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## *Abstracts of recently accepted papers*

### **MWC 297: a young high-mass star rotating at critical velocity**

**B. Acke<sup>1</sup>, T. Verhoelst<sup>1,7</sup>, M.E. van den Ancker<sup>2</sup>, P. Deroo<sup>1</sup>, C. Waelkens<sup>1</sup>, O. Chesneau<sup>3</sup>, E. Tatulli<sup>4</sup>, M. Benisty<sup>5</sup>, E. Puga<sup>1</sup>, L.B.F.M. Waters<sup>1,6</sup>, A. Verhoeff<sup>6</sup> and A. de Koter<sup>6</sup>**

<sup>1</sup> Instituut voor Sterrenkunde, KULeuven, Celestijnenlaan 200D, B-3001 Leuven, Belgium

<sup>2</sup> European Southern Observatory, Karl-Schwarzschild-Str. 2, D-85748 Garching, Germany

<sup>3</sup> Observatoire de la Côte d'Azur/CNRS, BP 4229, 06304 Nice Cédex 4, France

<sup>4</sup> Osservatorio Astrofisico di Arcetri, L.go E. Fermi, 5, 50125 Firenze, Italy

<sup>5</sup> Laboratoire d'Astrophysique de l'Observatoire de Grenoble, BP 53, F-38041 Grenoble Cédex 9, France

<sup>6</sup> Sterrenkundig Instituut 'Anton Pannekoek', Kruislaan 403, 1098 SJ Amsterdam, the Netherlands

<sup>7</sup> University of Manchester, Jodrell Bank Centre for Astrophysics, Manchester, M13 9PL, U.K.

E-mail contact: bram@ster.kuleuven.be

*Context.* MWC 297 is a nearby young massive B[e] star. The central star is attenuated by 8 magnitudes in the optical and has a high projected rotational velocity of  $350 \text{ km s}^{-1}$ . Despite the wealth of published observations, the nature of this object and its circumstellar environment is not understood very well.

*Aims.* With the present paper, we intend to shed light on the geometrical structure of the circumstellar matter that is responsible for the near- to mid-infrared flux excess.

*Methods.* The H-band ( $1.6\text{--}2.0 \mu\text{m}$ ), K-band ( $2.0\text{--}2.5 \mu\text{m}$ ), and N-band ( $8\text{--}13 \mu\text{m}$ ) brightness distribution of MWC 297 was probed with the ESO interferometric spectrographs AMBER and MIDI, mounted on the VLTI in Paranal, Chile. We obtained visibility measurements on 3 AMBER and 12 MIDI baselines, covering a wide range of spatial frequencies. Different models (parametrized circumstellar disks, a dusty halo) were invoked to fit the data, all of which fail to do so in a satisfying way. We approximated the brightness distribution in H, K, and N with a geometric model consisting of three Gaussian disks with different extents and brightness temperatures. This model can account for the entire near- to mid-IR emission of MWC 297.

*Results.* The circumstellar matter around MWC 297 is resolved on all baselines. The near- and mid-IR emission, including the silicate emission at 10 micron, emanates from a very compact region ( $\text{FWHM} < 1.5 \text{ AU}$ ) around the central star.

*Conclusions.* We argue that the extinction towards the MWC 297 star+disk system is interstellar and most likely due to remnants of the natal cloud from which MWC 297 was formed. Furthermore, we argue that the circumstellar matter in the MWC 297 system is organized in a circumstellar disk, seen under moderate ( $i < 40^\circ$ ) inclination. The disk displays no inner emission-free gap at the resolution of our interferometric observations. The low inclination of the disk implies that the already high projected rotational velocity of the star corresponds to an actual rotational velocity that exceeds the critical velocity of the star. This result shows that stars can obtain such high rotation rates at birth. We discuss the impact of this result in terms of the formation of high-mass stars and the main-sequence evolution of classical Be stars.

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<http://arxiv.org/abs/0804.1212>

# Turbulence in Extrasolar Planetary Systems Implies that Mean Motion Resonances are Rare

Fred C. Adams<sup>1,4</sup>, Gregory Laughlin<sup>2</sup> and Anthony M. Bloch<sup>3</sup>

<sup>1</sup> Michigan Center for Theoretical Physics, University of Michigan, Ann Arbor, MI 48109, USA

<sup>2</sup> Lick Observatory, University of California, Santa Cruz, CA 95064, USA

<sup>3</sup> Department of Mathematics, University of Michigan, Ann Arbor, MI 48109, USA

<sup>4</sup> Astronomy Department, University of Michigan, Ann Arbor, MI 48109, USA

E-mail contact: fca@umich.edu

This paper considers the effects of turbulence on mean motion resonances in extrasolar planetary systems and predicts that systems rarely survive in a resonant configuration. A growing number of systems are reported to be in resonance, which is thought to arise from the planet migration process. If planets are brought together and moved inward through torques produced by circumstellar disks, then disk turbulence can act to prevent planets from staying in a resonant configuration. This paper studies this process through numerical simulations and via analytic model equations, where both approaches include stochastic forcing terms due to turbulence. We explore how the amplitude and forcing time intervals of the turbulence affect the maintenance of mean motion resonances. If turbulence is common in circumstellar disks during the epoch of planet migration, with the amplitudes indicated by current MHD simulations, then planetary systems that remain deep in mean motion resonance are predicted to be rare. More specifically, the fraction of resonant systems that survive over a typical disk lifetime of  $\sim 1$  Myr is of order 0.01. If mean motion resonances are found to be common, their existence would place tight constraints on the amplitude and duty cycle of turbulent fluctuations in circumstellar disks. These results can be combined by expressing the expected fraction of surviving resonant systems in the approximate form  $P_b \approx C/N_{\text{orb}}^{1/2}$ , where the dimensionless parameter  $C \sim 10 - 50$  and  $N_{\text{orb}}$  is the number of orbits for which turbulence is active.

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## Formation of simple organic molecules in inner T Tauri disks

Marcelino Agúndez<sup>1</sup>, José Cernicharo<sup>1</sup> and Javier R. Goicoechea<sup>2</sup>

<sup>1</sup> Departamento de Astrofísica Molecular e Infrarroja, Instituto de Estructura de la Materia, CSIC, Serrano 121, 28006 Madrid, Spain

<sup>2</sup> LERMA-LRA, UMR 8112, CNRS, Observatoire de Paris and École Normale Supérieure, 24 rue Lhomond, 75231 Paris Cedex 05, France

E-mail contact: marce@damir.iem.csic.es

We present time dependent chemical models for a dense and warm O-rich gas exposed to a strong, far ultraviolet (FUV) field aimed at exploring the formation of simple organic molecules in the inner regions of protoplanetary disks around T Tauri stars. An up-to-date chemical network is used to compute the evolution of molecular abundances. Reactions of H<sub>2</sub> with small organic radicals such as C<sub>2</sub> and C<sub>2</sub>H, which are not included in current astrochemical databases, overcome their moderate activation energies at warm temperatures and become very important for the gas phase synthesis of C-bearing molecules. The photodissociation of CO and release of C triggers the formation of simple organic species such as C<sub>2</sub>H<sub>2</sub>, HCN, and CH<sub>4</sub>. In timescales between 1 and 10<sup>4</sup> years, depending on the density and FUV field, a steady state is reached in the model in which molecules are continuously photodissociated, but also formed, mainly through gas phase chemical reactions involving H<sub>2</sub>. The application of the model to the upper layers of inner protoplanetary disks predicts large gas phase abundances of C<sub>2</sub>H<sub>2</sub> and HCN. The implied vertical column densities are as large as several 10<sup>16</sup> cm<sup>-2</sup> in the very inner disk (< 1 AU), in good agreement with the recent infrared observations of warm C<sub>2</sub>H<sub>2</sub> and HCN in the inner regions of IRS 46 and GV Tau disks. We also compare our results with previous chemical models studying the photoprocessing in the outer disk regions, and find that the gas phase chemical composition in the upper layers of the inner terrestrial zone (a few AU) is predicted to be substantially different from that in the upper layers of the outer disk (> 50 AU).

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# The nearest X-ray emitting protostellar jet (HH 154) observed with Hubble

R. Bonito<sup>1,2,3</sup>, C. V. M. Fridlund<sup>4</sup>, F. Favata<sup>5</sup>, G. Micela<sup>2</sup>, G. Peres<sup>1</sup>, A. A. Djupvik<sup>6</sup> and R. Liseau<sup>7</sup>

<sup>1</sup> Dip. Scienze Fisiche ed Astronomiche, Sez. Astronomia, Universit di Palermo, P.zza del Parlamento 1, 90134 Palermo, Italy

<sup>2</sup> INAF, Osservatorio Astronomico di Palermo, P.zza del Parlamento 1, 90134 Palermo, Italy

<sup>3</sup> COMETA, via S. Sofia, 64 95123 Catania, Italy

<sup>4</sup> Astrophysics Div., Research and Science Support Dept. of ESA, ESTEC, Postbus 299, 2200 AG Noordwijk, The Netherlands

<sup>5</sup> European Space Agency Community Coordination and Planning Office 8-10 rue Mario Nikis 75738 Paris Cedex 15, France

<sup>6</sup> Nordic Optical Telescope Apartado 474 38700 Santa Cruz de La Palma Santa Cruz de Tenerife, Spain

<sup>7</sup> Onsala Space Observatory 439 92 Onsala, Sweden

E-mail contact: sbonito@astropa.unipa.it

The jet coming from the YSO binary L1551 IRS5 is the closest astrophysical jet known. It is therefore a unique laboratory for studies of outflow mechanisms and of the shocks occurring when expanding material hits the ambient medium as well as of how the related processes influence the star- (and planet-) forming process. The optical data are related to other data covering the spectrum from the optical band to X-rays with goal of understanding the energetics of low-mass star jets, in general, and of this jet in particular. We study the time evolution of the jet, by measuring the proper motions of knots as they progress outwards from the originating source. The nebulosities associated with the jet(s) from the protostellar binary L1551 IRS5 were imaged in a number of spectral bands using the Hubble Space Telescope. This allows the proper motion to be measured and permits a simple characterization of the physical conditions in different structures. To this end we developed a reproducible method of data analysis, which allows us to define the position and shape of each substructure observed within the protostellar jet. Using this approach, we derive the proper motion of the knots in the jet, as well as their flux variability and shock emission. The time base over which HST observations were carried out is now about ten years. The sub-structures within the jet undergo significant morphological variations: some knots seem to disappear in a few years and collision between different knots, ejected at different epochs and maybe with different speed, may occur. The velocities along the jet vary between  $\sim 100$  km/s and over 400 km/s, with the highest speed corresponding to the knots at the base of the jet. There are indications that the HH 154 jet has been active relatively recently. Our results suggest the presence of a new shock front at the base of the jet identified with an internal working surface. From the analysis of the terminal and internal working surfaces within the jet, we find that the more likely scenario for the HH 154 jet is that of a jet traveling through a denser ambient medium (a “light jet”). These results are consistent with the Bonito et al. (2007) model predictions. Furthermore, there is strong evidence that the knots at the base of the northern jet correspond to the location where the highest velocity and the highest excitation component are measured along the jet. More important, this is the location where the X-ray source has been discovered.

