THE STAR FORMATION NEWSLETTER

An electronic publication dedicated to early stellar evolution and molecular clouds

No. 176 — 24 June 2007 Editor: Bo Reipurth (reipurth@ifa.hawaii.edu)

Abstracts of recently accepted papers

The Dynamical State of the Starless Dense Globule FeSt 1-457: A Pulsating Globule?

E.D. Aguti[1,2], C.J. Lada[2], E.A. Bergin[3], J.F. Alves[4] and M. Birkinshaw[1]

[1] Astrophysics Group, Univeristy of Bristol, Tyndall Avenue, Bristol, BS8 1TL, UK
[2] Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138 USA
[3] Department of Astronomy, University of Michigan, Ann Arbor, MI 48109, USA
[4] Calar Alto Observatory, Centro Astronomico Hispano Aleman, c/Jesus Druban Remon 2-2, 04004 Almeria, Spain

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

High resolution molecular line observations of CS ($J = 2 \rightarrow 1$), HCO^+ ($J = 1 \rightarrow 0$), $C^{18}O$ ($J = 1 \rightarrow 0$), $C^{18}O$ ($J = 2 \rightarrow 1$) and N_2H^+ ($J = 1 \rightarrow 0$) were obtained toward the starless globule FeSt 1-457 in order to investigate its kinematics and chemistry. The HCO^+ and CS spectra show clear self-reversed and asymmetric profiles across the face of the globule. The sense of the observed asymmetry is indicative of the global presence of expansion motions in the outer layers of the globule. These motions appear to be subsonic and significantly below the escape velocity of the globule. Comparison of our observations with near-infrared extinction data indicate that the globule is gravitationally bound. Taken together these considerations lead us to suggest that the observed expansion has its origin in an oscillatory motion of the outer layers of the globule which itself is likely in a quasi-stable state near hydrostatic equilibrium. Analysis of the observed linewidths of $C^{18}O$ and N_2H^+ ($J = 1 \rightarrow 0$) confirm that thermal pressure is the dominant component of the cloud's internal support. A simple calculation suggests that the dominant mode of pulsation would be an $l = 2$ mode with a period of $\sim 3 \times 10^5$ yrs. Deformation of the globule due to the large amplitude $l = 2$ oscillation may be responsible for the double-peaked structure of the core detected in high resolution extinction maps.

Detailed comparison of the molecular-line observations and extinction data provides evidence for significant depletion of $C^{18}O$ and perhaps HCO^+ while N_2H^+ ($J = 1 \rightarrow 0$) may be undepleted to a cloud depth of ~ 40 magnitudes of visual extinction.

Accepted by Astrophysical Journal

www.cfa.harvard.edu/∼clada/pubs_html/Fest1.html/Fest_Esther_preprint.pdf

The initial conditions of star formation in the Ophiuchus main cloud: Kinematics of the protocluster condensations

Philippe André[1,2], Arnaud Belloche[1,3], Frédérique Motte[1,2] and Nicolas Peretto[1,4]

[1] CEA/DSM/DAPNIA, Service d'Astrophysique, C.E. Saclay, Orme des Merisiers, F-91191 Gif-sur-Yvette, France
[2] Laboratoire AIM, Unité Mixte de Recherche CEA – CNRS – Université Paris Diderot , C.E. Saclay, France
[3] Max-Planck-Institut für Radioastronomie, Auf dem Hügel 69, D-53121 Bonn, Germany
[4] Physics & Astronomy Department, University of Manchester, P.O. Box 88, Manchester M60 1QD, UK

E-mail contact: pandre *at* cea.fr

Context. The earliest phases of clustered star formation and the origin of the stellar initial mass function (IMF) are currently much debated. In one school of thought the IMF of embedded clusters is entirely determined by turbulent fragmentation at the prestellar stage of star formation, while in a major alternative view it results from dynamical

interactions and competitive accretion at the protostellar stage.
Aims. In an effort to discriminate between these two pictures for the origin of the IMF, we investigated the internal and relative motions of starless condensations and protostars previously detected by us in the dust continuum at 1.2 mm in the L1688 protocluster of the Ophiuchus molecular cloud complex. The starless condensations have a mass spectrum resembling the IMF and are therefore likely representative of the initial stages of star formation in the protocluster.
Methods. We carried out detailed molecular line observations, including some N_2H^+(1-0) mapping, of the Ophiuchus protocluster condensations using the IRAM 30m telescope.
Results. We measured subsonic or at most transonic levels of internal turbulence within the condensations, implying virial masses which generally agree within a factor of ~ 2 with the masses derived from the 1.2 mm dust continuum. This supports the notion that most of the L1688 starless condensations are gravitationally bound and prestellar in nature. We detected the classical spectroscopic signature of infall motions in CS(2–1), CS(3–2), $H_2CO(2_{12} - 1_{11})$, and/or HCO^+(3–2) toward six condensations, and obtained tentative infall signatures toward 10 other condensations. In addition, we measured a global one-dimensional velocity dispersion of less than 0.4 km s^{-1} (or twice the sound speed) between condensations. The small relative velocity dispersion implies that, in general, the condensations do not have time to interact with one another before evolving into pre-main sequence objects.
Conclusions. Our observations support the view that the IMF is partly determined by cloud fragmentation at the prestellar stage. Competitive accretion is unlikely to be the dominant mechanism at the protostellar stage in the Ophiuchus protocluster, but it may possibly govern the growth of starless, self-gravitating condensations initially produced by gravoturbulent fragmentation toward an IMF, Salpeter-like mass spectrum.

Accepted by Astronomy and Astrophysics

http://arxiv.org/abs/0706.1535

Massive planet migration: Theoretical predictions and comparison with observations

Philip J. Armitage[1]

[1] JILA, University of Colorado, Boulder, CO80309, USA

E-mail contact: pja *at* jilau1.colorado.edu

We quantify the utility of large radial velocity surveys for constraining theoretical models of Type II migration and protoplanetary disk physics. We describe a theoretical model for the expected radial distribution of extrasolar planets that combines an analytic description of migration with an empirically calibrated disk model. The disk model includes viscous evolution and mass loss via photoevaporation. Comparing the predicted distribution to a uniformly selected subsample of planets from the Lick / Keck / AAT planet search programs, we find that a simple model in which planets form in the outer disk at a uniform rate, migrate inward according to a standard Type II prescription, and become stranded when the gas disk is dispersed, is consistent with the radial distribution of planets for orbital radii 0.1 AU $\leq a <$ 2.5 AU and planet masses $M_p > 1.65\ M_J$. Some variant models are disfavored by existing data, but the significance is limited (~95%) due to the small sample of planets suitable for statistical analysis. We show that the favored model predicts that the planetary mass function should be almost independent of orbital radius at distances where migration dominates the massive planet population. We also study how the radial distribution of planets depends upon the adopted disk model. We find that the distribution can constrain not only changes in the power-law index of the disk viscosity, but also sharp jumps in the efficiency of angular momentum transport that might occur at small radii.

Accepted by ApJ

http://arxiv.org/abs/0705.3039

Geysers in the lagoon: new Herbig-Haro objects in M8

Rodolfo H. Barbá[1] **and Julia I. Arias**[1,2]

[1] Departamento de Física, Universidad de La Serena, Chile
[2] Facultad de Ciencias Astronómicas y Geofísicas, Universidad Nacional de La Plata, Argentina

E-mail contact: rbarba *at* dfuls.cl

As part of the search for direct evidence of ongoing star formation in the Lagoon Nebula (M8), we have conducted a

survey of Herbig-Haro objects, based on optical wide-field narrow-band imaging obtained at La Silla Observatory. We report the discovery of five new HH objects in the field. The new HH objects are identified as line-emission features indicative of outflow activity of the exciting sources. We study in detail their morphology and attempt to identify their potential driving sources among the population of T Tauri stars and embedded sources in the surroundings. The results presented here conclusively demonstrate the existence of very young stars going through the accreting phase in the M8 region.

Accepted by June 15th 2007, Astronomy & Astrophysics

http://arxiv.org/abs/0706.2378v1 or http://xeneize.dfuls.cl/~rbarba/geysers_m8_6081.pdf (figures at higher-resolution)

The young, wide and very low mass visual binary Lambda Orionis 167

D. Barrado y Navascués[1], A. Bayo[1], M. Morales-Calderón[1], N. Huélamo[1], J. R. Stauffer[2] and H. Bouy[3]

[1] Laboratorio de Astrofisica Espacial y Fisica Fundamental, LAEFF-INTA, Madrid, Spain
[2] IPAC, Caltech, Pasadena, USA
[3] Astronomy Department, University of California, Berkeley, USA

E-mail contact: barrado *at* laeff.inta.es

Aims. We look for wide, faint companions around members of the 5 Myr Lambda Orionis open cluster.

Methods. We used optical, near-infrared, and Spitzer/IRAC photometry.

Results. We report the discovery of a very wide very low mass visual binary, LOri167, formed by a brown dwarf and a planetary-mass candidate located at 5 arcsec, which seems to belong to the cluster. We derive $T_{\rm eff}$ of 2125 and 1750 K. If they are members, comparisons with theoretical models indicate masses of 17^{+3}_{-2} and 8^{+5}_{-1} $M_{\rm jup}$, with a projected separation of 2000 AU.

Conclusions. Such a binary system would be difficult to explain in most models, particularly those where substellar objects form in the disks surrounding higher mass stars.

Published by Astronomy & Astrophysics (Vol. 468, p. L5)

3D Radiative Hydrodynamics for Disk Stability Simulations: A Proposed Testing Standard and New Results.

Aaron C. Boley[1], Richard H. Durisen[1], Åke Nordlund[2] and Jesse Lord[3]

[1] Indiana University, Astronomy Department, 727 E. Third St., Bloomington, IN 47405-7105, USA
[2] Niels Bohr Institute, Copenhagen University, Juliane Maries Vej 30, 2100 Copenhagen Ø, Denmark
[3] Whitman College, Physics Department, 345 Boyer Avenue, Walla Walla, Washington 99362, USA

E-mail contact: acboley *at* astro.indiana.edu

Recent three-dimensional radiative hydrodynamics simulations of protoplanetary disks report disparate disk behaviors, and these differences involve the importance of convection to disk cooling, the dependence of disk cooling on metallicity, and the stability of disks against fragmentation and clump formation. To guarantee trustworthy results, a radiative physics algorithm must demonstrate the capability to handle both the high and low optical depth regimes. We develop a test suite that can be used to demonstrate an algorithm's ability to relax to known analytic flux and temperature distributions, to follow a contracting slab, and to inhibit or permit convection appropriately. We then show that the radiative algorithm employed by Mejía (2004) and Boley et al. (2006) and the algorithm employed by Cai et al. (2006) and Cai et al. (2007, in prep.) pass these tests with reasonable accuracy. In addition, we discuss a new algorithm that couples flux-limited diffusion with vertical rays, we apply the test suite, and we discuss the results of evolving the Boley et al. (2006) disk with this new routine. Although the outcome is significantly different in detail with the new algorithm, we obtain the same qualitative answers. Our disk does not cool fast due to convection, and it is stable to fragmentation. We find an effective $\alpha \approx 10^{-2}$. In addition, transport is dominated by low-order modes.

Accepted by ApJ

arXiv:0704.2532v1 [astro-ph]

25 Orionis: A kinematically distinct 10 Myr old group in Orion OB1a

César Briceño[1], Lee Hartmann[2], Jesus Hernández[1,2], Nuria Calvet[2], A. Katherina Vivas[1], Gabor Furesz[3] and Andrew Szentgyorgyi[3]

[1] Centro de Investigaciones de Astronomía (CIDA), Mérida, Venezuela
[2] Department of Astronomy, University of Michigan, Ann Arbor, MI, USA
[3] Harvard-Smithsonian Center for Astrophysics, 60 Garden St., Cambridge, MA, USA

E-mail contact: briceno *at* cida.ve

We report here on the photometric and kinematic properties of a well defined group of nearly 200 low-mass pre-main sequence stars, concentrated within $\sim 1^o$ of the early-B star 25 Ori, in the Orion OB1a sub-association. We refer to this stellar aggregate as the 25 Orionis group. The group also harbors the Herbig Ae/Be star V346 Ori and a dozen other early type stars with photometry, parallaxes, and some with IR excess emission, consistent with group membership. The number of high and low-mass stars is in agreement with expectations from a standard Initial Mass Function. The velocity distribution for the young stars in 25 Ori shows a narrow peak centered at $19.7\,\mathrm{km\,s^{-1}}$, very close to the velocity of the star 25 Ori. This velocity peak is offset $\sim -10\,\mathrm{km\,s^{-1}}$ from the velocity characterizing the younger stars of the Ori OB1b sub-association, and $-4\,\mathrm{km\,s^{-1}}$ from the velocity of more widely spread young stars of the Ori OB1a population near the σ Ori cluster; this result provides new and compelling evidence that the 25 Ori group is a distinct kinematic entity, and that considerable space and velocity structure is present in the Ori OB1a sub-association. The low-mass members follow a well defined band in the color-magnitude diagram, consistent with an isochronal age of $\sim 7-10$ Myr, depending on the assumed evolutionary model. The $\sim 2\times$ drop in the overall Li I equivalent widths and accretion fraction between the younger Ori OB1b and the 25 Ori group, is consistent with the later being significantly older, independent of the absolute age calibration.
The highest density of members is located near the star 25 Ori, but the actual extent of the cluster cannot be well constrained with our present data. In a simple-minded kinematic evolution scenario, the 25 Ori group may represent the evolved counterpart of a younger aggregate like the σ Ori cluster.
The 25 Ori stellar aggregate is the most populous ~ 10 Myr sample yet known within 500 pc, setting it as an excellent laboratory to study the evolution of solar-like stars and protoplanetary disks.

