THE STAR FORMATION NEWSLETTER

An electronic publication dedicated to early stellar evolution and molecular clouds

No. 214 — 25 Oct 2010 Editor: Bo Reipurth (reipurth@ifa.hawaii.edu)

Abstracts of recently accepted papers

Particle-gas Dynamics with Athena: Method and Convergence

Xue-Ning Bai[1] and James M. Stone[1]

[1] Deptartment of Astrophysical Sciences, Peyton Hall, Princeton University, Princeton, NJ, 08544, USA

E-mail contact: xbai *at* astro.princeton.edu

The Athena magnetohydrodynamics code has been extended to integrate the motion of particles coupled with the gas via aerodynamic drag in order to study the dynamics of gas and solids in protoplanetary disks (PPDs) and the formation of planetesimals. Our particle-gas hybrid scheme is based on a second-order predictor corrector method. Careful treatment of the momentum feedback on the gas guarantees exact conservation. The hybrid scheme is stable and convergent in most regimes relevant to PPDs. We describe a semi-implicit integrator generalized from the leap-frog approach. In the absence of drag force, it preserves the geometric properties of a particle orbit. We also present a fully implicit integrator that is unconditionally stable for all regimes of particle-gas coupling. Using our hybrid code, we study the numerical convergence of the nonlinear saturated state of the streaming instability. We find that gas flow properties are well converged with modest grid resolution (128 cells per pressure length ?r for dimensionless stopping time $\tau_s = 0.1$) and an equal number of particles and grid cells. On the other hand, particle clumping properties converge only at higher resolutions, and finer resolution leads to stronger clumping before convergence is reached. Finally, we find that the measurement of particle transport properties resulted from the streaming instability may be subject to error of about ±20%.

Accepted by ApJS

http://adsabs.harvard.edu/abs/2010ApJS..190..297B

Dynamics of Solids in the Midplane of Protoplanetary Disks: Implications for Planetesimal Formation

Xue-Ning Bai[1] and James M. Stone[1]

[1] Deptartment of Astrophysical Sciences, Peyton Hall, Princeton University, Princeton, NJ, 08544, USA

E-mail contact: xbai *at* astro.princeton.edu

We present local two-dimensional and three-dimensional hybrid numerical simulations of particles and gas in the midplane of protoplanetary disks (PPDs) using the Athena code. The particles are coupled to gas aerodynamically, with particle-to-gas feedback included. Magnetorotational turbulence is ignored as an approximation for the dead zone of PPDs, and we ignore particle self-gravity to study the precursor of planetesimal formation. Our simulations include a wide size distribution of particles, ranging from strongly coupled particles with dimensionless stopping time $\tau_s \equiv \Omega t_{\rm stop} = 10^{-4}$ (where Ω is the orbital frequency, $t_{\rm stop}$ is the particle friction time) to marginally coupled ones with $\tau_s = 1$, and a wide range of solid abundances. Our main results are as follows. (1) Particles with $\tau_s \geq 10^{-2}$ actively participate in the streaming instability (SI), generate turbulence, and maintain the height of the particle layer before Kelvin-Helmholtz instability is triggered. (2) Strong particle clumping as a consequence of the SI occurs when a substantial fraction of the solids are large ($\tau_s \geq 10^{-2}$) and when height-integrated solid-to-gas mass ratio Z is super-solar. We construct a toy model to offer an explanation. (3) The radial drift velocity is reduced relative to the conventional Nakagawa-Sekiya-Hayashi (NSH) model, especially at high Z. Small particles may drift outward.

We derive a generalized NSH equilibrium solution for multiple particle species which fits our results very well. (4) Collision velocity between particles with $\tau_s \geq 10^{-2}$ is dominated by differential radial drift, and is strongly reduced at larger Z. This is also captured by the multi-species NSH solution. Various implications for planetesimal formation are discussed. In particular, we show that there exist two positive feedback loops with respect to the enrichment of local disk solid abundance and grain growth. All these effects promote planetesimal formation.

Accepted by ApJ

http://adsabs.harvard.edu/abs/2010ApJ...722.1437B

The Effect of the Radial Pressure Gradient in Protoplanetary Disks on Planetesimal Formation

Xue-Ning Bai[1] and James M. Stone[1]

[1] Deptartment of Astrophysical Sciences, Peyton Hall, Princeton University, Princeton, NJ, 08544, USA

E-mail contact: xbai *at* astro.princeton.edu

The streaming instability provides a promising mechanism for planetesimal formation because of its ability to concentrate solids into dense clumps. The degree of clumping strongly depends on the height-integrated solid to gas mass ratio Z in protoplanetary disks. In this Letter, we show that the magnitude of the radial pressure gradient that drives the streaming instability (characterized by $\Pi \equiv \eta v_K/c_s$, where ηv_K is the reduction of Keplerian velocity due to the radial pressure gradient and c_s is the sound speed) also strongly affects clumping. We present local two-dimensional hybrid numerical simulations of aerodynamically coupled particles and gas in the midplane of protoplanetary disks. Magnetic fields and particle self-gravity are ignored. We explore three different radial pressure gradient values appropriate for typical protoplanetary disks: $\Pi = 0.025$, 0.05, and 0.1. For each Π value, we consider four different particle size distributions ranging from submillimeter to meter sizes and run simulations with solid abundance from Z = 0.01 up to Z = 0.07. We find that a small radial pressure gradient strongly promotes particle clumping in that: (1) at fixed particle size distribution, the critical solid abundance $Z_{\rm crit}$ above which particle clumping occurs monotonically increases with Π and (2) at fixed Z, strong clumping can occur for smaller particles when Π is smaller. Therefore, we expect planetesimals to form preferentially in regions of protoplanetary disks with a small radial pressure gradient.

Accepted by ApJL

http://adsabs.harvard.edu/abs/2010ApJ...722L.220B

Rotating toroids in G10.62−0.38, G19.61−0.23, and G29.96−0.02

M. T. Beltrán[1], R. Cesaroni[1], R. Neri[2], and C. Codella[1]

[1] INAF-Osservatorio Astrofisico di Arcetri, Largo E. Fermi 5, 50125 Firenze, Italy
[2] IRAM, 300 Rue de la Piscine, F-38406 Saint Martin d'Hères, France

E-mail contact: mbeltran *at* arcetri.astro.it

Context. In recent years, we have detected clear evidence of rotation in more than 5 hot molecular cores (HMCs). Their identification is confirmed by the fact that the rotation axes are parallel to the axes of the associated bipolar outflows. We have now pursued our investigation by extending the sample to 3 known massive cores, G10.62−0.38, G19.61−0.23, and G29.96−0.02.
Aims. We wish to make a thorough study of the structure and kinematics of HMCs and corresponding molecular outflows to reveal possible velocity gradients indicative of rotation of the cores.
Methods. We carried out PdBI observations at 2.7 and 1.4 mm of gas and dust with angular resolutions of $\sim 2''$–$3''$ and $\sim 1''$–$2''$, respectively. To trace both rotation and expansion, we simultaneously observed CH_3CN, a typical HMC tracer, and ^{13}CO, a typical outflow tracer.
Results. The CH_3CN (12–11) observations reveal clear velocity gradients in the three HMCs oriented perpendicular to the direction of the bipolar outflows. For G19 and G29 the molecular outflows are mapped in ^{13}CO. The gradients have been interpreted as rotating toroids. The rotation temperatures, used to derive the mass of the cores, have been obtained by means of the rotational diagram method, and lie in the range of 87–244 K. The diameters and masses of the toroids lie in the range of 4550–12600 AU and 28–415 $M_\odot$, respectively. Given that the dynamical masses are 2 to 30 times lower than those of the cores (if the inclination of the toroids with respect to the plane of the sky is

not much below 45°), we suggest that the toroids could be accreting onto the embedded cluster. For G19 and G29, the collapse is also suggested by the redshifted absorption seen in the ^{13}CO (2–1) line. We infer that infall onto the embedded (proto)stars must proceed with rates of $\sim 10^{-2}$ $M_{\odot}$ yr^{-1} and on timescales of $\sim 4\times10^{3}$–10^{4} yr. The infall rates derived for G19 and G29 are two orders of magnitude greater than the accretion rates indirectly estimated from the mass loss rate of the corresponding outflows. This suggests that the material in the toroids is not infalling onto a single massive star, which is responsible for the corresponding molecular outflow, but onto a cluster of stars. you write which journal accepted your paper, for example:

Accepted by A&A

http://arxiv.org/abs/1010.0843

Chemical pattern across the young associations ONC and OB1b

Katia Biazzo[1], Sofia Randich[1] and Francesco Palla[1]

[1] INAF - Osservatorio Astrofisico di Arcetri, Largo E. Fermi 5, 50125 Firenze, Italy

E-mail contact: kbiazzo *at* arcetri.astro.it

Abundances of iron-peak and alpha-elements are poorly known in Orion, and the available measurements yield contradictory results.

We aim to measure accurate and homogeneous elemental abundances of the Orion sub-groups ONC and OB1b, and to look for abundance differences across the Orion complex.
We present FLAMES/UVES spectroscopic observations of a sample of 20 members of the ONC and OB1b. We measured radial velocity, veiling, effective temperature through two spectroscopic methods, and determined chemical abundance of Fe, Na, Al, Si, Ca, Ti, and Ni using the code MOOG. We also performed a new consistent analysis of spectra previously analyzed by our group.
We find three new binaries in the ONC, two in OB1b, and three non-members in OB1b (two of them are most likely OB1a/25 Ori members). Veiling affects only one target in the ONC, and the effective temperatures derived using two spectroscopic techniques agree within the errors. The ONC and OB1b are characterized by a small scatter in iron abundance, with mean [Fe/H] values of -0.11+/-0.08 and -0.05+/-0.05, respectively. Small scatter in all the other elemental abundances is also found. We confirm P1455 as a metal-rich star in the ONC.
We conclude that the Orion metallicity is not above the solar value. The OB1b group might be slightly more metal-rich than the ONC; on the other hand, the two sub-groups share similar solar abundance of iron-peak and alpha-elements with high degree of homogeneity.

Accepted by Astronomy and Astrophysics

ftp://ftp.arcetri.astro.it/pub/outgoing/katia/Biazzoetal_accepted.ps

Heavy water around the L1448-mm protostar

C. Codella[1], C. Ceccarelli[2], B. Nisini[3], R. Bachiller[4], J. Cernicharo[5], F. Gueth[6], A. Fuente[4], B. Lefloch[2]

[1] INAF, Osservatorio Astrofisico di Arcetri, Firenze, Italy
[2] Laboratoire d'Astrophysique de Grenoble, UMR 5571-CNRS, Université Joseph Fourier, Grenoble, France
[3] INAF, Osservatorio Astronomico di Roma, via di Frascati 33, 00040 Monteporzio Catone, Italy
[4] Observatorio Astrónomico Nacional (IGN), Alfonso XII, E-28014 Madrid, Spain
[5] Laboratory of Molecular Astrophysics, CAB (CSIC-INTA), Crta Ajalvir km 4, E-28840 Madrid, Spain
[6] IRAM, 300 Rue de la Piscine, F-38406 Saint Martin d'Hères, France

E-mail contact: codella *at* arcetri.astro.it

Context: L1448-mm is the prototype of a low-mass Class 0 protostar driving a high-velocity jet. Given its bright H_2O spectra observed with ISO, L1448-mm is an ideal laboratory to observe heavy water (HDO) emission.
Aims: Our aim is to image the HDO emission in the protostar surroundings, the possible occurrence of HDO emission also investigating off L1448-mm, towards the molecular outflow.
Methods: We carried out observations of L1448-mm in the HDO(1_{10}–1_{11}) line at 80.6 GHz, an excellent tracer of HDO column density, with the IRAM Plateau de Bure Interferometer.

Results: We image for the first time HDO emission around L1448-mm. The HDO structure reveals a main clump at velocities close to the ambient one towards the the continuum peak that is caused by the dust heated by the protostar. In addition, the HDO map shows tentative weaker emission at $\simeq$ 2000 AU from the protostar towards the south, which is possibly associated with the walls of the outflow cavity opened by the protostellar wind.
Conclusions: Using an LVG code, modelling the density and temperature profile of the hot-corino, and adopting a gas temperature of 100 K and a density of 1.5×10^8 cm^{-3}, we derive a beam diluted HDO column density of $\sim 7 \times 10^{13}$ cm^{-2}, corresponding to a HDO abundance of $\sim 4 \times 10^{-7}$. In addition, the present map supports the scenario where HDO can be efficiently produced in shocked regions and not uniquely in hot corinos heated by the newly born star.

