THE STAR FORMATION NEWSLETTER

An electronic publication dedicated to early stellar evolution and molecular clouds

No. 184 — 16 Feb 2008 Editor: Bo Reipurth (reipurth@ifa.hawaii.edu)

Abstracts of recently accepted papers

V1647 Orionis: One Year into Quiescence

Colin Aspin[1], Tracy L. Beck[2] and Bo Reipurth[1]

[1] Institute for Astronomy, University of Hawaii, 640 N. A'ohoku Place, Hilo, HI 96720, USA
[2] Gemini Observatory, 670 N. A'ohoku Place, Hilo, HI 96720, USA

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

We present new optical, near-IR, and mid-IR observations of the young eruptive variable star V1647 Orionis that went into outburst in late 2004 for approximately two years. Our observations, taken one year after the star had faded to its pre-outburst optical brightness, show that V1647 Ori is still actively accreting circumstellar material. We compare and contrast these data with existing observations of the source from both pre-outburst and outburst phases. From near-IR spectroscopy we identify photospheric absorption features for the first time that allow us to constrain the classification of the young star itself. Our best-fit spectral type is M0 $\pm$ 2 sub-classes with a visual extinction of 19 ± 2 magnitudes and a K-band veiling of $r_K \sim 1.5 \pm 0.2$. We estimate that V1647 Ori has a quiescent bolometric luminosity of $\sim 9.5 L_\odot$ and a mass accretion rate of $\sim 1 \times 10^{-6}$ M$_\odot$ yr^{-1}. Our derived mass and age, from comparison with evolutionary models, are 0.8 ± 0.2 M$_\odot$ and $\lesssim 0.5$ Myr, respectively. The presence toward the star of shock-excited optical [S II] and [Fe II] emission as well as near-IR H_2 and [Fe II] emission perhaps suggests that a new Herbig-Haro flow is becoming visible close to the star.

Published by The Astronomical Journal (Vol. 135, p. 423)

Structure and evolution of super-Earth to super-Jupiter exoplanets: I. heavy element enrichment in the interior

I. Baraffe[1], G. Chabrier[1] and T. Barman[2]

[1] CRAL - ENS Lyon
[2] Lowell Observatory

E-mail contact: ibaraffe *at* ens-lyon.fr

We examine the uncertainties in current planetary models and we quantify their impact on the planet cooling histories and mass-radius relationships. These uncertainties include (i) the differences between the various equations of state used to characterize the heavy material thermodynamical properties, (ii) the distribution of heavy elements within planetary interiors, (iii) their chemical composition and (iv) their thermal contribution to the planet evolution. Our models, which include a gaseous H/He envelope, are compared with models of solid, gasless Earth-like planets in order to examine the impact of a gaseous envelope on the cooling and the resulting radius. We find that for a fraction of heavy material larger than 20% of the planet mass, the distribution of the heavy elements in the planet's interior affects substantially the evolution and thus the radius at a given age. For planets with large core mass fractions ($\gtrsim$ 50%), such as the Neptune-mass transiting planet GJ436b, the contribution of the gravitational and thermal energy from the core to the planet cooling history is not negligible, yielding a $\sim$ 10% effect on the radius after 1 Gyr. We show that the present mass and radius determinations of the massive planet Hat-P-2b require at least 200 M$_\oplus$ of heavy material in the interior, at the edge of what is currently predicted by the core-accretion model for planet formation. As an alternative avenue for massive planet formation, we suggest that this planet, and similarly HD 17156b, may have formed from collisions between one or several other massive planets. This would explain these planet unusual high density and high eccentricity. We show that if planets as massive as $\sim 25\ M_{\rm J}$ can form, as predicted by improved core-accretion models, deuterium is able to burn in the H/He layers above the core, even for core masses as large as $\sim 100\ \mathrm{M}_\oplus$. Such a result highlights the confusion provided by a definition of a planet based on the deuterium-burning limit. We provide extensive grids of planetary evolution models from 10 $\mathrm{M}_\oplus$ to 10 $\mathrm{M}_{\rm Jup}$, with various fractions of heavy elements. These models provide a reference to analyse the transit discoveries expected from the CoRoT and Kepler missions and to infer the internal composition of these objects.

Accepted by Astronomy and Astrophysics

arXiv:0802.1810

Near-infrared imaging polarimetry of young stellar objects in ρ Ophiuchi

A.F. Beckford[1], P.W. Lucas[1], A.C. Chrysostomou[1] and T.M. Gledhill[1]

[1] University of Hertfordshire

E-mail contact: p.w.lucas *at* herts.ac.uk

The results of a near-infrared (J H K LP) imaging linear polarimetry survey of 20 young stellar objects (YSOs) in ρ Ophiuchi are presented. The majority of the sources are unresolved, with K-band polarizations, PK below 6 per cent. Several objects are associated with extended reflection nebulae. These objects have centrosymmetric vector patterns with polarization discs over their cores; maximum polarizations of PK above 20 per cent are seen over their envelopes. Correlations are observed between the degree of core polarization and the evolutionary status inferred from the spectral energy distribution. K-band core polarizations above 6 per cent are only observed in Class I YSOs. A 3D Monte Carlo model with oblate grains aligned with a magnetic field is used to investigate the flux distributions and polarization structures of three of the ρ Oph YSOs with extended nebulae. A rho proportional to r to minus 1.5 power law for the density is applied throughout the envelopes. The large-scale centrosymmetric polarization structures are due to scattering. However, the polarization structure in the bright core of the nebula appears to require dichroic extinction by aligned non-spherical dust grains. The position angle indicates a toroidal magnetic field in the inner part of the envelope. Since the measured polarizations attributed to dichroic extinction are usually below 10 per cent, the grains must either be nearly spherical or very weakly aligned. The higher polarizations observed in the outer parts of the reflection nebulae require that the dust grains responsible for scattering have maximum grain sizes less than 1.05 μm.

Accepted by MNRAS

xxx.soton.ac.uk/pdf/0802.1863

Stars and brown dwarfs in the σ Orionis cluster: the Mayrit catalogue

J.A. Caballero[1]

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

E-mail contact: caballero *at* astrax.fis.ucm.es

Context. The young σ Orionis cluster is an indispensable basis for understanding the formation and evolution of stars, brown dwarfs, and planetary-mass objects. Our knowledge of its stellar population is, however, incomplete.

Aims. I present the Mayrit catalogue, which comprises most of the stars and high-mass brown dwarfs in the cluster.

Methods. The basis of this work is an optical-near infrared correlation between the 2MASS and DENIS catalogues in a circular area of radius 30 arcmin centred on the OB-type binary σ Ori AB. The analysis is supported by a bibliographic search of confirmed cluster members with features of youth and by additional X-ray, mid-infrared, and astrometric data.

Results. I list 241 σ Orionis stars and brown dwarfs with known features of youth, 97 candidate cluster members (40 are new), and 115 back- and foreground sources in the survey area. The 338 cluster members and member candidates constitute the Mayrit catalogue.

*Conclusions.*This catalogue is a suitable input for studying the spatial ditribution, multiplicity, properties and fre-

quency of discs, and the complete mass function of σ Orionis.

Published by Astronomy & Astrophysics (Vol. 478, p. 667)

Investigating the transport of angular momentum from young stellar objects : Do H_2 jets from class I YSOs rotate?

A. Chrysostomou[1], F. Bacciotti[2], B. Nisini[3], T.P. Ray[4], J. Eislöffel[5], C.J. Davis[6] and M. Takami[7]

[1] Centre for Astrophysics Research, Science & Technology Research Institute, University of Hertfordshire, Hatfield, HERTS AL10 9AB, UK

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

[3] INAF-Osservatorio Astronomico di Roma, Via di Frascati 33, I-00040 Monte Porzio Catone, Italy

[4] School of Cosmic Physics, Dublin Institute for Advanced Studies, 5 Merrion Square, Dublin 2, Ireland

[5] Thüringer Landessternwarte, Sternwarte 5, D-07778 Tautenberg, Germany

[6] Joint Astronomy Centre, 660 N. A'ohoku Place, Hilo, Hawaii 96720, USA

[7] Subaru Telescopes, 650 N. A'ohoku Place, Hilo, Hawaii 96720, USA

E-mail contact: a.chrysostomou *at* jach.hawaii.edu

In this pilot study, we examine molecular jets from the embedded Class I sources, HH 26 and HH 72, to search, for the first time, for kinematic signatures of jet rotation from young embedded sources.

High resolution long-slit spectroscopy of the H_2 1-0 S(1) transition was obtained using VLT/ISAAC. The slit was placed perpendicular to the flow direction about 2 arcsec from the sources. Position-velocity (PV) diagrams are constructed and intensity-weighted radial velocities *transverse* to the jet flow are measured.

Mean intensity-weighted velocities vary between $v_{\rm LSR} \sim$ -90 and -65 km s^{-1} for HH 26, and -60 and -10 km s^{-1} for HH 72; maxima occur close to the intensity peak and decrease toward the jet borders. Velocity dispersions are $\sim$ 45 and $\sim$ 80 km s^{-1} for HH 26 and HH 72, respectively, with gas motions as fast as -100 km s^{-1} present. Asymmetric PV diagrams are seen for both objects which a simple empirical model of a cylindrical jet section shows could in principle be reproduced by jet rotation alone. Assuming magneto-centrifugal launching, the observed HH 26 flow may originate at a disk radius of 2-4 AU from the star with the toroidal component of the magnetic field dominant at the observed location, in agreement with magnetic collimation models. We estimate that the kinetic angular momentum transported by the HH 26 jet is $\sim 2 \times 10^{-5}\,{\rm M}_\odot\,{\rm yr}^{-1}\,{\rm AU\ km\,s}^{-1}$. This value (a lower limit to the total angular momentum transported by the flow) already amounts to 70% of the angular momentum that has to be extracted from the disk for the accretion to proceed at the observed rate.

These results of this pilot study suggest that jet rotation may also be present at early evolutionary phases and supports the hypothesis that they carry away excess angular momentum, thus allowing the central protostar to increase its mass.

Accepted by Astronomy & Astrophysics

astro-ph/0802.1881

Evidence for Early Circumstellar Disk Evolution in NGC 2068/71

K. M. Flaherty[1] and J. Muzerolle[1]

[1] Steward Observatory, University of Arizona, Tucson, AZ 85721, USA

E-mail contact: kflaherty *at* as.arizona.edu

We study the disk and accretion properties of young stars in the NGC 2068 and NGC 2071 clusters. Using low-resolution optical spectra, we define a membership sample and determine an age for the region of ~2 Myr. Using high-resolution spectra of the Hα line we study the accretion activity of these likely members and also examine the disk properties of the likely members using IRAC and MIPS mid-infrared photometry. A substantial fraction (79%) of the 67 members have an infrared excess while all of the stars with significant infrared excess show evidence for active accretion. We find three populations of evolved disks (IRAC weak, MIPS weak, and transition disks) all of which show decreased accretion activity in addition to the evidence for evolution in the dust disk.