Accepted by The Astrophysical Journal

arXiv:astro-ph/0701710

The Evolution of Protoplanetary Disks Around Millisecond Pulsars: The PSR 1257 +12 System

Thayne Currie[1,2] and Brad Hansen[2]

[1] Harvard-Smithsonian Center for Astrophysics
[2] Department of Physics and Astronomy, University of California, Los Angeles

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

We model the evolution of protoplanetary disks surrounding millisecond pulsars, using PSR 1257+12 as a test case. Initial conditions were chosen to correspond to initial angular momenta expected for supernova-fallback disks and disks formed from the tidal disruption of a companion star. Models were run under two models for the viscous evolution of disks: fully viscous and layered accretion disk models. Supernova-fallback disks result in a distribution of solids confined to within 1-2 AU and produce the requisite material to form the three known planets surrounding PSR 1257+12. Tidal disruption disks tend to slightly underproduce solids interior to 1 AU, required for forming the pulsar planets, while overproducing the amount of solids where no body, lunar mass or greater, exists. Disks evolving under 'layered' accretion spread somewhat less and deposit a higher column density of solids into the disk. In all cases, circumpulsar gas dissipates on $\leq 10^5$ year timescales, making formation of gas giant planets highly unlikely.

Accepted by The Astrophysical Journal, September 20, 2007, v667n 1 issue

http://xxx.lanl.gov/abs/0705.3063

Terrestrial Zone Debris Disk Candidates in h & χ Persei

Thayne Currie[1], Scott J. Kenyon[1], George Rieke[2], Zoltan Balog[2] and Benjamin C. Bromley[3]

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

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

We analyze 8 sources with strong mid-infrared excesses in the 13 Myr-old double cluster h & χ Persei. New optical spectra and broadband SEDs (0.36-8 μm) are consistent with cluster membership. We show that material with T$\sim$300-400 K and $L_d/L_\star \sim 10^{-4}$-10^{-3} produces the excesses in these sources. Optically-thick blackbody disk models - including those with large inner holes - do not match the observed SEDs. The SEDs of optically-thin debris disks produced from terrestrial planet formation calculations match the observations well. Thus, some h & χ Persei stars may have debris from terrestrial zone planet formation.

Accepted by The Astrophysical Journal Letters

http://xxx.lanl.gov/abs/0706.0535

Pre-main sequence stars in open clusters

A. J. Delgado[1], E. J. Alfaro[1] and J. L. Yun[2]

[1] Instituto de Astrofísica de Andalucía, CSIC, Apdo 3004, 18080-Granada, Spain
[2] Centro de Astronomia e Astrofísica da Universidade de Lisboa, Observatório Astronómico de Lisboa, Tapada da Ajuda, 1349-018 Lisboa, Portugal

E-mail contact: delgado *at* iaa.es

Context. We present the basic ideas and first results from the project we are carrying out at present, the search for and characterisation of pre-main sequence (PMS) stars among the members of Galactic young clusters. The observations of 10 southern clusters, nine of them located in the Carina-Sagittarius spiral arm of the Milky Way are presented.

Aims. We aim at listing candidate PMS member stars in young clusters. The catalogued stars will serve as a basis for future spectroscopic studies of individual objects to determine the properties of stellar formation in the last phases before the main sequence stage. Properties such as the presence of residual envelopes or disks, age spread among PMS members, and the possible presence of several episodes of star formation in the clusters, are to be addressed.

Methods. Multicolour photometry in the $UBVR_CI_C$ system has been obtained for 10 southern young clusters in the fourth Galactic quadrant, located between Galactic longitudes l = 238° and l = 310°. For six clusters in the sample, the observations presented here provide the first published study based on CCD photometry. A quantitative comparison is performed with post-MS isochrones, and PMS isochrones from three different evolutionary models are used in the photometric membership analysis for possible PMS stars.

Results. The observations produce photometric indices in the Johnson-Cousins photometric systems for a total of 26 962 stars. The matching of our pixel coordinates with corresponding fields in the 2MASS data base provides astrometric calibration for all cataloged stars and JHK 2MASS photometric indices for 60% of them. Post-MS cluster ages range from 4 to 60 Myr, whereas the photometric membership analysis assigns PMS membership to a total of 842 stars, covering an age range between 1 and 10 Myr. This information on the PMS candidate members has been collected into a catalogue, named DAY-I, which contains 16 entries for 842 stars in the field of 10 southern clusters.

Published by Astronomy & Astrophysics (Vol. 467, p. 1407)

Water vapour and hydrogen in the terrestrial-planet-forming region of a protoplanetary disk

J.A. Eisner[1]

[1] UC Berkeley Department of Astronomy, 601 Campbell Hall, Berkeley, CA, USA

E-mail contact: jae *at* astro.berkeley.edu

Planetary systems, ours included, are formed in disks of dust and gas around young stars. Disks are an integral part of the star and planet formation process, and knowledge of the distribution and temperature of inner disk material is crucial for understanding terrestrial planet formation, giant planet migration, and accretion onto the central star. While the inner regions of protoplanetary disks in nearby star forming regions subtend only a few nano-radians, near-IR interferometry has recently enabled the spatial resolution of these terrestrial zones. Most observations have probed only dust, which typically dominates the near-IR emission. Here I report spectrally dispersed near-IR interferometric observations that probe gas (which dominates the mass and dynamics of the inner disk), in addition to dust, within one astronomical unit of the young star MWC 480. I resolve gas, including water vapor and atomic hydrogen, interior to the edge of the dust disk; this contrasts with results of previous spectrally dispersed interferometry observations. Interactions of this accreting gas with migrating planets may lead to short-period exoplanets like those detected around main-sequence stars. The observed water vapor is likely produced by the sublimation of migrating icy bodies, and provides a potential reservoir of water for terrestrial planets.

Published by Nature (May 31, 2007, Vol. 447, p562-564)

http://arxiv.org/abs/0706.1239

XMM-*Newton* observation of the classical T Tauri star SU Aur and the surrounding field

E. Franciosini[1], L. Scelsi[2], R. Pallavicini[1] and M. Audard[3,4]

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

[2] Dipartimento di Scienze Fisiche ed Astronomiche, Università di Palermo, Piazza del Parlamento 1, 90134 Palermo, Italy

[3] Integral Science Data Centre, Ch. d'Ecogia 16, 1290 Versoix, Switzerland

[4] Geneva Observatory, University of Geneva, Ch. des Maillettes 51, 1290 Sauverny, Switzerland

E-mail contact: francio *at* astropa.inaf.it

Aims. We investigate the properties of the X-ray emitting plasma of the classical T Tauri star SU Aurigae and of other sources in the field of view.

Methods. We use XMM-*Newton* to obtain a high-resolution RGS spectrum of SU Aur as well as EPIC imaging data and low-resolution spectra of the star and of other X-ray sources in the surrounding field. We reconstruct the emission measure distribution of SU Aur from the RGS spectrum using a line-based method, and we perform multi-temperature fits of the MOS spectra of the strongest sources both for the full observation and for selected time intervals to study their spectral variability.

Results. The emission from SU Aur is highly variable, showing three flares during the observation. The MOS spectra indicate a very hot corona, with significant emissivity up to $\sim$ 40 MK in quiescence, and temperatures up to 140 MK during flares. The emission measure distribution derived from the RGS spectrum peaks at $\log T = 7.0$; any contribution to the X-ray luminosity from cool plasma ($T \sim 2$ MK) cannot exceed 5% of the total emission. Abundances are $\sim 0.3 - 0.6$ solar with the exception of Mg and Ne that are solar. Spatial analysis of the full EPIC field results in the detection of 104 X-ray sources, 6 of which are associated with the known Taurus-Auriga members in the field of view (including SU Aur).

Conclusions. The characteristics of the X-ray emission of SU Aur are very similar to those of young active late-type stars, with a very hot corona and flares, suggesting magnetic activity as the origin of most of the X-ray emission, rather than accretion.

Accepted by A&A

http://www.astropa.unipa.it/~francio/papers.html

A large scale extinction map of the Galactic Anticenter from 2MASS

D. Froebrich[1,3], G.C. Murphy[2,3], M.D. Smith[1], J. Walsh[4] and C. del Burgo[3]

[1] Centre for Astrophysics and Planetary Science, University of Kent, Canterbury, CT2 7NH, UK

[2] Laboratoire d'Astrophysique, Observatoire de Grenoble, BP 53, 38041 Grenoble Cedex 9, France

[3] Dublin Institute for Advanced Studies, 5 Merrion Square, Dublin 2, Ireland

[4] School of Computer Science and Statistics, Trinity College, College Green, Dublin 2, Ireland

E-mail contact: df *at* star.kent.ac.uk

We present a $127° \times 63°$ extinction map of the Anticenter of the Galaxy, based on $\langle J-H \rangle$ and $\langle H-K \rangle$ colour excess maps from 2MASS. This 8001 square degree map with a resolution of 4 arcminutes is provided as online material. The colour excess ratio $\langle J-H \rangle / \langle H-K \rangle$ is used to determine the power law index of the reddening law (β) for individual regions contained in the area (e.g. Orion, Perseus, Taurus, Auriga, Monoceros, Camelopardalis, Cassiopeia). On average we find a dominant value of $\beta = 1.8 \pm 0.2$ for the individual clouds, in agreement with the canonical value for the interstellar medium. We also show that there is an internal scatter of β values in these regions, and that in some areas more than one dominant β value is present. This indicates large scale variations in the dust properties. The analysis of the A_V values within individual regions shows a change in the slope of the column density distribution with distance. This can either be attributed to a change in the governing physical processes in molecular clouds on spatial scales of about 1 pc or an A_V dilution with distance in our map.

Accepted by MNRAS

http://astro.kent.ac.uk/∼df/

Properties and stability of freely propagating nonlinear density waves in accretion disks

S. Fromang[1] and J. Papaloizou[1]

[1] Department of Applied Mathematics and Theoretical Physics, University of Cambridge, Centre for Mathematical Sciences, Wilberforce Road, Cambridge, CB3 0WA, UK

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

Aims. In this paper, we study the propagation and stability of nonlinear sound waves in accretion disks.

Methods. Using the shearing box approximation, we derive the form of these waves using a semi-analytic approach and go on to study their stability. The results are compared to those of numerical simulations performed using finite difference approaches such as employed by ZEUS as well as Godunov methods.

Results. When the wave frequency is between Ω and 2Ω (where Ω is the disk orbital angular velocity), it can couple resonantly with a pair of linear inertial waves and thus undergo a parametric instability. Neglecting the disk vertical stratification, we derive an expression for the growth rate when the amplitude of the background wave is small. Good agreement is found with the results of numerical simulations performed both with finite difference and Godunov codes. During the nonlinear phase of the instability, the flow remains well organised if the amplitude of the background wave is small. However, strongly nonlinear waves break down into turbulence. In both cases, the background wave is damped and the disk eventually returns to a stationary state. Finally, we demonstrate that the instability also develops when density stratification is taken into account and so is robust.

Conclusions. This destabilisation of freely propagating nonlinear sound waves may be important for understanding the complicated behaviour of density waves in disks that are unstable through the effects of self-gravity or magnetic fields and is likely to affect the propagation of waves that are tidally excited by objects such as a protoplanet or companion perturbing a protoplanetary disk. The nonlinear wave solutions described here as well as their stability properties were also found to be useful for testing and comparing the performance of different numerical codes.

Published by Astronomy & Astrophysics (Vol. 468, p. 1)

VLA observations of candidate high-mass protostellar objects at 7 mm

Guido Garay[1], Luis F. Rodríguez[2] and Itziar de Gregorio-Monsalvo[3]

[1] Departamento de Astronomía, Universidad de Chile, Casilla 36-D, Santiago, Chile
[2] Centro de Radioastronomía y Astrofísica, UNAM, Apdo. Postal 3-72, Morelia, Michoacán, 58089 México
[3] European Southern Observatory, Alonso de Córdoba 3107, Vitacura, Casilla 19001, Santiago 19, Chile

E-mail contact: guido *at* das.uchile.cl, luisfr *at* astrosmo.unam.mx, idegrego *at* eso.org

We present radio continuum observations at 7 mm made using the Very Large Array towards three massive star forming regions thought to be in very early stages of evolution selected from the sample of Sridharan et al. (2002). Emission was detected towards all three sources (IRAS 18470-0044, IRAS 19217+1651 and IRAS 23151+5912). We find that in all cases the 7 mm emission corresponds to thermal emission from ionized gas. The regions of ionized gas

associated with IRAS 19217+1651 and IRAS 23151+5912 are hypercompact with diameters of 0.009 and 0.0006 pc, and emission measures of 7.0×10^8 and 2.3×10^9 pc cm^{-6}, respectively.

Accepted by The Astronomical Journal

http://arxiv.org/abs/0705.3970

A multiwavelength study of young massive star forming regions: II. The dust environment

Guido Garay[1], Diego Mardones[1], Kate J. Brooks[2], Liza Videla[1] and Yanett Contreras[1]

[1] Departamento de Astronomía, Universidad de Chile, Santiago, Chile
[2] Australia Telescope National Facility, P.O. Box 76, Epping NSW 1710, Australia

E-mail contact: guido *at* das.uchile.cl

We present observations of 1.2-mm dust continuum emission, made with the Swedish ESO Submillimeter Telescope, towards eighteen luminous IRAS point sources, all with colors typical of compact HII regions and associated with CS(2→1) emission, thought to be representative of young massive star forming regions. Emission was detected toward all the IRAS objects. We find that the 1.2-mm sources associated with them have distinct physical parameters, namely sizes of ~ 0.4 pc, dust temperatures of ~ 30 K, masses of $\sim 2 \times 10^3$ $M_\odot$, column densities of $\sim 3 \times 10^{23}$ cm^{-2}, and densities of $\sim 4 \times 10^5$ cm^{-3}. We refer to these dust structures as massive and dense cores. Most of the 1.2-mm sources show single-peaked structures, several of which exhibit a bright compact peak surrounded by a weaker extended envelope. The observed radial intensity profiles of sources with this type of morphology are well fitted with power-law intensity profiles with power-law indices in the range $1.0 - 1.7$. This result indicates that massive and dense cores are centrally condensed, having radial density profiles with power-law indices in the range $1.5 - 2.2$. We also find that the UC HII regions detected with ATCA towards the IRAS sources investigated here (Paper I) are usually projected at the peak position of the 1.2-mm dust continuum emission, suggesting that massive stars are formed at the center of the centrally condensed massive and dense cores.