Accepted by A&A Letters

www.arcetri.astro.it/∼codella/papers/codella-hdo.ps.gz

Pre-Main Sequence stars in the star forming complex Sh 2-284

F. Cusano[1], V. Ripepi[1], J. M. Alcalá[1], D. Gandolfi[2], M. Marconi[1], S. Degl'Innocenti[3,4], F. Palla[5], E. W. Guenther[6], S. Bernabei[7], E. Covino[1], C. Neiner[8], E. Puga[9,10] and S. Hony[11]

[1] INAF-Osservatorio Astronomico di Capodimonte, Salita Moiariello16, 80131 - Napoli, Italy
[2] Research and Scientific Support Department, ESTEC/ESA, PO Box 299, 2200 AG Noordwijk, The Netherlands
[3] Dipartimento di Fisica, Università di Pisa, Largo B. Pontecorvo 3, 56126 Pisa, Italy
[4] INFN, Sezione di Pisa, Largo B. Pontecorvo 3, 56126 Pisa, Italy
[5] INAF-Osservatorio Astrofisico di Arcetri, Largo E. Fermi, 5, I-50125, Firenze, Italy
[6] Thüringer Landessternwarte Tautenburg, Sternwarte 5, D - 07778, Tautenburg, Germany
[7] INAF-Osservatorio Astronomico di Bologna, Via Ranzani 1, 40127 Bologna, Italy
[8] GEPI, UMR 8111 du CNRS, 5 place Jules Janssen, 92195 Meudon Cedex, France
[9] Katholieke Universiteit Leuven, Celestijnenlaan 200D, 3001 Leuven, Belgium
[10] Centro de Astrobiología (CSIC-INTA), Ctra. de Torrejón km-4,E28850, Torrejón de Ardoz, Madrid, Spain
[11] CEA Saclay, Bat.609 Orme des Merisiers, 91191 Gif-sur-Yvette, France

E-mail contact: fcusano *at* na.astro.it

Located at the galactic anticenter, Sh 2-284 is a HII region which harbors several young open clusters; Dolidze 25, a rare metal poor (Z∼0.004) young cluster, is one of these. Given its association with Sh 2-284, it is reasonable to assume the low metallicity for the whole HII region. Sh 2-284 is expected to host a significant population of Pre-Main Sequence (PMS) stars of both low and intermediate mass stars (Herbig Ae stars). We aim at characterizing these stars by means of a spectroscopic and photometric survey conducted with VIMOS@VLT and complemented with additional optical and infrared observations. In this survey we selected and characterized 23 PMS objects. We derived the effective temperature, the spectral energy distribution and luminosity of these objects; using theoretical PMS evolutionary tracks, with the appropriate metallicity, we estimated the mass and the age of the studied objects. We also estimated a distance of 4 Kpc for Sh 2-284 by using spectroscopic parallax of 3 OB stars. From the age determination we concluded that triggered star formation is in act in this region. Our results show that a significant fraction of the young stellar objects (YSOs) may have preserved their disk/envelopes, in contrast with what is found in other recent studies of low-metallicity star forming regions in the Galaxy. Finally, among the 23 bona fide PMS stars, we identified 8 stars which are good candidates to pulsators of the δ Scuti type.

Accepted by MNRAS

http://arxiv.org/abs/1009.0435

Averting the magnetic braking catastrophe on small scales: disk formation due to Ohmic dissipation

Wolf B. Dapp[1] and Shantanu Basu[1]

[1] Department of Physics & Astronomy, The University of Western Ontario, 1151 Richmond St., London, ON, Canada, N6A 3K7

E-mail contact: wdapp *at* uwo.ca

We perform axisymmetric resistive MHD calculations that demonstrate that centrifugal disks can indeed form around

Class 0 objects despite magnetic braking. We follow the evolution of a prestellar core all the way to near-stellar densities and stellar radii. Under flux-freezing, the core is braked and disk formation is inhibited, while Ohmic dissipation renders magnetic braking ineffective within the first core. In agreement with observations that do not show evidence for large disks around Class 0 objects, the resultant disk forms in close proximity to the second core and has a radius of only $\approx 10\ R_{\odot}$ early on. Disk formation does not require enhanced resistivity. We speculate that the disks can grow to the sizes observed around Class II stars over time under the influence of both Ohmic dissipation and ambipolar diffusion, as well as internal angular momentum redistribution.

Accepted by A&A Letters

A study of three southern high-mass star-forming regions

C. Dedes[1,2], S. Leurini[2,3], F. Wyrowski[2], P. Schilke[4], K. M. Menten[2], S. Thorwirth[4] and J. Ott[5]

[1] Institute for Astronomy, ETH Zurich
[2] Max-Planck-Institut fuer Radioastronomie
[3] ESO Garching
[4] 1. Physikalisches Institut, Universitaet zu Koeln
[5] NRAO, Socorro

E-mail contact: carolin.dedes *at* astro.phys.ethz.ch

Based on color-selected IRAS point sources, we have started to conduct a survey of 47 high-mass star-forming regions in the southern hemisphere in 870um dust continuum and molecular line emission in several frequency ranges between 290 GHz and 806 GHz. This paper describes the pilot study of the three sources IRAS12326-6245, IRAS16060-5146, and IRAS16065-5158. To characterize the physical and chemical properties of southern massive star-forming regions, three high-luminosity southern hemisphere hot cores are observed in continuum and molecular line emission. Based on the results obtained in the three sources, which served as templates for the survey, the most promising (and feasible) frequency setups for the remaining 44 sources were decided upon. The sources were observed with the Atacama Pathfinder EXperiment (APEX) in five frequency setups aimed at groups of lines from the following molecules: CH3OH, H2CO, and CH3CN. Using the LTE approximation, temperatures, source sizes, and column densities were determined through modeling of synthetic spectra with the XCLASS program. Dust continuum observations were done with the Large APEX BOlometer CAmera (LABOCA) at 870um and the 3mm continuum was imaged with the Australia Telescope Compact Array (ATCA). Based on the detection of high-excitation CH3CN lines and lines from complex organic species, the three sources are classified as line rich, hot core type sources. For all three, the modeling indicates that the line emission emerges from a combination of an extended, cooler envelope, and a hot compact component. All three sources show an overabundance of oxygen-bearing species compared to nitrogen-bearing species. While the chemistry in the three sources indicates that they are already in an evolved stage, the non-detection of infrared heating sources at the dust continuum peak of IRAS16065-5158 points to this source still being deeply embedded. Because this work served as a pilot study, the approach to observe the remaining 44 massive star-forming regions was chosen based on its results. The three sources are massive, luminous hot cores. While IRAS16065-5158 seems to be a very young deeply embedded object, IRAS12326-6245 and IRAS16060-5146 seem more evolved and have already developed UCHII regions.

Accepted by Astronomy and Astrophysics

http://arxiv.org/pdf/1010.3868

A gallery of bubbles - The nature of the bubbles observed by Spitzer and what ATLASGAL tells us about the surrounding neutral material

L. Deharveng[1], F. Schuller[2], L.D. Anderson[1], A. Zavagno[1], F. Wyrowski[2], K.M. Menten[2], L. Bronfman[3], L. Testi[4], C.M. Walmsley[5], M. Wienen[2]

[1] Laboratoire d'Astrophysique de Marseille (UMR 6110 CNRS & Université de Provence), 38 rue F. Joliot-Curie, 13388 Marseille Cedex 13, France
[2] Max-Planck Institut für Radioastronomie
[3] Departamento de Astronomia, Universidad de Chile, Casilla 36-D, Santiago, Chile [4] ESO, Karl Schwarzschild-Strasse 2, D-85748 Garching bei München, Germany [5] Osservatorio Astrofisico di Arcetri, Largo E. Fermi, 5, I-50125

Firence, Italy

E-mail contact: lise.deharveng *at* oamp.fr

Context This study deals with infrared bubbles, the H II regions they enclose, and triggered massive-star formation on their borders.
Aims We attempt to determine the nature of the bubbles observed by Spitzer in the Galactic plane, mainly to establish if possible their association with massive stars. We take advantage of the very simple morphology of these objects to search for star formation triggered by H II regions, and to estimate the importance of this mode of star formation.
Methods We consider a sample of 102 bubbles detected by Spitzer-GLIMPSE, and catalogued by Churchwell et al. (2006; hereafter CH06). We use mid-infrared and radio-continuum public data (respectively the Spitzer-GLIMPSE and -MIPSGAL surveys and the MAGPIS and VGPS surveys) to discuss their nature. We use the ATLASGAL survey at 870 μm to search for dense neutral material collected on their borders. The 870 μm data traces the distribution of cold dust, thus of the dense neutral material where stars may form.
Results We find that 86% of the bubbles contain ionized gas detected by means of its radio-continuum emission at 20-cm. Thus, most of the bubbles observed at 8.0 μm enclose H II regions ionized by O-B2 stars. This finding differs from the earlier CH06 results ($\sim$25% of the bubbles enclosing H II regions). Ninety-eight percent of the bubbles exhibit 24 μm emission in their central regions. The ionized regions at the center of the 8.0 μm bubbles seem to be devoid of PAHs but contain hot dust. PAH emission at 8.0 μm is observed in the direction of the photodissociation regions surrounding the ionized gas.
Among the 65 regions for which the angular resolution of the observations is high enough to resolve the spatial distribution of cold dust at 870 μm, we find that 40% are surrounded by cold dust, and that another 28% contain interacting condensations. The former are good candidates for the collect and collapse process, as they display an accumulation of dense material at their borders. The latter are good candidates for the compression of pre-existing condensations by the ionized gas. Thirteen bubbles exhibit associated ultracompact H II regions in the direction of dust condensations adjacent to their ionization fronts. Another five show methanol masers in similar condensations.
Conclusions Our results suggest that more than a quarter of the bubbles may have triggered the formation of massive objects. Therefore, star formation triggered by H II regions may be an important process, especially for massive-star formation.

Accepted by A&A.

available on astro-ph: http://arxiv.org/abs/1008.0926

Near-IR H2 Emission of Protostars: Probing Circumstellar Environments

Tom Greene[1], Mary Barsony[2,3] and David A. Weintraub[4]

[1] NASA Ames Research Center, MS 245-6, Moffett Field, CA 94035 USA
[2] Department of Physics and Astronomy, San Francisco State University, 1600 Holloway Drive, San Francisco, CA 94132 USA
[3] Space Science Institute, 4750 Walnut Street, Suite 205, Boulder, CO 80301 USA
[4] Department of Physics and Astronomy, Vanderbilt University, Nashville, TN 37235 USA

E-mail contact: tom.greene *at* nasa.gov

We present new observations of near-infrared molecular hydrogen (H_2) line emission in a sample of 18 Class I and flat-spectrum low mass protostars, primarily in the Tau-Aur and ρ Oph dark clouds. The line emission is extended by up to several arcseconds (several hundred AU) for most objects, and there is little night-to-night variation in line strength coincident with the continuum point source. Flux ratios of H_2 $v = 2-1$ $S(1)$ and $v = 1-0$ $S(1)$ lines are consistent with this emission arising in jets or winds in many objects. However, most objects have only small offsets (under 10 km s^{-1}) between their H_2 and photospheric radial velocities. No objects have line ratios which are clearly caused solely by UV excitation, but the H_2 emission of several objects may be caused by UV or X-ray excitation in the presence of circumstellar dust. There are several objects in the sample whose observed velocities *and* line fluxes suggest quiescent, non-mechanical origins for their molecular hydrogen emissions. Overall we find the H_2 emission properties of these protostars to be similar to the T Tauri stars studied in previous surveys.