Published by The Astronomical Journal (Vol. 135, p. 966)

Large-Scale Structure of the Molecular Gas in Taurus Revealed by High Linear Dynamic Range Spectral Line Mapping

Paul F. Goldsmith[1], Mark Heyer[2], Gopal Narayanan[2], Ronald Snell[2], Di Li[1] and Chris Brunt[3]

[1] Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA
[2] FCRAO, Department of Astronomy, University of Massachusetts, Amherst, MA, USA
[3] School of Physics, University of Exeter, Stocker Rd, EX4 4QL United Kingdom

E-mail contact: Paul.F.Goldsmith *at* jpl.nasa.gov

We report the results of a 100 square degree survey of the Taurus Molecular Cloud region in the J = 1 → 0 transition of ^{12}CO and of ^{13}CO. The image of the cloud in each velocity channel includes $\simeq 3{\times}10^6$ Nyquist-sampled pixels on a $20''$ grid. The high sensitivity and large linear dynamic range of the maps in both isotopologues reveal a very complex, highly structured cloud morphology. There are large scale correlated structures evident in ^{13}CO emission having very fine dimensions, including filaments, cavities, and rings. The ^{12}CO emission shows a quite different structure, with particularly complex interfaces between regions of greater and smaller column density defining the boundaries of the largest–scale cloud structures. The axes of the striations seen in the ^{12}CO emission from relatively diffuse gas are aligned with the direction of the magnetic field. We have developed a statistical method for analyzing the pixels in which ^{12}CO but not ^{13}CO is detected, which allows us to determine the CO column in the diffuse portion of the cloud as well as in the denser regions in which we detect both isotopologues. Using a column density–dependent model for the CO fractional abundance, we derive the mass of the region mapped to be $2.4{\times}10^4\ M_\odot$. This is more than a factor of two greater than would be obtained using a canonical fixed fractional abundance of ^{13}CO and a factor three greater than would be obtained using this fractional abundance restricted to the high column density regions. We determine that half the mass of the cloud is in regions having column density below $2.1{\times}10^{21}$ cm^{-2}. The distribution of young stars in the region covered is highly nonuniform, with the probability of finding a star in a pixel with a specified column density rising sharply for $N(H_2) = 6{\times}10^{21}$ cm^{-2}. We determine a relatively low star formation efficiency (mass of young stars/mass of molecular gas), between 0.3 and 1.2 percent, and an average star formation rate during the past 3 Myr of $8{\times}10^{-5}$ stars yr^{-1}

Accepted by The Astrophysical Journal

arXiv:0802.2206v1 [astro-ph]

Resolving the circumbinary dust disk surrounding HH 30

S. Guilloteau[1,2], A. Dutrey[1,2], J. Pety[3,4], and F. Gueth[3]

[1] Université Bordeaux 1; Laboratoire d'Astrophysique de Bordeaux (LAB), France
[2] CNRS/INSU - UMR5804, BP 89, 33270 Floirac, France
[3] IRAM, 300 rue de la Piscine, 38400 Saint Martin d'Hères, France
[4] LERMA, UMR 8112, CNRS, Observatoire de Paris, 61 Av. de l'Observatoire, 75014 Paris, France

E-mail contact: Stephane.Guilloteau *at* obs.u-bordeaux1.fr

Context. The jet-disk connection is an important part of the star formation process. HH 30 is a rare and beautiful example of a system exhibiting a flared edge-on disk, an optical jet and a CO molecular outflow. A recent analysis of the jet wiggling has revealed that the central star is in reality a binary object. Therefore, the dust and gas disk observed around HH 30 is circumbinary.

Aims. In this paper, we attempt to better constrain the system (disk + stars) properties, as well as the system age.

Methods. We obtained very high angular resolution ($\sim 0.4''$) observations in continuum at 1.3 mm with the IRAM interferometer. A standard disk model is used to fit the continuum and line data in the Fourier-plane and derive the disk properties.

Results. We find that the disk of HH 30 is truncated at an inner radius 37 ± 4 AU. The simplest explanation is tidal truncation in a binary system. This confirms the binarity of the HH 30 system, which consists of two stars on a low eccentricity, 15 AU semi-major axis orbit. The jet wiggling is due to orbital motion. The mass ratio is poorly constrained. The system age may be less than 2 Myr. The disk is optically thin at 1.3 mm and the dust opacity index, $\beta \approx 0.4$, indicates the presence of cm size grains.

Conclusions. These observations confirm that HH 30, often presented as an archetypal example of the jet-disk

paradigm, is a binary star, with one of the components at the origin of the optical jet. This suggests that many other objects similar to HH 30 may be unknown binary or multiple systems. These new data confirm that high angular resolution observations at millimeter wavelengths are powerful tools to unveil the inner dust disk properties. In this domain, ALMA will likely change our observational vision of these objects.

Published by Astronomy & Astrophysics (Vol. 478, p. L31)

Where are the hot ion lines in classical T Tauri stars formed?

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

[1] Hamburger Sternwarte, Gojenbergsweg 112,22029 Hamburg, Germany

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

Classical T Tauri stars show a plethora of in- and outflow signatures in a variety of wavelengths bands. In order to constrain gas velocities and temperatures we analyse the emission in the hot ion lines. We use all available archival FUSE spectra of CTTS to measure the line widths, fluxes and shifts and complement this sample with HST/GHRS and HST/STIS data. We present theoretical estimates for temperatures reached in possible emission models like jets, winds, disks and accretion funnels and look for correlations with X-ray lines and absorption properties. We find line shifts in the range from -170 km/s and +100 km/s. Most linewidths exceed the stellar rotational broadening. Those CTTS with blue-shifted lines also show excess absorption in X-rays. CTTS single out from MS stars by their large ratio of the O VII to O VI luminosities. No single emission mechanism can be found for all objects. The properties of those stars with blue-shifted lines are compatible with an origin in a shock-heated dust-depleted outflow.

Accepted by A&A

http://arxiv.org/abs/0801.2273

The X-Ray Origin of Herbig AeBe Systems: New Insights

Murad Hamidouche[1,2], Shiya Wang[1] and Leslie W. Looney[1]

[1] Astronomy Department, University of Illinois, 1002 W Green St., Urbana, IL 61801, USA
[2] Stratospheric Observatory for Infrared Astronomy-USRA, NASA Ames Research Center, Moffett Field, CA 94035, USA

E-mail contact: mhamidouche *at* sofia.usra.edu

We present a statistical study of the X-Ray emission toward 22 Herbig AeBe stars using the Chandra archive. We probe the origin of the X-Rays toward Herbig stars: are they intrinsic? This question is addressed by correlations between the physical stellar properties and the X-Ray emission. There is a weak correlation between the continuum radio emission at λ=3.6 cm and L_X, which suggests that the X-Ray emission depends upon the source. On the other hand, no correlation was found with the stellar rotational period, but that only excludes solar-like magnetic activity as the origin of the X-Rays. Most importantly, the X-Ray luminosity of Herbig AeBe stars have a different distribution than T Tauri stars, suggesting X-Ray emission from an unseen late type star companion can be ruled out with an 80% confidence level. This implies that the Herbig AeBe stars must have magnetic activity. In addition, we report the observation of five sources for the first time, three detections.

Accepted by Astronomical Journal

http://arxiv.org/abs/0802.1729

Detection of 6 K gas in Ophiuchus D

Jorma Harju[1], Mika Juvela[1], Stephan Schlemmer[2], Lauri Haikala[1], Kimmo Lehtinen[1] and Kalevi Mattila[1]

[1] Observatory, University of Helsinki, Finland
[2] I. Physikalisches Institut, University of Cologne, Germany

E-mail contact: jorma.harju *at* helsinki.fi

Cold cores in interstellar molecular clouds represent the very first phase in star formation. The physical conditions of these objects are studied in order to understand how molecular clouds evolve and how stellar masses are determined. The purpose of this study is to probe conditions in the dense, starless clump Ophichus D (Oph D). The ground-state ($1_{10} - 1_{11}$) rotational transition of ortho-H_2D^+ was observed with APEX towards the density peak of Oph D. The width of the H_2D^+ line indicates that the kinetic temperature in the core is about 6 K. So far, this is the most direct evidence of such cold gas in molecular clouds. The observed H_2D^+ spectrum can be reproduced with a hydrostatic model with the temperature increasing from about 6 K in the centre to almost 10 K at the surface. The model is unstable against any increase in the external pressure, and the core is likely to form a low-mass star. The results suggest that an equilibrium configuration is a feasible intermediate stage of star formation even if the larger scale structure of the cloud is thought to be determined by turbulent fragmentation. In comparison with the isothermal case, the inward decrease in the temperature makes smaller, i.e. less massive, cores susceptible to externally triggered collapse.

Accepted by Astronomy & Astrophysics

http://arxiv.org/abs/0802.1767

Spectropolarimetric Observations of Herbig Ae/Be Stars. I. HiVIS Spectropolarimetric Calibration and Reduction Techniques

D. M. Harrington[1] and J. R. Kuhn[1]

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

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

Using the High-Resolution Visible Spectrograph (HiVIS) spectropolarimeter built for the Haleakala 3.7 m Advanced Electro-optical System (AEOS) telescope in Hawaii, we are collecting a large number of high precision spectropolarimetric observations of stars. In order to precisely measure very small polarization changes, we have performed a number of polarization calibration techniques on the AEOS telescope and HiVIS spectrograph. We have extended our dedicated IDL reduction package and have performed some hardware upgrades to the instrument. We have also used the ESPaDOnS spectropolarimeter on CFHT to verify the HiVIS results with back-to-back observations of MWC 361 and HD 163296. Comparison of this and other HiVIS data with stellar observations from the Intermediate-dispersion Spectroscopic and Imaging System (ISIS) and William-Wehlau (WW) spectropolarimeters in the literature further shows the usefulness of this instrument.

Published by Publications of the Astronomical Society of the Pacific (Vol. 120, p. 89)

Dissipative structures of diffuse molecular gas III – Small-scale intermittency of intense velocity-shears

P. Hily-Blant[1,2], E. Falgarone[3] and J. Pety[1,3]

[1] IRAM, 300 rue de la Piscine, F-38406 Saint Martin d'Heres, France
[2] Laboratoire d'Astrophysique, Observatoire de Grenoble, BP 53, F-38041 Grenoble Cedex 9, France
[3] LRA/LERMA, UMR 8112, CNRS, Observatoire de Paris and Ecole normale superieure, 24 rue Lhomond, F-75231 Paris Cedex 05, France

E-mail contact: philybla *at* obs.ujf-grenoble.fr

We further characterize the structures tentatively identified on thermal and chemical grounds as the sites of dissipation of turbulence in molecular clouds (Papers I and II). Our study is based on two-point statistics of line centroid velocities (CV), computed from three large ^{12}CO maps of two fields. We build the probability density functions (PDF) of the CO line centroid velocity increments (CVI) over lags varying by an order of magnitude. Structure functions of the line CV are computed up to the 6^{th} order. We compare these statistical properties in two translucent parsec-scale fields embedded in different large-scale environments, one far from virial balance and the other virialized. We also address their scale dependence in the former, more turbulent, field. The statistical properties of the line CV bear the three signatures of intermittency in a turbulent velocity field: (1) the non-Gaussian tails in the CVI PDF grow as the lag decreases, (2) the departure from Kolmogorov scaling of the high-order structure functions is more pronounced in the more turbulent field, (3) the positions contributing to the CVI PDF tails delineate narrow filamentary structures (thickness ∼ 0.02 pc), uncorrelated to dense gas structures and spatially coherent with thicker ones (∼ 0.18 pc) observed on larger scales. We show that the largest CVI trace sharp variations of the extreme CO linewings and that they actually capture properties of the underlying velocity field, uncontaminated by density fluctuations. The confrontation with theoretical predictions leads us to identify these small-scale filamentary structures with extrema of velocity-shears. We estimate that viscous dissipation at the 0.02 pc-scale *in these structures* is up to 10 times higher than average, consistent with their being associated with gas warmer than the bulk. Last, their average direction is parallel (or close) to that of the local magnetic field projection. Turbulence in these translucent fields exhibits the statistical and structural signatures of small-scale and inertial-range intermittency. The more turbulent field on the 30 pc-scale is also the more intermittent on small scales. The small-scale intermittent structures coincide with those formerly identified as sites of enhanced dissipation. They are organized into parsec-scale coherent structures, coupling a broad range of scales.

