

THE STAR FORMATION NEWSLETTER

An electronic publication dedicated to early stellar evolution and molecular clouds

No. 208 — 28 April 2010

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

Abstracts of recently accepted papers

The COMPLETE Survey of Outflows in Perseus

Héctor G. Arce¹, Michelle A. Borkin², Alyssa A. Goodman³, Jaime E. Pineda³ and Michael W. Halle⁴

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

² School of Engineering and Applied Sciences, Harvard University, 29 Oxford Street, Cambridge MA 02138, USA

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

⁴ Surgical Planning Lab, Department of Radiology, Brigham and Women's Hospital, 75 Francis Street, Boston MA 02115, USA

E-mail contact: hector.arce *at* yale.edu

We present a study on the impact of molecular outflows in the Perseus molecular cloud complex using the COMPLETE survey large-scale $^{12}\text{CO}(1-0)$ and $^{13}\text{CO}(1-0)$ maps. We used three-dimensional isosurface models generated in RA-DEC-Velocity space to visualize the maps. This rendering of the molecular line data allowed for a rapid and efficient way to search for molecular outflows over a large ($\sim 16 \text{ deg}^2$) area. Our outflow-searching technique detected previously known molecular outflows as well as new candidate outflows. Most of these new outflow-related high-velocity features lie in regions that have been poorly studied before. These new outflow candidates more than double the amount of outflow mass, momentum, and kinetic energy in the Perseus cloud complex. Our results indicate that outflows have significant impact on the environment immediately surrounding localized regions of active star formation, but lack the energy needed to feed the observed turbulence in the *entire* Perseus complex. This implies that other energy sources, in addition to protostellar outflows, are responsible for turbulence on a global cloud scale in Perseus. We studied the impact of outflows in six regions with active star formation within Perseus of sizes in the range of 1 to 4 pc. We find that outflows have enough power to maintain the turbulence in these regions and enough momentum to disperse and unbind some mass from them. We found no correlation between outflow strength and star formation efficiency for the six different regions we studied, contrary to results of recent numerical simulations. The low fraction of gas that potentially could be ejected due to outflows suggests that additional mechanisms other than cloud dispersal by outflows are needed to explain low star formation efficiencies in clusters.

Accepted by The Astrophysical Journal

<http://www.astro.yale.edu/hga7/publications.html>

<http://www.cfa.harvard.edu/COMPLETE/projects/outflows.html>

Long-lived Magnetic-Tension-Driven Modes in a Molecular Cloud

Shantanu Basu¹ and Wolf B. Dapp¹

¹ Department of Physics and Astronomy, The University of Western Ontario, London, Ontario N6A 3K7, Canada

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

We calculate and analyze the longevity of magnetohydrodynamic wave modes that occur in the plane of a magnetic thin sheet. Initial turbulent conditions applied to a magnetically subcritical cloud are shown to lead to relatively rapid energy decay if ambipolar diffusion is introduced at a level corresponding to partial ionization primarily by cosmic rays. However, in the flux-freezing limit, as may be applicable to photoionized molecular cloud envelopes, the turbulence persists at “nonlinear” levels in comparison with the isothermal sound speed c_s , with one-dimensional rms

material motions in the range of $\approx 2 c_s - 5 c_s$ for cloud sizes in the range of $\approx 2 \text{ pc} - 16 \text{ pc}$. These fluctuations persist indefinitely, maintaining a significant portion of the initial turbulent kinetic energy. We find the analytic explanation for these persistent fluctuations. They are magnetic-tension-driven modes associated with the interaction of the sheet with the external magnetic field. The phase speed of such modes is quite large, allowing residual motions to persist without dissipation in the flux-freezing limit, even as they are nonlinear with respect to the sound speed. We speculate that long-lived large-scale magnetohydrodynamic modes such as these may provide the key to understanding observed supersonic motions in molecular clouds.

Accepted by The Astrophysical Journal

<http://www.astro.uwo.ca/~basu/pb.htm>, includes animations and 3D pdf

Water masers accompanying OH and methanol masers in star formation regions

Shari Breen^{1,2}, James Caswell², Simon Ellingsen¹ and Chris Phillips²

¹ University of Tasmania, Private Bag 37, Hobart, Tasmania 7001, Australia

² Australia Telescope National Facility, CSIRO, PO Box 76, Epping, NSW 1710, Australia

E-mail contact: slbreen@utas.edu.au

The Australia Telescope Compact Array (ATCA) has been used to measure positions with arcsecond accuracy for 379 masers at the 22-GHz transition of water. The principal observation targets were 202 OH masers of the variety associated with star formation regions (SFR)s in the Southern Galactic plane. At a second epoch, most of these targets were observed again, and new targets of methanol masers were added. Many of the water masers reported here are new discoveries and others had been reported, with position uncertainties exceeding 10 arcsec, from Parkes telescope single dish observations many years ago.

Variability in the masers is often acute, with very few features directly corresponding to those discovered two decades ago. Within our current observations, less than a year apart, spectra are often dissimilar, but positions at the later epoch, even when measured for slightly different features, mostly correspond to the detected maser site measured earlier, to within the typical extent of the whole site, of a few arcseconds.

The precise water positions show that approximately 79 per cent (160 of 202) of the OH maser sites show coincident water maser emission, the best estimate yet obtained for this statistic; however, there are many instances where additional water sites are present offset from the OH target, and consequently less than half of the water masers coincide with a 1665-MHz ground-state OH maser counterpart. Our less uniform sample of methanol targets is not suitable for a full investigation of their association with water masers, but we are able to explore differences between the velocities of peak emission from the three species, and quantify the typically larger deviations shown by water maser peaks from systemic velocities.

Clusters of two or three distinct but nearby sites, each showing one or several of the principal molecular masing transitions, are found to be common. We also report the detection of ultracompact HII regions towards some of the sites. In combination with an investigation of correlations with IR sources from the GLIMPSE catalogue, these comparative studies allow further progress in the use of the maser properties to assign relative evolutionary stages in star formation to individual sites.

Accepted by MNRAS

<http://arxiv.org/abs/1004.1060>

A bright radio HH object with large proper motions in the massive star-forming region W75N

Carlos Carrasco-González^{1,2}, Luis F. Rodríguez², José M. Torrelles³, Guillem Anglada¹ and Omaira González-Martín⁴

¹ Instituto de Astrofísica de Andalucía (CSIC), Camino Bajo de Huétor 50, E-18008 Granada, Spain

² Centro de Radioastronomía y Astrofísica (UNAM), Apartado Postal 3-72 (Xangari), 58089 Morelia, Michoacán, México

³ Instituto de Ciencias del Espacio (CSIC/IEEC)-UB, Universitat de Barcelona, Martí i Franquès 1, E-08028 Barcelona,

Spain

⁴ Physics Department, University of Crete, P. O. Box 2208, 71003 Heraklion, Crete, Greece

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

We analyze radio continuum and line observations from the archives of the Very Large Array, as well as X-ray observations from the *Chandra* archive of the region of massive star formation W75N. Five radio continuum sources are detected: VLA 1, VLA 2, VLA 3, Bc, and VLA 4. VLA 3 appears to be a radio jet; we detect $J=1-0$, $v=0$ SiO emission towards it, probably tracing the inner parts of a molecular outflow. The radio continuum source Bc, previously believed to be tracing an independent star, is found to exhibit important changes in total flux density, morphology, and position. These results suggest that source Bc is actually a radio Herbig-Haro object, one of the brightest known, powered by the VLA 3 jet source. VLA 4 is a new radio continuum component, located a few arcsec to the south of the group of previously known radio sources. Strong and broad (1,1) and (2,2) ammonia emission is detected from the region containing the radio sources VLA 1, VLA 2, and VLA 3. Finally, the 2-10 keV emission seen in the *Chandra*/ACIS image shows two regions that could be the termination shocks of the outflows from the multiple sources observed in W75N.

Accepted by The Astronomical Journal

arxiv.org/abs/1004.1141

Controlling Artificial Viscosity in SPH simulations of accretion disks

Annabel Cartwright¹ and Dimitrios Stamatellos¹

¹ School of Physics and Astronomy, Cardiff University, 5, The Parade, Cardiff CF24 3AA, UK

E-mail contact: Annabel.Cartwright *at* astro.cf.ac.uk

The fidelity of SPH simulations of accretion disks depends on how Artificial Viscosity is formulated. Here we test the operation of two methods for selective application of Artificial Viscosity in SPH simulations of Keplerian Accretion Disks, using a ring spreading test to quantify effective viscosity, and a correlation coefficient technique to measure the formation of unwanted prograde alignments of particles. Neither the Balsara Switch nor Time Dependent Viscosity work effectively, as they leave Artificial Viscosity active in areas of smooth shearing flow, and do not eliminate the accumulation of alignments of particles in the prograde direction. The effect of both switches is periodic, the periodicity dependent on radius and unaffected by the density of particles. We demonstrate that a very simple algorithm activates Artificial Viscosity only when truly convergent flow is detected and reduces the unwanted formation of prograde alignments. The new switch works by testing whether all the neighbours of a particle are in Keplerian orbit around the same point, rather than calculating the divergence of the velocity field, which is very strongly affected by Poisson noise in the positions of the SPH particles.

Accepted by Astronomy and Astrophysics

<http://www.astro.cardiff.ac.uk/pub/Annabel.Cartwright/avpaper.pdf>

Deuterium Fractionation as an Evolutionary Probe in the Infrared Dark Cloud G28.34+0.06

Huei-Ru Chen¹, Sheng-Yuan Liu², Yu-Nung Su² and Qizhou Zhang³

¹ Institute of Astronomy and Department of Physics, National Tsing Hua University, Taiwan

² Institute of Astronomy and Astrophysics, Academia Sinica, Taiwan

³ Harvard-Smithsonian Center for Astrophysics, USA

E-mail contact: hchen *at* phys.nthu.edu.tw

We have observed the $J = 3 - 2$ transition of N_2H^+ and N_2D^+ to investigate the trend of deuterium fractionation with evolutionary stage in three selected regions in the Infrared Dark Cloud (IRDC) G28.34+0.06 with the Submillimeter Telescope (SMT) and the Submillimeter Array (SMA). A comprehensible enhancement of roughly 3 orders of magnitude in deuterium fractionation over the local interstellar D/H ratio is observed in all sources. In particular, our sample of massive star-forming cores in G28.34+0.06 shows a moderate decreasing trend over a factor of 3 in the $N(N_2D^+)/N(N_2H^+)$ ratio with evolutionary stage, a behavior resembling what previously found in low-mass protostellar cores. This suggests a possible extension for the use of the $N(N_2D^+)/N(N_2H^+)$ ratio as an evolutionary tracer

to high-mass protostellar candidates. In the most evolved core, MM1, the N_2H^+ ($3 - 2$) emission appears to avoid the warm region traced by dust continuum emission and emission of ^{13}CO sublimated from grain mantles, indicating an instant release of gas-phase CO. The majority of the N_2H^+ and N_2D^+ emission is associated with extended structures larger than $8''$ (~ 0.2 pc).