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## Disks around CQ Tau and MWC 758: dense PDR or gas dispersal?

Edwige Chapillon<sup>1,2,3</sup>, Stéphane Guilloteau<sup>1,2</sup>, Anne Dutrey<sup>1,2</sup> and Vincent Piétu<sup>3</sup>

<sup>1</sup> Université Bordeaux 1, Laboratoire d’Astrophysique de Bordeaux (LAB)

<sup>2</sup> CNRS/INSU - UMR5804 , BP 89, F-33270 Floirac, France

<sup>3</sup> IRAM, 300 rue de la Piscine, 38400 Saint Martin d’Hères, France.

E-mail contact: edwige.chapillon@obs.u-bordeaux1.fr

*Context.* The overall properties of disks surrounding intermediate PMS stars (HAe) are not yet well constrained by current observations. The disk inclination, which significantly affect SED modeling, is often unknown.

*Aims.* We attempted to resolve the disks around CQ Tau and MWC 758, to provide accurate constraints on the disk parameters, in particular the temperature and surface density distribution.

*Methods.* We report arcsecond resolution observations of dust and CO lines emission with the IRAM array. We also searched for the HCO<sup>+</sup> J=1→0 transition. The disk properties are derived using a standard disk model. We use the Meudon PDR code to study the chemistry.

*Results.* The two disks share some common properties. The mean CO abundance is low despite disk temperatures above the CO condensation temperature. Furthermore, the CO surface density and dust opacity have different radial dependence. The CQ Tau disk appears warmer, and perhaps less dense than that of MWC 758. Modeling the chemistry, we find that photodissociation of CO is a viable mechanism to explain the low abundance. The photospheric flux is not sufficient for this: a strong UV excess is required. In CQ Tau, the high temperature is consistent with expectation for a PDR. The PDR model has difficulty explaining the mild temperatures obtained in MWC 758, for which a low gas-to-dust ratio is preferred. A yet unexplored alternative could be that, despite currently high gas temperatures, CO remains trapped in grains, as the models suggest that large grains can be cold enough to prevent thermal desorption of CO. The low inclination of the CQ Tau disk,  $\sim 30^\circ$ , challenges previous interpretations given for the UX Ori - like luminosity variations of this star.

*Conclusions.* We conclude that CO cannot be used as a simple tracer of gas-to-dust ratio, the CO abundance being affected by photodissociation, and grain growth.

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## ATCA and *Spitzer* Observations of the Binary Protostellar Systems CG 30 and BHR 71

Xuepeng Chen<sup>1</sup>, Ralf Launhardt<sup>1</sup>, Tyler L. Bourke<sup>2</sup>, Thomas Henning<sup>1</sup> and Peter J. Barnes<sup>3</sup>

<sup>1</sup> Max Planck Institute for Astronomy, Königstuhl 17, D-69117 Heidelberg, Germany

<sup>2</sup> Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA

<sup>3</sup> School of Physics A28, University of Sydney, Sydney NSW2006, Australia

E-mail contact: chen@mpia.de

We present interferometric observations with resolution of  $\sim 3''$  of the isolated, low-mass protostellar double cores CG 30 and BHR 71 in the  $N_2H^+$  (1–0) line and at 3 mm dust continuum, using the Australian Telescope Compact Array (ATCA). The results are complemented by infrared data from the *Spitzer Space Telescope*. In CG 30, the 3 mm dust continuum images resolve two compact sources with a separation of  $\sim 21.7''$  ( $\sim 8700$  AU). In BHR 71, strong dust continuum emission is detected at the position of the mid-infrared source IRS1, while only weak emission is detected from the secondary mid-infrared source IRS2. Assuming standard gas to dust ratio and optically thin 3 mm dust continuum emission, we derive hydrogen gas masses of  $0.05 - 2.1 M_\odot$  for the four sub-cores.  $N_2H^+$  (1–0) line emission is detected in both CG 30 and BHR 71, and is spatially associated with the thermal dust continuum emission. By simultaneously fitting the seven hyperfine line components of  $N_2H^+$ , we derive the velocity fields and find symmetric velocity gradients in both sources. Assuming that these gradients are due to core rotation, we estimate the specific angular momenta and ratios of rotational energy to gravitational energy for all cores. Estimated virial masses of the sub-cores range from  $0.1 - 0.6 M_\odot$ . We also find that the  $N_2H^+$  emission is strongly affected by the outflows, both in terms of entrainment and molecule destruction. *Spitzer* images show the mid-infrared emission from all four sub-cores, which is spatially associated with the 3 mm dust continuum emission. All four sources appear to drive their own outflows, as seen in the shock-excited  $4.5 \mu m$  images. Based on the ATCA and *Spitzer* observations, we construct spectral energy distributions (SEDs) and derive temperatures and luminosities for all cores. The analysis of the SEDs suggests an evolutionary discrepancy between the two sub-cores in both CG 30 and BHR 71, which could be due to effects of relative inclinations. Based on the morphology and velocity structure, we suggest that the sub-cores in CG 30 were formed by initial fragmentation of a filamentary prestellar core, while those in BHR 71 could originate from rotational fragmentation of a single collapsing protostellar core.

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## Diagnostics of inhomogeneous stellar jets: Convolution effects and data reconstruction.

Fabio De Colle<sup>1</sup>, Carlos del Burgo<sup>1</sup> and Alejandro Raga<sup>2</sup>

<sup>1</sup> Dublin Institute for Advanced Studies, Ireland

<sup>2</sup> Instituto de Ciencias Nucleares, UNAM, Mexico

E-mail contact: fdc@cp.dias.ie

CONTEXT: In the interpretation of stellar jet observations, the physical parameters are usually determined from

emission line ratios, obtained from spectroscopic observations or using the information contained in narrow band images. The basic hypothesis in the interpretation of the observations is that the emitting region is homogeneous along the line of sight. Actually, stellar jets are in general not homogeneous, and therefore line of sight convolution effects may lead to the main uncertainty in the determination of the physical parameters.

**AIMS:** This paper is aimed at showing the systematic errors introduced when assuming an homogeneous medium, and studying the effect of an inhomogeneous medium on plasma diagnostics for the case of a stellar jet. In addition, we explore how to reconstruct the volumetric physical parameters of the jet (i. e., with dependence both across and along the line of sight).

**METHODS:** We use standard techniques to determine the physical parameters, i. e., the electron density, temperature and hydrogen ionisation fraction across the jet, and a multi-Gaussian method to invert the Abel transform and determine the reconstructed physical structure.

**RESULTS:** When assuming an homogeneous medium the physical parameters, integrated along the line of sight, do not represent the average of the true values, and do not have a clear physical interpretation. We show that when some information is available on the emissivity profile across the jet, it is then possible to obtain appropriate derivations of the electron density, temperature and ionisation fraction.

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## **Stellar and Circumstellar Properties of the Pre-Main Sequence Binary GV Tau from Infrared Spectroscopy**

**Greg W. Doppmann<sup>1</sup>, Joan R. Najita<sup>1</sup> and John S. Carr<sup>2</sup>**

<sup>1</sup> NOAO, 950 North Cherry Avenue, Tucson, AZ 85719, USA

<sup>2</sup> Naval Research Laboratory, Code 7210, Washington, DC 20375, USA

E-mail contact: [gdoppmann@noao.edu](mailto:gdoppmann@noao.edu)

We report spatially resolved spectroscopy of both components of the low-mass pre-main-sequence binary GV Tau. High resolution spectroscopy in the K- and L-bands is used to characterize the stellar properties of the binary and to explore the nature of the circumstellar environment. We find that the southern component, GV Tau S, is a radial velocity variable, possibly as a result of an unseen low-mass companion. The strong warm gaseous HCN absorption reported previously toward GV Tau S (Gibb et al. 2007) was not present during the epoch of our observations. Instead, we detect warm ( $\sim 500$  K) molecular absorption with similar properties toward the northern infrared companion, GV Tau N. At the epoch of our observations, the absorbing gas toward GV Tau N was approximately at the radial velocity of the GV Tau molecular envelope, but it was redshifted with respect to the star by  $\sim 13$  km s<sup>-1</sup>. One interpretation of our results is that GV Tau N is also a binary and that most of the warm molecular absorption arises in a circumbinary disk viewed close to edge-on.

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## **On the Constancy of the Characteristic Mass of Young Stars**

**Bruce G. Elmegreen<sup>1</sup>, Ralf S. Klessen<sup>2</sup> and Christine D. Wilson<sup>3</sup>**

<sup>1</sup> IBM Research, Yorktown Hts. NY 10598 USA

<sup>2</sup> Institute for Theoretical Astrophysics, Heidelberg 69120 Germany

<sup>3</sup> McMaster University, Hamilton, Ontario L8S 4M1 Canada

E-mail contact: [bge@us.ibm.com](mailto:bge@us.ibm.com)

The characteristic mass  $M_c$  in the stellar initial mass function (IMF) is about constant for most star-forming regions. Numerical simulations consistently show a proportionality between  $M_c$  and the thermal Jeans mass  $M_J$  at the time of cloud fragmentation, but no models have explained how it can be the same in diverse conditions. Here we show that  $M_J$  depends weakly on density, temperature, metallicity, and radiation field in three environments: the dense cores where stars form, larger star-forming regions ranging from GMCs to galactic disks, and the interiors of HII regions and super star clusters. In dense cores, the quantity  $T^{3/2}n^{-1/2}$  that appears in  $M_J$  scales with core density as  $n^{0.25}$  or

with radiation density as  $U^{0.1}$  at the density where dust and gas come into thermal equilibrium. On larger scales, this quantity varies with ambient density as  $n^{-0.05}$  and ambient radiation field as  $U^{-0.033}$  when the Kennicutt-Schmidt law of star formation determines  $U(n)$ . In super star clusters with ionization and compression of pre-stellar globules,  $M_J$  varies as the 0.13 power of the cluster column density. These weak dependencies on  $n$ ,  $U$ , and column density imply that most environmental variations affect the thermal Jeans mass by at most a factor of  $\sim 2$ . Cosmological increases in  $M_J$ , which have been suggested by observations, may be explained if the star formation efficiency is systematically higher at high redshift for a given density and pressure, if dust grains are smaller at lower metallicity, and so hotter for a given radiation field, or if small pre-stellar cores are more severely ionized in extreme starburst conditions.