Accepted by ApJ

http://arxiv.org/abs/0706.2171

Spatial separation of small and large grains in the transitional disk around the young star IRS 48

V.C. Geers[1], K.M. Pontoppidan[2], E.F. van Dishoeck[1], C.P. Dullemond[3], J.-C. Augereau[4], B. Merín[5], I. Oliveira[1] and J.W. Pel[6]

[1] Leiden Observatory, Leiden University, P.O. Box 9513, 2300RA Leiden, The Netherlands
[2] Hubble Fellow, Division of GPS, Mail Code 150-21, California Institute of Technology, Pasadena, CA 91125, USA
[3] Max-Plank-Institut für Astronomie, Koenigstuhl 17, 69117 Heidelberg, Germany
[4] Laboratoire d'Astrophysique de l'Observatoire de Grenoble, B.P. 53, 38041 Grenoble Cedex 9, France
[5] Research and Scientific Support Department (ESTEC/ESA), Keplerlaan 1, 2200 AG Noordwijk, The Netherlands
[6] Kapteyn Astronomical Institute, Landleven 12, 9747 AD Groningen, The Netherlands

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

We present spatially resolved mid-infrared images of the disk surrounding the young star IRS 48 in the Ophiuchus cloud complex. The disk exhibits a ring-like structure at 18.7 μm, and is dominated by very strong emission from polycyclic aromatic hydrocarbons at shorter wavelengths. This allows a detailed study of the relative distributions of small and large dust grains.

Images of IRS 48 in 5 mid-infrared bands from 8.6 to 18.7 μm as well as a low resolution N-band spectrum are obtained with VLT-VISIR. Optical spectroscopy is used to determine the spectral type of the central star and to measure the strength of the Hα line.

The 18.7 μm ring peaks at a diameter of 110 AU, with a gap of ~ 60 AU. The shape of the ring is consistent with an inclination of $i = 48^\circ \pm 8^\circ$. In contrast, the 7.5-13 μm PAH emission bands are centered on the source and appear to fill the gap within the ring. The measured PAH line strengths are 10–100x stronger than those typically measured for young M0 stars and can only be explained with a high PAH abundance and/or strong excess optical/UV emission. The morphology of the images, combined with the absence of a silicate emission feature, imply that the inner disk has been cleared of micron-sized dust but with a significant population of PAHs remaining. We argue that the gap can be due to grain growth and settling or to clearing by an unseen planetary or low-mass companion. IRS 48 may represent a short-lived transitional phase from a classical to a weak-line T Tauri star.

Accepted by Astronomy & Astrophysics

http://arxiv.org/abs/0705.2969

A high-frequency radio continuum study of massive young stellar objects

A.G. Gibb[1] and M.G. Hoare[2]

[1] Department of Physics and Astronomy, University of British Columbia, 6224 Agricultural Road, Vancouver, B.C. V6T 1Z1, Canada
[2] School of Physics and Astronomy, University of Leeds, Leeds, West Yorkshire, LS2 9JT, UK

E-mail contact:agg *at* astro.ubc.ca

We present high-resolution observations made with the Very Large Array (VLA) in its A configuration at frequencies between 5 and 43 GHz of a sample of five massive young stellar objects (YSOs): LkHα101, NGC2024-IRS2, S106-IR, W75N and S140-IRS1. The resolution varied from 0.04 arcsec (at 43 GHz) to 0.5 arcsec (at 5 GHz), corresponding to a linear resolution as high as 17 AU for our nearest source. A MERLIN observation of S106-IR at 23 GHz with 0.03-arcsec resolution is also presented. S106-IR and S140-IRS1 are elongated at 43 GHz perpendicular to their large scale bipolar outflows. This confirms the equatorial wind picture for these sources seen previously in MERLIN 5 GHz observations. The other sources are marginally resolved at 43 GHz. The spectral indices we derive for the sources in our sample range from +0.2 to +0.8, generally consistent with ionized stellar winds. We have modelled our sources as uniform, isothermal spherical winds, with LkHα101 and NGC 2024-IRS2 yielding the best fits. However, in all cases our fits give wind temperatures of only 2000 to 5000 K, much less than the effective temperatures of main-sequence stars of the same luminosity, a result which is likely due to the clumpy nature of the winds.

Accepted by MNRAS

astro-ph/0705.4664

Pre-main sequence spectroscopic binaries suitable for VLTI observations

E. W. Guenther[1], M. Esposito[1,2], R. Mundt[3], E. Covino[4], J. M. Alcalá[4], F. Cusano[1] and B. Stecklum[1]

[1] Thüringer Landessternwarte Tautenburg, Sternwarte 5, 07778 Tautenburg, Germany
[2] Dipartimento di Fisica “E.R. Caianiello”, Università di Salerno, via S. Allende, 84081 Baronissi (Salerno), Italy
[3] Max-Planck-Institut für Astronomie, Königstuhl 17, 69117 Heidelberg, Germany
[4] INAF - Osservatorio Astronomico di Capodimonte via Moiariello 16, 80131 Napoli, Italy

E-mail contact: guenther *at* tls-tautenburg.de

Context. A severe problem for research in star-formation is that the masses of young stars are almost always estimated from evolutionary tracks alone. Since the tracks published by different groups differ, it is often only possible to give a rough estimate of the masses of young stars. It is thus crucial to test and calibrate the tracks. Up to now, only a few tests of the tracks could be carried out. However, it is now possible with the VLTI to set constrains on the tracks by determining the masses of many young binary stars precisely.

Aims. In order to use the VLTI efficiently, a first step is to find suitable targets, which is the purpose of this work. Given the distance of nearby star-forming regions, suitable VLTI targets are binaries with orbital periods between at least 50 days and a few years. Although a number of surveys for detecting spectroscopic binaries have been carried out, most of the binaries found so far have periods that are too short.

Methods. We thus surveyed the Chamaeleon, Corona Australis, Lupus, Sco-Cen, and ρ Ophiuchi star-forming regions in order to search for spectroscopic binaries with periods longer than 50 days, which are suitable for the VLTI observations.

Results. As a result of the 8 year campaign, we discovered 8 binaries with orbital periods longer than 50 days. Amongst

the newly discovered long-period binaries is CS Cha, which is one of the few classical T Tauri stars with a circumbinary disk. The survey is limited to objects with masses higher than 0.1 to 0.2 $M_\odot$ for periods between 1 and 8 years.

Conclusions. We find that the frequency of binaries with orbital periods $\leq$3000 days is of 20$\pm$5%. The frequency of long and short period pre-main sequence spectroscopic binaries is about the same as for stars in the solar neighbourhood. In total 14 young binaries are now known that are suitable for mass determination with the VLTI.

Published by Astronomy & Astrophysics (Vol. 467, p. 1147)

Habitable Planet Formation in Binary-Planetary Systems

Nader Haghighipour[1] and Sean N. Raymond[2]

[1] Institute for Astronomy, University of Hawaii-Manoa
[2] Center for Astrophysics and Space Astronomy, University of Colorado at Boulder

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

Recent radial velocity observations have indicated that Jovian-type planets can exist in moderately close binary star systems. Numerical simulations of the dynamical stability of terrestrial-class planets in such environments have shown that, in addition to their giant planets, these systems can also harbor Earth-like objects. In this paper, we study the late stage of terrestrial planet formation in such binary-planetary systems, and present the results of the simulations of the formation of Earth-like bodies in their habitable zones. We consider a circumprimary disk of Moon- to Mars-sized objects and numerically integrate the orbits of these bodies at the presence of the Jovian-type planet of the system and for different values of the mass, semimajor axis, and orbital eccentricity of the secondary star. Results indicate that, Earth-like objects, with substantial amounts of water, can form in the habitable zone of the primary star. Simulations also indicate that, by transferring angular momentum from the secondary star to protoplanetary objects, the giant planet of the system plays a key role in the radial mixing of these bodies and the water contents of the final terrestrial planets. We will discuss the results of our simulation and show that the formation of habitable planets in binary-planetary systems is more probable in binaries with moderate to large perihelia.

Accepted by Astrophysical Journal

Star Formation in Perseus: III. Outflows

J. Hatchell[1], G.A. Fuller[2] and J.S. Richer[3]

[1] School of Physics, University of Exeter, Stocker Road, Exeter EX4 4QL, U.K.
[2] School of Physics and Astronomy, University of Manchester, P.O. Box 88, Manchester M60 1QD, U.K.
[3] Cavendish Laboratory, J.J.Thomson Avenue, Cambridge CB3 0HE, U.K.

E-mail contact: hatchell *at* astro.ex.ac.uk

Context: We present a search for outflows towards 51 submillimetre cores in the Perseus molecular cloud.
Aims: Our first objective is to identify the protostellar population through the detection of molecular outflows. Our second aim is to consistently derive outflow properties from a large homogeneous dataset within one molecular cloud in order to investigate further the mass dependence and time evolution of protostellar mass loss.
Method: We used the James Clerk Maxwell Telescope to map $2' \times 2'$ regions around each core in ^{12}CO 3–2. Where molecular outflows were detected we derived momentum fluxes.
Results: Of the 51 cores, 37 show broad linewings indicative of molecular outflows. In 13 cases, the linewings could be due to confusion with neighbouring flows but 9 of those sources also have near-infrared detections confirming their protostellar nature. The total fraction of protostars in our sample is 65%. All but four outflow detections are confirmed as protostellar by Spitzer IR detections and only one Spitzer source has no outflow, showing that outflow maps at this sensitivity are equally good at identifying protostars as Spitzer. Outflow momentum flux correlates both with source luminosity and with core mass but there is considerable scatter even within this one cloud despite the homogeneous dataset. We fail to confirm the result of Bontemps et al. (1996) that Class I sources show lower momentum fluxes on average than Class 0 sources, with a KS test showing a significant probability that the momentum fluxes for both Class 0s and Class Is are drawn from the same distribution.
Conclusions: We find that outflow power may not show a simple decline between the Class 0 to Class I stages. Our sample includes low momentum flux, low-luminosity Class 0 sources, possibly at a very early evolutionary stage. If the

only mass loss from the core were due to outflows, cores would last for 10^5–10^8 years, longer than current estimates of 1.5–4 × 10^5 years for the mean lifetime for the embedded phase. Additional mechanisms for removing mass from protostellar cores may be necessary.

Accepted by A&A

http://www.astro.ex.ac.uk/people/hatchell/RecentPapers/hatchell07_outflows.pdf

A Spitzer Space Telescope Study of Disks in the Young σ Orionis Cluster

Jesús Hernández[1,2], L. Hartmann[1], T. Megeath[3], R. Gutermuth[4], J. Muzerolle[5], N. Calvet[1], A. K. Vivas[2], C. Briceño[2], L. Allen[4], J. Stauffer[6], E. Young[5] and G. Fazio[4]

[1] Department of Astronomy, University of Michigan, Ann Arbor, MI 48109, USA
[2] Centro de Investigaciones de Astronomía, Mérida 5101-A, Venezuela
[3] Department of Physics and Astronomy, University of Toledo, Toledo, OH 43606-3390, USA
[4] Harvard-Smithsonian Center for Astrophysics, Cambridge, MA 02138, USA
[5] Steward Observatory, University of Arizona, Tucson, AZ 85721, USA
[6] Spitzer Science Center, California Institute of Technology, Pasadena, CA 91125

We report new Spitzer Space Telescope observations, using the IRAC and MIPS instruments, of the young (∼3 Myr) σ Orionis cluster. We identify 336 stars as members of the cluster, using optical and near-infrared color-magnitude diagrams. Using the spectral energy distribution slopes in the IRAC spectral range, we place objects into several classes: non-excess stars, stars with optically thick disks (such as classical T Tauri stars), class I (protostellar) candidates, and stars with "evolved disks"; the last exhibit smaller IRAC excesses than optically thick disk systems. In general, this classification agrees with the location expected in IRAC-MIPS color-color diagrams for these objects. We find that the evolved disk systems are mostly a combination of objects with optically thick but nonflared disks, suggesting grain growth and/or settling, and transition disks, systems in which the inner disk is partially or fully cleared of small dust. In all, we identify seven transition disk candidates and three possible debris disk systems. As in other young stellar populations, the fraction of disks depends on the stellar mass, ranging from ∼ 10% for stars in the Herbig Ae/Be mass range (>2 $M_\odot$) to ∼ 35% for those in the T Tauri mass range (1 - 0.1 $M_\odot$). The IRAC infrared excesses found in stellar clusters and associations with and without central high-mass stars are similar, suggesting that external photoevaporation is not very important in many clusters. Finally, we find no correlation between the X-ray luminosity and the disk infrared excess, suggesting that the X-rays are not strongly affected by disk accretion.