Accepted by The Astrophysical Journal Letters (713, L50)

<http://arxiv.org/abs/1003.1365>

L1448 IRS2E: A Candidate First Hydrostatic Core

Xuepeng Chen¹, Hector G. Arce¹, Qizhou Zhang², Tyler L. Bourke², Ralf Launhardt³, Markus Schmalz³ and Thomas Henning³

¹ Yale Astronomy Department, USA

² Harvard-Smithsonian Center for Astrophysics, USA

³ Max Planck Institute for Astronomy, Germany

E-mail contact: xuepeng.chen *at* yale.edu

Intermediate between the prestellar and Class0 protostellar phases, the first core is a quasi-equilibrium hydrostatic object with a short lifetime and an extremely low luminosity. Recent MHD simulations suggest that the first core can even drive a molecular outflow before the formation of the second core (i.e., protostar). Using the Submillimeter Array and the *Spitzer Space Telescope*, we present high angular resolution observations towards the embedded dense core IRS2E in L1448. We find that source L1448 IRS2E is not visible in the sensitive *Spitzer* infrared images (at wavelengths from 3.6 to 70 μm), and has weak (sub-) millimeter dust continuum emission. Consequently, this source has an extremely low bolometric luminosity ($< 0.1 L_\odot$). Infrared and (sub-) millimeter observations clearly show an outflow emanating from this source; L1448 IRS2E represents thus far the lowest luminosity source known to be driving a molecular outflow. Comparisons with prestellar cores and Class0 protostars suggest that L1448 IRS2E is more evolved than prestellar cores but less evolved than Class0 protostars, i.e., at a stage intermediate between prestellar cores and Class0 protostars. All these results are consistent with the theoretical predictions of the radiative/magneto hydrodynamical simulations, making L1448 IRS2E the most promising candidate of the first hydrostatic core revealed so far.

Accepted by Astrophysical Journal

<http://arxiv.org/archive/astro-ph/>

Sloan Low-Mass Wide Pairs of Kinematically Equivalent Stars (SLoWPoKES): A Catalog of Very Wide, Low-mass Pairs

Saurav Dhital¹, Andrew A. West^{2,3}, Keivan G. Stassun^{1,4} and John J. Bochanski³

¹ Vanderbilt University, USA

² Boston University, USA

³ Kavli Institute for Astrophysics & Space Science, USA

⁴ Fisk University, USA

E-mail contact: Saurav.Dhital *at* Vanderbilt.Edu

We present the Sloan Low-mass Wide Pairs of Kinematically Equivalent Stars (SLoWPoKES), a catalog of 1342 very-wide (projected separation > 500 AU), low-mass (at least one mid-K ? mid-M dwarf component) common proper motion pairs identified from astrometry, photometry, and proper motions in the Sloan Digital Sky Survey. A Monte Carlo based Galactic model is constructed to assess the probability of chance alignment for each pair; only pairs with a probability of chance alignment < 0.05 are included in the catalog. The overall fidelity of the catalog is expected to be 98.35%. The selection algorithm is purposely exclusive to ensure that the resulting catalog is efficient for follow-up studies of low-mass pairs. The SLoWPoKES catalog is the largest sample of wide, low-mass pairs to date and is intended as an ongoing community resource for detailed study of bona fide systems. Here we summarize the general characteristics of the SLoWPoKES sample and present preliminary results describing the properties of wide, low-mass pairs. While the majority of the identified pairs are disk dwarfs, there are 70 halo subdwarf pairs and 21 white dwarf/disk dwarf pairs, as well as four triples. Most SLoWPoKES pairs violate the previously defined empirical

limits for maximum angular separation or binding energies. However, they are well within the theoretical limits and should prove very useful in putting firm constraints on the maximum size of binary systems and on different formation scenarios. We find a lower limit to the wide binary frequency for the mid-K - mid-M spectral types that constitute our sample to be 1.1%. This frequency decreases as a function of Galactic height, indicating a time evolution of the wide binary frequency. In addition, the semi-major axes of the SLoWPoKES systems exhibit a distinctly bimodal distribution, with a break at separations around 0.1 pc that is also manifested in the system binding energy. Comparing with theoretical predictions for the disruption of binary systems with time, we conclude that the SLoWPoKES sample comprises two populations of wide binaries: an 'old' population of tightly bound systems, and a 'young' population of weakly bound systems that will not survive more than a few Gyr. The SLoWPoKES catalog and future ancillary data are publicly available on the world wide web for utilization by the astronomy community.

Accepted by Astronomical Journal

<http://people.vanderbilt.edu/~saurav.dhital/slowpokes/slowpokes.pdf>

A Synthetic 21-cm Galactic Plane Survey of an SPH Galaxy Simulation

Kevin A. Douglas¹, David M. Acreman¹, Clare L. Dobbs^{1,2,3} and Christopher M. Brunt¹

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

² Max-Planck-Institut für extraterrestrische Physik, Giessenbachstraße, D-85748 Garching, Germany

³ Universitäts-Sternwarte München, Scheinerstraße 1, D-81679 München, Germany

E-mail contact: douglas at astro.ex.ac.uk

We have created synthetic neutral hydrogen (HI) Galactic Plane Survey data cubes covering $90^\circ \leq \ell \leq 180^\circ$, using a model spiral galaxy from SPH simulations and the radiative transfer code TORUS. The density, temperature and other physical parameters are fed from the SPH simulation into TORUS, where the HI emissivity and opacity are calculated before the 21-cm line emission profile is determined. Our main focus is the observation of Outer Galaxy 'Perseus Arm' HI, with a view to tracing atomic gas as it encounters shock motions as it enters a spiral arm interface, an early step in the formation of molecular clouds. The observation of HI self-absorption features at these shock sites (in both real observations and our synthetic data) allows us to investigate further the connection between cold atomic gas and the onset of molecular cloud formation.

Accepted by MNRAS

Comparing the statistics of interstellar turbulence in simulations and observations: Solenoidal versus compressive turbulence forcing

C. Federrath^{1,2,3}, J. Roman-Duval^{4,5}, R. S. Klessen¹, W. Schmidt^{6,7} and M.-M. Mac Low^{2,3}

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

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

³ Department of Astrophysics, American Museum of Natural History, Central Park West at 79th Street, New York, NY 10024-5192, USA

⁴ Space Telescope Science Institute, 3700 San Martin Drive, Baltimore, MD 21218, USA

⁵ Astronomy Department, Boston University, 725 Commonwealth Avenue, Boston, MA 02215, USA

⁶ Institut für Astrophysik, Universität Göttingen, Friedrich-Hund-Platz 1, D-37077 Göttingen, Germany

⁷ Lehrstuhl für Astronomie, Institut für Theoretische Physik und Astrophysik, Universität Würzburg, Am Hubland, D-97074 Würzburg, Germany

E-mail contact: chfeder at ita.uni-heidelberg.de

Context. Density and velocity fluctuations on virtually all scales observed with modern telescopes show that molecular clouds (MCs) are turbulent. The forcing and structural characteristics of this turbulence are, however, still poorly understood.

Aims: To shed light on this subject, we study two limiting cases of turbulence forcing in numerical experiments: solenoidal (divergence-free) forcing and compressive (curl-free) forcing, and compare our results to observations.

Methods: We solve the equations of hydrodynamics on grids with up to 1024^3 cells for purely solenoidal and purely

compressive forcing. Eleven lower-resolution models with different forcing mixtures are also analysed.

Results: Using Fourier spectra and Δ -variance, we find velocity dispersion–size relations consistent with observations and independent numerical simulations, irrespective of the type of forcing. However, compressive forcing yields stronger compression at the same RMS Mach number than solenoidal forcing, resulting in a three times larger standard deviation of volumetric and column density probability distributions (PDFs). We compare our results to different characterisations of several observed regions, and find evidence of different forcing functions. Column density PDFs in the Perseus MC suggest the presence of a mainly compressive forcing agent within a shell, driven by a massive star. Although the PDFs are close to log-normal, they have non-Gaussian skewness and kurtosis caused by intermittency. Centroid velocity increments measured in the Polaris Flare on intermediate scales agree with solenoidal forcing on that scale. However, Δ -variance analysis of the column density in the Polaris Flare suggests that turbulence is driven on large scales, with a significant compressive component on the forcing scale. This indicates that, although likely driven with mostly compressive modes on large scales, turbulence can behave like solenoidal turbulence on smaller scales. Principal component analysis of G216-2.5 and most of the Rosette MC agree with solenoidal forcing, but the interior of an ionised shell within the Rosette MC displays clear signatures of compressive forcing.

Conclusions: The strong dependence of the density PDF on the type of forcing must be taken into account in any theory using the PDF to predict properties of star formation. We supply a quantitative description of this dependence. We find that different observed regions show evidence of different mixtures of compressive and solenoidal forcing, with more compressive forcing occurring primarily in swept-up shells. Finally, we emphasise the role of the sonic scale for protostellar core formation, because core formation close to the sonic scale would naturally explain the observed subsonic velocity dispersions of protostellar cores.

Published as Highlight Paper in A&A, 512, A81 (2010)

<http://adsabs.harvard.edu/abs/2010A%26A...512A..81F>

The Structure of Molecular Clouds: II - Column Density and Mass Distributions

Dirk Froebrich¹ and Jonathan Rowles¹

¹ University of Kent, UK

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

The formation of stars is inextricably linked to the structure of their parental molecular clouds. Here we take a number of nearby giant molecular clouds (GMCs) and analyse their column density and mass distributions. This investigation is based on four new all-sky median colour excess extinction maps determined from 2MASS. The four maps span a range of spatial resolution of a factor of eight. This allows us to determine cloud properties at a common spatial scale of 0.1 pc, as well as to study the scale dependence of the cloud properties.

We find that the low column density and turbulence dominated part of the clouds can be well fit by a log-normal distribution. However, above a universal extinction threshold of 6.0 ± 1.5 mag A_V there is excess material compared to the log-normal distribution in all investigated clouds. This material represents the part of the cloud that is currently involved in star formation, and thus dominated by gravity. Its contribution to the total mass of the clouds ranges over two orders of magnitude from 0.1 to 10%. This implies that our clouds sample various stages in the evolution of GMCs. Furthermore, we find that the column density and mass distributions are extremely similar between clouds if we analyse only the high extinction material. On the other hand, there are significant differences between the distributions if only the low extinction, turbulence dominated regions are considered. This shows that the turbulent properties differ between clouds depending on their environment. However, no significant influence on the predominant mode of star formation (clustered or isolated) could be found. Furthermore, the fraction of the cloud actively involved in star formation is only governed by gravity, with the column density and mass distributions not significantly altered by local feedback processes.

Accepted by MNRAS

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

Enstatite-rich Warm Debris Dust around HD165014

Hideaki Fujiwara¹, Takashi Onaka¹, Daisuke Ishihara², Takuya Yamashita³, Misato Fukagawa⁴, Takao Nakagawa⁵, Hirokazu Kataza⁵, Takafumi Ootsubo⁶ and Hiroshi Murakami⁵

¹ Department of Astronomy, School of Science, University of Tokyo, Bunkyo-ku, Tokyo 113-0033, Japan

² Graduate School of Science, Nagoya University, Furo-cho, Chikusa-ku, Nagoya 464-8602, Japan

³ National Astronomical Observatory of Japan, 2-21-1 Osawa, Mitaka, Tokyo 181-0015, Japan

⁴ Graduate School of Science, Osaka University, 1-1 Machikaneyama, Toyonaka 560-0043, Osaka, Japan

⁵ Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 3-1-1 Yoshinodai, Chuo-ku, Sagami-hara, Kanagawa 252-5210, Japan

⁶ Astronomical Institute, Graduate School of Science, Tohoku university, Aramaki, Aoba-ku, Sendai, 980-8578, Japan

E-mail contact: hideaki at ir.isas.jaxa.jp

We present the *Spitzer*/Infrared Spectrograph spectrum of the main-sequence star HD165014, which is a warm ($\gtrsim 200$ K) debris disk candidate discovered by the *AKARI* All-Sky Survey. The star possesses extremely large excess emission at wavelengths longer than $5 \mu\text{m}$. The detected flux densities at 10 and $20 \mu\text{m}$ are ~ 10 and ~ 30 times larger than the predicted photospheric emission, respectively. The excess emission is attributable to the presence of circumstellar warm dust. The dust temperature is estimated as 300–750 K, corresponding to the distance of 0.7–4.4 AU from the central star. Significant fine-structured features are seen in the spectrum and the peak positions are in good agreement with those of crystalline enstatite. Features of crystalline forsterite are not significantly seen. HD165014 is the first debris disk sample that has enstatite as a dominant form of crystalline silicate rather than forsterite. Possible formation of enstatite dust from differentiated parent bodies is suggested according to the solar system analog. The detection of an enstatite-rich debris disk in the current study suggests the presence of large bodies and a variety of silicate dust processing in warm debris disks.

