THE STAR FORMATION NEWSLETTER

An electronic publication dedicated to early stellar evolution and molecular clouds

No. 159 — 22 January 2006 Editor: Bo Reipurth (reipurth@ifa.hawaii.edu)

Abstracts of recently accepted papers

Physical Conditions in Orion's Veil II: A Multi-Component Study of the Line of Sight Towards the Trapezium

N. P. Abel[1], G. J. Ferland[1], C. R. O'Dell[2], G. Shaw[1] and T. H. Troland[1]

[1] University of Kentucky, Department of Physics and Astronomy, Lexington, KY 40506, USA
[2] Department of Physics and Astronomy, Vanderbilt University, Box 1807-B, Nashville, TN 37235, USA

E-mail contact: npabel2@uky.edu

Orion's Veil is an absorbing screen that lies along the line of sight to the Orion H II region. It consists of two or more layers of gas that must lie within a few parsecs of the Trapezium cluster. Our previous work considered the Veil as a whole and found that the magnetic field dominates the energetics of the gas in at least one component. Here we use high-resolution STIS UV spectra that resolve the two velocity components in absorption and determine the conditions in each. We derive a volume hydrogen density, 21 cm spin temperature, turbulent velocity, and kinetic temperature, for each. We combine these estimates with magnetic field measurements to find that magnetic energy significantly dominates turbulent and thermal energies in one component, while the other component is close to equipartition between turbulent and magnetic energies. We observe molecular hydrogen absorption for highly excited v, J levels that are photoexcited by the stellar continuum, and detect blueshifted S III and P III absorption lines. These ions must arise from ionized gas between the mostly neutral portions of the Veil and the Trapezium and shields the Veil from ionizing radiation. We find that this layer of ionized gas is also responsible for He I 3889 angstrom absorption towards the Veil, which resolves a 40-year-old debate on the origin of He I absorption towards the Trapezium. Finally, we determine that the ionized and mostly atomic layers of the Veil will collide in less than 85,000 years.

Accepted by The Astrophysical Journal

http://www.arxiv.org/ftp/astro-ph/papers/0512/0512546.pdf

Resolving the disk rotation of HD 97048 and HD 100546 in the [O I] 6300A line: evidence for a giant planet orbiting HD 100546

B. Acke[1] and M.E. van den Ancker[2]

[1] KULeuven, Belgium
[2] ESO, Germany

E-mail contact: bram@ster.kuleuven.be

Aim. We intend to spatially and spectrally resolve the [O I] emission region in two nearby Herbig stars. Method. We present high-resolution (R = 80,000) VLT/UVES echelle spectra of the [O I] 6300Å line in the Herbig Ae/Be stars HD 97048 and HD 100546. Apart from the spectral signature, also the spatial extent of the [O I] emission region is investigated. For both stars, we have obtained spectra with the slit positioned at different position angles on the sky. Conclusions.The [O I] emission region of HD 100546 appears to be coinciding with the dust disk, its major axis located at 150±11°east of north. The SE part of the disk moves towards the observer, while the NW side is redshifted. The [O I] emission region rotates counterclockwise around the central star. For HD 97048, the position angle of the emission region is 160±19°east of north, which is the first determination of this angle in the literature. The southern parts of the disk are blueshifted, the northern side moves away from us. Our data support the idea that a gap is

present at 10 AU in the disk of HD 100546. Such a gap is likely planet-induced. We estimate the mass and orbital radius of this hypothetical companion responsible for this gap to be 20 $M_{\rm Jupiter}$ and 6.5 AU respectively. Results. Based on temporal changes in the [O I] line profile, we conclude that inhomogeneities are present in the [O I] emission region of HD 100546. These "clumps" could be in resonance with the suggested companion, orbiting the central star in about 11 yr. If confirmed, these observations could point to the existence of an object straddling the line between giant planet and brown dwarf in a system as young as 10 million years.

Accepted by A&A

http://arxiv.org/abs/astro-ph/0512562

Early Evolution of Stellar Groups and Clusters: Environmental Effects on Forming Planetary Systems

Fred C. Adams[1,2], Eva M. Proszkow[1], Marco Fatuzzo[3] and Philip C. Myers[4]

[1] Michigan Center for Theoretical Physics, University of Michigan, Ann Arbor, MI 48109, USA
[2] Astronomy Department, University of Michigan, Ann Arbor, MI 48109, USA
[3] Physics Department, Xavier University, Cincinnati, OH 45207, USA
[4] Harvard Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA

E-mail contact: fca@umich.edu

This paper studies the dynamical evolution of young groups/clusters, with $N = 100 - 1000$ members, from their embedded stage out to ages of ~ 10 Myr. We use N-body simulations to explore how their evolution depends on the system size N and the initial conditions. Motivated by recent observations suggesting that stellar groups begin their evolution with subvirial speeds, this study compares subvirial starting states with virial starting states. Multiple realizations of equivalent cases (100 simulations per initial condition) are used to build up a robust statistical description of these systems, e.g., the probability distribution of closest approaches, the mass profiles, and the probability distribution for the radial location of cluster members. These results provide a framework from which to assess the effects of groups/clusters on the processes of star and planet formation, and to study cluster evolution. The distributions of radial positions are used in conjunction with the probability distributions of the expected FUV luminosities (calculated here as a function of cluster size N) to determine the radiation exposure of circumstellar disks. The distributions of closest approaches are used in conjunction with scattering cross sections (calculated here as a function of stellar mass using $\sim 10^5$ Monte Carlo scattering experiments) to determine the probability of disruption for newly formed solar systems. We use the nearby cluster NGC 1333 as a test case in this investigation. The main conclusion of this study is that clusters in this size range have only a modest effect on forming planetary systems. The interaction rates are low so that the typical solar system experiences a single encounter with closest approach distance $b \sim 1000$ AU. The radiation exposure is also low, with median FUV flux $G_0 \sim 900$ (1.4 erg s^{-1} cm^{-2}), so that photoevaporation of circumstellar disks is only important beyond 30 AU. Given the low interaction rates and modest radiation levels, we suggest that solar system disruption is a rare event in these clusters.

Accepted by The Astrophysical Journal

astro-ph/0512330

Spectra and Sizes of Hypercompact HII Regions

Martín Avalos[1], Susana Lizano[1], Luis F. Rodríguez[1], Ramiro Franco-Hernández[1,2] and James M. Moran[2]

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

E-mail contact: m.avalos@astrosmo.unam.mx

We present the analysis of the spectra and sizes of the hypercompact HII regions G34.26+0.15 A and B. We compare their radio continuum spectra and angular sizes with simple models of spherical ionized regions bounded by an inner and an outer radius, with a power-law electron density profile, $n_e(r) \propto r^{-\alpha}$. The radio continuum spectra and sizes can be reasonably reproduced by both uniform sphere models and shell models with large inner radii, of the order of 500 AU. High spatial resolution observations at $\nu > 15$ GHz, where the regions are optically thin, could distinguish

between both models. The optically thin radio emission implies, after accounting for dust absorption of ionizing photons, that the ionizing stars of sources A and B have spectral types earlier than main sequence B1 type.

Accepted by Astrophysical Journal

On the binarity of Herbig Ae/Be stars

Debbie Baines[1], Rene Oudmaijer[1], John Porter[2] and Monica Pozzo[3]

[1] School of Physics and Astronomy, University of Leeds, Leeds LS2 9JT, UK
[2] Astrophysics Research Insitute, Liverpool John Moores University, Liverpool, UK
[3] Astrophysics Group, Blackett Laboratory, Imperial College, London, UK

E-mail contact: roud@ast.leeds.ac.uk

We present high resolution spectro-astrometry of a sample of 28 Herbig Ae/Be and 3 F-type pre-main sequence stars. The spectro-astrometry is shown from both empirical and simulated data to be capable of detecting binary companions that are fainter by up to 6 magnitudes at separations larger than 0.1 arcsec. The nine targets that were previously known to be a binary are all detected. In addition, we report the discovery of 6 new binaries and present 5 further possible binaries. The resulting binary fraction of 68+/-11 per cent is the largest reported for any observed sample of Herbig Ae/Be stars, presumably because of the exquisite sensitivity of spectro-astrometry for detecting binary systems. The data hint that the binary frequency of the Herbig Be stars is larger than for the Herbig Ae stars. The appendix presents model simulations to assess the capabilities of spectro-astrometry and reinforces the empirical findings. Two objects, HD 87643 and Z CMa, display evidence for asymmetric outflows. Finally, the position angles of the binary systems have been compared with available orientations of the circumprimary disc and these appear to be co-planar. The alignment between the circumprimary discs and the binary systems strongly suggests that the formation of binaries with intermediate mass primaries is due to fragmentation as the alternative, stellar capture, does not naturally predict aligned discs. The aligment extends to the most massive B-type stars in our sample. This leads us to conclude that formation mechanisms that do result in massive stars, but predict random angles beween the binaries and the circumprimary disks, such as stellar collisions, are also ruled out for the same reason.

Accepted by MNRAS

astro-ph/0512534

Outflows and Jets from Collapsing Magnetized Cloud Cores

Robi Banerjee[1] and Ralph E. Pudritz[1,2]

[1] Department of Physics and Astronomy, McMaster University,Hamilton, Ontario L8S 4M1, Canada
[2] Origins Institute, McMaster University, Arthur Bourns Bldg 241,Hamilton, Ontario L8S 4M1, Canada

E-mail contact: banerjee@physics.mcmaster.ca

Star formation is usually accompanied by outflow phenomena. There is strong evidence that these outflows and jets are launched from the protostellar disk by magneto-rotational processes. Here, we report on our three dimensional, adaptive mesh, magneto-hydrodynamic simulations of collapsing, rotating, magnetized Bonnor-Ebert-Spheres whose properties are taken directly from observations. In contrast to the pure hydro case where no outflows are seen, our present simulations show an outflow from the protodisk surface at $\sim 130\,\mathrm{AU}$ and a jet at $\sim 0.07\,\mathrm{AU}$ after a strong toroidal magnetic field build up. The large scale outflow, which extends up to $\sim 600\,\mathrm{AU}$ at the end of our simulation, is driven by toroidal magnetic pressure (spring), whereas the jet is powered by magneto-centrifugal force (fling). At the final stage of our simulation these winds are still confined within two respective shock fronts. Furthermore, we find that the jet-wind and the disk-anchored magnetic field extracts a considerable amount of angular momentum from the protostellar disk. The initial spin of our cloud core was chosen high enough to produce a binary system. We indeed find a close binary system (separation $\sim 3\,R_\odot$) which results from the fragmentation of an earlier formed ring structure. The magnetic field strength in these protostars reaches $\sim$ 3kGauss and becomes about 3 Gauss at 1 AU from the center in agreement with recent observational results.

Accepted by Astrophysical Journal

http://arxiv.org/abs/astro-ph/0508374 http://www.physics.mcmaster.ca/~banerjee/outflows.pdf

Dynamics of the young multiple system GG Tauri - II. Relation between the stellar system and the circumbinary disk

H. Beust[1] **and A. Dutrey**[1,2]

[1] Laboratoire d'Astrophysique de Grenoble, Université J. Fourier, BP 53, 38041 Grenoble Cedex 9, France
[2] Laboratoire d'Astrodynamique, d'Astrophysique et d'Aéronomie de Bordeaux, 2 rue de l'Observatoire, BP 89, 33270 Floirac, France

E-mail contact: herve.beust@obs.ujf-grenoble.fr

The quadruple young system GG Tauri is an example of a multiple T Tauri system. Its consists of two binaries, the brighter one (GG Tau A) being surrounded by a ring-shape circumbinary disk. In a recent paper, we performed a dynamical study of circumbinary and showed that there is an apparent discrepancy between the orbital fit of GG Tau A and the observed inner edge of the disk. In this paper, we now investigate the dynamics of the whole quadruple system together with the disk. We show that it is possible to design an orbital configuration between the two binaries in such a way that the outer profile of the circumbinary ring may be explained by tidal interaction with repeated periastron passages of the outer binary GG Tau B. We show that the observed characteristics of the disk are not compatible with some orbital configurations, such as those giving rise to the Kozai resonance. Surprisingly, the outer binary GG Tau B appears only marginally stable against tidal disruption by GG Tau A. GG Tau B appears stable only if its internal orbit is retrograde with respect to the motion of its center of mass around GG Tau A. We also find that the CB disk should be almost coplanar with the inner binary.

Published by Astronomy & Astrophysics (Vol. 446, p. 137)

Desorption rates and sticking coefficients for CO and N_2 interstellar ices

S. E. Bisschop[1], **H. J. Fraser**[2], **K. I. Öberg**[1,3], **E. F. van Dishoeck**[1] **and S. Schlemmer**[4]

[1] Raymond and Beverly Sackler Laboratory for Astrophysics at Leiden Observatory, Postbus 9513, 2300 RA Leiden, Netherlands
[2] Department of Physics, University of Strathclyde, 107 Rottenrow East, Glasgow G4 ONG, Scotland
[3] Division of Geological and Planetary Sciences, California Institute of Technology, Mail Stop 150-21, Pasadena, CA 91125, USA
[4] I. Physikalisches Institut, Universität zu Köln, Zulpicher Strasse 77, 50937 Köln, Germany

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

We present Temperature Programmed Desorption (TPD) experiments of CO and N_2 ices in pure, layered and mixed morphologies at various ice "thicknesses" and abundance ratios as well as simultaneously taken Reflection Absorption Infrared Spectra (RAIRS) of CO. A kinetic model has been developed to constrain the binding energies of CO and N_2 in both pure and mixed environments and to derive the kinetics for desorption, mixing and segregation. For mixed ices N_2 desorption occurs in a single step whereas for layered ices it proceeds in two steps, one corresponding to N_2 desorption from a pure N_2 ice environment and one corresponding to desorption from a mixed ice environment. The latter is dominant for astrophysically relevant ice "thicknesses". The ratio of the binding energies, $R_{\rm BE}$, for pure N_2 and CO is found to be 0.936 ± 0.03, and to be close to 1 for mixed ice fractions. The model is applied to astrophysically relevant conditions for cold pre-stellar cores and for protostars which start to heat their surroundings. The importance of treating CO desorption with zeroth rather than first order kinetics is shown. The experiments also provide lower limits of 0.87 ± 0.05 for the sticking probabilities of CO-CO, N_2-CO and N_2-N_2 ices at 14 K. The combined results from the desorption experiments, the kinetic model, and the sticking probability data lead to the conclusion that these solid-state processes of CO and N_2 are very similar under astrophysically relevant conditions. This conclusion affects the explanations for the observed anti-correlations of gaseous CO and N_2H^+ in pre-stellar and protostellar cores.