Published by the Astrophysical Journal (Vol. 662, p. 1067)

Distance to Orion KL Measured with VERA

Tomoya Hirota[1,2], Takeshi Bushimata[1,3], Yoon Kyung Choi[1,4], Mareki Honma[1,2], Hiroshi Imai[5], Kenzaburo Iwadate[6], Takaaki Jike[6], Seiji Kameno[5], Osamu Kameya[2,6], Ryuichi Kamohara[1], Yukitoshi Kan-ya[7], Noriyuki Kawaguchi[1,2,3], Masachika Kijima[2], Mi Kyoung Kim[1,4], Hideyuki Kobayashi[1,3,4,6], Seisuke Kuji[6], Tomoharu Kurayama[1], Seiji Manabe[2,6], Kenta Maruyama[8], Makoto Matsui[8], Naoko Matsumoto[8], Takeshi Miyaji[1,3], Takumi Nagayama[8], Akiharu Nakagawa[5], Kayoko Nakamura[8], Chung Sik Oh[1,4], Toshihiro Omodaka[5], Tomoaki Oyama[1], Satoshi Sakai[6], Tetsuo Sasao[9,10], Katsuhisa Sato[6], Mayumi Sato[1,4], Katsunori M. Shibata[1,2,3], Motonobu Shintani[8], Yoshiaki Tamura[2,6], Miyuki Tsushima[8] and Kazuyoshi Yamashita[2]

[1] Mizusawa VERA Observatory, National Astronomical Observatory of Japan, 2-21-1 Osawa, Mitaka, Tokyo 181-8588, Japan
[2] Department of Astronomical Sciences, Graduate University for Advanced Studies, 2-21-1 Osawa, Mitaka, Tokyo 181-8588, Japan
[3] Space VLBI Project, National Astronomical Observatory of Japan, 2-21-1 Osawa, Mitaka, Tokyo 181-8588, Japan
[4] Department of Astronomy, Graduate School of Science, The University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-0033, Japan
[5] Faculty of Science, Kagoshima University, 1-21-35 Korimoto, Kagoshima, Kagoshima 890-0065, Japan
[6] Mizusawa VERA Observatory, National Astronomical Observatory of Japan, 2-12 Hoshi-ga-oka, Mizusawa-ku, Oshu-shi, Iwate 023-0861, Japan

[7] Department of Astronomy, Yonsei University, 134 Shinchong-dong, Seodaemun-gu, Seoul 120-749, Republic of Korea
[8] Graduate School of Science and Engineering, Kagoshima University, 1-21-35 Korimoto, Kagoshima, Kagoshima 890-0065, Japan
[9] Department of Space Survey and Information Technology, Ajou University, Suwon 443-749, Republic of Korea
[1]0 Korean VLBI Network, Korea Astronomy and Space Science Institute, P.O.Box 88, Yonsei University, 134 Shinchon-dong, Seodaemun-gu, Seoul 120-749, Republic of Korea

E-mail contact: tomoya.hirota *at* nao.ac.jp

We present the initial results of multi-epoch VLBI observations of the 22 GHz H_2O masers in the Orion KL region with VERA (VLBI Exploration of Radio Astrometry). With the VERA dual-beam receiving system, we have carried out phase-referencing VLBI astrometry and successfully detected an annual parallax of Orion KL to be 2.29±0.10 mas, corresponding to the distance of 437±19 pc from the Sun. The distance to Orion KL is determined for the first time with the annual parallax method in these observations. Although this value is consistent with that of the previously reported, 480±80 pc, which is estimated from the statistical parallax method using proper motions and radial velocities of the H_2O maser features, our new results provide the much more accurate value with an uncertainty of only 4%. In addition to the annual parallax, we have detected an absolute proper motion of the maser feature, suggesting an outflow motion powered by the radio source I along with the systematic motion of source I itself.

Accepted by PASJ (Vol. 59, No. 5, October 25, 2007 issue)

http://arxiv.org/abs/0705.3792

The formation of massive stars: accretion, disks, and the development of hypercompact HII regions

Eric Keto [1]

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

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

The hypothesis that massive stars form by accretion can be investigated by simple analytical calculations that describe the effect that the formation of a massive star has on its own accretion flow. Within a simple accretion model that includes angular momentum, that of gas flow on ballistic trajectories around a star, the increasing ionization of a massive star growing by accretion produces a three-stage evolutionary sequence. The ionization first forms a small quasi-spherical HII region gravitationally trapped within the accretion flow. At this stage the flow of ionized gas is entirely inward. As the ionization increases, the HII region transitions to a bipolar morphology in which the inflow is replaced by outflow within a narrow range of angle with about the bipolar axis. At higher rates of ionization, the opening angle of the outflow region progressively increases. Eventually, in the third stage, the accretion is confined to a thin region about an equatorial disk. Throughout this early evolution, the HII region is of hypercompact to ultracompact size depending on the mass of the enclosed star or stars. These small HII regions whose dynamics are dominated by stellar gravitation and accretion are different than compact and larger HII regions whose dynamics are dominated by the thermal pressure of the ionized gas.

Accepted by the Astrophysical Journal

astro-ph/0603856

The Role of Mass and Environment in Multiple-Star Formation: A 2MASS Survey of Wide Multiplicity in Three Young Associations

Adam L. Kraus[1] **and Lynne A. Hillenbrand**[1]

[1] Department of Astrophysics, California Institute of Technology, Pasadena, CA 91125, USA

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

We present the results of a search for wide binary systems among 783 members of three nearby young associations: Taurus-Auriga, Chamaeleon I, and two subgroups of Upper Scorpius. Near-infrared (JHK) imagery from 2MASS was analyzed to search for wide ($1''$ - $30''$; $\sim$ 150 - 4500 AU) companions to known association members, using color-magnitude cuts to reject likely background stars. We identify a total of 131 candidate binary companions with colors consistent with physical association, of which 39 have not been identified previously in the literature. Our results suggest that the wide binary frequency is a function of both mass and environment, with significantly higher frequencies among high-mass stars than lower mass stars and in the T associations than in the OB association. We discuss the implications for wide binary formation and conclude that the environmental dependence is not a direct result of stellar density or total association mass, but instead might depend on another environmental parameter like the gas temperature. The binary populations in these associations generally follow the empirical mass-maximum separation relation observed for field binaries, but we have found one candidate low-mass system (USco 160611.9-193532; $M_{tot} \sim 0.4$ $M_\odot$) that has a projected separation (10.8″; 1550 AU) much larger than the suggested limit for its mass. Finally, we find that the binary frequency in the USco-B subgroup is significantly higher than in the USco-A subgroup and is consistent with the measured values in Taurus and ChamI. This discrepancy, the absence of high-mass stars in USco-B, and its marginally distinct kinematics suggest that it might not be directly associated with the OB associations of Sco-Cen but instead represents an older analog of the younger ρ Oph or Lupus associations.

Published by the Astrophysical Journal (Vol. 662, p. 413)

Equations and Algorithms for Mixed Frame Flux-Limited Diffusion Radiation Hydrodynamics

Mark R. Krumholz[1], Richard I. Klein[2,3], Christopher F. McKee[3,4] and John Bolstad[2]

[1] Department of Astrophysical Sciences, Princeton University, Princeton, NJ 08544, USA
[2] Lawrence Livermore National Laboratory, PO Box 808, L-23, Livermore, CA 94550, USA
[3] Department of Astronomy, University of California, Berkeley, CA 94720, USA
[4] Department of Physics, University of California, Berkeley, CA 94720, USA

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

We analyze the mixed frame equations of radiation hydrodynamics under the approximations of flux-limited diffusion and a thermal radiation field, and derive the minimal set of evolution equations that includes all terms that are of leading order in any regime of non-relativistic radiation hydrodynamics. Our equations are accurate to first order in v/c in the static diffusion regime. In contrast, we show that previous lower order derivations of these equations omit leading terms in at least some regimes. In comparison to comoving frame formulations of radiation hydrodynamics, our equations have the advantage that they manifestly conserve total energy, making them very well-suited to numerical simulations, particularly with adaptive meshes. For systems in the static diffusion regime, our analysis also suggests an algorithm that is both simpler and faster than earlier comoving frame methods. We implement this algorithm in the Orion adaptive mesh refinement code, and show that it performs well in a range of test problems.

Accepted by ApJS

http://www.astro.princeton.edu/∼krumholz/recent.html, http://arxiv.org/abs/astro-ph/0611003

Three-dimensional simulations of molecular cloud fragmentation regulated by magnetic fields and ambipolar diffusion

Takahiro Kudoh[1], Shantanu Basu[2], Youichi Ogata[3] and Takashi Yabe[4]

[1] Division of Theoretical Astronomy, National Astronomical Observatory of Japan, Mitaka, Tokyo 181-8588, Japan
[2] Department of Physics and Astronomy, University of Western Ontario, London, Ontario N6A 3K7, Canada
[3] Department of Mechanical Engineering and Science, Tokyo Institute of Technology, O-okayama, Meguro-ku, Tokyo 152-8552, Japan
[4] Integrated Research Institute, Solutions Research Organization, Tokyo Institute of Technology, O-okayama, Meguro-ku, Tokyo 152-8552, Japan

E-mail contact: kudoh *at* th.nao.ac.jp

We employ the first fully three-dimensional simulation to study the role of magnetic fields and ion-neutral friction in regulating gravitationally-driven fragmentation of molecular clouds. The cores in an initially subcritical cloud develop gradually over an ambipolar diffusion time while the cores in an initially supercritical cloud develop in a dynamical time. The infall speeds on to cores are subsonic in the case of an initially subcritical cloud, while an extended ($\gtrsim 0.1$ pc) region of supersonic infall exists in the case of an initially supercritical cloud. These results are consistent with

previous two-dimensional simulations. We also found that a snapshot of the relation between density (ρ) and the strength of the magnetic field (B) at different spatial points of the cloud coincides with the evolutionary track of an individual core. When the density becomes large, both relations tend to $B \propto \rho^{0.5}$.

Accepted by Monthly Notices of the Royal Astronomical Society

http://arxiv.org/abs/0706.2696

Spitzer-IRAC GLIMPSE of high mass protostellar objects. I Infrared point sources and nebulae

M. S. N. Kumar[1] and J. M. C. Grave[1]

[1] Centro de Astrofísica da Universidade do Porto, Rua das Estrelas, s/n, 4150-762, Porto, Portugal

E-mail contact: nanda *at* astro.up.pt

Aims: To conduct a statistical study of candidate massive protostellar objects in the 3.6–8.0μm, bands of the Spitzer Space Telescope.
Methods: The GLIMPSE archive was used to obtain 3.6–8.0μm, point source photometry and images for 381 massive protostellar candidates lying in the Galactic mid-plane. The colours, magnitudes and spectral indicies of sources in each of the 381 target fields were analysed and compared with the predictions of 2D radiative transfer model simulations.
Results: Infrared point sources with intrinsic redenning were found associated with several massive protostars. Although no discernable embedded clusters were found in any targets, multiple sources or associations of redenned young stellar objects were found in many sources indicating multiplicity at birth. The spectral index (α) of these point sources in 3.6–8.0μm, bands display large values of α=2–5. A color-magnitude analog plot was used to identify 79 infrared counterparts to the HMPOs that are bright at 8μm, ,centered on millimeter peaks and display α values in excess of 2. Compact nebulae are found in 75% of the detected sources with morphologies that can be well described by core-halo, cometary, shell-like and bipolar geometries similar to those observed in ultra-compact HII regions.
Conclusions: The IRAC band spectral energy distributions (SED) of the infrared counterparts of massive protostellar candidates are best described to represent YSOs with a mass range of 8–20$M_\odot$ in their Class I evolutionary stages when compared with 2D radiative transfer models. They also suggest that the high α values represent reprocessed star/star+disk emission that is arising in the dense envelopes. Thus we are witnessing the luminous envelopes around the protostars rather than their photospheres or disks. We argue that the compact infrared nebulae likely reflect the underlying physical structure of the dense cores and are found to imitate the morphologies of known UCHII regions. The observations are consistent with a scenario where massive protostars have formed inside dense cores and continue to accrete matter. Our results favour models of continuuing accretion involving both molecular and ionised accretion components to build the most massive stars rather than purely molecular rapid accretion flows.

Accepted by Astronomy and Astrophysics

http://www.astro.up.pt/investigacao/index.php?WID=221&CID=1&Lang=pt&ID=251
astroph0705.4399

The spatial distribution of substellar objects in IC348 and the Orion Trapezium Cluster

M. S. N. Kumar[1] and S. Schmeja[1]

[1] Centro de Astrofísica da Universidade do Porto, Rua das Estrelas, 4150-762 Porto, Portugal

E-mail contact: nanda *at* astro.up.pt

Aims: Some theoretical scenarios suggest the formation of brown dwarfs as ejected stellar embryos in star-forming clusters. Such a formation mechanism can result in different spatial distributions of stars and substellar objects. We aim to investigate the spatial structure of stellar and substellar objects in two well sampled and nearby embedded clusters, namely IC348 and the Orion Trapezium Cluster (OTC) to test this hypothesis.
Methods: Deep near-infrared K-band data complete enough to sample the substellar population in IC348 and OTC are obtained from the literature. The spatial distribution of the K-band point sources is analysed using the Minimum Spanning Tree (MST) method. The Q parameter and the spanning trees are evaluated for stellar and substellar objects as a function of cluster core radius R_c.

Results: The stellar population in both IC348 and OTC display a clustered distribution whereas the substellar population is distributed homogeneously in space within twice the cluster core radius. Although the substellar objects do not appear to be bound by the cluster potential well, they are still within the limits of the cluster and not significantly displaced from their birth sites.
Conclusions: The spatially homogeneous distribution of substellar objects is best explained by assuming higher initial velocities, distributed in a random manner and going through multiple interactions. The overall spatial coincidence of these objects with the cluster locations can be understood if these objects are nevertheless travelling slowly enough so as to feel the gravitational influence of the cluster. The observations support the scenario of formation of substellar objects as "ejected stellar embryos". Higher ejection velocities are necessary but net spatial displacements may not be necessary to explain the observational data.