Accepted by A&A

http://fr.arxiv.org/abs/0802.0758

CN in prestellar cores

P. Hily-Blant[1,2], M. Walmsley[3], G. Pineau des Forts[4,5] and D. Flower[6]

[1] IRAM, Domaine Universitaire, 300 rue de la Piscine, 38406 Saint-Martin d'Hères, France
[2] Laboratoire d'Astrophysique, Observatoire de Grenoble, BP 53, F-38041 Grenoble Cedex 9, France
[3] INAF, Osservatorio Astrofisico di Arcetri, Largo Enrico Fermi 5, I-50125 Firenze, Italy
[4] IAS (UMR 8617 du CNRS), Université de Paris–Sud, F-91405 Orsay, France
[5] LERMA (UMR 8112 du CNRS), Observatoire de Paris, 61 Avenue de l'Observatoire, F-75014, Paris, France
[6] Physics Department, The University, Durham DH1 3LE, UK

E-mail contact: philybla *at* obs.ujf-grenoble.fr

Determining the structure of and the velocity field in prestellar cores is essential to understanding protostellar evolution. We have observed the dense prestellar cores L 1544 and L 183 in the $N = 1 \rightarrow 0$ rotational transition of CN and ^{13}CN in order to test whether CN is depleted in the high–density nuclei of these cores. We have used the IRAM 30 m telescope to observe along the major and minor axes of these cores. We compare these observations with the 1 mm dust emission, which serves as a proxy for the hydrogen column density. We find that while CN$(1-0)$ is optically thick, the distribution of ^{13}CN$(1-0)$ intensity follows the dust emission well, implying that the CN abundance does not vary greatly with density. We derive an abundance ratio of $[\mathrm{CN}]/[\mathrm{H_2}] = 10^{-9}$ in L 183 and $1-3{\times}10^{-9}$ in L 1544, which, in the case of L 183, is similar to previous estimates obtained by sampling lower–density regions of the core.We conclude that CN is not depleted towards the high–density peaks of these cores and thus behaves like the N-containing molecules N_2H^+ and NH_3. CN is, to our knowledge, the first C–containing molecule to exhibit this characteristic.

Accepted by A&A Letters

http://fr.arxiv.org/abs/0801.2876

Gas and Dust Emission at the Outer Edges of Protoplanetary Disks

A. M. Hughes[1], D. J. Wilner[1], C. Qi[1] and M. R. Hogerheijde[2]

[1] Harvard-Smithsonian Center for Astrophysics, 60 Garden St., Cambridge, MA 02138, USA
[2] Leiden Observatory, Leiden University, P.O. Box 9513, 2300 RA, Leiden, The Netherlands

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

We investigate the apparent discrepancy between gas and dust outer radii derived from millimeter observations of protoplanetary disks. Using 230 and 345 GHz continuum and CO J=3-2 data from the Submillimeter Array for four nearby disk systems (HD 163296, TW Hydrae, GM Aurigae, and MWC 480), we examine models of circumstellar disk structure and the effects of their treatment of the outer disk edge. We show that for these disks, models described by power laws in surface density and temperature that are truncated at an outer radius are incapable of reproducing both the gas and dust emission simultaneously: the outer radius derived from the dust continuum emission is always significantly smaller than the extent of the molecular gas disk traced by CO emission. However, a simple model motivated by similarity solutions of the time evolution of accretion disks that includes a tapered exponential edge in

the surface density distribution (and the same number of free parameters) does much better at reproducing both the gas and dust emission. While this analysis does not rule out the disparate radii implied by the truncated power-law models, a realistic alternative disk model, grounded in the physics of accretion, provides a consistent picture for the extent of both the gas and dust.

Accepted by Astrophysical Journal

http://www.cfa.harvard.edu/∼mhughes/download/disk_outer_apj.ps

The Monitor project: rotation of low-mass stars in NGC 2362 testing the disc regulation paradigm at 5 Myr

Jonathan Irwin[1,2], Simon Hodgkin[1], Suzanne Aigrain[3], Jerome Bouvier[4], Leslie Hebb[5], Mike Irwin[1] and Estelle Moraux[4]

[1] Institute of Astronomy, University of Cambridge, Madingley Road, Cambridge CB3 0HA UK
[2] HarvardSmithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA
[3] Astrophysics Group, School of Physics, University of Exeter, Stocker Road, Exeter EX4 4QL, UK
[4] Laboratoire d'Astrophysique, Observatoire de Grenoble, BP 53, F-38041 Grenoble Cedex 9, France
[5] School of Physics and Astronomy, University of St Andrews, North Haugh, St Andrews KY16 9SS, UK

E-mail contact: jmi *at* ast.cam.ac.uk

We report on the results of a time-series photometric survey of NGC 2362, carried out using the CTIO 4-m Blanco telescope and Mosaic-II detector as part of the Monitor project. Rotation periods were derived for 271 candidate cluster members over the mass range $0.1 < M/M_{\odot} < 1.2$. The rotation period distributions show a clear mass-dependent morphology, qualitatively similar to that in NGC 2264, as would be expected from the age of this cluster. Using models of angular momentum evolution, we show that angular momentum losses over the $\sim$ 1-5 Myr age range appear to be needed in order to reproduce the evolution of the slowest rotators in the sample from the ONC to NGC 2362, as found by many previous studies. By incorporating Spitzer IRAC mid-infrared (mid-IR) measurements, we found that three to four objects showing mid-IR excesses indicative of the presence of circumstellar discs were all slow rotators, as would be expected in the disc regulation paradigm for early pre-main-sequence angular momentum evolution, but this result is not statistically significant at present, given the extremely limited sample size.

Published by Monthly Notices of the Royal Astronomical Society (Vol. 384, p. 675)

Integral field spectroscopy of L449-1 : A test case for spectral differential imaging with SINFONI

M. Janson[1], W. Brandner[1], and T. Henning[1]

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

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

Spectral differential imaging is an increasingly used technique for ground-based direct imaging searches for brown dwarf and planetary mass companions to stars. The technique takes advantage of absorption features that exist in these cool objects, but not in stars, and is normally implemented through simultaneous narrow-band imagers in 2 to 4 adjacent channels. However, by instead using an integral field unit, different spectral features could be used depending on the actual spectrum, potentially leading to greater flexibility and stronger detection limits. In this paper, we present the results of a test of spectral differential imaging using the SINFONI integral field unit at the VLT to study the nearby active star L449-1. No convincing companion candidates are found. We find that the method provides a 3σ contrast limit of 7.5 mag at $0.35''$, which is about 1.5 mag lower than for NACO-SDI at the same telescope, using the same integration time. We discuss the reasons for this, and the implications. In addition, we use the SINFONI data to constrain the spectral type in the NIR for L449-1, and find a result between M3.0 and M4.0, in close agreement with a previous classification in the visual range.

Published by Astronomy & Astrophysics (Vol. 478, p. 597)

Parametrization of C-shocks. Evolution of the Sputtering of Grains.

I. Jimenez-Serra[1,2], P.Caselli[2,3], J. Martin-Pintado[1] and T. W. Hartquist[2]

[1] DAMIR, Instituto de Estructura de la Materia, CSIC, C/ Serrano 121, E-28006, Madrid, Spain
[2] School of Physics and Astronomy, University of Leeds LS2 9JT, Leeds, United Kingdom
[3] INAF-Osservatorio Astrofisico di Arcetri, Largo E. Fermi 5, I-50125 Firenze, Italy
E-mail contact: I.Jimenez-Serra *at* leeds.ac.uk

Context:The detection of a narrow SiO line emission toward the young shocks of the L1448-mm outflow has been interpreted as a signature of the magnetic precursor of C-shocks. In contrast with the very low SiO abundances ($\leq 10^{-12}$) derived from the ambient gas, the narrow SiO emission in the precursor component at almost ambient velocities reveals enhanced SiO abundances of $\sim 10^{-11}$. This enhancement has been proposed to be produced by the sputtering of the grain mantles at the very first stages of C-shocks. However, modelling of the sputtering of grains has usually averaged the SiO abundances over the dissipation region of C-shocks, which cannot explain the recent observations.
Aims: To model the evolution of the gas phase abundances of molecules like SiO, CH_3OH and H_2O, produced by the sputtering of the grain mantles and cores as the shock propagates through the ambient gas. We consider different initial gas densities and shock velocities.
Methods: We propose a parametric model to describe the physical structure of C-shocks as a function of time. Using the known sputtering yields for water mantles (with other minor constituents like silicon and CH_3OH) and olivine cores by collisions with H_2, He, C, O, Si, Fe and CO, we follow the evolution of the abundances of silicon, CH_3OH and H_2O ejected from grains along the evolution of the shock.
Results: The evolution of the abundances of the sputtered silicon, CH_3OH and H_2O shows that CO seems to be the most efficient sputtering agent in low velocity shocks. The velocity threshold for the sputtering of silicon from the grain mantles is appreciably reduced (by 5-10 $\mathrm{km\,s^{-1}}$) by CO compared to other models. The sputtering by CO can generate SiO abundances of $\sim 10^{-11}$ at the early stages of low velocity shocks, consistent with those observed in the magnetic precursor component of L1448-mm. Our model satisfactorily reproduce the progressive enhancement of SiO, CH_3OH and H_2O observed in this outflow, suggesting that this enhancement may be due to the propagation of two shocks with v_s=30 $\mathrm{km\,s^{-1}}$ and v_s=60 $\mathrm{km\,s^{-1}}$ coexisting within the same region.
Conclusions: Our simple model can be used to estimate the time dependent evolution of the abundances of molecular shock tracers like SiO, CH_3OH, H_2O or NH_3 in very young molecular outflows.

Accepted by Astronomy & Astrophysics

Preprints available on http://arxiv.org/abs/0802.0594

Global Models for the Evolution of Embedded, Accreting Protostellar Disks

Kaitlin M. Kratter[1], Christopher D. Matzner[1] and Mark R. Krumholz[2]

[1] University of Toronto
[2] Princeton University
E-mail contact: kratter *at* astro.utoronto.ca

Most analytic work to date on protostellar disks has focused on those in isolation from their environments. However, observations are now beginning to probe the earliest, most embedded phases of star formation, during which disks are rapidly accreting from their parent cores and cannot be modeled in isolation. We present a simple, one-zone model of protostellar accretion disks with high mass infall rates. Our model combines a self-consistent calculation of disk temperatures with an approximate treatment of angular momentum transport via two mechanisms. We use this model to survey the properties of protostellar disks across a wide range of stellar masses and evolutionary times, and make predictions for disks' masses, sizes, spiral structure, and fragmentation that will be directly testable by future large-scale surveys of deeply embedded disks. We define a dimensionless accretion-rotation parameter which, in conjunction with the disk's temperature, controls the disk evolution. We track the dominant mode of angular momentum transport, and demonstrate that for stars with final masses greater than roughly one solar mass, gravitational instabilities are the most important mechanism as most of the mass accumulates. We predict that binary formation through disk fission, fragmentation of the disk into small objects, and spiral arm strength all increase in importance to higher stellar masses

Accepted by ApJ

http://arxiv.org/abs/0709.4252

Three-dimensional simulations of rotationally-induced line variability from a Classical T Tauri star with a misaligned magnetic dipole

Ryuichi Kurosawa[1], M. M. Romanova[2] and Tim J. Harries[3]

[1] Department of Physics and Astronomy, University of Nevada Las Vegas, Box 454002, 4505 Maryland Pkwy, Las Vegas, NV 89154-4002, USA
[2] Department of Astronomy, Cornell University, 410 Space Sciences Building, Ithaca, NY, 14853-6801, USA.
[3] School of Physics, University of Exeter, Stocker Road, Exeter EX4 4QL, UK.