Accepted by A&A

astro-ph/0601082

Hydraulic/Shock-Jumps in Protoplanetary Disks

A. C. Boley[1] **and R. H. Durisen**[1]

[1] Dept. of Astronomy, Indiana University, Swain Hall West 319, 727 East 3rd Street, Bloomington, IN 47405, USA

E-mail contact: acboley@astro.indiana.edu

In this paper, we describe the nonlinear outcome of spiral shocks in protoplanetary disks. Spiral shocks, for most protoplanetary disk conditions, create a loss of vertical force balance in the post-shock region and result in rapid expansion of the gas perpendicular to the disk midplane. This expansion has characteristics similar to hydraulic jumps, which occur in incompressible fluids. We present a theory to describe the behavior of these hybrids between shocks and hydraulic jumps (shock bores) and then compare the theory to three-dimensional hydrodynamics simulations. We discuss the fully three-dimensional shock structures that shock bores produce and discuss possible consequences for disk mixing, turbulence, and evolution of solids.

Accepted by ApJ

astro-ph/0510305

On the Formation of Gas Giant Planets on Wide Orbits

Alan P. Boss

DTM, Carnegie Institution of Washington, 5241 Broad Branch Road, NW, Washington, DC 20015-1305, USA

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

A new suite of three dimensional radiative, gravitational hydrodynamical models is used to show that gas giant planets are unlikely to form by the disk instability mechanism at distances of $\sim$ 100 AU to $\sim$ 200 AU from young stars. A similar result seems to hold for the core accretion mechanism. These results appear to be consistent with the paucity of detections of gas giant planets on wide orbits by infrared imaging surveys, and also imply that if the object orbiting GQ Lupus is a gas giant planet, it most likely did not form at a separation of $\sim$ 100 AU. Instead, a wide planet around GQ Lup must have undergone a close encounter with a third body that tossed the planet outward to its present distance from its protostar. If it exists, the third body may be detectable by NASA's *Space Interferometry Mission*.

Accepted by Astrophys. J. Letters

Preprint available at http://www.dtm.ciw.edu/boss/ftp/200AU

Rapid Formation of Gas Giant Planets around M Dwarf Stars

Alan P. Boss

DTM, Carnegie Institution of Washington, 5241 Broad Branch Road, NW, Washington, DC 20015-1305, USA

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

Extrasolar planet surveys have begun to detect gas giant planets in orbit around M dwarf stars. While the frequency of gas giant planets around M dwarfs so far appears to be lower than that around G dwarfs, it is clearly not zero. Previous work has shown that the core accretion mechanism does not seem to be able to form gas giant planets around M dwarfs, because the time required for core formation scales with the orbital period, which lengthens for lower mass stars, resulting in failed (gas-poor) cores unless the gaseous protoplanetary disk survives for $>$ 10 Myr. Disk instability, on the other hand, is rapid enough ($\sim 10^3$ yrs) that it should be able to form gas giant protoplanets around even low mass stars well before the gaseous disk disappears. A new suite of three dimensional radiative, gravitational hydrodynamical models is presented that calculates the evolution of initially marginally gravitationally unstable disks with masses of 0.021 to 0.065 $M_\odot$ orbiting around stars with masses of 0.1 and 0.5 $M_\odot$, respectively. The models show that gas giant planets are indeed likely to form by the disk instability mechanism in orbit around M dwarf stars, the opposite of the prediction for formation by the core accretion mechanism. This difference offers another observational test for discriminating between these two theoretical end members for giant planet formation. Ongoing and future extrasolar planet searches around M dwarfs by spectroscopy, microlensing, photometry, and astrometry offer the opportunity to help decide between the dominance of the two mechanisms.

Accepted by Astrophys. J.

Preprint available at http://www.dtm.ciw.edu/boss/ftp/mdwarf

Frequency of Debris Disks around Solar-Type Stars: First Results from a *Spitzer* MIPS Survey

G. Bryden[1], C. A. Beichman[2], D. E. Trilling[3], G. H. Rieke[3], E. K. Holmes[1], S. M. Lawler[1], K. R. Stapelfeldt[1], M. W. Werner[1], T. N. Gautier[1], M. Blaylock[3], K. D. Gordon[3], J. A. Stansberry[3] and K. Y. L. Su[3]

[1] Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, CA 91109, USA
[2] Michelson Science Center, California Institute of Technology, Pasadena, CA 91125, USA
[3] Steward Observatory, University of Arizona, 933 North Cherry Avenue, Tucson, AZ 85721, USA

We have searched for infrared excesses around a well-defined sample of 69 FGK main-sequence field stars. These stars were selected without regard to their age, metallicity, or any previous detection of IR excess; they have a median age of ~ 4 Gyr. We have detected 70 μm excesses around seven stars at the 3σ confidence level. This extra emission is produced by cool material (< 100 K) located beyond 10 AU, well outside the "habitable zones" of these systems and consistent with the presence of Kuiper Belt analogs with ~ 100 times more emitting surface area than in our own planetary system. Only one star, HD 69830, shows excess emission at 24 μm, corresponding to dust with temperatures ≥ 300 K located inside of 1 AU. While debris disks with $L_{dust}/L_\star \geq 10^{-3}$ are rare around old FGK stars, we find that the disk frequency increases from $2\% \pm 2\%$ for $L_{dust}/L_\star \geq 10^{-4}$ to $12\% \pm 5\%$ for $L_{dust}/L_\star \geq 10^{-5}$. This trend in the disk luminosity distribution is consistent with the estimated dust in our solar system being within an order of magnitude greater or less than the typical level around similar nearby stars. Although there is no correlation of IR excess with metallicity or spectral type, there is a weak correlation with stellar age, with stars younger than a gigayear more likely to have excess emission.

Published by The Astrophysical Journal (Vol. 636, p. 1098)

S Ori J053825.4-024241: a classical T Tauri-like object at the substellar boundary

J. A. Caballero[1], E. L. Martín[1,2], M. R. Zapatero Osorio[3], V. J. S. Béjar[4], R. Rebolo[1,5], Ya. Pavlenko[6,7] and R. Wainscoat[8]

[1] Instituto de Astrofísica de Canarias, 38205 La Laguna, Tenerife, Spain
[2] University of Central Florida, Dept. of Physics, PO Box 162385, Orlando, FL 32816-2385, USA
[3] LAEFF-INTA, PO Box 50727, 28080, Madrid, Spain
[4] Proyecto Gran Telescopio Canarias, Instituto de Astrofísica de Canarias
[5] Consejo Superior de Investigaciones Cientficas, Spain
[6] Centre for Astrophysics Research, University of Hertfordshire, College Lane, Hatfield, Hertfordshire AL10 9AB, UK
[7] Main Astronomical Observatory of Academy of Sciences of Ukraine, Golosiiv Woods, Kyiv-127, 03680, Ukraine
[8] Institute for Astronomy, University of Hawai'i, 2680 Woodlawn Drive, Honolulu, HI 96822, USA

E-mail contact: zvezda@ll.iac.es

We present a spectrophotometric analysis of S Ori J053825.4-024241, a candidate member close to the substellar boundary of the young (1-8 Myr), nearby (~ 360 pc) σ Orionis star cluster. Our optical and near-infrared photometry and low-resolution spectroscopy indicate that S Ori J053825.4-024241 is a likely cluster member with a mass estimated from evolutionary models at $0.06^{+0.07}_{-0.02} M_\odot$, which makes the object a probable brown dwarf. The radial velocity of S Ori J053825.4-024241 is similar to the cluster systemic velocity. This target, which we have classified as an M 6.0 ± 1.0 low-gravity object, shows excess emission in the near-infrared and anomalously strong photometric variability for its type (from the blue to the J band), suggesting the presence of a surrounding disc. The optical spectroscopic observations show a continuum excess at short wavelengths and a persistent and resolved Hα emission (pseudo-equivalent width of ~ -250 Å) in addition to the presence of other forbidden and permitted emission lines, which we interpret as indicating accretion from the disc and possibly mass loss. We conclude that despite the low mass of S Ori J053825.4-024241, this object exhibits some of the properties typical of active classical T Tauri stars.

Published by Astronomy & Astrophysics (Vol. 445, p. 143)

The Evolution of the Water Distribution in a Viscous Protoplanetary Disk

Fred J. Ciesla[1,2] and Jeff Cuzzi[1]

[1] NASA Ames Research Center, MS 245-3, Moffett Field, CA, 94035, USA
[2] now at: Department of Terrestrial Magnetism, Carnegie Institution of Washington, 5241 Broad Branch Road NW, Washington, DC 20015, USA

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

Astronomical observations have shown that protoplanetary disks are dynamic objects through which mass is transported and accreted by the central star. This transport causes the disks to decrease in mass and cool over time, and such evolution is expected to have occurred in our own solar nebula. Age dating of meteorite constituents shows that their creation, evolution, and accumulation occupied several Myr, and over this time disk properties would evolve significantly. Moreover, on this timescale, solid particles decouple from the gas in the disk and their evolution follows a different path. It is in this context that we must understand how our own solar nebula evolved and what effects this evolution had on the primitive materials contained within it. Here we present a model which tracks how the distribution of water changes in an evolving disk as the water-bearing species experience condensation, accretion, transport, collisional destruction, and vaporization. Because solids are transported in a disk at different rates depending on their sizes, the motions will lead to water being concentrated in some regions of a disk and depleted in others. These enhancements and depletions are consistent with the conditions needed to explain some aspects of the chemistry of chondritic meteorites and formation of giant planets. The levels of concentration and depletion, as well as their locations, depend strongly on the combined effects of the gaseous disk evolution, the formation of rapidly migrating rubble, and the growth of immobile planetesimals. Understanding how these processes operate simultaneously is critical to developing our models for meteorite parent body formation in the Solar System and giant planet formation throughout the galaxy. We present examples of evolution under a range of plausible assumptions and demonstrate how the chemical evolution of the inner region of a protoplanetary disk is intimately connected to the physical processes which occur in the outer regions.

Accepted by Icarus

http://xxx.lanl.gov/abs/astro-ph/0511372

Large Proper Motions in the Jet of the High-mass YSO Cepheus A HW2

S. Curiel[1], P. T. P. Ho[2], N. A. Patel[2], J. M. Torrelles[3], L. F. Rodríguez[4], M. A. Trinidad[5], J. Cantó[1], L. Hernández[1], J. F. Gómez[6,7], G. Garay[8] and G. Anglada[7]

[1] Instituto de Astronomía, Universidad Nacional Autónoma de México
[2] Harvard−Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138
[3] Instituto de Ciencias del Espacio (CSIC)-IEEC, C/ Gran Capità 2-4, E-08034 Barcelona (Spain).
[4] Centro de Radioastronomía y Astrofísica, UNAM, Apartado Postal 3-72 (Xangari) 58089 Morelia, Michoacán, Mexico
[5] Dept. de Astronomía, Universidad de Guanajuato, Apartado Postal 144, 36240 Guanajuato, Guanajuato, Mexico
[6] Laboratorio de Astrofísica Espacial y Física Fundamental (INTA),
[7] Instituto de Astrofísica de Andalucia, CSIC, Apartado 3004, E-18080
[8] Departamento de Astronomía, Universidad de Chile, Casilla 36-D, Santiago, Chile

E-mail contact: scuriel@astroscu.unam.mx

Using high angular resolution ($\sim 0\farcs25-0\farcs05$) Very Large Array (VLA) observations made at 3.6 cm, 1.3 cm and 7 mm during the period 1991−2004, we report the detection of large proper motions in the components of the radio continuum jet associated with the high-mass young stellar object (YSO) HW2 in the star-forming region Cepheus A. The relative proper motions observed for the two main components of the outflow, moving away from the central source in nearly opposite directions, are of the order of 140 $mas\ yr^{-1}$, or $\sim$ 480 $km\ s^{-1}$ at a distance of 725 pc. The proper motions observed in the northeast northeast and southwest lobes are not completely antiparallel and the central elongated source seems to be changing orientation. We discuss possible scenarios to account for these and other observed characteristics. We also report the detection of a 7 mm compact continuum condensation of emission near the center of the thermal radio continuum jet, which we propose as the location of the exciting star.

Accepted by Astrophysical Journal, (vol. 638, 2006 February 20)

http://www.astroscu.unam.mx/∼scuriel/preprints/cepha-jet.pdf

Spectropolarimetry of the Classical T Tauri Star T Tauri

Antoun G. Daou[1], Christopher M. Johns-Krull[1] and Jeff A. Valenti[2]

[1] Department of Physics and Astronomy, Rice University, Mail Stop 108, 6100 Main Street, Houston, TX 77005, USA

[2] Space Telescope Science Institute, 3700 San Martin Drive, Baltimore, MD 21210, USA

E-mail contact: agdaou@rice.edu, cmj@rice.edui, valenti@stsci.edu

High-resolution ($R \approx 60,000$) circular spectropolarimetry of the classical T Tauri star T Tau is presented. The star was observed on 1997 November 21 and 22. Analyzing 12 photospheric absorption lines, the mean longitudinal magnetic field is found to be $B_z = 12 \pm 35$ G. The 3σ upper limit of $|B_z| \leq 105$ G. Previously, T Tau was reported to have a mean longitudinal field of 160 ± 40 G. A strong mean magnetic field (~ 2.4 kG) has been reported on the surface of T Tau based on Zeeman broadening measurements in unpolarized light. The present observations indicate that it is very unlikely that this field is dipolar in nature. In order to verify the observing techniques and analysis methods used on T Tau, spectra of the Sun obtained by observing the asteroid Vesta are analyzed in the same fashion. Here the mean longitudinal field is $B_z = -4 \pm 3$ G, which is well within the limits of previous observations. As a further check on our results, we also present data for the magnetic Ap star 53 Cam, which gives a mean longitudinal magnetic field that agrees well with the published field variations for this star.

Published by The Astronomical Journal (Vol. 131, p. 520)

On the Submillimeter Opacity of Protoplanetary Disks

B. T. Draine

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

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

Solid particles with the composition of interstellar dust and power-law size distribution $dn/da \propto a^{-p}$ (for $a \leq a_{max}$ with $a_{max} \geq 3\lambda$ and $3 < p < 4$) will have submillimeter opacity spectral index $\beta(\lambda) \equiv d\ln(\kappa)/d\ln(\nu) \approx (p-3)\beta_{ISM}$, where $\beta_{ISM} \approx 1.7$ is the opacity spectral index of interstellar dust material in the Rayleigh limit. For the power-law index $p \approx 3.5$, which characterizes interstellar dust and may apply for particles growing by agglomeration in protoplanetary disks, grain growth to sizes $a \geq 3$ mm will result in $\beta(1\ \mathrm{mm}) \leq 1$. Grain growth can naturally account for $\beta \approx 1$ observed for protoplanetary disks, provided that $a_{max} \geq 3\lambda$.