Accepted by Astronomy and Astrophysics Letters

astroph:0706.3328
http://www.astro.up.pt/investigacao/index.php?WID=221&Lang=uk

Optical and Near-IR Imaging of the Dark Globule CB 52

B. Maiolo[1], F. Strafella[1,3], L. Campeggio[1], D. Elia[1] and S. Aiello[2]

[1] Dipartimento di Fisica, Università di Lecce, CP 193, 73100 Lecce, Italy
[2] Dipartimento di Astronomia e Scienza dello Spazio, Università di Firenze, Italy
[3] Also at IFSI-INAF, Rome, Italy

E-mail contact: maiolo *at* le.infn.it

The internal structure of the dark globule CB 52 is investigated by means of broadband imaging in the optical and near-IR spectral range. By exploiting the extinction of the stellar light within this object, we derive observational parameters suitable to infer the internal structure of this cloud. Extinction maps were obtained at different wavelengths by using both stellar counts and two-color diagrams. While in the optical region the extinction is better evaluated at the cloud boundaries, the internal regions are more conveniently probed in the near-IR, so a combined map was derived. The total-to-selective extinction ratio R_V was also observed to increase toward the inner regions, and a plot versus the extinction A_V suggests that grain growth processes are active in this cloud. The statistical fluctuation of the A_V, estimated in the line of sight of the background stars, is investigated by comparing the observed stellar colors with those of the unreddened stars. The dispersion σ, derived from optical observations, is found to be almost independent of the mean extinction, A_V, while by using near-IR data we find a more complex behavior: the σ versus A_V relation increases until $A_V \sim 6$ and then decreases for larger extinctions. This is discussed in the framework of a simple model, suggesting that a clumpy and clustered structure can explain the observations in the inner regions, while outside the cloud the mass distribution remains more homogeneous.

Published by the Astrophysical Journal (Vol. 661, p. 926)

Planetary Formation Scenarios Revisited: Core-Accretion versus Disk Instability

T. Matsuo[1], H. Shibai[1], T. Ootsubo[1] and M. Tamura[2]

[1] Nagoya University, Furo-cho, Chikusa-ku, Nagoya, 464-8602, Japan
[2] National Astronomical Observatory, Osawa, Mitaka, Tokyo, 181-8588, Japan

E-mail contact: matsuo *at* u.phys.nagoya-u.ac.jp

The core-accretion and disk instability models have so far been used to explain planetary formation. These models have different conditions, such as planet mass, disk mass, and metallicity for formation of gas giants. The core-accretion model has a metallicity condition ([Fe/H] > -1.17 in the case of G-type stars), and the mass of planets formed is less than 6 times that of the Jupiter mass M_J. On the other hand, the disk instability model does not have the metallicity condition, but requires the disk to be 15 times more massive than the minimum mass solar nebulae model. The mass of planets formed is more than 2 M_J. These results are compared to the 161 detected planets for each spectral type of the central stars. The results show that 90% of the detected planets are consistent with the core-accretion model regardless of the spectral type. The remaining 10% are not in the region explained by the core-accretion model, but are explained by the disk instability model. We derived the metallicity dependence of the formation probability of gas

giants for the core-accretion model. Comparing the result with the observed fraction having gas giants, they are found to be consistent. On the other hand, the observation cannot be explained by the disk instability model, because the condition for gas giant formation is independent of the metallicity. Consequently, most of planets detected so far are thought to have been formed by the core-accretion process, and the rest by the disk instability process.

Published by the Astrophysical Journal (Vol. 662, p. 1282)

Proper motion studies of outflows from Classical T Tauri stars

F. McGroarty[1,2], T. P. Ray[2] and D. Froebrich[3]

[1] Department of Experimental Physics, National University of Ireland Maynooth, Maynooth, Co. Kildare, Ireland
[2] Dublin Institute for Advanced Studies, 5 Merrion Square, Dublin 2, Ireland
[3] Centre for Astrophysics & Planetary Science, School of Physical Sciences, University of Kent, Canterbury CT2 7NH, UK

E-mail contact: fiona.mcgroarty *at* nuim.ie

In a previous paper (McGroarty & Ray 2004) we examined the environment of a number of evolved low-mass young stars, i.e. Classical T Tauri Stars, to see if they are capable of driving parsec-scale outflows. These stars - CW Tau, DG Tau, DO Tau, HV Tau C and RW Aur - were previously known to drive only "micro-jets" or small-scale outflows of $\leq 1'$ or 0.04 pc at the distance of the Taurus-Auriga Cloud. We found that they drive outflows of 0.5 pc-1 pc, based on the morphology and alignment of newly discovered and previously known HH objects with these sources and their "micro-jets". Here, we use a cross-correlation method to determine the proper motions of the HH objects in these five outflows (HH 220, HH 229, HH 702, HH 705 and HH 826 - HH 835) which in turn allows us to confirm their driving sources. Moreover, the tangential velocities of HH objects at large distances from their origin are currently poorly known so these proper motions will allow us to determine how velocities evolve with distance from their source. We find tangential velocities of typically 200 km s^{-1} for the more distant objects in these outflows. Surprisingly, we find similar tangential velocities for the "micro-jets" that are currently being ejected from these sources. This leads us to suggest that either the outflow velocity was much higher 10^3 years ago when the more distant objects were ejected and that these objects have decelerated to their current velocity or that the outflow velocity at the source has remained approximately constant and the more distant objects have not undergone significant deceleration due to interactions with the ambient medium. Numerical simulations are needed before we can decide between these scenarios.

Published by Astronomy & Astrophysics (Vol. 467, p. 1197)

Massive Clumps in the NGC 6334 Star Forming Region

Diego J. Munoz[1], Diego Mardones[1], Guido Garay[1], David Rebolledo[1], Kate Brooks[2] and Sylvain Bontemps[3]

[1] Departamento de Astronomia. Universidad de Chile, Casilla 36-D, Santiago, Chile
[2] Australia Telescope National Facility,P.O. Box 76, Epping NSW 1710 Australia
[3] Observatoire de Bordeaux, 2 rue de l'Observatoire, 33270 Floirac, France

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

We report observations of dust continuum emission at 1.2 mm toward the star forming region NGC 6334 made with the SEST SIMBA bolometer array. The observations cover an area of ~ 2 square degrees with approximately uniform noise. We detected 181 clumps spanning almost three orders of magnitude in mass ($3M_\odot$-$6\times10^3\ M_\odot$) and with sizes in the range 0.1–1.0 pc. We find that the clump mass function $dN/d\log M$ is well fit with a power law of the mass with exponent -0.6 (or equivalently $dN/dM \propto M^{-1.6}$). The derived exponent is similar to those obtained from molecular line emission surveys and is significantly different from that of the stellar initial mass function. We investigated changes in the mass spectrum by changing the assumptions on the temperature distribution of the clumps and on the contribution of free-free emission to the 1.2 mm emission, and found little changes on the exponent. The Cumulative Mass Distribution Function is also analyzed giving consistent results in a mass range excluding the high-mass end where a power-law fit is no longer valid. The masses and sizes of the clumps observed in NGC 6334 indicate that they are not direct progenitors of stars and that the process of fragmentation determines the distribution of masses later on or occurs at smaller spatial scales. The spatial distribution of the clumps in NGC 6334 reveals clustering which is

strikingly similar to that exhibited by young stars in other star forming regions. A power law fit to the surface density of companions gives $\Sigma \propto \theta^{-0.62}$.

Accepted by The Astrophysical Journal

http://arxiv.org/abs/0706.3035

Protostellar Turbulence Driven by Collimated Outflows

Fumitaka Nakamura[1,2] and Zhi-Yun Li[3]

[1] Faculty of Education and Human Sciences, Niigata University, Niigata 950-2181, Japan
[2] Visiting Astronomer, Division of Theoretical Astrophysics, National Astronomical Observatory, Mitaka, Tokyo 181-8588, Japan
[3] Department of Astronomy, University of Virginia, Charlottesville, VA 22904, USA

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

We investigate the global properties of the outflow-driven protostellar turbulence through 3D MHD simulations. The simulations show that the turbulence in regions of active cluster formation is quickly transformed by the forming stars through protostellar outflows, and that strongly influences and perhaps controls protostellar turbulence cluster formation. We find that collimated outflows are more efficient in driving turbulence than spherical outflows that carry the same amounts of momentum. This is because collimated outflows can propagate farther away from their sources, effectively increasing the turbulence driving length; turbulence driven on a larger scale decays more slowly. Gravity plays an important role in shaping the turbulence, generating infall motions that balance the outward motions driven by outflows. The resulting quasi-equilibrium state is maintained through a slow rate of star formation, with a fraction of the total mass converted into stars per free-fall time as low as a few percent. Magnetic fields are dynamically important even in magnetically supercritical clumps, provided that their initial strengths are not far below the critical value for static cloud support. They contain an energy comparable to the turbulent energy and can significantly reduce the rate of star formation. The mass-weighted probability distribution function (PDF) of the volume density of the protostellar turbulence is often, although not always, approximately lognormal. The PDFs of the column density deviate more strongly from lognormal distributions. There is a prominent break in the power spectrum, which may provide a way to distinguish it from other types of turbulence.

Published by the Astrophysical Journal (Vol. 662, p. 395)

Observational Characteristics of the First Protostellar Cores

Kazuyuki Omukai[1]

[1] National Astronomical Observatory of Japan

E-mail contact: omukai *at* th.nao.ac.jp

First protostellar cores are young stellar objects in the earliest evolutionary stage. They are hydrostatic objects formed soon after the central portions of star-forming cores become optically thick to dust emission. We consider their characteristics in the emitted radiation, and discuss their evolution with increasing mass of the cores. Particular attention is paid to detailed radiative and chemical processes in the postshock relaxation layer located at the surface of the core, where the majority of radiation is emitted. Most of the radiation is originally emitted in the dust continuum in mid-infrared wavelength ($\sim 10-30\mu$m), which reprocessed to far-infrared with $\sim 100-200\mu$m. Although some fraction (~ 0.1) of the radiation energy is emitted in the H_2O lines at the accretion shock, most is absorbed and reemitted in the dust continuum in the envelope. The H_2O lines account for at most $\sim$1/100 of the observed luminosity. If a cavity is present in the envelope due to outflow or rotation, the dust and H_2O line emission in the mid-infrared wavelength from the shock can be observed directly, or as a reflection nebula. Among forthcoming observational facillities, SPICA is the most suitable for detecting either direct or processed radiation from first-core objects.

Accepted by PASJ

http://arxiv.org/abs/0705.3300

Interaction of Supernova Ejecta with Nearby Protoplanetary Disks

N. Ouellette[1], S. J. Desch[2] and J. J. Hester[2]

[1] Department of Physics, Arizona State University, Tempe, AZ 85287 , USA
[2] School of Earth and Space Exploration, Arizona State University, Tempe, AZ 85287, USA

The early solar system contained short-lived radionuclides such as ^{60}Fe ($t_{1/2} = 1.5$ Myr) whose most likely source was a nearby supernova. Previous models of solar system formation considered a supernova shock that triggered the collapse of the Sun's nascent molecular cloud. We advocate an alternative hypothesis, that the solar system's protoplanetary disk had already formed when a very close (<1 pc) supernova injected radioactive material directly into the disk. We conduct the first numerical simulations designed to answer two questions related to this hypothesis: Will the disk be destroyed by such a close supernova, and will any of the ejecta be mixed into the disk? Our simulations demonstrate that the disk does not absorb enough momentum from the shock to escape the protostar to which it is bound. Only low amounts (<1%) of mass loss occur, due to stripping by Kelvin-Helmholtz instabilities across the top of the disk, which also mix into the disk about 1% of the intercepted ejecta. These low efficiencies of destruction and injection are due to the fact that the high disk pressures prevent the ejecta from penetrating far into the disk before stalling. Injection of gas-phase ejecta is too inefficient to be consistent with the abundances of radionuclides inferred from meteorites. On the other hand, the radionuclides found in meteorites would have condensed into dust grains in the supernova ejecta, and we argue that such grains will be injected directly into the disk with nearly 100% efficiency. The meteoritic abundances of the short-lived radionuclides such as ^{60}Fe therefore are consistent with injection of grains condensed from the ejecta of a nearby (<1 pc) supernova, into an already formed protoplanetary disk.

Published by the Astrophysical Journal (Vol. 662, p. 1268)

Observations of Water Masers in the NGC 1333 IRAS 4 Region

Geumsook Park[1,2] and Minho Choi[1]

[1] International Center for Astrophysics, Korea Astronomy and Space Science Institute, Daejeon, South Korea
[2] Department of Astronomy and Space Science, Chungnam National University, Daejeon, South Korea

E-mail contact: pgs *at* kasi.re.kr

The NGC 1333 IRAS 4 region was observed in the 22 GHz H2O maser line with an angular resolution of about 0.08 arcseconds. Two groups of masers were detected, one near IRAS 4A and the other near BI. Among the eight maser spots detected near IRAS 4A, six spots are located close to A2, within 100 AU, and the maser velocities are also near the systemic velocity of the cloud core. These masers are probably related with the circumstellar disk. Since there is no maser spot detected around A1, the star forming process is relatively more active in A2 than in A1. Four maser spots were detected near IRAS 4BI. Since most of them are distributed along a straight line in the direction of the outflow, BI masers are most likely related with the jet or outflow. The disk-outflow dichotomy of H2O masers is discussed briefly. No maser was detected near H2O(C), another maser source reported previously.

