opacities of the dust and gas mixture are computed and the results are compared with other studies. In addition, I investigate how the adopted opacity table may influence the modelling of the hydrodynamical disc structure.

I summarise the basics of astrochemical modelling in Chapter 2: what kind of processes control the chemical evolution of protoplanetary discs, what the role of dust grains is, what the initial conditions are, and where the main numerical difficulties arise. In addition, I describe the chemical model that is applied in the next two chapters.

In Chapter 3, I present a technique to reduce chemical networks by removing those reactions which are not particularly important for the chemical evolution of selected molecules under pre-defined ranges of physical conditions. This method is applied to investigate what chemical processes control the evolution of the ionisation degree in different regions of a protoplanetary disc. Also, column densities of observationally important molecules are calculated and compared to other recent theoretical studies and observational data. The relevance of the obtained results to the magneto-hydrodynamical modelling of protoplanetary discs is discussed.

Finally, I confront a theoretical disc model with observations in Chapter 4, where I develop and describe the first self-consistent model of the physical, chemical, and dynamical structure of the circumstellar matter orbiting around the intermediate-mass star AB Aur using available observational data. A robust heuristic modelling approach is elaborated and applied to constrain the orientation, size, physical structure, mass, and dynamical state of this system. General conclusions about the evolutionary status of the AB Aur system are provided.

http://www.db-thueringen.de/dissOnline/FSU_Jena_Semenov_Dmitry

Moving ... ??

If you move or your e-mail address changes, please send the editor your new address. If the Newsletter bounces back from an address for three consecutive months, the address is deleted from the mailing list.

Dust and gas diagnostics of the structure, dynamics and evolution of protoplanetary disks around Herbig Ae/Be stars

Bram Acke

Thesis work conducted at: Instituut voor Sterrenkunde, KULeuven, Belgium

Current address: Instituut voor Sterrenkunde, Celestijnenlaan 200B, B-3001 Leuven, Belgium

Electronic mail: bram@ster.kuleuven.be

Ph.D dissertation directed by: Christoffel Waelkens & Mario van den Ancker

Ph.D degree awarded: May 2005

In this thesis we investigate the structure, dynamics and evolution of protoplanetary disks around Herbig Ae/Be stars, based on observational fingerprints of the circumstellar dust and gas. The thesis consists of a 8 chapters, of which at present five are published as articles in *A&A* and *ApJ*. Chapter 1 consists of a short introduction to Herbig Ae/Be stars. Chapter 8 discusses remaining issues and ideas for the future. We briefly summarize our main results.

In Chapter 2, we investigate the photospheric abundances of a sample of Herbig Ae/Be and young Vega-type stars in search for λ Bootis stars. The latter are metal-deficient A/F stars. The peculiar abundance pattern may be due to selective accretion of metal-depleted gas. We find a few stars which show metal deficiency, with HD 100546 being the clearest λ Bootis star.

The structure of protoplanetary disks around Herbig Ae/Be stars was studied based on a few observational characteristics. Our starting point is the group I/II SED classification of Meeus et al. (2001). The models of Dullemond et al. (2001, 2002, 2004) suggest that the disk geometry is different in group I and II: group I sources have flared disks, while group II members have self-shadowed disks. We have tested this hypothesis.

UX Orionis variability is generally assigned to extinction events due to dusty clouds moving in the line of sight. Natta et al. (2001) suggested that the puffed-up inner rim of the disk is the ideal location for these events to occur. In Chapter 3 we argue why the disks in UX Orionis stars must be self-shadowed. The observations indeed show that most of these sources are group II members.

In Chapter 4, we have investigated the sample of ISO observations of Herbig Ae/Be stars as a whole. We have mainly focused on the presence of the polycyclic aromatic hydrocarbon (PAH) features in the 3–11 micron region. We show that most group I sources are fairly strong PAH emitters, while group II objects display weak or undetected PAH emission. We suggest that this is due to the disk geometry: group I sources have flared disks, in which the surface of the outer parts is directly illuminated by the stellar radiation field. The PAHs in these systems are therefore excited and radiate in the infrared. In this Chapter we discuss some of the properties of the 10 micron silicate feature and the crystalline silicate feature at 11.2 micron as well.

We have observed a sample of ~ 70 southern hemisphere Herbig Ae/Be stars in the 3 micron region in search for the 3.43 and 3.53 micron features. The latter are attributed to circumstellar diamonds. In Chapter 5 we present the current status of this survey. We did not find a new spectacular diamond-feature emitting source. Possible reasons for the rareness of the features are discussed.

