

THE STAR FORMATION NEWSLETTER

An electronic publication dedicated to early stellar evolution and molecular clouds

No. 235 — 24 July 2012

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

Abstracts of recently accepted papers

Effects of Collisions with Rocky Planets on the Properties of Hot Jupiters

Kassandra R. Anderson¹ and Fred C. Adams^{1,2}

¹ Physics Department, University of Michigan, Ann Arbor, MI 48109, USA

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

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

Observed Hot Jupiters exhibit a wide range of physical properties. For a given mass, many planets have inflated radii, while others are surprisingly compact and may harbor large central cores. Motivated by the observational sample, this paper considers possible effects from collisions of smaller rocky planets with gas giant planets. In this scenario, the Jovian planets migrate first and enter into ~ 4 day orbits, whereas rocky planets (mass $m_p = 0.1 - 20M_{\text{earth}}$) migrate later and then encounter the gaseous giants. Previous work indicates that the collision rates are high for such systems. This paper calculates the trajectories of incoming rocky planets as they orbit within the gaseous planets and are subjected to gravitational, frictional, and tidal forces. These collisions always increase the metallicity of the Jovian planets. If the incoming rocky bodies survive tidal destruction and reach the central regions, they provide a means of producing large planetary cores. Both the added metallicity and larger cores act to decrease the radii of the gas giants at fixed mass. The energy released during these collisions provides the Jovian planet with an additional heat source; here we determine the radial layers where kinetic energy of the colliding body is dissipated, including the energy remaining upon impact with the existing core. This process could have long-term effects if the colliding body deposits significant energy deep in the interior, in regions of high opacity. Both Hot Jupiters and newly formed gas giants have inflated radii, large enough to allow incoming rocky planets to survive tidal disruption, enhance the central core mass, and deposit significant energy (in contrast, denser giant planets with the mass and radius of Jupiter are expected to tidally destroy incoming rocky bodies).

Accepted by PASP

(arXiv:1206.5857)

Interferometric Identification of a Pre-Brown Dwarf

Philippe André¹, Derek Ward-Thompson² and Jane Greaves³

¹ Laboratoire AIM, CEA/DSM-CNRS-Université Paris Diderot, IRFU/Service d'Astrophysique, C.E. Saclay, Orme des Merisiers, 91191 Gif-sur-Yvette Cedex, France

² Jeremiah Horrocks Institute, University of Central Lancashire, PR1 2HE, UK

³ SUPA, Physics and Astronomy, University of St Andrews, North Haugh, St Andrews, Fife KY16 9SS, UK

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

It is not known whether brown dwarfs (stellar-like objects with masses less than the hydrogen-burning limit, $0.075 M_{\odot}$) are formed in the same way as solar-type stars or by some other process. Here we report the clear-cut identification of a self-gravitating condensation of gas and dust with a mass in the brown-dwarf regime, made through millimeter interferometric observations. The level of thermal millimeter continuum emission detected from this object indicates a mass $\sim 0.02\text{-}0.03 M_{\odot}$, while the small radius < 460 AU and narrow spectral lines imply a dynamical mass of $0.015\text{-}0.02 M_{\odot}$. The identification of such a pre-brown dwarf core supports models according to which brown dwarfs are

formed in the same manner as hydrogen-burning stars.

Accepted by Science (published in Vol. 337, 6 July 2012)

<http://arxiv.org/abs/1207.1220>

<http://www.sciencemag.org/content/337/6090/69.full.pdf>

Can grain growth explain transition disks?

T. Birnstiel^{1,2}, S. M. Andrews³ and B. Ercolano^{1,2}

¹ University Observatory Munich, Scheinerstr. 1, D-81679 München, Germany

² Excellence Cluster Universe, Technische Universität München, Boltzmannstr. 2, 85748 Garching, Germany

³ Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA

E-mail contact: til.birnstiel@lmu.de

Aims: Grain growth has been suggested as one possible explanation for the diminished dust optical depths in the inner regions of protoplanetary “transition” disks. In this work, we directly test this hypothesis in the context of current models of grain growth and transport.

Methods: A set of dust evolution models with different disk shapes, masses, turbulence parameters, and drift efficiencies is combined with radiative transfer calculations in order to derive theoretical spectral energy distributions (SEDs) and images.

Results: We find that grain growth and transport effects can indeed produce dips in the infrared SED, as typically found in observations of transition disks. Our models achieve the necessary reduction of mass in small dust by producing larger grains, yet not large enough to be fragmenting efficiently. However, this population of large grains is still detectable at millimeter wavelengths. Even if perfect sticking is assumed and radial drift is neglected, a large population of dust grains is left behind because the time scales on which they are swept up by the larger grains are too long. This mechanism thus fails to reproduce the large emission cavities observed in recent millimeter-wave interferometric images of accreting transition disks.

Accepted by A&A

<http://dx.doi.org/10.1051/0004-6361/201219262>

Reverse Rotation of the Accretion Disk in RW Aur A: Observations and a Physical Model

D.V. Bisikalo¹, A.V. Dodin², P.V. Kaygorodov¹, S.A. Lamzin², E.V. Malogolovets³, A.M. Fateeva¹

¹ Institute of Astronomy, Russian Academy of Sciences, Pyatnitskaya st. 48, Moscow, 109017 Russia

² Sternberg Astronomical Institute, Moscow State University, Universitetskii pr. 13, Moscow, 119991 Russia

³ Special Astrophysical Observatory, Russian Academy of Sciences, Nizhnii Arkhyz, Karachaevo-Cherkessia Republic, 369167 Russia

E-mail contact: bisikalo@inasan.ru; lamzin@sai.msu.ru

Speckle interferometry of the young binary system RW Aur was performed with the 6-m telescope of the Special Astrophysical Observatory of the Russian Academy of Sciences using filters with central wavelengths of 550 nm and 800 nm and pass-band halfwidths of 20 nm and 100 nm, respectively. The angular separation of the binary components was $1.448'' \pm 0.005''$ and the position angle of the system was $255.9^\circ \pm 0.3^\circ$ at the observation epoch (JD 2 454 255.9). We find using published data that these values have been changing with mean rates of $+0.002''/\text{yr}$ and $+0.02^\circ/\text{yr}$, respectively, over the past 70 years. This implies that the direction of the orbital motion of the binary system is opposite to the direction of the disk rotation in RW Aur A. We propose a physical model to explain the formation of circumstellar accretion disks rotating in the reverse direction relative to young binary stars surrounded by protoplanetary disks. Our model can explain the characteristic features of the matter flow in RW Aur A: the high accretion rate, small size of the disk around the massive component, and reverse direction of rotation.

Accepted by Astronomy Reports

<http://arxiv.org/abs/1207.4022>

Cosmochemical Consequences of Particle Trajectories During FU Orionis Outbursts by the Early Sun

Alan P. Boss¹, Conel M. O'D. Alexander¹ and Morris Podolak²

¹ DTM, Carnegie Institution, 5241 Broad Branch Road, NW, Washington, DC 20015-1305 United States

² Dept. of Geophysics & Planetary Sciences, Tel Aviv University, Ramat, Tel Aviv, 69978 Israel

E-mail contact: boss *at* dtm.ciw.edu

The solar nebula is thought to have undergone a number of episodes of FU Orionis outbursts during its early evolution. We present here the first calculations of the trajectories of particles in a marginally gravitationally unstable solar nebula during an FU Orionis outburst, which show that 0.1 to 10 cm-sized particles traverse radial distances of 10 AU or more, inward and outward, in less than 200 yrs, exposing the particles to temperatures from ~ 60 K to ~ 1500 K. Such trajectories can thus account for the discovery of refractory particles in comets. Refractory particles should acquire Wark-Lovering-like rims as they leave the highest temperature regions of the disk, and these rims should have significant variations in their stable oxygen isotope ratios. Particles are likely to be heavily modified or destroyed if they pass within 1 AU of the Sun, and so are only likely to survive if they formed in the final few FU Orionis outbursts, or were transported to the outer reaches of the solar system. Calcium, aluminum-rich inclusions (CAIs) from primitive meteorites are the oldest known solar system objects and have a very narrow age range. Most CAIs may have formed at the end of the FU Orionis outbursts phase, with an age range reflecting the period between the last few outbursts.

Accepted by Earth & Planetary Science Letters

<http://www.dtm.ciw.edu/users/boss/ftp/cosmochemical.pdf>

Supernova-Triggered Molecular Cloud Core Collapse and the Rayleigh-Taylor Fingers that Polluted the Solar Nebula

Alan P. Boss¹ and Sandra A. Keiser¹

¹ DTM, Carnegie Institution, 5241 Broad Branch Road, NW, Washington, DC 20015-1305 United States

E-mail contact: boss *at* dtm.ciw.edu

A supernova is a likely source of short-lived radioisotopes (SLRIs) that were present during the formation of the earliest solar system solids. A suitably thin and dense supernova shock wave may be capable of triggering the self-gravitational collapse of a molecular cloud core while simultaneously injecting SLRIs. Axisymmetric hydrodynamics models have shown that this injection occurs through a number of Rayleigh-Taylor (RT) rings. Here we use the FLASH adaptive mesh refinement (AMR) hydrodynamics code to calculate the first fully three dimensional (3D) models of the triggering and injection process. The axisymmetric RT rings become RT fingers in 3D. While ~ 100 RT fingers appear early in the 3D models, only a few RT fingers are likely to impact the densest portion of the collapsing cloud core. These few RT fingers must then be the source of any SLRI spatial heterogeneity in the solar nebula inferred from isotopic analyses of chondritic meteorites. The models show that SLRI injection efficiencies from a supernova several pc away fall at the lower end of the range estimated for matching SLRI abundances, perhaps putting them more into agreement with recent reassessments of the level of ^{60}Fe present in the solar nebula.

Accepted by Astrophysical Journal Letters

<http://www.dtm.ciw.edu/users/boss/ftp/RTfingers.pdf>

Testing Disk-Locking in NGC 2264

P. Wilson Cauley¹, Christopher M. Johns-Krull¹, Catrina M. Hamilton² and Kelly Lockhart³

¹ Rice University

² Dickinson College

³ University of Hawaii Manoa

E-mail contact: pwcl *at* rice.edu

We test analytic predictions from different models of magnetospheric accretion, which invoke disk-locking, using stellar and accretion parameters derived from models of low resolution optical spectra of 36 T Tauri stars (TTs) in NGC

2264 (age 3 Myrs). Little evidence is found for models that assume purely dipolar field geometries; however, strong support is found in the data for a modified version of the X-wind model (Shu et al. 1994) which allows for non-dipolar field geometries. The trapped flux concept in the X-wind model is key to making the analytic predictions which appear supported in the data. By extension, our analysis provides support for the outflows predicted by the X-wind as these also originate in the trapped flux region. In addition, we find no support in the data for accretion powered stellar winds from young stars. By comparing the analysis presented here of NGC 2264 with a similar analysis of stars in Taurus (age 1-2 Myr), we find evidence that the equilibrium interaction between the magnetic field and accretion disk in TTS systems evolves as the stars grow older, perhaps as the result of evolution of the stellar magnetic field geometry. We compare the accretion rates we derive with accretion rates based on U-band excess, finding good agreement. In addition, we use our accretion parameters to determine the relationship between accretion and H-beta luminosity, again finding good agreement with previously published results; however, we also find that care must be used when applying this relationship due to strong chromospheric emission in young stars which can lead to erroneous results in some cases.