Accepted by ApJ

http://lanl.arxiv.org/abs/0706.2016

Convective Cooling and Fragmentation of Gravitationally Unstable Disks

Roman R. Rafikov[1]

[1] Canadian Institute for Theoretical Astrophysics, University of Toronto, Toronto, ON M5S 3H8, Canada

E-mail contact: rrr *at* cita.utoronto.ca

Gravitationally unstable disks can fragment and form bound objects provided that their cooling time is short. In protoplanetary disks, radiative cooling is likely to be too slow to permit formation of planets by fragmentation within several tens of AU from the star. Recently, convection has been suggested as a faster means of heat loss from the disk, but here we demonstrate that it is only marginally more efficient than radiative cooling. The crucial factor is the rate at which energy can be radiated from the disk's photosphere, which is robustly limited from above in the convective case by the adiabatic temperature gradient (given a certain midplane temperature). Thus, although vigorous convection is definitely possible in disks, the inefficiency of radiative loss from the photosphere may create

a bottleneck, limiting the ability of the disk to form self-gravitating objects. Based on this argument, we derive a set of analytical constraints that diagnose the susceptibility of an unstable disk to fragmentation and show that the formation of giant planets by fragmentation of protoplanetary disks is unlikely to occur at distances of tens of AU. At the same time, these constraints do not preclude the possibility of fragmentation and star formation in accretion disks around supermassive black holes.

Published by the Astrophysical Journal (Vol. 662, p. 642)

Imaging the Ionized Disk of the High-Mass Protostar Orion-I

M. J. Reid[1], K. M. Menten[2], L. J. Greenhill[1] and C. J. Chandler[3]

[1] Harvard–Smithsonian Center for Astrophysics
[2] MPIfR
[3] National Radio Astronomy Observatory

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

We have imaged the enigmatic radio source-I (Orion–I) in the Orion-KL nebula with the VLA at 43 GHz with 34 mas angular resolution. The continuum emission is highly elongated and is consistent with that expected from a nearly edge-on disk. The high brightness and lack of strong molecular lines from Orion–I can be used to argue against emission from dust. Collisional ionization and H^- free-free opacity, as in Mira variables, require a central star with $\gtrsim 10^5$ $L_\odot$, which is greater than infrared observations allow. However, if significant local heating associated with accretion occurs, lower total luminosities are possible. Alternatively, photo-ionization from an early B-type star and p^+/e^- bremsstrahlung can explain our observations, and Orion–I may be an example of ionized accretion disk surrounding a forming massive star. Such accretion disks may not be able to form planets efficiently.

Accepted by ApJ

arXiv:0704.2309

X-rays from RU Lupi - Accretion and winds in CTTS

J. Robrade[1] and J.H.M.M. Schmitt[1]

[1] Hamburger Sternwarte, Gojenbergsweg 112, D-21029 Hamburg, Germany

E-mail contact: jrobrade *at* hs.uni-hamburg.de

Context: Low-mass stars are known to exhibit strong X-ray emission during their early evolutionary stages. This applies also to classical T Tauri stars (CTTS), whose X-ray emission differs from that of main-sequence stars in a number of aspects.

Aims: We study the specific case of RU Lup, a well known accreting and wind-driving CTTS. In comparison with other bright CTTS we study possible signatures of accretion and winds in their X-ray emission.

Methods: Using three XMM-Newton observations of RU Lup, we investigate its X-ray properties and their generating mechanisms. High resolution X-ray spectra of RU Lup and other CTTS are compared to main-sequence stars. We examine the presence of a cool plasma excess and enhanced plasma density in relation to X-rays from accretion shocks and investigate anomalous strong X-ray absorption and its connection to winds or circumstellar material. Results: We find three distinguishable levels of activity among the observations of RU Lup. While no large flares are present, this variability is clearly of magnetic origin due to the corresponding plasma temperatures of around 30 MK; in contrast the cool plasma component at 2–3 MK is quite stable over a month, resulting in average plasma temperature from 35 MK down to 10 MK. Density analysis with the OVII triplet indicates high densities in the cool plasma, suggesting accretion shocks to be a significant contributor to the soft X-ray emission. No strong overall metal depletion is observed, with Ne being more abundant than Fe, that is at solar value, and especially O. Excess emission at 6.4 keV during the more active phase suggest the presence of iron fluorescence. Additionally RU Lup exhibits an extraordinary strong X-ray absorption, incompatible with estimates obtained at optical and UV wavelengths. Comparing spectra from a sample of main-sequence stars with those of accreting stars we find an excess of cool plasma as evidenced by lower OVIII/OVII line ratios in all accreting stars. High density plasma appears to be only present in low-mass CTTS, while accreting stars with intermediate masses ($\geq 2M_\odot$) have lower densities.

Conclusions: In all investigated CTTS the characteristics of the cooler X-ray emitting plasma are influenced by the accretion process. We suspect different accretion rates and amount of funneling, possibly linked to stellar mass and radius, to be mainly responsible for the different properties of their cool plasma component. The exceptional X-ray absorption in RU Lup and other CTTS is probably related to the accretion flows and an optically transparent wind emanating from the star or the disk.

Accepted by A&A

http://arxiv.org/abs/0706.2879

Chemical chronology of the Southern Coalsack

S.D. Rodgers[1], S.B. Charnley[1], R.G. Smith[2] and H.M. Butner[3]

[1] Space Science & Astrobiology Division, MS 245-3, NASA Ames Research Center, Moffett Field, CA 94035
[2] School of Physical, Environmental & Mathematical Sciences, The University of New South Wales, Australian Defence Force Academy, Canberra ACT 2600, Australia
[3] Department of Physics, James Madison University, 901 Carrier Drive, Harrisonburg, VA 22807-7702

E-mail contact: rodgers *at* dusty.arc.nasa.gov

We show how the observed H_2O ice column densities toward three dense globules in the Southern Coalsack can be used to constrain the ages of these sources. We derive ages of $\sim 10^5$ yr, in agreement with dynamical studies of these objects. We have modelled the chemical evolution of the globules, and show how the molecular abundances are controlled by both the gas density and the initial chemical conditions as the globules formed. Based on our derived ages, we predict the column densities of several species of interest. These predictions should be straightforward to test by performing molecular line observations.

Accepted by MNRAS

arXiv:0705.3262

Hα line profiles for a sample of supergiant HII regions

M. Rozas[1], M. G. Richer[1], W. Steffen[1], G. García-Segura[1] and J. A. López[1]

[1] Instituto de Astronomía, Universidad Nacional Autónoma de México, Ensenada, CP 22800, Baja California, Mexico

E-mail contact: maite *at* astrosen.unam.mx

We carried out a series of 1D hydrodynamical computations with the ZEUS fluid solver in order to reproduce the salient features in our high-resolution Hα emission line profiles of a sample of HII regions (see Rozas et al. 2006a,b). Four models were computed. In the first and second cases, an ionization-bounded HII region was modeled with and without a shell produced by stellar winds. In the third and fourth cases, a density-bounded HII region was considered, both with and without a shell driven by stellar winds. The resulting line profiles have been modeled using the SHAPE rendering program. We find that our observed high-quality profiles are well-reproduced in the density-bounded model that includes an expanding shell formed as a result of the stellar winds from the ionizing stars. Finally, we consider the effects that the finite slit widths used for the observations have on the physical conditions deduced from the line profile of the ionized bubble.

Published by Astronomy & Astrophysics (Vol. 467, p. 603)

Near-infrared Study of the Carina Nebula

Kaushar Sanchawala[1], Wen-Ping Chen[2], Devendra Ojha[3], Swarna Kanti Ghosh[4], Yasushi Nakajima[5], Motohide Tamura[6], Daisuke Baba[7], Shuji Sato[8] and Masahiro Tsujimoto[9]

[1] Institute of Astronomy, National Central University, Taiwan
[2] Institute of Astronomy, National Central University, Taiwan
[3] Tata Institute of Fundamental Research, India
[4] Tata Institute of Fundamental Research, India
[5] National Astronomical Observatory of Japan, Japan
[6] National Astronomical Observatory of Japan, Japan

[7] Department of Physics, Nagoya University, Japan
[8] Department of Physics, Nagoya University, Japan
[9] Pennsylvania State University, USA

E-mail contact: kaushar *at* outflows.astro.ncu.edu.tw

We have carried out near-infrared (NIR) imaging observations of the Carina Nebula for an area of ∼400 arcmin^2 including the star clusters Trumpler 14 (Tr 14) and Trumpler 16 (Tr 16). With 10 σ limiting magnitudes of J ∼18.5, H ∼17.5 and K_s ∼16.5, we identified 544 Class II and 11 Class I young star candidates. We find some 40 previously unknown very red sources with $H - K_s > 2$, most of which remain undetected at the J band. These young star candidates provide a comprehensive sample to diagnose the star-formation history of this massive star-forming region. The red NIR sources are found to be concentrated to the south-east of Tr 16, along the 'V' shaped dust lane, where the next generation of stars seems to be forming. In addition, we find indications of ongoing star formation near the three MSX point sources, G287.51-0.49, G287.47-0.54, and G287.63-0.72. A handful of red NIR sources are seen to populate around each of these MSX sources. Apart from this, we identified two hard *Chandra* X-ray sources near G287.47-0.54, one of which does not have an NIR counterpart and may be associated with a Class I/Class 0 object. The majority of the Class II candidates, on the other hand, are seen to be distributed in the directions of the clusters, demarcating different evolutionary stages in this massive star-forming region. A comparison of the color-magnitude diagrams of the clusters with pre–main-sequence (PMS) model tracks shows that the stellar population of these clusters is very young ($\leq$ 3 Myr). The K_s-band luminosity function (KLF) of Tr 14 shows structure at the faint end, including a sharp peak due to the onset of deuterium burning, implying an age of 1–2 Myr for the cluster. The KLF of Tr 16, in contrast, is found to rise smoothly until it turns over. The slopes of the mass functions derived for the clusters are found to be in agreement with the canonical value of the field star initial mass function (IMF) derived by Salpeter.

Accepted by The Astrophysical Journal

http://arxiv.org/abs/0706.1834

Rotation and Activity of Pre-Main Sequence Stars

Alexander Scholz[1], Jaime Coffey[2], Alexis Brandeker[3] and Ray Jayawardhana[3]

[1] SUPA, School of Physics and Astronomy, University of St. Andrews, North Haugh, St. Andrews, Fife KY16 8SS, UK
[2] Department of Physics and Astronomy, University of British Columbia, 6224 Agricultural Road, Vancouver, BC V6T 1Z1, Canada
[3] Department of Astronomy and Astrophysics, University of Toronto, 50 St. George Street, Toronto, ON M5S 3H4, Canada

E-mail contact: as110 *at* st-andrews.ac.uk

We present a study of rotation (v sin i) and chromospheric activity (Hα equivalent width) based on an extensive set of high-resolution optical spectra obtained with the MIKE instrument on the 6.5 m Magellan Clay telescope. Our targets are 74 F-M dwarfs in four young stellar associations, spanning ages from 6 to 30 Myr. By comparing Hα EWs in our sample to results in the literature, we see a clear evolutionary sequence: Chromospheric activity declines steadily from the T Tauri phase to the main sequence. Using activity as an age indicator, we find a plausible age range for the Tuc-Hor association of 10-40 Myr. Between 5 and 30 Myr, we do not see evidence for rotational braking in the total sample, and thus angular momentum is conserved, in contrast to younger stars. This difference indicates a change in the rotational regulation at ∼ 5-10 Myr, possibly because disk braking cannot operate longer than typical disk lifetimes, allowing the objects to spin up. The rotation-activity relation is flat in our sample; in contrast to main-sequence stars, there is no linear correlation for slow rotators. We argue that this is because young stars generate their magnetic fields in a fundamentally different way from main-sequence stars, and not just the result of a saturated solar-type dynamo. By comparing our rotational velocities with published rotation periods for a subset of stars, we determine ages of 13^{+7}_{-6} and 9^{+8}_{-2} Myr for the η Cha and TWA associations, respectively, consistent with previous estimates. Thus we conclude that stellar radii from evolutionary models by Baraffe et al. (1998) are in agreement with the observed radii to within ±15%.

Published by the Astrophysical Journal (Vol. 662, p. 1254)

A Census of the Carina Nebula – II. Energy Budget and Global Properties of the Nebulosity

Nathan Smith[1] and Kate J. Brooks[2]

[1] Astronomy Department, UC Berkeley, 601 Campbell Hall, Berkeley, CA 94720, USA
[2] Australia Telescope National Facility, CSIRO, PO Box 76, Epping, NSW 1710, Australia

E-mail contact: nathans *at* astro.berkeley.edu

The first paper in this series took a direct census of energy input from the known OB stars in the Carina Nebula, and in this paper we study the global properties of the surrounding nebulosity. This detailed comparison may prove useful for interpreting observations of extragalactic giant H II regions and ultraluminous infrared galaxies. We find that the total IR luminosity of Carina is about 1.2×10^7 $L_\odot$, accounting for only about 50–60% of the known stellar luminosity from Paper I. Similarly, the ionizing photon luminosity derived from the integrated radio continuum is about 7×10^{50} s^{-1}, accounting for ∼75% of the expected Lyman continuum from known OB stars. The total kinetic energy of the nebula is about 8×10^{51} ergs, or ∼30% of the mechanical energy from stellar winds over the lifetime of the nebula, so there is no need to invoke a supernova (SN) explosion based on energetics. Warm dust grains residing in the H II region interior dominate emission at 10-30 μm, but cooler grains at 30–40 K dominate the IR luminosity and indicate a likely gas mass of $\sim 10^6$ $M_\odot$. We find an excellent correlation between the radio continuum and 20-25 μm emission, consistent with the idea that the ∼80 K grain population is heated by trapped Lyα photons. Similarly, we find a near perfect correlation between the far-IR optical depth map of cool grains and 8.6 μm hydrocarbon emission, indicating that most of the nebular mass resides as atomic gas in photodissociation regions and not in dense molecular clouds. Synchronized star formation around the periphery of Carina provides a strong case that star formation here was indeed triggered by stellar winds and UV radiation. This second generation appears to involve a cascade toward preferentially intermediate- and low-mass stars, but this may soon change when η Car and its siblings explode. If the current reservoir of atomic and molecular gas can be tapped at that time, massive star formation may be rejuvinated around the periphery of Carina much as if it were a young version of Gould's Belt. Also, when these multiple SNe occur, the triggered second generation will be pelted repeatedly with SN ejecta bearing short-lived radioactive nuclides. Carina may therefore represent the most observable analog to the cradle of our own Solar System.