Accepted by The Astrophysical Journal

http://arxiv.org/abs/1010.2174

A candidate protostellar object in the L 1457 / MBM 12 cloud

Andreas Heithausen[1], Christoph Böttner[2]

[1] Institut für integrierte Naturwissenschaften, Abteilung Physik, Universität Koblenz-Landau, Universitätsstr. 1, 56070 Koblenz, Germany

[2] Radioastronomisches Institut, Universität Bonn, Auf dem Hügel 71, 53121 Bonn, Germany

E-mail contact: heithausen *at* uni-koblenz.de

The association of young T Tauri stars, MBM 12A, indicates that L 1457 was forming stars not too long ago. With our study we want to find out whether or not there are still signs for ongoing star formation in that cloud. Using the Max-Planck-Millimeter-Bolometer MAMBO at the IRAM 30m telescope we obtained a map of about $8' \times 8'$ centered on L 1457 in the dust continuum emission at 230 GHz. Towards the most intense regions in our bolometer map we obtained spectra at high angular resolution in the CS ($2 \rightarrow 1$) and the N_2H^+ ($1 \rightarrow 0$) lines using the IRAM 30m telescope. We find that the cold dust in L 1457 is concentrated in several small cores with high H_2 column densities and solar masses. The density profiles of the cores are inconsistent with a sphere with constant density. These cores are closer to virial equilibrium than the cloud as a whole. Data from the VLA and Spitzer archives reveal two point sources in the direction of one dust core. One of the sources is probably a distant quasar, whereas the other source is projected right on a local maximum of our dust map and shows characteristics of a protostellar object.

Accepted by Astron. Astroph

http://arxiv.org/abs/1010.0543

The Effects of Metallicity, and Grain Growth and Settling on the Early Evolution of Gaseous Protoplanets

Ravit Helled[1] and Peter Bodenheimer[2]

[1] Department of Earth and Space Sciences, University of California, Los Angeles, CA 90095 1567, USA

[2] Department of Astronomy and Astrophysics,UCO/ Lick Observatory, University of California, Santa Cruz, CA 95064, USA

E-mail contact: r.helled *at* gmail.com

Giant protoplanets formed by gravitational instability in the outer regions of circumstellar disks go through an early phase of quasi-static contraction during which radii are large ($\sim$ 1 AU) and internal temperatures are low ($<$ 2000 K). The main source of opacity in these objects is dust grains. We investigate two problems involving the effect of opacity on the evolution of isolated, non-accreting planets of 3, 5, and 7 M_J. First, we pick three different overall metallicitiesfor the planet and simply scale the opacity accordingly. We show that higher metallicity results in slower contraction as a result of higher opacity. It is found that the pre-collapse time scale is proportional to the metallicity. In this scenario, survival of giant planets formed by gravitational instability is predicted to be more likely around low-metallicity stars, since they evolve to the point of collapse to small size on shorter time scales. But metal-rich planets, as a result of longer contraction times, have the best opportunity to capture planetesimals and form heavy-element cores. Second, we investigate the effects of opacity reduction as a result of grain growth and settling, for the same three planetary masses and for three different values of overall metallicity. When these processes are included, the pre-collapse time scale is found to be of order 1000 years for the three masses, significantly shorter than the time scale calculated without these effects. In this case the time scale is found to be relatively insensitive to planetary mass and composition. However, the effects of planetary rotation and accretion of gas and dust, which could increase the timescale, are not included in the calculation. The short time scale we find would preclude metal enrichment by planetesimal capture, as well as heavy-element core formation, over a large range of planetary masses and metallicities.

Accepted by Icarus

http://arxiv.org/abs/1005.4039

Millimeter imaging of MWC 758: probing the disk structure and kinematics

Andrea Isella[1], Antonella Natta[2], David Wilner[3], John M. Carpenter[1] and Leonardo Testi[4]

[1] Department of Astronomy, California Institute of Technology, MC 249-17, Pasadena, CA 91125, USA

[2] Osservatorio Astrofisico di Arcetri, INAF, Largo E. Fermi 5, 50125, Firenze, Italy
[3] Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, MS 42, Cambridge, MA 02138, USA
[4] European Southern Observatory, Karl Schwarzschild str. 2, D-85748 Garching, Germany

E-mail contact: isella *at* astro.caltech.edu

We investigate the structure and kinematics of the circumstellar disk around the Herbig Ae star MWC 758 using high resolution observations of the ^{12}CO (3-2) and dust continuum emission at the wavelengths of 0.87 and 3.3 mm. We find that the dust emission peaks at an orbital radius of about 100 AU, while the CO intensity has a central peak coincident with the position of the star. The CO emission is in agreement with a disk in keplerian rotation around a 2.0 $M_\odot$ star, confirming that MWC 758 is indeed an intermediate mass star. By comparing the observation with theoretical disk models, we derive that the disk surface density $\Sigma(r)$ steeply increases from 40 to 100 AU, and decreases exponentially outward. Within 40 AU, the disk has to be optically thin in the continuum emission at millimeter wavelengths to explain the observed dust morphology, though our observations lack the angular resolution and sensitivity required to constrain the surface density on these spatial scales. The surface density distribution in MWC 758 disk is similar to that of "transition" disks, though no disk clearing has been previously inferred from the analysis of the spectral energy distribution (SED). Moreover, the asymmetries observed in the dust and CO emission suggest that the disk may be gravitationally perturbed by a low mass companion orbiting within a radius of 30 AU. Our results emphasize that SEDs alone do not provide a complete picture of disk structure and that high resolution millimeter-wave images are essential to reveal the structure of the cool disk mid plane.

Accepted by ApJ

http://arxiv.org/abs/1010.3016

Origins of the H, He I, and Ca II Line Emission in Classical T Tauri Stars

John Kwan[1] and William Fischer[2]

[1] Department of Astronomy, University of Massachuetts, Amherst, MA, USA
[2] Department of Physics and Astronomy, University of Toledo, Toledo, OH, USA

E-mail contact: kwan *at* nova.astro.umass.edu

We perform local excitation calculations to obtain line opacities and emissivity ratios and compare them with observed properties of H, He I, O I, Ca II, and Na I lines to determine the density, temperature, and photon ionization rate. We find that UV photoionization is the most probable excitation mechanism for generating the He I λ10830 opacities that produce all the associated absorption features. We also calculate the specific line flux at an observed velocity of $v_{\rm obs} = \pm 150$ km s^{-1} for both radial wind and infall models. All the model results, together with observed correlations between absorption and emission features and between narrow and broad emission components, are used to deduce the origins of the strong H, He I, and Ca II broad line emission. We conclude that the first two arise primarily in a radial outflow that is highly clumpy. The bulk of the wind volume is filled by gas at a density $\sim 10^9$ cm^{-3} and optically thick to He I λ10830 and Hα, but optically thin to He I λ5876, Paγ, and the Ca II infrared triplet. The optically thick He I λ5876 emission occurs mostly in regions of density $\geq 10^{11}$ cm^{-3} and temperature $\geq 1.5 \times 10^4$ K, while the optically thick Hα and Paγ emission occur mostly in regions of density around 10^{11} cm^{-3} and temperature between 8750 and 1.25×10^4 K. In producing the observed line fluxes at a given $v_{\rm obs}$, the covering factor of these emission clumps is sufficiently small not to incur significant absorption of the stellar and veiling continua in either He I or H lines. The strong Ca II broad line emission likely arises in both the magnetospheric accretion flow and the disk boundary layer, where the gases dissipate part of their rotational energies before infalling along magnetic field lines. The needed density and temperature are $\sim 10^{12}$ cm^{-3} and ≤ 7500 K.

Accepted by MNRAS

http://arxiv.org/abs/1010.3265

High-contrast optical imaging of companions: the case of the brown dwarf binary HD 130948 BC

Lucas Labadie[1,2], Rafael Rebolo[1,6], Isidro Villo[3], Jorge Perez-Prieto[1], Antonio Perez-Garrido[3], Sergi Hildebrandt[4], Bruno Femenia[1,2], Anastasio Diaz-Sanchez[3], Victor Bejar[1,2], Alejandro Oscoz[1], Roberto Lopez[1], Jose Piqueras[5] and Luis-Fernando Rodriguez[1]

[1] Instituto de Astrofisica de Canarias, C/ Via Lactea s/n, La Laguna, Tenerife E-38200, Spain
[2] Departamento de Astrofisica, Universidad de La Laguna, 38205 La Laguna, Tenerife, Islas Canarias, Spain
[3] Universidad Politecnica de Cartagena, Campus Muralla del Mar, Cartagena, Murcia E-30202, Spain
[4] Laboratoire de Physique Subatomique et de Cosmologie, 53 Avenue des Martyrs, 38026 Grenoble, France
[5] Max-Planck-Institut fuer Sonnensystemforschung, Max-Planck-Str. 2, 37191 Katlenburg-Lindau, Germany
[6] Consejo Superior de Investigaciones Cientificas, Spain

E-mail contact: labadie *at* iac.es

High contrast imaging at optical wavelengths is limited by the modest correction of conventional near-IR optimized AO systems. We take advantage of new fast and low-readout-noise detectors to explore the potential of fast imaging coupled to post-processing techniques to detect faint companions to stars at small separations. We have focused on I-band direct imaging of the previously detected brown dwarf binary HD 130948 BC, attempting to spatially resolve the L2+L2 benchmark system. We used the Lucky-Imaging instrument FastCam at the 2.5-m Nordic Telescope to obtain quasi diffraction-limited images of HD 130948 with ~0.1" resolution. In order to improve the detectability of the faint binary in the vicinity of a bright (I = 5.19 ± 0.03) solar-type star, we implemented a post-processing technique based on wavelet transform filtering of the image which allows us to strongly enhance the presence of point-like sources in regions where the primary halo dominates. We detect for the first time the BD binary HD130948BC in the optical band I with a SNR ~ 9 at 2.561" ± 0.007" (46.5 AU) from HD 130948 A and confirm in two independent dataset that the object is real, as opposed to time-varying residual speckles. We do not resolve the binary, which can be explained by astrometric results posterior to our observations that predict a separation below the NOT resolution. We reach at this distance a contrast of ΔI = 11.30 ± 0.11, and estimate a combined magnitude for this binary to I = 16.49 ± 0.11 and a I-J colour 3.29 ± 0.13. At 1", we reach a detectability 10.5 mag fainter than the primary after image post-processing. We obtain on-sky validation of a technique based on speckle imaging and wavelet-transform processing, which improves the high contrast capabilities of speckle imaging. The I-J colour measured for the BD companion is slightly bluer, but still consistent with what typically found for L2 dwarfs (~3.4-3.6).

Accepted by Astronomy and Astrophysics

http://arxiv.org/abs/1009.5670

On the Star Formation Rates in Molecular Clouds

Charles J. Lada[1], Marco Lombardi[2] and João F. Alves[3]

[1] Smithsonian Astrophysical Observatory
[2] European Southern Observatory
[3] Institute for Astronomy, University of Vienna

E-mail contact: clada *at* cfa.harvard.edu

In this paper we investigate the level of star formation activity within nearby molecular clouds. We employ a uniform set of infrared extinction maps to provide accurate assessments of cloud mass and structure and compare these with inventories of young stellar objects within the clouds. We present evidence indicating that both the yield and rate of star formation can vary considerably in local clouds, independent of their mass and size. We find that the surface density structure of such clouds appears to be important in controlling both these factors. In particular, we find that the star formation rate (SFR) in molecular clouds is linearly proportional to the cloud mass ($M_{0.8}$) above an extinction threshold of $A_K \approx 0.8$ magnitudes, corresponding to a gas surface density threshold of $\Sigma_{gas} \approx 116$ $M_\odot$ pc^{-2}. We argue that this surface density threshold corresponds to a gas volume density threshold which we estimate to be $n(H_2) \approx 10^4$ cm^{-3}. Specifically we find SFR ($M_\odot yr^{-1}$) = $4.6 \pm 2.6 \times 10^{-8}$ $M_{0.8}$ ($M_\odot$) for the clouds in our sample. This relation between the rate of star formation and the amount of dense gas in molecular clouds appears to be in excellent agreement with previous observations of both galactic and extragalactic star forming activity. It is likely the underlying physical relationship or empirical law that most directly connects star formation activity with interstellar gas over many spatial scales within and between individual galaxies. These results suggest that the key to obtaining a predictive understanding of the star formation rates in molecular clouds and galaxies is to understand those physical factors which give rise to the dense components of these clouds.

Accepted by The Astrophysical Journal

http://arxiv.org/abs/1009.2985

A Change of Rotation Profile in the Envelope in the HH 111 Protostellar System: A Transition to a Disk?