E-mail contact: rk *at* physics.unlv.edu

We present three-dimensional (3-D) simulations of rotationally induced line variability arising from complex circumstellar environment of classical T Tauri stars (CTTS) using the results of the 3-D magnetohydrodynamic (MHD) simulations of Romanova et al., who considered accretion onto a CTTS with a misaligned dipole magnetic axis with respect to the rotational axis. The density, velocity and temperature structures of the MHD simulations are mapped on to the radiative transfer grid, and corresponding line source function and the observed profiles of neutral hydrogen lines (Hβ, Paβ and Brγ) are computed using the Sobolev escape probability method. We study the dependency of line variability on inclination angles (i) and magnetic axis misalignment angles (Θ). We find the line profiles are relatively insensitive to the details of the temperature structure of accretion funnels, but are influenced more by the mean temperature of the flow and its geometry. By comparing our models with the Paβ profiles of 42 CTTS observed by Folha & Emerson, we find that models with a smaller misalignment angle ($\Theta <\sim 15^\circ$) are more consistent with the observations which show that majority of Paβ are rather symmetric around the line centre. For a high inclination system with a small dipole misalignment angle ($\Theta \approx 15^\circ$), only one accretion funnel (on the upper hemisphere) is visible to an observer at any given rotational phase. This can cause an anti-correlation of the line equivalent width in the blue wing ($v < 0$) and that in the red wing ($v > 0$) over a half of a rotational period, and a positive correlation over other half. We find a good overall agreement of the line variability behaviour predicted by our model and those from observations.

Accepted by MNRAS

`http://www.physics.unlv.edu/$\sim$rk/preprint/inclined_dipole.pdf`

Circumstellar Dust Created by Terrestrial Planet Formation in HD 113766

C. M. Lisse[1], C. H. Chen[2], M. C. Wyatt[3] and A. Morlok[4]

[1] Planetary Exploration Group, Space Department, Johns Hopkins University Applied Physics Laboratory, 11100 Johns Hopkins Road, Laurel, MD 20723, USA
[2] NOAO, 950 North Cherry Avenue, Tucson, AZ 85719, USA
[3] Institute of Astronomy, University of Cambridge, Madingley Road, Cambridge CB3 0HA, UK
[4] Department of Earth and Planetary Sciences, Faculty of Science, Kobe University, Nada, Kobe 6578501, Japan

E-mail contact: carey.lisse *at* jhuapl.edu

We present an analysis of the gas-poor circumstellar material in the HD 113766 binary system (F3/F5, 10-16 Myr), recently observed by the Spitzer Space Telescope. For our study we have used the IR mineralogical model derived from observations of the Deep Impact experiment. We find the dust dominated by warm, fine ($\sim 1\ \mu$m) particles, abundant in Mg-rich olivine, crystalline pyroxenes, amorphous silicates, Fe-rich sulfides, amorphous carbon, and colder water ice. The warm dust material mix is akin to an inner main-belt asteroid of S-type composition. The ~ 440 K effective temperature of the warm dust implies that the bulk of the observed material is in a narrow belt ~ 1.8 AU from the 4.4 $L_\odot$ central source, in the terrestrial planet-forming region and habitable zone of the system (equivalent to 0.9 AU in the solar system). The icy dust lies in two belts, located at 4-9 and 30-80 AU. The lower bound of warm dust mass in 0.1-20 μm, $dn/da \sim a^{-3.5}$ particles is very large, at least 3×10^{20} kg, equivalent to a 320 km radius asteroid of 2.5 g cm^3 density. Assuming 10 m particles are the largest present, the lower bound of warm dust mass is at least 0.5 M_{Mars}. Neither primordial nor mature, the dust around HD 113766A originates from catastrophic disruption of terrestrial planet embryo(s) and subsequent grinding of the fragments or from collisions in a young, extremely dense asteroid belt undergoing planetary aggregation. The persistence of the strong IR excess over the last two decades argues for a mechanism to provide replenishment of the circumstellar material on yearly timescales.

Published by The Astrophysical Journal (Vol. 673, p. 1106)

Long-Term Collisional Evolution of Debris Disks

Torsten Löhne[1], Alexander V. Krivov[1] and Jens Rodmann[2]

[1] Astrophysikalisches Institut und Universitätssternwarte, Friedrich Schiller University Jena, 07745 Jena, Germany
[2] SCISA, Research and Scientific Support Department of ESA, ESTEC, 2200 AG Noordwijk, Netherlands

E-mail contact: tloehne *at* astro.uni-jena.de

IR surveys indicate that the dust content in debris disks gradually declines with stellar age. We simulated the long-term collisional depletion of debris disks around solar-type (G2 V) stars with our collisional code. The numerical results were supplemented by, and interpreted through, a new analytic model. General scaling rules for the disk evolution are suggested. The timescale of the collisional evolution is inversely proportional to the initial disk mass and scales with radial distance as $r^{4.3}$ and with eccentricities of planetesimals as $e^{2.3}$. Further, we show that at actual ages of debris disks between 10 Myr and 10 Gyr, the decay laws of the dust mass and the total disk mass are different. The reason is that the collisional lifetime of planetesimals is size dependent. At any moment, there exists a transitional size, which separates larger objects that still retain the "primordial" size distribution set in the growth phase from smaller objects whose size distribution is already set by disruptive collisions. The dust mass and its decay rate evolve as that transition affects objects of ever larger sizes. Under standard assumptions, the dust mass, fractional luminosity, and thermal fluxes all decrease as t^{ξ} with $\xi = -0.3$ to 0.4. Specific decay laws of the total disk mass and the dust mass, including the value of ξ, largely depend on a few model parameters, such as the critical fragmentation energy as a function of size, the primordial size distribution of largest planetesimals, and the characteristic eccentricity and inclination of their orbits. With standard material prescriptions and a distribution of disk masses and extents, a synthetic population of disks generated with our analytic model agrees quite well with the observed Spitzer MIPS statistics of 24 and 70 μm fluxes and colors versus age.

Published by The Astrophysical Journal (Vol. 673, p. 1123)

Accretion-Powered Stellar Winds II: Numerical Solutions for Stellar Wind Torques

Sean Matt[1] and Ralph E. Pudritz[2]

[1] University of Virginia, Charlottesville, Virginia, USA
[2] McMaster University, Hamilton, Ontario, Canada

E-mail contact: spm5x *at* virginia.edu

In order to explain the slow rotation observed in a large fraction of accreting pre-main-sequence stars (CTTSs), we explore the role of stellar winds in torquing down the stars. For this mechanism to be effective, the stellar winds need to have relatively high outflow rates, and thus would likely be powered by the accretion process itself. Here, we use numerical magnetohydrodynamical simulations to compute detailed 2-dimensional (axisymmetric) stellar wind solutions, in order to determine the spin down torque on the star. We discuss wind driving mechanisms and then adopt a Parker-like (thermal pressure driven) wind, modified by rotation, magnetic fields, and enhanced mass loss rate (relative to the sun). We explore a range of parameters relevant for CTTSs, including variations in the stellar mass, radius, spin rate, surface magnetic field strength, the mass loss rate, and wind acceleration rate. We also consider both dipole and quadrupole magnetic field geometries.

Our simulations indicate that the stellar wind torque is of sufficient magnitude to be important for spinning down a "typical" CTTS, for a mass loss rate of $\sim 10^{-9} M_{\odot}$ yr^{-1}. The winds are wide-angle, self-collimated flows, as expected of magnetic rotator winds with moderately fast rotation. The cases with quadrupolar field produce a much weaker torque than for a dipole with the same surface field strength, demonstrating that magnetic geometry plays a fundamental role in determining the torque. Cases with varying wind acceleration rate show much smaller variations in the torque suggesting that the details of the wind driving are less important. We use our computed results to fit a semi-analytic formula for the effective Alfvén radius in the wind, as well as the torque. This allows for considerable predictive power, and is an improvement over existing approximations.

Accepted by ApJ

http://xxx.lanl.gov/abs/0801.0436

Accretion-Powered Stellar Winds III: Spin Equilibrium Solutions

Sean Matt[1] and Ralph E. Pudritz[2]

[1] University of Virginia, Charlottesville, Virginia, USA
[2] McMaster University, Hamilton, Ontario, Canada

E-mail contact: spm5x *at* virginia.edu

We compare the stellar wind torque calculated in a previous work (Paper II) to the spin-up and spin-down torques expected to arise from the magnetic interaction between a slowly rotating (∼ 10% of breakup) pre-main-sequence star and its accretion disk. This analysis demonstrates that stellar winds can carry off orders of magnitude more angular momentum than can be transferred to the disk, provided that the mass outflow rates are greater than the solar wind. Thus, the equilibrium spin state is simply characterized by a balance between the angular momentum deposited by accretion and that extracted by a stellar wind. We derive a semi-analytic formula for predicting the equilibrium spin rate as a function only of the ratio of $\dot{M}_{\rm w}/\dot{M}_{\rm a}$ and a dimensionless magnetization parameter, $\Psi \equiv B_*^2 R_*^2 (\dot{M}_{\rm a} v_{\rm esc})^{-1}$, where $\dot{M}_{\rm w}$ is the stellar wind mass outflow rate, $\dot{M}_{\rm a}$ the accretion rate, B_* the stellar surface magnetic field strength, R_* the stellar radius, and $v_{\rm esc}$ the surface escape speed. For parameters typical of accreting pre-main-sequence stars, this explains spin rates of ∼ 10% of breakup speed for $\dot{M}_{\rm w}/\dot{M}_{\rm a} \sim 0.1$. Finally, the assumption that the stellar wind is driven by a fraction of the accretion power leads to an upper limit to the mass flow ratio of $\dot{M}_{\rm w}/\dot{M}_{\rm a} < 0.6$.

Accepted by ApJ

http://xxx.lanl.gov/abs/0801.0440

The Massive Star Content of NGC 3603

Nicholas W. Melena[1], Philip Massey[1], Nidia I. Morrell[2] and Amanda M. Zangari[1,3]

[1] Lowell Observatory, 1400 W Mars Hill Road, Flagstaff, AZ 86001, USA
[2] Las Campanas Observatory, The Carnegie Observatories, Colina El Pino s/n, Casilla 601, La Serena, Chile
[3] Current address: Wellesley College, 106 Central Street, Wellesley, MA 02481, USA

E-mail contact: nmelena *at* lowell.edu

We investigate the massive star content of NGC 3603, the closest known giant H II region. We have obtained spectra of 26 stars in the central cluster using the Baade 6.5 m telescope (Magellan I). Of these 26 stars, 16 had no previous spectroscopy. We also obtained photometry of all of the stars with previous or new spectroscopy, primarily using archival HST Advanced Camera for Surveys/High-Resolution Camera images. The total number of stars that have been spectroscopically classified in NGC 3603 now stands at 38. The sample is dominated by very early O-type stars (O3); there are also several (previously identified) H-rich WN+abs stars. We derive E(B - V) = 1.39, and find that there is very little variation in reddening across the cluster core, in agreement with previous studies. Our spectroscopic parallax is consistent with the kinematic distance only if the ratio of total to selective extinction is anomalously high within the cluster, as argued by Pandey et al. Adopting their reddening, we derive a distance of 7.6 kpc. We discuss the various distance estimates to the cluster, and note that although there has been a wide range of values in the recent literature (6.3-10.1 kpc) there is actually good agreement with the apparent distance modulus of the clusterthe disagreement has been the result of the uncertain reddening correction. We construct our H-R diagram using the apparent distance modulus with a correction for the slight difference in differential reddening from star to star. The resulting H-R diagram reveals that the most massive stars are highly coeval, with an age of 1-2 Myr, and of very high masses (120 $M_\odot$). The three stars with Wolf-Rayet features are the most luminous and massive, and are coeval with the non-WRs, in accord with what was found in the R136 cluster. There may be a larger age spread (1-4 Myr) for the lower mass objects (20-40 $M_\odot$). Two supergiants (an OC9.7 I and the B1 I star Sher 25) both have an age of about 4 Myr. We compare the stellar content of this cluster to that of R136, finding that the number of very high luminosity ($M_{bol} \leq -10$) stars is only about $1.1 - 2.4\times$ smaller in NGC 3603. The most luminous members in both clusters are H-rich WN+abs stars, basically "Of stars on steroids," relatively unevolved stars whose high luminosities results in high-mass loss rates, and hence spectra that mimic that of evolved WNs. To derive an initial-mass function for the massive stars in NGC 3603 requires considerably more spectroscopy; we estimate from a color-magnitude diagram that less than a third of the stars with masses above 20 $M_\odot$ have spectral types known.