Accepted by the Astrophysical Journal Letters

<http://arxiv.org/abs/1004.0560>

Formation of an O-Star Cluster by Hierarchical Accretion in G20.08-0.14 N

Roberto Galvan-Madrid¹, Eric Keto¹, Qizhou Zhang¹, Stan Kurtz², Luis F. Rodriguez² and Paul Ho³

¹ Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge MA 02138, USA

² Centro de Radioastronomía y Astrofísica, Universidad Nacional Autónoma de México, Morelia 58090, México

³ Academia Sinica Institute of Astronomy and Astrophysics, P.O. Box 23-141, Taipei 106, Taiwan

E-mail contact: rgalvan at cfa.harvard.edu

Spectral line and continuum observations of the ionized and molecular gas in G20.08-0.14 N explore the dynamics of accretion over a range of spatial scales in this massive star-forming region. Very Large Array observations of NH_3 at $4''$ angular resolution show a large-scale (0.5 pc) molecular accretion flow around and into a star cluster with three small, bright HII regions. Higher resolution ($0.4''$) observations with the Submillimeter Array in hot core molecules (CH_3CN , OCS , and SO_2) and the VLA in NH_3 , show that the two brightest and smallest HII regions are themselves surrounded by smaller scale (0.05 pc) accretion flows. The axes of rotation of the large and small scale flows are aligned, and the timescale for the contraction of the cloud is short enough, 0.1 Myr, for the large-scale accretion flow to deliver significant mass to the smaller scales within the star formation timescale. The flow structure appears to be continuous and hierarchical from larger to smaller scales.

Millimeter radio recombination line (RRL) observations at 0.4 arcsec angular resolution indicate rotation and outflow of the ionized gas within the brightest HII region (A). The broad recombination lines and a continuum spectral energy distribution (SED) that rises continuously from cm to mm wavelengths, are both characteristic of the class of HII regions known as “broad recombination line objects”. The SED indicates a density gradient inside this HII region, and the RRLs suggest supersonic flows. These observations are consistent with photoevaporation of the inner part of the rotationally flattened molecular accretion flow.

We also report the serendipitous detection of a new NH_3 (3,3) maser.

Published by The Astrophysical Journal, Volume 706, pp. 1036-1053 (Dec 2009)

<http://arxiv.org/abs/0910.2270>

The Rare 23.1 GHz Methanol Masers in NGC 7538 IRS 1

Roberto Galvan-Madrid¹, Gabriela Montes², Edgar A. Ramirez³, Stan Kurtz⁴, Esteban Araya⁵ and Peter Hofner⁶

¹ Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge MA 02138, USA

² Instituto de Astrofísica de Andalucía, CSIC, Camino Bajo de Huétor 50, E-18008 Granada, Spain

³ Department of Physics and Astronomy, University of Sheffield, Sheffield S3 7RH, England

⁴ Centro de Radioastronomía y Astrofísica, Universidad Nacional Autónoma de México, Morelia 58090, México

⁵ Physics Department, Western Illinois University, 1 University Circle, Macomb IL 61455, USA

⁶ Physics Department, New Mexico Tech, 801 Leroy Place, Socorro NM 87801, USA

E-mail contact: rgalvan at cfa.harvard.edu

We present high angular resolution ($\theta_{syn} < 0''.2$) observations of the 23.1-GHz methanol (CH₃OH) transition toward the massive star forming region NGC 7538 IRS 1. The two velocity components previously reported by Wilson et al. are resolved into distinct spatial features with brightness temperatures (T_B) greater than 10^4 K, proving their maser nature. Thus, NGC 7538 IRS 1 is the third region confirmed to show methanol maser emission at this frequency. The brighter 23.1-GHz spot coincides in position with a rare formaldehyde (H₂CO) maser, and marginally with a 22.2-GHz water (H₂O) maser, for which we report archival observations. The weaker CH₃OH spot coincides with an H₂O maser. The ratio of T_B for the 23.1-GHz masers to that of the well-known 12.2-GHz CH₃OH masers in this region roughly agrees with model predictions. However, the 23.1-GHz spots are offset in position from the CH₃OH masers at other frequencies. This is difficult to interpret in terms of models that assume that all the masers arise from the same clumps, but it may result from turbulent conditions within the gas or rapid variations in the background radiation field.

Published by The Astrophysical Journal, Volume 713, pp. 423-428 (Apr 2010)

<http://arxiv.org/abs/1003.1230>

Physical Properties of Giant Molecular Clouds in the Large Magellanic Cloud

A. Hughes^{1,2}, T. Wong³, J. Ott⁴, E. Müller⁵, J. L. Pineda⁶, Y. Mizuno⁵, J.-P. Bernard⁷, D. Paradis⁸, S. Maddison¹, W. T. Reach^{8,9}, L. Staveley-Smith¹⁰, A. Kawamura⁵, M. Meixner^{11,12}, S. Kim¹³, T. Onishi^{5,14}, N. Mizuno¹⁵ and Y. Fukui⁵

¹ Centre for Supercomputing and Astrophysics, Swinburne University of Technology, Hawthorn VIC 3122, Australia

² CSIRO Australia Telescope National Facility, PO Box 76, Epping NSW 1710, Australia

³ Astronomy Department, University of Illinois, 1002 W. Green St, Urbana, IL 61801, USA

⁴ National Radio Astronomy Observatory, P.O. Box O, 1003 Lopezville Road, Socorro, NM 87801, USA

⁵ Department of Astrophysics, Nagoya University, Furo-cho, Chikusa-ku, Nagoya 464-8602, Japan

⁶ Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, CA 91109-8099, USA

⁷ Centre d'Etude Spatiale des Rayonnements, Université Paul Sabatier, 9 Av du Colonel Roche, BP 44346, Toulouse, France

⁸ Spitzer Science Center, Caltech, MS220-6, Pasadena, CA 91125, USA

⁹ Stratospheric Observatory for Infrared Astronomy, Universities Space Research Association, Mail Stop 211-3, Moffett Field, CA 94035, USA

¹⁰ International Centre for Radio Astronomy Research, M468, University of Western Australia, 35 Stirling Hwy, Crawley, WA 6009, USA

¹¹ Space Telescope Science Institute, 3700 San Martin Drive, Baltimore, MD 21218, USA

¹² Radio and Geoastronomy Division, Harvard-Smithsonian for Astrophysics, 60 Garden St, MS 42, Cambridge, MA 02138-1516, USA

¹³ Department of Astronomy and Space Science, Sejong University, KwangJin-gu, KunJa-dong 98, Seoul 143-747, Korea

¹⁴ Department of Physical Science, Osaka Prefecture University, Gakeun 1-1, Sakai, Osaka 599-8531, Japan

¹⁵ ALMA-J Project Office, National Astronomical Observatory of Japan, 2-21-1 Osawa, Mitaka, Tokyo 181-8588, Japan

E-mail contact: ahughes *at* astro.swin.edu.au

The Magellanic Mopra Assessment (MAGMA) is a high angular resolution CO mapping survey of giant molecular clouds (GMCs) in the Large and Small Magellanic Clouds using the Mopra Telescope. Here we report on the basic physical properties of 125 GMCs in the Large Magellanic Cloud (LMC) that have been surveyed to date. The observed clouds exhibit scaling relations that are similar to those determined for Galactic GMCs, although LMC clouds have narrower linewidths and lower CO luminosities than Galactic clouds of a similar size. The average mass surface density of the LMC clouds is $50 M_{\odot} \text{ pc}^{-2}$ approximately half that of GMCs in the inner Milky Way. We compare the properties of GMCs with and without signs of massive star formation, finding that non-star-forming GMCs have lower peak CO brightness than star-forming GMCs. We compare the properties of GMCs with estimates for local interstellar conditions: specifically, we investigate the HI column density, radiation field, stellar mass surface density and the external pressure. Very few cloud properties demonstrate a clear dependence on the environment; the exceptions are significant positive correlations between i) the HI column density and the GMC velocity dispersion, ii) the stellar mass surface density and the average peak CO brightness, and iii) the stellar mass surface density and the CO surface brightness. The molecular mass surface density of GMCs without signs of massive star formation shows no dependence on the local radiation field, which is inconsistent with the photoionization-regulated star formation theory proposed by McKee (1989). We find some evidence that the mass surface density of the MAGMA clouds increases with the interstellar pressure, as proposed by Elmegreen (1989), but the detailed predictions of this model are not fulfilled once estimates for the local radiation field, metallicity and GMC envelope mass are taken into account.

Accepted by MNRAS

<http://arxiv.org/abs/1004.2094>

The Properties of Massive, Dense, Clumps: Mapping Surveys of HCN and CS

Jingwen Wu^{1,2}, Neal Evans³, Yancy Shirley⁴ and Claudia Knez⁵

¹ Harvard-Smithsonian Center for Astrophysics, 60 Garden st., Cambridge, MA 02138, USA

² Jet Propulsion Laboratory, 4800 Oak Grove Drive Pasadena, CA 91109, USA

³ The University of Texas at Austin, 1 University Station, C1400, Austin, Texas 78712, USA

⁴ Steward Observatory, University of Arizona, Tucson, AZ 85721, USA

⁵ University of Maryland, College Park, MD 20742, USA

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

We have mapped over 50 massive, dense clumps with four dense gas tracers: HCN J=1-0 and 3-2; and CS J=2-1 and 7-6 transitions. Spectral lines of optically thin H^{13}CN 3-2 and C^{34}S 5-4 were also obtained towards the map centers. These maps usually demonstrate single well-peaked distributions at our resolution, even with higher J transitions. The size, virial mass, surface density, and mean volume density within a well-defined angular size (FWHM) were calculated from the contour maps for each transition. We found that transitions with higher effective density usually trace the more compact, inner part of the clumps but have larger linewidths, leading to an inverse linewidth-size relation using different tracers. The mean surface densities are 0.29, 0.33, 0.78, 1.09 g cm^{-2} within FWHM contours of CS 2-1, HCN 1-0, HCN 3-2 and CS 7-6, respectively. We find no correlation of L_{IR} with surface density and a possible inverse correlation with mean volume density, contrary to some theoretical expectations. Molecular line luminosities L'_{mol} were derived for each transition. We see no evidence in the data for the relation between L'_{mol} and mean density posited by modelers. The correlation between L'_{mol} and the virial mass is roughly linear for each dense gas tracer. No obvious correlation was found between the line luminosity ratio and infrared luminosity, bolometric temperature, or the L_{IR}/M_{Vir} ratio. A nearly linear correlation was found between the infrared luminosity and the line luminosity of all dense gas tracers for these massive, dense clumps, with a lower cutoff in luminosity at $L_{IR}=10^{4.5}$ L_{sun} . The $L_{IR}-L'_{HCN1-0}$ correlation agrees well with the one found in galaxies. These correlations indicate a constant star formation rate per unit mass from the scale of dense clumps to that of distant galaxies when the mass is measured for dense gas. These results support the suggestion that starburst galaxies may be understood as having a large fraction of gas in dense clumps.