Chin-Fei Lee[1]

[1] ASIAA, P.O. Box 23-141, Taipei 106, Taiwan

E-mail contact: cflee *at* asiaa.sinica.edu.tw

The HH 111 protostellar system consists of two Class I sources (VLA 1 and 2) with putative disks deeply embedded in a flattened envelope at a distance of 400 pc. Here is a follow-up study of this system in $C^{18}O$ (J=2-1), SO ($N_J = 5_6 - 4_5$), and 1.33 mm continuum at $\sim 1''$ (400 AU) resolution, and it may show for the first time how a rotationally supported disk can be formed inside an infalling envelope. The 1.33 mm continuum emission is seen arisen from both sources, likely tracing the dusty putative disks around them. In particular, the emission around the VLA 1 source is elongated in the equatorial plane with a radius of $\sim$ 300 AU. The envelope is well seen in $C^{18}O$, extending to $\sim$ 7000 AU out from the VLA 1 source, with the innermost part overlapping with the dusty disk. It has a differential rotation, with the outer part ($\sim$ 2000–7000 AU) better described by a rotation that has constant specific angular momentum and the inner part ($\sim$ 60–2000 AU) by a Keplerian rotation. The envelope seems to also have some infall motion that is smaller than the rotation motion. Thus, the material in the outer part of the envelope seems to be slowly spiraling inward with its angular momentum and the rotation can indeed become Keplerian in the inner part. A compact SO emission is seen around the VLA 1 source with a radius of $\sim$ 400 AU and it may trace a shock such as an (inner) accretion shock around the disk.

Accepted by The ApJ

http://arxiv.org/abs/1010.1310

Stability of Magnetized Disks and Implications for Planet Formation

Susana Lizano[1], Daniele Galli[2], Mike J. Cai[3] and Fred C. Adams[4]

[1] Centro de Radioastronomia y Astrofisica, UNAM, Apartado Postal 3-72, 58089 Morelia, Michoacan, Mexico
[2] INAF-Osservatorio Astrofisico di Arcetri, Largo Enrico Fermi 5, I-50125 Firenze, Italy
[3] Academia Sinica, Institute of Astronomy and Astrophysics, Taiwan
[4] Michigan Center for Theoretical Physics, Physics Department, University of Michigan, Ann Arbor, MI 48109

E-mail contact: s.lizano *at* crya.unam.mx

This paper considers gravitational perturbations in geometrically thin disks with rotation curves dominated by a central object, but with substantial contributions from magnetic pressure and tension. The treatment is general, but the application is to the circumstellar disks that arise during the gravitational collapse phase of star formation. We find the dispersion relation for spiral density waves in these generalized disks and derive the stability criterion for axisymmetric ($m = 0$) disturbances (the analog of the Toomre parameter Q_T) for any radial distribution of the mass-to-flux ratio λ. The magnetic effects work in two opposing directions: on one hand, magnetic tension and pressure stabilize the disk against gravitational collapse and fragmentation; on the other hand, they also lower the rotation rate making the disk more unstable. For disks around young stars the first effect generally dominates, so that magnetic fields allow disks to be stable for higher surface densities and larger total masses. These results indicate that magnetic fields act to suppress the formation of giant planets through gravitational instability. Finally, even if gravitational instability can form a secondary body, it must lose an enormous amount of magnetic flux in order to become a planet; this latter requirement represents an additional constraint for planet formation via gravitational instability and places a lower limit on the electrical resistivity.

Accepted by ApJ

http://xxx.lanl.gov/abs/1009.5717

Larson's third law and the universality of molecular cloud structure

Marco Lombardi[1], Joao Alves[2] and Charles Lada[3]

[1] University of Milan, Department of Physics, via Celoria 16, 20133 Milan, Italy
[2] University of Vienna, Tuerkenschanzstrasse 17, 1180 Vienna, Austria
[3] Harvard-Smithsonian Center for Astrophysics, Mail Stop 42, 60 Garden Street, Cambridge, MA 02138, USA

E-mail contact: mlombard *at* eso.org

Larson (1981) first noted a scaling relation between masses and sizes in molecular clouds that implies that these objects have approximately constant column densities. This original claim, based upon millimeter observations of carbon monoxide lines, has been challenged by many theorists, arguing that the apparent constant column density observed is merely the result of the limited dynamic range of observations, and that in reality clouds have column density variations over two orders of magnitudes. In this letter we investigate a set of nearby molecular clouds with near-infrared excess methods, which guarantee very large dynamic ranges and robust column density measurements, to test the validity of Larson's third law. We verify that different clouds have almost identical average column densities above a given extinction threshold; this holds regardless of the extinction threshold, but the actual average surface mass density is a function of the specific threshold used. We show that a second version of Larson's third law, involving the mass-radius relation for single clouds and cores, does not hold in our sample, indicating that individual clouds are not objects that can be described by constant column density. Our results instead indicate that molecular clouds are characterized by a universal structure. Finally we point out that this universal structure can be linked to the log-normal nature of cloud column density distributions.

Accepted by Astronomy & Astrophysics

http://de.arxiv.org/abs/1008.4251

A Widely Separated, Highly Occluded Companion to the Nearby Low-mass T Tauri Star TWA 30

Dagny L. Looper[1], John J. Bochanski[2], Adam J. Burgasser[2,3], Subhanjoy Mohanty[4], Eric E. Mamajek[5], Jacqueline K. Faherty[6,7], Andrew A. West[8] and Mark A. Pitts[1]

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

[2] MIT Kavli Institute for Astrophysics & Space Research, 77 Massachusetts Avenue, Building 37-664B, Cambridge, MA 02139, USA

[3] Center for Astrophysics and Space Science, University of California San Diego, 9500 Gilman Drive, Mail Code 0424, La Jolla, CA 92093, USA

[4] Imperial College London, 1010 Blackett Laboratory, Prince Consort Road, London, SW7 2AZ, UK

[5] Department of Physics and Astronomy, University of Rochester, P.O. Box 270171, 500 Wilson Boulevard, Rochester, NY 14627-0171, USA

[6] Department of Physics and Astronomy, Stony Brook University, Stony Brook, NY 11794-3800, USA

[7] Department of Astrophysics, American Museum of Natural History, Central Park West at 79th Street, New York, NY 10034, USA

[8] Department of Astronomy, Boston University, 725 Commonwealth Avenue, Boston, MA 02215, USA

E-mail contact: dagny *at* ifa.hawaii.edu

We report the discovery of TWA 30B, a wide (∼3400 AU), co-moving M dwarf companion to the nearby (∼42 pc) young star TWA 30. Companionship is confirmed from their statistically consistent proper motions and radial velocities (RVs), as well as a chance alignment probability of only 0.08%. Like TWA 30A, the spectrum of TWA 30B shows signatures of an actively accreting disk (H I and alkali line emission) and forbidden emission lines tracing outflowing material ([O I], [O II], [O III], [S II], and [N II]). We have also detected [C I] emission in the optical data, marking the first such detection of this line in a pre-main-sequence star. Negligible RV shifts in the emission lines relative to the stellar frame of rest ($\Delta V \leq 30$ km s^{-1}) indicate that the outflows are viewed in the plane of the sky and that the corresponding circumstellar disk is viewed edge-on. Indeed, TWA 30B appears to be heavily obscured by its disk, given that it is 5 mag fainter than TWA 30A at K band despite having a slightly earlier spectral type (M4 versus M5). The near-infrared spectrum of TWA 30B also evinces an excess that varies on day timescales, with colors that follow classical T Tauri tracks as opposed to variable reddening (as is the case for TWA 30A). Multi-epoch data show this excess to be well modeled by a black body component with temperatures ranging from 630 to 880 K and emitting areas that scale inversely with the temperature. The variable excess may arise from disk structure such as a rim or a warp at the inner disk edge located at a radial distance of ∼3-5 $R_\odot$. As the second and third closest actively accreting and outflowing stars to the Sun (after TWA 3), TWA 30AB presents an ideal system for a detailed study of star and planetary formation processes at the low-mass end of the hydrogen-burning spectrum.

Accepted by The Astronomical Journal (Volume 140, Issue 5, pp. 1486-1499, 2010)

Spectrophotometric Distances to Galactic HII Regions

Alessandro P. Moisés[1], Augusto Damineli[1], Elysandra Figuerêdo[1], Robert D. Blum[2], Peter S. Conti[3] and Cássio L. Barbosa[4]

[1] IAG-USP, Rua do Matao, 1226, 05508-090, Sao Paulo, SP Brazil
[2] NOAO, 950 N Cherry Ave., Tuczon, AZ 85719 USA
[3] JILA, University of Colorado, Boulder, CO 80309-0440, USA
[4] IP&D-UNIVAP, Av. Shishima Hifumi, 2911, 12244-000 S. J. dos Campos, SP Brazil

E-mail contact: apmoises *at* astro.iag.usp.br

We present a near infrared study of the stellar content of 35 HII regions in the Galactic plane, 24 of them have been classified as giant HII regions. We have selected these optically obscured star forming regions from the catalogs of Russeil (2003), Conti & Crowther (2004) and Bica et al. (2003). In this work, we have used the near infrared domain J, H and Ks band color images to visually inspect the sample. Also, color-color and color-magnitude diagrams were used to indicate ionizing star candidates, as well as, the presence of young stellar objects such as classical TTauri Stars (CTTS) and massive young stellar objects (MYSOs). We have obtained Spitzer IRAC images for each region to help further characterize them. Spitzer and near infrared morphology to place each cluster in an evolutionary phase of development. Spitzer photometry was also used to classify the MYSOs. Comparison of the main sequence in color-magnitude diagrams to each observed cluster was used to infer whether or not the cluster kinematic distance is consistent with brightnesses of the stellar sources. We find qualitative agreement for a dozen of the regions, but about half the regions have near infrared photometry that suggests they may be closer than the kinematic distance. A significant fraction of these already have spectrophotometric parallaxes which support smaller distances. These discrepancies between kinematic and spectrophotometric distances are not due to the spectrophotometric methodologies, since independent non-kinematic measurements are in agreement with the spectrophotometric results. For instance, trigonometric parallaxes of star-forming regions were collected from the literature and show the same effect of smaller distances when compared to the kinematic results. In our sample of Hii regions, most of the clusters are evident in the near infrared images. Finally, it is possible to distinguish among qualitative evolutionary stages for these objects.

Accepted by MNRAS

http://adsabs.harvard.edu/abs/2010arXiv1009.3924M

Spitzer spectral line mapping of protostellar outflows: II H_2 emission in L1157

Brunella Nisini[1], Teresa Giannini[1], David A. Neufeld[2], Yuan Yuan[2], Simone Antoniucci[1], Edwin A. Bergin[3] and Gary J. Melnick[4]

[1] INAF-Osservatorio Astronomico di Roma, 00040 Monte Porzio Catone, Italy [2] Department of Physics and Astronomy, John Hopkins University, 3400 North Charles Sreet, Baltimore, MF 21218, USA
[3] Department of Astronomy, University of Michigan, 500 Church Street, Ann Arbor, MI 48109-1042, USA
[4] Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA

E-mail contact: nisini *at* oa-roma.inaf.it

We present an analysis of Spitzer-IRS spectroscopic maps of the L1157 protostellar outflow in the H_2 pure-rotational lines from S(0) to S(7). The aim of this work is to derive the physical conditions pertaining to the warm molecular gas and study their variations within the flow. The mid-IR H_2 emission follows the morphology of the precessing flow, with peaks correlated with individual CO clumps and H_2 2.12 μm, ro-vibrational emission. More diffuse emission delineating the CO cavities is detected only in the low-laying transitions, with $J_{lower} \leq 2$. The H_2 line images have been used to construct 2D maps of $N(H_2)$, H_2 ortho-to-para ratio and temperature spectral index β, in the assumption of a gas temperature stratification where the H_2 column density varies as $T^{-\beta}$. Variations of these parameters are observed along the flow. In particular, the ortho-to-para ratio ranges from ∼0.6 to 2.8, highlighting the presence of regions subject to recent shocks where the ortho-to-para ratio has not had time yet to reach the equilibrium value. Near-IR spectroscopic data on ro-vibrational H_2 emission have been combined with the mid-IR data and used to derive additional shock parameters in the brightest blue- and red-shifted emission knots. A high abundance of atomic hydrogen ($H/H_2 \sim$ 0.1-0.3) is implied by the observed H_2 column densities, assuming $n(H_2)$ values as derived by independent SiO observations. The presence of a high fraction of atomic hydrogen, indicates that a partially-dissociative shock component should be considered for the H_2 excitation in these localized regions. However, planar

shock models, either of C- or J-type, are not able to consistently reproduce all the physical parameters derived from our analysis of the H_2 emission. Globally, H_2 emission contributes to about 50% of the total shock radiated energy in the L1157 outflow. We find that the momentum flux through the shocks derived from the radiated luminosity is comparable to the thrust of the associated molecular outflow, supporting the scenario where this latter is driven by the shock working surface.