Published by The Astrophysical Journal (Vol. 636, p. 1114)

Spatially Resolving the Inner Disk of TW Hya

J.A. Eisner[1], E.I. Chiang[1] and L.A. Hillenbrand[2]

[1] University of California at Berkeley, Astronomy Department, 601 Campbell Hall, Berkeley, CA 94720

[2] California Institute of Technology, Astronomy Department, MC 105-24, Pasadena, CA 91125

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

We present Keck Interferometer observations of TW Hya that spatially resolve its emission at 2 μm wavelength. Analyzing these data together with existing K-band veiling and near-infrared photometric measurements, we conclude that the inner disk consists of optically thin, sub-micron-sized dust extending from ~ 4 AU to within 0.06 AU of the central star. The inner disk edge may be magnetospherically truncated. Even if we account for the presence of gas in the inner disk, these small dust grains have survival times against radiation blow-out that are orders of magnitude shorter than the age of the system, suggesting continual replenishment through collisions of larger bodies.

Accepted by ApJ Letters

http://arxiv.org/abs/astro-ph/0601034

Massive Protoplanetary Disks in the Trapezium Region

J.A. Eisner[1] and John M. Carpenter[2]

[1] University of California at Berkeley, Astronomy Department, 601 Campbell Hall, Berkeley, CA 94720
[2] California Institute of Technology, Astronomy Department, MC 105-24, Pasadena, CA 91125

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

We determine the disk mass distribution around 336 stars in the young (~ 1 Myr) Orion Nebula cluster by imaging a $2\farcm5 \times 2\farcm5$ region in $\lambda 3$ mm continuum emission with the Owens Valley Millimeter Array. For this sample of 336 stars, we observe 3 mm emission above the 3σ noise level toward ten sources, six of which have also been detected optically in silhouette against the bright nebular background. In addition, we detect 20 objects in 3 mm continuum emission that do not correspond to known near-IR cluster members. Comparisons of our measured fluxes with longer wavelength observations enable rough separation of dust emission from thermal free-free emission, and we find substantial dust emission toward most objects. For the sample of ten objects detected at both 3 mm and near-IR wavelengths, eight exhibit substantial dust emission. Excluding the two high-mass stars (θ^1OriA and the BN object) and assuming a gas-to-dust ratio of 100, we estimate circumstellar masses ranging from 0.13 to 0.39 $M_\odot$. For the cluster members not detected at 3 mm, images of individual objects are stacked to constrain the mean 3 mm flux of the ensemble. The average flux is detected at the 3σ confidence level, and implies an average disk mass of 0.005 $M_\odot$, comparable to the minimum mass solar nebula. The percentage of stars in Orion surrounded by disks more massive than ~ 0.1 $M_\odot$ is consistent with the disk mass distribution in Taurus, and we argue that massive disks in Orion do not appear to be truncated through close encounters with high-mass stars. Comparison of the average disk mass and number of massive dusty structures in Orion with similar surveys of the NGC 2024 and IC 348 clusters is used to constrain the evolutionary timescales of massive circumstellar disks in clustered environments.

Accepted by ApJ

http://arxiv.org/abs/astro-ph/0601033

Braking the Gas in the β Pictoris Disk

Rodrigo Fernández[1], Alexis Brandeker[1] and Yanqin Wu[1]

[1] Dept. of Astronomy and Astrophysics, University of Toronto. 60 St. George Street, Toronto, ON M5S 3H8, Canada

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

Metallic gas detected in the β Pictoris circumstellar debris disk raises many questions. The origin of this gas is unclear and its very presence is difficult to explain: many constituents of the gas are expected to be radiatively accelerated outward, yet their motion appears to be consistent with Keplerian rotation out to at least 300 AU. Hydrogen has previously been hypothesized to exist in the disk, acting as a braking agent, but the amount required to brake individual elements conflicted with observed upper limits.

To resolve this discrepancy, we search for alternative braking mechanisms for the metallic gas. We find that all species affected by radiation force are heavily ionized. Frequent Coulomb collisions couple the ions into a single fluid, reducing the radiation force on species feeling the strongest acceleration. For a gas of solar composition, the resulting total radiation force still exceeds gravity, while a gas of enhanced carbon abundance could be self-braking. We also explore two other braking agents: collisions with dust grains and neutral gas. Grains surrounding β Pic are photoelectrically charged to a positive electrostatic potential. If a significant fraction of the dust grains are carbonaceous (10% in the midplane and larger at higher altitudes), ions can be slowed down to satisfy the observed velocity constraints. In this case, both the gas kinematics and spatial distributions are expected to coincide with those of small grains, the latter being indeed observed. For neutral gas to brake the coupled ion fluid, we find the minimum required mass to be $\approx 0.03\,M_\oplus$, consistent with observed upper limits of the hydrogen column density, and substantially reduced relative to previous estimates.

Our results favor a scenario in which metallic gas is generated by grain evaporation in the disk, perhaps during grain-grain collisions. We exclude a primordial origin for the gas, but cannot rule out the possibility of its production by falling evaporating bodies near the star. We discuss the implications of this work for observations of gas in other debris disks.

Accepted by The Astrophysical Journal – http://www.arxiv.org/abs/astro-ph/0601244

The importance of the ortho:para H_2 ratio for the deuteration of molecules during pre–protostellar collapse

D.R. Flower[1], G. Pineau des Forêts[2] and C.M. Walmsley[3]

[1] Physics Dept., The University, Durham DH1 3LE, UK
[2] Institut d'Astrophysique Spatiale(IAS), Bâtiment 121, F-91405 Orsay, France
[3] INAF, Osservatorio Astrofisico di Arcetri, Largo E. Fermi 5, I-50125, Firenze, Italy

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

We have studied the evolution of molecular gas during the early stages of protostellar collapse. In addition to allowing for the freeze out of 'heavy' species on to grains, we have computed the variation of population densities of the different nuclear spin states of "tracer" molecular ions such as H_2D^+ and D_2H^+. Processes which determine the relative populations of the nuclear spin states of molecules and molecular ions have received much less attention in the literature than those involved in their deuteration; but in fact the former processes are as significant as the latter and often involve the same reactants. We find that the ortho:para ratio of some species, e.g. H_2D^+, vary considerably as the density increases. Because the dynamical timescale is much shorter than some of the chemical timescales, there can be large departures of the predictions of the free–fall model from the steady state solution at the same density and temperature. In the case of H_2, it seems unlikely that the steady state value of the ortho:para ratio is attained before protostellar collapse from the progenitor molecular cloud commences. Values of the ortho:para H_2 ratio much higher than in steady state, which would prevail in "young" molecular clouds, are found to be inconsistent with high levels of deuteration of the gas. The internal energy of ortho–H_2 acts as a reservoir of chemical energy which inhibits the deuteration of H_3^+ and hence of other species, such as N_2H^+ and NH_3. In essence, the deuteration of molecular ions and molecules is sensitive to the ortho:para H_2 ratio and hence to the chemical and thermal history of the parent molecular cloud.

Accepted by A&A

Near-Infrared Images of Protoplanetary Disk Surrounding HD 142527

Misato Fukagawa[1,2], Motohide Tamura[3,4], Yoichi Itoh[5], Tomoyuki Kudo[4], Yusuke Imaeda[5], Yumiko Oasa[5], Saeko S. Hayashi[4,6] and Masahiko Hayashi[4,6]

[1] *Spitzer* Science Center, California Institute of Technology, Mail Code 220-6, Pasadena, CA 91125, USA
[2] Nagoya University, Furo-cho, Chikusa-ku, Nagoya 464-8602, Japan
[3] National Astronomical Observatory of Japan, 2-21-1 Osawa, Mitaka, Tokyo 181-8588, Japan
[4] Department of Astronomical Science, The Graduate University for Advanced Studies (SOKENDAI), 2-21-1 Osawa, Mitaka, Tokyo 181-8588, Japan
[5] Graduate School of Science and Technology, Kobe University, 1-1 Rokkodai, Nada, Kobe 657-8501, Japan
[6] Subaru Telescope, National Astronomical Observatory of Japan, 650 North A'ohoku Place, Hilo, HI 96720, USA

E-mail contact: misato@ipac.caltech.edu

We discovered a unique morphology in a disk around the Herbig Ae star HD 142527 by near-infrared (H and K bands) adaptive optics imaging observations. The almost face-on disk consists of two bright arcs facing one another along the east-west direction (banana-split structure) and one spiral arm extending to the north from the western arc. The eastern arc is located at $\sim 100 - 400$ AU in radius from the star, and the western one is detected at $\sim 150 - 490$ AU. The stellar position is displaced from the center of the disk by about 20 AU to the north, and also from the center of the inner hole. The two arcs show an asymmetry in their size and brightness; the larger western arc is brighter than the east one by about 2 mag. The morphology of the disk, consisting of a banana-split structure and a spiral arm, most likely suggests the presence of an unseen eccentric binary and a recent stellar encounter.

Published by The Astrophysical Journal (Vol. 636, p. L153)

Post-Outburst Infrared Spectra of V1647 Ori, the Illuminating Star of McNeil's Nebula

E. L. Gibb[1], T. W. Rettig[2], S. D. Brittain[3], D. Wasikowski[2], Theodore Simon[4], William D. Vacca[5], Michael C. Cushing[6] and C. Kulesa[7]

[1] University of Missouri - St Louis, St Louis, MO, 63121
[2] Center for Astrophysics, University of Notre Dame, Notre Dame, IN, 46556

[3] National Optical Astronomy Observatory, 950 N Cherry Avenue, Tucson, AZ 85719
[4] Institute for Astronomy, University of Hawaii, 2680 Woodlawn Drive, Honolulu, HI 96822
[5] SOFIA-USRA, NASA Ames Research Center, MS 144-2, Moffett Field, CA 94035
[6] SETI Institute, NASA Ames Research Center, MS 245-3, Moffett Field, CA 94035
[7] Steward Observatory, University of Arizona, 933 N. Cherry Avenue, Tucson, AZ 85721

E-mail contact: gibbe@umsl.edu

V1647 Ori is a low mass star in the L1630 star-forming region that underwent an outburst in late 2003/early 2004. We present post-outburst infrared spectra obtained with NIRSPEC (Keck II) and SpeX (IRTF) and compare these to spectra taken during the outburst. The results show that the temperature of the hot CO formed in the inner part of the disk has declined by ∼800 K, while the water and CO ice and low-J CO gas features remained unchanged, consistent with previous assertions that the latter, low-temperature features arise in the foreground cloud. The P-Cygni profiles of the Paschen series that were present in the outburst spectra taken in March 2004 disappeared by late 2004. The equivalent width of the helium absorption line at 1.0830 μm decreased from 8.9 Å to 3.9 Å between March and November 2004, evidence that the hot, fast wind has decreased substantially. We discuss the implications for categorizing V1647 Ori among the known classes of outbursting young stars.

Accepted by Astrophysical Journal

http://www.journals.uchicago.edu/ApJ/future.html

Evidence supporting the kinematic interpretation of water maser proper motions

C. Goddi[1], L. Moscadelli[1], J.M. Torrelles[2], L. Uscanga[3] and R. Cesaroni[4]

[1] INAF, Osservatorio Astronomico di Cagliari, Loc. Poggio dei Pini, Str. 54, 09012 Capoterra (CA), Italy
[2] Instituto de Ciencias del Espacio (CSIC)–IEEC, Gran Capitá 2, E-08034 Barcelona, Spain. On sabbatical leave at the United Kingdom Astronomy Technology Centre, Royal Observatory Edinburgh, UK
[3] Instituto de Astronomía, UNAM, Apdo. Postal 70-264, 04510 México, D.F., México
[4] INAF, Osservatorio Astrofisico di Arcetri, Largo E. Fermi 5, 50125 Firenze, Italy

E-mail contact: cgoddi@ca.astro.it

We have analyzed multi-epoch 22 GHz water maser observations performed with the Very Long Baseline Array (VLBA) towards the high-mass star forming region (SFR) G24.78+0.08. The spatial structure of the water maser integrated intensity has been obtained at three different epochs and found to maintain a very remarkable persistent morphology over the three epochs. Evidence of systematic (expanding) motions for the whole structure traced by the maser emission is also reported. In addition, we have obtained, from previously reported data, the integrated emission of a cluster of water masers spread over $\simeq$ 10 mas within the expanding shell of $\simeq 0.16''$ size around the young stellar object W75 N (B)-VLA 2. As in G24.78+0.8, we also find that the morphology of the integrated intensity of the water masers of this cluster persists over different observed epochs. These results strongly support the interpretation that the measured proper motions of the water masers are due to real physical motions of distinct blobs of maser-emitting gas, rather than to other effects, such as a travelling background illuminating wave or turbulence in the circumstellar medium. This result is crucial in astrophysical applications of maser proper-motion measurements, including distance determinations and studies of circumstellar gas kinematics in SFRs and late-type stars.

Accepted by Astronomy&Astrophysics Letters

http://hubble.dsf.unica.it/ cgoddi/documents/Hl071.ps

The Low-Mass Pre-Main-Sequence Population of the Stellar Association LH 52 in the Large Magellanic Cloud Discovered with *Hubble Space Telescope* WFPC2 Observations

D. Gouliermis[1], W. Brandner[1] and Th. Henning[1]

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

E-mail contact: dgoulier@mpia.de, brandner@mpia.de, henning@mpia.dehenning@mpia.de

We report on the serendipitous discovery of ∼ 500 low-mass candidate pre-main-sequence (PMS) stars in the vicinity of the stellar association LH 52 in the Large Magellanic Cloud. We present evidence that the red faint sequence of

these stars seen in the CMD of LH 52 from *Hubble Space Telescope* (*HST*) WFPC2 observations belongs only to the association and follows almost perfectly isochrone models for PMS stars of masses down to $\sim 0.3 M_{\odot}$. We find that this feature has a Galactic counterpart and that the mass spectrum of the candidate PMS stars in LH 52 seems to correspond to a Salpeter initial mass function with a slope $\Gamma \simeq -1.26$ in the mass range $0.8 - 1.4 M_{\odot}$.