Accepted by ApJ

<http://arxiv.org/abs/1207.3295>

CID: Chemistry In Disks VII. First detection of HC₃N in protoplanetary disks

Edwige Chapillon¹, Anne Dutrey^{2,3}, Stéphane Guilloteau^{2,3}, Vincent Piétu⁴, Valentine Wakelam^{2,3}, Franck Hersant^{2,3}, Frédéric Gueth⁴, Thomas Henning⁵, Ralf Launhardt⁵, Katharina Schreyer⁶ and Dmitry Semenov⁵

¹ Institute of Astronomy and Astrophysics, Academia Sinica, P.O. Box 23-141, Taipei 10617, Taiwan

² Univ. Bordeaux, LAB, UMR 5804, 2 rue de l'observatoire, F-33270, Floirac, France

³ CNRS, LAB, UMR 5804, F-33270 Floirac, France

⁴ IRAM, 300 rue de la piscine, F-38406 Saint Martin d'Hères, France

⁵ Max-Planck-Institut für Astronomie, Königstuhl 17, D-69117, Germany

⁶ Astrophysikalisches Institut und Universitäts-Sternwarte, Schillergsschen 2-3, 07745 Jena, Germany

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

Molecular line emission from protoplanetary disks is a powerful tool to constrain their physical and chemical structure. Nevertheless, only a few molecules have been detected in disks so far. We take advantage of the enhanced capabilities of the IRAM 30m telescope by using the new broad band correlator (FTS) to search for so far undetected molecules in the protoplanetary disks surrounding the T Tauri stars DM Tau, GO Tau, LkCa15 and the Herbig Ae star MWC 480. We report the first detection of HC₃N at 5 σ in the GO Tau and MWC 480 disks with the IRAM 30-m, and in the LkCa 15 disk (5 σ), using the IRAM array, with derived column densities of the order of 10¹²cm⁻². We also obtain stringent upper limits on CCS (N < 1.5 \times 10¹²cm⁻³). We discuss the observational results by comparing them to column densities derived from existing chemical disk models (computed using the chemical code Nautilus) and based on previous nitrogen and sulfur-bearing molecule observations. The observed column densities of HC₃N are typically two orders of magnitude lower than the existing predictions and appear to be lower in the presence of strong UV flux, suggesting that the molecular chemistry is sensitive to the UV penetration through the disk. The CCS upper limits reinforce our model with low elemental abundance of sulfur derived from other sulfur-bearing molecules (CS, H₂S and SO).

Accepted by Astrophysical Journal

<http://arxiv.org/abs/1207.2682>

The Envelope and Embedded Disk around the Class 0 Protostar L1157-mm: Dual-wavelength Interferometric Observations and Modeling

Hsin-Fang Chiang^{1,2}, Leslie W. Looney¹ and John J. Tobin³

¹ Department of Astronomy, University of Illinois at Urbana-Champaign, Urbana, Illinois, USA

² Institute for Astronomy, University of Hawaii at Manoa, Hilo, Hawaii, USA

³ National Radio Astronomy Observatory, Charlottesville, Virginia, USA

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

We present dual-wavelength observations and modeling of the nearly edge-on Class 0 young stellar object L1157-mm. Using the Combined Array for Research in Millimeter-wave Astronomy, a nearly spherical structure is seen from the circumstellar envelope at the size scale of 10^2 to 10^3 AU in both 1 mm and 3 mm dust emission. Radiative transfer modeling is performed to compare data with theoretical envelope models, including a power-law envelope model and the Terebey-Shu-Cassen model. Bayesian inference is applied for parameter estimation and information criteria is used for model selection. The results prefer the power-law envelope model against the Terebey-Shu-Cassen model. In particular, for the power-law envelope model, a steep density profile with an index of ~ 2 is inferred. Moreover, the dust opacity spectral index β is estimated to be ~ 0.9 , implying that grain growth has started at L1157-mm. Also, the unresolved disk component is constrained to be < 40 AU in radius and $< 4\text{--}25 M_{Jup}$ in mass. However, the estimate of the embedded disk component relies on the assumed envelope model.

Accepted by ApJ

<http://arxiv.org/abs/1207.3843>

Synthetic observations of first hydrostatic cores in collapsing low-mass dense cores. I. Spectral energy distributions and evolutionary sequence

Benoît Commerçon^{1,2}, Ralf Launhardt², Cornelis Dullemond³ and Thomas Henning²

¹ Laboratoire de radioastronomie, UMR 8112 du CNRS, École normale supérieure et Observatoire de Paris, 24 rue Lhomond, 75231 Paris Cedex 05, France

² Max-Planck-Institut für Astronomie, Königstuhl 17, 69117 Heidelberg, Germany

³ Zentrum für Astronomie der Universität Heidelberg, Institut für Theoretische Astrophysik, Albert-Ueberle-Str. 2, 69120 Heidelberg, Germany

E-mail contact: benoit.commercon *at* ira.ens.fr

The low-mass star formation evolutionary sequence is relatively well-defined both from observations and theoretical considerations. The first hydrostatic core is the first protostellar equilibrium object that is formed during the star formation process. Using state-of-the-art radiation-magneto-hydrodynamic 3D adaptive mesh refinement calculations, we aim to provide predictions for the dust continuum emission from first hydrostatic cores. We investigated the collapse and the fragmentation of magnetized $1 M_{\odot}$ prestellar dense cores and the formation and evolution of first hydrostatic cores using the RAMSES code. We used three different magnetization levels for the initial conditions, which cover a wide variety of early evolutionary morphology, e.g., the formation of a disk or a pseudo-disk, outflow launching, and fragmentation. We post-processed the dynamical calculations using the 3D radiative transfer code RADMC-3D. We computed spectral energy distributions and usual evolutionary stage indicators such as bolometric luminosity and temperature. We find that the first hydrostatic core lifetimes depend strongly on the initial magnetization level of the parent dense core. We derive, for the first time, spectral energy distribution evolutionary sequences from high-resolution radiation-magneto-hydrodynamic calculations. We show that under certain conditions, first hydrostatic cores can be identified from dust continuum emission at $24 \mu\text{m}$ and $70 \mu\text{m}$. We also show that single spectral energy distributions cannot help in distinguishing between the formation scenarios of the first hydrostatic core, i.e., between the magnetized and non-magnetized models. Spectral energy distributions are a first useful and direct way to target first hydrostatic core candidates but high-resolution interferometry is definitively needed to determine the evolutionary stage of the observed sources.

Accepted by Astronomy and Astrophysics

<http://dx.doi.org/10.1051/0004-6361/201118706>

Externally Fed Accretion onto Protostars

Paul A. Dalba¹ and Steven W. Stahler¹

¹ Astronomy Dept., U. of California, Berkeley, CA 94720, USA

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

The asymmetric molecular emission lines from dense cores reveal slow, inward motion in the clouds' outer regions. This

motion is present both before and after the formation of a central star. Motivated by these observations, we revisit the classic problem of steady, spherical accretion of gas onto a gravitating point mass, but now include self-gravity of the gas and impose a finite, subsonic velocity as the outer boundary condition. We find that the accretion rate onto the protostar is lower than values obtained for isolated, collapsing clouds, by a factor that is the Mach number of the outer flow. Moreover, the region of infall surrounding the protostar spreads out more slowly, at a speed close to the subsonic, incoming velocity. Our calculation, while highly idealized, provides insight into two longstanding problems – the surprisingly low accretion luminosities of even the most deeply embedded stellar sources, and the failure so far to detect spatially extended, supersonic infall within their parent dense cores. Indeed, the observed subsonic contraction in the outer regions of dense cores following star formation appears to rule out a purely hydrodynamic origin for these clouds.

Accepted by MNRAS

<http://arxiv.org/abs/1207.1453>

Giant Molecular clouds: what are they made from, and how do they get there?

C. L. Dobbs¹, J. E. Pringle² and A. Burkert³

¹ University of Exeter

² University of Cambridge

³ MPE, USM

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

We analyse the results of four simulations of isolated galaxies: two with a rigid spiral potential of fixed pattern speed, but with different degrees of star-formation induced feedback, one with an axisymmetric galactic potential and one with a 'live' self-gravitating stellar component. Since we use a Lagrangian method we are able to select gas that lies within giant molecular clouds (GMCs) at a particular timeframe, and to then study the properties of this gas at earlier and later times. We find that gas which forms GMCs is not typical of the interstellar medium at least 50 Myr before the clouds form and reaches mean densities within an order of magnitude of mean cloud densities by around 10 Myr before. The gas in GMCs takes at least 50 Myr to return to typical ISM gas after dispersal by stellar feedback, and in some cases the gas is never fully recycled. We also present a study of the two-dimensional, vertically-averaged velocity fields within the ISM. We show that the velocity fields corresponding to the shortest timescales (that is, those timescales closest to the immediate formation and dissipation of the clouds) can be readily understood in terms of the various cloud formation and dissipation mechanisms. Properties of the flow patterns can be used to distinguish the processes which drive converging flows (e.g. spiral shocks, supernovae) and thus molecular cloud formation, and we note that such properties may be detectable with future observations of nearby galaxies.

Accepted by MNRAS

<http://adsabs.harvard.edu/abs/2012arXiv1206.4904D>

Revealing The Millimeter Environment of the New FU Orionis Candidate HBC722 with the Submillimeter Array

Michael M. Dunham¹, Héctor G. Arce¹, Tyler L. Bourke², Xuepeng Chen¹, Tim A. van Kempen^{3,4} and Joel D. Green⁵

¹ Department of Astronomy, Yale University, P.O. Box 208101, New Haven, CT 06520, USA

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

³ Joint ALMA Offices, Av. Alonso de Cordova, Santiago, Chile

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

⁵ Department of Astronomy, The University of Texas at Austin, 1 University Station, C1400, Austin, Texas 78712–0259, USA

E-mail contact: michael.dunham@yale.edu

We present 230 GHz Submillimeter Array continuum and molecular line observations of the newly discovered FUor candidate HBC722. We report the detection of seven 1.3 mm continuum sources in the vicinity of HBC722, none of which correspond to HBC722 itself. We compile infrared and submillimeter continuum photometry of each source from

previous studies and conclude that three are Class 0 embedded protostars, one is a Class I embedded protostar, one is a Class I/II transition object, and two are either starless cores or very young, very low luminosity protostars or first hydrostatic cores. We detect a northwest-southeast outflow, consistent with the previous detection of such an outflow in low-resolution, single-dish observations, and note that its axis may be precessing. We show that this outflow is centered on and driven by one of the nearby Class 0 sources rather than HBC722, and find no conclusive evidence that HBC722 itself is driving an outflow. The non-detection of HBC722 in the 1.3 mm continuum observations suggests an upper limit of $0.02 M_{\odot}$ for the mass of the circumstellar disk. This limit is consistent with typical T Tauri disks and with a disk that provides sufficient mass to power the burst.

Accepted by ApJ

Warm H₂O and OH in the disk around the Herbig star HD 163296

D. Fedele¹, S. Bruderer¹, E.F. van Dishoeck^{1,2}, G.J.Herczeg³, N.J. Evans⁴, J. Bouwman⁵, Th. Henning⁵ and J. Green⁴

¹ Max Planck Institut für Extraterrestrische Physik, Giessenbachstrasse 1, 85748 Garching, Germany

² Leiden Observatory, PO Box 9513, 2300 RA Leiden, The Netherlands

³ Kavli Institute for Astronomy and Astrophysics, Yi He Yuan Lu 5, Beijing, 100871, P.R. China

⁴ University of Texas at Austin, Department of Astronomy, 2515 Speedway, Stop C1400, Austin TX 78712-1205, USA

⁵ Max Planck Institute for Astronomy, Königstuhl 17, 69117, Heidelberg, Germany

E-mail contact: fedele *at* mpe.mpg.de

We present observations of far-infrared (50-200 μm) OH and H₂O emission of the disk around the Herbig Ae star HD 163296 obtained with Herschel/PACS in the context of the DIGIT key program. In addition to strong [OI] emission, a number of OH doublets and a few weak highly excited lines of H₂O are detected. The presence of warm H₂O in this Herbig disk is confirmed by a line stacking analysis, enabled by the full PACS spectral scan, and by lines seen in *Spitzer* data. The line fluxes are analyzed using an LTE slab model including line opacity. The H₂O column density is $10^{14} - 2 \times 10^{15} \text{ cm}^{-2}$, and the excitation temperature is 200-300 K implying warm gas with a density $n > 10^5 \text{ cm}^{-3}$. For OH we find N_{mol} of $10^{14} - 10^{15} \text{ cm}^{-2}$ and $T_{\text{ex}} \sim 300\text{-}500 \text{ K}$. For both species we find an emitting region of $r \sim 15 - 20 \text{ AU}$ from the star. We argue that the molecular emission arises from the protoplanetary disk rather than from an outflow. This far-infrared detection of both H₂O and OH contrasts with near- and mid-infrared observations, which have generally found a lack of water in the inner disk around Herbig AeBe stars due to strong photodissociation of H₂O. Given the similarity in column density and emitting region, OH and H₂O emission seems to arise from an upper layer of the disk atmosphere of HD 163296, probing a new reservoir of water. The slightly lower temperature of H₂O compared to OH suggests a vertical stratification of the molecular gas with OH located higher and H₂O deeper in the disk, consistent with thermo-chemical models.