Accepted by Astrophysical Journal

http://arxiv.org/abs/1009.3834

Vortex migration in protoplanetary disks

S.-J. Paardekooper[1], G. Lesur[1] and J. C. B. Papaloizou[1]

[1] DAMTP, University of Cambridge, Wilberforce Road, Cambridge CB3 0WA, UK

E-mail contact: S.Paardekooper *at* damtp.cam.ac.uk

We consider the radial migration of vortices in two-dimensional isothermal gaseous disks. We find that a vortex core, orbiting at the local gas velocity, induces velocity perturbations that propagate away from the vortex as density waves. The resulting spiral wave pattern is reminiscent of an embedded planet. There are two main causes for asymmetries in these wakes: geometrical effects tend to favor the outer wave, while a radial vortensity gradient leads to an asymmetric vortex core, which favors the wave at the side that has the lowest density. In the case of asymmetric waves, which we always find except for a disk of constant pressure, there is a net exchange of angular momentum between the vortex and the surrounding disk, which leads to orbital migration of the vortex. Numerical hydrodynamical simulations show that this migration can be very rapid, on a time scale of a few thousand orbits, for vortices with a size comparable to the scale height of the disk. We discuss the possible effects of vortex migration on planet formation scenarios.

Accepted by The Astrophysical Journal

http://arxiv.org/abs/1009.5197

The ubiquity of micrometer-sized dust grains in the interstellar medium

Laurent Pagani[1], Juergen Steinacker[1,2], Aurore Bacmann[3], Amelia Stutz[2,4] and Thomas Henning[2]

[1] LERMA & UMR8112 du CNRS, Observatoire de Paris, 61, Av. de l'Observatoire, 75014 Paris, France
[2] MPIA, Königstuhl 17, D-69117 Heidelberg, Germany
[3] LAOG & UMR5571 du CNRS, Boite Postale 53, 38041 Grenoble Cedex 09, France
[4] Department of Astronomy and Steward Observatory, University of Arizona, 933 North Cherry Avenue, Tucson, AZ 85721, USA

E-mail contact: laurent.pagani *at* obspm.fr

Cold molecular clouds are the birthplaces of stars and planets, where dense cores of gas collapse to form protostars. The dust mixed in these clouds is thought to be made of grains of an average size of 0.1 micrometer. We report the widespread detection of the coreshine effect as a direct sign of the existence of grown, micrometer-sized dust grains. This effect is seen in half of the cores we have analyzed in our survey, spanning all Galactic longitudes, and is dominated by changes in the internal properties and local environment of the cores, implying that the coreshine effect can be used to constrain fundamental core properties such as the three-dimensional density structure and ages and also the grain characteristics themselves.

Accepted by Published in Science, 24 sep. 2010, 329, 5999, 1622

http://aramis.obspm.fr/~pagani/biblio_laurent_pagani.php

Atmospheric Phase Correction using CARMA-PACS: High Angular Resolution Observations of the FU-Orionis star PP 13S*

Laura M. Pérez[1], James W. Lamb[2], David P. Woody[2], John M. Carpenter[1], B. Ashley Zauderer[3], Andrea Isella[1], Douglas C. Bock[4], Alberto D. Bolatto[3], John Carlstrom[5], Thomas L. Culverhouse[5], Marshall Joy[6], Woojin Kwon[7], Erik M. Leitch[2,5], Daniel P. Marrone[5,8], Stephen J. Muchovej[2], Richard

L. Plambeck[9], Stephen L. Scott[2], Peter J. Teuben[3] and Melvyn C. H. Wright[9]

[1] Department of Astronomy, California Institute of Technology, 1200 East California Blvd, Pasadena, CA 91125, USA
[2] Owens Valley Radio Observatory, California Institute of Technology, Big Pine, CA 93513, USA
[3] Department of Astronomy, University of Maryland, College Park, MD 20742-2421, USA
[4] Combined Array for Research in Millimeter-wave Astronomy, P.O. Box 968, Big Pine, CA 93513, USA
[5] Department of Astronomy and Astrophysics, University of Chicago, 5640 S. Ellis Ave. Chicago, IL 60637, USA
[6] Space Sciences - VP62, NASA Marshall Space Flight Center, Huntsville, AL 35812, USA
[7] Department of Astronomy, University of Illinois, Urbana, IL 61801, USA
[8] Jansky Fellow, National Radio Astronomy Observatory
[9] Astronomy Department, University of California at Berkeley, Berkeley, CA 94720-3411, USA

E-mail contact: lperez *at* astro.caltech.edu

We present 0.15″ resolution observations of the 227 GHz continuum emission from the circumstellar disk around the FU-Orionis star PP 13S*. The data were obtained with the Combined Array for Research in Millimeter-wave Astronomy (CARMA) Paired Antenna Calibration System (C-PACS), which measures and corrects the atmospheric delay fluctuations on the longest baselines of the array in order to improve the sensitivity and angular resolution of the observations. A description of the C-PACS technique and the data reduction procedures are presented. C-PACS was applied to CARMA observations of PP 13S*, which led to a factor of 1.6 increase in the observed peak flux of the source, a 36% reduction in the noise of the image, and a 52% decrease in the measured size of the source major axis. The calibrated complex visibilities were fitted with a theoretical disk model to constrain the disk surface density. The total disk mass from the best fit model corresponds to 0.06 $M_\odot$, which is larger than the median mass of a disk around a classical T Tauri star. The disk is optically thick at a wavelength of 1.3 mm for orbital radii less than 48 AU. At larger radii, the inferred surface density of the PP 13S* disk is an order of magnitude lower than that needed to develop a gravitational instability.

Accepted by ApJ

http://arxiv.org/abs/1009.4748

The distant young embedded stellar cluster CBJC 8 associated with G085.40-0.00.

Paolo Persi[1], Mauricio Tapia[2] and Mercedes Gomez[3]

[1] INAF-IASF sez.di Roma, Italy
[2] Instituo de AStronomia, UNAM, Ensenada, Baja California, Mexico
[3] Observatorio Astronomico de Cordoba, Cordoba, Argentina

E-mail contact: paolo.persi *at* iasf-roma.inaf.it

The infrared cluster CBJC 8 is associated with a 6.7 GHz methanol maser and a compact radio-continuum source, G85.40-0.00. It is located at a distance of about 8 kpc. The aim is to study the characteristics of this distant and compact embedded cluster and derive the properties of its stellar population. We present new ground-based near- and mid-infrared imaging observations of this region. The calibrated images were analysed together with archive Spitzer IRAC images. Based on the discovery of a considerable fraction of embedded sources with infrared excess emission that are concentrated within a radius around 16" centred near the position of the compact HII region G85.40-0.00, we were able to confirm the presence of a very young embedded cluster. It was found to contain more than 58 members brighter than $M_K = 2.6$, two-thirds of which showing significant near- or mid-IR excess emission. We present spectral energy distributions and extrapolated total luminosities for nine sources with large mid-infrared excesses that were measured in all four IRAC bands. For the brightest of these, G8540A, which is associated with a methanol maser and a compact HII region, we fitted a model of an infalling envelope plus disc plus central star to its observed 1.6 to 850 μm fluxes to get an idea of its physical properties. We also report a single 2.12 μm molecular hydrogen line emission knot near the centre of the cluster, which support the idea about an outflow activity.

Accepted by Astronomy & Astrophysics

request of preprints to paolo.persi *at* iasf-roma.inaf.it

Limiting Accretion onto Massive Stars by Fragmentation-Induced Starvation

Thomas Peters[1], Ralf S. Klessen[1], Mordecai-Mark Mac Low[2] and Robi Banerjee[1]

[1] Zentrum für Astronomie der Universität Heidelberg, Institut für Theoretische Astrophysik, Albert-Ueberle-Str. 2, D-69120 Heidelberg, Germany

[2] Department of Astrophysics, American Museum of Natural History, 79th Street at Central Park West, New York, New York 10024-5192, USA

E-mail contact: thomas.peters *at* ita.uni-heidelberg.de

Massive stars influence their surroundings through radiation, winds, and supernova explosions far out of proportion to their small numbers. However, the physical processes that initiate and govern the birth of massive stars remain poorly understood. Two widely discussed models are monolithic collapse of molecular cloud cores and competitive accretion. To learn more about massive star formation, we perform simulations of the collapse of rotating, massive, cloud cores including radiative heating by both non-ionizing and ionizing radiation using the FLASH adaptive mesh refinement code. These simulations show fragmentation from gravitational instability in the enormously dense accretion flows required to build up massive stars. Secondary stars form rapidly in these flows and accrete mass that would have otherwise been consumed by the massive star in the center, in a process that we term fragmentation-induced starvation. This explains why massive stars are usually found as members of high-order stellar systems that themselves belong to large clusters containing stars of all masses. The radiative heating does not prevent fragmentation, but does lead to a higher Jeans mass, resulting in fewer and more massive stars than would form without the heating. This mechanism reproduces the observed relation between the total stellar mass in the cluster and the mass of the largest star. It predicts strong clumping and filamentary structure in the center of collapsing cores, as has recently been observed. We speculate that a similar mechanism will act during primordial star formation.

Accepted by ApJ

http://arxiv.org/abs/1005.3271

Orphaned Protostars

Bo Reipurth[1], Seppo Mikkola[2], Michael Connelley[1], and Mauri Valtonen[2]

[1] Institute for Astronomy, University of Hawaii at Manoa, 640 N. Aohoku Place, HI 96720, USA

[2] Tuorla Observatory, Department of Physics and Astronomy, University of Turku, Väisäläntie 20, Piikkiö, Finland

E-mail contact: reipurth *at* ifa.hawaii.edu

We explore the origin of a population of distant companions (∼1000 - 5000 AU) to Class I protostellar sources recently found by Connelley and co-workers, who noted that the companion fraction diminished as the sources evolved. Here we present N-body simulations of unstable triple systems embedded in dense cloud cores. Many companions are ejected into unbound orbits and quickly escape, but others are ejected with insufficient momentum to climb out of the potential well of the cloud core and associated binary. These loosely bound companions reach distances of many thousands of AU before falling back and eventually being ejected into escapes as the cloud cores gradually disappear. We use the term *orphans* to denote protostellar objects that are dynamically ejected from their placental cloud cores, either escaping or for a time being tenuously bound at large separations. Half of all triple systems are found to disintegrate during the protostellar stage, so if multiple systems are a frequent outcome of the collapse of a cloud core, then orphans should be common. Bound orphans are associated with embedded close protostellar binaries, but escaping orphans can travel as far as ∼0.2 pc during the protostellar phase. The steep climb out of a potential well ensures that orphans are not kinematically distinct from young stars born with a less violent pre-history. The identification of orphans outside their heavily extincted cloud cores will allow the detailed study of protostars high up on their Hayashi tracks at near-infrared and in some cases even at optical wavelengths.