In Chapter 6, we report on the correlation found between the group I/II classification and the spectral slope of the (sub-)mm energy distribution. We argue that the slope indicates the typical grain sizes of the dust particles in the disk. The correlation may be a first indication that, when grain growth occurs, flared disks evolve into self-shadowed disks due to dust settling and alteration of the dust opacities.

The [O I] emission line at 6300Å is present in roughly half of the 50 Herbig Ae/Be spectra we have investigated. Unlike typical T Tauri profiles, the line does not show a very strong blue wing in the majority of the objects. In the highest-resolution spectra of group I (=flared-disk) sources, a clear double-peaked shape is observed. We have modeled the [O I] emission of a rotating, Chiang & Goldreich (1997) flared disk. Thermal emission is unable to reproduce the observed line strengths. Photodissociation of OH molecules and subsequent emission by the excited oxygen atoms which are released in this process can explain the shape and strength of the lines in group I sources, assuming a fractional OH abundance of 10^{-7} – 10^{-6} in the disk surface.

The electronic version of the thesis can be downloaded free of charge at http://www.ster.kuleuven.be/pub/acke_phd/. A hardcopy can be requested by sending an email to bram@ster.kuleuven.be.

New Jobs

PhD studentship Molecular simulation of porous ices under extraterrestrial conditions

The Faculty of Engineering, University of Strathclyde, is pleased to offer a PhD studentship, commencing in October 2005. Funding for the studentship will cover fees and provide maintenance (tax free) of £12,000 for three years. Closing date is July 31st 2005.

This studentship will support a joint theoretical/experimental collaboration between the Departments of Chemical Engineering (Dr. Martin Sweatman) and Physics (Dr. Helen Fraser) at the University of Strathclyde, UK. The student will be based in the Department of Chemical Engineering and will perform computer simulations of amorphous solid water adsorbed on dust surfaces under extraterrestrial conditions, with a view to understanding its structure, porosity and subsequent chemistry. In addition the results will be utilised in the analysis / driving of experiments carried out in the Physics Department.

The successful candidate should be a national of the European Union and should have, or expect to gain prior to October 2005, a 1st or good upper 2nd class Masters degree in physics, mathematics, engineering, chemistry, or the equivalent. Your skills and interests should be in the areas of molecular modelling, computer programming and astrophysics. Candidates may apply directly, sending a CV, the names and addresses (including email and telephone numbers) of two referees (at least one of these must know your academic work well) and a covering letter, explaining your interest in this studentship.

For further or additional information, please contact Dr Martin Sweatman, martin.sweatman@strath.ac.uk, 0141 548 2393.

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

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

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

Post-Doctoral Position

The Center for Astronomy and Astrophysics of the University of Lisbon (CAAUL – <http://www.oal.ul.pt/caaul/>), Portugal, announces the opening of a postdoctoral position in extra-solar planets, which will be financed by FCT (Fundao para a Ciencia e a Tecnologia – Portuguese NSF) under Project POCTI/CTE-AST/56453/2004, "Extra-solar planet searches: studying their formation and evolution".

The successful applicant is expected to do research in one of the following topics: extra-solar planet searches, statistical properties of exoplanets, chemical abundances of planet-host stars, planet formation and evolution, dynamics of multi-planetary systems. Applications by researchers working on other research topics related to the field of exoplanets will also be accepted and evaluated.

The duration of the appointment will be 12 months and will *start in January 2006*. The FCT is regularly accepting applications for 3 year post-doc positions. The CAAUL will be happy to support any applications in order to increase the duration of the announced position.

The deadline for submission of applications is **31th October 2005**

The application, including a detailed CV, list of publications and two recommendation letters should be addressed to:

Nuno C. Santos
Centro de Astronomia e Astrofisica da Universidade de Lisboa
Observatorio Astronomico de Lisboa
1349-018 Lisboa
Portugal
e-mail: nuno.santos@oal.ul.pt
Tel: +351 21 361 67 43
Fax: +351 21 361 67 52

Any other inquire should be sent to the same address.

Postdoc position in Portugal

Submitted by: Paulo JV Garcia

Electronic mail: pgarcia@astro.up.pt

The Centre for Astrophysics at the University of Porto (CAUP) invites applications for a post-doctoral position starting in September 2005. The position is for one year with a possible extension of up to three years. Amount of the grant: 18,940 euros/year net plus some amount of travel money.

DEADLINE for applications is 17 July 2005.

The research at the institute covers a broad range of topics projects within two broad areas:

STELLAR ASTROPHYSICS: star formation and early stages of evolution, both low and high mass stars; activity and variability in young stellar objects; stellar winds, accretion, jets and HH objects; solar activity; internal structure of stars; stellar seismology; optical interferometry.

and **COSMOLOGY AND EXTRAGALACTIC ASTRONOMY**

Priority will be given to candidates with expertise in observational programmes (from ground or space) or experience in instrumentation.