Accepted by ApJS

<http://arxiv.org/abs/1004.0398>

Variations on Debris Disks II. Icy Planet Formation as a Function of the Bulk Properties and Initial Sizes of Planetesimals

Scott J. Kenyon¹ and Benjamin C. Bromley²

¹ Smithsonian Astrophysical Observatory, 60 Garden Street, Cambridge, MA 02138, USA

² Department of Physics, University of Utah, 201 JFB, Salt Lake City, UT 84112, USA

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

We describe comprehensive calculations of the formation of icy planets and debris disks at 30–150 AU around 1–3 M_{\odot} stars. Disks composed of large, strong planetesimals produce more massive planets than disks composed of small, weak planetesimals. The maximum radius of icy planets ranges from ~ 1500 km to 11,500 km. The formation rate of 1000 km objects – ‘Plutos’ – is a useful proxy for the efficiency of icy planet formation. Plutos form more efficiently in massive disks, in disks with small planetesimals, and in disks with a range of planetesimal sizes. Although Plutos form throughout massive disks, Pluto production is usually concentrated in the inner disk. Despite the large number of Plutos produced in many calculations, icy planet formation is inefficient. At the end of the main sequence lifetime of the central star, Plutos contain less than 10% of the initial mass in solid material. This conclusion is independent of the initial mass in the disk or the properties of the planetesimals. Debris disk formation coincides with the formation of planetary systems containing Plutos. As Plutos form, they stir leftover planetesimals to large velocities. A cascade of collisions then grinds the leftovers to dust, forming an observable debris disk. In disks with small ($\lesssim 1$ –10 km) planetesimals, collisional cascades produce luminous debris disks with maximum luminosity $\sim 10^{-2}$ times the stellar luminosity. Disks with larger planetesimals produce debris disks with maximum luminosity $\sim 5 \times 10^{-4}$ (10 km) to 5×10^{-5} (100 km) times the stellar luminosity. Following peak luminosity, the evolution of the debris disk emission is roughly a power law, $f \propto t^{-n}$ with $n \approx 0.6$ –0.8. Observations of debris disks around A-type and G-type stars strongly favor models with small planetesimals. In these models, our predictions for the time evolution and detection frequency of debris disks agree with published observations. We suggest several critical observations that can test key features of our calculations.

Accepted by Astrophysical Journal Supplement Series

<http://lanl.arxiv.org/abs/0911.4129>

Looking into the hearts of Bok globules: MM and submm continuum images of isolated star-forming cores

R. Launhardt¹, D. Nutter², D. Ward-Thompson², T. L. Bourke³, Th. Henning¹, T. Khanzadyan^{1,4}, M. Schmalzl¹, S. Wolf^{1,5} and R. Zylka⁶

¹ Max Planck Institute for Astronomy, Koenigstuhl 17, D-69117 Heidelberg, Germany

² School of Physics and Astronomy, Cardiff University, Queens Buildings, The Parade, Cardiff, CF24 3AA, UK

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

⁴ Dept. Experimental Physics, National University of Ireland Galway, Galway, Ireland

⁵ University of Kiel, Institute of Theoretical Physics and Astrophysics, Leibnizstrasse 15, 24098 Kiel, Germany

⁶ Institut de Radio Astronomie Millimétrique, 300 Rue de la Piscine, Domaine Universitaire, 38406 Saint Martin d’Heres, France

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

We present the results of a comprehensive infrared, submillimetre, and millimetre continuum emission study of isolated low-mass star-forming cores in 32 Bok globules, with the aim to investigate the process of star formation in these regions. The submillimetre and millimetre dust continuum emission maps together with the spectral energy distributions are used to model and derive the physical properties of the star-forming cores, such as luminosities, sizes, masses, densities, etc. Comparisons with ground-based near-infrared and space-based mid and far-infrared images from Spitzer are used to reveal the stellar content of the Bok globules, association of embedded young stellar objects with the submm dust cores, and the evolutionary stages of the individual sources. Submm dust continuum emission was detected in 26 out of the 32 globule cores observed. For 18 globules with detected (sub)mm cores we derive evolutionary stages and physical parameters of the embedded sources. We identify nine starless cores, most of which are presumably prestellar, nine Class 0 protostars, and twelve Class I YSOs. Specific source properties like bolometric temperature, core size, and central densities are discussed as function of evolutionary stage. We find that at least

two thirds (16 out of 24) of the star-forming globules studied here show evidence of forming multiple stars on scales between 1,000 and 50,000 AU. However, we also find that most of these small protostar and star groups are comprised of sources with different evolutionary stages, suggesting a picture of slow and sequential star formation in isolated globules

Accepted by The Astrophysical Journal Supplement Series

Grain growth across protoplanetary discs: 10- μ m silicate feature versus millimetre slope

Dave Lommen^{1,8}, Ewine van Dishoeck^{1,2}, Chris Wright³, Sarah Maddison⁴, Michiel Min^{5,6}, David Wilner⁷, Demerese Salter¹, Huib Jan van Langevelde^{8,1}, Tyler Bourke⁷, Remco van der Burg¹ and Geoffrey Blake⁹

¹ Leiden Observatory, Leiden University, P.O. Box 9513, 2300 RA Leiden, The Netherlands

² Max-Planck-Institut für extraterrestrische Physik, Garching, Germany

³ School of Physical, Environmental and Mathematical Sciences, UNSW@ADFA, Canberra ACT 2600, Australia

⁴ Centre for Astrophysics and Supercomputing, Swinburne University of Technology, PO Box 218, Hawthorn, VIC 3122, Australia

⁵ Astronomical Institute Utrecht, Princetonplein 5, 3584 CC Utrecht, The Netherlands

⁶ Astronomical institute Anton Pannekoek, University of Amsterdam, Kruislaan 403, 1098 SJ Amsterdam, The Netherlands

⁷ Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, 02138 Cambridge, MA, USA

⁸ Joint Institute for VLBI in Europe, PO Box 2, 7990 AA Dwingeloo, The Netherlands

⁹ California Institute of Technology, Pasadena, CA 91125, USA

E-mail contact: DaveLommen *at* gmail.com

Context. Young stars are formed with dusty discs around them. The dust grains in the disc are originally of the same size as interstellar dust, i.e., of the order of 0.1 micron. Models predict that these grains will grow in size through coagulation. Observations of the silicate features around 10 and 20 micron are consistent with growth from submicron to micron sizes in selected sources whereas the slope of the spectral energy distribution (SED) at mm and cm wavelengths traces growth up to mm sizes and larger.

Aims. We here look for a correlation between these two grain growth indicators.

Methods. A large sample of T-Tauri and Herbig-Ae/Be stars, spread over the star-forming regions in Chamaeleon, Lupus, Serpens, Corona Australis, and the Gum nebula in Vela, was observed with the Spitzer Space Telescope at 5.8 micron and a subsample was observed with the SMA, ATCA, CARMA, and VLA at mm wavelengths. We complement this subsample with data from the literature to maximise the overlap between micron and mm observations and search for correlations in the grain-growth signatures. Synthetic spectra are produced to determine which processes may produce the dust evolution observed in protoplanetary discs.

Results. Dust disc masses in the range 1 to 7 x 10⁻⁴ solar masses are obtained. The majority of the sources have a mm spectral slope consistent with grain growth. There is a tentative correlation between the strength and the shape of the 10-micron silicate feature and the slope of the SED between 1 and 3 mm. The observed sources seem to be grouped per star-forming region in the 10-micron-feature vs mm-slope diagram. The modelling results show that, if only the maximum grain size is increased, first the 10-micron feature becomes flatter and subsequently the mm slope becomes shallower. To explain the sources with the shallowest mm slopes, a grain size distribution shallower than that of the interstellar medium is required. Furthermore, the strongest 10-micron features can only be explained with bright (6 solar masses), hot (Teff = 4000 K) central stars. Settling of larger grains towards the disc midplane results in a stronger 10-micron feature, but has a very limited effect on the mm slope.

Conclusions. A tentative correlation between the strength of the 10-micron feature and the mm slope is found, which would imply that the inner and outer disc evolve simultaneously. Dust with a mass dominated by large, mm-sized, grains is required to explain the shallowest mm slopes. Other processes besides grain growth, such as the clearing of an inner disc by binary interaction, may also be responsible for the removal of small grains. Observations with future telescopes with larger bandwidths or collecting areas are required to provide the necessary statistics to study these processes of disc and dust evolution.

Accepted by Astronomy and Astrophysics

<http://fr.arxiv.org/abs/1004.0158>

The Complex Structure of HH 110 as Revealed from Integral Field Spectroscopy

Rosario Lopez¹, Begoa Garcia-Lorenzo², Sebastin F. Sanchez³, Gabriel Gomez⁴, Robert Estalella¹ and Angels Riera⁵

¹ Departament d’Astronomia i Meteorologia (UB), Marti i Franques,1, Barcelona, Spain

² Instituto de Astrofisica de Canarias & U. La Laguna, La Laguna, Spain

³ CEFCA & CAHA, General Pizarro, 1, Teruel & Jesus Durban Remon, 2, Almera, Spain

⁴ GTC Project Office, CALP, La Palma, Spain

¹ Departament d’Astronomia i Meteorologia (UB), Marti i Franques,1, Barcelona, Spain

⁵ Departament Fsica i Enginyeria Nuclear (UPC), Comte d’Urgel 187, Barcelona, Spain

E-mail contact: rosario *at* am.ub.es

HH 110 is a rather peculiar Herbig-Haro object in Orion that originates due to the deflection of another jet (HH 270) by a dense molecular clump, instead of being directly ejected from a young stellar object. Here we present new results on the kinematics and physical conditions of HH 110 based on Integral Field Spectroscopy. The 3D spectral data cover the whole outflow extent (~ 4.5 arcmin, ~ 0.6 pc at a distance of 460 pc) in the spectral range 6500–7000 Å. We built emission-line intensity maps of H α , [NII] and [SII] and of their radial velocity channels. Furthermore, we analysed the spatial distribution of the excitation and electron density from [NII]/H α , [SII]/H α , and [SII] 6716/6731 integrated line-ratio maps, as well as their behaviour as a function of velocity, from line-ratio channel maps. Our results fully reproduce the morphology and kinematics obtained from previous imaging and long-slit data. In addition, the IFS data revealed, for the first time, the complex spatial distribution of the physical conditions (excitation and density) in the whole jet, and their behaviour as a function of the kinematics. The results here derived give further support to the more recent model simulations that involve deflection of a pulsed jet propagating in an inhomogeneous ambient medium. The IFS data give richer information than that provided by current model simulations or laboratory jet experiments. Hence, they could provide valuable clues to constrain the space parameters in future theoretical works.