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## The Mass Distribution and Lifetime of Prestellar Cores in Perseus, Serpens, and Ophiuchus

Melissa L. Enoch<sup>1,3</sup>, Neal J. Evans II<sup>2</sup>, Anneila I. Sargent<sup>3</sup>, Jason Glenn<sup>4</sup>, Erik Rosolowsky<sup>5,6</sup> and Philip Myers<sup>6</sup>

<sup>1</sup> Department of Astronomy, University of California, Berkeley, CA, 94720, USA

<sup>2</sup> The University of Texas at Austin, 1 University Station C1400, Austin, TX, 78712-0259, USA

<sup>3</sup> California Institute of Technology, Pasadena, CA 91125, USA

<sup>4</sup> CASA, 389-UCB, University of Colorado, Boulder, CO 80309, USA

<sup>5</sup> Univ. of British Columbia, Okanagan, 3333 University Way, Kelowna BC V1V 1V7 Canada

<sup>6</sup> Harvard-Smithsonian Center for Astrophysics, 60 Garden St., Cambridge, MA 02138, USA

E-mail contact: menoch@astro.berkeley.edu

We present an unbiased census of starless cores in Perseus, Serpens, and Ophiuchus, assembled by comparing large-scale Bolocam 1.1 mm continuum emission maps with Spitzer c2d surveys. We use the c2d catalogs to separate 108 starless from 92 protostellar cores in the 1.1 mm core samples from Enoch et al. (2006), Young et al. (2006), and Enoch et al. (2007). A comparison of these populations reveals the initial conditions of the starless cores. Starless cores in Perseus have similar masses but larger sizes and lower densities on average than protostellar cores, with sizes that suggest density profiles substantially flatter than  $r^{-2}$ . By contrast, starless cores in Serpens are compact and have lower masses than protostellar cores; future star formation will likely result in lower mass objects than the currently forming protostars. Comparison to dynamical masses estimated from the  $\text{NH}_3$  survey of Perseus cores by Rosolowsky et al. (2007) suggests that most of the starless cores are likely to be gravitationally bound, and thus prestellar. The combined prestellar core mass distribution includes 108 cores and has a slope of  $\alpha = -2.3 \pm 0.4$  for  $M > 0.8 M_\odot$ . This slope is consistent with recent measurements of the stellar initial mass function, providing further evidence that stellar masses are directly linked to the core formation process. We place a lower limit on the core-to-star efficiency of 25%. There are approximately equal numbers of prestellar and protostellar cores in each cloud, thus the dense prestellar core lifetime must be similar to the lifetime of embedded protostars, or  $4.5 \times 10^5$  years, with a total uncertainty of a factor of two. Such a short lifetime suggests a dynamic, rather than quasi-static, core evolution scenario, at least at the relatively high mean densities ( $n > 2 \times 10^4 \text{ cm}^{-3}$ ) to which we are sensitive.

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## A detailed study of the L1641N star formation region

M. Galfalk<sup>1</sup> and G. Olofsson<sup>1</sup>

<sup>1</sup> Stockholm Observatory, Sweden

E-mail contact: magnusg@astro.su.se

*Aims.* We search for young stellar objects (YSOs) in the L1641N cluster and characterize the star formation activity through determination of the age distribution, mass function, spatial distribution, and the star formation history.

*Methods.* Multi-wavelength broad band photometry both from space and the ground are used to look for IR excess in order to separate field stars from YSOs and to sample the spectral energy distributions. Space-based observations were

obtained using the ISO satellite (ISOCAM) in two filters, centred at 6.7 and 14.3  $\mu\text{m}$ , and Spitzer (IRAC) at 3.6, 4.5, 5.8, and 8.0  $\mu\text{m}$ . Our ground-based observations were made with the Nordic Optical Telescope (NOT) using ALFOSC (*I* band), NOTCam (*J*, *K<sub>S</sub>* and 2.12  $\mu\text{m}$  H<sub>2</sub>), and SIRCA (*L'*). More than 50 of the brightest *I*-band sources were then studied with follow-up optical spectroscopy (5780–8340 Å) to check for signs of accretion (H $\alpha$  in emission) and youth (Li I  $\lambda$ 6707 in absorption) and to determine their effective temperatures. By comparing theoretical evolution tracks with our YSO sample in the H-R diagram, we calculated an age, luminosity, and mass distribution.

*Results.* We detect a total of 216 (Spitzer or *I* band) sources in L1641N, 89 of which are YSO candidates. Most of the spectra are of M-type with H $\alpha$  strongly in emission, and many have Li 6707 in absorption. The four brightest *I* band sources (F and G stars) are suggested as foreground stars, and the L1641N IRAS source is shown to be the combined flux of at least four sources. We find that the interstellar extinction is well-fit in the optical and near-IR by a power law with an exponent of 1.58, although in the mid-IR the Spitzer observations show a higher extinction than expected from theory. The median age of the YSO sample is  $\sim 1$  Myr and the resulting MF has a flat distribution for low masses down to the completeness limit. There is evidence of a constant star formation rate of one star in  $3.7 \times 10^4$  yr during the past few Myr. We find 11 sources older than 10 Myr and a spatial separation between younger and older YSOs, suggesting that many of the older stars formed in L1641N could have left the cluster, giving the appearance of an increased star formation rate with time.

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## Fragmentation of Shocked Flows: Gravity, Turbulence and Cooling

Fabian Heitsch<sup>1</sup>, Lee Hartmann<sup>1</sup> and Andreas Burkert<sup>2</sup>

<sup>1</sup> University of Michigan

<sup>2</sup> University Observatory Munich

E-mail contact: fheitsch@umich.edu

The observed rapid onset of star formation in molecular clouds requires rapid formation of dense fragments which can collapse individually before being overtaken by global gravitationally-driven flows. Many previous investigations have suggested that supersonic turbulence produces the necessary fragmentation, without addressing however the source of this turbulence. Motivated by our previous (numerical) work on the flow-driven formation of molecular clouds, we investigate the expected timescales of the dynamical and thermal instabilities leading to the rapid fragmentation of gas swept up by large-scale flows, and compare them with global gravitational collapse timescales. We identify parameter regimes in gas density, temperature and spatial scale within which a given instability will dominate. We find that dynamical instabilities disrupt large-scale coherent flows via generation of turbulence, while strong thermal fragmentation amplifies the resulting low-amplitude density perturbations, thus leading to small-scale, high-density fragments as seeds for *local* gravity to act upon. Global gravity dominates only on the largest scales; large-scale gravitationally-driven flows promote the formation of groups and clusters of stars formed by turbulence, thermal fragmentation, and rapid cooling.

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## Analytical theory for the initial mass function: CO clumps and prestellar cores

Patrick Hennebelle<sup>1</sup>, Gilles Chabrier<sup>2</sup>

<sup>1</sup> LERMA, ENS, Paris (patrick.hennebelle@lra.ens.fr)

<sup>2</sup> CRAL, ENS-Lyon (chabrier@ens-lyon.fr)

We derive an analytical theory of the prestellar core initial mass function based on an extension of the Press-Schechter statistical formalism applied in cosmology. With the same formalism, we also obtain the mass spectrum for the non self-gravitating clumps produced in supersonic flows. The mass spectrum of the self-gravitating cores reproduces very well the observed initial mass function and identifies the different mechanisms responsible for its behaviour. The theory predicts that the shape of the IMF results from two competing contributions, namely a power-law at large scales and an exponential cut-off (lognormal form) centered around the characteristic mass for gravitational collapse. The cut-off exists already in the case of pure thermal collapse, provided that the underlying density field

has a lognormal distribution. Whereas pure thermal collapse produces a power-law tail steeper than the Salpeter value,  $dN/d\log M \propto M^{-x}$ , with  $x \simeq 1.35$ , this latter is recovered exactly for the (3D) value of the spectral index of the velocity power spectrum,  $n \simeq 3.8$ , found in observations and in numerical simulations of isothermal supersonic turbulence. Indeed, the theory predicts that  $x = (n + 1)/(2n - 4)$  for self-gravitating structures and  $x = 2 - n'/3$  for non self-gravitating structures, where  $n'$  is the power spectrum index of  $\log(\rho)$ . We show that, whereas supersonic turbulence promotes the formation of both massive stars and brown dwarfs, it has an overall negative impact on star formation, decreasing the star formation efficiency. This theory provides a novel theoretical foundation to understand the origin of the IMF and to infer its behaviour in different environments. It also provides a complementary approach and useful guidance to numerical simulations exploring star formation, while making testable predictions.

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## An infrared-submillimeter study of star-forming regions selected by the ISOSS 170 $\mu\text{m}$ survey

Martin Hennemann<sup>1</sup>, Stephan M. Birkmann<sup>1</sup>, Oliver Krause<sup>1</sup> and Dietrich Lemke<sup>1</sup>

<sup>1</sup> Max-Planck-Institut für Astronomie (MPIA), Königstuhl 17, D-69117 Heidelberg, Germany

E-mail contact: hennemann@mpia.de

Using the ISOPHOT Serendipity Survey (ISOSS) at 170  $\mu\text{m}$  a sample of galactic star-forming regions exhibiting very cold dust temperatures ( $< 20\text{ K}$ ) and high masses ( $> 100 M_{\odot}$ ) has been established. We characterise the star-forming content of five regions that were selected as potential sites for early stage high-mass star formation. We use SCUBA (JCMT) observations in the submillimeter to identify the dense condensations of cold gas and dust. Sensitive mid- to far-infrared *Spitzer* observations with IRAC and MIPS allow us to detect associated young stellar objects. From the long-wavelength emission we derive dust temperatures and masses for the identified clumps. A sample of associated mid-infrared sources is investigated using infrared color-color diagrams and the comparison to a model SED grid to constrain their evolutionary stages and derive estimates for additional parameters like the central mass. In every region we identify between one and four submillimeter clumps with projected sizes between 0.1 and 0.4 pc. The dust temperatures range from 11.6 to 21.3 K and the estimated clump masses are 2 to 166  $M_{\odot}$ . Towards the majority of submillimeter peaks we find point sources in the near- to mid-infrared. Most are interpreted as low-mass young stellar objects but we also detect very red sources. They probably represent very young and deeply embedded protostars that continue to accrete clump material and may reach higher masses. Several candidate intermediate-mass proto- or pre-main-sequence stars embedded in the clumps are identified. A subset of four clumps may be massive enough ( $> 100 M_{\odot}$ ) to form high-mass stars and accompanying clusters. The absence of stellar precursors with current masses in the high-mass regime leave the type of star formation occurring in the clumps unsettled. We confirm the presence of large fractions of cold material as derived from large-scale far-infrared measurements which dominates the emission of most clumps and suggests that the star-forming process will continue.