Published by The Astrophysical Journal (Vol. 636, p. L133)

CCS and NH_3 associated with low-mass YSOs

Itziar de Gregorio-Monsalvo[1], José F. Gómez[1,2], Olga Suárez[1], Thomas B. H. Kuiper[3], Luis F. Rodríguez[4], Elena Jiménez-Bailón[5]

[1] Laboratorio de Astrofísica Espacial y Física Fundamental (INTA), Apartado 50727, E-28080 Madrid, Spain
[2] Instituto de Astrofísica de Andalucía (CSIC), Apartado 3004, E-18080 Granada, Spain
[3] Jet Propulsion Laboratory, California Institute of Technology, USA [4] Centro de Radioastronomía y Astrofísica, UNAM, Apartado Postal 3-72 (Xangari), 58089 Morelia, Michoacán. Mexico [5] XMM-Newton Science Operation Center/RSSD-ESA, Apartado 50727, E-28080 Madrid, Spain. example:

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

In this work we present a sensitive and systematic single-dish survey of CCS emission (complemented with ammonia observations) at 1 cm, toward a sample of low- and intermediate-mass young star forming regions known to harbor water maser emission, made with NASA's 70 m antenna at Robledo de Chavela, Spain. Out of the 40 star forming regions surveyed in the CCS(2_1-1_0) line, only 6 low-mass sources show CCS emission: one transitional object between pre-stellar and protostellar Class 0 phase (GF9-2), three Class 0 protostars (L1448-IRS3, L1448C, and B1-IRS), a Class I source (L1251A), and a young T Tauri star (NGC2071-North). Since CCS is considered an "early-time" ($\leq 10^5$ yr) molecule, we explain these results by either proposing a revision of the classification of the age of NGC2071-North and L1251A, or suggesting the possibility that the particular physical conditions and processes of each source affect the destruction/production of the CCS. No statistically significant relationship was found between the presence of CCS and parameters of the molecular outflows and their driving sources. Nevertheless, we found a significant relationship between the detectability of CCS and the ammonia peak intensity (higher in regions with CCS), but not with its integrated intensity. This tendency found may suggest that the narrower ammonia line widths in the less turbulent medium associated with younger cores may compensate for the differences in ammonia peak intensity, rendering differences in integrated intensity negligible. From the CCS detection rate we derive a lifetime of this molecule of $\simeq (0.7-3)\times 10^4$ yr in low-mass star forming regions.

Accepted by The Astrophysical Journal

http://arxiv.org/abs/astro-ph/0512616

Gravitationally unstable protoplanetary discs

Evgeny Griv

Department of Physics, Ben-Gurion University of the Negev, PO Box 653, Beer-Sheva 84105, Israel

E-mail contact: griv@bgumail.bgu.ac.il

The possibility that protoplanetary gaseous discs are dynamically unstable to axisymmetric and non-axisymmetric gravity perturbations (e.g. those produced by spontaneous disturbances) with characteristic scales larger than the vertical scale height is discussed analytically, using a local Wentzel-Kramers-Brillouin (WKB) approach. It is shown that such discs might be clumpy, and these gravitationally bound clumps may later collapse to become giant planets ('hot Jupiters'). The chief aim in this paper is to underscore a fact of vital importance for application in the planetary formation process: gravitationally unstable non-axisymmetric (spiral) perturbations can effectively transport both the angular momentum and the mass in a spatially inhomogeneous disc.

Published by Monthly Notices of the Royal Astronomical Society (Vol. 365, p. 1007)

Probing turbulence with infrared observations in OMC1

M. Gustafsson[1], D. Field[1], J. L. Lemaire[2] and F. P. Pijpers[3]

[1] Department of Physics and Astronomy, University of Aarhus, 8000 Aarhus C, Denmark

[2] Observatoire de Paris & Université de Cergy-Pontoise, LERMA & UMR 8112 du CNRS, 92195 Meudon, France
[3] Space and Atmospheric Physics, Dept. Physics, Imperial College London, UK

E-mail contact: maikeng@phys.au.dk

A statistical analysis is presented of the turbulent velocity structure in the Orion Molecular Cloud at scales ranging from 70 AU to 3×10^4 AU. Results are based on IR Fabry-Perot interferometric observations of shock and photon-excited H_2 in the K-band S(1) v=1-0 line at 2.121 μm and refer to the dynamical characteristics of warm perturbed gas. Data consist of a spatially resolved image with a measured velocity for each resolution limited region (70 AU $\times$ 70 AU) in the image. The effect of removal of apparent large scale velocity gradients is discussed and the conclusion drawn that these apparent gradients represent part of the turbulent cascade and should remain within the data. Using our full data set, observations establish that the Larson size-linewidth relation is obeyed to the smallest scales studied here extending the range of validity of this relationship by nearly 2 orders of magnitude. The velocity probability distribution function (PDF) is constructed showing extended exponential wings, providing evidence of intermittency, further supported by the skewness (third moment) and kurtosis (fourth moment) of the velocity distribution. Variance and kurtosis of the PDF of velocity differences are constructed as a function of lag. The variance shows an approximate power law dependence on lag, with exponent significantly lower than the Kolmogorov value, and with deviations below 2000 AU which are attributed to outflows and possibly disk structures associated with low mass star formation within OMC1. The kurtosis shows strong deviation from a Gaussian velocity field, providing evidence of velocity correlations at small lags. Results agree accurately with semi-empirical simulations in Eggers & Wang (1998).

In addition, 170 individual H_2 emitting clumps have been analysed with sizes between 500 and 2200 AU. These show considerable diversity with regard to PDFs and variance functions (related to second order structure functions) displaying a variety of shapes of the PDF and different values of the scaling exponent within a restricted spatial region. However, a region associated with an outflow from a deeply embedded O-star shows high values of the scaling exponent of the variance function, representing a strong segregation of high and low exponent clumps. Our analysis constitutes the first characterization of the turbulent velocity field at the scale of star formation and provide a dataset which models of star-forming regions should aim to reproduce.

Published by Astronomy & Astrophysics (Vol. 445, p. 601)

Three-dimensional Models of Embedded High-Mass Stars: Effects of a Clumpy Circumstellar Medium

R. Indebetouw[1], B. A. Whitney[2], K. E. Johnson[1], and K. Wood[3]

[1] Astronomy Department, University of Virginia, P.O. Box 3818, Charlottesville, VA 22903-0818, USA
[2] Space Science Institute, 4750 Walnut Street, Suite 205, Boulder, CO 80301, USA
[3] School of Physics and Astronomy, University of St. Andrews, North Haugh, St. Andrews, Fife KY16 9SS, Scotland

We use three-dimensional radiative transfer models to show the effects of clumpy circumstellar material on the observed infrared colors of high-mass stars embedded in molecular clouds. We highlight differences between three-dimensional clumpy and one-dimensional smooth models that can affect the interpretation of data. We discuss several important properties of the emergent spectral energy distribution (SED). More near-infrared light (scattered and direct from the central source) can escape than in smooth one-dimensional models. The near- and mid-infrared SED of the same object can vary significantly with viewing angle, depending on the clump geometry along the sight line. Even the wavelength-integrated flux can vary with angle by more than a factor of 2. Objects with the same *average* circumstellar dust distribution can have very different near- and mid-IR SEDs, depending on the clump geometry and the proximity of the most massive clump to the central source. Although clumpiness can cause similar objects to have very different SEDs, there are some observable trends. Near- and mid-infrared colors are sensitive to the weighted average distance of clumps from the central source and to the magnitude of clumpy density variations (smooth-to-clumpy ratio). Far-infrared emission remains a robust measure of the total dust mass. We present simulated SEDs, colors, and images for 2MASS and Spitzer filters. We compare them to observations of some ultracompact H II regions and find that three-dimensional clumpy models fit better than smooth models. In particular, clumpy models with fractal dimensions in the range $2.3-2.8$, smooth-to-clumpy ratios of $\leq 50\%$, and density distributions with shallow average radial density profiles fit the SEDs best ($\langle\rho\rangle \propto r^{\alpha}, -1.0 < \alpha < 0.0$).

Published by The Astrophysical Journal (Vol. 636, p. 362)

The effect of a strong external radiation field on protostellar envelopes in Orion

Jes K. Jørgensen[1,2], Doug Johnstone[3,4], Ewine F. van Dishoeck[1] and Steven D. Doty[5]

[1] Leiden Observatory, PO Box 9513, NL-2300 RA Leiden, The Netherlands
[2] Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, MS42, Cambridge, MA 02138, USA
[3] National Research Council Canada, Herzberg Institute of Astrophysics, 5071 West Saanich Rd, Victoria, BC, V9E 2E7, Canada
[4] Department of Physics & Astronomy, University of Victoria, Victoria, BC, V8P 1A1, Canada
[5] Department of Physics and Astronomy, Denison University, Granville, OH 43023, USA

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

We discuss the effects of an enhanced interstellar radiation field (ISRF) on the observables of protostellar cores in the Orion cloud region. Dust radiative transfer is used to constrain the envelope physical structure by reproducing SCUBA 850 μm emission. Previously reported ^{13}CO, C^{17}O and H_2CO line observations are reproduced through detailed Monte Carlo line radiative transfer models. It is found that the ^{13}CO line emission is marginally optically thick and sensitive to the physical conditions in the outer envelope. An increased temperature in this region is needed in order to reproduce the ^{13}CO line strengths and it is suggested to be caused by a strong heating from the exterior, corresponding to an ISRF in Orion 10^3 times stronger than the "standard" ISRF. The typical temperatures in the outer envelope are higher than the desorption temperature for CO. The C^{17}O emission is less sensitive to this increased temperature but rather traces the bulk envelope material. The data are only fit by a model where CO is depleted, except in the inner and outermost regions where the temperature increases above 30-40 K. The fact that the temperatures do not drop below $\approx$ 25 K in any of the envelopes whereas a significant fraction of CO is frozen-out suggest that the interstellar radiation field has changed through the evolution of the cores. The H_2CO lines are successfully reproduced in the model of an increased ISRF with constant abundances of 3–5$\times10^{-10}$.

Accepted by A&A

astro-ph/0512314

First Optical Images of Circumstellar Dust Surrounding the Debris Disk Candidate HD 32297

Paul Kalas[1,2]

[1] Astronomy Department, University of California, Berkeley, CA 94720, USA
[2] National Science Foundation Center for Adaptive Optics, University of California, Santa Cruz, CA 95064, USA

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

Near-infrared imaging with the *Hubble Space Telescope* recently revealed a circumstellar dust disk around the A star HD 32297. Dust-scattered light is detected as far as 400 AU radius, and the linear morphology is consistent with a disk $\sim 10^\circ$ away from an edge-on orientation. Here we present the first optical images that show the dust-scattered light morphology from 560 to 1680 AU radius. The position angle of the putative disk midplane diverges by $\sim 31^{circ}$, and the color of dust scattering is most likely blue. We associate HD 32297 with a wall of interstellar gas and the enigmatic region south of the Taurus molecular cloud. We propose that the extreme asymmetries and blue disk color originate from a collision with a clump of interstellar material as HD 32297 moves southward, and discuss evidence consistent with an age of 30 Myr or younger.

Published by The Astrophysical Journal (Vol. 635, p. L169)

Formation of Giant Planets by Concurrent Accretion of Solids and Gas inside an Anti-Cyclonic Vortex

Hubert Klahr[1] and Peter Bodenheimer[2]

[1] Max-Planck-Institute for Astronomy, Heidelberg, Germany
[2] UCO/Lick Observatory, University of California, Santa Cruz, CA, USA

E-mail contact: klahr@mpia.de

We study the formation of a giant gas planet by the core–accretion gas–capture process, with numerical simulations,

under the assumption that the planetary core forms in the center of an anti-cyclonic vortex. The presence of the vortex concentrates particles of centimeter to meter size from the surrounding disk, and speeds up the core formation process. Assuming that a planet of Jupiter mass is forming at 5 AU from the star, the vortex enhancement results in considerably shorter formation times than are found in standard core–accretion gas–capture simulations. Also, formation of a gas giant is possible in a disk with mass comparable to that of the minimum mass solar nebula.

Accepted by ApJ

http://arxiv.org/pdf/astro-ph/0510479

3D-radiation hydro simulations of disk-planet interactions. I. Numerical algorithm and test cases

Hubert Klahr[1] **and Willy Kley**[2]

[1] Max-Planck-Institute for Astronomy, Heidelberg
[2] Universitaet Tuebingen, Institut fuer Astronomie und Astrophysik, Abt. Computational Physics

E-mail contact: klahr@mpia.de

We study the evolution of an embedded protoplanet in a circumstellar disk using the 3D-Radiation Hydro code TRAMP, and treat the thermodynamics of the gas properly in three dimensions. The primary interest of this work lies in the demonstration and testing of the numerical method. We show how far numerical parameters can influence the simulations of gap opening. We study a standard reference model under various numerical approximations. Then we compare the commonly used locally isothermal approximation to the radiation hydro simulation using an equation for the internal energy. Models with different treatments of the mass accretion process are compared. Often mass accumulates in the Roche lobe of the planet creating a hydrostatic atmosphere around the planet. The gravitational torques induced by the spiral pattern of the disk onto the planet are not strongly affected in the average magnitude, but the short time scale fluctuations are stronger in the radiation hydro models. An interesting result of this work lies in the analysis of the temperature structure around the planet. The most striking effect of treating the thermodynamics properly is the formation of a hot pressure-supported bubble around the planet with a pressure scale height of H/R ≈ 0.5 rather than a thin Keplerian circumplanetary accretion disk.

Accepted by A&A

http://arxiv.org/pdf/astro-ph/0510391

Nonlinear Criterion for the Stability of Molecular Clouds

Ruben Krasnopolsky[1] **and Charles F. Gammie**[1]

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

Dynamically significant magnetic fields are routinely observed in molecular clouds, with mass-to-flux ratio $\lambda \equiv (2\pi\sqrt{G})\Sigma/B \sim 1$ (here Σ is the total column and B the field strength). It is widely believed that "subcritical" clouds with $\lambda < 1$ cannot collapse, based on virial arguments by Mestel and Spitzer and a linear stability analysis by Nakano and Nakamura. Here we confirm, using high-resolution numerical models that begin with a strongly supersonic velocity dispersion, that this criterion is a fully nonlinear stability condition. All the high-resolution models with $\lambda \leq 0.95$ form "Spitzer sheets" but collapse no further. All models with $\lambda \geq 1.02$ collapse to the maximum numerically resolvable density. We also investigate other factors determining the collapse time for supercritical models. We show that there is a strong stochastic element in the collapse time: models that differ only in details of their initial conditions can have collapse times that vary by as much as a factor of 3. The collapse time cannot be determined from just the velocity dispersion; it depends also on its distribution. Finally, we discuss the astrophysical implications of our results.