Accepted by MNRAS

<http://www.am.ub.es/~robert/ISMpub.html>

Initial conditions for globular clusters and assembly of the old globular cluster population of the Milky Way

Michael Marks^{1,2} and Pavel Kroupa¹

¹ Argelander Institute for Astronomy, University of Bonn, Auf dem Hügel 71, 53121 Bonn, Germany

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

E-mail contact: mmarks *at* astro.uni-bonn.de

By comparing the outcome of N -body calculations that include primordial residual-gas expulsion with the observed properties of 20 Galactic globular clusters (GCs) for which the stellar mass function (MF) has been measured, we constrain the time-scale over which the gas of their embedded cluster counterparts must have been removed, the star formation efficiency the progenitor cloud must have had and the strength of the tidal-field the clusters must have formed in. The three parameters determine the expansion and mass-loss during residual-gas expulsion. After applying corrections for stellar and dynamical evolution we find birth cluster masses, sizes and densities for the GC sample and the same quantities for the progenitor gas clouds. The pre-cluster cloud core masses were between 10^5 – $10^7 M_{\odot}$ and half-mass radii were typically below 1 pc and reach down to 0.2 pc. We show that the low-mass present day (PD) MF slope, initial half-mass radius and initial density of clusters correlates with cluster metallicity, unmasking metallicity as an important parameter driving cluster formation and the gas expulsion process. This work predicts that PD low-concentration clusters should have a higher binary fraction than PD high-concentration clusters.

Since the oldest GCs are early residuals from the formation of the Milky Way (MW) and the derived initial conditions probe the environment in which the clusters formed, we use the results as a new tool to study the formation of the inner GC system of the Galaxy. We achieve time-resolved insight into the evolution of the pre-MW gas cloud on short time-scales (tens of Myr) via cluster metallicities. The results are shown to be consistent with a contracting and self-gravitating cloud in which fluctuations in the primordial pre-MW potential grow with time. An initially relatively smooth tidal-field evolved into a grainy potential within the collapse-time of the cloud.

Where is the warm H₂ ?

A search for H₂ emission from disks around Herbig Ae/Be stars

C. Martin-Zaïdi¹, J.-C. Augereau¹, F. Ménard¹, J. Olofsson¹, A. Carmona², C. Pinte³, and E. Habart⁴

¹ Université Joseph Fourier - Grenoble 1 / CNRS, Laboratoire d'Astrophysique de Grenoble (LAOG) UMR 5571, BP 53, 38041 Grenoble Cedex 09, France

² ISDC Data Centre for Astrophysics & Geneva Observatory, University of Geneva, chemin d'Ecogia 16, 1290 Versoix, Switzerland

³ School of Physics, University of Exeter, Stocker Road, Exeter EX4 4QL, United Kingdom

⁴ Institut d'Astrophysique Spatiale, Université Paris-Sud, 91405 Orsay Cedex, France

E-mail contact: claire.martin-zaidi@obs.ujf-grenoble.fr

Context: Mid-infrared (mid-IR) emission lines of molecular hydrogen (H₂) are useful probes to determine the mass of warm gas present in the surface layers of circumstellar disks. In the past years, numerous observations of Herbig Ae/Be stars (HAeBes) have been performed, but only two detections of H₂ mid-IR emission toward HD 97048 and AB Aur have been reported.

Aims: We aim at tracing the warm gas in the circumstellar environment of five additional HAeBes with gas-rich environments and/or physical characteristics close to those of AB Aur and/or HD 97048, to discuss whether the detections toward these two objects are suggestive of peculiar conditions for the observed gas.

Methods: We search for the H₂ S(1) emission line at 17.035 μm using high-resolution mid-IR spectra obtained with VLT/*VISIR*, and complemented by CH molecule observations with VLT/*UVES*. We gather the H₂ measurements from the literature to put the new results in context and search for a correlation with some disk properties.

Results: None of the five *VISIR* targets shows evidence for H₂ emission at 17.035 μm . From the 3σ upper limits on the integrated line fluxes we constrain the amount of optically thin warm ($> 150\text{ K}$) gas to be less than $\sim 1.4 M_{\text{Jup}}$ in the disk surface layers. There are now 20 HAeBes observed with *VISIR* and *TEXES* instruments to search for warm H₂, but only two detections (HD 97048 and AB Aur) were made so far. We find that the two stars with detected warm H₂ show at the same time high 30/13 μm flux ratios and large PAH line fluxes at 8.6 and 11.3 μm compared to the bulk of observed HAeBes and have emission CO lines detected at 4.7 μm . We detect the CH 4300.3 \AA absorption line toward both HD 97048 and AB Aur with *UVES*. The CH to H₂ abundance ratios that this would imply if it were to arise from the same component as well as the radial velocity of the CH lines both suggest that CH arises from a surrounding envelope, while the detected H₂ would reside in the disk.

Conclusions: The two detections of the S(1) line in the disks of HD 97048 and AB Aur suggest either peculiar physical conditions or a particular stage of evolution. New instruments such as *Herschel* / *PACS* should bring significant new data for the constraints of thermodynamics in young disks by observing the gas and the dust simultaneously.

Accepted by A&A

The Evolutionary State of the Pre-Main Sequence Population in Ophiuchus: A Large Infrared Spectrograph Survey

M. K. McClure^{1,2}, E. Furlan³, P. Manoj², K. L. Luhman⁴, D. M. Watson², W. J. Forrest², C. Espaillat¹, N. Calvet¹, P. D'Alessio⁵, B. Sargent², J. J. Tobin¹ and Chiang Hsin-Fang⁶

¹ Department of Astronomy, The University of Michigan, 500 Church St., 830 Dennison Bldg., Ann Arbor, MI 48109, USA

² Department of Physics and Astronomy, University of Rochester, Rochester, NY 14627, USA

³ JPL, Caltech, Mail Stop 264-767, 4800 Oak Grove Dr., Pasadena, CA 91109, USA

⁴ Department of Astronomy and Astrophysics, The Pennsylvania State University, University Park, PA 16802, USA

⁵ Centro de Radioastronomía y Astrofísica, Universidad Nacional Autónoma de México, 58089 Morelia, Michoacán, México, México

⁶ Q1 2 Department of Astronomy, University of Illinois, 1002 West Green Street, Urbana, IL 61801, USA

E-mail contact: melisma@umich.edu

Variations in molecular cloud environments have the potential to affect the composition and structure of the cir-

cumstellar disks therein. To this end, comparative analyses of nearby star-forming regions are essential to informing theoretical work. In particular, the Ophiuchus molecular clouds are ideal for comparison as they are more compact with much higher extinction than Taurus, the low-mass exemplar, and experience a moderate amount of external radiation. We have carried out a study of a collection of 136 young stellar objects in the <1 Myr old Ophiuchus star-forming region, featuring Spitzer Infrared Spectrograph spectra from 5 to 36 μm , supplemented with photometry from 0.3 μm to 1.3 mm. By classifying these objects using the McClure new molecular cloud extinction law to establish an extinction-independent index, we arrive at a 10% embedded objects fraction, producing an embedded lifetime of 0.2 Myr, similar to that in Taurus. We analyze the degree of dust sedimentation and dust grain processing in the disks, finding that the disks are highly settled with signs of significant dust processing even at 0.3 Myr. Finally, we discuss the wealth of evidence for radial gap structures which could be evidence for disk-planet interactions and explore the effects of stellar multiplicity on the degree of settling and radial structure.

Accepted by ApJS

<http://astro.lsa.umich.edu/~melisma/McClure2010ApJSOph.ps>

Exploring the conditions required to form giant planets via gravitational instability in massive protoplanetary discs

Farzana Meru¹ and Matthew R. Bate¹

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

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

We carry out global three-dimensional radiation hydrodynamical simulations of self-gravitating accretion discs to determine if, and under what conditions, a disc may fragment to form giant planets. We explore the parameter space (in terms of the disc opacity, temperature and size) and include the effect of stellar irradiation. We find that the disc opacity plays a vital role in determining whether a disc fragments. Specifically, opacities that are smaller than interstellar Rosseland mean values promote fragmentation (even at small radii, $R < 25\text{AU}$) since low opacities allow a disc to cool quickly. This may occur if a disc has a low metallicity or if grain growth has occurred. With specific reference to the HR 8799 planetary system, given its star is metal-poor, our results suggest that the formation of its imaged planetary system could potentially have occurred by gravitational instability. We also find that the presence of stellar irradiation generally acts to inhibit fragmentation (since the discs can only cool to the temperature defined by stellar irradiation). However, fragmentation may occur if the irradiation is sufficiently weak that it allows the disc to attain a low Toomre stability parameter.

Accepted by MNRAS

<http://arxiv.org/abs/1004.3766>

Star-forming gas in young clusters

Philip C. Myers¹

¹ Harvard-Smithsonian Center for Astrophysics

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

Initial conditions for star formation in clusters are estimated for protostars whose masses follow the initial mass function from 0.05 to 10 M_{\odot} . Star-forming infall is assumed equally likely to stop at any moment, due to gas dispersal dominated by stellar feedback. For spherical infall, the typical initial condensation must have a steep density gradient, as in low-mass cores, surrounded by a shallower gradient, as in the clumps around cores. These properties match observed column densities in cluster-forming regions when the mean infall stopping time is 0.05 Myr and the accretion efficiency is 0.5. The infall duration increases with final protostar mass, from 0.01 to 0.3 Myr, and the mass accretion rate increases from 3 to $300 \times 10^{-6} M_{\odot} \text{ yr}^{-1}$. The typical spherical accretion luminosity is $\sim 5 L_{\odot}$, reducing the “luminosity problem” to a factor ~ 3 . The initial condensation density gradient changes from steep to shallow at radius 0.04 pc, enclosing 0.9 M_{\odot} , with mean column density $2 \times 10^{22} \text{ cm}^{-2}$, and with effective central temperature 16 K. These initial conditions are denser and warmer than those for isolated star formation.

Accepted by Astrophysical Journal

<http://arxiv.org/abs/1003.4900>

Magnetic Fields Structures and Turbulent Components in the Star Forming Clouds OMC-2 and OMC-3

F. Poidevin¹, P. Bastien² and B. C. Matthews³

¹ Universidade de São Paulo, Instituto de Astronomia, Geofísica e Ciências Atmosféricas, Rua do Matão 1226, Butantã, São Paulo, SP 05508-900, Brazil

² Département de Physique and Observatoire du Mont-Mégantic, Université de Montréal, C.P. 6128, Succ. Centre-ville, Montréal, Québec H3C 3J7, Canada

³ Herzberg Institute of Astrophysics, National Research Council of Canada, Victoria, BC, Canada

E-mail contact: poidevin at astro.iag.usp.br

The SCUBA polarized 850 μm thermal emission data of the region OMC-2 in Orion A are added to and homogeneously reduced with data already available in the region OMC-3. The data set shows that OMC-2 is a region generally less polarized than OMC-3. Where coincident, most of the 850 μm polarization pattern is similar to that measured in 350 μm polarization data. Only 850 μm polarimetry data have been obtained in and around MMS7, FIR1 & FIR2, and in the region south of FIR6. A realignment of the polarization vectors with the filament can be seen near FIR1 in the region south of OMC-3. An analysis shows that the energy injected by CO outflows and H₂ jets associated to OMC-2 and OMC-3 does not appear to alter the polarization patterns at a scale of the 14'' resolution beam. A second order structure function analysis of the polarization position angles shows that OMC-2 is a more turbulent region than OMC-3. OMC-3 appears to be a clear case of a magnetically dominated region with respect to the turbulence. However for OMC-2 it is not clear that this is the case. A more in-depth analysis of five regions displayed along OMC-2/3 indicates a decrease of the mean polarization degree and an increase of the turbulent angular dispersion from north to south. A statistical analysis suggests the presence of two depolarization regimes in our maps. One regime including the effects of the cores, the other one excluding it.