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<http://arxiv.org/abs/0804.3405>

## Current Star Formation in the Ophiuchus and Perseus Molecular Clouds: Constraints and Comparisons from Unbiased Submillimeter and Mid-Infrared Surveys. II.

Jes K. Jørgensen<sup>1,2</sup>, Doug Johnstone<sup>3,4</sup>, Helen Kirk<sup>4,3</sup>, Philip C. Myers<sup>2</sup>, Lori E. Allen<sup>2</sup> and Yancy L. Shirley<sup>5</sup>

<sup>1</sup> Argelander-Institut für Astronomie, University of Bonn, Auf dem Hügel 71, 53121, Bonn, Germany

<sup>2</sup> Harvard-Smithsonian Center for Astrophysics, 60 Garden Street MS42, Cambridge, MA 02138, USA

<sup>3</sup> Herzberg Institute of Astrophysics, National Research Council of Canada, 5071 West Saanich Road, Victoria, BC V9E 2E7, Canada

<sup>4</sup> Department of Physics & Astronomy, University of Victoria, Victoria, BC, V8P 1A1, Canada

<sup>5</sup> Steward Observatory, University of Arizona, 933 N. Cherry Ave., Tucson, AZ 85721, USA

E-mail contact: jes@astro.uni-bonn.de

We present a census of the population of deeply embedded young stellar objects (YSOs) in the Ophiuchus molecular cloud complex based on a combination of Spitzer Space Telescope mid-infrared data from the ‘‘Cores to Disks’’ (c2d) legacy team and JCMT/SCUBA submillimeter maps from the COMPLETE team. We have applied a method developed for identifying embedded protostars in Perseus to these datasets and in this way construct a relatively unbiased sample of 27 candidate embedded protostars with envelopes more massive than our sensitivity limit (about  $0.1 M_{\odot}$ ). As in Perseus, the mid-infrared sources are located close to the center of the SCUBA cores and the narrowness of the spatial distribution of mid-infrared sources around the peaks of the SCUBA cores suggests that no significant dispersion of the newly formed YSOs has occurred. Embedded YSOs are found in 35% of the SCUBA cores - less than in Perseus (58%). On the other hand the mid-infrared sources in Ophiuchus have less red mid-infrared colors, possibly indicating that they are less embedded. We apply a nearest neighbor surface density algorithm to define the substructure in each of the clouds and calculate characteristic numbers for each subregion - including masses, star formation efficiencies, fraction of embedded sources etc. Generally the main clusters in Ophiuchus and Perseus (L1688, NGC1333 and IC 348) are found to have higher star formation efficiencies than small groups such as B1, L1455 and L1448, which on the other hand are completely dominated by deeply embedded protostars. We discuss possible explanations for the differences between the regions in Perseus and Ophiuchus, such as different evolutionary timescales for the YSOs or differences, e.g., in the accretion in the two clouds.

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## Millimeter Imaging of HH 24 MMS: A Misaligned Protobinary System

Miju Kang<sup>1,2,3</sup>, Minho Choi<sup>1</sup>, Paul T. P. Ho<sup>4,5</sup> and Youngung Lee<sup>1</sup>

<sup>1</sup> Korea Astronomy and Space Science Institute, Hwaam 61-1, Yuseong, Daejeon 305-348, South Korea

<sup>2</sup> Department of Astronomy and Space Science, Chungnam National University, Daejeon 305-764, South Korea

<sup>3</sup> Steward Observatory, 933 North Cherry Avenue, Tucson, AZ 85721, USA

<sup>4</sup> Academia Sinica Institute of Astronomy and Astrophysics, Taipei 106, Taiwan

<sup>5</sup> Harvard-Smithsonian Center for Astrophysics, Cambridge, MA 02138, USA

E-mail contact: [mjkang@kasi.re.kr](mailto:mjkang@kasi.re.kr)

The HH 24 MMS protostellar system was observed in the 6.9 mm continuum with a high angular resolution ( $0.5''$ ). HH 24 MMS was resolved into two sources. The separation between sources 1 and 2 is  $\sim 0.9''$  or 360 AU. The spectral energy distribution suggests that the 6.9 mm flux is almost entirely from dust. The 6.9 mm image and the spectrum suggest that HH 24 MMS may be a protostellar binary system. Total mass including the accretion disks and the inner protostellar envelope is  $\sim 1.4 M_{\odot}$ . Disk masses of sources 1 and 2 are 0.6 and  $0.3 M_{\odot}$ , respectively. Both sources are highly elongated. The difference in the position angle of the two disks is  $\sim 45^{\circ}$ , which means that HH 24 MMS is a highly misaligned protobinary system. The misalignment suggests that turbulent fragmentation may be the formation mechanism relevant to the binary systems with a separation of a few hundreds of AU, such as the HH 24 MMS system.

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## Star formation around the HII region Sh2-235

M. S. Kirsanova<sup>1</sup>, A. M. Sobolev<sup>2</sup>, M. Thomasson<sup>3</sup>, D. S. Wiebe<sup>1</sup>, L. E. B. Johansson<sup>3</sup> and A. F. Seleznev<sup>2</sup>

<sup>1</sup> Institute of Astronomy of the RAS, 48 Pyatnitskaya Str., 119017, Moscow, Russian Federation

<sup>2</sup> Ural State University, 51 Lenin Ave., 620083 Ekaterinburg, Russian Federation

<sup>3</sup> Onsala Space Observatory, SE-439 92, Onsala, Sweden

E-mail contact: [kirsanova@inasan.ru](mailto:kirsanova@inasan.ru)

We present a picture of star formation around the HII region Sh2-235 (S235) based upon data on the spatial distribution of young stellar clusters and the distribution and kinematics of molecular gas around S235. We observed 13CO(1-0) and CS(2-1) emission toward S235 with the Onsala Space Observatory 20-m telescope and analysed the star density distribution with archival data from the 2MASS survey. Dense molecular gas forms a shell-like structure at the

south-eastern part of S235. The young clusters found with 2MASS data are embedded in this shell. The positional relationship of the clusters, the molecular shell and the HII region indicates that expansion of S235 is responsible for the formation of the clusters. The gas distribution in the S235 molecular complex is clumpy, which hampers interpretation exclusively on the basis of the morphology of the star forming region. We use data on kinematics of molecular gas to support the hypothesis of induced star formation, and distinguish three basic types of molecular gas components. The first type is primordial undisturbed gas of the giant molecular cloud, the second type is gas entrained in motion by expansion of the HII region (this is where the embedded clusters were formed), and the third type is a fast-moving gas, which might have been accelerated by winds from the newly formed clusters. The clumpy distribution of molecular gas and its kinematics around the HII region implies that the picture of triggered star formation around S235 can be a mixture of at least two possibilities: the "collect-and-collapse" scenario and the compression of pre-existing dense clumps by the shock wave.

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## **Star Formation in the Most Distant Molecular Cloud in the Extreme Outer Galaxy: A Laboratory of Star Formation in an Early Epoch of the Galaxy's Formation**

**Naoto Kobayashi<sup>1</sup>, Chikako Yasui<sup>1</sup>, Alan T. Tokunaga<sup>2</sup> and Masao Saito<sup>3</sup>**

<sup>1</sup> Institute of Astronomy, 2-21-1 Osawa, Mitaka, Tokyo 181-0015, Japan

<sup>2</sup> Institute for Astronomy, 2680 Woodlawn Dr, Honolulu, HI 96720, USA

<sup>3</sup> ALMA Project, NAOJ, 2-21-1 Osawa, Mitaka, Tokyo 181-8588, Japan

E-mail contact: [naoto@ioa.s.u-tokyo.ac.jp](mailto:naoto@ioa.s.u-tokyo.ac.jp)

We report the discovery of active star formation in Digel's Cloud 2, which is one of the most distant giant molecular clouds known in the extreme outer Galaxy (EOG). At the probable Galactic radius of  $\sim 20$  kpc, Cloud 2 has a quite different environment from that in the solar neighborhood, including lower metallicity, much lower gas density, and small or no perturbation from spiral arms. With new wide-field near-infrared (NIR) imaging that covers the entire Cloud 2, we discovered two young embedded star clusters located in the two dense cores of the cloud. Using our NIR and  $^{12}\text{CO}$  data as well as HI, radio continuum, and IRAS data in the archives, we discuss the detailed star formation processes in this unique environment. We show clear evidences of a sequential star formation triggered by the nearby huge supernova remnant, GSH 138-01-94. The two embedded clusters show a distinct morphology difference: the one in the northern molecular cloud core is a loose association with isolated-mode star formation, while the other in the southern molecular cloud core is a dense cluster with cluster-mode star formation. We propose that high compression by the combination of the SNR shell and an adjacent shell caused the dense cluster formation in the southern core. Along with the low metallicity range of the EOG, we suggest that EOG could be an excellent laboratory for the study of star formation processes, such as those triggered by supernovae, that occurred during an early epoch of the Galaxy's formation. In particular, the study of the EOG may shed light on the origin and role of the thick disk, whose metallicity range matches with that of the EOG well.