Published by The Astronomical Journal (Vol. 135, p. 878)

Eccentricity evolution of giant planet orbits due to circumstellar disk torques

Althea V. Moorhead[1] and Fred C. Adams[1,2]

[1] Michigan Center for Theoretical Physics, Physics Department, University of Michigan, 450 Church Street, Ann Arbor, MI 48109, USA
[2] Astronomy Department, University of Michigan, Ann Arbor, MI 48109, USA

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

The extrasolar planets discovered to date possess unexpected orbital elements. Most orbit their host stars with larger eccentricities and smaller semi-major axes than similarly sized planets in our own Solar System do. It is generally agreed that the interaction between giant planets and circumstellar disks (Type II migration) drives these planets inward to small radii, but the effect of these same disks on orbital eccentricity, ϵ, is controversial. Several recent analytic calculations suggest that diskplanet interactions can excite eccentricity, while numerical studies generally produce eccentricity damping. This paper addresses this controversy using a quasi-analytic approach, drawing on several preceding analytic studies. This work refines the current treatment of eccentricity evolution by removing several approximations from the calculation of disk torques. We encounter neither uniform damping nor uniform excitation of orbital eccentricity, but rather a function $d\epsilon/dt$ that varies in both sign and magnitude depending on eccentricity and other Solar System properties. Most significantly, we find that for every combination of disk and planet properties investigated herein, corotation torques produce negative values of $d\epsilon/dt$ for some range in ϵ within the interval [0.1, 0.5]. If corotation torques are saturated, this region of eccentricity damping disappears, and excitation occurs on a short timescale of less than 0.08 Myr. Thus, our study does not produce eccentricity excitation on a timescale of a few Myr we obtain either eccentricity excitation on a short time scale, or eccentricity damping on a longer time scale. Finally, we discuss the implications of this result for producing the observed range in extrasolar planet eccentricity.

Published by Icarus (Vol. 193, p. 475)

Building giant-planet cores at a planet trap

A. Morbidelli[1], A. Crida[2], F. Masset[3,4], and R. P. Nelson[5]

[1] Observatoire de la Côte d'Azur, BP 4229, 06304 Nice Cedex 4, France
[2] Institut für Astronomie & Astrophysik, Univ. of Tubingen, Germany
[3] Laboratoire AIM, CEA/Saclay, France
[4] IA-UNAM, Mexico City, Mexico
[5] Queen Mary, University of London, UK

E-mail contact: morby *at* obs-nice.fr

Context. A well-known bottleneck for the core-accretion model of giant-planet formation is the loss of the cores into the star by type I migration, due to the tidal interactions with the gas disk. It has been shown that a steep surface-density gradient in the disk, such as the one expected at the boundary between an active and a dead zone, acts as a planet trap and prevents isolated cores from migrating down to the central star.

Aims. We study the relevance of the planet trap concept for the accretion and evolution of systems of multiple planetary embryos/cores.

Methods. We performed hydrodynamical simulations of the evolution of systems of multiple massive objects in the vicinity of a planet trap. The planetary embryos evolve in 3 dimensions, whereas the disk is modeled with a 2D grid. Synthetic forces are applied onto the embryos to mimic the damping effect that the disk has on their inclinations.

Results. Systems with two embryos tend to acquire stable, separated and non-migrating orbits, with the more massive embryo placed at the planet trap and the lighter one farther out in the disk. Systems of multiple embryos are intrinsically unstable. Consequently, a long phase of mutual scattering can lead to accreting collisions among embryos; some embryos are injected into the inner part of the disk, where they can be evacuated into the star by type I migration. The system can resume a stable, non-migrating configuration only when the number of surviving embryos decreases to a small value ($\sim$ 2-4). This can explain the limited number of giant planets in our solar system. These results should apply in general to any case in which the type I migration of the inner embryo is prevented by some mechanism, and not solely to the planet trap scenario.

Published by Astronomy & Astrophysics (Vol. 478, p. 929)

The *c2d* Spitzer spectroscopy survey of ices around low-mass young stellar objects, III: CH_4

Karin I. Oberg[1], A. C. Adwin Boogert[2], Klaus M. Pontoppidan[3], Geoffrey A. Blake[3], Neal J. Evans[4], Fred Lahuis[5] and Ewine F. van Dishoeck[1]

[1] Leiden Observatory, Leiden University, P.O. Box 9513, NL 2300 RA Leiden, The Netherlands
[2] IPAC, NASA Herschel Science Center, Mail Code 100-22, California Institute of Technology, Pasadena, CA 91125, USA
[3] Division of Geological and Planetary Sciences, California Institute of Technology, Mail Stop 150-21, Pasadena, CA 91125, USA
[4] Department of Astronomy, University of Texas at Austin, 1 University Station C1400, Austin, TX 78712-0259, USA
[5] SRON, PO Box 800, NL 9700 AV Groningen, The Netherlands

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

CH_4 is proposed to be the starting point of a rich organic chemistry. Solid CH_4 abundances have previously been determined mostly toward high mass star forming regions. Spitzer/IRS now provides a unique opportunity to probe solid CH_4 toward low mass star forming regions as well. Infrared spectra from the Spitzer Space Telescope are presented to determine the solid CH_4 abundance toward a large sample of low mass young stellar objects. 25 out of 52 ice sources in the *c2d* (cores to disks) legacy have an absorption feature at 7.7 μm, attributed to the bending mode of solid CH_4. The solid CH_4 / H_2O abundances are 2-8%, except for three sources with abundances as high as 11–13%. These latter sources have relatively large uncertainties due to small total ice column densities. Toward sources with H_2O column densities above 2×10^{18} cm^{-2}, the CH_4 abundances (20 out of 25) are nearly constant at 4.7±1.6%. Correlation plots with solid H_2O, CH_3OH, CO_2 and CO column densities and abundances relative to H_2O reveal a closer relationship of solid CH_4 with CO_2 and H_2O than with solid CO and CH_3OH. The inferred solid CH_4 abundances are consistent with models where CH_4 is formed through sequential hydrogenation of C on grain surfaces. Finally the equal or higher abundances toward low mass young stellar objects compared with high mass objects and the correlation studies support this formation pathway as well, but not the two competing theories: formation from CH_3OH and formation in gas phase with subsequent freeze-out.

Accepted by ApJ

http://arxiv.org/abs/0801.1223

Planetesimal and gas dynamics in binaries

S.-J. Paardekooper[1], P. Thebault[2,3] and G. Mellema[2]

[1] DAMTP, University of Cambridge, Wilberforce Road, Cambridge CB3 0WA, United Kingdom
[2] Stockholm Observatory, Albanova Universitetcentrum, SE-10691, Stockholm, Sweden
[3] LESIA, Observatoire de Paris, Section de Meudon, F-92195 Meudon, Principal Cedex, France

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

Observations of extrasolar planets reveal that planets can be found in close binary systems, where the semi-major axis of the binary orbit is less than 20 AU. The existence of these planets challenges planet formation theory because the strong gravitational perturbations due to the companion increase encounter velocities between planetesimals and make it difficult for them to grow through accreting collisions. We study planetesimal encounter velocities in binary systems, where the planetesimals are embedded in a circumprimary gas disc that is allowed to evolve under influence of the gravitational perturbations of the companion star. We use the RODEO method to evolve the vertically integrated Navier-Stokes equations for the gas disc. Embedded within this disc is a population of planetesimals of various sizes, that evolve under influence of the gravitational forces of both stars and friction with the gas. The equations of motion for the planetesimals are integrated using a 4th order symplectic algorithm. We find that the encounter velocities between planetesimals of different size strongly depend on the gas disc eccentricity. Depending on the amount of wave damping, we find two possible states of the gas disc: a quiet state, where the disc eccentricity reaches a steady state that is determined by the forcing of the binary, for which the encounter velocities do not differ more than a factor of 2 from the case of a circular gas disc, and an excited state, for which the gas disc obtains a large free eccentricity, which drives up the encounter velocities more substantially. In both cases, inclusion of the full gas dynamics increases the encounter velocity compared to the case of a static, circular gas disc. Full numerical parameter exploration is still

impossible, but we derive analytical formulae to estimate encounter velocities between bodies of different sizes given the gas disc eccentricity. The gas dynamical evolution of a protoplanetary disc in a binary system tends to make planetesimal accretion even more difficult than in a static, axisymmetric gas disc.

Accepted by MNRAS

http://arxiv.org/abs/0802.0927

On the evolution of multiple low mass planets embedded in a circumbinary disc

A. Pierens[1] and R.P. Nelson[1]

[1] Astronomy Unit, Queen Mary, University of London, Mile End Rd, London E1 4NS, UK

E-mail contact: a.pierens *at* qmul.ac.uk

Context. Previous work has shown that the tidal interaction between a binary system and a circumbinary disc leads to the formation of a large inner cavity in the disc. Subsequent formation and inward migration of a low mass planet causes it to become trapped at the cavity edge, where it orbits until further mass growth or disc dispersal. The question of how systems of multiple planets in circumbinary discs evolve has not yet been addressed.

Aims. We present the results of hydrodynamic simulations of multiple low mass planets embedded in a circumbinary disc. The aim is to examine their long term evolution as they approach and become trapped at the edge of the tidally truncated inner cavity.

Methods. A grid-based hydrodynamics code was used to compute simulations of 2D circumbinary disc models with embedded planets. The 3D evolution of the planet orbits was computed, and inclination damping due to the disc was calculated using prescribed forces. We present a suite of simulations which study the evolution of pairs of planets migrating in the disc. We also present the results of hydrodynamic simulations of five-planet systems, and study their long term evolution after disc dispersal using a N-body code.

Results. For the two-planet simulations we assume that the innermost planet has migrated to the edge of the inner cavity and remains trapped there, and study the subsequent evolution of the system as the outermost planet migrates inward. We find that the outcomes largely depend on the mass ratio $q = m_{\rm i}/m_{\rm o}$, where $m_{\rm i}(m_{\rm o})$ is the mass of the innermost (outermost) planet. For $q < 1$, planets usually undergo dynamical scattering or orbital exchange. For values of $q > 1$ the systems reach equilibrium configurations in which the planets are locked into mean motion resonances, and remain trapped at the edge of the inner cavity without further migration. Most simulations of five-planet systems we performed resulted in collisions and scattering events, such that only a single planet remained in orbit about the binary. In one case however, a multiplanet resonant system was found to be dynamically stable over long time scales, suggesting that such systems may be observed in planet searches focussed on close binary systems.