Accepted by The Astrophysical Journal

<http://arxiv.org/abs/1003.5596>

Initial phases of massive star formation in high infrared extinction clouds. I. Physical parameters

K. L. J. Rygl¹, F. Wyrowski¹, F. Schuller¹ and K. M. Menten¹

¹ Max-Planck-Institut für Radioastronomie (MPIfR), Auf dem Hügel 69, 53121 Bonn, Germany

E-mail contact: kazi at mpifr-bonn.mpg.de

The earliest phases of massive star formation are found in cold and dense infrared dark clouds (IRDCs). Since the detection method of IRDCs is very sensitive to the local properties of the background emission, we present here an alternative method to search for high column density in the Galactic plane by using infrared extinction maps. Using this method we find clouds between 1–5 kpc, of which most were missed by previous surveys. By studying the physical conditions of a subsample of these clouds, we aim at a better understanding of the initial conditions of massive star formation. We have made extinction maps of the Galactic plane based on the 3.6–4.5 μm color excess between the two shortest wavelength Spitzer IRAC bands, reaching to visual extinctions of ~ 100 mag and column densities of $5 \times 10^{22} \text{ cm}^{-2}$. From this we compiled a new sample of cold and compact high extinction clouds. We used the MAMBO array at the IRAM 30m telescope to study the morphology, masses and densities of the clouds and the dense clumps within them. The latter were followed up by pointed ammonia observations with the 100m Effelsberg telescope, to determine rotational temperatures and kinematic distances. Extinction maps of the Galactic plane trace large scale structures such as the spiral arms. The extinction method probes lower column densities, $N_{\text{H}_2} \sim 4 \times 10^{22} \text{ cm}^{-2}$, than the 1.2 mm continuum, which reaches up to $N_{\text{H}_2} \sim 3 \times 10^{23} \text{ cm}^{-2}$ but is less sensitive to large scale structures. The 1.2 mm emission maps reveal that the high extinction clouds contain extended cold dust emission, from filamentary structures to still diffuse clouds. Most of the clouds are dark in 24 μm , but several show already signs of star formation via maser emission or bright infrared sources, suggesting that the high extinction clouds contain a variety of evolutionary stages. The observations suggest an evolutionary scheme from dark, cold and diffuse clouds, to clouds with a stronger 1.2 mm peak and to finally clouds with many strong 1.2 mm peaks, which are also warmer, more turbulent and already have some star formation signposts.

Accepted by Astronomy and Astrophysics

<http://arxiv.org/abs/1003.5102>

A detailed study of the accretion disk surrounding the high-mass protostar NGC 7538 S

Göran Sandell¹ and Melvyn Wright²

¹ SOFIA-USRA, NASA Ames Research Center, Mail Stop 211-3, Building N211, Rm. 249, P.O. Box 1, Moffett Field, CA 94035-0001, USA

² Radio Astronomy Laboratory, University of California, Berkeley, 601 Campbell Hall, Berkeley, CA 94720, USA

E-mail contact: Goran.H.Sandell *at* nasa.gov

We present deep high angular resolution observations of the high-mass protostar NGC 7538 S, which is in the center of a cold dense cloud core with a radius of 0.5 pc and a mass of $\sim 2,000 M_{\odot}$. These observations show that NGC 7538 S is embedded in a compact elliptical core with a mass of 85 - 115 M_{\odot} . The star is surrounded by a rotating accretion disk, which powers a very young, hot molecular outflow approximately perpendicular to the rotating accretion disk. The accretion rate is very high, $\sim 1.4 - 2.8 \cdot 10^{-3} M_{\odot} \text{ yr}^{-1}$. Evidence for rotation of the disk surrounding the star is seen in all largely optically thin molecular tracers, $\text{H}^{13}\text{CN } J = 1 \rightarrow 0$, $\text{HN}^{13}\text{C } J = 1 \rightarrow 0$, $\text{H}^{13}\text{CO}^+ J = 1 \rightarrow 0$, and $\text{DCN } J = 3 \rightarrow 2$. Many molecules appear to be affected by the hot molecular outflow, including DCN and H^{13}CO^+ . The emission from CH_3CN , which has often been used to trace disk rotation in young high-mass stars, is dominated by the outflow, especially at higher K-levels. Our new high-angular resolution observations show that the rotationally supported part of the disk is smaller than we previously estimated. The enclosed mass of the inner, rotationally supported part of the disk ($D \sim 5''$, i.e 14,000 AU) is $\sim 14 - 24 M_{\odot}$.

Accepted by Astrophysical Journal

<http://arxiv.org/abs/1004.0643>

A near-infrared variability study in the cloud IC1396W: low star-forming efficiency and two new eclipsing binaries

Alexander Scholz¹, Dirk Froebrich², Chris J. Davis³ and Helmut Meusinger⁴

¹ School of Cosmic Physics, Dublin Institute for Advanced Studies, 31 Fitzwilliam Place, Dublin 2, Ireland

² Centre for Astrophysics and Planetary Science, University of Kent, Canterbury, CT2 7NH, United Kingdom

³ Joint Astronomy Centre, 660 North A'ohoku Place, University Park, Hilo, Hawaii 96720, United States of America

⁴ Thüringer Landessternwarte Tautenburg, Sternwarte 5, D-07778 Tautenburg, Germany

E-mail contact: aleks *at* cp.dias.ie

Identifying the population of young stellar objects (YSOs) in high extinction regions is a prerequisite for studies of star formation. This task is not trivial, as reddened background objects can be indistinguishable from YSOs in near-infrared colour-colour diagrams. Here we combine deep JHK photometry with J- and K-band lightcurves, obtained with UKIRT/WFCAM, to explore the YSO population in the dark cloud IC1396W. We demonstrate that a colour-variability criterion can provide useful constraints on the star forming activity in embedded regions. For IC1396W we find that a near-infrared colour analysis alone vastly overestimates the number of YSOs. In total, the globule probably harbours not more than ten YSOs, among them a system of two young stars embedded in a small (~ 10000 AU) reflection nebula. This translates into a star forming efficiency SFE of $\sim 1\%$, which is low compared with nearby more massive star forming regions, but similar to less massive globules. We confirm that IC1396W is likely associated with the IC1396 HII region. One possible explanation for the low SFE is the relatively large distance to the ionizing O-star in the central part of IC1396. Serendipitously, our variability campaign yields two new eclipsing binaries, and eight periodic variables, most of them with the characteristics of contact binaries.

Accepted by MNRAS

<http://xxx.uni-augsburg.de/abs/1003.2632>

Chandra Detects the Rare Oxygen-type Wolf-Rayet Star WR 142 and OB Stars in Berkeley 87

Kimberly R. Sokal¹, Stephen L. Skinner¹, Svetozar A. Zhekov^{2,3}, Manuel Güdel⁴, and Werner Schmutz⁵

¹ CASA, Univ. of Colorado, Boulder, CO, USA 80309-0389

² JILA, Univ. of Colorado, Boulder, CO, USA 80309-0440

³ On leave from Space Research Institute, Sofia, Bulgaria

⁴ Dept. of Astronomy, Univ. of Vienna, Türkenschanzstr. 17, A-1180 Vienna, Austria

⁵ Physikalisch-Meteorologisches Observatorium Davos and World Radiation Center (PMOD/WRC), Dorfstrasse 33, CH-7260 Davos Dorf, Switzerland

E-mail contact: kimberly.sokal *at* colorado.edu or skimmers *at* casa.colorado.edu

We present first results of a *Chandra* X-ray observation of the rare oxygen-type Wolf-Rayet star WR 142 (= Sand 5 = St 3) harbored in the young, heavily-obscured cluster Berkeley 87. Oxygen type WO stars are thought to be the most evolved of the WRs and progenitors of supernovae or gamma ray bursts. As part of an X-ray survey of supposedly single Wolf-Rayet stars, we observed WR 142 and the surrounding Berkeley 87 region with *Chandra* ACIS-I. We detect WR 142 as a faint, yet extremely hard X-ray source. Due to weak emission, its nature as a thermal or nonthermal emitter is unclear and thus we discuss several emission mechanisms. Additionally, we report seven detections and eight non-detections by *Chandra* of massive OB stars in Berkeley 87, two of which are bright yet soft X-ray sources whose spectra provide a dramatic contrast to the hard emission from WR 142.

Accepted by ApJ

Preprints: <http://arxiv.org/abs/1004.0462>

Near-Infrared Imaging Polarimetry of the Serpens Cloud Core: Magnetic Field Structure, Outflows, and Inflows in A Cluster Forming Clump

Koji Sugitani¹, Fumitaka Nakamura², Motohide Tamura³, Makoto Watanabe⁴, Ryo Kandori³, Shogo Nishiyama⁵, Nobuhiko Kusakabe³, Jun Hashimoto³, Tetsuya Nagata⁴ and Shuji Sato⁶

¹ Graduate School of Natural Sciences, Nagoya City University, Mizuho-ku, Nagoya 467-8501, Japan

² Faculty of Education and Human Sciences, Niigata University, Niigata 950- 2181, Japan

³ National Astronomical Observatory, 2-21-1 Osawa, Mitaka, Tokyo 181-8588, Japan

⁴ Department of CosmoSciences, Hokkaido University, Kita 10, Nishi 8, Kita-ku, Sapporo, Hokkaido 060-0810, Japan

⁵ Department of Astronomy, Kyoto University, Sakyo-ku, Kyoto 606-8502, Japan

⁶ Department of Astrophysics, Nagoya University, Chikusa-ku, Nagoya 464-8602, Japan

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

We made deep near-infrared (*JHKs*) imaging polarimetry toward the Serpens cloud core, which is a nearby, active cluster forming region. The polarization vector maps show that the near-infrared reflection light in this region mainly originates from SVS2 and SVS20, and enable us to detect 24 small infrared reflection nebulae associated with YSOs. Polarization measurements of near-infrared point sources indicate an hourglass-shaped magnetic field, of which symmetry axis is nearly perpendicular to the elongation of the C¹⁸O ($J = 1 - 0$) or submillimeter continuum emission. The bright part of C¹⁸O ($J = 1 - 0$), submillimeter continuum cores as well as many class 0/I objects are located just toward the constriction region of the hourglass-shaped magnetic field. Applying the Chandrasekhar & Fermi method and taking into account the recent study on the signal integration effect for the dispersion component of the magnetic field, the magnetic field strength was estimated to be $\sim 100 \mu\text{G}$, suggesting that the ambient region of the Serpens cloud core is moderately magnetically supercritical. These suggest that the Serpens cloud core first contracted along the magnetic field to be an elongated cloud, which is perpendicular to the magnetic field, and that then the central part contracted cross the magnetic field due to the high density in the central region of the cloud core, where star formation is actively continuing.

Comparison of this magnetic field with the previous observations of molecular gas and large-scale outflows suggests a possibility that the cloud dynamics is controlled by the magnetic field, protostellar outflows and gravitational inflows. Furthermore, the outflow energy injection rate appears to be larger than the dissipation rate of the turbulent energy in this cloud, indicating that the outflows are the main source of turbulence and that the magnetic field plays an important role both in allowing the outflow energy to escape from the central region of the cloud core and enabling the gravitational inflows from the ambient region to the central region. These characteristics appear to be in good agreement with the outflow-driven turbulence model and imply the importance of the magnetic field to continuous star formation in the center region of the cluster forming region.