Accepted by A&A

<http://arxiv.org/abs/1207.3969>

Multiwavelength Observations of V2775 Ori, an Outbursting Protostar in L 1641: Exploring the Edge of the FU Orionis Regime

William J. Fischer¹, S. Thomas Megeath¹, John J. Tobin², Amelia M. Stutz^{3,4}, Babar Ali⁵, Ian Remming⁶, Marina Kounkel¹, Thomas Stanke⁷, Mayra Osorio⁸, Thomas Henning³, P. Manoj⁶ and T. L. Wilson⁹

¹ Department of Physics and Astronomy, University of Toledo, Toledo, OH, USA

² National Radio Astronomy Observatory, Charlottesville, VA, USA

³ Max-Planck-Institut für Astronomie, Heidelberg, Germany

⁴ Department of Astronomy and Steward Observatory, University of Arizona, Tucson, AZ, USA

⁵ NHSC/IPAC/Caltech, Pasadena, CA, USA

⁶ Department of Physics and Astronomy, University of Rochester, Rochester, NY, USA

⁷ European Southern Observatory, Garching bei München, Germany

⁸ Instituto de Astrofísica de Andalucía, CSIC, Granada, Spain

⁹ Naval Research Laboratory, Washington, DC, USA

E-mail contact: wfische *at* utnet.utoledo.edu

Individual outbursting young stars are important laboratories for studying the physics of episodic accretion and the extent to which this phenomenon can explain the luminosity distribution of protostars. We present new and archival data for V2775 Ori (HOPS 223), a protostar in the L 1641 region of the Orion molecular clouds that was discovered by Caratti o Garatti et al. (2011) to have recently undergone an order-of-magnitude increase in luminosity. Our near-infrared spectra of the source have strong blueshifted He I λ 10830 absorption, strong H₂O and CO absorption, and no H I emission, all typical of FU Orionis sources. With data from IRTF, 2MASS, HST, Spitzer, WISE, Herschel, and APEX that span from 1 to 70 μ m pre-outburst and from 1 to 870 μ m post-outburst, we estimate that the outburst began between 2005 April and 2007 March. We also model the pre- and post-outburst spectral energy distributions of the source, finding it to be in the late stages of accreting its envelope with a disk-to-star accretion rate that increased from $\sim 2 \times 10^{-6} M_{\odot} \text{ yr}^{-1}$ to $\sim 10^{-5} M_{\odot} \text{ yr}^{-1}$ during the outburst. The post-outburst luminosity at the epoch of the FU Orionis-like near-IR spectra is $28 L_{\odot}$, making V2775 Ori the least luminous documented FU Orionis outburster with a protostellar envelope. The existence of low-luminosity outbursts supports the notion that a range of episodic accretion phenomena can partially explain the observed spread in protostellar luminosities.

Accepted by ApJ

<http://arxiv.org/abs/1207.2466>

Young starless cores embedded in the magnetically dominated Pipe Nebula. II. Extended dataset

P. Frau¹, J. M. Girart¹, M. T. Beltrán², M. Padovani¹, G. Busquet³, O. Morata⁴,
J. M. Masqué⁵, F. O. Alves⁶, Á. Sánchez-Monge², G. A. P. Franco⁷, and R. Estalella⁵

¹ Institut de Ciències de l’Espai (CSIC-IEEC), Campus UAB, Facultat de Ciències, Torre C-5p, 08193 Bellaterra, Catalunya, Spain

² INAF-Osservatorio Astrofisico di Arcetri, Largo Enrico Fermi 5, 50125 Firenze, Italy

³ INAF-Istituto di Astrofisica e Planetologia Spaziali, via Fosso del Cavaliere 100, 00133 Roma, Italy

⁴ Institute of Astronomy and Astrophysics, Academia Sinica, P.O. Box 23-141, Taipei 10617, Taiwan

⁵ Departament d’Astronomia i Meteorologia and Institut de Ciències del Cosmos (IEEC-UB),

Universitat de Barcelona, Martí i Franquès 1, 08028 Barcelona, Catalunya, Spain

⁶ Argelander-Institut für Astronomie der Universität Bonn, Auf dem Hügel 71, 53121 Bonn, Germany

⁷ Departamento de Física - ICEx - UFMG, Caixa Postal 702, 30.123-970, Belo Horizonte, Brazil

E-mail contact: frau *at* ice.cat

The Pipe nebula is a massive, nearby, filamentary dark molecular cloud with a low star-formation efficiency threaded by a uniform magnetic field perpendicular to its main axis. It harbors more than a hundred, mostly quiescent, very chemically young starless cores. The cloud is, therefore, a good laboratory to study the earliest stages of the star-formation process. We aim to investigate the primordial conditions and the relation among physical, chemical, and magnetic properties in the evolution of low-mass starless cores. We used the IRAM 30-m telescope to map the 1.2 mm dust continuum emission of five new starless cores, which are in good agreement with previous visual extinction maps. For the sample of nine cores, which includes the four cores studied in a previous work, we derived a A_V to N_{H_2} factor of $(1.27 \pm 0.12) \times 10^{-21} \text{ mag cm}^2$ and a background visual extinction of ~ 6.7 mag possibly arising from the cloud material. We derived an average core diameter of ~ 0.08 pc, density of $\sim 10^5 \text{ cm}^{-3}$, and mass of $\sim 1.7 M_{\odot}$. Several trends seem to exist related to increasing core density: (*i*) diameter seems to shrink, (*ii*) mass seems to increase, and (*iii*) chemistry tends to be richer. No correlation is found between the direction of the surrounding diffuse medium magnetic field and the projected orientation of the cores, suggesting that large scale magnetic fields seem to play a secondary role in shaping the cores. We also used the IRAM 30-m telescope to extend the previous molecular survey at 1 and 3 mm of early- and late-time molecules toward the same five new Pipe nebula starless cores, and analyzed the normalized intensities of the detected molecular transitions. We confirmed the chemical differentiation toward the sample and increased the number of molecular transitions of the “diffuse” (e.g. the “ubiquitous” CO, C₂H, and CS), “oxo-sulfurated” (e.g. SO and CH₃OH), and “deuterated” (e.g. N₂H⁺, CN, and HCN) starless core groups. The chemically defined core groups seem to be related to different evolutionary stages: “diffuse” cores present the cloud chemistry and are the less dense, while “deuterated” cores are the densest and present a chemistry typical of evolved dense cores. “Oxo-sulfurated” cores might be in a transitional stage exhibiting intermediate properties and a very

characteristic chemistry.

Accepted by ApJ

Do all stars in the solar neighbourhood form in clusters? A cautionary note on the use of the distribution of surface densities

Mark Gieles¹, Nick Moeckel¹ and Cathie J. Clarke¹

¹ Institute of Astronomy, Cambridge, UK

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

Bressert et al. recently showed that the surface density distribution of low-mass, young stellar objects in the solar neighbourhood is approximately lognormal. The authors conclude that the star formation process is hierarchical and that only a small fraction of stars form in dense star clusters. Here we show that the peak and the width of the density distribution is also what follows if all stars form in bound clusters which are not significantly affected by the presence of gas and expand by two-body relaxation. The peak of the surface density distribution is simply obtained from the typical ages (few Myrs) and cluster membership number (few hundred) typifying nearby star forming regions. This result depends weakly on initial cluster sizes, provided that they are sufficiently dense (initial half mass radius of ~ 0.3 pc) for dynamical evolution to be important at an age of a few Myrs. We conclude that the degeneracy of the YSO surface density distribution complicates its use as a diagnostic of the stellar formation environment.

Accepted by MNRAS Letters

<http://arxiv.org/abs/1207.2059>

X-raying the Beating Heart of a Newborn Star: Rotational Modulation of High-energy Radiation from V1647 Ori

Kenji Hamaguchi^{1,2}, Nicolas Grosso³, Joel H. Kastner⁴, David A. Weintraub⁵, Michael Richmond⁴, Robert Petre⁶, William K. Teets⁵ and David Principe⁴

¹ CRESST and X-ray Astrophysics Laboratory NASA/GSFC, USA

² Department of Physics, University of Maryland, Baltimore County, USA

³ Observatoire Astronomique de Strasbourg, Université de Strasbourg, France

⁴ Laboratory for Multiwavelength Astrophysics, Rochester Institute of Technology, USA

⁵ Department of Physics & Astronomy, Vanderbilt University, USA

⁶ X-Ray Astrophysics Laboratory, NASA Goddard Space Flight Center, USA

E-mail contact: Kenji.Hamaguchi *at* nasa.gov

We report a periodicity of ~ 1 day in the highly elevated X-ray emission from the protostar V1647 Ori during its two recent multiple-year outbursts of mass accretion. This periodicity is indicative of protostellar rotation at near-breakup speed. Modeling of the phased X-ray light curve indicates the high-temperature (~ 50 MK), X-ray-emitting plasma, which is most likely heated by accretion-induced magnetic reconnection, resides in dense ($> \sim 5 \times 10^{10}$ cm⁻³), pancake-shaped magnetic footprints where the accretion stream feeds the newborn star. The sustained X-ray periodicity of V1647 Ori demonstrates that such protostellar magnetospheric accretion configurations can be stable over timescales of years.

Accepted by ApJ

<http://iopscience.iop.org/0004-637X/754/1/32/>, <http://arxiv.org/abs/1207.0570>

A 1 mm Spectral Line Survey toward GLIMPSE Extended Green Objects (EGOs)

J. H. He¹, S. Takahashi² and X. Chen³

¹ Key Laboratory for the Structure and Evolution of Celestial Objects, Yunnan Astronomical Observatory/National Astronomical Observatory, Chinese Academy of Sciences, P.O. Box 110, Kunming, 650011 Yunnan Province, China

² Academia Sinica, Institute of Astronomy and Astrophysics, P.O. Box 23-141, Taipei 10617, Taiwan

³ Key Laboratory for Research in Galaxies and Cosmology, Key Laboratory for Research in Galaxies and Cosmology,

Shanghai Astronomical Observatory, Chinese Academy of Sciences, 80 Nandan Road, Shanghai 200030, China

E-mail contact: [jinhuahe at ynao.ac.cn](mailto:jinhuahe@ynao.ac.cn)

A northern subsample of 89 *Spitzer GLIMPSE* extended green objects (EGOs), the candidate massive young stellar objects, are surveyed for molecular lines in two 1-GHz ranges: 251.5-252.5 and 260.188-261.188 GHz. A comprehensive catalog of observed molecular line data and spectral plots are presented. Eight molecular species are undoubtedly detected: H^{13}CO^+ , SiO, SO, CH_3OH , CH_3OCH_3 , $\text{CH}_3\text{CH}_2\text{CN}$, HCOOCH_3 , and HN^{13}C . H^{13}CO^+ 3-2 line is detected in 70 EGOs among which 37 ones also show SiO 6-5 line, demonstrating their association to dense gas and supporting the outflow interpretation of the extended $4.5\ \mu\text{m}$ excess emission. Our major dense gas and outflow tracers (H^{13}CO^+ , SiO, SO and CH_3OH) are combined with our previous survey of ^{13}CO , ^{12}CO and C^{18}O 1-0 toward the same sample of EGOs for a multi-line multi-cloud analysis of line width and luminosity correlations. Good log-linear correlations are found among all considered line luminosities, which requires a universal similarity of density and thermal structures and probably of shock properties among all EGO clouds to explain. It also requires that the shocks should be produced within the natal clouds of the EGOs. Diverse degrees of correlation are found among the line widths. However, both the line width and luminosity correlations tend to progressively worsen across larger cloud subcomponent size-scales, depicting the increase of randomness across cloud subcomponent sizes. Moreover, the line width correlations among the three isotopic CO 1-0 lines show data scatter as linear functions of the line width itself, indicating that the velocity randomness also increases with whole-cloud sizes in a regular way.