Accepted by ApJ Letters

http://arxiv.org/abs/1010.3307

The (sub-)millimeter SED of protoplanetary disks in the outskirts of the Orion Nebula Cluster

L. Ricci[1], R. K. Mann[2], L. Testi[1], J. P. Williams[3], A. Isella[4], M. Robberto[5], A. Natta[6] and K. J. Brooks[7]

[1] European Southern Observatory, Karl-Schwarzschild-Strasse 2, D-85748 Garching, Germany
[2] National Research Council Canada, Herzberg Institute of Astrophysics, 5071 West Saanich Road, Victoria, BC V9E 2E7, Canada
[3] Institute for Astronomy, University of Hawaii, 2680 Woodlawn Drive, Honolulu, HI 96822, USA
[4] Division of Physics, Mathematics and Astronomy, California Institute of Technology, MC 249-17, Pasadena, CA, USA
[5] Space Telescope Science Institute, 3700 San Martin Dr., Baltimore, MD 21218, USA
[6] INAF - Osservatorio Astrofisico di Arcetri, Largo Fermi 5, I-50125 Firenze, Italy
[7] Australia Telescope National Facility, P.O. Box 76, Epping, NSW 1710, Australia

E-mail contact: lricci *at* eso.org

We present the sub-mm/mm SED for a sample of eight young circumstellar disks in the outer regions of the Orion Nebula Cluster. New observations were carried out at 2.9 mm with the CARMA array and for one disk, 216-0939, at 3.3 and 6.8 mm with ATCA. By combining these new millimeter data with literature measurements at sub-millimeter wavelengths we investigate grain growth and measure the dust mass in protoplanetary disks in the Orion Nebula Cluster. These data provide evidence for dust grain growth to at least millimeter-sizes for the first time in a high-mass star forming region. The obtained range in sub-mm/mm spectral index, namely 1.5-3.2, indicates that for disks in the outskirts of the Orion Nebula Cluster (projected distance from the cluster center between about 0.4 pc and 1.5 pc) grain growth to mm sizes occurs in the same manner as disks in regions where only low-mass stars form. Finally, in our sample three disks are more massive than about $0.05\,M_{\odot}$, confirming that massive disks are present in the outer regions of the Orion Nebula.

Accepted by Astronomy and Astrophysics

http://arxiv.org/abs/1010.1677

U-band study of the accretion properties in the sigma Orionis star-forming region

E. Rigliaco[1,2], A. Natta[1], S. Randich[1], L. Testi[3] and K. Biazzo[1]

[1] Osservatorio Astrofisico di Arcetri, INAF, Largo E.Fermi 5, 50125 Firenze, Italy
[2] Universita' di Firenze, Dipartimento di Astronomia, Largo E.Fermi 2, 50125 Firenze, Italy
[3] ESO, Karl-Schwarschild Strasse 2, D-85748 Garching bei München, Germany

E-mail contact: erigliaco *at* arcetri.astro.it

This paper presents the results of an U band survey with FORS1/VLT of a large area in the σ Ori star-forming region. We combine the U-band photometry with literature data to compute accretion luminosity and mass accretion rates from the U-band excess emission for all objects (187) detected by *Spitzer* in the FORS1 field and classified by Hernandez et al. (2007) as likely members of the cluster. The sample stars range in mass from ~ 0.06 to $\sim 1.2\ M_{\odot}$; 72 of them show evidence of disks and we measure mass accretion rates $\dot{M}_{acc}$between $< 10^{-11}$ and few $10^{-9}\ M_{\odot}$/y, using the colors of the diskless stars as photospheric templates. Our results confirm the dependence of $\dot{M}_{acc}$ on the mass of the central object, which is stronger for low-mass stars and flattens out for masses larger than $\sim 0.3\ M_{\odot}$; the spread of $\dot{M}_{acc}$for any value of the stellar mass is $\sim$2 orders of magnitude. We discuss the implications of these results in the context of disk evolution models. Finally, we analyze the relation between $\dot{M}_{acc}$and the excess emission in the *Spitzer* bands, and find that at $\dot{M}_{acc}\sim 10^{-10}\ M_{\odot}$/y the inner disks change from optically thin to optically thick.

Accepted by A&A

Star formation in the Taurus filament L1495: From Dense Cores to Stars

Markus Schmalzl[1], Jouni Kainulainen[1], Sascha P. Quanz[2], João Alves[3], Alyssa A. Goodman[4], Thomas Henning[1], Ralf Launhardt[1], Jaime E. Pineda[4] and Carlos G. Román-Zúñiga[5]

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

[2] Institute for Astronomy - Swiss Federal Institute of Technology (ETH), Wolfgang-Pauli-Strasse 27, 8093 Zurich, Switzerland
[3] University of Vienna, Türkenschanzstrasse 17, 1180 Vienna, Austria
[4] Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, MS 42, Cambridge, MA 02138, USA
[5] Centro Astronómico Hispano Alemán/Instituto de Astrofísica de Andalucía (IAA-CSIC). Glorieta de la Astronomía, S/N, Granada 18008, Spain

E-mail contact: schmalzl *at* mpia.de

We present a study of dense structures in the L 1495 filament in the Taurus Molecular Cloud and examine its star-forming properties. In particular we construct a dust extinction map of the filament using deep near-infrared observations, exposing its small-scale structure in unprecedented detail. The filament shows highly fragmented substructures and a high mass-per-length value of $M_{\rm line} = 17 M_\odot pc^{-1}$, reflecting star-forming potential in all parts of it. However, a part of the filament, namely B 211, is remarkably devoid of young stellar objects. We argue that in this region the initial filament collapse and fragmentation is still taking place and star formation is yet to occur. In the star-forming part of the filament, we identify 39 cores with masses from $0.4 \ldots 10 M_\odot$ and preferred separations in agreement with the local Jeans length. Most of these cores exceed the Bonnor-Ebert critical mass, and are therefore likely to collapse and form stars. The Dense Core Mass Function follows a power law with exponent $\Gamma = 1.2 \pm 0.2$, a form commonly observed in star-forming regions.

Accepted by ApJ

http://arxiv.org/abs/1010.2755

A quantification of the non-spherical geometry and accretion of collapsing cores

Rowan J. Smith[1], Simon C. O. Glover[1], Ian A. Bonnell[2], Paul C. Clark[1] and Ralf S. Klessen[1,3]

[1] Zentrum für Astronomie der Universität Heidelberg, Institut für Theoretische Astrophysik, Albert-Ueberle-Str. 2, 69120 Heidelberg, Germany
[2] SUPA, School of Physics & Astronomy, University of St Andrews, North Haugh, St Andrews, Fife, KY16 9SS, UK
[3] Kavli Institute for Particle Astrophysics and Cosmology, Stanford University, Menlo Park, CA 94025, USA

E-mail contact: rowan *at* ita.uni-heidelberg.de

We present the first detailed classification of the structures of Class 0 cores in a high resolution simulation of a giant molecular cloud. The simulated cloud contains 10^4 $M_\odot$and produces over 350 cores which allows for meaningful statistics. Cores are classified into three types according to how much they depart from spherical symmetry. We find that three quarters of the cores are better described as irregular filaments than as spheres. Recent Herschel results have shown that cores are formed within a network of filaments, which we find has had a significant impact on the resulting core geometries. We show that the column densities and ram pressure seen by the protostar are not uniform and generally peak along the axes of the filament. The angular momentum vector of the material in the cores varies both in magnitude and direction, which will cause the rotation vector of the central source to fluctuate during the collapse of the core. In the case of the more massive stars, accretion from the environment outside the original core volume is even more important than that from the core itself. This additional gas is primarily accreted onto the cores along the dense filaments in which the cores are embedded, and the sections of the surfaces of the cores which do not coincide with a filament have very little additional material passing through them. The assumption of spherical symmetry cannot be applied to the majority of collapsing cores, and is never a good description of how stars accrete gas from outside the original core radius. This has ramifications for our understanding of collapsing cores, in particular their line profiles, the effect of radiation upon them and their ability to fragment.

Accepted by MNRAS

http://arxiv.org/abs/1009.5395

Dynamics of the 6.7 and 12.2 GHz methanol masers around Cepheus A HW2

K. J. E. Torstensson[1,2], H. J. van Langevelde[2,1], W. H. T. Vlemmings[3] and S. Bourke[2]

[1] Leiden Observatory, Leiden University, PO Box 9513, 2300 RA Leiden, The Netherlands
[2] Joint Institute for VLBI in Europe, Postbus 2, 7990 AA Dwingeloo, The Netherlands

[3] Argelander-Institut für Astronomie, University of Bonn, Auf dem Hügel 71, D-53121 Bonn, Germany

E-mail contact: kalle *at* strw.leidenuniv.nl

The 6.7 GHz methanol maser is exclusively associated with high-mass star formation. However, it remains unclear what structures harbour the methanol masers. Cepheus A is one of the closest regions of massive star formation, making it an excellent candidate for detailed studies. We determine the dynamics of maser spots in the high-mass star-forming region Cepheus A in order to infer where and when the maser emission occurs. Very long baseline interferometry (VLBI) observations of the 6.7 and 12.2 GHz methanol masers allows for mapping their spatial and velocity distribution. Phase-referencing is used to determine the astrometric positions of the maser emission, and multi-epoch observations can reveal 3D motions. The 6.7 GHz methanol masers are found in a filamentary structure over ∼1350 AU, straddling the waist of the radio jet HW2. The positions agree well with previous observations of both the 6.7 and 12.2 GHz methanol masers. The velocity field of the maser spots does not show any sign of rotation, but is instead consistent with an infall signature. The 12.2 GHz methanol masers are closely associated with the 6.7 GHz methanol masers, and the parallax that we derive confirms previous measurements. We show that the methanol maser emission very likely arises in a shock interface in the equatorial region of Cepheus A HW2 and presents a model in which the maser emission occurs between the infalling gas and the accretion disk/process.

Accepted by Astronomy and Astrophysics

High-resolution Study of the Massive Star-forming Region IRAS 06061+2151

M. A. Trinidad[1] and T. Rodriguez[1]

[1] Departamento de Astronomia, Universidad de Guanajuato, Apdo. Postal 144, Guanajuato, Gto. 36240, Mexico

E-mail contact: trinidad *at* astro.ugto.mx

We present observations of 3.6 cm continuum and water maser emission towards the high-mass star forming region IRAS 06061+2151 (AFGL 5182), made at $\sim 0.3''$ and $\sim 0.1''$ resolution respectively, using the VLA in the A configuration. Continuum and maser emission are not detected towards the center of AFGL 5182. However, we detected two groups of continuum sources located $\sim 12''$ and $\sim 3'$ to the west and northeast from AFGL 5182, respectively. The first group, labeled as G188.79+1.03 complex, is composed of three continuum sources in a region of about $6'' \times 10''$, while the second group, associated with the source G188.77+1.07, is composed of at least two continuum sources in a region of $\sim 1''$ in diameter. The physical parameters estimated, based on the morphology and the continuum emission, suggest that all the continuum sources in both groups are ultracompact H II regions, associated with ZAMS B-type stars. Water maser emission is only detected towards the compact source VLA N2, which is located in the G188.79+1.03 complex. Accuracy in the relative positions between the radio continuum source and the water masers is of the order of 15 mas. In addition, the observed spatial and kinematical distribution of the water maser features have remained stable for several years, and we confirm that they are tracing a bipolar outflow, where the best candidate of the source powering the water masers and the outflow is VLA 2N.

Accepted by Astronomical Journal

Dense molecular gas towards W49A: A template for extragalactic starbursts?

Helen Roberts[1], Floris van der Tak[2], Gary Fuller[3], René Plume[4], Estelle Bayet[5]

[1] Queen's University, Belfast, UK
[2] SRON, Groningen, NL
[3] U Manchester, UK
[3] U Calgary, Canada
[3] UCL, London, UK

E-mail contact: vdtak *at* sron.nl

Context The HCN, HCO^+, and HNC molecules are commonly used as tracers of dense star-forming gas in external galaxies, but such observations are spatially unresolved. Reliably inferring the properties of galactic nuclei and disks requires detailed studies of sources whose structure is spatially resolved.
Aims To understand the origin of extragalactic molecular line emission, we compare the spatial distributions and abundance ratios of HCN, HCO^+, and HNC in W49A, the most massive and luminous star-forming region in the

Galactic disk.
Methods Maps of a 2′ (6.6 pc) field at 14″ (0.83 pc) resolution of the J=4–3 transitions of HCN, $H^{13}CN$, $HC^{15}N$, HCO^+, $H^{13}CO^+$, $HC^{18}O^+$, and HNC are combined with supplementary observations of the J=5–4 transition of DCN and the J=3–2 transitions of HCN and $H^{13}CO^+$. Most of the data are from HARP/ACSIS, with supplementary data from JCMT Receiver A and the SCUBA archive. We use maps of the integrated intensity and line-profiles to pick out regions of the source to study in more detail. We compare column densities and abundance ratios towards these regions with each other and with predictions from gas-phase chemical models.
Results The kinematics of the molecular gas in W49A appears complex, with a mixture of infall and outflow motions. Both the line profiles and comparison of the main and rarer species show that the main species are optically thick. Two "clumps" of infalling gas that we look at in more detail appear to be at ∼40 K, compared to ≥100 K at the source centre, and may be ∼10× denser than the rest of the outer cloud. The chemical modelling suggests that the HCN/HNC ratio probes the current gas temperature, while the HCN/HCO^+ ratio and the deuterium fractionation were set during an earlier, colder phase of evolution.
Conclusions The similarity in the derived physical conditions in W49A and those inferred for the molecular gas in external galaxies suggest W49A is an appropriate analogue of an extragalactic star forming region. Our data show that the use of $HCN/HNC/HCO^+$ line ratios as proxies for the abundance ratios is incorrect for W49A, suggesting that using these line ratios as abundance ratios in galactic nuclei is invalid too. On the other hand, our observed isotopic line ratios such as $H^{13}CN/H^{13}CO^+$ approach our modeled abundance ratios quite well in W49A. Second, the 4–3 lines of HCN and HCO^+ are much better tracers of the dense star-forming gas in W49A than the 1–0 lines, confirming similar indications for galactic nuclei. Finally, our observed HCN/HNC and HCN/HCO^+ ratios in W49A are inconsistent with homogeneous PDR or XDR models, indicating that irradiation does not strongly affect the gas chemistry in W49A. Overall, the W49A region appears to be a useful template for starburst galaxies.