Accepted by ApJ

<http://arxiv.org/abs/1004.3409>

Age Determination Method of Pre-Main Sequence Stars with High-Resolution I-Band Spectroscopy

Yuhei Takagi¹, Yoichi Itoh¹ and Yumiko Oasa²

¹ Kobe University, 1-1 Rokkodai, Nada, Kobe, Hyogo, Japan

² Saitama University, 255 Shimo-Okubo, Sakura, Saitama, Saitama, Japan

E-mail contact: takagi *at* stu.kobe-u.ac.jp

We present a new method for determining the age of late-K type pre-main sequence (PMS) stars by deriving their surface gravity from high-resolution I-band spectroscopy. Since PMS stars contract as they evolve, age can be estimated from surface gravity. We used the equivalent width ratio (EWR) of nearby absorption lines to create a surface gravity diagnostic of PMS stars that is free of uncertainties due to veiling. The ratios of Fe (818.67nm and 820.49nm) and Na (818.33nm and 819.48nm) absorption lines were calculated for giants, main-sequence stars, and weak-line T Tauri stars. Effective temperatures were nearly equal across the sample. The Fe to Na EWR (Fe/Na) decreases significantly with increasing surface gravity, denoting that Fe/Na is a desirable diagnostic for deriving the surface gravity of pre-main sequence stars. The surface gravity of PMS stars with 0.8 solar mass is able to be determined with an accuracy of 0.1-0.2, which conducts the age of PMS stars within a factor of 1.5, in average.

Accepted by Publications of the Astronomical Society of Japan (PASJ)

<http://arxiv.org/abs/1004.1971>

Radiation Magnetohydrodynamics Simulation of Proto-stellar Collapse: Two-component Molecular Outflow

Kengo Tomida^{1,2}, Kohji Tomisaka^{1,2}, Tomoaki Matsumoto³, Ken Ohsuga^{1,2}, Masahiro N. Machida² and Kazuya Saigo²

¹ Department of Astronomical Science, The Graduate University for Advanced Studies (SOKENDAI), Osawa, Mitaka, Tokyo 181-8588, Japan

² National Astronomical Observatory of Japan, Osawa, Mitaka, Tokyo 181-8588, Japan

³ Faculty of Humanity and Environment, Hosei University, Fujimi, Chiyodaku, Tokyo 102-8160, Japan

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

We perform a three-dimensional nested-grid radiation magneto-hydrodynamics (RMHD) simulation with self-gravity to study the early phase of the low-mass star formation process from a rotating molecular cloud core to a first adiabatic core just before the second collapse begins. Radiation transfer is handled with the flux-limited diffusion approximation, operator-splitting and implicit time-integrator. In the RMHD simulation, the outer region of the first core attains a higher entropy and the size of first core is larger than that in the magnetohydrodynamics simulations with the barotropic approximation. Bipolar molecular outflow consisting of two components is driven by magnetic Lorentz force via different mechanisms, and shock heating by the outflow is observed. Using the RMHD simulation we can predict and interpret the observed properties of star-forming clouds, first cores and outflows with millimeter/submillimeter radio interferometers, especially the Atacama Large Millimeter/submillimeter Array (ALMA).

Accepted by The Astrophysical Journal Letters

<http://jp.arxiv.org/abs/1001.4796>

Shock-triggered formation of magnetically-dominated clouds. II. Weak shock-cloud interaction in three dimensions.

S. Van Loo^{1,2}, S. A. E. G. Falle³ and T. W. Hartquist¹

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

² Department of Astronomy, University of Florida, Gainesville, Florida 32611, USA

³ Department of Applied Mathematics, University of Leeds, Leeds LS2 9JT, UK

E-mail contact: svenvl *at* astro.ufl.edu

To understand the formation of a magnetically dominated molecular cloud from an atomic cloud, we study the interac-

tion of a weak, radiative shock with a magnetised cloud. The thermally stable warm atomic cloud is initially in static equilibrium with the surrounding hot ionised gas. A shock propagating through the hot medium then interacts with the cloud. We follow the dynamical evolution of the shocked cloud with a time-dependent ideal magnetohydrodynamic code. By performing the simulations in 3D, we investigate the effect of different magnetic field orientations including parallel, perpendicular and oblique to the shock normal. We find that the angle between the shock normal and the magnetic field must be small to produce clouds with properties similar to observed molecular clouds.

Accepted by MNRAS

<http://arxiv.org/abs/1003.5843>

HD 95881: A gas rich to gas poor transition disk?

A.P. Verhoeff¹, M. Min², B. Acke³, R. van Boekel⁴, E. Pantin⁵, L.B.F.M. Waters^{1,3}, A.G.G.M. Tielens⁶, M.E. van den Ancker⁷, G.D. Mulders^{1,8}, A. de Koter^{1,2} and J. Bouwman⁴

¹ Astronomical Institute 'Anton Pannekoek', University of Amsterdam, P.O. Box 94249, 1090 GE Amsterdam, The Netherlands

² Astronomical Institute Utrecht, University of Utrecht, P.O. Box 80000, 3508 TA Utrecht, The Netherlands

³ Institute for Astronomy, KU Leuven Celestijnenlaan 200B, B-3001 Leuven, Belgium

⁴ Max Planck Institut für Astronomie, Königstuhl 17, 69117 Heidelberg, Germany

⁵ CEA/DSM/DAPNIA/Service d'Astrophysique, CE Saclay F-91191 Gif-sur-Yvette, France

⁶ Leiden Observatory, Niels Bohrweg 2, 2300 RA Leiden, The Netherlands

⁷ European Southern Observatory, Karl-Schwarzschild-Strasse 2, 85748 Garching bei München, Germany

⁸ SRON Netherlands Institute for Space Research, PO Box 800, 9700 AV, Groningen, The Netherlands

E-mail contact: verhoeff *at* uva.nl

Context. Based on the far infrared excess the Herbig class of stars is divided into a group with flaring circumstellar disks (group I) and a group with flat circumstellar disks (group II). Dust sedimentation is generally proposed as an evolution mechanism to transform flaring disks into flat disks. Theory predicts that during this process the disks preserve their gas content, however observations of group II Herbig Ae stars demonstrate a lack of gas. *Aims.* We map the spatial distribution of the gas and dust around the group II Herbig Ae star HD 95881. *Methods.* We analyze optical photometry, Q-band imaging, infrared spectroscopy, and K and N-band interferometric spectroscopy. We use a Monte Carlo radiative transfer code to create a model for the density and temperature structure which quite accurately reproduces all the observables. *Results.* We derive a consistent picture in which the disk consists of a thick puffed up inner rim and an outer region which has a flaring gas surface and is relatively void of 'visible' dust grains. *Conclusions.* HD 95881 is in a transition phase from a gas rich flaring disk to a gas poor self-shadowed disk.

Accepted by A&A

<http://arxiv.org/abs/1004.2208>

A Chandra Study of the Rosette Star-Forming Complex. III. The NGC 2237 Cluster and the Region's Star Formation History

Junfeng Wang^{1,2}, Eric D. Feigelson¹, Leisa K. Townsley¹, Patrick S. Broos¹, Carlos G. Román-Zúñiga³, Elizabeth Lada⁴ and Gordon Garmire¹

¹ Penn State, USA

² Harvard-Smithsonian Center for Astrophysics, USA

³ CAHA, Spain

⁴ University of Florida, USA

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

We present high spatial resolution *Chandra* X-ray images of the NGC 2237 young stellar cluster on the periphery of the Rosette Nebula. We detect 168 X-ray sources, 80% of which have stellar counterparts in USNO, 2MASS, and deep FLAMINGOS images. These constitute the first census of the cluster members with $0.2 \lesssim M \lesssim 2 M_{\odot}$. Star locations in near-infrared color-magnitude diagrams indicate a cluster age around 2 Myr with a visual extinction of $1 \lesssim A_V \lesssim 3$ at 1.4 kpc, the distance of the Rosette Nebula's main cluster NGC 2244. We derive the K-band luminosity function and

the X-ray luminosity function of the cluster, which indicate a population ~ 400 – 600 stars. The X-ray-selected sample shows a K -excess disk frequency of 13%. The young Class II counterparts are aligned in an arc ~ 3 pc long suggestive of a triggered formation process induced by the O stars in NGC 2244. The diskless Class III sources are more dispersed. Several X-ray emitting stars are located inside the molecular cloud and around gaseous pillars projecting from the cloud. These stars, together with a previously unreported optical outflow originating inside the cloud, indicate that star formation is continuing at a low level and the cluster is still growing.

This X-ray view of young stars on the western side of the Rosette Nebula complements our earlier studies of the central cluster NGC 2244 and the embedded clusters on the eastern side of the Nebula. The large scale distribution of the clusters and molecular material is consistent with a scenario in which the rich central NGC 2244 cluster formed first, and its expanding HII region triggered the formation of the now-unobscured satellite clusters RMC XA and NGC 2237. A large swept-up shell material around the HII region is now in a second phase of collect-and-collapse fragmentation, leading to the recent formation of subclusters. Other clusters deeper in the molecular cloud appear unaffected by the Rosette Nebula expansion.

Accepted by ApJ

<http://arxiv.org/abs/1004.1422>

The Effects of Large-Scale Magnetic Fields on Disk Formation and Evolution

Arieh Königl¹ and Raquel Salmeron²

¹ Department of Astronomy & Astrophysics, The University of Chicago, Chicago IL 60637, USA

² Research School of Astronomy & Astrophysics and Research School of Earth Sciences, The Australian National University, Canberra ACT 0200, Australia

E-mail contact: akonigl *at* uchicago.edu

Sect. 1 presents the motivation for considering the effects of a large-scale, ordered magnetic field on the formation and evolution of protostellar disks. Sect. 2 outlines the physical principles that underlie the magnetohydrodynamics of disks that are threaded by such a field. Sect. 3 discusses the formation and early evolution of disks that result from the collapse of a rotating molecular cloud core that is coupled to the interstellar magnetic field. Sect. 4 reviews the observational evidence for the disk–wind connection and describes the structure of magnetically accelerated disk outflows, focusing on centrifugally driven winds; it then goes on to discuss the equilibrium and stability properties of weakly ionized protostellar accretion disks in which the transport of angular momentum is dominated by a wind of this type. Sect. 5 considers the coupling between the central protostar and the surrounding disk through the protostellar magnetic field, covering, in turn, the phenomenology, basic concepts, and results of numerical simulations. The chapter is summarized in Sect. 6, which also contains a discussion of future research directions.

To be published as a chapter in *Physical Processes in Circumstellar Disks around Young Stars*, a volume in the Theoretical Astrophysics Series by the University of Chicago Press.

<http://arxiv.org/abs/1004.1875>

Debris Disks: Seeing Dust, Thinking of Planetesimals and Planets

Alexander V. Krivov¹

¹ Astrophysical Institute and University Observatory, Friedrich Schiller University Jena, Schillergäßchen 2–3, 07745 Jena, Germany

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

Debris disks are optically thin, almost gas-free dusty disks observed around a significant fraction of main-sequence stars older than about 10 Myr. Since the circumstellar dust is short-lived, the very existence of these disks is considered as evidence that dust-producing planetesimals are still present in mature systems, in which planets have formed — or failed to form — a long time ago. It is inferred that these planetesimals orbit their host stars at asteroid to Kuiper-belt distances and continually supply fresh dust through mutual collisions. This review outlines observational techniques and results on debris disks, summarizes their essential physics and theoretical models, and then places them into the general context of planetary systems, uncovering interrelations between the disks, dust parent bodies, and planets. It is shown that debris disks can serve as tracers of planetesimals and planets and shed light on the planetesimal and planet formation processes that operated in these systems in the past.