Published by The Astrophysical Journal (Vol. 635, p. 1126)

Nonlinear Hydromagnetic Wave Support of a Stratified Molecular Cloud II: A Parameter Study

Takahiro Kudoh[1,2] and Shantanu Basu[1]

[1] Department of Physics and Astronomy, University of Western Ontario, London, Ontario N6A 3K7, Canada
[2] National Astronomical Observatory of Japan, Mitaka, Tokyo 181-8588, Japan

E-mail contact: kudoh@th.nao.ac.jp

We use numerical simulations to study the effect of nonlinear MHD waves in a stratified, self-gravitating molecular cloud that is bounded by a hot and tenuous external medium. In a previous paper, we had shown the details of a standard model and studied the effect of varying the dimensionless amplitude $\tilde{a}_d$ of sinusoidal driving. In this paper, we present the results of varying two other important free parameters: β_0, the initial ratio of gas to magnetic pressure at the cloud midplane, and $\tilde{\nu}_0$, the dimensionless frequency of driving. Furthermore, we present the case of a temporally random driving force. Our results demonstrate that a very important consideration for the actual level of turbulent support against gravity is the ratio of driving wavelength λ_0 to the the size of the initial non-turbulent cloud; maximum cloud expansion is achieved when this ratio is close to unity. All of our models yield the following basic results: (1) the cloud is lifted up by the pressure of nonlinear MHD waves and reaches a steady-state characterized by oscillations about a new time-averaged equilibrium state; (2) after turbulent driving is discontinued, the turbulent energy dissipates within a few sound crossing times of the expanded cloud; (3) the line-width–size relation is obtained by an ensemble of clouds with different free parameters and thereby differing time-averaged self-gravitational equilibrium states. The best consistency with the observational correlation of magnetic field strength, turbulent line width, and density is achieved by cloud models with $\beta_0 \approx 1$. We also calculate the spatial power spectra of the turbulent clouds, and show that significant power is developed on scales larger than the scale length H_0 of the initial cloud, even if the input wavelength of turbulence $\lambda_0 \approx H_0$, The cloud stratification and resulting increase of Alfvén speed toward the cloud edge allows for a transfer of energy to wavelengths significantly larger than λ_0. This explains why the relevant time scale for turbulent dissipation is the crossing time over the cloud scale rather than the crossing time over the driving scale.

Accepted by The Astrophysical Journal

http://yso.mtk.nao.ac.jp/~kudoh/publist_e.html -or- astro-ph/0601072

Hot Organic Molecules toward a Young Low-Mass Star: A Look at Inner Disk Chemistry

F. Lahuis[1,2], E. F. van Dishoeck[1], A. C. A. Boogert[3], K. M. Pontoppidan[1,4], G. A. Blake[4], C. P. Dullemond[5], N. J. Evans II[6], M. R. Hogerheijde[1], J. K. Jørgensen[7], J. E. Kessler-Silacci[6] and C. Knez[6]

[1] Leiden Observatory, P.O. Box 9513, 2300 RA Leiden, Netherlands
[2] SRON Netherlands Institute for Space Research, P.O. Box 800, 9700 AV Groningen, Netherlands
[3] Division of Physics, Mathematics, and Astronomy, MS 105-24, California Institute of Technology, Pasadena, CA 91125, USA
[4] Division of Geological and Planetary Sciences, MS 150-21, California Institute of Technology, Pasadena, CA 91125, USA
[5] Max-Planck-Institut fr Astronomie, Königstuhl 17, D-69117 Heidelberg, Germany
[6] Department of Astronomy, University of Texas at Austin, 1 University Station C1400, Austin, TX 78712-0259, USA
[7] Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Mail Stop 42, Cambridge, MA 02138, USA

E-mail contact: f.lahuis@sron.rug.nl

Spitzer Space Telescope spectra of the low-mass young stellar object (YSO) IRS 46 ($L_{bol} \approx 0.6 L_{\odot}$) in Ophiuchus reveal strong vibration-rotation absorption bands of gaseous C_2H_2, HCN, and CO_2. This is the only source out of a sample of $\sim$ 100 YSOs that shows these features, and this is the first time that they are seen in the spectrum of a solar-mass YSO. Analysis of the *Spitzer* data combined with Keck L- and M-band spectra reveals excitation temperatures of $\geq$ 350 K and abundances of 10^{-6} to 10^{-5} with respect to H_2, orders of magnitude higher than those found in cold clouds. In spite of this high abundance, the HCN $J = 4 - 3$ line is barely detected with the James Clerk

Maxwell Telescope (JCMT), indicating a source diameter less than 13 AU. The (sub)millimeter continuum emission and the absence of scattered light in near-infrared images limit the mass and temperature of any remnant collapsing envelope to less than 0.01 $M_\odot$ and 100 K, respectively. This excludes a hot-core-type region as found in high-mass YSOs. The most plausible origin of this hot gas rich in organic molecules is in the inner (< 6 AU radius) region of the disk around IRS 46, either the disk itself or a disk wind. A nearly edge-on two-dimensional disk model fits the spectral energy distribution (SED) and gives a column of dense warm gas along the line of sight that is consistent with the absorption data. These data illustrate the unique potential of high-resolution infrared spectroscopy to probe the organic chemistry, gas temperatures, and gas kinematics in the planet-forming zones close to a young star.

Published by The Astrophysical Journal (Vol. 636, p. L145)

The extremely high-velocity molecular outflow in IRAS 20126+4104

M. Lebrón[1], H. Beuther[2,3], P. Schilke[4] and Th. Stanke[5,4]

[1] Arecibo Observatory, HC 03 Box 53995, Arecibo, Puerto Rico 00612
[2] Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, MS 78 Cambridge, MA 02138, USA
[3] Max-Planck-Institute for Astronomy Königstuhl 17, 69117 Heidelberg, Germany
[4] Max-Planck-Institut für Radioastronomie, Auf dem Hügel 69, D-53121 Bonn, Germany
[5] University of Hawaii, Institute for Astronomy, 2680 Woodlawn Drive, Honolulu, Hawaii 96822-1897, USA

E-mail contact: mlebron@naic.edu

New sensitive CO(2-1) observations of the massive star-forming region IRAS 20126+4104 reveal a high-velocity gas component that has not been observed before. Comparing the morphologies of the high-velocity CO and the molecular jet traced by H_2 and SiO, we found various orientations projected on the plane of the sky that could be interpreted in terms of jet precession. The outflow shows a steepening mass spectrum with increasing flow velocities. The high-velocity gas in IRAS 20126+4104 contributes significantly to the energy and momentum of the flow.

Accepted by A&A

Discovery of a Planetary-Mass Brown Dwarf with a Circumstellar Disk

K. L. Luhman[1], Luca Adame[2], Paola D'Alessio[3], Nuria Calvet[4], Lee Hartmann[4], S. T. Megeath[5] and G. G. Fazio[5]

[1] Department of Astronomy and Astrophysics, The Pennsylvania State University, University Park, PA 16802, USA
[2] Instituto de Astronomía, UNAM, Apartado Postal 70-264, Ciudad Universitaria, México DF, CP 04510, México
[3] Centro de Radioastronomía y Astrofísica, UNAM, Apartado Postal 72-3 (Xangari), Morelia, Michoacán, CP 58089, México
[4] Department of Astronomy, The University of Michigan, 500 Church Street, 830 Dennison Building, Ann Arbor, MI 48109, USA
[5] Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA

E-mail contact: kluhman@astro.psu.edu, adamel@astroscu.unam.mx, p.dalessio@astrosmo.unam.mx, ncalve@umich.edut, lhartm@umich.edu, tmegeath@cfa.harvard.edu, gfazio@cfa.harvard.edu

Using the *Hubble Space Telescope*, the 4 m Blanco Telescope at the Cerro Tololo Inter-American Observatory, and the *Spitzer Space Telescope*, we have performed deep imaging from 0.8 to 8 μm of the southern subcluster in the Chamaeleon I star-forming region. In these data, we have discovered an object, Cha 110913-773444, whose colors and magnitudes are indicative of a very low mass brown dwarf with a circumstellar disk. In a near-infrared spectrum of this source obtained with the Gemini Near-Infrared Spectrograph, the presence of strong steam absorption confirms its late-type nature ($\geq$M9.5) while the shapes of the $H-$ and $K-$band continua and the strengths of the Na I and K I lines demonstrate that it is a young, pre-main-sequence object rather than a field dwarf. A comparison of the bolometric luminosity of Cha 110913-773444 to the luminosities predicted by the evolutionary models of Chabrier & Baraffe and Burrows and coworkers indicates a mass of $8^{+7}_{-3} M_J$, placing it fully within the mass range observed for extrasolar planetary companions ($M \leq 15 M_J$). The spectral energy distribution of this object exhibits mid-infrared excess emission at $\lambda > 5\mu$m, which we have successfully modeled in terms of an irradiated viscous accretion disk with $\dot{M} \leq 10^{-12} M_\odot yr^{-1}$. Cha 110913-773444 is now the least massive brown dwarf observed to have a circumstellar disk,

and indeed is one of the least massive free-floating objects found to date. These results demonstrate that the raw materials for planet formation exist around free-floating planetary-mass bodies.

Published by The Astrophysical Journal (Vol. 635, p. L93)

Alignment of Outflows with Magnetic Fields in Cloud Cores

Tomoaki Matsumoto[1], Takeshi Nakazato[2,3] and Kohji Tomisaka[4]

[1] Department of Humanity and Environment, Hosei University, Fujimi, Chiyoda-ku, Tokyo 102-8160, Japan
[2] National Astronomical Observatory, Mitaka, Tokyo 181-8588, Japan
[3] Institut de Radioastronomie Millimétrique, 300 rue de la Piscine, 38406 Saint Martin d'Hères, France
[4] Division of Theoretical Astrophysics, National Astronomical Observatory, Mitaka, Tokyo 181-8588, Japan

E-mail contact: matsu@i.hosei.ac.jp

We estimate the polarized thermal dust emission from MHD simulations of protostellar collapse and outflow formation in order to investigate alignment of outflows with magnetic fields. The polarization maps indicate that alignment of an outflow with the magnetic field depends on the field strength inside the cloud core; the direction of the outflow, projected on the plane of the sky, is aligned preferentially with the mean polarization vector for a cloud core with a magnetic field strength of 80 μG, while it does not tend to be aligned for 50 μG as long as the 1000 AU scale is considered. The direction of the magnetic field at the cloud center is probed by the direction of the outflow. In addition, the magnetic field at the cloud center can be revealed by *ALMA* even when the source is embedded deeply in the envelope. The Chandrasekhar-Fermi formula is examined using the polarization maps, indicating that the field strength predicted by the formula should be corrected by a factor of $0.24 - 0.44$. The correction factor has a tendency to be lower for a cloud core with a weaker magnetic field.

Accepted by ApJ Letters

`http://meric.i.hosei.ac.jp/~matsu/polari06/`

Dead zones and extrasolar planetary properties

Soko Matsumura[1] and Ralph E. Pudritz[1,2]

[1] Department of Physics and Astronomy, McMaster University, 1280 Main Street West, Hamilton, ON, Canada L8S 4M1
[2] Origins Institute, ABB 241, McMaster University, 1280 Main Street West, Hamilton, ON, Canada L8S 4M1

E-mail contact: soko@physics.mcmaster.ca, pudritz@physics.mcmaster.ca

Most low-mass protostellar discs evolve in clustered environments where they are affected by external radiation fields, while others evolve in more isolated star-forming regions. Assuming that the magnetorotational instability (MRI) is the main source of viscosity, we calculate the size of a poorly ionized, MRI inactive and hence low viscosity region–the 'dead zone'–in these protostellar discs. We include disc ionization by X-rays, cosmic rays, radioactive elements and thermal collisions, recombination by molecules, metals and grains, as well as the effect of turbulence stimulation in the dead zone by the active layers lying above it. We also calculate the gap-opening masses of planets, which are determined by a disc's viscosity and a disc aspect ratio, for discs in these environments and compare them with each other.

We find that the dead zone is a robust feature of the protostellar discs that is largely independent of their environment, typically stretching out to ~ 15 au. We analyse the possible effects of dead zones on planet formation, migration and eccentricity evolution. We show that the gap-opening mass inside the dead zone is expected to be of the order of terrestrial and ice giant mass planets while that outside the dead zone is Jovian or super-Jovian mass planets, largely independent of the star-forming environment. We show that dead zones can significantly slow down both type I and type II planetary migration due to their lower viscosity. We also find that the growth of eccentricity of massive extrasolar planets is particularly favourable through the planet-disc interaction inside the dead zones due to the large gaps expected to be opened by planets.

Published by Monthly Notices of the Royal Astronomical Society (Vol. 365, p. 572)

Investigating Disk Evolution: A High Spatial Resolution Mid-Infrared Survey of T Tauri Stars

C. McCabe[1,2], A. M. Ghez[1,4], L. Prato[1,5], G. Duchêne[1,6], R. S. Fisher[7] and C. Telesco[8]

[1] Department of Physics and Astronomy, UCLA, Box 951547, Knudsen Hall, Los Angeles, CA 90095-1547, USA
[2] Current address: NASA Jet Propulsion Laboratory, California Institute of Technology, MS 183-900, 4800 Oak Grove Drive, Pasadena, CA 91109-8099, USA
[4] Inst. of Geophysics and Planetary Physics, University of California, 1156 High Street, Santa Cruz, CA 95064, USA
[5] Current address: Lowell Observatory, 1400 West Mars Hill Road, Flagstaff, AZ 86001, USA
[6] Current address: Laboratoire d'Astrophysique, Observatoire de Grenoble, Universite Joseph Fourier, BP 53, F-38041 Grenoble Cedex 9, France
[7] Gemini Observatory, 670 North A'ohoku Place, Hilo, HI 96720, USA
[8] Department of Astronomy, University of Florida, P.O. Box 112055, 211 Bryant Space Science Center, Gainesville, FL 32611, USA

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

We present a high spatial resolution, $10-20\mu$m survey of 65 T Tauri binary stars in Taurus, Ophiuchus, and Corona Australis using the Keck 10 m telescopes. Designed to probe the inner $\sim$ 1 AU region of the circumstellar disks around the individual stellar components in these binary systems, this study increases the number of binaries with spatially resolved measurements at 10 μm by a factor of $\sim$ 5. Combined with resolved near-infrared photometry and spectroscopic accretion diagnostics, we find that $\sim$ 10% of stars with a mid-infrared excess do not appear to be accreting. In contrast to an actively accreting disk system, these passive disks have significantly lower near-infrared colors that are, in most cases, consistent with photospheric emission, suggesting the presence of an inner disk hole. In addition, there appears to be a spectral type/mass dependence associated with the presence of a passive disk, with all passive disks occurring around M-type stars. The presence of a passive disk does not appear to be related to the fact that these objects are in visual binary systems; the passive disk systems span the entire range of binary separations present in the sample, and a similar fraction of passive disks is observed in a sample of single stars. The possibility that the passive disks are caused by the presence of an as yet undetected companion at a small separation ($0.3-3$ AU) is possible for any individual system; however, it cannot account for the spectral type dependence of the passive disk sample as a whole. We propose that these passive disks represent a subset of T Tauri stars that are undergoing significant disk evolution. The fraction of observed passive disks and the observed spectral type dependence can both be explained by models of disk evolution that include disk photoevaporation from the central star.