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(a version w/full-resolution color figures is available at

[http://www.ioa.s.u-tokyo.ac.jp/~naoto/papers/apj.cl2\\_quirc/ms2p\\_final.pdf](http://www.ioa.s.u-tokyo.ac.jp/~naoto/papers/apj.cl2_quirc/ms2p_final.pdf))

## **Three-dimensional Simulation of Magnetized Cloud Fragmentation Induced by Nonlinear Flows and Ambipolar Diffusion**

**Takahiro Kudoh<sup>1</sup> and Shantanu Basu<sup>2</sup>**

<sup>1</sup> Division of Theoretical Astronomy, National Astronomical Observatory of Japan, Mitaka, Tokyo 181-8588

<sup>2</sup> Department of Physics and Astronomy, University of Western Ontario, London, Ontario N6A 3K7

E-mail contact: [kudoh@th.nao.ac.jp](mailto:kudoh@th.nao.ac.jp)

We demonstrate that the formation of collapsing cores in subcritical clouds is accelerated by nonlinear flows, by performing three-dimensional non-ideal MHD simulations. An initial random supersonic (and trans-Alfvénic) turbulent-

like flow is input into a self-gravitating gas layer that is threaded by a uniform magnetic field (perpendicular to the layer) such that the initial mass-to-flux ratio is subcritical. Magnetic ambipolar diffusion occurs very rapidly initially due to the sharp gradients introduced by the turbulent flow. It subsequently occurs more slowly in the traditional near-quasistatic manner, but in regions of greater mean density than present in the initial state. The overall timescale for runaway growth of the first core(s) is several  $\times 10^6$  yr, even though previous studies have found a timescale of several  $\times 10^7$  yr when starting with linear perturbations and similar physical parameters. Large-scale supersonic flows exist in the cloud and provide an observationally testable distinguishing characteristic from core formation due to linear initial perturbations. However, the nonlinear flows have decayed sufficiently that the relative infall motions onto the first core are subsonic, as in the case of starting from linear initial perturbations. The ion infall motions are very similar to those of neutrals; however, they lag the neutral infall in directions perpendicular to the mean magnetic field direction and lead the neutral infall in the direction parallel to the mean magnetic field.

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## High-mass star formation in the IRAS 17233-3606 region: a new nearby and bright hot core in the southern sky

S. Leurini<sup>1,2</sup>, C. Hieret<sup>2</sup>, S. Thorwirth<sup>2</sup>, F. Wyrowski<sup>2</sup>, P. Schilke<sup>2</sup>, K.M. Menten<sup>2</sup>, R. Guesten<sup>2</sup> and L. Zapata<sup>2</sup>

<sup>1</sup> European Southern Observatory, Karl-Schwarzschild-Strasse 2, D-85748 Garching bei Muenchen, Germany

<sup>2</sup> Max-Planck-Institut fuer Radioastronomie, Auf dem Huegel 69, D?53121 Bonn, Germany

E-mail contact: sleurini@eso.org

*Aims.* We present molecular line observations of the massive star-forming region IRAS 17233-3606 aimed at studying the molecular core associated with the source.

*Methods.* The observations were made using the Atacama Pathfinder Experiment telescope in the CO (3-2) and HCO<sup>+</sup> (4-3) transitions and in the CH<sub>3</sub>OH (6<sub>K</sub> – 5<sub>K</sub>), (7<sub>K</sub> – 6<sub>K</sub>), and CH<sub>3</sub>CN (16<sub>K</sub> – 15<sub>K</sub>) bands. For the CO(3-2) and HCO<sup>+</sup> (4-3) transitions, we obtained maps with a size of 70''  $\times$  70''. The typical angular resolution of the data is  $\sim$  18''.

*Results.* Our observations reveal an exceptionally rich molecular spectrum, one signpost of hot core activity. Comparisons with two other prominent southern hot cores were made through observations in the same frequency setups. We also detected a bipolar outflow in CO (3-2) and HCO<sup>+</sup> (4-3) lines. Modelling reveals a hot core of size  $\sim$  3'' and a temperature of 150 K in the IRAS 17233–3606 region. The parameters of the molecular outflow are derived through the analysis of the CO (3-2) emission, and are typical of outflows driven by high-mass young stellar objects.

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## Sub-Alfvénic Non-Ideal MHD Turbulence Simulations with Ambipolar Diffusion: I. Turbulence Statistics

Pak Shing Li<sup>1</sup>, Christopher F. McKee<sup>2</sup>, Richard I. Klein<sup>3</sup> and Robert T. Fisher<sup>4</sup>

<sup>1</sup> Astronomy Department, University of California, Berkeley, CA 94720, USA

<sup>2</sup> Physics Department and Astronomy Department, University of California, Berkeley, CA 94720, USA

<sup>3</sup> Astronomy Department, University of California, Berkeley, CA 94720; and Lawrence Livermore National Laboratory, P.O. Box 808, L-23, Livermore, CA 94550, USA

<sup>4</sup> Flash Center, Department of Astronomy and Astrophysics, University of Chicago, 5640 S. Ellis Ave., Chicago, IL 60637, USA

E-mail contact: psli@astro.berkeley.edu

Most numerical investigations on the role of magnetic fields in turbulent molecular clouds (MCs) are based on ideal magneto-hydrodynamics (MHD). However, MCs are weakly ionized, so that the time scale required for the magnetic field to diffuse through the neutral component of the plasma by ambipolar diffusion (AD) can be comparable to the dynamical time scale. We have performed a series of 256<sup>3</sup> and 512<sup>3</sup> simulations on supersonic but sub-Alfvénic turbulent

systems with AD using the Heavy-Ion Approximation developed in Li, McKee, & Klein (2006). Our calculations are based on the assumption that the number of ions is conserved, but we show that these results approximately apply to the case of time-dependent ionization in molecular clouds as well. Convergence studies allow us to determine the optimal value of the ionization mass fraction when using the heavy-ion approximation for low Mach number, sub-Alfvénic turbulent systems. We find that ambipolar diffusion steepens the velocity and magnetic power spectra compared to the ideal MHD case. Changes in the density PDF, total magnetic energy, and ionization fraction are determined as a function of the AD Reynolds number. The power spectra for the neutral gas properties of a strongly magnetized medium with a low AD Reynolds number are similar to those for a weakly magnetized medium; in particular, the power spectrum of the neutral velocity is close to that for Burgers turbulence.

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## Molecular hydrogen in the circumstellar environments of Herbig Ae/Be stars probed by FUSE

C. Martin-Zaidi<sup>1</sup>, M. Deleuil<sup>2</sup>, J. Le Bourlot<sup>3</sup>, J.-C. Bouret<sup>2</sup>, A. Roberge<sup>4</sup>, C.P. Dullemond<sup>5</sup>, L. Testi<sup>6</sup>, P.D. Feldman<sup>7</sup>, A. Lecavelier des Etangs<sup>8</sup> and A. Vidal-Madjar<sup>8</sup>

<sup>1</sup> Laboratoire d’Astrophysique de Grenoble, CNRS, Université Joseph-Fourier, UMR5571, Grenoble, France

<sup>2</sup> Laboratoire d’Astrophysique de Marseille, BP 8, Les trois Lucs, 13376 Marseille Cedex 12, France

<sup>3</sup> LUTH, Observatoire de Paris, Université Paris 7, 92195 Meudon Cedex, France

<sup>4</sup> NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA

<sup>5</sup> Max-Planck-Institut für Astronomie, Königstuhl 17, D-69117 Heidelberg, Germany

<sup>6</sup> Osservatorio Astrofisico di Arcetri, Largo E. Fermi 5, 50125 Firenze, Italy

<sup>7</sup> Department of Physics and Astronomy, JHU, Baltimore, MD 21218, USA

<sup>8</sup> Institut d’Astrophysique de Paris, CNRS, 98bis Boulevard Arago, 75014 Paris, France

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

Molecular hydrogen ( $H_2$ ) gas is the most abundant molecule in the circumstellar (CS) environments of young stars. It is thus a key element in our understanding of the evolution of pre-main sequence stars and their environments towards the main sequence. At the present time, little is known about the gas as compared to the dust in the environments of young stars. We thus observed molecular hydrogen around a sample of pre-main sequence stars in order to better characterize their gaseous CS environments. The *FUSE* (*Far Ultraviolet Spectroscopic Explorer*) spectral range offers access to electronic transitions of  $H_2$ . We analyzed the *FUSE* spectra of a sample of Herbig Ae/Be stars (HAeBes) covering a broad spectral range (from F4 to B2), including the main-sequence A5 star  $\beta$  Pictoris. To better diagnose the origin of the detected molecular gas and its excitation conditions, we used a model of a photodissociation region. Our analysis demonstrates that the excitation of  $H_2$  is clearly different around most of the HAeBes compared to the interstellar medium. Moreover, the characteristics of  $H_2$  around Herbig Ae and Be stars give evidence for different excitation mechanisms. For the most massive stars of our sample (B8 to B2 type), the excitation diagrams are reproduced well by a model of photodissociation regions (PDR). Our results favor an interpretation in terms of large CS envelopes, remnants of the molecular clouds in which the stars were formed. On the other hand, the group of Ae stars (later than B9 type) known to possess disks is more inhomogeneous. In most cases, when CS  $H_2$  is detected, the lines of sight do not pass through the disks. The excitation conditions of  $H_2$  around Ae stars cannot be reproduced by PDR models and correspond to warm and/or hot excited media very close to the stars. In addition, no clear correlation has been found between the ages of the stars and the amount of circumstellar  $H_2$ . Our results suggest structural differences between Herbig Ae and Be star environments. Herbig Be stars do evolve faster than Ae stars, and consequently, most Herbig Be stars are younger than Ae ones at the time we observe them. It is thus more likely to find remnants of their parent cloud around them.

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## Radio continuum imaging of the R CrA star-forming region with the ATCA

O. Miettinen<sup>1</sup>, S. Kontinen<sup>1</sup>, J. Harju<sup>1</sup> and J. Higdon<sup>2</sup>

<sup>1</sup> Observatory, P.O. Box 14, 00014 University of Helsinki, Finland

<sup>2</sup> Dept. of Physics, Georgia Southern University, Statesboro, GA 30460-8031, USA

E-mail contact: [oskari.miettinen@helsinki.fi](mailto:oskari.miettinen@helsinki.fi)

**Aims:** The aim of this study is to investigate the nature of radio sources associated with young stellar objects (YSOs) belonging to the R CrA cluster. By combining the centimetre radio data with the wealth of shorter wavelength data accumulated recently we wish to refine estimates of the evolutionary stages of the YSOs.

**Methods:** The region was imaged at 3, 6, and 20 cm using the Australia Telescope Compact Array. Fluxes and spectral indices for the brightest radio sources were derived from these observations. Some of the 3 and 6 cm data were obtained simultaneously, which is useful for reliable spectral index determinations of variable sources.