More details available at: <http://www.astro.up.pt/investigacao/opportunidades/reserch20050613.html>

New Books

Debris Disks and the Formation of Planets

A Symposium in Memory of Fred Gillett

Edited by Larry Caroff, L. Juleen Moon, Dana Backman, and Elizabeth Praton

These are the proceedings of a conference held in Tucson, Arizona on 11-13 April 2002. The book contains the following chapters based on oral presentations, as well as 25 poster papers:

- Fred Gillett's Role in the Discovery of Planetary Disks: A Commemorative History *F.J. Low & HH. Aumann*
Debris Disks: An Overview *D. Backman*
Circumstellar Disks in Pre-Main Sequence Stars *A. Natta*
Dynamics of Gaseous Disks with Planets *P. Artymowicz*
The Nearest Herbig Ae Stars: Identifying the Source of the Infall Activity *C.A. Grady*
Is Beta Pictoris a Typical Young Planetary Disk System? *B.Y. Welsh & A.M. Lagrange*
High Resolution Millimeter-Wave to Infrared Spectroscopy of Circumstellar Disks *G.A. Blake*
Gas in Debris Disks *M. Jura*
Stellar Ages: Harder Than Most People Seem to Think *J.R. Stauffer*
The Evolution of the Vega Phenomenon *M.D. Silverstone*
Signs for Heavy Bombardment in Debris Disks *C. Dominik & J. Bouwman*
Characteristics of Extrasolar Planets *D.A. Fischer, G.W. Marcy, R.P. Butler, & S.S. Vogt*
The Main Sequence Disk We Call the Kuiper Belt *S.A. Stern*
A Fairy Tale about the Formation of Uranus and Neptune and the Lunar Late Bombardment *H.F. Levison, E. Thommes, M.J. Duncan, & L. Dones*
Dispersal of Disks around Young Stars: Constraints on Kuiper Belt Formation *D. Hollenbach & F.C. Adams*
SIRTF (Spitzer), Debris Disks, and Fred Gillett *M.W. Werner & K.R. Stapelfeldt*
Stratospheric Observatory for Infrared Astronomy (SOFIA) *E.E. Becklin & L.J. Moon*

ISBN 1-58381-186-9, hardbound, 286 pages, 2004
US\$77.00

The Astronomical Society of the Pacific
Ordering Department
390 Ashton Avenue
San Francisco, CA 94112, USA

Tel: 800-335-2624
Fax: 415-337-5205
E-mail: service@astrosociety.org

<http://www.astrosociety.org/pubs/cs/confseries.html>

Extrasolar Planets: Today and Tomorrow

Edited by J.-P. Beaulieu, A. Lecavelier des Etangs and C. Terquem

These are the proceedings of a conference held in Paris on 30 June - 4 July 2003. The book contains 34 articles based on the oral presentations and 50 poster papers. The following are the largest of the papers.

- A Doppler Planet Survey of 1330 FGKM Stars *G.W. Marcy, R.P. Butler, D.A. Fischer, and S.S. Vogt*
The Physics of Extrasolar Gaseous Planets: from Theory to Observable Signatures *G. Chabrier, F. Allard, I. Baraffe, T. Barman, & P.H. Hauschildt*
Non-thermal Radio Emission from Extrasolar Planets *P. Zarka*
The Atmosphere of Terrestrial Exoplanets: Detection and Characterization *F. Selsis*
Search for Life on Exoplanets: The Darwin/TPF Mission(s) *M. Ollivier*
Observations of Protostellar Disks *F. Ménard*
Protostellar Disk Structure *S.A. Balbus*
Formation of Giant Planets and Brown Dwarfs *J.J. Lissauer*
Structures in Dusty Disks *J.-C. Augereau*
Orbital Migration and Disc-Planet Interactions *R.P. Nelson & J.C.B. Papaloizou*
On the Eccentricities of the Extrasolar Planets *J.C.B. Papaloizou & R.P. Nelson, & C. Terquem*
Stellar Planetary Motion in Double Stars *E. Pilat-Lohinger, R. Dvorak, E. Bois, & B. Funk*

ISBN 1-58381-183-4, hardbound, 424 pages, 2004

US\$77.00

The Astronomical Society of the Pacific
Ordering Department
390 Ashton Avenue
San Francisco, CA 94112, USA

Tel: 800-335-2624

Fax: 415-337-5205

E-mail: service@astrosociety.org

<http://www.astrosociety.org/pubs/cs/confseries.html>