Accepted by A&A

http://arxiv.org/abs/1010.4443

Short Lifetime of Protoplanetary Disks in Low-metallicity Environments

Chikako Yasui[1,2], Naoto Kobayashi[2], Alan T. Tokunaga[3], Masao Saito[1] and Chihiro Tokoku[4]

[1] National Astronomical Observatory of Japan, 2-21-1 Osawa, Mitaka, Tokyo, 181-8588, Japan
[2] Institute of Astronomy, School of Science, University of Tokyo, 2-21-1 Osawa, Mitaka, Tokyo 181-0015, Japan
[3] Institute for Astronomy, University of Hawaii, 2680 Woodlawn Drive, Honolulu, HI 96822, USA
[4] Astronomical Institute, Tohoku University, Aramaki, Aoba, Sendai 980-8578, Japan

E-mail contact: ck.yasui *at* nao.ac.jp

We studied near-infrared disk fractions of six young clusters in the low-metallicity environments with [O/H] ~ -0.7 using deep JHK images with Subaru 8.2 m telescope. We found that disk fraction of the low-metallicity clusters declines rapidly in <1 Myr, which is much faster than the ∼5–7 Myr observed for the solar-metallicity clusters, suggesting that disk lifetime shortens with decreasing metallicity possibly with an $\sim 10^Z$ dependence.
Since the shorter disk lifetime reduces the time available for planet formation, this could be one of the major reasons for the strong planet–metallicity correlation.
Although more quantitative observational and theoretical assessments are necessary, our results present the first direct observational evidence that can contribute to explaining the planet–metallicity correlation.

Accepted by The Astrophysical Journal Letters

http://iopscience.iop.org/2041-8205/723/1/L113/

http://jp.arxiv.org/abs/1010.1668

New Panoramic View of ^{12}CO and 1.1 mm Continuum Emission in the Orion A Molecular Cloud. I. Survey Overview and Possible External Triggers of Star Formation

Y. Shimajiri[1,2], R. Kawabe[2,3], S. Takakuwa[4], M. Saito[3,5], T. Tsukagoshi[6], M. Momose[7], N. Ikeda[8], E. Akiyama[7], Austermann, J. E.[9,10], H. Ezawa[3], K. Fukue[1,5], M. Hiramatsu[4], D. Hughes[11], Y. Kitamura[8], K. Kohno[6], Y. Kurono[3,5], Scott, K. S.[12], G. Wilson[9], A. Yoshida[13] and M.S. Yun[9]

[1] Department of Astronomy, School of Science, University of Tokyo, Japan
[2] Nobeyama Radio Observatory, Japan
[3] National Astronomical Observatory of Japan
[4] Academia Sinica Institute of Astronomy and Astrophysics, Taiwan
[5] ALMA Project Office, National Astronomical Observatory of Japan
[6] Institute of Astronomy, Faculty of Science, University of Tokyo, Japan
[7] Institute of Astrophysics and Planetary Sciences, Ibaraki University, Japan
[8] Institute of Space and Astronoutical Science, Japan Aero Space Exploration Agency
[9] Department of Astronomy, University of Massachusetts, Amherst, USA
[1]0 Center for Astrophysics and Space Astronomy, University of Colorado, USA
[1]1 Instituto Nacional de Astrofísica, Óptica y Electrónica (INAOE), Mexico
[1]2 Department of Physics and Astronomy, University of Pennsylvania, USA
[1]3 Department of Earth and Planetary Sciences Tokyo Institute of Technology, Japan

E-mail contact: yoshito.shimajiri *at* nao.ac.jp

We present new, wide and deep images in the 1.1 mm continuum and the ^{12}CO (J=1–0) emission toward the northern part of the Orion A Giant Molecular Cloud (Orion-A GMC). The 1.1 mm data were taken with the AzTEC camera mounted on the Atacama Submillimeter Telescope Experiment (ASTE) 10 m telescope in Chile, and the ^{12}CO (J=1–0) data were with the 25 beam receiver (BEARS) on the NRO 45 m telescope in the On-The-Fly (OTF) mode. The present AzTEC observations are the widest 1.7 degree x 2.3 degree, corresponding to 12 pc x 17 pc) and the highest-sensitivity (9 mJy beam^{-1}) 1.1 mm dust-continuum imaging of the Orion-A GMC with an effective spatial resolution of 40 arcsec. The ^{12}CO (J=1–0) image was taken over the northern 1.2 degree x 1.2 degree (corresponding 9 pc x 9 pc) area with a sensitivity of 0.93 K in T_{MB}, a velocity resolution of 1.0 km s^{-1}, and an effective spatial resolution of 21arcsec. With these data, together with the MSX 8 um, Spitzer 24 um and the 2MASS data, we have investigated the detailed structure and kinematics of molecular gas associated with the Orion-A GMC and have found evidence for interactions between molecular clouds and the external forces that may trigger star formation. Two types of possible triggers were revealed; 1) Collision of the diffuse gas on the cloud surface, particularly at the eastern side of the OMC-2/3 region, and 2) Irradiation of UV on the pre-existing filaments and dense molecular cloud cores. Our wide-field and high-sensitivity imaging have provided the first comprehensive view of the potential sites of triggered star formation in the Orion-A GMC.

Accepted by PASJ

The Inner Regions of Protoplanetary Disks

C.P. Dullemond[1] **and J.D. Monnier**[2]

[1] MPIA, Heidelberg, Germany
[2] Astronomy Department, University of Michigan, Ann Arbor, MI, USA

E-mail contact: dullemon *at* mpia.de

To understand how planetary systems form in the dusty disks around pre-main-sequence stars, a detailed knowledge of the structure and evolution of these disks is required. Although this is reasonably well understood for the regions of the disk beyond about 1 AU, the structure of these disks inward of 1 AU remains a puzzle. This is partly because it is very difficult to spatially resolve these regions with current telescopes. But it is also because the physics of this region, where the disk becomes so hot that the dust starts to evaporate, is poorly understood. With infrared interferometry it has become possible in recent years to directly spatially resolve the inner 1 AU of protoplanetary disks, albeit in a somewhat limited way. These observations have partly confirmed current models of these regions, but also posed new questions and puzzles. Moreover, it has turned out that the numerical modeling of these regions is extremely challenging. In this review, we give a rough overview of the history and recent developments in this exciting field of astrophysics.

Accepted by Annual Review Astron. Astrophys. (vol. 48, 205-240)

http://arxiv.org/pdf/1006.3485

Cosmic Silicates

Thomas Henning[1]

[1] MPIA, Heidelberg, Germany

E-mail contact: henning *at* mpia-hd.mpg.de

Silicate dust particles are an important player in the cosmic life cycle of matter. They have been detected in a wide variety of environments, ranging from nearby protoplanetary disks to distant quasars. This review summarizes the fundamental properties of silicates relevant to astronomical observations and processes. It provides a review of our knowledge about cosmic silicates, mostly based on results from IR spectroscopy.

Accepted by Annual Review Astron. Astrophys. (vol. 48, 21-46)

Young Massive Star Clusters

Simon F. Portegies Zwart[1]**, Stephen L.W. McMillan**[2] **and Mark Gieles**[3,4]

[1] Leiden Observatory, Leiden, The Netherlands
[2] Department of Physics, Drexel University, Philadelphia, Pennsylvania, USA
[3] European Southern Observatory, Santiago 19, Chile
[4] Institute of Astronomy, University of Cambridge, Cambridge, UK

E-mail contact: spz *at* strw.leidenuniv.nl

Young massive clusters are dense aggregates of young stars that form the fundamental building blocks of galaxies. Several examples exist in the Milky Way Galaxy and the Local Group, but they are particularly abundant in starburst and interacting galaxies. The few young massive clusters that are close enough to resolve are of prime interest for studying the stellar mass function and the ecological interplay between stellar evolution and stellar dynamics. The distant unresolved clusters may be effectively used to study the star-cluster mass function, and they provide excellent constraints on the formation mechanisms of young cluster populations. Young massive clusters are expected to be the nurseries for many unusual objects, including a wide range of exotic stars and binaries. So far only a few such objects have been found in young massive clusters, although their older cousins, the globular clusters, are unusually rich in stellar exotica. In this review we focus on star clusters younger than ~ 100 Myr, more than a few current crossing times old, and more massive than $\sim 10^4$ $M_\odot$, irrespective of cluster size or environment. We describe the global properties of the currently known young massive star clusters in the Local Group and beyond, and discuss the

state of the art in observations and dynamical modeling of these systems. In order to make this review readable by observers, theorists, and computational astrophysicists, we also review the cross-disciplinary terminology.

Accepted by Annual Review Astron. Astrophys. (vol. 48, 431-494)

http://arxiv.org/abs/1002.1961

The Astrophysical Environment of the Solar Birthplace

Jonathan P. Williams[1]

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

E-mail contact: jpw *at* ifa.hawaii.edu

Our Sun, like all stars, formed within a cold molecular cloud. Astronomical observations and theory provide considerable detail into this process. Yet cosmochemical observations of short lived radionuclides in primitive meteorites, in particular ^{60}Fe, provide unequivocal evidence that the early solar system inherited fresh nucleosynthetic material from the core of a hot, massive star, almost certainly ejected in a supernova explosion. I give a short introduction to the fields of star formation and meteoritics and discuss how the reconciliation of their disparate clues to our origin places strong constraints on the environment of the Solar birthplace. Direct injection of supernova ejecta into a protoplanetary disk or a dense molecular core is unlikely since their small sizes require placement unusually close to the massive star. Lower density molecular cloud clumps can capture more ejecta but the radionuclides decay during the slow gravitational collapse. The most likely scenario is on the largest scales via the formation of enriched molecular clouds at the intersection of colliding supernova bubbles in spiral arms.

[This is an introductory review intended for advanced undergraduate or beginning graduate students.]

Accepted by Contemporary Physics

http://arxiv.org/abs/1008.2973

Chemical Evolution in Low-Mass Star Forming Cores

Jo-Hsin Chen

University of Texas at Austin

Jet Propulsion Laboratory

Electronic mail: Jo-Hsin.Chen *at* jpl.nasa.gov

Ph.D dissertation directed by: Neal J. Evans II

Ph.D degree awarded: August 2010

In this thesis, I focus on the physical and chemical evolution at the earliest stages of low-mass star formation. I report results from the Spitzer Space Telescope and molecular line observations of 9 species toward the dark cloud L43, a survey of 10 Class 0 and 6 Class I protostars with 8 molecular lines, and a survey of 9 Very Low Luminosity Objects (VeLLOs) with 11 molecular lines. From the observational results, CO depletion is extensively observed with $C^{18}O$(2-1) maps. A general evolutionary trend is also seen toward the Class 0 and I samples: higher deuterium fractionation at higher CO depletion. For the VeLLO candidates and starless cores with N_2D^+(3-2) detection, we found the deuterium ratio of N_2D^+/N_2H^+ is higher comparing with the Class 0 and I samples. We use DCO^+(3-2) maps to trace the velocity structures. Also, HCO^+(3-2) blue profiles are seen toward the VeLLO candidate L328, indicating possible infall.