Accepted by MNRAS

http://lanl.arxiv.org/abs/0705.3053

The dust temperatures of the prestellar cores in the ρ Oph main cloud and in other star forming regions: consequences for the core mass function.

Dimitris Stamatellos[1], Anthony P. Whitworth[1] and Derek Ward-Thompson[1]

[1] School of Physics & Astronomy, Cardiff University, Wales, UK

E-mail contact: D.Stamatellos *at* astro.cf.ac.uk

We estimate the dust temperatures of the clumps in the ρ Oph main cloud taking into account the 3D geometry of the region, and external heating from the interstellar radiation field and from HD147879, a nearby luminous B2V star, which is believed to dominate the radiation field in the region. We find that the regions where prestellar cores are observed (i.e. at optical visual extinctions > 7 mag) are colder than $\sim 10 - 11$ K. These dust temperatures are smaller than those which previous studies of the same region have assumed. We use the new dust temperatures to estimate the masses of the prestellar cores in the ρ Oph main cloud from mm observations, and we find core masses that are larger than previous estimates by a factor of $\sim 2 - 3$. This affects the core mass function (CMF) of the region; we find that the mass at which the core mass spectrum steepens from a slope $\alpha \sim 1.5$ to a slope $\alpha \sim 2.5$ has moved from ~ 0.5 $M_\odot$ to ~ 1 $M_\odot$. In contrast with the CMF in other star forming regions (e.g. Orion), there is no indication for a turnover down to the completeness limit (~ 0.2 $M_\odot$), but the CMF may flatten at around ~ 0.4 $M_\odot$.

We generalize our results to the prestellar cores in Taurus and in Orion. In Taurus the ambient radiation field heating the prestellar cores is believed to be weaker than than that in ρ Oph. Hence, the dust temperatures of the cores in Taurus are expected to be below $\sim 10 - 11$ K. In Orion the radiation field is believed to be 10^3 times stronger than the standard interstellar radiation field. Based on this assumption we estimate that the dust temperatures of the prestellar cores in Orion are around $\sim 20 - 30$ K.

Accepted by MNRAS

http://arxiv.org/abs/0705.2941

Near-Infrared Polarimetry of the Eagle Nebula (M16)

Koji Sugitani[1], Makoto Watanabe[2], Motohide Tamura[3], Ryo Kandori[3], J. H. Hough[4], Shogo Nishiyama[3], Yasushi Nakajima[3], Nobuhiko Kusakabe[5], Jun Hashimoto[1,6], Takahiro Nagayama[7], Chie Nagashima[8], Daisuke Kato[8] and Naoya Fukuda[9]

[1] Graduate School of Natural Sciences, Nagoya City University, Mizuho-ku, Nagoya 467-8501, Japan
[2] Subaru Telescope, National Astronomical Observatory of Japan, Hilo, HI 96720, USA
[3] National Astronomical Observatory of Japan, 2-21-1 Osawa, Mitaka, Tokyo 181-8588, Japan
[4] Center for Astrophysics Research, University of Hertfordshire, Hatfield, Herts AL10 9AB, UK
[5] Graduate University of Advanced Science, 2-21-1 Osawa, Mitaka, Tokyo 181-8588, Japan
[6] Department of Astrophysics, Tokyo University of Science, Shinjuku-ku, Tokyo 162-8601, Japan
[7] Department of Astrophysics, Kyoto University, Sakyo-ku, Kyoto 606-8502, Japan
[8] Department of Astrophysics, Nagoya University, Nagoya 464-8602, Japan
[9] Department of Computer Simulation, Okayama University of Science, Okayama 700-0005, Japan

E-mail contact: sugitani *at* nsc.nagoya-cu.ac.jp

We carried out deep and wide (∼8' × 8') $JHKs$ imaging polarimetry in the southern region of the Eagle Nebula (M16). The polarization intensity map reveals that two YSOs with near-IR reflection nebulae are located at the tips of two famous molecular pillars (Pillars 1 and 2) facing toward the exciting stars of M16. The centrosymmetric polarization pattern are consistent with those around class I objects having circumstellar envelopes, confirming that star formation is now taking place at the two tips of the pillars under the influence of UV radiation from the exciting stars. Polarization measurements of point sources show that magnetic fields are aligned along some of the pillars but in a direction that is quite different to the global structure in M16.

Accepted by PASJ (Vol.59, No.3, June 25, 2007)

http://www.nsc.nagoya-cu.ac.jp/ sugitani/preprints/M16_SIRPOL.pdf
http://arxiv.org/abs/0706.1626

A Case Study of Low-Mass Star Formation

Jonathan J. Swift[1] and Wm. J. Welch[2]

[1] Institute for Astronomy, 2680 Woodlawn Dr., Honolulu, HI 96822-1897, USA
[2] Department of Astronomy and Radio Astronomy Laboratory, University of California, 601 Campbell Hall, Berkeley, CA 94720-3411, USA

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

This article synthesizes observational data from an extensive program aimed toward a comprehensive understanding of star formation in a low-mass star-forming molecular cloud. New observations and published data spanning from the centimeter wave band to the near infrared reveal the high and low density molecular gas, dust, and pre-main sequence stars in L1551.

The total cloud mass of $\sim 160\,M_\odot$ contained within a 0.9 pc has a dynamical timescale, $t_{\rm dyn} = 1.1$ Myr. Thirty-five pre-main sequence stars with masses from ~ 0.1 to $1.5\,M_\odot$ are selected to be members of the L1551 association constituting a total of $22 \pm 5\,M_\odot$ of stellar mass. The observed star formation efficiency, SFE = 12%, while the total efficiency, $\rm SFE_{tot}$, is estimated to fall between 9 and 15%.

L1551 appears to have been forming stars for several $t_{\rm dyn}$ with the rate of star formation increasing with time. Star formation has likely progressed from east to west, and there is clear evidence that another star or stellar system will form in the high column density region to the northwest of L1551 IRS5.

High-resolution, wide-field maps of L1551 in CO isotopologue emission display the structure of the molecular cloud at 1600 AU physical resolution. The ^{13}CO emission clearly reveals the disruption of the ambient cloud by outflows in the line core and traces the interface between regions of outflow and quiescent gas in the line wings. Kinetic energy from

outflows is being deposited back into the cloud on a physical scale $\lambda_{\rm peak} \approx 0.05\,{\rm pc}$ at a rate, $\dot{E}_{\rm input} \approx 0.05\,{\rm L}_\odot$. The remaining energy afforded by the full mechanical luminosity of outflow in L1551 destroys the cloud or is otherwise lost to the greater interstellar medium.

The $C^{18}O$ emission is optically thin and traces well the turbulent velocity structure of the cloud. The total turbulent energy is close to what is expected from virial equilibrium. The turbulent velocities exist primarily on small scales in the cloud and the energy spectrum of turbulent fluctuations, $E(k) \propto k^{-\beta}$, is derived by various methods to have $\beta \approx 1$–2. The turbulent dissipation rate estimated using the results of current numerical simulations is $\dot{E}_{\rm diss} \approx \dot{E}_{\rm input}$. This study reveals that stellar feedback is a significant factor in the evolution of the L1551 cloud.

Accepted by ApJS

http://xxx.lanl.gov/abs/0706.2206

SIM PlanetQuest Key Project Precursor Observations to Detect Gas Giant Planets Around Young Stars

Angelle Tanner[1], Charles Beichman[1], Rachel Akeson[1], Andrea Ghez[2], Konstantin N. Grankin[3], William Herbst[4], Lynne Hillenbrand[5], Marcos Huerta[6], Quinn Konopacky[2], Stanimir Metchev[2], Subhanjoy Mohanty[7], L. Prato[8] and Michal Simon[9]

[1] Michelson Science Center, Caltech, 770 S. Wilson Ave., Pasadena, CA 91125, USA
[2] UCLA, Division of Astronomy, 430 Portola Plaza, Box 951547, Los Angeles, CA 90095-1547, USA
[3] Astronomical Institute of the Uzbek Academy of Sciences,Uzbekistan
[4] Astronomy Department, Wesleyan University, Middletown, CT 06459, USA
[5] Caltech, MS 320-47, Pasadena, California 91125, USA
[6] University of Florida, 211 Bryant Space Science Center, Gainesville, FL, 32611-2055, USA
[7] Center for Astrophysics, Harvard University, 60 Garden Street Cambridge, MA 02138, USA
[8] Lowell Observatory, 1400 W. Mars Hill Rd., Flagstaff, AZ 86001, USA
[9] State University of New York at Stony Brook Dept. of Physics and Astronomy, Stony Brook, NY 11794-3800, USA

E-mail contact: angelle.tanner *at* jpl.nasa.gov

We present a review of precursor observing programs for the SIM PlanetQuest Key project devoted to detecting Jupiter mass planets around young stars. In order to ensure that the stars in the sample are free of various sources of astrometric noise that might impede the detection of planets, we have initiated programs to collect photometry, high contrast images, interferometric data and radial velocities for stars in both the Northern and Southern hemispheres. We have completed a high contrast imaging survey of target stars in Taurus and the Pleiades and found no definitive common proper motion companions within one arcsecond (140 AU) of the SIM targets. Our radial velocity surveys have shown that many of the target stars in Sco-Cen are fast rotators and a few stars in Taurus and the Pleiades may have sub-stellar companions. Interferometric data of a few stars in Taurus show no signs of stellar or sub-stellar companions with separations of ¡5 mas. The photometric survey suggests that approximately half of the stars initially selected for this program are variable to a degree (1 sigma¿0.1 mag) that would degrade the astrometric accuracy achievable for that star. While the precursor programs are still a work in progress, we provide a comprehensive list of all targets ranked according to their viability as a result of the observations taken to date. By far, the observable that removes the most targets from the SIM-YSO program is photometric variability.

Accepted by Publications of the Astronomical Society of the Pacific

arXiv:0705.3687

Collisional processes and size distribution in spatially extended debris discs

Philippe Thebault[1] and Jean-Charles Augereau[2]

[1] Stockholm Observatory and Paris Observatory
[2] LAOG, Grenoble Observatory

E-mail contact: philippe.thebault *at* obspm.fr

We present a new multi–annulus code for the study of collisionally evolving extended debris discs. We first wish to

confirm and extend our early result obtained for a single–annulus system, namely that the size distribution in realistic debris discs always departs from the theoretical collisional "equilibrium" $dN \propto R^{-3.5}dR$ power law, especially in the crucial size range of observable particles ($R < 1\,\mathrm{cm}$), where it displays a characteristic wavy pattern. We also aim at studying how debris discs density distributions, scattered light luminosity profiles, and SEDs are affected by the coupled effect of collisions and radial mixing due to radiation pressure affected small grains. The size distribution evolution is modeled over 10 orders of magnitude, going from μm-sized grains to 50 km-sized bodies. The model takes into account the crucial influence of radiation pressure–affected small grains. We consider the collisional evolution of a fiducial, idealized a=120 AU radius disc with an initial surface density $\Sigma(a) \propto a^{\alpha}$. Several key parameters are explored: surface density profile, system's dynamical excitation, total dust mass, collision outcome prescriptions. We show that the system's radial extension plays a crucial role and that the waviness of the size distribution is amplified by inter–annuli interactions: in most regions the collisional and size evolution of the dust is imposed by small particles on eccentric or unbound orbits produced further inside the disc. Moreover, the spatial distribution of all grains $< 1\,\mathrm{cm}$ significantly departs from the initial profile in $\Sigma(a) \propto a^{\alpha}$, while the bigger objects, containing most of the system's mass, still follow the initial distribution. This has consequences on the scattered–light radial profiles which get significantly flatter, and we propose an empirical law to trace back the distribution of large unseen parent bodies from the observed profiles. We also show that the the waviness of the size distribution has a clear observable signature in the far-infrared and at (sub-)millimeter wavelengths. This suggests a test of our collision model, that requires observations with future facilities such as Herschel, SOFIA, SCUBA-2 and ALMA. We finally provide empirical formulae for the collisional size distribution and collision timescale that can be used for future debris disc modeling.

Accepted by Astronomy and Astrophysics

http://xxx.lanl.gov/abs/0706.0344

Shock-triggered formation of magnetically-dominated clouds

S. Van Loo[1], S. A. E. G. Falle[2], T. W. Hartquist[1] and T. J. T. Moore[3]

[1] School of Physics and Astronomy, University of Leeds, Leeds LS2 9JT, UK

[2] Department of Applied Mathematics, University of Leeds, Leeds LS2 9JT, UK

[3] Astrophyscis Research Institute, Liverpool John Moores University, Birkenhead CH41 1LD, UK

E-mail contact: svenvl *at* ast.leeds.ac.uk

To understand the formation of a magnetically dominated molecular cloud out of an atomic cloud, we follow the dynamical evolution of the cloud with a time-dependent axisymmetric magnetohydrodynamic code. A thermally stable warm atomic cloud is initially in static equilibrium with the surrounding hot ionised gas. A shock propagating through the hot medium interacts with the cloud. As a fast-mode shock propagates through the cloud, the gas behind it becomes thermally unstable. The β-value of the gas also becomes much smaller than the initial value of order unity. These conditions are ideal for magnetohydrodynamic waves to produce high-density clumps embedded in a rarefied warm medium. A slow-mode shock follows the fast-mode shock. Behind this shock a dense shell forms, which subsequently fragments. This is a primary region for the formation of massive stars. Our simulations show that only weak and moderate-strength shocks can form cold clouds which have properties typical of giant molecular clouds.