**Results:** Eight pointlike sources were detected. Seven of them can be assigned to YSOs, which have counterparts in the X-rays, infrared or submm. One of the YSOs, Radio Source 9, is a Class 0 candidate, and another, IRS 7B, is suggested to be in the Class 0/I transition stage. IRS 7B is associated with extended radio lobes at 6 and 20 cm. The lobes may have a gyrosynchrotron emission component, which could be understood in terms of Fermi acceleration in shocks. The Class I objects detected here seem to be a mixed lot. One of these, the wide binary IRS 5, shows a negative spectral index, rapid variability, and a high degree of circular polarisation with  $V/I \approx 33\%$  on one of the days of observation. These signs of magnetic activity suggest that at least one of the binary components has advanced beyond the Class I stage. The radio source without YSO assignment, Radio Source 5, has been suggested to be a brown dwarf. The radio properties, in particular its persistent strong emission, do not support this classification.

**Conclusions:** The radio characteristics of the detected YSOs roughly agree with the scheme where the dominant emission mechanism changes with age. The heterogeneity of the Class I group can possibly be explained by a drastic decline in the jet activity during this stage, which also changes the efficiency of free-free absorption around the protostar.

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## Probing the centre of the large circumstellar disc in M17

Markus Nielbock<sup>1</sup>, Rolf Chini<sup>2</sup>, Vera H. Hoffmeister<sup>2</sup>, Dieter E. A. Nürnberger<sup>3</sup>, C. Michael Scheyda<sup>2</sup> and Jürgen Steinacker<sup>1,4</sup>

<sup>1</sup> Max-Planck-Institut für Astronomie, Königstuhl 17, 69117 Heidelberg, Germany

<sup>2</sup> Astronomisches Institut, Ruhr-Universität Bochum, Universitätsstr. 150, 44780 Bochum, Germany

<sup>3</sup> European Southern Observatory, Casilla 19001, Santiago 19, Chile

<sup>4</sup> Astronomisches Recheninstitut, Zentrum für Astronomie, Mönchhofstr. 12-14, 69120 Heidelberg, Germany

E-mail contact: [nielbock@mpia.de](mailto:nielbock@mpia.de)

We investigated the nature of the hitherto unresolved elliptical infrared emission in the centre of the  $\sim 20\,000$  AU disc silhouette in M17. We combined high-resolution *JHKLM* band imaging carried out with NAOS/CONICA at the VLT with [Fe II] narrow band imaging using SOFI at the NTT. The analysis is supported by Spitzer/GLIMPSE archival data and by already published SINFONI/VLT Integral Field Spectroscopy data. For the first time, we resolve the elongated central infrared emission into a point-source and a jet-like feature that extends to the northeast in the opposite direction of the recently discovered collimated H<sub>2</sub> jet. They are both orientated almost perpendicular to the disc plane. In addition, our images reveal a curved southwestern emission nebula whose morphology resembles that of the previously detected northeastern one. Both nebulae are located at a distance of 1500 AU from the disc centre. We describe the infrared point-source in terms of a protostar that is embedded in circumstellar material producing a visual extinction of  $60 \leq A_V \leq 82$ . The observed *Ks* band magnitude is equivalent to a stellar mass range of  $2.8 M_\odot \leq M_\star \leq 8 M_\odot$  adopting conversions for a main-sequence star. Altogether, we suggest that the large M17 accretion disc is forming an intermediate to high-mass protostar. Part of the accreted material is expelled through a symmetric bipolar jet/outflow.

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## The Solar-System-Scale Disk Around AB Aurigae

Ben R. Oppenheimer<sup>1</sup>, Douglas Brenner<sup>1</sup>, Sasha Hinkley<sup>2</sup>, Neil Zimmerman<sup>2</sup>, Anand Sivaramakrishnan<sup>1</sup>, Remi Soumerai<sup>1</sup>, Jeffrey Kuhn<sup>3</sup>, James R. Graham<sup>4</sup>, Marshall Perrin<sup>4</sup>, James P. Lloyd<sup>5</sup>, Lewis C. Roberts, Jr.<sup>6</sup> and David M. Harrington<sup>3</sup>

<sup>1</sup> Department of Astrophysics, American Museum of Natural History, 79<sup>th</sup> Street at Central Park West, New York, NY 10024, USA

<sup>2</sup> Department of Astronomy, Columbia University, 550 West 120<sup>th</sup> Street, New York, NY 10027, USA

<sup>3</sup> Institute for Astronomy, University of Hawaii, 2680 Woodlawn Drive, Honolulu, HI 96822, USA

<sup>4</sup> Department of Astronomy, University of California at Berkeley, 601 Campbell Hall, Berkeley, CA 94720, USA

<sup>5</sup> Department of Astronomy, Cornell University, 610 Space Sciences Building, Ithaca, NY 14853, USA

<sup>6</sup> The Boeing Company, 535 Lipoa Parkway, Suite 200, Kihei, HI 96753, USA

E-mail contact: bro *at* amnh.org

The young star AB Aurigae is surrounded by a complex combination of gas-rich and dust dominated structures. The inner disk which has not been studied previously at sufficient resolution and imaging dynamic range seems to contain very little gas inside a radius of least 130 astronomical units (AU) from the star. Using adaptive-optics coronagraphy and polarimetry we have imaged the dust in an annulus between 43 and 302 AU from the star, a region never seen before. An azimuthal gap in an annulus of dust at a radius of 102 AU, along with a clearing at closer radii inside this annulus, suggests the formation of at least one small body at an orbital distance of about 100 AU. This structure seems consistent with crude models of mean motion resonances, or accumulation of material at two of the Lagrange points relative to the putative object and the star. We also report a low significance detection of a point source in this outer annulus of dust. This source may be an overdensity in the disk due to dust accreting onto an unseen companion. An alternate interpretation suggests that the object's mass is between 5 and 37 times the mass of Jupiter. The results have implications for circumstellar disk dynamics and planet formation.

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(<http://arxiv.org/abs/0803.3629>)

## On disc protoplanet interactions in a non-barotropic disc with thermal diffusion

S.-J. Paardekooper<sup>1</sup> and J.C.B. Papaloizou<sup>1</sup>

<sup>1</sup> DAMTP, University of Cambridge, Wilberforce Road, Cambridge CB3 0WA, United Kingdom

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

We study the disc planet interactions of low-mass protoplanets embedded in a circumstellar disc. We extend the standard theory of planet migration from the usual locally isothermal assumption to include non-barotropic effects, focusing on the validity of linear theory. We compared solutions of the linear equations with results from non-linear hydrodynamic simulations, where in both cases we adopted a background entropy gradient and solved the energy equation. We show that the migration behavior of embedded planets depends critically on the background radial entropy gradient in the disc. The presence of such a gradient not only changes the corotation torque on the planet, but also always guarantees a departure from linear behavior, which gives a singular density response at corotation, in the absence of thermal or viscous diffusion. A negative entropy gradient tends to give rise to positive, non-linear corotation torques apparently produced as material executes horseshoe turns at approximately constant entropy. These torques have no counterpart in linear theory, but can be strong enough to push the planet outwards until saturation starts to occur after a horseshoe libration period. Increased thermal diffusion acts to reduce these non-linear torques, but, at the same time, it can help to prevent their saturation. In combination with a small kinematic viscosity that is able to maintain a smooth density profile the positive torque could be sustained.

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<http://arxiv.org/abs/0804.4547>

## The Evolution of Circumstellar Disks in Ophiuchus Binaries

J. Patience<sup>1,2</sup>, R. Akeson<sup>2</sup> and E. Jensen<sup>3</sup>

<sup>1</sup> University of Exeter, School of Physics, Stocker Road, Exeter, EX4 4QL, UK

<sup>2</sup> California Institute of Technology, 1200 East California Blvd., Pasadena, CA, 91125, USA

<sup>3</sup> Swarthmore College, Swarthmore, PA, 19081, USA

E-mail contact: [patience@astro.ex.ac.uk](mailto:patience@astro.ex.ac.uk)

Four Ophiuchus binaries, two Class I systems and two Class II systems, with separations of 450-1100 AU, were observed with the Owens Valley Radio Observatory (OVRO) millimeter interferometer. In each system, the 3 mm continuum maps show dust emission at the location of the primary star, but no emission at the position of the secondary. This result is different from observations of less evolved Class 0 binaries, in which dust emission is detected from both sources. The nondetection of secondary disks is, however, similar to the dust distribution seen in wide Class II Taurus binaries. The combined OVRO results from the Ophiuchus and Taurus binaries suggest that secondary disk masses are significantly lower than primary disk masses by the Class II stage, with initial evidence that massive secondary disks are reduced by the Class I stage. Although some of the secondaries retain hot inner disk material, the early dissipation of massive outer disks may negatively impact planet formation around secondary stars. Masses for the circumprimary disks are within the range of masses measured for disks around single T Tauri stars and, in some cases, larger than the minimum mass solar nebula. More massive primary disks are predicted by several formation models and are broadly consistent with the observations. Combining the 3 mm data with previous 1.3 mm observations, the dust opacity power-law index for each primary disk is estimated. The opacity index values are all less than the scaling for interstellar dust, possibly indicating grain growth within the circumprimary disks.

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## The Initial Mass Function of the Stellar Association NGC 602 in the Small Magellanic Cloud with Hubble Space Telescope ACS Observations

Markus Schmalzl<sup>1</sup>, Dimitrios Gouliermis<sup>1</sup>, Andrew E. Dolphin<sup>2</sup> and Thomas Henning<sup>1</sup>

<sup>1</sup> Max Planck Institute for Astronomy, Koenigstuhl 17, 69117 Heidelberg, Germany

<sup>2</sup> Raytheon Corporation, 870 Winter Street Waltham, MA 02451, USA

E-mail contact: [schmalzl@mpia.de](mailto:schmalzl@mpia.de)

We present our photometric study of the stellar association NGC 602 in the wing of the Small Magellanic Cloud (SMC). The data were taken in the filters F555W and F814W using the Advanced Camera for Surveys (ACS) on-board the Hubble Space Telescope (HST). Photometry was performed using the ACS module of the stellar photometry package DOLPHOT. We detected more than 5,500 stars with a magnitude range of  $14 \lesssim m_{555} \lesssim 28$  mag. Three prominent stellar concentrations are identified with star counts in the observed field, the association NGC 602 itself, and two clusters, one of them not being currently in any known catalog. The Color-Magnitude Diagrams (CMDs) of both clusters show features typical for young open clusters, while that of the association reveals bright main sequence (MS) and faint pre-main sequence (PMS) stars as the members of the system. We construct the initial mass spectrum (IMS) of the association by applying an age-independent method of counting the PMS stars within evolutionary tracks, while for the bright MS stars we transform their magnitudes to masses with the use of mass-luminosity relations. The IMS of NGC 602 is found to be well represented by a single-power law, corresponding to an Initial Mass Function (IMF) of slope  $\Gamma \approx -1.2$  for  $1 \lesssim M/M_{\odot} \lesssim 45$ . This indicates that the shape of the IMF of a star forming system in the SMC for stars with masses higher than  $1 M_{\odot}$  seems to be quite similar to the field IMF in the solar neighborhood.