Published by The Astrophysical Journal (Vol. 636, p. 932)

Using near-IR spectroscopy to classify substellar candidates in the Trapezium Cluster

G. Meeus[1] and M.J. McCaughrean[2]

[1] Astrophysikalisches Institut Potsdam, An der Sternwarte 16, 14482 Potsdam, Germany
[2] School of Physics, University of Exeter, Stocker Road, Exeter EX4 4QL, UK

E-mail contact: gwendolyn@aip.de

We discuss the use of near-IR spectroscopy to confirm young substellar candidates that were selected by photometry. We first review near-IR spectroscopic methods used to classify young brown dwarf candidates. In a subsequent part, we present ISAAC/VLT photometric and spectroscopic data of substellar candidates in the Trapezium Cluster. These data will be used to derive the effective temperature and reddening of the objects. We create a grid of synthetic spectra from Allard et al. 2000 with different degrees of reddening and compare those with our spectra, assuming a gravity of $\log g = [3.5, 4.0]$, which is typical for young objects. The best fitting reddened synthetic spectrum gives us the most likely effective temperature and extinction for our sources. Next, we compare the temperature derived from dereddening the objects towards a 1 Myr isochrone in a colour-magnitude diagram with the one obtained by fitting synthetic atmosphere models to the spectra, and show what effect the differences have when deriving the masses of the objects (under the assumption of an age of 1 Myr).

Published by Astronomische Nachrichten (Astronomical Notes), Vol. 326, Issue 10, p.977

http://www3.interscience.wiley.com/cgi-bin/abstract/112210538/ABSTRACT

The 10 μm amorphous silicate feature of fractal aggregates and compact particles with complex shapes

M. Min[1], C. Dominik[1], J. W. Hovenier[1], A. de Koter[1] and L. B. F. M. Waters[1]

[1] Astronomical Institute Anton Pannekoek, Univ. of Amsterdam, Kruislaan 403, Amsterdam, The Netherlands

E-mail contact: mmin@science.uva.nl

We model the 10 μm absorption spectra of nonspherical particles composed of amorphous silicate. We consider two classes of particles, compact ones and fractal aggregates composed of homogeneous spheres. For the compact particles we consider Gaussian random spheres with various degrees of non-sphericity. For the fractal aggregates we compute the absorption spectra for various fractal dimensions. The 10 μm spectra are computed for ensembles of these particles in random orientation using the well-known Discrete Dipole Approximation. We compare our results to spectra obtained when using volume equivalent homogeneous spheres and to those computed using a porous sphere approximation. We conclude that, in general, nonspherical particles show a spectral signature that is similar to that of homogeneous spheres with a smaller material volume. This effect is overestimated when approximating the particles by porous spheres with the same volume filling fraction. For aggregates with fractal dimensions typically predicted for cosmic dust, we show that the spectral signature characteristic of very small homogeneous spheres (with a volume equivalent radius $r_V \leq 0.5\mu$m) can be detected even in very large particles. We conclude that particle sizes are underestimated when using homogeneous spheres to model the emission spectra of astronomical sources. In contrast, the particle sizes are severely overestimated when using equivalent porous spheres to fit observations of 10m silicate emission.

Published by Astronomy & Astrophysics (Vol. 445, p. 1005)

Jupiter's obliquity and a long-lived circumplanetary disk

Ignacio Mosqueira[1] and Paul R. Estrada[2]

[1] NASA Ames/SETI Institute, Mail Stop 245-3, Moffett Field, CA 94035, USA
[2] NASA Ames Research Center, Mail Stop 245-3, Moffett Field, CA 94035, USA

E-mail contact: mosqueir@cosmic.arc.nasa.gov, estrada@cosmic.arc.nasa.gov

It has been claimed [Canup, R.M., Ward, W.R., 2002. Astron. J. 124, 3404-3423; Ward, W.R., 2003. In: AGU, Fall Meeting 2003] that a long-lived minimum mass circumplanetary gas disk is inconsistent with Jupiter's low obliquity. Here we find that while Jupiter's obliquity may constrain its characteristics it does not rule out a long-lived massive (compared to the mass of the Galilean satellites) disk. This is because the argument assumes a Solar System much like that of the present day with the one exception of a circumjovian disk which is then allowed to dissipate on a long timescale (10^6-10^7 yr). Given that the sequence of events in Solar System history that fit known constraints is non-unique, we choose for the sake of clarity of exposition the orbital architecture framework of Tsiganis et al. [Tsiganis, K., Gomes, R., Morbidelli, A., Levison, H.F., 2005. Nature 435, 459-461], in which Jupiter and Saturn were once in compact, nearly coplanar orbits, and show that in this case Jupiter's low obliquity is consistent with the SEMM (solids-enhanced minimum mass) satellite formation model of Mosqueira and Estrada [Mosqueira, I., Estrada, P.R., 2003a. Icarus 163, 198-231; Mosqueira, I., Estrada, P.R., 2003b. Icarus 163, 232-255]. We suggest that a low inclination starting condition may apply, but stress that our SEMM satellite formation model could be compatible with Jupiter's obliquity even for mutually inclined giant planets.

Published by Icarus (Vol. 180, p. 93)

Observational Constraints on the Ages of Molecular Clouds and the Star-Formation Timescale: Ambipolar-Diffusion–Controlled or Turbulence-Induced Star Formation?

T. Ch. Mouschovias[1], K. Tassis[2] and M. W. Kunz[1]

[1] University of Illinois at Urbana-Champaign
[2] University of Chicago

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

We revisit the problem of the star formation timescale and the ages of molecular clouds. The apparent overabundance of star-forming molecular clouds over clouds without active star formation has been thought to indicate that molecular clouds are "short-lived" and that star formation is "rapid". We show that this statistical argument lacks

self-consistency and, even within the rapid star-formation scenario, implies cloud lifetimes ≈ 10 Myr. We discuss additional observational evidence from external galaxies that indicate lifetimes of molecular clouds and a timescale of star formation of $\approx 10^7$. These long cloud lifetimes in conjunction with the rapid (≈ 1 Myr) decay of supersonic turbulence present severe difficulties for the scenario of turbulence-controlled star formation. By contrast, we show that all 31 existing observations of objects for which the linewidth, the size, and the magnetic field strength have been reliably measured are in excellent *quantitative* agreement with the predictions of the ambipolar-diffusion theory. Within the ambipolar-diffusion-controlled star formation theory the linewidths may be attributed to large-scale non-radial cloud oscillations (essentially standing large-amplitude, long-wavelength Alfvén waves), and the predicted relation between the linewidth, the size, and the magnetic field is a natural consequence of magnetic support of self-gravitating clouds.

Accepted by ApJ

astro-ph/0512043

Dust Size Growth and Settling in a Protoplanetary Disk

Hideko Nomura[1] **and Yoshitsugu Nakagawa**[1]

[1] Department of Earth and Planetary Sciences, Kobe University, Kobe 657-8501, Japan

E-mail contact: hnomura@kobe-u.ac.jp

We have studied dust evolution in a quiescent or turbulent protoplanetary disk by numerically solving coagulation equation for settling dust particles, using the minimum mass solar nebular model. As a result, if we assume an ideally quiescent disk, the dust particles settle toward the disk midplane to form a gravitationally unstable layer within 2×10^3–4×10^4yr at 1–30 AU, which is in good agreement with an analytic calculation by Nakagawa, Sekiya, & Hayashi (1986) although they did not take into account the particle size distribution explicitly. In an opposite extreme case of a globally turbulent disk, on the other hand, the dust particles fluctuate owing to turbulent motion of the gas and most particles become large enough to move inward very rapidly within 70–3×10^4yr at 1–30 AU, depending on the strength of turbulence. Our result suggests that global turbulent motion should cease for the planetesimal formation in protoplanetary disks.

Accepted by ApJ

http://arxiv.org/abs/astro-ph/0601013

Crystalline silicates in comets: How did they form?

Joseph A. Nuth III[1] **and Natasha M. Johnson**[1,2]

[1] Astrochemistry Lab, NASA's Goddard Space Flight Center, Code 691, Greenbelt, MD 20771, USA
[2] NAS/NRC Resident Research Associate, NASA's Goddard Space Flight Center, Greenbelt, MD 20771, USA

E-mail contact: joseph.a.nuth@nasa.gov

Two processes have been proposed to explain observations of crystalline silicate minerals in comets and in protostellar sources, both of which rely on the thermal annealing of amorphous grains. First, high temperatures generated by nebular shock processes can rapidly produce crystalline magnesium silicate grains and will simultaneously produce a population of crystalline iron silicates whose average grain size is $\sim 10 - 15\%$ that of the magnesium silicate minerals. Second, exposure of amorphous silicate grains to hot nebular environments can produce crystalline magnesium silicates that might then be transported outward to regions of comet formation. At the higher temperatures required for annealing amorphous iron silicates to crystallinity the evaporative lifetime of the grains is much shorter than a single orbital period where such temperatures are found in the nebula. Thermal annealing is therefore unable to produce crystalline iron silicate grains for inclusion into comets unless such grains are very quickly transported away from the hot inner nebula. It follows that observation of pure crystalline magnesium silicate minerals in comets or protostars is a direct measure of the importance of simple thermal annealing of grains in the innermost regions of protostellar nebulae followed by dust and gas transport to the outer nebula. The presence of crystalline iron silicates would signal the action of transient processes such as shock heating that can produce crystalline iron, magnesium and mixed iron-magnesium silicate minerals. These different scenarios result in very different predictions for the organic content of protostellar systems.

Published by Icarus (Vol. 180, p. 243)

A Mid-Infrared Study of the Class 0 Cluster in LDN 1448

JoAnn C. O'Linger[1], David M. Cole[2], Michael E. Ressler[2] and Grace Wolf-Chase[3,4]

[1] Spitzer Science Center, California Institute of Technology
[2] Jet Propulsion Laboratory
[3] University of Chicago
[4] Adler Planetarium

E-mail contact: joanno@ipac.caltech.edu

We present ground-based mid-infrared observations of Class 0 protostars in LDN 1448. Of the five known protostars in this cloud, we detected two, L1448N:A and L1448C, at 12.5, 17.9, 20.8, and 24.5 μm, and a third, L1448 IRS 2, at 24.5 μm. We present high-resolution images of the detected sources, and photometry or upper limits for all five Class 0 sources in this cloud. With these data, we are able to augment existing spectral energy distributions (SEDs) for all five objects and place them on an evolutionary status diagram.

Accepted by The Astronomical Journal

http://arxiv.org/abs/astro-ph/0512541

Encounter-Triggered Disc Mass Loss in the ONC

C. Olczak[1], S. Pfalzner[1] and R. Spurzem[2]

[1] I. Physikalisches Institut, University of Cologne, Germany
[2] Astronomisches Rechen-Institut, Zentrum für Astronomie, Univ. Heidelberg, Germany

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

The relevance of encounters on the destruction of protoplanetary discs in the Orion Nebula Cluster (ONC) is investigated by combining two different types of numerical simulation. First, star-cluster simulations are performed to model the stellar dynamics of the ONC, the results of which are used to investigate the frequency of encounters, the mass ratio and separation of the stars involved, and the eccentricity of the encounter orbits. The results show that interactions that could influence the star-surrounding disc are more frequent than previously assumed in the core of the ONC, the so-called Trapezium cluster. Second, a parameter study of star-disc encounters is performed to determine the upper limits of the mass loss of the discs in encounters. For simulation times of $\sim$1-2 Myr (the likely age of the ONC) the results show that gravitational interaction might account for a significant disc mass loss in dense clusters. Disc destruction is dominated by encounters with high-mass stars, especially in the Trapezium cluster, where the fraction of discs destroyed due to stellar encounters can reach 10-15%. These estimates are in accord with observations of (Lada et al. 2000) who determined a stellar disc fraction of 80-85%. Thus, it is shown that in the ONC - a typical star-forming region - stellar encounters do have a significant effect on the mass of protoplanetary discs and thus affect the formation of planetary systems.

Accepted by ApJ

astro-ph/0601166

Molecular hydrogen formation on porous dust grains

Hagai B. Perets[1] and Ofer Biham[2]

[1] Center for Astrophysics, Weizmann Institute of Science, Rehovot 76100, Israel
[2] Racah Institute of Physics, The Hebrew University, Jerusalem 91904, Israel

E-mail contact: biham@phys.huji.ac.il

Recent laboratory experiments on interstellar dust analogues have shown that H_2 formation on dust-grain surfaces is efficient in a range of grain temperatures below 20 K. These results indicate that surface processes may account for the observed H_2 abundance in cold diffuse and dense clouds. However, high abundances of H_2 have also been observed in warmer clouds, including photon-dominated regions (PDRs), where grain temperatures may reach 50 K, making the surface processes extremely inefficient. It was suggested that this apparent discrepancy can be resolved by chemisorption sites. However, recent experiments indicate that chemisorption processes may not be efficient at PDR

temperatures. Here we consider the effect of grain porosity on H_2 formation, and analyse it using a rate-equation model. It is found that porosity extends the efficiency of the recombination process to higher temperatures. This is because H atoms that desorb from the internal surfaces of the pores may re-adsorb many times and thus stay longer on the surface. However, this porosity-driven extension may enable efficient H_2 formation in PDRs only if porosity also contributes to significant cooling of the grains, compared to non-porous grains.

Published by Monthly Notices of the Royal Astronomical Society (Vol. 365, p. 801)

Discovery of two new methanol masers in NGC7538, Location of massive protostars

Michele Pestalozzi[1], Vincent Minier[2], Frederique Motte[3] and John Conway[4]

[1] University of Hertfordshire, UK
[2] Service d'astrophysique, Saclay, Paris, France
[3] CNRS, Paris, France
[4] Onsala Space Observatory, Sweden

E-mail contact: michele.pestalozzi@gmail.com

Context: NGC 7538 is known to host a 6.7 and 12.2 GHz methanol maser cospatial with a Ultra Compact (UC) HII region, IRS 1.

Aims: We report on the serendipitous discovery of two additional 6.7 GHz methanol masers in the same region, not associated with IRS 1.

Methods: Interferometry maser positions are compared with recent single-dish and interferometry continuum observations.

Results: The positions of the masers agree to high accuracy with the 1.2 mm continuum peak emission in NGC 7538 IRS 9 and NGC 7538 S. This clear association is also confirmed by the positional agreement of the masers with existing high resolution continuum observations at cm and/or mm wavelengths.