Published by Astronomy & Astrophysics (Vol. 478, p. 939)

CO isotopologues in the Perseus Molecular Cloud Complex: the X-factor and regional variations

Jaime E. Pineda[1], Paola Caselli[2,3] and Alyssa A. Goodman[4]

[1] Harvard-Smithsonian Center for Astrophysics, 60 Garden St., MS-10, Cambridge, MA 02138, USA
[2] School of Physics and Astronomy, University of Leeds, LS2 9JT, UK
[3] INAF, Osservatorio Astrofisico di Arcetri, Largo E. Fermi 5, I-50125 Firenze, Italy
[4] Harvard-Smithsonian Center for Astrophysics, 60 Garden St., MS-42, Cambridge, MA 02138, USA

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

The COMPLETE Survey of Star-Forming regions offers an unusually comprehensive and diverse set of measurements of the distribution and temperature of dust and gas in molecular clouds, and in this paper we use those data to find new calibrations of the "X-factor" and the ^{13}CO abundance within Perseus. To carry out our analysis, we: 1) apply the NICER (Near-Infrared Color Excess Method Revisited) algorithm to 2MASS data to measure dust extinction; 2) use dust temperatures derived from re-processed IRAS data; and 3) make use of the ^{12}CO and ^{13}CO (1-0) transition maps gathered by COMPLETE to measure gas distribution and temperature. Here, we divide Perseus into six sub-regions, using groupings in a plot of dust temperature as a function of LSR velocity. The standard X

factor, $X \equiv N(H_2)/W(^{12}CO)$, is derived both for the whole Perseus Complex and for each of the six sub-regions with values consistent with previous estimates. However, the X factor is heavily affected by the saturation of the emission above $A_V \sim 4$ mag, and variations are found between regions. We derive linear fits to relate $W(^{12}CO)$ and A_V using only points below 4 mag of extinction. This linear fit yields a better estimation of the A_V than the X factor. We derive linear relations of $W(^{13}CO), N(^{13}CO)$ and $W(C^{18}O)$ with A_V. In general, the extinction threshold above which ^{13}CO (1-0) and $C^{18}O$ (1-0) are detected is about 1 mag larger than previous estimates, so that a more efficient shielding is needed for the formation of CO than previously thought. The fractional abundances (w.r.t. H_2 molecules) are in agreement with previous works. The (1-0) lines of ^{12}CO and ^{13}CO saturate above 4 and 5 mag, respectively, whereas $C^{18}O$ (1-0) never saturates in the whole A_V range probed by our study (up to 10 mag). Approximately 60% of the positions with ^{12}CO (1-0) emission have sub-thermally excited lines, and almost all positions have ^{12}CO (1-0) excitation temperatures below the dust temperature. We compare our data with PDR models using the Meudon code, finding that ^{12}CO (1-0) and ^{13}CO (1-0) emission can be explained by these uniform slab models with densities ranging between about 10^3 and 10^4 cm^{-3}. In general, local variations in the volume density and non-thermal motions (linked to different star formation activity) can explain the observations. Higher densities are needed to reproduce CO data toward active star forming sites, such as NGC 1333, where the larger internal motions driven by the young protostars allow more photons from the embedded high density cores to escape the cloud. In the most quiescent region, B5, the ^{12}CO and ^{13}CO emission appears to arise from an almost uniform thin layer of molecular material at densities around 10^4 cm^{-3}, and the integrated intensities of the two CO isotopologues are the lowest in the whole complex.

Accepted by The Astrophysical Journal

http://cfa-www.harvard.edu/COMPLETE/papers/cal-co-v2.pdf (high-resolution) or
http://arxiv.org/abs/0802.0708 (low-resolution)

Nitrogen superfractionation in dense cloud cores

S.D. Rodgers and S.B. Charnley

Space Science & Astrobiology Division, MS 245-3, NASA Ames Research Center, Moffett Field, CA 94035, U.S.A.

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

We report new calculations of interstellar ^{15}N fractionation. Previously, we have shown that large enhancements of $^{15}N/^{14}N$ can occur in cold, dense gas where CO is frozen out, but that the existence of an NH + N channel in the dissociative recombination of N_2H^+ severely curtails the fractionation. In the light of recent experimental evidence that this channel is in fact negligible, we have reassessed the ^{15}N chemistry in dense cloud cores. We consider the effects of temperatures below 10 K, and of the presence of large amounts of atomic nitrogen. We also show how the temporal evolution of gas-phase isotope ratios is preserved as spatial heterogeneity in ammonia ice mantles, as monolayers deposited at different times have different isotopic compositions. We demonstrate that the upper layers of this ice may have $^{15}N/^{14}N$ ratios an order of magnitude larger than the underlying elemental value. Converting our ratios to δ-values, we obtain $\delta^{15}N > 3,000$ ‰ in the uppermost layer, with values as high as 10,000 ‰ in some models. We suggest that this material is the precursor to the ^{15}N 'hotspots' recently discovered in meteorites and IDPs.

Accepted by MNRAS

arXiv:0802.1940

Unstable Disk Accretion to Magnetized Stars: First Global 3D MHD Simulations

Marina M. Romanova[1], Akshay K. Kulkarni[1] and Richard V.E. Lovelace[1]

[1] Department of Astronomy, Cornell University, Ithaca, NY 14853, USA

E-mail contact: romanova *at* astro.cornell.edu

We report on the first global three-dimensional (3D) MHD simulations of disk accretion onto a rotating magnetized star through the Rayleigh-Taylor instability. The star has a dipole field misaligned relative to the rotation axis by a small angle Θ. Simulations show that, depending on the accretion rate, a star may be in the stable or unstable regime of accretion. In the unstable regime, matter penetrates deep into the magnetosphere through several elongated "tongues" which deposit matter at random places on the surface of the star, leading to stochastic light-curves. In the stable regime, matter accretes in ordered funnel streams and the light-curves are almost periodic. A star may

switch between these two regimes depending on the accretion rate and may thus show alternate episodes of ordered pulsations and stochastic light-curves. In the intermediate regime, both stochastic and ordered pulsations are observed. For $\Theta > 30°$, the instability is suppressed and stable accretion through funnel streams dominates.

Accepted by Astrophysical Journal Letters (2008, vol. 673, p L171)

See animation at: http://www.astro.cornell.edu/~romanova/instab.htm
See stereoscopic animation at: http://www.astro.cornell.edu/us-rus/stereo.htm

The Stellar Mass Distribution in the Giant Star Forming Region NGC 346

E. Sabbi[1], M. Sirianni[1,2], A. Nota[1,2], M. Tosi[3], J. Gallagher[4], L. J. Smith[1,2,5], L. Angeretti[3], M. Meixner[1], M. S. Oey[6], R. Walterbos[7] and A. Pasquali[8]

[1] Space Telescope Science Institute, 3700 San Martin Drive, Baltimore, USA
[2] European Space Agency, Research and Scientific Support Department, Baltimore, USA
[3] INAFOsservatorio di Bologna, Italy
[4] University of Wisconsin, Madison, WI, USA
[5] University College London, London, UK
[6] University of Michigan, Ann Arbor, MI, USA
[7] New Mexico State University, Las Cruces, NM, USA
[8] Max-Plank-Institut für Astronomie, Heidelberg, Germany

E-mail contact: sabbi *at* stsci.edu

Deep F555W and F814W Hubble Space Telescope (HST) Advanced Camera for Survey (ACS) images are the basis for a study of the present-day mass function (PDMF) of NGC 346, the largest active star-forming region in the Small Magellanic Cloud (SMC). We find a PDMF slope of $\Gamma = -1.43 \pm 0.18$ in the mass range 0.8-60 $M_\odot$, in excellent agreement with the Salpeter initial mass function (IMF) in the solar neighborhood. Caveats on the conversion of the PDMF to the IMF are discussed. The PDMF slope changes, as a function of the radial distance from the center of the NGC 346 star cluster, indicating a segregation of the most massive stars. This segregation is likely primordial considering the young age ($\sim$ 3 Myr) of NGC 346, and its clumpy structure which suggests that the cluster has likely not had sufficient time to relax. Comparing our results for NGC 346 with those derived for other star clusters in the SMC and the Milky Way (MW), we conclude that, while the star formation process might depend on the local cloud conditions, the IMF does not seem to be affected by general environmental effects such as galaxy type, metallicity, and dust content.

Published by The Astronomical Journal (Vol. 135, p. 173)

Detection of HCO2+ toward the Low-Mass Protostar IRAS 04368+2557 in L1527

Nami Sakai[1], Takeshi Sakai[2], Yuri Aikawa[3] and Satoshi Yamamoto[1]

[1] Department of Physics, The University of Tokyo
[2] Nobeyama Radio Observatory
[3] Department of Earth and Planetary Sciences, Kobe University

E-mail contact: nami *at* taurus.phys.s.u-tokyo.ac.jp

The millimeter-wave rotational emission lines (4(04)-3(03) and 5(05)-4(04)) of protonated carbon dioxide, HCO2+(HOCO+), has been detected toward the low-mass class 0 protostar IRAS 04368+2557 in L1527 with the IRAM 30 m telescope. This is the first detection of HCO2+ except for the Galactic Center clouds. The column density of HCO2+ averaged over the beam size (29") is determined to be 7.6x10^{10} cm^{-2}, assuming the rotational temperature of 12.3 K. The fractional abundance of gaseous CO2 relative to H2 is estimated from the column density of HCO2+ with an aid of a simplified chemical model. If the HCO2+ emission only comes from the evaporation region of CO2 near the protostar (T>50 K), the fractional abundance of CO2 is estimated to be higher than 6.6x10^{-4}. This is comparable to the elemental abundance of carbon in interstellar clouds, and hence, the direct evaporation of CO2 from dust grain is unrealistic as a source of gaseous CO2 in L1527. A narrow line width of HCO2+ also supports this. On the other hand, the fractional abundance of CO2 is estimated to be 2.9x10^{-7}, if the source size is comparable to the beam size. These results indicate that gaseous CO2 is abundant even in the low-mass star-forming region. Possible production

mechanisms of gaseous CO2 are discussed.

Accepted by ApJ Letters

http://arxiv.org/pdf/0801.4441

The massive star binary fraction in young open clusters I. NGC 6231 revisited

H. Sana[1], E. Gosset[2], Y. Naze[2], G. Rauw[2] and N. Linder[2]

[1] European Southern Observatory, Chile
[2] Liege University, Belgium

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

We present the results of a long-term high-resolution spectroscopy campaign on the O-type stars in NGC 6231. We revise the spectral classification and multiplicity of these objects and we constrain the fundamental properties of the O-star population. Almost three quarters of the O-type stars in the cluster are members of a binary system. The minimum binary fraction is 0.63, with half the O-type binaries having an orbital period of the order of a few days. The eccentricities of all the short-period binaries are revised downward, and henceforth match a normal period-eccentricity distribution. The mass-ratio distribution shows a large preference for O+OB binaries, ruling out the possibility that, in NGC 6231, the companion of an O-type star is randomly drawn from a standard IMF. Obtained from a complete and homogeneous population of O-type stars, our conclusions provide interesting observational constraints to be confronted with the formation and early-evolution theories of O stars.

Accepted by MNRAS

http://arxiv.org/abs/0707.2847

VLBA Observations of the Zeeman Effect in H_2O Masers in OH 43.8-0.1

A. P. Sarma[1], T. H. Troland[2], J. D. Romney[3] and T. H. Huynh[1]

[1] Physics Department, DePaul University, Byrne Hall 211, 2219 North Kenmore Avenue, Chicago, IL 60614, USA
[2] Department of Physics and Astronomy, University of Kentucky, Lexington, KY 40506, USA
[3] National Radio Astronomy Observatory, Socorro, NM 87801, USA

E-mail contact: asarma *at* depaul.edu

We present VLBA observations of the Zeeman effect in H_2O masers in the high-mass star-forming region OH 43.8-0.1, where we observed 116 maser features. These masers may be arranged in several groups: the most prominent are an arc-shaped structure to the north, a central cluster, two groups located symmetrically around the central cluster to its northeast and southwest, and a group in the extreme south. The highest velocity (redshifted) masers are in the center of the northern arc. The observed morphology of masers in OH 43.8-0.1 suggests a stellar object (or objects) located within the central cluster of masers, driving outflows to the north and south; the redshifted and blueshifted group in the northern arc may represent the leading edge of two or more such outflows. The two groups located symmetrically around the central cluster may suggest a circumstellar disk of diameter 3000 AU. Seven masers in OH 43.8-0.1 are above our Zeeman detection limit. We detected magnetic fields in the range 10-20 mG in four of these masers and imposed sensitive upper limits on the other three. Three detections are for masers in the northern arc; the fourth is in the central cluster. We find no significant difference between the magnetic field strengths in these two groups. In the northern arc we detect a magnetic field reversal over a scale as small as 170 AU. We use our Zeeman-effect results to examine connections between the pre- and postshock magnetic fields and densities. The predicted preshock magnetic field strength and density are consistent with the fields and densities observed in typical preshock regions. The predicted postshock density also appears to be in the regime for optimal H_2O maser pumping. Finally, we find that the magnetic and kinetic energy densities are likely in equilibrium in both pre- and postshock regions, meaning that the magnetic field must affect significantly the outflow dynamics.