Accepted by ApJ

<http://www.astro.uni-bonn.de/~dgoulier/Science/NGC602/ms.pdf>

## The structures of embedded clusters in the Perseus, Serpens and Ophiuchus molecular clouds

S. Schmeja<sup>1,2</sup>, M. S. N. Kumar<sup>1</sup> and B. Ferreira<sup>3</sup>

<sup>1</sup> Centro de Astrofísica da Universidade do Porto, Rua das Estrelas, 4150-762 Porto, Portugal

<sup>2</sup> Zentrum für Astronomie der Universität Heidelberg, Institut für Theoretische Astrophysik, Albert-Ueberle-Str. 2, 69120 Heidelberg, Germany

<sup>3</sup> Department of Astronomy, University of Florida, Gainesville, FL 32611-2055, USA

E-mail contact: [sschmeja@ita.uni-heidelberg.de](mailto:sschmeja@ita.uni-heidelberg.de)

The young stellar population data of the Perseus, Ophiuchus and Serpens molecular clouds are obtained from the *Spitzer* c2d legacy survey in order to investigate the spatial structure of embedded clusters using the nearest neighbour and minimum spanning tree method. We identify the embedded clusters in these clouds as density enhancements and analyse the clustering parameter  $Q$  with respect to source luminosity and evolutionary stage. This analysis shows that the older Class 2/3 objects are more centrally condensed than the younger Class 0/1 protostars, indicating that clusters evolve from an initial hierarchical configuration to a centrally condensed one. Only IC 348 and the Serpens core, the older clusters in the sample, shows signs of mass segregation (indicated by the dependence of  $Q$  on the source magnitude), pointing to a significant effect of dynamical interactions after a few Myr. The structure of a cluster may also be linked to the turbulent energy in the natal cloud as the most centrally condensed cluster is found in the cloud with the lowest Mach number and vice versa. In general these results agree well with theoretical scenarios of star cluster formation by gravoturbulent fragmentation.

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<http://www.ita.uni-heidelberg.de/~sschmeja/c2dstruct.pdf> or <http://arxiv.org/abs/0805.2049>

## Spatially-resolved Chandra Imaging Spectroscopy of the classical/weak-lined T Tauri system V710 Tau

Sonali J. Shukla<sup>1</sup>, David A. Weintraub<sup>1</sup> and Joel H. Kastner<sup>2</sup>

<sup>1</sup> Department of Physics & Astronomy, Vanderbilt University, Nashville, TN 37235, USA

<sup>2</sup> Chester F. Carlson Center for Imaging Science, Rochester Institute of Technology, 54 Lomb Memorial Drive, Rochester, NY 14623, USA

E-mail contact: [sonali.j.shukla@vanderbilt.edu](mailto:sonali.j.shukla@vanderbilt.edu)

We present spatially-resolved X-ray observations of the binary T Tauri star system V710 Tau. Using Chandra's Advanced CCD Imaging Spectrometer (ACIS), we imaged this 3.2'' separation binary system, consisting of a classical T Tauri star, V710 Tau N, and a weak-lined T Tauri star, V710 Tau S. The Chandra ACIS-S3 images — obtained in two 9 ks exposures separated by about three months (2004 December and 2005 April) — cleanly resolve the V710 Tau binary, demonstrating that both stars emit X-rays and thereby enabling the first spectral/temporal study of the individual components of this mixed (classical and weak-lined) T Tauri star binary system. The northern component, V710 Tau N, appears to have been in a flaring state during the first (2004 December) exposure. During this flare event, the X-ray flux of the classical T Tauri star hardened significantly. Single-component plasma models with plasma temperatures in the range  $kT_X \sim 0.7 - 1.1$  keV are adequate to fit the observed X-ray spectra of V710 Tau S in 2004 December and both stars in 2005 April. The 2004 December flare-state observation of V710 Tau N requires a higher-temperature plasma component ( $kT_X \sim 2.5 - 3.0$  keV) in addition to the soft component ( $kT_X \sim 0.5$  keV) and is better fit by a model that includes a slightly enhanced Ne/Fe abundance ratio. These results are generally consistent with statistical contrasts between the X-ray emission properties of classical (rapidly accreting) vs. weak-lined (weakly accreting or non-accreting) T Tauri stars.

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<http://arxiv.org/abs/0805.1232>

## High-Resolution Chandra X-ray Imaging and Spectroscopy of the $\sigma$ Orionis Cluster

Stephen L. Skinner<sup>1</sup>, Kimberly R. Sokal<sup>1</sup>, David H. Cohen<sup>2</sup>, Marc Gagné<sup>3</sup>, Stanley P. Owocki<sup>4</sup>, and Richard D. Townsend<sup>4</sup>

<sup>1</sup> CASA, Univ. of Colorado, Boulder, CO 80309-0389 USA

<sup>2</sup> Dept. of Physics and Astronomy, Swarthmore College, Swarthmore, PA 19081

<sup>3</sup> Dept. of Geology and Astronomy, West Chester Univ., West Chester, PA 19383-2130

<sup>4</sup> Bartol Research Inst., Univ. of Delaware, Newark, DE 19716

E-mail contact: [skinnners@origins.colorado.edu](mailto:skinnners@origins.colorado.edu)

We present results of a 90 ksec *Chandra* X-ray observation of the young  $\sigma$  Orionis cluster (age  $\sim 3$  Myr) obtained with the High Energy Transmission Grating Spectrometer. We use the high resolution grating spectrum and moderate resolution CCD spectrum of the massive central star  $\sigma$  Ori AB (O9.5V + B0.5V) to test wind shock theories of X-ray emission and also analyze the high spatial resolution zero-order ACIS-S image of the central cluster region.

*Chandra* detected 42 X-ray sources on the primary CCD (ACIS-S3). All but five have near-IR or optical counterparts and about one-fourth are variable. Notable high-mass stellar detections are  $\sigma$  Ori AB, the magnetic B star  $\sigma$  Ori E, and the B5V binary HD 37525. Most of the other detections have properties consistent with lower mass K or M-type stars. We present the first X-ray spectrum of the unusual infrared source IRS1, located  $\approx 3''$  north of  $\sigma$  Ori AB. Its X-ray properties and elongated mid-IR morphology suggest it is an embedded low mass T Tauri star whose disk/envelope is being photo-evaporated by  $\sigma$  Ori AB.

We focus on the radiative wind shock interpretation of the soft luminous X-ray emission from  $\sigma$  Ori AB, but also consider possible alternatives including magnetically-confined wind shocks and colliding wind shocks. Its emission lines show no significant asymmetries or centroid shifts and are moderately broadened to  $\text{HWHM} \approx 264 \text{ km s}^{-1}$ , or one-fourth the terminal wind speed. Forbidden lines in He-like ions are formally undetected, implying strong UV suppression. The Mg XI triplet forms in the wind acceleration zone within one stellar radius above the surface. These X-ray properties are consistent in several respects with the predictions of radiative wind shock theory for an optically thin wind, but explaining the narrow line widths presents a challenge to the theory.

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Preprints: <http://lanl.arxiv.org/abs/0805.0714>

## Discovery of superthermal hydroxyl (OH) in the HH 211 outflow

A. Tappe<sup>1</sup>, C. J. Lada<sup>1</sup>, J. H. Black<sup>2</sup> and A. A. Muench<sup>1</sup>

<sup>1</sup> Harvard-Smithsonian Center for Astrophysics, Cambridge, USA

<sup>2</sup> Onsala Space Observatory, Chalmers University of Technology, Onsala, Sweden

E-mail contact: [atappe@cfa.harvard.edu](mailto:atappe@cfa.harvard.edu)

We present a 5–37  $\mu\text{m}$  infrared spectrum obtained with the Spitzer Space Telescope toward the southeastern lobe of the young protostellar outflow HH 211. The spectrum shows an extraordinary sequence of OH emission lines arising in highly excited rotational levels up to an energy  $E/k \approx 28200 \text{ K}$  above the ground level. This is, to our knowledge, by far the highest rotational excitation of OH observed outside Earth. The spectrum also contains several pure rotational transitions of  $\text{H}_2\text{O}$  ( $v = 0$ ),  $\text{H}_2$  ( $v = 0$ ) S(0) to S(7), HD ( $v = 0$ ) R(3) to R(6), and atomic fine-structure lines of [Fe II], [Si II], [Ne II], [S I], and [Cl I]. The origin of the highly excited OH emission is most likely the photodissociation of  $\text{H}_2\text{O}$  by the UV radiation generated in the terminal outflow shock of HH 211.

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<http://arxiv.org/abs/0805.1737>

## Molecular line profiles as diagnostics of protostellar collapse: modelling the ‘blue asymmetry’ in inside-out infall

Y. G. Tsamis<sup>1</sup>, J. M. C. Rawlings<sup>1</sup>, J. A. Yates<sup>1</sup> and S. Viti<sup>1</sup>

<sup>1</sup> Department of Physics and Astronomy, University College London, Gower Street, London WC1E 6BT, UK

E-mail contact: [ygt@star.ucl.ac.uk](mailto:ygt@star.ucl.ac.uk)

The evolution of star-forming core analogues undergoing inside-out collapse is studied with a multi-point chemodynamical model which self-consistently computes the abundance distribution of chemical species in the core. For several collapse periods the output chemistry of infall tracer species such as  $\text{HCO}^+$ , CS, and  $\text{N}_2\text{H}^+$ , is then coupled to an accelerated  $\Lambda$ -iteration radiative transfer code, which predicts the emerging molecular line profiles using two different input gas/dust temperature distributions. We investigate the sensitivity of the predicted spectral line profiles and

line asymmetry ratios to the core temperature distribution, the time-dependent model chemistry, as well as to *ad hoc* abundance distributions. The line asymmetry is found to be strongly dependent on the adopted chemical abundance distribution. In general, models with a warm central region show higher values of blue asymmetry in optically thick HCO<sup>+</sup> and CS lines than models with a starless core temperature profile. We find that in the formal context of Shu-type inside-out infall, and in the absence of rotation or outflows, the *relative* blue asymmetry of certain HCO<sup>+</sup> and CS transitions is a function of time and, subject to the foregoing caveats, can act as a collapse chronometer. The sensitivity of simulated HCO<sup>+</sup> line profiles to linear radial variations, subsonic or supersonic, of the internal turbulence field is investigated in the separate case of static cores.