To test theoretical models and to interpret the observations, we adopt a modeling sequence with self-consistent calculations of dust radiative transfer, gas energetics, chemistry, and line radiative transfer. In the L43 region described in Chapter 2, a starless core and a Class I protost ar are evolving in the same environment. We modeled both sources with the same initial conditions to test the chemical characteristics with and without protostellar heating. The physical model consists of a series of Bonner-Ebert spheres describing the pre-protostellar (PPC) stages following by standard inside-out collapse (Shu 1977). The model best matches the observed lines suggests a longer total timescale at the PPC stage, with faster evolution at the later steps with higher densities. In Chapter 3, we modeled the entire group of Class 0 and I protostars. The trend of decreasing deuterium ratio can be seen after the temperature is high enough for CO to evaporate. After the evaporation, the history of heavy depletion (e.g, from longer PPC timescales or different grain surface properties) no longer affects the line intensities of gas-phase CO. The HCO^+ blue profiles, which are used as infall indicators, are predicted to be observed when infall is beyond the CO evaporation front.

The low luminosity of VeLLOs cannot be explained by standard models with steady accretion, and we tested an evolutionary model incorporating episodic accretion to investigate the thermal history and chemical behaviors. We tested a few chemical parameters to compare with the observations and the results from Chapter 2 and 3. The modeling results from episodic accretion models show that CO and N_2 evaporate from grain mantle surfaces at the accretion bursts and can freeze back onto grain surfaces during the long periods of quiescent phases. Deuterated species, such as N_2D^+ and H_2D^+, are most sensitive to the temperature. Possible good tracers for the thermal history include the line intensities of gas-phase N_2H^+ relative to CO, as well as CO_2 and CO ice features.

Shapes of Stellar Birth: A Statistical Analysis Of The Internal Structure Of Young Embedded Clusters

Bruno Ferreira

University of Florida, USA

670 54th St, Oakland, CA, 94609

Electronic mail: bruno *at* astro.ufl.edu

Ph.D dissertation directed by: Elizabeth Lada

Ph.D degree awarded: May 2010

We now know that the majority of stars form in clusters deeply embedded in molecular gas. Young embedded clusters are seen as being one of the best sites for studying the formation and early evolution of stars because of the large number of stars located in a small spatial volume; as such, the study of clusters is an extremely active field. However, many of these studies have been independent of each other, which has often made it challenging to compare the derived cluster properties; this has been accentuated by the lack of coherent statistical methods for measuring the cluster properties. Furthermore, we know now that, in addition to forming in a clustered mode, stars also form through a distributed mode, characterized by lower surface densities; the physical processes which govern these modes are still not understood.

My goal was to further our understanding of how clusters form and evolve, through a comprehensive, uniform and unbiased study and comparison of their properties. In this dissertation I have developed a method which identifies clusters as well as measures some of their fundamental properties such as size, number of members, extinction and infrared excess fraction. My novel approach is based upon a nearest-neighbor method of sampling surface density; clusters are, by definition, surface density enhancements, and we show that the nearest-neighbor is a good tool for evaluating a wide range of density distributions. This method was designed to be applicable to a large variety of cluster fields, and allows us to remove biases incurred by other currently used forms of cluster detection. To arrive at a robust method of cluster identification, I have used Monte Carlo simulations to generate artificial clusters. Using these simulations I recreated a wide range of cluster scenarios to test and optimize the nearest-neighbor method; once tested, I then applied the method to 43 known clusters, constituting a representative sample of nearby young embedded clusters. Studying this sample of clusters has allowed me to obtain a global understanding of clusters by comparing their properties. Upon applying the method to the cluster catalog I find that the average total radius and core radius of a cluster is, respectively, 0.61 pc and 0.28 pc; the clusters have an average number of members of 132, average IRx_{frac} of 22% and average V-band extinction of 16 magnitudes. In addition to the clusters upon which I centered the fields, I also find 13 new clusters; I believe that some of these may, in fact, be substructure of the main cluster but without independent distance estimates to these new clusters it is not possible to be sure of this or of the measured values for the parameters.

In addition to quantifying some of the more well-known cluster properties, I also studied a cluster's internal density structure; this was accomplished by using the distribution of its nearest-neighbor separations and by developing a new parameter which quantifies a cluster's degree of central condensation. In analyzing a cluster's internal structure I find that clusters can be categorized as either centrally condensed or flat; centrally condensed clusters can be fit by power-law functions and are thought to be the product of a gravitationally-driven formation scenario, whereas flat clusters are thought to be formed through a turbulence-dominated formation. I find that 64% of the known, nearby, young clusters fall in the centrally condensed category. I also find evidence indicating the presence of a halo population; a halo component has been previously suggested for a couple of clusters and I show that, by using the distribution of nearest-neighbour separations to evaluate the internal density structure, there is strong evidence for the presence of a halo in many of our clusters.

Furthermore, I have applied the methods of cluster identification and analysis to a giant molecular cloud; this was done with the intent of both applying the cluster identification method to a large area and to study the clusters in the context of their environment. To perform this study I have used data from the FLAMINGOS near-infrared survey which, by using infrared excess as an indicator of youth, allowed me to trace the cloud's young stellar population.

Results show that the molecular cloud's young stellar population can be divided into 4 categories: i) core, ii) halo, iii) aggregate and iv) field, according to its nearest neighbour distribution. Using this method I have estimated that, for Monoceros OB1 giant molecular cloud, the number of stars born in clusters is 68%.

Finally, I have taken a closer look at the region surrounding the well-studied NGC 2264 cluster. I find the existence of a large halo component connecting the three known star forming regions (IRS1, IRS2 and S Mon) in NGC 2264, and I have compared the distribution of young sources, as identified using FLAMINGOS, to the distribution of Class I, thick disk Class II, and anemic disk Class II sources, as identified using SPITZER, for cluster NGC 2264. I find that the FLAMINGOS young sources and the thick disk Class II sources share very similar spatial distributions which coincide with the known regions of star formation.

Postdoctoral position on observational star formation and cosmochemistry

Applications are invited for a post doctoral position at Centre for Star and Planet Formation, a research center started as an initiative between the Natural History Museum of Denmark and the Niels Bohr Institute at University of Copenhagen. The successful candidate will join an active research group focusing on star and planet formation, linking high precision isotope studies of meteorites with astronomical observations and astrophysical simulations. On the astronomical side, members of the center are involved in a number of ongoing observing program, in particular, utilizing the ESO facilities as well as Herschel, the IRAM telescopes and the SMA. The successful candidate shall carry out a research program in collaboration with center members to utilize these facilities to measure the isotope composition of key elements in star forming regions - also taking advantage of opportunities offered by upcoming ALMA early science observations. In addition to this specific project, the candidate will be encouraged to develop and pursue additional research projects within the general theme of star and planet formation.

The position is open for candidates of all nationalities with experience in infrared and/or submillimeter observations. The candidate should have finished his/her doctoral thesis before taking up the position. The position is initially for two years with an extension possible depending on satisfactory progress and continued funding. We envision a starting date of mid-2011, but are somewhat flexible concerning the exact date.

Salaries depend on seniority, as agreed between the Ministry of Finance and the Danish Confederation of Professional Associations. Currently, starting salaries are about 36,750 DKK (4,937 Euro) per month for post docs before tax including a mandatory 17% pension contribution. Non-Danish candidates and Danish candidates who have lived abroad for an extended period of time before taking up the position, may be eligible for significant tax reductions. The position carry the full benefits for example in terms of enrollment in the public Danish health care system. The University of Copenhagen wishes to reflect the surrounding society and encourage all qualified applicants regardless of personal background to apply for the positions.

Applications should consist of (preferably as a single pdf) a CV, publication list, a summary of previous research and outline of the proposed research plan. These material as well as three letters of recommendation should be sent to the StarPlan center administrator Lene Bentzen (lb *at* snm.ku.dk). Reviews of applications will begin December 15th 2010 and continue until the position has been filled. For further information feel free to contact Jes Jørgensen (jes *at* snm.ku.dk) or Martin Bizzarro (bizzarro *at* snm.ku.dk) - or see the center web page at: http://www.starplan.net.

3-Year Job Contracts in Star Formation for EU nationals staying in non-EU countries

The Portuguese National Science Foundation has created attractive Job Contracts, promoting the return of EU member state/associated country nationality researchers. The hired researchers are grouped into categories A and B with annual salaries of 61000 and 68745 Euro, which are equivalent to the pay scales of assistant and associate professor's in Portuguese Universities. The Center for Astrophysics at the University of Porto invites applications to host independent researchers in the area of Star Formation. The applicants must have spent the last three years of their career (either PhD or Post-Doc) in non-EU countries to be eligible for these contracts. The deadline for pre-applications is 29th November 2010. Please contact Prof. Mario Monteiro (Mario.Monteiro *at* astro.up.pt) or Dr. Nanda Kumar (nanda *at* astro.up.pt) for further details. The following link provides information about the contracts.

http://omega.fct.mctes.pt/contratacaodoutorados/welcomeII.pdf

Post-doctoral Researcher on Origin of the IMF (4 years) University of Vienna

The Institute of Astronomy at the University of Vienna is seeking highly qualified applicants for one (or two) 4 year postdoctoral position(s) in the field of Star Formation, more specifically on the origin of the (Salpeter) IMF. Creativeness, motivation, and expertise with radio and/or IR observations of molecular clouds and young clusters are especially welcome, although all excellent applicants working on Galactic and extra-galactic Star Formation will be considered. The applicant will be part of a new research group led by Prof. João Alves. Participation in teaching activities at a modest level is expected.

The Institute is undergoing a major new development with the establishment of three new chairs in astrophysics. It offers a stimulating research environment with a large staff working in various areas of astrophysics. As a member state of ESO and ESA, Austria has access to their first-class facilities. The department is involved in, or is planning participation in major observatories of ESO (VLT instrumentation, E-ELT) and ESA/JAXA/NASA (Spica, Plato, Euclid, JWST). The beautiful city of Vienna scored highest in the world for overall quality of living according to a Mercer's 2010 survey.

Review of applications starts Oct 30, 2010 and will continue until the position is filled. Applications should include CV, publication list, and a brief description of past research and future plans. These documents must be submitted electronically as a PDF file via: http://jobcenter.univie.ac.at/en/applications/ (job 1490). Three letters of reference should be sent directly by the referees to Prof. João Alves (joao.alves *at* univie.ac.at).

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.

The Molecular Universe
May 30 - June 3, 2011
Toledo, Spain

This meeting is the sixth in a series of the International Astronomical Union Symposia on Astrochemistry, following the 1985 Goa, 1991 Brazil, 1996 Leiden, 1999 Korea and 2005 Asilomar Symposia. The main goal of the meeting is to bring together observers, theoreticians, and experimentalists from different communities to discuss the many different aspects of our rapidly developing field. The Scientific Organising Committee is formed by the IAU Working Group on Astrochemistry of IAU Commission 34/Division VI (Interstellar Medium), whereas the Local Organising Committee is led by the Department of Astrophysics at the Centro de Astrobiologia (CSIC-INTA), the Observatorio Astronomico Nacional (OAN-IGN) in Madrid and the Universidad de Castilla La Mancha (UCLM) in Toledo.

Topics include:

- Star-forming regions from cold pre-stellar clouds to hot cores
- Protoplanetary disks
- Exoplanets and their atmospheres
- Solar system objects from comets to the Kuiper Belt
- Envelopes around evolved stars
- Extragalactic astrochemistry out to high redshift
- Molecules and galaxy formation
- Diffuse and dense interstellar clouds
- Laboratory astrochemistry: gas and solid state
- Theoretical studies of basic molecular data
- New tools for the analysis of spectral data
- Role of heterogeneity and dynamics in chemical modeling
- ”Hot” results from Herschel and the promise of ALMA

This meeting will be held on the beautifully renovated campus of the Universidad de Castilla-La Mancha (UCLM) in Toledo, close to the old city walls. Toledo is about 1 hour travel from Madrid and it can be reached easily by train or car.

http://cab.inta-csic.es/molecular_universe/