Accepted by ApJS

<http://arxiv.org/abs/1207.0306>

YSO jets in the Galactic Plane from UWISH2: II - Outflow Luminosity and Length distributions in Serpens and Aquila

G. Ioannidis¹ and D. Froebrich¹

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

E-mail contact: [df at star.kent.ac.uk](mailto:df@star.kent.ac.uk)

Jets and outflows accompany the mass accretion process in protostars and young stellar objects. Using a large and unbiased sample, they can be used to study statistically the local feedback they provide and the typical mass accretion history. Here we analyse such a sample of Molecular Hydrogen emission line Objects in the Serpens and Aquila part of the Galactic Plane. Distances are measured by foreground star counts with an accuracy of 25%. The resulting spatial distribution and outflow luminosities indicate that our objects sample the formation of intermediate mass objects. The outflows are unable to provide a sizeable fraction of energy and momentum to support, even locally, the turbulence levels in their surrounding molecular clouds. The fraction of parsec scale flows is one quarter and the typical dynamical jet age of the order of 10^4 yrs. Groups of emission knots are ejected every 10^3 yrs. This might indicate that low level accretion rate fluctuations and not FU-Ori type events are responsible for the episodic ejection of material. Better observational estimates of the FU-Ori duty cycle are needed.

Accepted by MNRAS

<http://astro.kent.ac.uk/~df/>

Structure of dynamical condensation fronts in the interstellar medium

Kazunari Iwasaki¹ and Shu-ichiro Inutsuka¹

¹ Department of Physics, Nagoya University, Furo-cho, Chikusa-ku, Nagoya, Aichi 464-8602, Japan

E-mail contact: [iwasaki at nagoya-u.jp](mailto:iwasaki@nagoya-u.jp)

In this paper, we investigate the structure of condensation fronts from warm diffuse gas to cold neutral medium (CNM) under the plane-parallel geometry. The solutions have two parameters, the pressure of the CNM and the mass flux across the transition front, and their ranges are much wider than previously thought. First, we consider the pressure range where the three phases, the CNM, the unstable phase and the warm neutral medium, can coexist in pressure equilibrium. In a wide range of the mass flux, we find solutions connecting the CNM and the unstable phase. Moreover, we find solutions in larger pressure range where there is only one thermal equilibrium state or the CNM.

These solutions can be realized in shock-compressed regions that are promising sites of molecular cloud formation. We also find remarkable properties in our solutions. Heat conduction becomes less important with increasing mass flux, and the thickness of the transition layer is characterized by the cooling length instead of the Field length.

Accepted by Monthly Notices of the Royal Astronomical Society

<http://jp.arxiv.org/abs/1204.5532>

Is the Taurus B213 Region a True Filament?: Observations of Multiple Cyanoacetylene Transitions

Di Li^{1,2,3} and Paul F. Goldsmith³

¹ National Astronomical Observatories, Chinese Academy of Sciences, Chaoyang District, Datun Rd, A20, Beijing 100012, China

² Space Science Institute, Boulder, CO, USA

³ Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA

E-mail contact: ithaca.li@gmail.com

We have obtained spectra of the J=2-1 and J=10-9 transitions of cyanoacetylene (HC₃N) toward a collection of positions in the most prominent filament, B213, in the Taurus molecular cloud. The analysis of the excitation conditions of these transitions reveals an average gas H₂ volume density of $(1.8 \pm 0.7) \times 10^4$ cc. Based on column density derived from 2MASS and this volume density, the line of sight dimension of the high density portion of B213 is found to be $\simeq 0.12$ pc, which is comparable to the smaller projected dimension and much smaller than the elongated dimension of B213 (~ 2.4 pc). B213 is thus likely a true cylinder-like filament rather than a sheet seen edge-on. The line width and velocity gradient seen in HC₃N are also consistent with Taurus B213 being a self-gravitating filament in the early stage of either fragmentation and/or collapse.

Accepted by ApJ

<http://arxiv.org/abs/1207.0044>

Profiling filaments: comparing near-infrared extinction and submillimetre data in TMC-1

J. Malinen¹, M. Juvela¹, M. G. Rawlings^{2,3}, D. Ward-Thompson⁴, P. Palmeirim⁵ and Ph. André⁵

¹ Department of Physics, University of Helsinki, P.O. Box 64, FI-00014 Helsinki, Finland

² Joint ALMA Observatory / European Southern Observatory, Alonso de Córdova 3107, Vitacura 763-0355, Santiago, Chile

³ Joint Astronomy Centre, 660 N. A'ohoku Place, Hilo, HI 96720, U. S. A.

⁴ School of Physics and Astronomy, Cardiff University, Queen's Buildings, Cardiff CF24 3AA

⁵ Laboratoire AIM, CEA/DSM-CNRS-Université Paris Diderot, IRFU/Service d'Astrophysique, C.E.A. Saclay, Orme des Merisiers, 91191 Gif-sur-Yvette, France

E-mail contact: johanna.malinen@helsinki.fi

Interstellar filaments are an important part of the star formation process. In order to understand the structure and formation of filaments, the filament cross-section profiles are often fitted with the so-called Plummer profile function. Currently this profiling is often approached with submillimetre studies, especially with Herschel. If these data are not available, it would be more convenient if filament properties could be studied using groundbased near-infrared (NIR) observations.

We compare the filament profiles obtained by NIR extinction and submillimetre observations to find out if reliable profiles can be derived using NIR observations. We use J-, H-, and K-band data of a filament north of TMC-1 to derive an extinction map from colour excesses of background stars. We also use 2MASS data of this and another filament in TMC-1. We compare the Plummer profiles obtained from these extinction maps with Herschel dust emission maps. We present two new methods to estimate profiles from NIR data: Plummer profile fits to median A_V of stars within certain offset or directly to the A_V of individual stars. We compare these methods by simulations.

In simulations the extinction maps and the new methods give correct results to within ~ 10 -20% for modest densities

($\rho_c = 10^4\text{--}10^5 \text{ cm}^{-3}$). The direct fit to data on individual stars usually gives more accurate results than the extinction map, and can work in higher density. In the profile fits to real observations, the values of Plummer parameters are generally similar to within a factor of ~ 2 (up to a factor of ~ 5). Although the parameter values can vary significantly, the estimates of filament mass usually remain accurate to within some tens of per cent. Our results for TMC-1 are in good agreement with earlier results obtained with SCUBA and ISO. High resolution NIR data give more details, but 2MASS data can be used to estimate approximate profiles.

NIR extinction maps can be used as an alternative to submm observations to profile filaments. Direct fits of stars can also be a valuable tool in profiling. However, the Plummer profile parameters are not always well constrained, and caution should be taken when making the fits and interpreting the results. In the evaluation of the Plummer parameters, one can also make use of the independence of the dust emission and NIR data and the difference in the shapes of the associated confidence regions.

Accepted by Astronomy & Astrophysics

www.aanda.org/articles/aa/pdf/forth/aa19573-12.pdf, <http://arxiv.org/abs/1206.4837>

HST measures of Mass Accretion Rates in the Orion Nebula Cluster

Carlo F. Manara^{1,2,4}, Massimo Robberto¹, Nicola Da Rio³, Giuseppe Lodato⁴, Lynne A. Hillenbrand⁵, Keivan G. Stassun^{6,7,8} and David R. Soderblom¹

¹ Space Telescope Science Institute, 3700 San Martin Dr., Baltimore MD, 21218, USA

² European Southern Observatory, Karl Schwarzschild-Str. 2, 85748 Garching, Germany

³ European Space Agency, Keplerlaan 1, 2200 AG Noordwijk, The Netherlands

⁴ Dipartimento di Fisica, Università Degli Studi di Milano, Via Celoria, 16, Milano, 20133, Italy

⁵ California Institute of Technology, 1200 East California Boulevard, 91125 Pasadena, CA, USA

⁶ Vanderbilt Univ., Dept. of Physics & Astronomy 6301 Stevenson Center Ln., Nashville, TN 37235, USA

⁷ Fisk University, Department of Physics, 1000 17th Ave. N., Nashville, TN 37208, USA

⁸ Massachusetts Institute of Technology, Department of Physics, 77 Massachusetts Ave., Cambridge, MA 02139, USA

E-mail contact: cmanara@eso.org

The present observational understanding of the evolution of the mass accretion rates (\dot{M}_{acc}) in pre-main sequence stars is limited by the lack of accurate measurements of \dot{M}_{acc} over homogeneous and large statistical samples of young stars. Such observational effort is needed to properly constrain the theory of star formation and disk evolution. Based on HST/WFPC2 observations, we present a study of \dot{M}_{acc} for a sample of ~ 700 sources in the Orion Nebula Cluster, ranging from the Hydrogen-burning limit to $M_* \sim 2M_{\odot}$. We derive \dot{M}_{acc} from both the U -band excess and the $H\alpha$ luminosity ($L_{H\alpha}$), after determining empirically both the shape of the typical accretion spectrum across the Balmer jump and the relation between the accretion luminosity (L_{acc}) and $L_{H\alpha}$, that is $L_{\text{acc}}/L_{\odot} = (1.31 \pm 0.03) \cdot L_{H\alpha}/L_{\odot} + (2.63 \pm 0.13)$. Given our large statistical sample, we are able to accurately investigate relations between \dot{M}_{acc} and the parameters of the central star such as mass and age. We clearly find \dot{M}_{acc} to increase with stellar mass, and decrease over evolutionary time, but we also find strong evidence that the decay of \dot{M}_{acc} with stellar age occurs over longer timescales for more massive PMS stars. Our best fit relation between these parameters is given by: $\log(\dot{M}_{\text{acc}}/M_{\odot}\cdot\text{yr}) = (-5.12 \pm 0.86) - (0.46 \pm 0.13) \cdot \log(t/\text{yr}) - (5.75 \pm 1.47) \cdot \log(M_*/M_{\odot}) + (1.17 \pm 0.23) \cdot \log(t/\text{yr}) \cdot \log(M_*/M_{\odot})$. These results also suggest that the similarity solution model could be revised for sources with $M_* > 0.5M_{\odot}$. Finally, we do not find a clear trend indicating environmental effects on the accretion properties of the sources.

Accepted by ApJ

<http://arxiv.org/abs/1206.4319>

Molecular Outflows Identified in the FCRAO CO Survey of the Taurus Molecular Cloud

Gopal Narayanan¹, Ronald Snell¹ and Ashley Bemis^{1,2}

¹ Dept. of Astronomy, Univ. of Massachusetts, Amherst MA 01003, USA

² Department of Physics and Astronomy, Bonn University, Wegelerstrasse 8, 53115 Bonn, Germany

E-mail contact: gopal@astro.umass.edu

Jets and outflows are an integral part of the star formation process. While there are many detailed studies of molecular outflows towards individual star-forming sites, few studies have surveyed an entire star-forming molecular cloud for this phenomenon. The 100 square degree FCRAO CO survey of the Taurus molecular cloud provides an excellent opportunity to undertake an unbiased survey of a large, nearby, molecular cloud complex for molecular outflow activity. Our study provides information on the extent, energetics and frequency of outflows in this region, which are then used to assess the impact of outflows on the parent molecular cloud. The search identified 20 outflows in the Taurus region, 8 of which were previously unknown. Both CO and ^{13}CO data cubes from the Taurus molecular map were used, and dynamical properties of the outflows are derived. Even for previously known outflows, our large-scale maps indicate that many of the outflows are much larger than previously suspected, with eight of the flows (40%) being more than a parsec long. The mass, momentum and kinetic energy from the 20 outflows are compared to the repository of turbulent energy in Taurus. Comparing the energy deposition rate from outflows to the dissipation rate of turbulence, we conclude that outflows by themselves cannot sustain the observed turbulence seen in the entire cloud. However, when the impact of outflows is studied in selected regions of Taurus, it is seen that locally, outflows can provide a significant source of turbulence and feedback. The L1551 dark cloud which is just south of the main Taurus complex was not covered by this survey, but the outflows in L1551 have much higher energies compared to the outflows in the main Taurus cloud. In the L1551 cloud, outflows can not only account for the turbulent energy present, but are probably also disrupting their parent cloud. We conclude that for a molecular cloud like Taurus, a L1551-like episode occurring once every 10^5 years is sufficient to sustain the turbulence observed. Five of the eight newly discovered outflows have no known associated stellar source, indicating that they may be embedded Class 0 sources. In Taurus, 30% of Class I sources and 12% of Flat spectrum sources from the Spitzer YSO catalogue have outflows, while 75% of known Class 0 objects have outflows. Overall, the paucity of outflows in Taurus compared to the embedded population of Class I and Flat Spectrum YSOs indicate that molecular outflows are a short-lived stage marking the youngest phase of protostellar life. The current generation of outflows in Taurus highlights an ongoing period of active star-formation, while a large fraction of YSOs in Taurus has evolved well past the Class I stage.