Conclusions: Making use of the established strong relation between methanol masers and high-mass star formation, we claim that we have accurately positioned the high-mass protostars within the regions where they are detected. The variety of objects hosting a 6.7 GHz methanol maser in NGC 7538 shows that this emission probably traces different evolutionary stages within the protostellar phase.

Accepted by Astronomy and Astrophysics

astro-ph/0601419

Cluster Origin of the Triple Star HD 188753 and Its Planet

Eric Pfahl

Kavli Institute for Theoretical Physics, Kohn Hall, University of California, Santa Barbara, Santa Barbara, CA 93106-4030, USA

E-mail contact: pfahl@kitp.ucsb.edu

The recent discovery by M. Konacki of a "hot Jupiter" in the hierarchical triple star system HD 188753 challenges established theories of giant planet formation. If the orbital geometry of the triple has not changed since the birth of the planet, then a disk around the planetary host star would probably have been too compact and too hot for a Jovian planet to form by the core accretion model or gravitational collapse. This paradox is resolved if the star was initially either single or had a much more distant companion. It is suggested here that a close multistar dynamical encounter transformed this initial state into the observed triple, an idea that follows naturally if HD 188753 formed in a moderately dense stellar system–perhaps an open cluster–that has since dissolved. Three distinct types of encounters are investigated. The most robust scenario involves an initially single planetary host star that changes places with the outlying member of a preexisting hierarchical triple.

Published by The Astrophysical Journal (Vol. 635, p. L89)

Propeller-driven Outflows and Disk Oscillations

M. M. Romanova[1], G. V. Ustyugova[2], A. V. Koldoba[3] and R. V. E. Lovelace[4]

[1] Department of Astronomy, Cornell University, Ithaca, NY 14853-6801, USA
[2] Keldysh Institute of Applied Mathematics, Russian Academy of Sciences, Moscow, Russia
[3] Institute of Mathematical Modeling, Russian Academy of Sciences, Moscow, Russia
[4] Departments of Astronomy, and Applied and Engineering Physics, Cornell University, Ithaca, NY 14853-6801, USA

E-mail contact: romanova@astro.cornell.edu, ustyugg@spp.Keldysh.ru, koldoba@spp.Keldysh.ru, RVL1@cornell.edu

We report the discovery of propeller-driven outflows in axisymmetric magnetohydrodynamic simulations of disk accretion to rapidly rotating magnetized stars. Matter outflows in a wide cone and is centrifugally ejected from the inner regions of the disk. Closer to the axis there is a strong, collimated, magnetically dominated outflow of energy and angular momentum carried by the open magnetic field lines from the star. The "efficiency" of the propeller may be very high in the respect that most of the incoming disk matter is expelled from the system in winds. The star spins down rapidly due to the magnetic interaction with the disk through closed field lines and with the corona through open field lines. Diffusive and viscous interaction between the magnetosphere and the disk are important: no outflows were observed for very small values of the diffusivity and viscosity. These simulation results are applicable to the early stages of evolution of classical T Tauri stars (CTTSs) and to different stages of evolution of cataclysmic variables and neutron stars in binary systems. As an example, we show that young rapidly rotating magnetized CTTSs spin down to their present slow rotation in less than 10^6 yr.

Published by The Astrophysical Journal (Vol. 635, p. L165)

On the properties of fractal cloud complexes

Néstor Sánchez[1,2], Emilio J. Alfaro[1] and Enrique Pérez[1]

[1] Instituto de Astrofísica de Andalucía, Granada, Spain
[2] Universidad del Zulia, Maracaibo, Venezuela

E-mail contact: nestor@iaa.es

We study the physical properties derived from interstellar cloud complexes having a fractal structure. We first generate fractal clouds with a given fractal dimension and associate each clump with a maximum in the resulting density field. Then, we discuss the effect that different criteria for clump selection has on the derived global properties. We calculate the masses, sizes and average densities of the clumps as a function of the fractal dimension (D_f) and the fraction of the total mass in the form of clumps (ϵ). In general, clump mass does not fulfill a simple power law with size of the type $M_{cl} \sim R_{cl}^{\gamma}$, instead the power changes, from $\gamma \simeq 3$ at small sizes to $\gamma < 3$ at larger sizes. The number of clumps per logarithmic mass interval can be fitted to a power law $N_{cl} \sim M_{cl}^{-\alpha_M}$ in the range of relatively large masses, and the corresponding size distribution is $N_{cl} \sim R_{cl}^{-\alpha_R}$ at large sizes. When all the mass is forming clumps ($\epsilon = 1$) we obtain that as D_f increases from 2 to 3 α_M increases from ~ 0.3 to ~ 0.6 and α_R increases from ~ 1.0 to ~ 2.1. Comparison with observations suggests that $D_f \simeq 2.6$ is roughly consistent with the average properties of the ISM. On the other hand, as the fraction of mass in clumps decreases ($\epsilon < 1$) α_M increases and α_R decreases. When only $\sim 10\%$ of the complex mass is in the form of dense clumps we obtain $\alpha_M \simeq 1.2$ for $D_f = 2.6$ (not very different from the Salpeter value 1.35), suggesting this a likely link between the stellar initial mass function and the internal structure of molecular cloud complexes.

Accepted by The Astrophysical Journal

http://arxiv.org/abs/astro-ph/0512243

A rotating disk around the very young massive star AFGL 490

K. Schreyer[1], D. Semenov[2], Th. Henning[2] and J. Forbrich[1,3]

[1] Astrophysikalisches Institut und Universitaetssternwarte, Schillergaesschen 2–3, D–07745, Jena, Germany
[2] Max–Planck–Institut fuer Astronomie, Koenigstuhl 17, D–69117 Heidelberg, Germany
[3] Max–Planck–Institut fuer Radioastronomie Bonn, Auf dem Huegel 69, D-53121 Bonn, Germany

E-mail contact: martin@astro.uni-jena.de

We observed the embedded, young 8–10 $M_\odot$ star AFGL 490 at subarcsecond resolution with the Plateau de Bure Interferometer in the $C^{17}O$ (2–1) transition and found convincing evidence that AFGL 490 is surrounded by a rotating disk. Using two-dimensional modeling of the physical and chemical disk structure coupled to line radiative transfer, we constrain its basic parameters. We obtain a relatively high disk mass of 1 $M_\odot$ and a radius of $\sim$ 1 500 AU. A plausible explanation for the apparent asymmetry of the disk morphology is given.

Accepted by ApJL

astro-ph/0601270

An X-ray Observation of the L1251 Dark Cloud

Theodore Simon[1]

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

An X-ray image of the L1251 dark cloud in Cepheus was obtained with the XMM-Newton telescope. More than three dozen sources were detected above a 3σ limit in X-ray luminosity of $L_X = 10^{29.0}$ ergs s^{-1}. Among the detections are eight optically visible T Tauri stars, which had been identified in earlier work from their emission at Hα. The two strongest X-ray sources have steady luminosities of $L_X \sim 10^{31}$ ergs s^{-1} and are at the saturation limit for X-ray activity in late-type stars, $L_X/L_{bol} \sim 10^{-3}$. X-ray emission was also observed from two CO emission cores in L1251, core C (L1251A) and core E (L1251B). Both regions contain high-velocity molecular gas, bright IRAS sources (Class I protostars), thermal radio sources, and Herbig-Haro (HH) jets. In L1251A strong X-ray emission was discovered in close proximity to the near-infrared and radio source IRS A/VLA 7 and to IRAS 22343+7501. IRS A/VLA 7 thus appears to be the most likely source of the molecular and HH outflows in L1251A. In L1251B X-ray emission was observed from a visible T Tauri star, KP2-44, which is thought to be the driving source for HH 189. Also reported is the tentative detection of X-ray emission from VLA 3, a thermal radio continuum source in L1251B that is closely associated with the extreme Class I protostar IRAS 22376+7455.

Published by The Astronomical Journal (Vol. 131, p. 501)

Subaru IR Echelle Spectroscopy of Herbig-Haro Driving Sources I. H_2 and [Fe II] Emission

M. Takami[1,2], **A. Chrysostomou**[2], **T.P. Ray**[3], **C.J. Davis**[4], **W.R.F. Dent**[5], **J. Bailey**[6], **M. Tamura**[7], **H. Terada**[1] **and T.S. Pyo**[1]

[1] Subaru Telescope, 650 North A'ohoku Place, Hilo, Hawaii 96720, USA
[2] Centre for Astrophysics Research, University of Hertfordshire, Hatfield, HERTS AL10 9AB, UK
[3] School of Cosmic Physics, Dublin Institute for Advanced Studies, 5 Merrion Square, Dublin 2, Ireland
[4] Joint Astronomy Centre, 660 North A'ohoku Place, University Park, Hilo, Hawaii 96720, USA
[5] UK Astronomy Technology Centre, Royal Observatory, Blackford Hill, Edinburgh EH9 3HJ, UK
[6] Australian Centre for Astrobiology, Macquarie University, NSW 2109, Australia
[7] National Astronomical Observatory of Japan, Osawa, Mitaka, Tokyo 181-8588, Japan

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

We present infrared echelle spectroscopy of three Herbig-Haro (HH) driving sources (SVS 13, B5-IRS 1 and HH 34 IRS) using Subaru-IRCS. The large diameter of the telescope and wide spectral coverage of the spectrograph allowed us to detect several H_2 and [Fe II] lines in the H- and K-bands. These include H_2 lines arising from v=1–3 and J=1–11, and [Fe II] lines with upper level energies of $E/k = 1.1 - 2.7 \times 10^4$ K. For all objects the outflow is found to have two velocity components: (1) a high-velocity (-70 to -130 km s^{-1}) component (HVC), seen in [Fe II] or H_2 emission and associated with a collimated jet; and (2) a low-velocity (-10 to -30 km s^{-1}) component (LVC), which is seen in H_2 emission only and is spatially more compact. Such a kinematic structure resembles optical forbidden emission line outflows associated with classical T Tauri stars, whereas the presence of H_2 emission reflects the low-excitation nature of the outflowing gas close to these protostars. The observed H_2 flux ratios indicate a temperature of $2 - 3 \times 10^3$ K, and a gas density of 10^5 cm^{-3} or more, supporting shocks as the heating mechanism. B5-IRS 1 exhibits faint extended emission associated with the H_2-LVC, in which the radial velocity slowly increases with distance from the protostar (by $\sim$ 20 km s^{-1} at $\sim$ 500 AU). This is explained as warm molecular gas entrained by an unseen wide-angled wind. The [Fe II] flux ratios indicate electron densities to be $\sim 10^4$ cm^{-3} or greater, similar to forbidden line outflows associated

with classical T Tauri stars. Finally the kinematic structure of the [Fe II] emission associated with the base of the B5-IRS 1 and HH 34 IRS outflows is shown to support disk-wind models.

Accepted by Astrophys. J.

astro-ph/0512268

Imaging studies of NGC 3372, the Carina nebula – II. Evidence of activity in the complex Tr 14/Car I photodissociation region

M. Tapia[1], P. Persi[2], J. Bohigas[1], M. Roth[3], and M. Gómez[4]

[1]Instituto de Astronomía UNAM, Apdo. Postal 877, 22800 Ensenada, BC, Mexico
[2]Istituto Nazionale di Astrofisica - IASF, Via del Foso del Cavaliere, I-00133, Roma, Italy
[3]Las Campanas Observatory, Carnegie Institution of Washington, Casilla 601, La Serena, Chile
[4]Observatorio Astronómico de Córdoba, Laprida 854, 5000 Córdoba, Argentina

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

We present the results of an imaging survey, from the optical to the mid-infrared, of the dark cloud associated with Car I, a dense cloud that is subject to an intense ultraviolet radiation field from the rich stellar cluster Trumpler 14. New ground-based broad- and narrow-band near-infrared and narrow-band optical images are analyzed in combination with archived *Spitzer* IRAC images to study this photodissociation region and the triggering of a new generation of stars within the cloud, particularly close to its edges. Evidence is given of a clumpy morphology of the dense cloud. The ionization/dissociation front is delineated at the edges of theses clumps. The existence of a number of embedded low- to intermediate-mass pre-main sequence objects is confirmed by their considerable infrared excesses arising from discs and/or detectable X-ray emission. Most of the young stellar objects are located on or just behind ionization fronts, though a few are also outside the cloud. The infrared properties of the young stellar objects are discussed. Two Class I objects stand out, one of them is an FU Orionis system candidate that had an outburst of more than three magnitudes in K between 1993 and 2003, with further evidence that it occurred in the 2000 to 2002 period. Molecular hydrogen line filamentary emission behind the Balmer and Brackett lines along the ionization front is seen delineating the edges of the dense cloud. This emission is also seen in all IRAC images. The diffuse, filamentary emission is very similar in all four 3.6, 4.5, 5.8 and 8 μm bands, though there seem to be subtle differences. Across a bright section of the ionization/dissociation front, we found that, within the observational uncertainties, the maximum emission in all 4 IRAC channels coincides with that of H_2 2.12 μm. The western, embedded, dissociation front close to the CO peak (Car I-W) is seen delineated by a bright, long bar of emission in the 3 - 12 μm images, in the *MSX* bands A and C and also in radio continuum and hydrogen line emission. These occur in the vicinity of a region of previously reported strong [CI], [CII], and [OI] emission, tracers of photodissociation regions. A few bright, compact knots of H_2 emission, some possibly associated with [SII] emission, are found within the cloud. These may be shock-excited.

Accepted by MNRAS

The thermodynamics of collapsing molecular cloud cores using smoothed particle hydrodynamics with radiative transfer

Stuart C. Whitehouse[1] and Matthew R. Bate[1]

[1] School of Physics, University of Exeter, Stocker Road, Exeter EX4 4QL

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

We present the results of a series of calculations studying the collapse of molecular cloud cores performed using a three-dimensional smoothed particle hydrodynamics code with radiative transfer in the flux-limited diffusion approximation. The opacities and specific heat capacities are identical for each calculation. However, we find that the temperature evolution during the simulations varies significantly when starting from different initial conditions. Even spherically symmetric clouds with different initial densities show markedly different development. We conclude that simple barotropic equations of state like those used in some previous calculations provide at best a crude approximation to the thermal behaviour of the gas. Radiative transfer is necessary to obtain accurate temperatures.