Accepted by Research in Astronomy and Astrophysics

<http://arxiv.org/abs/1003.5229>

Postdoctoral position - Laboratoire d'Astrophysique de Bordeaux

The Laboratoire d'Astrophysique de Bordeaux (LAB) carries out observational, interpretative and theoretical research in various fields of astrophysics including the interstellar medium, planet and star formation, and stellar populations. The LAB has also been involved in the technical development and commissioning of several major sub-systems for the Herschel satellite and ground-based millimeter interferometer ALMA, along with preparation of the astrometric space mission Gaia. In this context, applications are invited for a postdoctoral fellow to work on one of the following research topics:

- T1: Measuring magnetic fields in proto-planetary discs: a high resolution search for polarized emission in the millimeter domain
- T2: Complex molecules in Orion KL - A high resolution interferometric study
- T3: Herschel M33 Extended Survey - A study of molecular cloud and star formation in M33
- T4: Astrometry and spectroscopy of open clusters and young associations for probing the galactic disc in the perspective of Gaia

Scientific details on each of these topics are available at <http://www.obs.u-bordeaux1.fr/LABpostdoc.html>

To be considered, applicants must have a Ph. D. in astrophysics and substantial background in the relevant field. The initial appointment will be available from September 1, 2010, and will be for one year, with the possibility of extending for a second year (subject to satisfactory performance). The gross salary will be 31200 Euros per year (net salary: 25800 Euros).

Applicants should submit a brief summary of past scientific research, curriculum vitae, bibliography and a cover letter to charlot@obs.u-bordeaux1.fr before June 1, 2010. Applicants should indicate which topic (T1 to T4) is concerned and have two reference letters sent to the above address by the same deadline.

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.

Planetary Systems
Detection, Formation and Habitability of Extrasolar Planets

M. Ollivier, T. Encrenaz, F. Roques, F. Selsis, F. Casoli

The study of exoplanets has virtually exploded in the little more than a decade since the first one was detected. More than 400 exoplanets are now known, with a new one appearing twice a week thanks to ever more sensitive detection methods. These discoveries have brought one surprise after the other, to the point where it is uncertain whether the architecture of our own solar system is an exception among planetary systems. The authors have taken on the task of distilling the key results from the wealth of studies, observational as well as theoretical, that have been forthcoming in recent years. This is a courageous effort, given the rapid pace of exoplanet studies, and it is not clear how long the book will remain à jour. But at least for now, the book provides a wide ranging and insightful account of our current knowledge of exoplanets and their formation, properties and physics. The book will also serve well as the basis for a graduate course on exoplanets. The book is richly illustrated (although Springer could have done a better job of reproducing the figures). Each chapter has a bibliography to key papers.

The book contains the following chapters:

1. Planetary Systems

1. Introduction
2. The Plurality of Worlds
3. First Searches for Other Worlds
4. The Solar System: A Typical Planetary System?

2. Detection Methods

1. The Extent of the Problem
2. The Indirect Detection of Exoplanets
3. Direct Detection of Exoplanets

3. Extrasolar Planets, 12 Years After the First Discovery

1. Exoplanets and Exoplanetary Systems
2. The Mass-Distribution of Exoplanets
3. The Distance-Distribution of Exoplanets
4. The Relationship between the Mass of Exoplanets and their Distance from their Star
5. Orbital Eccentricity among Exoplanets
6. Exoplanets and their Parent Stars
7. Mass/Diameter Ratio
8. Characteristics of Extrasolar Planetary Atmospheres

4. What we Learn from the Solar System

1. Observational Methods
2. The Observational Data
3. The Emergence of a 'Standard Model'
4. The Physical and Chemical Properties of Solar-System Objects
5. Conclusions: The Solar System Compared with Other Planetary Systems

5. Stellar Formation and Protoplanetary Disks

1. The First Stages in Stellar Formation
2. Structure and Evolution of Protoplanetary Disks
3. Planetary Disks and Debris Disks
4. The Formation of Planetesimals and Planetary Embryos

6. The Dynamics of Planetary Systems

1. Characteristics of the Orbits

2. Migration
3. Stability of Planetary Systems
4. Planetary Systems around Pulsars
5. The Dynamics of Debris Disks

7. Structure and Evolution of an Exoplanet

1. The Internal Structure of Giant Exoplanets
2. The Internal Structure of Terrestrial-Type Exoplanets and Ocean Planets
3. The Atmospheres of Exoplanets: Their Structure, Evolution and Spectral Characteristics

8. Present and Future Instrumental Projects

1. Indirect Methods of Detection
2. Direct Methods of Detection

9. The Search for Life in Planetary Systems

1. What is Life?
2. Prebiotic Material in the Universe
3. Stages on the Road to Complexity
4. The Appearance of Life on the Primitive Earth
5. The Search for Habitable Locations in the Solar System
6. The Search for Life on Exoplanets
7. The Search for Extraterrestrial Civilisations

Springer Verlag, ISBN 978-3-540-75747-4, hardback, 342 pages, 2009, US\$119.00

Available from

<http://www.springer.com/astronomy/astrophysics+and+astroparticles/book/978-3-540-75747-4>

The Origin of Stellar Masses

18 – 22 October 2010

Tenerife, Canary Islands, Spain

Stars are one of the fundamental building blocks of the Universe: the source of most of the chemical elements; a crucial ingredient in the formation and evolution of galaxies; the progenitors of supernovae, gamma ray bursts, and black holes; the hosts of planetary systems; and the sustainer of life. In some ways, stars are relatively simple objects; the evolution and fate of a star is almost uniquely determined by its mass. However, the formation of a star is anything but simple, involving a complex interplay between gravity, hydrodynamics, magnetic fields, radiation transport, and chemistry. Great progress has been made in delineating the roles of these physical processes through theory and observations, but a fundamental mystery remains, one of the most important questions in astronomy. What determines the masses of stars and how does the distribution of stellar masses arise, the so-called Initial Mass Function (IMF)?

We expect that progress in answering this question will accelerate with the advent of several new instruments operating at (sub-)mm wavelengths and the increasing ability for numerical models to include the relevant physics. The Herschel Space Observatory has just begun science observations, SCUBA-2 on the JCMT has just become operational, and the first early science observations with ALMA should be made in the year following this meeting. On the theoretical side, hydrodynamical simulations of star formation have been able to begin including magnetic fields, radiation transport, and chemistry.

Thus, the time is right for a meeting focussing on the observational and theoretical aspects of the origin of stellar masses, with the programme centred around three topical questions:

- From clouds to core to protostars: what processes are involved in transforming molecular clouds into clusters of protostars?
- The birth and influence of massive stars: how and why do massive stars form and what is their influence on further star formation?
- The physics of the low-mass end of the IMF: how and why do brown dwarfs form, and what is the physics of their atmospheres?

In recognition of the fact that this field is highly active with many young researchers, there will be an emphasis on talks given by young researchers and the programme will include ample time for discussion led by panels of experience researchers.

Invited Speakers include: Lori Allen, Philippe André, Isabelle Baraffe, Shantanu Basu (tbc), Henrik Beuther, Jerome Bouvier, Chris Brunt, Gilles Chabrier (tbc), Pavel Kroupa (tbc), Kevin Luhman, Lee Hartmann, Phil Myers (tbc), Francesco Palla, Jonathan Tan

Scientific Organizing Committee: Matthew Bate (chair), Philippe André, Isabelle Baraffe, Ian Bonnell, Jérôme Bouvier, Nicolas Lodieu, Ana López Sepulcre, Eduardo Martin, Mark McCaughrean, Michael Meyer, Giusi Micela, Jan Palous, Elaine Winston, João Yun, Hans Zinnecker,

Local Organizing Committee: Nicolas Lodieu (chair), Judith de Araoz, Vctor Béjar, Eva Bejarano, Susie Burdett, Tanja Karthaus, Eduardo Martin, Karla Peña Ramirez, Manuel Perger

For registration, contact details, and further information, please visit the website:

<http://www.iac.es/congreso/constellation10/>

Herschel and the Formation of Stars and Planetary Systems

September 6-9, 2010

Gothenburg, Sweden

The goal of this conference is to bring together researchers from the infrared and star formation communities to share recent research results, contrast them with earlier insights gained from ground-based and space-based observatories, and help guide our theoretical understanding of physical and chemical processes in regions of star and planet formation. The meeting comes at a time when the early, exciting results from the Herschel Key Programs will become available. The scientific themes of the meeting include:

1. The characteristics of dust and gas in prestellar cores
2. The characteristics of dust and gas around protostars
3. From protoplanetary disks to debris disks
4. The organic inventory of regions of star and planet formation

The format for the workshop would allow for invited reviews and contributed talks in approximately equal number. In addition, there will be poster sessions. Total attendance will be limited to 150 participants.

The conference is now open for registration, please, visit the web site.

Invited Speakers:

Willy Benz: Theory of planet formation

Jeroen Bouwman: Evolution of solids in protoplanetary discs

Sylvie Cabrit (tbc): Protostellar outflows

Nuria Calvet: Evidence for planet formation

Paola Caselli: The chemical interaction of dust and gas in prestellar cores

Carsten Dominik: Characteristics and evolution of protoplanetary discs

Neal Evans: The early evolution of protostars

Robin Garrod: The chemical evolution of regions of star formation

Fabian Heitsch: From clouds to prestellar cores

Brenda Matthews: Observations of debris discs

Amaya Moro-Martin: Debris discs and our understanding of the evolution of planetary systems

Frederique Motte: Herschel studies of molecular clouds and prestellar cores

Ilaria Pascucci: Evolution of gas in protoplanetary discs

Leonardo Testi: The formation of massive stars

Ewine van Dishoeck: Herschel observations of the earliest phases of star formation

Mark Wyatt: The Solar System and our understanding of debris discs

Members of the SOC:

J. Black, M. Griffin, E. Herbst, F. Helmich, Th. Henning, R. Liseau (co-chair), M. Meyer, A. Natta, G. Pilbratt, A. Poglitsch, A. Sargent, M. Tafalla, A. Tielens (chair), R. Waters

Members of the LOC:

Camilla Andersson, Per Bjerkerli, Kay Justtanont, Rene Liseau (chair), Michael Olberg, Carina Persson

Web Address: <http://www.chalmers.se/herschel>

Great Barriers in High Mass Star Formation
to be held in Townsville, North Queensland, Australia
13-17th September 2010

<http://www.jcu.edu.au/hmsf10>

Registration and abstract submission are now open for the conference. Please follow the link to the above website and then to "Registration". There are only a limited number of places available for the Great Barrier Reef dive/snorkel trip, so please register early if you are interested.

Note that early registration, and the abstract submission deadline is 15th of June, 2010.

Andrew Walsh
hmsf10 at jcu.edu.au
on behalf of the SOC and LOC

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

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

The Star Formation Newsletter is available on the World Wide Web at <http://www.ifa.hawaii.edu/users/reipurth/newsletter.htm>.