Accepted by MNRAS

<http://arxiv.org/abs/1206.5708>

The Evolution of Protoplanetary Discs in the Arches Cluster

C. Olczak^{1,2,3,4}, T. Kaczmarek⁵, S. Harfst⁶, S. Pfalzner⁵ and S. Portegies Zwart⁷

¹ Astronomisches Rechen-Institut (ARI), Zentrum für Astronomie Universität Heidelberg, Mönchhofstrasse 12-14, 69120 Heidelberg, Germany

² Max-Planck-Institut für Astronomie (MPIA), Königstuhl 17, 69117 Heidelberg, Germany

³ National Astronomical Observatories of China, Chinese Academy of Sciences (NAOC/CAS), 20A Datun Lu, Chaoyang District, Beijing 100012, China

⁴ The Kavli Institute for Astronomy and Astrophysics at Peking University (KIAA), Yi He Yuan Lu 5, Hai Dian Qu, Beijing 100871, China

⁵ Max-Planck-Institut für Radioastronomie, Auf dem Hügel 7, 53121 Bonn, Germany

⁶ Technische Universität Berlin, Zentrum für Astronomie und Astrophysik, Hardenbergstraße 36, 10623 Berlin, Germany

⁷ Sterrewacht Leiden, Leiden University, Postbus 9513, 2300 RA Leiden, The Netherlands

E-mail contact: olczak@ari.uni-heidelberg.de

Most stars form in a cluster environment. These stars are initially surrounded by discs from which potentially planetary systems form. Of all cluster environments starburst clusters are probably the most hostile for planetary systems in our Galaxy. The intense stellar radiation and extreme density favour rapid destruction of circumstellar discs via photoevaporation and stellar encounters. Evolving a virialized model of the Arches cluster in the Galactic tidal field we investigate the effect of stellar encounters on circumstellar discs in a prototypical starburst cluster. Despite its proximity to the deep gravitational potential of the Galactic centre only a moderate fraction of members escapes to form an extended pair of tidal tails. Our simulations show that encounters destroy one third of the circumstellar discs in the cluster core within the first 2.5 Myr of evolution, preferentially affecting the least and most massive stars. A small fraction of these events causes rapid ejection and the formation of a weaker second pair of tidal tails that is overpopulated by disc-poor stars. Two predictions arise from our study: (i) If not destroyed by photoevaporation

protoplanetary discs of massive late B- and early O-type stars represent the most likely hosts of planet formation in starburst clusters. (ii) Multi-epoch *K*- and *L*-band photometry of the Arches cluster would provide the kinematically selected membership sample required to detect the additional pair of disc-poor tidal tails.

Accepted by Astrophysical Journal

<http://arxiv.org/abs/1207.2256>

How not to build Tatooine: the difficulty of in situ formation of circumbinary planets Kepler 16b, Kepler 34b and Kepler 35b

S.-J. Paardekooper¹, Z.M. Leinhardt², P. Thebault³ and C. Baruteau¹

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

² School of Physics, University of Bristol, H.H. Wills Physics Laboratory, Tyndall Avenue, Bristol BS8 1TL, UK

³ Observatoire de Paris, F-92195 Meudon Principal Cedex, France

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

We study planetesimal evolution in circumbinary disks, focusing on the three systems Kepler 16, 34 and 35 where planets have been discovered recently. We show that for circumbinary planetesimals, in addition to secular forcing, eccentricities evolve on a dynamical timescale, which leads to orbital crossings even in the presence of gas drag. This makes the current locations of the circumbinary Kepler planets hostile to planetesimal accretion. We then present results from simulations including planetesimal formation and dust accretion, and show that even in the most favourable case of 100% efficient dust accretion, in situ growth starting from planetesimals smaller than ~ 10 km is difficult for Kepler 16b, Kepler 34b and Kepler 35b. These planets were likely assembled further out in the disk, and migrated inward to their current location.

Accepted by ApJL

<http://arxiv.org/abs/1206.3484>

Understanding hydrogen recombination line observations with ALMA and EVLA

Thomas Peters^{1,2}, Steven N. Longmore³ and Cornelis P. Dullemond¹

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

² Institut für Theoretische Physik, Universität Zürich, Winterthurerstrasse 190, CH-8057 Zürich, Switzerland

³ European Southern Observatory, Karl-Schwarzschild-Str. 2, D-85748 Garching bei München, Germany

E-mail contact: tpeters *at* physik.uzh.ch

Hydrogen recombination lines are one of the major diagnostics of H II region physical properties and kinematics. In the near future, the Expanded Very Large Array (EVLA) and the Atacama Large Millimeter Array (ALMA) will allow observers to study recombination lines in the radio and sub-mm regime in unprecedented detail. In this paper, we study the properties of recombination lines, in particular at ALMA wavelengths. We find that such lines will lie in almost every wideband ALMA setup and that the line emission will be equally detectable in all bands. Furthermore, we present our implementation of hydrogen recombination lines in the adaptive-mesh radiative transfer code RADMC-3D. We particularly emphasize the importance of non-LTE (local thermodynamical equilibrium) modeling since non-LTE effects can drastically affect the line shapes and produce asymmetric line profiles from radially symmetric H II regions. We demonstrate how these non-LTE effects can be used as a probe of systematic motions (infall & outflow) in the gas. We use RADMC-3D to produce synthetic observations of model H II regions and study the necessary conditions for observing such asymmetric line profiles with ALMA and EVLA.

Accepted by MNRAS

<http://arxiv.org/abs/1206.7041v1>

The First ALMA view of IRAS 16293-2422: Direct detection of infall onto source B and high-resolution kinematics of source A

Jaime E. Pineda^{1,2}, Anaëlle J. Maury¹, Gary A. Fuller², Leonardo Testi^{1,3}, Diego García-Appadoo^{4,5}, Alison B. Peck^{5,6}, Eric Villard⁵, Stuartt A. Corder⁶, Tim A. van Kempen^{5,7}, Jean L. Turner⁸, Kengo Tachihara^{5,9} and William Dent⁵

¹ European Southern Observatory (ESO), Garching, Germany

² UK ARC Node, Jodrell Bank Centre for Astrophysics, School of Physics and Astronomy, University of Manchester, Manchester, M13 9PL, UK

³ INAF-Osservatorio Astrofisico di Arcetri, Largo E. Fermi 5, I-50125 Firenze, Italy

⁴ European Southern Observatory, Alonso de Córdova 3107, Vitacura, Casilla 19001, Santiago 19, Chile

⁵ Joint ALMA Observatory, Alonso de Córdova 3107, Vitacura, Santiago, Chile

⁶ North American ALMA Science Center, National Radio Astronomy Observatory, 520 Edgemont Road, Charlottesville, VA 22903, USA

⁷ Leiden Observatory, Leiden University, PO Box 9513, 2300 RA Leiden, The Netherlands

⁸ Department of Physics and Astronomy, UCLA, Los Angeles, CA 90095, USA

⁹ National Astronomical Observatory of Japan, Chile Observatory, 2-21-1 Osawa Mitaka Tokyo 181-8588 Japan

E-mail contact: jaime.pineda at manchester.ac.uk

Aims: In this paper, we focus on the kinematical properties of a proto-binary to study the infall and rotation of gas towards its two protostellar components.

Methods: We present ALMA Science Verification observations with high-spectral resolution of IRAS 16293-2422 at 220.2 GHz. The wealth of molecular lines in this source and the very high spectral resolution offered by ALMA allow us to study the gas kinematics with unprecedented detail.

Results: We present the first detection of an inverse P-Cygni profile towards source B in the three brightest lines. The line profiles are fitted with a simple two-layer model to derive an infall rate of $4.5 \times 10^{-5} M_{\odot}/\text{yr}$. This infall detection would rule-out the previously suggested possibility of source B being a T Tauri star. A position velocity diagram for source A shows evidence for rotation with an axis close to the line-of-sight.

Accepted by A&A Letters

<http://arxiv.org/abs/1206.5215>

Herschel/PACS observations of young sources in Taurus: the far-infrared counterpart of optical jets

L. Podio^{1,2}, I. Kamp², D. Flower³, C. Howard⁴, G. Sandell⁴, A. Mora⁵, G. Aresu², S. Brittain⁶, W. R. F. Dent⁷, C. Pinte¹ and G. J. White^{8,9}

¹ Institut de Planétologie et d'Astrophysique de Grenoble, 414, Rue de la Piscine, 38400 St-Martin d'Hères, France

² Kapteyn Institute, Landleven 12, 9747 AD Groningen, The Netherland

³ Physics Department, The University of Durham, Durham DH1 3LE, United Kingdom

⁴ SOFIA-USRA, NASA Ames Research Center, USA

⁵ ESA-ESAC Gaia SOC, PO Box 78, 28691 Villanueva de la Cañada, Madrid, Spain

⁶ Department of Physics & Astronomy, 118 Kinard Laboratory, Clemson University, Clemson, SC 29634, USA

⁷ ALMA, Avda Apoquindo 3846, Piso 19, Edificio Alsacia, Las Condes, Santiago, Chil

⁸ Department of Physical Sciences, The Open University, Milton Keynes MK7 6AA, United Kingdom

⁹ RALSpace, The Rutherford Appleton Laboratory, Chilton, Didcot, OX11 0QX, UK

E-mail contact: linda.podio at obs.ujf-grenoble.fr

Context: Observations of the atomic and molecular line emission associated with jets and outflows emitted by young stellar objects provide sensitive diagnostics of the excitation conditions, and can be used to trace the various evolutionary stages they pass through as they evolve to become main sequence stars.

Aims: To understand the relevance of atomic and molecular cooling in shocks, and how accretion and ejection efficiency evolves with the evolutionary state of the sources, we will study the far-infrared counterparts of bright optical jets associated with Class I and II sources in Taurus (T Tau, DG Tau A, DG Tau B, FS Tau A+B, and RW Aur).

Methods: We have analysed *Herschel*/PACS observations of a number of atomic ([OI]63 μm , 145 μm , [CII]158 μm) and molecular (high-J CO, H₂O, OH) lines, collected within the Open Time Key project GASPS (PI: W. R. F. Dent).

To constrain the origin of the detected lines we have compared the obtained FIR emission maps with the emission from optical-jets and millimetre-outflows, and the measured line fluxes and ratios with predictions from shock and disk models.

Results: All of the targets are associated with extended emission in the atomic lines; in particular, the strong [OI] 63 μm emission is correlated with the direction of the optical jet/mm-outflow. The line ratios suggest that the atomic lines can be excited in fast dissociative J-shocks occurring along the jet. The molecular emission, on the contrary, originates from a compact region, that is spatially and spectrally unresolved, and lines from highly excited levels are detected (e.g., the o-H₂O 8₁₈ - 7₀₇ line, and the CO J=36-35 line). Disk models are unable to explain the brightness of the observed lines (CO and H₂O line fluxes up to 10^{-15} - $6 \cdot 10^{-16}$ W m⁻²). Slow C- or J- shocks with high pre-shock densities reproduce the observed H₂O and high-J CO lines; however, the disk and/or UV-heated outflow cavities may contribute to the observed emission.