Published by The Astrophysical Journal (Vol. 674, p. 295)

Dynamics of charged dust particles in protoplanetary discs

Mohsen Shadmehri[1,2]

[1] School of Mathematical Sciences, Dublin City University, Glasnevin, Dublin 9, Ireland
[2] Department of Physics, School of Science, Ferdowsi University, Mashhad, Iran

E-mail contact: mohsen.shadmehri *at* dcu.ie

We study the effect of an imposed magnetic field on the motion of charged dust particles in magnetically active regions of a protoplanetary disc. Assuming a power law structure for the vertical and the toroidal components of the magnetic field for the regions beyond magnetically dead region of the disc, the radial and the vertical velocities of the charged particles, in the asymptotic case of small particles, are calculated analytically. While grains with radii smaller than a critical radius significantly are affected by the magnetic force, motion of the particles with larger radii is independent of the magnetic field. The critical radius depends on the magnetic geometry and the charge of the grains. Assuming that a grain particle has one elementary charge and the physical properties of the disc correspond to a minimum-mass solar nebula, we show that only micron-sized grains are affected by the magnetic force. Also, charge polarity determines direction of the radial velocity. For such small particles, both the radial and the vertical velocities increase due to the magnetic force.

Accepted by Astrophysics & Space Science

arXiv:0711.2090

Near infrared photometric and optical spectroscopic study of 22 low mass star clusters embedded in nebulae

J. B. Soares[1,2]**, E. Bica**[1]**, A. V. Ahumada**[3]**, and J. J. Clariá**[3]

[1] Universidade Federal do Rio Grande do Sul, IF, CP 15051, Porto Alegre 91501-970, RS, Brazil
[2] LATO-DCET-UESC, Rodovia Ilhéus-Itabuna, km 16, Ilhéus 45662-000, BA, Brazil
[3] Observatorio Astronómico de Córdoba, Universidad Nacional de Córdoba, Laprida 854, 5000 Córdoba, Argentina

E-mail contact: jules *at* if.ufrgs.br

Aims. Among the star clusters in the Galaxy, those embedded in nebulae represent the youngest group, which has only recently been explored. The analysis of a sample of 22 candidate embedded stellar systems in reflection nebulae and/or HII environments is presented.

Methods. We employed optical spectroscopic observations of stars in the directions of the clusters carried out at CASLEO (Argentina) together with near infrared photometry from the 2MASS catalogue. Our analysis is based on source surface density, colour-colour diagrams and on theoretical pre-main sequence isochrones. We take into account the field star contamination by carrying out a statistical subtraction.

Results. The studied objects have the characteristics of low mass systems. We derive their fundamental parameters. Most of the cluster ages are younger than 2 Myr. The studied embedded stellar systems in reflection nebulae and/or HII region complexes do not have stars of spectral types earlier than B. The total stellar masses locked in the clusters are in the range 20-220 $M_{\odot}$. They are found to be gravitationally unstable and are expected to dissolve in a timescale of a few Myr.

Published by Astronomy & Astrophysics (Vol. 478, p. 419)

The Pre-Main-Sequence Eclipsing Binary ASAS J052821+0338.5

H.C. Stempels[1]**, L. Hebb**[1]**, K.G. Stassun**[2]**, J. Holtzman**[3]**, N. Dunstone**[1]**, L. Glowienka**[4,5] **and S. Frandsen**[5]

[1] School of Physics & Astronomy, University of St Andrews, North Haugh, St Andrews KY16 9SS, Scotland
[2] Physics and Astronomy Department, Vanderbilt University, Nashville, TN 37235, USA
[3] Astronomy Department, New Mexico State University, Las Cruces, NM 88003, USA
[4] Nordic Optical Telescope, Apartado 474, 38700 Santa Cruz de La Palma, Spain
[5] Department of Physics and Astronomy, Århus University, Denmark

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

In this paper we present the first results of a detailed spectroscopic and photometric analysis of the $V = 11.7^{\rm m}$ eclipsing binary ASAS J052821+0338.5. With the FIES spectrograph at the Nordic Optical Telescope, we obtained a series of high-resolution spectra ($R \approx 47000$) covering the entire orbit of the system. In addition we obtained simultaneous broadband photometry from three small aperture telescopes. From these spectroscopic and photometric data we have derived the system's orbital parameters and determined the fundamental stellar parameters of the two components. Our results indicate that ASAS J052821+0338.5 is a K1/K3 pre-main-sequence eclipsing binary, with component masses of $1.38\,{\rm M}_\odot$ and $1.33\,{\rm M}_\odot$ and a period of 3.87 days, located at a distance of 280 ± 30 pc. The kinematics, physical location, and the evolutionary status of the two stars suggest that ASAS J052821+0338.5 is a member of the $\sim$ 11 Myr old Orion OB1a subassociation. The systems also exhibits smooth $\sim 0.15^{\rm m}$ out-of-eclipse variations that are similar to those found in RS CVn binaries. Furthermore, the parameters we derived are consistent with the 10–13 Myr isochrones of the popular Baraffe stellar evolutionary models.

Accepted by Astronomy & Astrophysics

http://arxiv.org/abs/0801.3927

The Initial Mass Function and Young Brown Dwarf Candidates in NGC 2264. III. Photometric Data

Hwankyung Sung[1], Michael S. Bessell[2], Moo-Young Chun[3], Rivkat Karimov[4] and Mansur Ibrahimov[4]

[1] Department of Astronomy and Space Science, Sejong University, Kunja-dong 98, Kwangjin-gu, Seoul 143-747, Korea

[2] Research School of Astronomy and Astrophysics, Australian National University, MSO, Cotter Road, Weston, ACT 2611, Australia

[3] Optical Astronomy Division, Korea Astronomy and Space Science Institute, Whaam-dong 61-1, Yusung-gu, Taejeon 305-348, Korea

[4] Ulugh Beg Astronomical Institute, 33 Astronomical Street, Tashkent 700052, Uzbekistan

E-mail contact: sungh *at* sejong.ac.kr

We have performed deep wide-field CCD photometry of the young open cluster NGC 2264 to study the extent of star-forming regions (SFRs) and the shape of the initial mass function. In this paper, we present VRI and Hα photometry for more than 67,000 stars. From the spatial distribution of the selected Hα emission stars, we identify two active SFRs and a less active halo region surrounding these two SFRs. There are several Hα emission stars in the field region outside the halo region, and these may be newly formed stars in the Mon OB1 association surrounding the cluster. The locus of pre-main-sequence (PMS) stars in the I_C versus V - I_C diagram is revised from the distribution of Hα and X-ray emission stars in the diagram. The mean reddening of late-type PMS stars is estimated to be E(B - V) $\approx$ 0.2 mag using the distribution of X-ray emission stars in the 2MASS color-color diagram. We can confirm that the Hα emission stars below the PMS locus (so-called BMS stars) are bona-fide members of NGC 2264 from their spatial distribution as well as from their near-IR excess in the 2MASS color-color diagram. In addition, four objects around IRS-2 detected with the Spitzer IRAC are also classified as BMS stars.

Published by The Astronomical Journal (Vol. 135, p. 441)

Magnetic Fields in Dark Cloud Cores: Arecibo OH Zeeman Observations

Thomas H. Troland[1] and Richard M. Crutcher[2]

[1] Physics and Astronomy Department, University of Kentucky, Lexington, KY 40502, USA
[2] Astronomy Department, University of Illinois, Urbana, IL 61801, USA

E-mail contact: crutcher *at* uiuc.edu

We have carried out an extensive survey of magnetic field strengths toward dark cloud cores in order to test models of star formation: ambipolar-diffusion driven or turbulence driven. The survey involved $\sim$ 500 hours of observing with the Arecibo telescope in order to make sensitive OH Zeeman observations toward 34 dark cloud cores. Nine new probable detections were achieved at the 2.5-sigma level; the certainty of the detections varies from solid to marginal, so we discuss each probable detection separately. However, our analysis includes all the measurements and does not depend on whether each position has a detection or just a sensitive measurement. Rather, the analysis establishes

mean (or median) values over the set of observed cores for relevant astrophysical quantities. The results are that the mass-to-flux ratio is supercritical by ~ 2, and that the ratio of turbulent to magnetic energies is also ~ 2. These results are compatible with both models of star formation. However, these OH Zeeman observations do establish for the first time on a statistically sound basis the energetic importance of magnetic fields in dark cloud cores at densities of order 10^{3-4} cm^{-3}, and they lay the foundation for further observations that could provide a more definitive test.

Accepted by Astrophysical Journal

http://xxx.lanl.gov/abs/0802.2253

The Structure of Protoplanetary Disks Surrounding Three Young Intermediate Mass Stars. I. Resolving the disk rotation in the [OI] 6300 line

G. van der Plas[1,2], M.E. van den Ancker[1], D. Fedele[1,3,4], B. Acke[5], C. Dominik[2], L.B.F.M. Waters[2] and J. Bouwman[4]

[1] European Southern Observatory, Karl-Schwarzschild-Str.2, D 85748 Garching bei Munchen, Germany

[2] Sterrenkundig Instituut 'Anton Pannekoek', University of Amsterdam, Kruislaan 403, 1098 SJ Amsterdam, The Netherlands

[3] Dipartimento di Astronomia, Universita Degli Studi Di Padova, Vicolo Dell, Osservatorio 2, 35122 Padova, Italy

[4] Max-Planck-Institut fur Astronomie, Konigstuhl 17, 69117 Heidelberg, Germany

[5] Institute of Astronomy, KU Leuven, Celestijnenlaan 200D, 3001 Leuven, Belgium

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

We present high spectral resolution optical spectra of three young intermediate mass stars, in all of which we spectrally resolve the 6300 Angstrom [OI] emission line. Two of these have a double peaked line profile. We fit these data with a simple model of the [OI] emission caused by photo-dissociation of OH molecules in the upper layer of a circumstellar disk by stellar UV radiation and thus translate the Doppler broadened [OI] emission profile into an amount of emission as a function of distance from the central star. The resulting spectra are in agreement with the expected disk shapes as derived from their spectral energy distribution. We find evidence for shadowing by an inner rim in the disk surrounding HD101412 and see a flaring disk structure in HD179218 while the [OI] spectrum of HD135344 is more complex. The [OI] emission starts for all three targets at velocities corresponding to their dust sublimation radius and extends up to radii of 10 – 90 AU. This shows that this method can be a valuable tool in the future investigation of circumstellar disks.

Accepted by Astronomy and Astrophysics

http://arxiv.org/abs/0802.0707

Mass accretion rates in self-regulated disks of T Tauri stars

E. I. Vorobyov[1] and Shantanu Basu[2]

[1] Institute for Computational Astrophysics, Saint Mary's University, Halifax, B3H 3C3, Canada

[2] Department of Physics and Astronomy, University of Western Ontario, London, Ontario, N6A 3K7, Canada

E-mail contact: vorobyov *at* ap.smu.ca

We have studied numerically the evolution of protostellar disks around intermediate and upper mass T Tauri stars ($0.25\ M_\odot < M_* < 3.0\ M_\odot$) that have formed self-consistently from the collapse of molecular cloud cores. In the T Tauri phase, disks settle into a self-regulated state, with low-amplitude nonaxisymmetric density perturbations persisting for at least several million years. Our main finding is that the global effect of gravitational torques due to these perturbations is to produce disk accretion rates that are of the correct magnitude to explain observed accretion onto T Tauri stars. Our models yield a correlation between accretion rate $\dot{M}$ and stellar mass M_* that has a best fit $\dot{M} \propto M_*^{1.7}$, in good agreement with recent observations. We also predict a near-linear correlation between the disk accretion rate and the disk mass.