Accepted by Astronomy and Astrophysics

http://uk.arxiv.org/abs/0706.0434

IRAS 18511+0146: a proto Herbig Ae/Be cluster?

S. Vig[1], L. Testi[1,2], M. Walmsley[1], S. Molinari[3], S. Carey[4] and A. Noriega-Crespo[4]

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

[2] ESO, Karl Schwarzschild str. 2, D-85748 Garching, Germany

[3] INAF-Istituto di Fisica dello Spazio Interplanetario, Via Fosso del Cavaliere, I-00133 Roma, Italy

[4] Spitzer Science Center, California Institute of Technology, Pasadena, CA 91125, USA

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

Context: The evolution of a young protocluster depends on the relative spatial distribution and dynamics of both stars and gas.

Aims: We study the distribution and properties of the gas and stars surrounding the luminous (10^4 $L_\odot$) protocluster IRAS 18511+0146.
Methods: IRAS 18511+0146 and the cluster associated with it has been investigated using the sub-millimetre (JCMT-SCUBA), infrared (Spitzer-MIPSGAL, Spitzer-GLIMPSE, Palomar) and radio (VLA) continuum data. Cluster simulations have been carried out in order to understand the properties of clusters as well as to compare with the observations.
Results: The central most obscured part of the protocluster coincident with the compact sub-millimetre source found with SCUBA is responsible for at least 2/3 of the total luminosity. A number of cluster members have been identified which are bright in mid infrared and show rising (near to mid infrared) spectral energy distributions suggesting that these are very young stellar sources. In the mid infrared 8.0 μm image, a number of filamentary structures and clumps are detected in the vicinity of IRAS 18511+0146.
Conclusions: Based on the luminosity and cluster size as well as on the evolutionary stages of the cluster members, IRAS 18511+0146 is likely to be protocluster with the most massive object being a precursor to a Herbig type star.

Accepted by Astronomy and Astrophysics

High-Dispersion Optical Spectra of Nearby Stars Younger Than The Sun

Russel J. White[1], Jared M. Gabor[2] and Lynne A. Hillenbrand[3]

[1] University of Alabama in Huntsville
[2] University of Arizona
[3] California Institute of Technology

E-mail contact: russel.white *at* uah.edu

We present high dispersion (R $\sim$ 16,000) optical (3900 − 8700 Å) spectra of 390 stars obtained with the Palomar 60-inch Telescope. The majority of stars observed are part of the Spitzer Legacy Science Program *The Formation & Evolution of Planetary Systems*. Through detailed analysis we determine stellar properties for this sample, including radial and rotational velocities, Li I λ 6708 and $H\alpha$ equivalent widths, the chromospheric activity index R'_{HK}, and temperature- and gravity-sensitive line ratios. Several spectroscopic binaries are also identified. From our tabulations, we illustrate basic age- and rotation-related correlations among measured indices. One novel result is that Ca II chromospheric emission appears to saturate at $v\sin i$ values above $\sim$ 30 km s^{-1}, similar to the well established saturation of x-rays that originate in the spatially separate coronal region.

Accepted by The Astronomical Journal (Vol. 133, p. 2524)

Super stellar clusters with a bimodal hydrodynamic solution: an Approximate Analytic Approach

Richard Wünsch[1], Sergiy Silich[2], Jan Palous[1] and Guillermo Tenorio-Tagle[2]

[1] Astronomical Institute, Academy of Sciences of the Czech Republic, v.v.i., Bocni II 1401, 141 31 Prague, Czech Republic
[2] Instituto Nacional de Astrofisica Optica y Electronica, AP 51, 72000 Puebla, Mexico

E-mail contact: richard *at* wunsch.cz

Aims: We look for a simple analytic model to distinguish between stellar clusters undergoing a bimodal hydrodynamic solution from those able to drive only a stationary wind. Clusters in the bimodal regime undergo strong radiative cooling within their densest inner regions, which results in the accumulation of the matter injected by supernovae and stellar winds and eventually in the formation of further stellar generations, while their outer regions sustain a stationary wind.

Methods: The analytic formulae are derived from the basic hydrodynamic equations. Our main assumption, that the density at the star cluster surface scales almost linearly with that at the stagnation radius, is based on results from semi-analytic and full numerical calculations.

Results: The analytic formulation allows for the determination of the threshold mechanical luminosity that separates clusters evolving in either of the two solutions. It is possible to fix the stagnation radius by simple analytic expressions and thus to determine the fractions of the deposited matter that clusters evolving in the bimodal regime blow out as

a wind or recycle into further stellar generations.

Accepted by Astronomy and Astrophysics

arXiv:astro-ph/0706.1889

A new young stellar cluster embedded in a molecular cloud in the far outer Galaxy

Joao L. Yun[1], Ana Lopez-Sepulcre[2] and Jose M. Torrelles[3]

[1] Universidade de Lisboa - Faculdade de Ciencias - Centro de Astronomia e Astrofisica
[2] Departament dAstronomia i Meteorologia, Facultat de Fisica, Universitat de Barcelona
[3] Instituto de Ciencias del Espacio (CSIC) and Institut dEstudis Espacials de Catalunya

E-mail contact: yun *at* oal.ul.pt

We report the discovery of a new young stellar cluster and molecular cloud located in the far outer Galaxy, seen towards IRAS 06361-0142, and we characterise their properties. Near-infrared images were obtained with VLT/ISAAC through JHKs filters, millimetre line observations of CO(1-0) were obtained with SEST, and VLA 6 cm continuum maps obtained from archive data. The cloud and cluster are located at a distance of 7 kpc and a Galactocentric distance of 15 kpc, well in the far outer Galaxy. Morphologically, IRAS 06361-0142 appears as a cluster of several tens of stars surrounded by a nearly spherical nebular cavity centred at the position of the IRAS source. The cluster appears composed of low and intermediate-mass, young reddened stars with a large fraction having cleared the inner regions of their circumstellar discs responsible for (H - Ks) colour excess. The observations are compatible with a 4 Myr cluster with variable spatial extinction between Av = 6 and Av = 13.

Accepted by Astronomy & Astrophysics

http://astro.oal.ul.pt/yun/yun_distant_cluster.pdf

Abstracts of recently accepted major reviews

Cold Dark Clouds: The Initial Conditions for Star Formation

Edwin A. Bergin[1] and Mario Tafalla[2]

[1] University of Michigan, 825 Dennison Building, 500 Church St., Ann Arbor, MI 48109-1090, USA
[2] Observatorio Astronómico Nacional, Alfonso XII 3, E-28014 Madrid, Spain

E-mail contact: ebergin *at* umich.edu

Cold dark clouds are nearby members of the densest and coldest phase in the galactic interstellar medium, and represent the most accessible sites where stars like our Sun are currently being born. In this review we discuss recent progress in their study, including the newly discovered infrared dark clouds that are likely precursors to stellar clusters. At large scales, dark clouds present filamentary mass distributions with motions dominated by supersonic turbulence. At small, sub-parsec scales, a population of subsonic starless cores provides a unique glimpse of the conditions prior to stellar birth. Recent studies of starless cores reveal a combination of simple physical properties together with a complex chemical structure dominated by the freeze-out of molecules onto cold dust grains. Elucidating this combined structure is both an observational and theoretical challenge whose solution will bring us closer to understanding how molecular gas condenses to form stars.

Accepted by Annual Reviews of Astronomy and Astrophysics Vol. 45

http://arxiv.org/abs/0705.3765

Astrophysicist Position in Exoplanet Instrumentation

NASA's Ames Research Center, Space Science Division in Mountain View, CA invites applications for a new civil service position in instrumentation development for and observational studies of extrasolar planets. This is roughly equivalent to a university tenure track position. NASA Ames is home to the Kepler mission to find Earth-sized transiting exoplanets which is scheduled for launch in 2008. Ames scientists are also very active in the observational study and theoretical modeling of exoplanets and exoplanet systems, and they are recognized as leaders in these fields.

Ames now seeks to expand its activities in technology development for future exoplanet missions. We are seeking an individual to lead the development of a high contrast imaging testbed to demonstrate the capabilities of an end-to-end imaging system featuring a new Phase Induced Amplitude Apodization coronagraph in a space-like environment. This development requires integration of the coronagraph, a scale primary mirror, light source, and a state-of-the-art wavefront control system into the testbed which shall be operated in both air and vacuum environments. Some engineering and technician support will be available for these tasks, and this work will also be supported by Ames's partners in industry and academia. The incumbent will also pursue an active research program in observational astronomy or astronomical instrumentation development for NASA-funded opportunities.

Applicants should have strong records of achievement in related astronomical instrumentation projects. This record should include significant technical and scientific publications and some history of funding. Experience with developing high stability or high contrast astronomical instrumentation is required, and experience in developing or operating wavefront control systems is beneficial. The ideal candidate will have at least 3 years postdoctoral experience, and more experienced candidates are also encouraged to apply. Relocation expenses will be provided. Salary will be dependent upon experience.

To apply for the position, go to www.usajobs.opm.gov and enter keyword "AR07D0167" or

http://jobsearch.usajobs.opm.gov/ftva.asp?opmcontrol=928036

and follow the instructions on "How to Apply". Address technical inquiries to Dr. Tom Greene (thomas.p.greene@nasa.gov). The final application deadline is September 28, 2007, but qualified applicants may be selected before then. NASA is an EEO employer.

Origin and Evolution of Stars and Planetary Systems
Post-doctoral positions - Centro de Astrofísica da Universidade do Porto

The Centro de Astrofísica da Universidade do Porto (CAUP) **will open** a call for applications in July (for two months), for 4 contracts of post-doctoral researchers under a "Contrato-Programa" with Fundação para a Ciência e Tecnologia (FCT). Additional positions may be considered by FCT, by proposal of CAUP, if the profile of the candidates is adequate. The positions are for 5 years starting preferentially before the end of 2007. The net yearly income is above 42 000 euros (before taxes) corresponding to the salary of an Assistant Professor.
CAUP is the largest Astronomy research institute in Portugal, the only one evaluated as "Excellent" by FCT. The objective of CAUP is to be an institute with internationally recognised front-line research and actively involved with the leading institutes in Europe on the areas identified as the focus of our research activity. The ongoing research activities at CAUP (involving 22 researchers and 12 PhD students) are organised in five broad main lines of research: Origin and Evolution of Stars and Planets (Star Formation, Planetary Systems, Stellar Structure and Evolution) and Galaxies and the Evolution of the Universe (Physical Properties of Galaxies, Observational Cosmology).

An important goal is to make sure that CAUP is optimally placed to contribute to large projects within ESA (preparation and exploitation of existing and future space missions) and ESO (use of existing and forthcoming facilities and the scientific driving of the development of the next generation of instrumentation) and participation in other international initiatives.
The contracts are aimed at researchers with relevant scientific curriculum and publication record and with significant experience in their field of research. They will be expected to supervise research students and to propose and conduct new research projects/programmes, as well as lead the participation of CAUP in relevant international initiatives in

their field of research. A minimum of three years experience as a postdoc is required.

Contact:

Mário João Monteiro, Rua das estrelas, 4150-762 Porto, Portugal

E-mail contact: direccao *at* astro.up.pt
Web page: http://www.astro.up.pt/

Meetings

70TH METEORITICAL SOCIETY MEETING

The final announcement for the 70th Meteoritical Society Meeting to be held August 13-17, 2007, at the in Tucson, Arizona is now available on the meeting website:

http://www.lpi.usra.edu/meetings/metsoc2007/

The announcement includes the program with abstracts and meeting registration information. The deadline for preregistration at the lower rate is FRIDAY, JULY 13. Registrations received after that date will be assessed a higher fee.

Principles of Astrophysical Fluid Dynamics

Cathie Clarke and Bob Carswell

This new textbook is aimed at advanced undergraduate or graduate students, who want an introduction to the concepts and methods of fluid dynamics in an astrophysical context. The book introduces the necessary fluid dynamics to understand a wide range of astronomical phenomena, from stellar structures to supernovae blast waves, to accretion discs. The authors' approach is to introduce and derive the fundamental equations, supplemented by text that conveys a more intuitive understanding of the subject, and to emphasize the observable phenomena that rely on fluid dynamical processes. The textbook contains over fifty exercises. The authors have both taught a course on this subject for several years, and the book is based on their lecture notes.

10 Fluid instabilities
10.1 Rayleigh-Taylor instability – 10.2 Gravitational instability (Jeans instability) – 10.3 Thermal instability – 10.4 Method summary

11 Viscous flows
11.1 Linear shear and viscosity – 11.2 Navier-Stokes equation – 11.3 Evolution of vorticity in viscous flows – 11.4 Energy dissipation in incompressible viscous flows – 11.5 Viscous flow through a circular pipe and the transition to turbulence

12 Accretion discs in astrophysics
12.1 Derivation of viscous evolution equations for accretion discs – 12.2 Viscous evolution equation with constant viscosity – 12.3 Steady thin discs – 12.4 Radiation from steady thin discs

13 Plasmas
13.1 Magnetohydrodynamic equations – 13.2 Charge neutrality – 13.3 Ideal hydromagnetic equations – 13.4 Waves in plasmas – 13.5 The Rayleigh-Taylor instability revisited

Appendix Equations in curvilinear coordinates

Cambridge University Press

ISBN 978-0-521-85331-6, hardbound, 226 pages, 2007
US$65.00

Available from:
http://www.cambridge.org:80/us/catalogue/catalogue.asp?isbn=9780521853316