Conclusions: Similarly to Class 0 sources, the FIR emission associated with Class I and II jet-sources is likely to be shock-excited. While the cooling is dominated by CO and H₂O lines in Class 0 sources, [OI], becomes an important coolant as the source evolves and the environment is cleared. The cooling and mass loss rates estimated for Class II and I sources are one to four orders of magnitude lower than for Class 0 sources. This provides strong evidence to indicate that the outflow activity decreases as the source evolves.

Accepted by A&A

<http://arxiv.org/abs/1207.3435>

An HST Imaging Survey of Low-Mass Stars in the Chamaeleon I Star Forming region

M. Robberto¹, L. Spina^{1,7}, N. Da Rio², D. Apai³, I. Pascucci⁴, L. Ricci⁵, C. Goddi⁶, L. Testi⁶, F. Palla⁷, and F. Bacciotti⁷

¹ Space Telescope Science Institute, Baltimore, MD 21218, USA

² European Space Agency - ESTEC, Keplerlaan 1, 2201 AZ Noordwijk, The Netherlands

³ Department of Astronomy, 933 N. Cherry Avenue, Tucson, AZ 85721, USA

⁴ Lunar and Planetary Laboratory, 1629 E. University Blvd., Tucson AZ 85721, USA

⁵ California Institute of Technology, MC 249-17, 1200 East California Blvd, Pasadena CA 91125, USA

⁶ European Southern Observatory, Karl Schwarzschild Strasse 2, D-85748 Garching, Germany

⁷ Osservatorio Astrofisico di Arcetri, Largo E. Fermi 5, I-50125 Firenze, Italy

E-mail contact: robberto@stsci.edu

We present new HST/WFPC2 observations of 20 fields centered around T Tauri stars in the Chamaeleon I star forming region. Images have been obtained in the F631N ([OI] λ 6300), F656N (H α) and F673N ([SII] λ λ 6716, 6731) narrow-band filters, plus the Johnson V-band equivalent F547M filter. We detect 31 T Tauri stars falling within our fields. We discuss the optical morphology of 10 sources showing evidence of either binarity, circumstellar material, or mass loss. We supplement our photometry with a compilation of optical, infrared and sub-millimeter data from the literature, together with new sub-mm data for three objects, to build the Spectral Energy Distributions (SED) of 19 single sources. Using an SED model fitting tool, we self-consistently estimate a number of stellar and disk parameters, while mass accretion rates are directly derived from our H α photometry. We find that bolometric luminosities derived from dereddened optical data tend to be underestimated in systems with high α IR spectral index, suggesting that disks seen nearly edge-on may occasionally be interpreted as low luminosity (and therefore more evolved) sources. On the other hand, the same α IR spectral index, a tracer of the amount of dust in the warmer layers of the circumstellar disks, and the mass accretion rate appear to decay with the isochronal stellar age, suggesting that the observed age spread ($\simeq 0.5$ Myr) within the cluster is real. Our sample contains a few outliers that may have dissipated their circumstellar disks on shorter time-scale.

Accepted by Astron. J.

Radio and Optical Observations of DG Tau B

Luis F. Rodriguez^{1,2}, Sergio A. Dzib¹, Laurent Loinard^{1,3}, Luis A. Zapata¹, Alejandro C. Raga⁴, Jorge Cantó⁵ and Angels Riera⁶

¹ Centro de Radioastronomía y Astrofísica, UNAM, Campus Morelia, Mexico

² Astronomy Department, Faculty of Science, King Abdulaziz University, P.O. Box 80203, Jeddah 21589, Saudi Arabia

³ Max-Planck-Institut für Radioastronomie, Bonn, Germany

⁴ Instituto de Ciencias Nucleares, UNAM, Mexico

⁵ Instituto de Astronomía, UNAM, Mexico

⁶ Departament de Física i Enginyeria Nuclear, EUETIB, Universitat Politècnica de Catalunya, Spain

E-mail contact: l.rodriguez *at* crya.unam.mx

DG Tau B is a Class I young stellar source that drives the asymmetric HH 159 bipolar jet. At optical wavelengths it is obscured by circumstellar optically-thick material. Using VLA and JVLA observations, we determine for the first time the proper motions of this source and find them to be consistent, within error, with those of the nearby young star DG Tau. We also discuss an ejection event that is evident in the 1994 VLA data. As the optical and molecular outflows, this ejection traced in the radio continuum is markedly asymmetric and was detected only to the NW of the star. We propose that this knot, no longer detectable in the radio, could be observed in future optical images of DG Tau B. The positions of the VLA source and of a nearby infrared object are not coincident and we suggest that the VLA source traces the exciting object, while the infrared source could be a reflection lobe.

Accepted by Revista Mexicana de Astronomía y Astrofísica

<http://arxiv.org/abs/1206.5342>

Compact radio sources in M17

Luis F. Rodríguez^{1,2}, Ricardo F. González¹, Gabriela Montes³, Hassan M. Asiri², Alejandro C. Raga⁴ and Jorge Cantó⁵

¹ Centro de Radioastronomía y Astrofísica, Universidad Nacional Autónoma de México, Apdo. Postal 3-72, Morelia, Michoacán 58089, Mexico

² Astronomy Department, Faculty of Science, King Abdulaziz University, P.O. Box 80203, Jeddah 21589, Saudi Arabia

³ Instituto de Astrofísica de Andalucía (IAA), CSIC, Camino Bajo de Huétor 50, 18006 Granada, Spain

⁴ Instituto de Ciencias Nucleares, Universidad Nacional Autónoma de México, Apdo. Postal 70-543, CP. 04510, D. F., México

⁵ Instituto de Astronomía, Universidad Nacional Autónoma de México, Apdo. Postal 70-264, CP. 04510, D. F., México

E-mail contact: l.rodriguez *at* crya.unam.mx

The classic HII region M17 is one of the best studied across the electromagnetic spectrum. We present sensitive, high angular resolution observations made with the Jansky Very Large Array (JVLA) at 4.96 and 8.46 GHz that reveal the presence of 38 compact radio sources, in addition to the well known hypercompact cometary HII region M17 UC1. For this last source we find that its spectral index of value ~ 1 is due to a gradient in opacity across its face. Of the 38 compact radio sources detected, 19 have stellar counterparts detected in the infrared, optical, or X-rays. Finally, we discuss the nature of the radio emission from the massive binary system CEN 1a and 1b, concluding that both are most probably non-thermal emitters, although the first is strongly time variable and the second is steady.

Accepted by The Astrophysical Journal

<http://arxiv.org/abs/1206.5339>

Star Formation and Young Population of the H II Complex Sh2-294

M.R. Samal^{1,4}, A.K. Pandey¹, D.K. Ojha², N. Chauhan¹, J. Jose¹ and B. Pandey³

¹ Aryabhata Research Institute of Observational Sciences, Nainital 263 129, India

² Tata Institute of Fundamental Research, Mumbai 400 005, India

³ Physics Department, D.S.B. Campus, Kumaun University, Nainital 263 129, India

⁴ Laboratoire d'Astrophysique de Marseille (UMR7326 CNRS & Université d'Aix-Marseille), 38 rue F. Joliot-Curie, 13388 Marseille CEDEX 13, France

E-mail contact: manash.samal *at* oamp.fr

The Sh2-294 H II region ionized by a single B0V star features several infrared excess sources, a photodissociation region, and also a group of reddened stars at its border. The star formation scenario in the region seems to be quite complex. In this paper, we present follow-up results of Sh2-294 H II region at 3.6, 4.5, 5.8, and 8.0 μm observed with the *Spitzer*

Space Telescope Infrared Array Camera (IRAC), coupled with H_2 ($2.12 \mu\text{m}$) observation, to characterize the young population of the region and to understand its star formation history. We identified 36 young stellar object (YSO, Class I, Class II and Class I/II) candidates using IRAC color-color diagrams. It is found that Class I sources are preferentially located at the outskirts of the H II region and associated with enhanced H_2 emission; none of them are located near the central cluster. Combining the optical to mid-infrared (MIR) photometry of the YSO candidates and using the spectral energy distribution fitting models, we constrained stellar parameters and the evolutionary status of 33 YSO candidates. Most of them are interpreted by the model as low-mass ($<4 M_\odot$) YSOs; however, we also detected a massive YSO ($\sim 9 M_\odot$) of Class I nature, embedded in a cloud of visual extinction of ~ 24 mag. Present analysis suggests that the Class I sources are indeed younger population of the region relative to Class II sources (age $\sim 4.5 \times 10^6$ yr). We suggest that the majority of the Class I sources, including the massive YSOs, are second-generation stars of the region whose formation is possibly induced by the expansion of the H II region powered by a $\sim 4 \times 10^6$ yr B0 main-sequence star.

Accepted by The Astrophysical Journal

<http://arxiv.org/pdf/1206.5578>

Chemistry in Infrared Dark Cloud Clumps: a Molecular Line Survey at 3 mm

Patricio Sanhueza¹, James M. Jackson¹, Jonathan B. Foster¹, Guido Garay², Andrea Silva³ and Susanna C. Finn¹

¹ Institute for Astrophysical Research, Boston University, Boston, MA 02215, USA

² Departamento de Astronomía, Universidad de Chile, Casilla 36-D, Santiago, Chile

³ Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA

E-mail contact: patricio at bu.edu

We have observed 37 Infrared Dark Clouds (IRDCs), containing a total of 159 clumps, in high-density molecular tracers at 3 mm using the 22-meter ATNF Mopra Telescope located in Australia. After determining kinematic distances, we eliminated clumps that are not located in IRDCs and clumps with a separation between them of less than one Mopra beam. Our final sample consists of 92 IRDC clumps. The most commonly detected molecular lines are (detection rates higher than 8%): N_2H^+ , HNC, $HN^{13}C$, HCO^+ , $H^{13}CO^+$, HCN, C_2H , HC_3N , HNC, and SiO. We investigate the behavior of the different molecular tracers and look for chemical variations as a function of an evolutionary sequence based on *Spitzer* IRAC and MIPS emission. We find that the molecular tracers behave differently through the evolutionary sequence and some of them can be used to yield useful relative age information. The presence of HNC and N_2H^+ lines do not depend on the star formation activity. On the other hand, HC_3N , HNC, and SiO are predominantly detected in later stages of evolution. Optical depth calculations show that in IRDC clumps the N_2H^+ line is optically thin, the C_2H line is moderately optically thick, and HNC and HCO^+ are optically thick. The HCN hyperfine transitions are blended, and, in addition, show self-absorbed line profiles and extended wing emission. These factors combined prevent the use of HCN hyperfine transitions for the calculation of physical parameters. Total column densities of the different molecules, except C_2H , increase with the evolutionary stage of the clumps. Molecular abundances increase with the evolutionary stage for N_2H^+ and HCO^+ . The N_2H^+/HCO^+ and N_2H^+/HNC abundance ratios act as chemical clocks, increasing with the evolution of the clumps.

Accepted by The Astrophysical Journal

<http://arxiv.org/abs/1206.6500>

An Empirical Correction for Activity Effects on the Temperatures, Radii, and Estimated Masses of Low-Mass Stars and Brown Dwarfs

Keivan G. Stassun¹, Kaitlin M. Kratter², Aleks Scholz³ and Trent J. Dupuy²

¹ Vanderbilt University, USA

² Harvard CfA, USA

³ Dublin Institute for Astrophysics, Ireland

E-mail contact: keivan.stassun at vanderbilt.edu

We present empirical relations for determining the amount by which the effective temperatures and radii—and therefore

the estimated masses—of low-mass stars and brown dwarfs are altered due to chromospheric activity. We base our relations on a large set of low-mass stars in the field with $H\alpha$ activity measurements, and on a set of low-mass eclipsing binaries with X-ray activity measurements from which we indirectly infer the $H\alpha$ activity. Both samples yield consistent relations linking the amount by which an active object’s temperature is suppressed, and its radius inflated, to the strength of its $H\alpha$ emission. These relations are found to approximately preserve bolometric luminosity. We apply these relations to the peculiar brown-dwarf eclipsing binary 2M0535-05, in which the active, higher-mass brown dwarf has a cooler temperature than its inactive, lower-mass companion. The relations correctly reproduce the observed temperatures and radii of 2M0535-05 after accounting for the $H\alpha$ emission; 2M0535-05 would be in precise agreement with theoretical isochrones were it inactive. The relations that we present are applicable to brown dwarfs and low-mass stars with masses below $0.8 M_{\odot}$ and for which the activity, as measured by the fractional $H\alpha$ luminosity, is in the range $-4.6 < \log L_{H\alpha}/L_{bol} < -3.3$. We expect these relations to be most useful for correcting radius and mass estimates of low-mass stars and brown dwarfs over their active lifetimes (few Gyr) and when the ages or distances (and therefore luminosities) are unknown. We also discuss the implications of this work for improved determinations of young cluster initial mass functions.