Accepted by MNRAS

http://xxx.lanl.gov/abs/astro-ph/0511671

Large Scale CO Observations of a Far-Infrared Loop in Pegasus; Detection of a Large Number of Very Small Molecular Clouds Possibly Formed via Shocks

Hiroaki Yamamoto[1], Akiko Kawamura[1], Kengo Tachihara[2], Norikazu Mizuno[1], Toshikazu Onishi[1] and Yasuo Fukui[1]

[1] Department of Astrophysics, Nagoya University, Chikusa-ku, Nagoya, Japan 464-8602
[2] Graduate School of Science and Technology, Kobe University, 1-1 Rokko-dai, Nada-ku, Kobe, Japan

E-mail contact: hiro@a.phys.nagoya-u.ac.jp

We have carried out large scale CO observations with a mm/sub-mm telescope NANTEN toward a far infrared loop-like structure whose angular extent is about 20×20 degrees around (l, b) ∼ (109°, −45°) in Pegasus. Its diameter corresponds to ∼ 25 pc at a distance of 100 pc, adopted from that of a star HD886 (B2IV) near the center of the loop. We covered the loop-like structure in the ^{12}CO (J = 1–0) emission at 4′–8′ grid spacing and in the ^{13}CO (J = 1–0) emission at 2′ grid spacing for the ^{12}CO emitting regions. The ^{12}CO distribution is found to consist of 78 small clumpy clouds whose masses range from 0.04 $M_\odot$ to 11 $M_\odot$, and ∼ 83% of the ^{12}CO clouds have very small masses less than 1.0 $M_\odot$. ^{13}CO observations revealed that 18 of the 78 ^{12}CO clouds show significant ^{13}CO emission. ^{13}CO emission was detected in the region where the column density of H_2 derived from ^{12}CO is greater than 5×10^{20} cm^{-2}, corresponding to Av of ∼ 1 mag, which takes into account that of H I. We find no indication of star formation in these clouds in IRAS Point Source Catalog and 2MASS Point Source Catalog. The very low mass clouds, $M \leq 1M_\odot$, identified are unusual in the sense that they have very weak ^{12}CO peak temperature of 0.5 K–2.7 K and that they aggregate in a region of a few pc with no main massive clouds; contrarily to this, similar low mass clouds less than 1 $M_\odot$ in other regions previously observed including those at high Galactic latitude are all associated with more massive main clouds of ∼ 100 $M_\odot$. A comparison with a theoretical work on molecular cloud formation (Koyama & Inutsuka 2002) suggests that the very low-mass clouds may have been formed in the shocked layer through the thermal instability. The star HD886 (B2IV) may be the source of the mechanical luminosity via stellar winds to create shocks, forming the loop-like structure where the very low-mass clouds are embedded.

Accepted by Astrophysical Journal

http://www.a.phys.nagoya-u.ac.jp/~hiro/paper/YamamotoHLC.pdf

Spitzer and Magellan Observations of NGC 2264: A Remarkable Star Forming Core near IRS-2

E.T. Young[1], P.S.Teixeira[2,3], C.J. Lada[2], J. Muzerolle[1], S.E. Persson[4], D.C. Murphy[4], N. Siegler[1], M. Marengo[2], O. Krause[1], & A.K. Mainzer[5]

[1] Steward Observatory, University of Arizona, 933 N Cherry Ave., Tucson AZ 85721, USA
[2] Harvard-Smithsonian Center for Astrophysics, 60 Garden St., Cambridge MA 02138, USA
[3] Dept. de Física, Faculdade de Ciências de Universidade de Lisboa, Lisbon, Portugal
[4] Observatories of the Carnegie Institution of Washington, 813 Santa Barbara St, Pasadena, CA 91101, USA
[5] Jet Propulsion Laboratory, Caltech, 4800 Oak Grove Dr., Pasadena CA 91109, USA

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

We analyze *Spitzer* and Magellan observations of a star forming core near IRS-2 in the young cluster NGC 2264. The submillimeter source IRAS 12 S1, previously believed to be an intermediate mass Class 0 object is shown to be a dense collection of embedded, low mass stars. We argue that this group of stars represents the fragmenting collapse of a dense, turbulent core, based on a number of indicators of extreme youth. With reasonable estimates for the velocity dispersion in the group, we estimate a dynamical lifetime of only a few x 10^4 years. Spectral energy distributions of stars in the core are consistent with Class I or Class 0 assignments. We present observations of an extensive system of molecular hydrogen emission knots. The luminosity of the objects in the core region are consistent with roughly solar mass protostars.

Accepted by Ap. J.

astro-ph/0601300

Meetings

Science with ALMA: A New Era for Astrophysics

13 - 16 November 2006
Madrid, Spain

Currently under construction in the Andean Altiplano, Northern Chile, the Atacama Large Millimeter Array (ALMA) is an international radio interferometer with about 7000 m2 of collecting area comprised of 64 12-m antennas. Initially covering the most interesting spectral wavelength ranges from 3 to 0.3 mm, ALMA will be a revolutionary telescope providing astronomy with the first detailed view of the dark and youngest objects of the Universe.

The scientific preparations for ALMA are being extremely active since the birth of the project. The various science committees, groups of astronomers working for ALMA, and regional communities interested in the project meet regularly to exchange ideas about the scientific capabilities and first observations to be carried out with the interferometer. A first world-wide conference on "Science with the Atacama Large Millimeter Array" took place in Washington, D.C. (USA), on 6-8 October 1999.

The conference to be held in Madrid (Spain), on 13-16 November 2006, will be the second world-wide meeting on "Science with the Atacama Large Millimeter Array". This international ALMA conference is envisioned as a way for the astronomers interested on ALMA, not necessarily radioastronomers, to exchange views, to plan preparatory observations in view of the scientific exploitation of the interferometer, and to obtain the information needed to orient their scientific work to the best possible use of ALMA.

The conference will cover a wide range of topics, which will indeed include the main scientific drivers of ALMA: the formation and evolution of galaxies, the physics and chemistry of the interstellar medium, and the processes of star and planet formation.

The web page for the symposium is **http://www.oan.es/alma2006/**

Preliminary Registration for IoA Conference 2006: The Planet-Disc Connection

As previously announced, the Institute of Astronomy, Cambridge, is hosting the Conference "The Planet-Disc Connection" from 17-21 July 2006 (see **http://www.ast.cam.ac.uk/meetings/discs06/** for details)

At this stage, we are requesting PRELIMINARY REGISTRATION, in which you are invited to fill out the web form at the above address. The results of this process will be used to allocate contributed talks and to assess accommodation requirements. A further registration call (confirming accommodation requests etc.) will follow.

The deadline for preliminary registration is 15th FEBRUARY 2006. Please email discs06@ast.cam.ac.uk with any queries.

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.

New Jobs

PhD Studentships in Star or Planet Formation

The Astrophysics Group at the University of Exeter has 6 PhD studentships to fill, beginning October 2006. British applicants are elligible for any of the positions, but some of the positions do not require British or EU citizenship. Therefore, we encourage applications from candidates worldwide. Potential projects include observational studies (particularly at optical, infrared, and (sub-)millimetre wavelengths) of galactic and extragalactic star formation, binary stars and brown dwarfs, protoplanetary discs, molecular clouds, and high-redshift galaxies. Theoretical studies include hydrodynamical and radiative transfer numerical simulations of star and planet formation.

Those interested in applying should contact Matthew Bate (mbate@astro.ex.ac.uk) and/or visit our web site (http://www.astro.ex.ac.uk/).

Star Formation Theory in the Berkeley Astronomy Department

A two-year postdoctoral appointment has just opened up in the Berkeley Astronomy Department to work with Al Glassgold and Joan Najita (NOAO) on modeling the inner disks of protoplanetary disks. The focus of the research would be the development of the physics and chemistry of models and on the interpretation of the observations. Additional opportunities will be available in the theory of star formation and related topics.

Please submit your CV (with publications and research plans, current and future) by February 28,2006 if possible, and also ask that two or three letters of support be sent, all by email.

Al Glassgold, Astronomy Department, University of California, 601 Campbell Hall, Berkeley, CA 94720, USA phone 510 642-6708, fax 510 642-3411, aglassgold@astron.berkeley.edu

Post-Doctoral Fellowship on Star Formation at High Redshift University College London

A 3 years Leverhulme-supported position for a postdoctoral research assistantship is available, to work on a programme involving both theoretical and observational aspects of the study of massive star formation in high redshift galaxies. The programme is highly interdisciplinary and the PDRA, working together with Dr Viti, Dr Rawlings, Prof Williams and Prof Lahav, will be involved in the development and application of chemical models, as well as in observations of molecular emission from high redshift galaxies.

The PDRA will interact with members of the star formation group as well as the cosmology group. Candidates should have a background in computational modelling in molecular astrophysics, and preferably also in extragalactic observations and galaxy formation, with a strong interest in star-formation studies.

Prospective applicants are encouraged to make informal contact with Dr. Serena Viti (sv@star.ucl.ac.uk; +44-(0)20-7679-3435)

Applications, accompanied by a CV, list of publications and a statement of research interests and plans, plus full contact details of three referees, should be sent to Mrs Christine Johnson, Department of Physics and Astronomy, University College London, Gower Street, London WC1E 6BT, UK (email: christine.johnston@ucl.ac.uk).

The application form may be downloaded from: **http://www.ucl.ac.uk/hr/docs/download_forms/job_app.doc** The closing date for the receipt of the applications is 28 February 2006.

Postdoctoral Research Position, University of Kentucky

Applications are invited for a postdoctoral research position in theoretical astrophysics to work with Prof. Moshe Elitzur at the University of Kentucky, Lexington, KY, USA. The start date is around September 2006. Interest in radiative processes is advantageous. Applicants should send curriculum vita, bibliography and a statement of research interests by e-mail to moshe@pa.uky.edu and arrange for three letters of recommendation to be sent the same way. The initial appointment is for one year, with an expected extension for another year. The review of applications will start at the end of February, and will be continued until the position is filled.

Postdoctoral Position in Star Formation
Dublin City University, Ireland

A post-doctoral position is available to work on a joint Dublin City University and Dublin Institute for Advanced Studies project in star formation as part of the CosmoGrid consortium (http://www.cosmogrid.ie/). Ideally, the successful candidate would have a background in astrophysical numerical simulations. Preference will be given to candidates with interests in the areas of simulations of transport in accretion disks, jet launching or multifluid phenomena. Candidates must have a PhD, or have recently submitted their thesis.

The position has a salary of 39,000 Euro per annum. This position is expected to be for two years. Application is by letter and CV naming 3 academic referees. The letter should contain a description of research interests. The closing date for applications is Friday 3rd March, 2006. Letters of application and CVs should be sent to: Dr. Turlough Downes, School of Mathematical Sciences, Dublin City University, Glasnevin, Dublin 9, Ireland.

For further details please contact Dr. Turlough Downes, School of Mathematical Sciences, Dublin City University, Glasnevin, Dublin 9, Ireland
(`turlough.downes@dcu.ie`).

Funded by the Program for Research in Third Level Institutions under the Irish National Development Plan and with assistance from the European Regional Development Fund.

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/ .

New Books

Stardust from Meteorites
An Introduction to Presolar Grains

Maria Lugaro

The detailed analysis of meteorites have revealed the presence of presolar dust grains formed in evolved stars and mixed up into the early solar nebula. The grains are identified through their anomalous isotopic compositions, which are the signatures of processes that predated the formation of the solar nebula. This is a relatively new field, less than 20 years old, yet major advances have taken place, in part due to new developments of laboratory techniques that have allowed detailed studies of increasingly small grains. The present book provides an up to date account of our knowledge of presolar grains, the techniques used to analyse them, and the nuclesynthetic processes that lead to their formation. Each chapter is followed by a section of exercises, with the results given at the end, thus making the book suitable as a textbook for a graduate course.

1. Meteoritic Presolar Grains and Their Significance
1.1 Presolar isotopic signatures and their carriers - 1.2 The discovery of presolar stellar grains - 1.3 Meteorites carrying stellar grains - 1.4 Types of presolar grains - 1.5 New information from presolar grains

2. Basics of Stellar Nuclesynthesis
2.1 Hydrogen burning, and the life of most stars - 2.2 Helium burning, and the evolution of star of low mass - 2.3 The α process: C, Ne and O burnings, and the evolution of stars of high mass - 2.4 The e process: Si burning, and supernova explosions - 2.5 The production of elements heavier than Fe - 2.6 Exercises

3. Laboratory Analysis of Presolar Grains
3.1 The isolation of diamond, graphite and SiC grains - 3.2 Looking at presolar grains - 3.3 Isotopic measurements with mass spectrometers - 3.4 Location and analysis of rare types of presolar grains 3.5 Concluding remarks - 3.6 Exercises

4. The Origin of Presolar SiC Grains
4.1 Classification of SiC grains on the basis of their C, N, and Si compositions - 4.2 Where did mainstream presolar SiC grains come from? - 4.3 Carbon and notrogen in mainstream SiC grains and in AGB stars - 4.4 The Ne-E(H) anomalous component - 4.5 The presence of of ^{26}Al - 4.6 The puzzle of the silicon isotopic composition of mainstream SiC grains - 4.7 Titanium isotopic composition of mainstream SiC grains - 4.8 A, B, X, Y and Z: The minor SiC grains populations - 4.9 Exercises

5. Heavy Elements in presolar SiC Grains
5.1 Modelling the s process in AGB stars - 5.2 SiC grain data and the s process in AGB stars - 5.3 The heavy noble gases: Kr and Xe - 5.4 Exercises

6. Diamond, Graphite and Oxide Grains
6.1 Diamond - 6.2 Graphite - 6.3 Ocide Grains - 6.4 Exercises

ISBN 981-256-099-8, hardbound, 209 pages, 2005
£23 or US$38

World Scientific Series in Astronomy and Astrophysics - Vol. 9

http://www.worldscibooks.com/physics/5705.html

The Origin of Chondrules and Chondrites

Derek Sears

Chondrites and their associated chondrules have been known and studied for a long time. This book summarizes the history of these objects and presents an overview of the great mass of facts that have been accumulated together with a summary of the large number of hypotheses for their origin. It is sobering to note that despite the enormous efforts invested, there is still no consensus on how chondrites and chondrules have formed. The author advocates that both chondrules and their chondrite hosts are impact pyroclastics formed by impacts in the asteroid belt, but he also mentions competing popular theories like the nebular shock theory and the outflow theory, among the almost two dozen theories for chondrule formation. The book provides the big picture and is written in a manner so it is accessible for researchers outside the field of meteoritics, and as such it is particularly welcome for astronomers dealing with star and planet formation who need to understand the constraints on formation processes posed by the earliest meteorites. The book ends with a 25 page bibliography that includes all important papers ever published on this subject.

ISBN 0-521-83603-4, hardbound, 209 pages, 2004
£65 or US$110

Cambridge Planetary Science – Cambridge University Press

http://www.cambridge.org/uk/catalogue/catalogue.asp?isbn=0521836034