Accepted by ApJ Letters

The Efficiency of Grain Alignment in Dense Interstellar Clouds: a Reassessment of Constraints from Near-Infrared Polarization

D. C. B. Whittet[1], J. H. Hough[2], A. Lazarian[3] and Thiem Hoang[3]

[1] Department of Physics, Applied Physics, and Astronomy, Rensselaer Polytechnic Institute, 110 Eighth Street, Troy, NY 12180, USA
[2] Centre for Astrophysics Research, University of Hertfordshire, Hatfield AL10 9AB, UK
[3] Department of Astronomy, University of Wisconsin, Madison, WI 53706, USA

E-mail contact: whittd *at* rpi.edu

We present the results of a detailed study of interstellar polarization efficiency (as measured by the ratio p_λ/τ_λ) toward molecular clouds, with the aim of discriminating between grain alignment mechanisms in dense regions of the interstellar medium. The data set includes both continuum measurements in the K (2.2 μm) passband and values based on ice and silicate spectral features. Background field stars are used to probe polarization efficiency in quiescent regions of dark clouds, yielding a dependence on visual extinction well-represented by a power law ($p_\lambda/\tau_\lambda \propto [A_V]^{-0.52}$), in agreement with previous work. No significant change in this behavior is observed in the transition region between the diffuse outer layers and dense inner regions of clouds, where icy mantles are formed, and we conclude that mantle formation has little or no effect on the efficiency of grain alignment. The field-star data are used as a template for comparison with results for embedded young stellar objects (YSOs). The latter generally exhibit greater polarization efficiency compared with field stars at comparable extinctions, some displaying enhancements in p_λ/τ_λ by factors of up to $\sim$6 with respect to the power-law fit. Of the proposed alignment mechanisms, that based on radiative torques appears best able to explain the data. The attenuated external radiation field appears adequate to account for the observed polarization in quiescent regions for extinctions up to $A_V \sim 10$ mag. Radiation from the embedded stars themselves may enhance alignment in the lines of sight to YSOs. Enhancements in p_λ/τ_λ observed in the ice features toward several YSOs are of greatest significance, as they demonstrate efficient alignment in cold molecular clouds associated with star formation.

Published by The Astrophysical Journal (Vol. 674, p. 304)

A Multi-wavelength Study of the Massive Star-forming Region S87

Rui Xue[1,2] and Yuefang Wu[1]

[1] Department of Astronomy, Peking University, Beijing 100871, China
[2] National Astronomical Observatories, Chinese Academy of Sciences, Beijing 100012, China

E-mail contact: rxue *at* pku.org.cn

This article presents a multi-wavelength study towards S87, based on a dataset of submillimeter/far-/mid-infrared (sub-mm/FIR/MIR) images and molecular line maps. The sub-mm continuum emission measured with JCMT/SCUBA reveals three individual clumps, namely, SMM 1, SMM 2, and SMM 3. The MIR/FIR images obtained by the *Spitzer Space Telescope* indicate that both SMM 1 and SMM 3 harbor point sources. The $J = 1-0$ transitions of CO, ^{13}CO, $C^{18}O$, and HCO^+, measured with the 13.7 m telescope of the Purple Mountain Observatory, exhibit asymmetric line profiles. Our analysis of spectral energy distributions (SEDs) shows that all of the three sub-mm clumps are massive ($110 — 210\,M_\odot$), with average dust temperatures in the range $\sim 20 — 40$ K. A multi-wavelength comparison convinces us that the asymmetric profiles of molecular lines should result from two clouds at slightly different velocities, and it further confirms that the star-forming activity in SMM 1 is stimulated by a cloud-cloud collision. The stellar contents and SEDs suggest that SMM 1 and SMM 3 are high-mass and intermediate-mass star-forming sites respectively. However, SMM 2 has no counterpart downwards 70 μm, which is likely to be a cold high-mass starless core. These results, as mentioned above, expose multiple phases of star formation in S87.

Accepted by the Astrophysical Journal

http://arxiv.org/abs/0802.2036

Comparing the Observational Instability Regions for Pulsating Pre-Main-Sequence and Classical δ Scuti Stars

K. Zwintz[1]

[1] Institute of Astronomy, Türkenschanzstrasse 17, A1180 Vienna, Austria

E-mail contact: zwintz *at* astro.univie.ac.at

A comparison of the hot and cool boundaries of the classical instability strip with observations has been an important test for stellar structure and evolution models of post- and main-sequence stars. Over the last few years, the number of pulsating pre-main-sequence (PMS) stars has increased significantly: 36 PMS pulsators and candidates are known as of 2007 June. This number allows to investigate the location of the empirical PMS instability region and to compare its boundaries to those of the classical (post- and main-sequence) instability strip. Due to the structural differences of PMS and (post-)main-sequence stars, the frequency spacings for nonradial modes will be measurably different, thus challenging asteroseismology as a diagnostic tool.

Published by The Astrophysical Journal (Vol. 673, p. 1088)

Abstracts of recently accepted major reviews

The Formation and Evolution of Prestellar Cores

Philippe André[1], **Shantanu Basu**[2] **and Shu-ichiro Inutsuka**[3]

[1] Service d'Astrophysique, UMR AIM, CEA/DSM - CNRS - Univ. Paris 7, CEA Saclay, France

[2] Department of Physics and Astronomy, University of Western Ontario, London, Canada

[3] Department of Physics, Graduate School of Science, Kyoto University, Japan

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

Improving our understanding of the initial conditions and earliest stages of star formation is crucial to gain insight into the origin of stellar masses, multiple systems, and protoplanetary disks. We review the properties of low-mass dense cores as derived from recent millimeter/submillimeter observations of nearby molecular clouds and discuss them in the context of various contemporary scenarios for cloud core formation and evolution. None of the extreme scenarios can explain all observations. Pure laminar ambipolar diffusion has relatively long growth times for typical ionization levels and has difficulty satisfying core lifetime constraints. Purely hydrodynamic pictures have trouble accounting for the inefficiency of core formation and the detailed velocity structure of individual cores. A possible favorable scenario is a mixed model involving gravitational fragmentation of turbulent molecular clouds close to magnetic criticality. The evolution of the magnetic field and angular momentum in individual cloud cores after the onset of gravitational collapse is also discussed. In particular, we stress the importance of radiation-magnetohydrodynamical processes and resistive MHD effects during the protostellar phase. We also emphasize the role of the formation of the short-lived first (protostellar) core in providing a chance for sub-fragmentation into binary systems and triggering MHD outflows. Future submillimeter facilities such as *Herschel* and ALMA will soon provide major new observational constraints in this field. On the theoretical side, an important challenge for the future will be to link the formation of molecular clouds and prestellar cores in a coherent picture.

Accepted for Proceedings of the Conference "Structure Formation in the Universe", Ed. G. Chabrier, Cambridge University Press

Preprint available at `http://arxiv.org/abs/0801.4210 [astro-ph]`

Post-doctoral Position in Theoretical/Numerical Star Formation at Cardiff University

A 2-year postdoctoral position is available to do theoretical and numerical work in the Star Formation Group at Cardiff University (http://www.astro.cf.ac.uk/groups/starform), in the framework of the European Commission FP6 Marie Curie Research Training Network "CONSTELLATION: the origin of stellar masses" (http://www.constellation-rtn.eu). The Cardiff Astronomy Group is now one of the largest in the UK, containing strong observational and theory groups, and is involved in many international projects. The Star Formation Theory and Observational Groups are led by Ant Whitworth and Derek Ward-Thompson.

The successful candidate will participate in a programme of numerical smulations aimed at understanding the formation of star forming clouds and the origin of the core mass function, the collapse and fragentation of individual cores and protostellar discs, the role of impulsive processes in triggering star formation, the influence of feedback (bipolar outflows, non-ionising and ionising radiation, stellar winds and supernova explosions) in determining the IMF, and the external appearance of star-forming regions. She/he will also contribute to the development, testing and optimisation of improved numerical codes.

The appointment is for 2 years, starting no later than December 01 2008. Candidates with expertise in numerical simulations of star formation, N-body dynamics, and/or radiation transport, are encouraged to apply.

Application forms, eligibility criteria, and terms of employment are to be found at:

http://www.constellation-rtn.eu/wiki/index.php/PhD_and_Postdoctoral_Positions_Available

The closing date for applications is May 31st, 2008. Informal enquiries to ant *at* astro.cf.ac.uk.

Postdoctoral Research Position in Saclay, France

The Origin of Stellar Masses with *Herschel*

In the framework of the European Commission FP6 Research Training Network CONSTELLATION on "The Origin of Stellar Masses" (http://www.constellation-rtn.eu), a postdoctoral position is available for two years in the Star Formation Group of CEA Saclay, France.

The "Service d'Astrophysique" (SAp) at CEA Saclay is a major space astrophysics laboratory located about 20 km south-west of Paris. It has been actively involved in the development of the two far-infrared and submillimeter imaging instruments PACS and SPIRE of the Herschel Space Observatory (HSO) to be launched by ESA by the end of 2008. It is also responsible for instruments on the ground, such as the VLT Imager and Spectrometer for the mid-Infrared (VISIR) and the ArTéMiS submillimeter bolometer array for the APEX telescope.

In recent years, the Star Formation Group has focused on millimeter/submillimeter studies of the earliest phases of star formation and detailed comparisons with hydrodynamic simulations of cloud fragmentation and collapse.

The successful applicant is expected to take an active role in a major *Herschel* guaranteed-time Key Project aiming to provide a complete census of prestellar cores and young protostars in the cloud complexes of the Gould Belt (http://starformation-herschel.iap.fr/gouldbelt/).

We invite applications from scientists with a PhD in astrophysics and a strong background in star formation and/or molecular cloud studies. Demonstrated experience in (sub)millimeter observations will be an asset. The initial appointment is for two years, starting as early as 1 September 2008, but no later than 30 November 2008.

Please send a CV, a list of publications and a statement of research interests, and arrange for three letters of recommendation before 30 April 2008.

Attention: Dr. Philippe André, CEA Saclay, DSM/IRFU Service d'Astrophysique,
Orme des Merisiers - Bât. 709, F-91191 Gif-sur-Yvette Cedex, France
(Phone: + 33 1 69 08 92 65; FAX: + 33 1 69 08 65 77; E-mail: pandre *at* cea.fr)

Protostellar Jets in Context

"Protostellar Jets in Context" is an international astrophysics conference which will take place from July 7-11, 2008 inclusive on the island of Rhodes, Greece. The main goal is to review the recent contributions of theoretical and computational modelling, high-resolution observations, and laboratory experiments to our understanding of jets and outflows from young stars. The connection with accretion disks and the similarities with outflow phenomena in other astrophysical contexts will also be explored.

Topics to be discussed include: (1) The jet/wind-launching region, (2) The propagation, cooling, stability, and environmental impact of jets on scales from the stellar envelope to the parent cloud. (3) Laboratory experiments that reproduce, in a scaled manner, key aspects of the dynamics of astrophysical jets. (4) Similarities and differences between protostellar jets and their astrophysical siblings.

The conference aims to bring together scientists working in these various fields to stimulate cross-disciplinary exchange. It will contain both invited and contributed talks, as well as poster sessions. Proceedings will be published.

For more information : **http://conferences.phys.uoa.gr/jets2008/**

The Star Formation Newsletter is a vehicle for fast distribution of information of interest for astronomers working on star formation and molecular clouds. You can submit material for the following sections: *Abstracts of recently accepted papers* (only for papers sent to refereed journals), *Abstracts of recently accepted major reviews* (not standard conference contributions), *Dissertation Abstracts* (presenting abstracts of new Ph.D dissertations), *Meetings* (announcing meetings broadly of interest to the star and planet formation and early solar system community), *New Jobs* (advertising jobs specifically aimed towards persons within the areas of the Newsletter), and *Short Announcements* (where you can inform or request information from the community).

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

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

Moving ... ??

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