Accepted by ApJ

<http://arxiv.org/abs/1206.4930>

Fundamental aspects of episodic accretion chemistry explored with single-point models

Ruud Visser¹ and Edwin A. Bergin¹

¹ University of Michigan, Department of Astronomy, 500 Church Street, Ann Arbor, MI 48109-1042, USA

E-mail contact: visserr@umich.edu

We explore a set of single-point chemical models to study the fundamental chemical aspects of episodic accretion in low-mass embedded protostars. Our goal is twofold: (1) to understand how the repeated heating and cooling of the envelope affects the abundances of CO and related species; and (2) to identify chemical tracers that can be used as a novel probe of the timescales and other physical aspects of episodic accretion. We develop a set of single-point models that serve as a general prescription for how the chemical composition of a protostellar envelope is altered by episodic accretion. The main effect of each accretion burst is to drive CO ice off the grains in part of the envelope. The duration of the subsequent quiescent stage (before the next burst hits) is similar to or shorter than the freeze-out timescale of CO, allowing the chemical effects of a burst to linger long after the burst has ended. We predict that the resulting excess of gas-phase CO can be observed with single-dish or interferometer facilities as evidence of an accretion burst in the past 10^3 – 10^4 yr.

Accepted by ApJ Letters

<http://arxiv.org/abs/1206.5749>

ALMA Observations of the Outflow from the Source I in the Orion-KL Region

Luis A. Zapata¹, Luis F. Rodríguez¹, Johannes Schmid-Burgk², Laurent Loinard^{1,2}, Karl M. Menten¹, and Salvador Curiel³

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

² Max-Planck-Institut für Radioastronomie, Auf dem Hügel 69, 53121, Bonn, Germany

³ Instituto de Astronomía, Universidad Nacional Autónoma de México, Ap. 70-264, 04510 DF, México

E-mail contact: lzapata@crya.unam.mx

In this *Letter*, we present sensitive millimeter SiO ($J=5-4$; $\nu=0$) line observations of the outflow arising from the enigmatic object Orion Source I made with the Atacama Large Millimeter/Submillimeter Array (ALMA). The observations reveal that at scales of a few thousand AU, the outflow has a marked “butterfly” morphology along a northeast-southwest axis. However, contrary to what is found in the SiO and H_2O maser observations at scales of tens of AU, the blueshifted radial velocities of the moving gas are found to the northwest, while the redshifted velocities are in the southeast. The ALMA observations are complemented with SiO ($J=8-7$; $\nu=0$) maps (with a similar spatial resolution) obtained with the Submillimeter Array (SMA). These observations also show a similar morphology and velocity structure in this outflow. We discuss some possibilities to explain these differences at small and large scales across the flow.

A Multi-Wavelength High Resolution Study of the S255 Star Forming Region. General structure and kinematics

I. Zinchenko^{1,2}, S.-Y. Liu³, Y.-N. Su³, S. Kurtz⁴, D. K. Ojha⁵, M. R. Samal⁶ and S. K. Ghosh⁷

¹ Institute of Applied Physics of the Russian Academy of Sciences, 46 Ulyanov st., Nizhny Novgorod 603950, Russia

² Nizhny Novgorod University, 23 Gagarin av., Nizhny Novgorod 603950, Russia

³ Institute of Astronomy and Astrophysics, Academia Sinica. P.O. Box 23-141, Taipei 10617, Taiwan, R.O.C.

⁴ Centro de Radioastronomía y Astrofísica, Universidad Nacional Autónoma de México, Morelia, Michoacán, México

⁵ Infrared Astronomy Group, Department of Astronomy and Astrophysics, Tata Institute of Fundamental Research, Homi Bhabha Road, Colaba, Mumbai (Bombay) – 400 005, India

⁶ Laboratoire d'Astrophysique de Marseille (UMR 6110 CNRS & Université de Provence), 38 rue F. Joliot-Curie, 13388 Marseille Cedex 13, France

⁷ National Centre for Radio Astrophysics, Tata Institute of Fundamental Research, Pune 411007, India

E-mail contact: zin *at* appl.sci-nnov.ru

We present observational data for two main components (S255IR and S255N) of the S255 high mass star forming region in continuum and molecular lines obtained at 1.3 mm and 1.1 mm with the SMA, at 1.3 cm with the VLA and at 23 and 50 cm with the GMRT. The angular resolution was from $\sim 2''$ to $\sim 5''$ for all instruments. With the SMA we detected a total of about 50 spectral lines of 20 different molecules (including isotopologues). About half of the lines and half of the species (in particular N_2H^+ , SiO, $C^{34}S$, DCN, DNC, DCO^+ , HC_3N , H_2CO , H_2CS , SO_2) have not been previously reported in S255IR and partly in S255N at high angular resolution. Our data reveal several new clumps in the S255IR and S255N areas by their millimeter wave continuum emission. Masses of these clumps are estimated at a few solar masses. The line widths greatly exceed expected thermal widths. These clumps have practically no association with NIR or radio continuum sources, implying a very early stage of evolution. At the same time, our SiO data indicate the presence of high-velocity outflows related to some of these clumps. In some cases, strong molecular emission at velocities of the quiescent gas has no detectable counterpart in the continuum. We discuss the main features of the distribution of NH_3 , N_2H^+ , and deuterated molecules. We estimate properties of decimeter wave radio continuum sources and their relationship with the molecular material.

Accepted by Astrophysical Journal

arXiv:1206.5906

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@ifahawaii.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/newsletter.htm>.

Early solar system solids: geochemistry and dynamics

Emmanuel Jacquet

Muséum National d'Histoire Naturelle, Paris, France

54 rue de la Chapelle, 75018 Paris, France

Electronic mail: ejacquet at phare.normalesup.org

Ph.D dissertation directed by: M. Gounelle

Ph.D degree awarded: June 2012

This thesis focuses on the history of the early Solar System solids by contributing to and combining two approaches: the astrophysical modeling of the protoplanetary disk and the cosmochemical study of those solids preserved in the most primitive meteorites, the chondrites. Specifically, we study the dynamics of solids and the trace element geochemistry of chondrules.

The wide age spread of chondrite components in individual meteorites, ranging from ~ 4568 Ma-old refractory inclusions to ~ 4566 - 4564 Ma-old chondrules, indicates that they spent a few Ma as free-floating objects in the disk prior to agglomeration. Using analytic and semi-analytic considerations, such a long preservation suggests the presence, long expected on theoretical grounds, of a low-turbulence disk region known as the “dead zone”, deprived of magnetorotational or gravitational instabilities (MRI and GI, respectively), over the bulk of the disk’s history. Refractory inclusions could have formed prior to the emergence of the dead zone, and have been transported outward during the viscous expansion of the disk provided it started off being compact ($\gtrsim 10$ AU) after infall.

We have measured trace element concentrations in individual mineral phases in chondrules using Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS) and report results for the chondrites Vigarano (CV3), Renazzo (CR2), Acfer 187 (CR2), Bishunpur (LL3.15) and Sahara 97096 (EH3). The composition of olivine in type I chondrules indicates batch crystallization at low cooling rates ($\gtrsim 10$ K/h) whereas enstatite appears to record rapid cooling rates (~ 1000 K/h) and is consistent with formation via silica introduction in the melt. This may hint at two separate heating events. The fractionation between heavy and light rare earth elements in olivine correlates with grain size and approaches the equilibrium prediction for the coarsest-grained chondrules, consistent with a kinetic control of this fractionation.

We have revisited analytically the aerodynamic redistribution of chondrite components in the disk before accretion. The dynamics of solid particles are essentially governed by a single parameter S defined as the ratio between the non-dimensional drag stopping time St and the turbulence parameter α . If $S < 1$, the solid particles are tightly coupled to the gas ; if $S > 1$, they tend to settle toward the midplane and drift sunward relative to the gas. Petrographic, chemical and isotopic arguments support our conjecture that non-matrix chondrite components had $S < 1$ and $S > 1$ when carbonaceous and non-carbonaceous chondrites accreted, respectively. This would indicate that carbonaceous chondrites accreted earlier than enstatite, ordinary and Rumuruti-type chondrites and also support a genetic relationship between refractory inclusions and their host carbonaceous chondrites in the sense that their constituent elements stem from the same reservoir.

We have studied reduced models of two concentration mechanisms of solids—a prerequisite for accretion—where the effect of solids on the gas dynamics can no longer be ignored. The first one is settling in an MRI-turbulent disk: settling is counteracted by turbulence, but on the other hand, turbulence is suppressed if dust lowers gas ionization below the threshold for MRI to operate. We find that an equilibrium exists, where dust concentration is strongly peaked at the midplane, and that this equilibrium is unconditionally linearly stable. The second mechanism envisioned is the streaming instability where drag exerted by *solids* on the *gas* allows a “collectivization” of the motion of the former. We physically interpret its linear phase as follows: pressure maxima attract solids, which entrain the gas, strengthening these maxima, hence a positive feedback loop, for which (Keplerian) rotation and background solid/gas drift are found to be necessary ingredients.

**Protoplanetary Disks
Postdoctoral Fellow/Research Fellow
at The Australian National University**

Applications are invited for an exciting post-doctoral research position on the theoretical/numerical modelling of protoplanetary disks.

This is a 2-year, fixed-term, research-only position funded by the Australian Research Council at the Research School of Astronomy and Astrophysics, The Australian National University. The successful appointee will work with Dr. Raquel Salmeron (The Australian National University) and Prof. Mark Wardle (Macquarie University) on theoretical and numerical studies relating to the physics of accretion disks surrounding young stars.

The successful candidate will have demonstrated clear research achievements in theoretical and/or numerical astrophysics. The appointee will have access to the computational environment of the National Computational Infrastructure Peak Facility, subject to successful time application proposals.

We offer generous remuneration benefits, including four weeks paid vacation per year, assistance with relocation expenses and 17% employer contribution to superannuation. Consistent with our values of integrity and respect, ANU welcomes diversity in its staff, welcoming applications from women and applicants from diverse backgrounds.

The level of appointment will be determined by the qualifications and experience of the successful candidate. Please submit your CV/Resume and claims against the selection criteria. For further information please contact Dr Raquel Salmeron, T (02) 6125 8902 (raquel@mso.anu.edu.au) or Professor Mark Wardle, T (02) 9850 8909 (mark.wardle@mq.edu.au)

Applications should be submitted through the ANU website before 29 July 2012, Reference Number A243-12SK, <http://jobs.anu.edu.au/PositionDetail.aspx?p=2731>

Salary Package: Level A (AUD 73,669) or Level B (AUD 80,166 -91,299) plus 17% superannuation.

Postgraduate Scholarship in Star Formation

The Dublin Institute for Advanced Studies, is offering a postgraduate scholarship to work in the star formation group led by Prof. Tom Ray. Funding is available for 4 years starting in October 2012 and includes a stipend, payment of postgraduate fees, an equipment grant as well as travel support.

The student will work on the interpretation of observations of young stellar objects, their disks, and outflows. In particular it is hoped that he/she will strongly interact with the two new Mid-Infrared Instrument (MIRI) scientists who will commence working in the Institute later this year. While the PhD project will be focused on observations in star formation, there will be opportunities to include modelling and the student will have access to extensive high performance computing facilities. A primary degree in physics, or a related field, and a background in observational astronomy are mandatory. Programming skills and experience with astronomical data analysis are beneficial. Interested students are encouraged to send a brief statement of intent and a curriculum vitae to Ms. Eileen Flood, eflood@cp.dias.ie, with the names of two referees. Inquiries can be made to Prof. Tom Ray (tr@cp.dias.ie). The deadline for submissions is September 30, 2012. Further details are available from Prof Tom Ray tr@cp.dias.ie

Astrophysical Jets and Beams

Michael D. Smith

Astrophysical jets are spectacular displays of gas or dust ejected from a range of cosmic bodies; they are seemingly ubiquitous on scales from comets to black holes. This volume offers a comprehensive, up-to-date study of astrophysical jets on all scales, reviews our understanding of jet processes, and provides a modern guide to their observation and the role they play in many long-standing problems in astrophysics. It covers the major discoveries in gamma-ray bursts, solar and stellar jets and cometary jets. Specific physical processes for all classes of jet are illustrated and discussed in depth, as a backdrop to explaining spectacular jet images. Current jet models raise as many issues as they solve, so the final chapter looks at the new questions to be answered. Written at an entry level for postgraduate students, this volume incorporates introductions to all the governing physics, providing a comprehensive and insightful guide to the study of jets for researchers across all branches of astrophysics.

The book contains the following chapters:

1. Introduction

- 1.1 Rudimentary definitions and concepts
- 1.2 Jet presence and function
- 1.3 Early history
- 1.4 Surprising discoveries
- 1.5 Overview and points of view
- 1.6 Summary

2. Detection and measurement

- 2.1 Synchrotron radiation
- 2.2 Self-absorption and polarisation
- 2.3 Compton processes
- 2.4 Electrons: free-free and brehmsstrahlung processes
- 2.5 Atomic processes
- 2.6 Molecular processes
- 2.7 Maser beams
- 2.8 Power and size
- 2.9 Summary

3. The dynamical toolbox

- 3.1 The inviscid hydrodynamic equations
- 3.2 Viscosity
- 3.3 Magnetohydrodynamics
- 3.4 Steady jets and potential flows
- 3.5 Streamlines: rotating MHD flows
- 3.6 Special relativistic flow
- 3.7 Shock waves
- 3.8 Non-ideal MHD and non-MHD
- 3.9 Summary

4. Observations of extragalactic jets

- 4.1 The morphological classes of radio galaxies
- 4.2 Detailed structure and multiwavelength features
- 4.3 Host galaxies and triggering jets
- 4.4 Summary

5. Jets in galactic nuclei

- 5.1 Individual blazar jets

- 5.2 Speed and Doppler boosting
- 5.3 The class of blazar jets
- 5.4 Variability and temperature
- 5.5 The Lorentz factor crisis
- 5.6 Polarisation
- 5.7 Summary
- 6. Jets from young stars and protostars**
 - 6.1 Optical jets
 - 6.2 Embedded protostellar jets
 - 6.3 Termination: Herbig-Haro and molecular hydrogen objects
 - 6.4 Bipolar outflows
 - 6.5 Small-scale jets: radio and masers
 - 6.6 Summary
- 7. Jets associated with evolved stars**
 - 7.1 Planetary nebulae
 - 7.2 Symbiotic systems
 - 7.3 Supersoft X-ray sources
 - 7.4 Cataclysmic variables
 - 7.5 Microquasars: XRB jet systems
 - 7.6 Pulsar jets
 - 7.7 Gamma-ray bursts
 - 7.8 Summary
- 8. Jets within the solar system**
 - 8.1 Cometary jets, pre-2000
 - 8.2 Cometary jets, post-2000
 - 8.3 Moon jets
 - 8.4 Solar jets
 - 8.5 Summary
- 9. Jet launching**
 - 9.1 Hydrodynamic methods
 - 9.2 Jets via magnetic reconnection
 - 9.3 Magnetic field methods
 - 9.4 Alternative models and mechanisms
 - 9.5 Summary
- 10. Jet propagation**
 - 10.1 Components and structure
 - 10.2 Jet shapes
 - 10.3 Jet disruption
 - 10.4 Jet flares and knots
 - 10.5 Instability
 - 10.6 Changing direction
 - 10.7 Summary
- 11. The astrophysical jet**
 - 11.1 Composition
 - 11.2 Regulation
 - 11.3 Feedback
 - 11.4 Unification
 - 11.5 The future

Cambridge University Press 2012, ISBN:9780521834766
CAPS Series, Volume 49
260 pages, hardcover US \$105.00
Available from <http://www.cambridge.org/9780521834766>

Meetings

30 Doradus: The Starburst Next Door

A mini-workshop to be held at STScI Sep 16-19, 2012

Registration deadline is August 17th

The 30 Doradus or Tarantula Nebula region of the Large Magellanic Cloud is synonymous with many superlatives in astronomy, hosting as it does the most massive young resolved cluster (R136), the most massive stars yet discovered, the fastest rotating O-type stars, the most massive runaway star.

Its unique accessibility to detailed study covering the electromagnetic spectrum from X-ray, UV, optical, IR through radio is reflected in the many detailed surveys of this region with facilities such as HST, Chandra, Spitzer, VLT-Flames and VISTA. While it is certainly a challenge to understand this wealth of information for what is a very complex region it is one well worth addressing since 30 Doradus may have much to teach us about more distant unresolved starbursts and super star clusters.

The aim of this mini-workshop is to review recent results and outstanding theoretical issues and to examine the extent to which our knowledge of 30 Doradus can be used to improve our understanding of distant starbursts and star clusters. It will focus on five closely related themes: formation, environment, content, evolution and relevance to Super Star Clusters and Starbursts.

Invited Speakers: Daniela Calzetti - University of Massachusetts, You-Hua Chu - University of Illinois, Paul Crowther - University of Sheffield, Chris Evans - UK Astronomy Technology Centre Edinburgh, Jay Gallagher - University of Wisconsin-Madison, Remy Indebetouw - University of Virginia, Laura Lopez - Massachusetts Institute of Technology, Hugues Sana - University of Amsterdam, Leisa Townsley - Penn State University, Hans Zinnecker - SOFIA

SOC at STScI: Selma de Mink, Linda Smith, Karl Gordon, Nolan Walborn, Daniel Lennon (chair), Brad Whitmore, Elena Sabbi, Aida Wofford, Sherita Hanna (coordinator)

Website:

<http://www.stsci.edu/institute/conference/doradus>

From Stars to Life - Connecting our understanding of star formation, planet formation, astrochemistry and astrobiology

Wed. 3rd - Sat. 6th April 2013

University of Florida, Gainesville, FL, USA

<http://conference.astro.ufl.edu/STARSTOLIFE/>

Science topics: Star Formation (including isolated and clustered star formation), Circumstellar Disks, Planet Formation, Exoplanets (including search and characterization), Astrochemistry, Prebiotic Chemistry.

We would like to understand the physical and chemical processes that lead to habitable planet formation, starting from the simplest interstellar medium initial conditions of pre-stellar cores, through star formation, accretion & protoplanetary disk evolution, and planet & planetary system formation & evolution. We will discuss theoretical, observational and laboratory constraints on these processes. The conference aims to foster inter and multidisciplinary collaboration between researchers interested in these topics. Space is limited to about 125 participants.

The conference will be held at the University of Florida in Gainesville, located within 2 hours drive from Orlando, Tampa, Jacksonville, St. Augustine, and the Atlantic and Gulf Coasts. The weather in April is generally dry, sunny and warm.

If you are interested in attending the conference and want to join the email list, please visit the conference webpage and follow the pre-registration instructions.

Best regards,

Jonathan Tan

Paola Caselli

on behalf of the the SOC:

Phil Armitage, Aaron Boley, Dan Britt, Paola Caselli, Eric Ford, Eduardo Martin, Matthew Pasek, Jonathan Tan, Susanna Widicus Weaver

Frontiers in Star Formation
A conference to honor Dr. Richard Larson
October 26-27, 2012, Yale University

We would like to inform you about "Frontiers in Star Formation," a conference that will be held at Yale University on October 26-27, 2012 to honor Dr. Richard Larson, who has retired after serving at Yale for 43 years. The goal of this meeting is to bring together observers and theorists in the field of star formation, at all cosmic scales, to discuss the latest discoveries and the exciting research that will be conducted in the near future. In so doing, we will celebrate Dr. Larson's great contributions to this field.

Twenty-five invited speakers have confirmed to speak on a variety of topics that have been split into four sessions: - The First Stars - The Heydays of Cosmic Star Formation (SF at z 2-3) - Towards a Complete Picture of Galactic Star Formation - Bridging the Gap Between Galactic and Extra-Galactic Star Formation

There will be no contributed talks solicited, but we encourage anyone who would like to present his or her science to bring a poster to the poster session.

There will also be a banquet in honor of Dr. Larson on Friday night.

More information on the conference and registration can be found at: <http://www.astro.yale.edu/sf.frontiers/> and on the conference poster, which can be found at http://www.astro.yale.edu/sf_frontiers/images/RLPosterSmall5.pdf. Please forward this E-mail and poster to any who you might think would be interested in attending. The deadline to register is September 1, 2012, and space is limited so act now!

We hope to see you in New Haven in the Fall!

Hector Arce on behalf of The Scientific Organizing Committee

Volker Bromm, Paolo Coppi, Neal Evans, Alyssa Goodman, Mordecai-Mark Mac Low, Chris McKee, Priya Natarajan, Hans Zinnecker

Victoria Leigh Gardner Coordinator of Yale Research Observatories

Exploring the Formation and Evolution of Planetary Systems
2-7 June 2013, Victoria, BC, Canada

This is the first announcement for the 299th Symposium of the International Astronomical Union (IAU), "Exploring the Formation and Evolution of Planetary Systems", co-organized by the Dunlap Institute for Astronomy & Astrophysics and the National Research Council of Canada. The goal of this meeting is to bring together the communities studying the formation of planets in protoplanetary discs and those who study evolved exoplanet systems. The timing is chosen to highlight the first results from a number of new facilities and instruments which will impact these fields.

Topics will include:

- Observations of protoplanetary discs, debris discs and exoplanets
- Planetesimal and planet formation
- Exoplanet atmospheres and interior structure
- Dynamics in planetary systems: migration, multiplicity and planet-disc interactions

The meeting will be held at the Victoria Conference Centre in the heart of picturesque Victoria, British Columbia, on Canada's Pacific coast. Local attractions include whale watching, wine tours, the world-famous Butchart Gardens, and the Dominion Astrophysical Observatory. Excellent beaches, diving, camping and hiking are all within a day's drive from Victoria.

Pre-Registration

Registration will open on 1 September 2012, but those interested in attending the meeting are welcome to submit their names to our pre-registration list. Pre-registrants will be sent the invitation to register for the meeting directly, but places are not reserved once registration is officially opened. There will be a hard limit of 200 attendees for the symposium. To pre-register and be placed on the mailing list, just send an email indicating your interest to the conference email: iaus-299@di.utoronto.ca.

Financial Assistance

In keeping with the spirit of the IAU Symposia, the costs of the meeting will be kept as low as possible. In addition, financial assistance in the form of IAU Support Grants is available for those needing financial assistance to attend. All student attendees who register in the Early Registration period (1 Sept - 7 Dec 2012) will receive financial support. The deadline for submission of grant applications to the Science Organizing Committee is 7 December 2012; forms and directions are available on the symposium website, <http://www.iaus299.org>.

Key Dates

- 1 Sept 2012: Early Registration Opens
- 7 Dec 2012: Deadline for Early Registration and Applications for IAU Support Grants
- 31 March 2013: Deadline for Registration and Abstract Submission
- 2 June 2013: Evening Reception/Symposium Begins
- 3-7 June 2013: Symposium

<http://www.iaus299.org>

<https://www.facebook.com/events/376085279113847/>

Email: iaus-299@di.utoronto.ca

For more information, please visit our website, facebook event entry or email the conference. We hope to see you in Victoria in June 2013!

Brenda Matthews

LOC Chair, on behalf of the LOC and SOC

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.