Accepted by MNRAS

<http://lanl.arxiv.org/abs/0803.0519>

## Modeling water emission from low-mass protostellar envelopes

**T.A. van Kempen<sup>1</sup>, S.D. Doty<sup>2</sup>, E.F. van Dishoeck<sup>1,3</sup>, M.R. Hogerheijde<sup>1</sup> and J.K. Jørgensen<sup>4</sup>**

<sup>1</sup> Leiden Observatory, Leiden University, Leiden, Netherlands

<sup>2</sup> Denison University, Ohio, USA

<sup>3</sup> Max Planck Institut für Extraterrestrische Physik, Garching, Germany

<sup>4</sup> Argelander Institut, Universität Bonn, Germany

E-mail contact: kempen@strw.leidenuniv.nl

Within low-mass star formation, water vapor plays a key role in the chemistry and energy balance of the circumstellar material. The Herschel Space Observatory will open up the possibility to observe water lines originating from a wide range of excitation energies. Our aim is to simulate the emission of rotational water lines from envelopes characteristic of embedded low-mass protostars. A large number of parameters that influence the water line emission are explored: luminosity, density, density slope, and water abundances. Both dust and water emission are modeled using full radiative transfer in spherical symmetry. The temperature profile is calculated for a given density profile. The H<sub>2</sub>O level populations and emission profiles are in turn computed with a non-LTE line code. The results are analyzed to determine the diagnostic value of different lines, and are compared with existing observations. Lines can be categorized in: (i) optically thick lines, including ground-state lines, mostly sensitive to the cold outer part; (ii) highly excited ( $E_u > 200 - 250$  K) optically thin lines sensitive to the abundance in the hot inner part; and (iii) lines which vary from optically thick to thin depending on the abundances. Dust influences the emission of water significantly by becoming optically thick at the higher frequencies, and by pumping optically thin lines. A good physical model of a source, including the correct treatment of dust, is a prerequisite for inferring the water abundance structure and possible jumps at the evaporation temperature from observations. The inner warm ( $T > 100$  K) envelope can be probed by highly excited lines, while a combination of excited and spectrally resolved ground state lines probes the outer envelope. Observations of H<sub>2</sub><sup>18</sup>O lines, although weak, provide even stronger constraints on abundances.

Accepted by A&A

## A Pilot Survey for the H<sub>2</sub>O Southern Galactic Plane Survey (HOPS)

**Andrew J. Walsh<sup>1</sup>, Nadia Lo<sup>2,3</sup>, Michael G. Burton<sup>2</sup>, Graeme L. White<sup>1</sup>, Cormac R. Purcell<sup>4</sup>, Steven N. Longmore<sup>5</sup>, Chris J. Phillips<sup>3</sup> and Kate J. Brooks<sup>3</sup>**

<sup>1</sup> Centre for Astronomy, School of Maths, Physics and IT, James Cook University, Townsville, QLD, 4811, Australia

<sup>2</sup> School of Physics, University of NSW, Sydney, NSW, 2052, Australia

<sup>3</sup> Australia Telescope National Facility, CSIRO, PO Box 76, Epping, NSW, 1710, Australia

<sup>4</sup> Alan Turing Building, University of Manchester, Oxford Road, Manchester, M13 9PL, UK

<sup>5</sup> Harvard-Smithsonian Center for Astrophysics, 60, Garden Street, Cambridge, MA, 02138, USA

E-mail contact: andrew.walsh@jcu.edu.au

We describe observations with the Mopra radiotelescope designed to assess the feasibility of the H<sub>2</sub>O maser southern Galactic plane survey (HOPS). We mapped two one-square-degree regions along the Galactic plane using the new 12mm receiver and the UNSW Mopra spectrometer (MOPS). We covered the entire spectrum between 19.5 and 27.5 GHz using this setup with the main aims of finding out which spectral lines can be detected with a quick mapping

survey. We report on detected emission from H<sub>2</sub>O masers, NH<sub>3</sub> inversion transitions (1,1), (2,2) and (3,3), HC<sub>3</sub>N (3-2), as well as several radio recombination lines.

Accepted by PASA

<http://arxiv.org/abs/0804.4035>

## Galactic interstellar <sup>18</sup>O/<sup>17</sup>O ratios - a radial gradient?

J.G.A. Wouterloot<sup>1</sup>, C. Henkel<sup>2</sup>, J. Brand<sup>3</sup> and G.R. Davis<sup>1</sup>

<sup>1</sup> Joint Astronomy Centre, 660 N. A'ohoku Place, Hilo, HI 96720, USA <sup>2</sup> Max-Planck-Institut für Radioastronomie, Auf dem Hügel 69, 53121 Bonn, Germany

<sup>3</sup> INAF - Istituto di Radioastronomia, Via P. Gobetti 101, 40129 Bologna, Italy

E-mail contact: [j.wouterloot@jach.hawaii.edu](mailto:j.wouterloot@jach.hawaii.edu)

The determination of interstellar abundances is essential for a better understanding of stellar nucleosynthesis and the “chemical” evolution of the Galaxy. The aim is to determine <sup>18</sup>O/<sup>17</sup>O abundance ratios across the entire Galaxy. These provide a measure of the amount of enrichment by high-mass versus intermediate-mass stars. Such ratios, derived from the C<sup>18</sup>O and C<sup>17</sup>O  $J=1-0$  lines alone, may be affected by systematic errors. Therefore, the C<sup>18</sup>O and C<sup>17</sup>O (1-0), (2-1), and (3-2), as well as the <sup>13</sup>CO(1-0) and (2-1) lines, were observed towards 18 prominent galactic targets (a total of 25 positions). The combined dataset was analysed with a large velocity gradient model, accounting for optical depth effects. The data cover galactocentric radii between 0.1 and 16.9 kpc (solar circle at 8.5 kpc). Near the centre of the Galaxy, <sup>18</sup>O/<sup>17</sup>O = 2.88±0.11. For the galactic disc out to a galactocentric distance of ~10 kpc, <sup>18</sup>O/<sup>17</sup>O = 4.16±0.09. At ~16.5 kpc from the galactic centre, <sup>18</sup>O/<sup>17</sup>O = 5.03±0.46. Assuming that <sup>18</sup>O is synthesised predominantly in high-mass stars ( $M > 8 M_{\odot}$ ), while C<sup>17</sup>O is mainly a product of lower mass stars, the ratio from the inner Galaxy indicates a dominance of CNO-hydrogen burning products that is also apparent in the carbon and nitrogen isotope ratios. The high <sup>18</sup>O/<sup>17</sup>O value of the solar system (5.5) relative to that of the ambient interstellar medium suggests contamination by nearby high-mass stars during its formation. The outer Galaxy poses a fundamental problem. High values in the metal-poor environment of the outer Galaxy are not matched by the low values observed towards the even more metal-poor Large Magellanic Cloud. Apparently, the outer Galaxy cannot be considered as an intermediate environment between the solar neighbourhood and the interstellar medium of small metal-poor galaxies. The apparent <sup>18</sup>O/<sup>17</sup>O gradient along the galactic disc and the discrepancy between outer disc and LMC isotope ratios may be explained by different ages of the respective stellar populations. More data from the central and far outer parts of the Galaxy are, however, needed to improve the statistical significance of our results.

Accepted by Astronomy & Astrophysics

<http://xxx.sissa.it/abs/0805.3399>

## **PhD position on organic chemistry in the protosolar nebula**

The Kapteyn Astronomical Institute in Groningen, The Netherlands, is seeking an ambitious, highly motivated applicant for a 4-year PhD bursary position in Star and Planet Formation to work on organic chemistry in the protosolar nebula. The starting date can be anytime in 2008.

The PhD project will specifically study the processing and stability of organic material in the early Solar System and thereby studying the initial conditions for the formation of life. The goal is to assess the impact of stellar activity (UV and X-rays), winds and highly energetic particles on the formation and survival of abiotic organic species. The work will involve the extension of currently existing chemical reaction databases, the development of a multi-phase gas-grain chemistry and the incorporation of laboratory results into local models of the protosolar nebula. The institute is part of the Netherlands Research School for Astronomy and belongs to the top research institutions in Astronomy worldwide. Research topics currently include cosmology, galaxy evolution, star and planet formation and interstellar matter. Interested applicants should have a very good academic track record and hold the equivalent of a Masters degree, including a substantial thesis, in Astronomy or Physics when starting the position. Previous numerical experience and a strong chemistry background would be an asset.

Interested candidates should send application material, including curriculum vitae, education history with transcripts of study record, a brief statement of research experience and two letters of reference. Selection of candidates will start May 30, 2008, and will continue until the position is filled.

Please send applications to

Dr. Inga Kamp  
Kapteyn Astronomical Institute  
Postbus 800  
9700 AV Groningen  
The Netherlands  
Tel: +31 (0)50 363 4070  
email: [kamp@astro.rug.nl](mailto:kamp@astro.rug.nl)

For inquiries about the position or project, please contact Dr. Kamp. For further information on the Kapteyn Astronomical Institute, please visit the webpages at <http://www.rug.nl/sterrenkunde/>

## *Meetings*

### FIRST ANNOUNCEMENT

## **New Light on Young Stars: Spitzer's View of Circumstellar Disks**

October 26-30 2008, Hilton Hotel, Pasadena CA

<http://www.ipac.caltech.edu/spitzer2008>

The unprecedented infrared sensitivity of the Spitzer Space Telescope has enabled major advances in the study of protostellar, protoplanetary, and debris disks. Now, as Spitzer nears the transition from cryogenic to warm mission, it is an opportune time to assess and synthesize recent progress in our understanding of circumstellar disks and focus on the outstanding science questions for future work. At the meeting, results from Spitzer's surveys of circumstellar matter in the Milky Way will be considered in the context of work at other wavelengths and underlying theory in the following topic areas:

- \* Surveys of star-formation regions
- Effects of environment and central object on disk properties
- Structure of protostellar/protoplanetary disks and envelopes
- Spectroscopic diagnostics of circumstellar gas and dust
- Transition disks, disk evolution, and planet formation
- Frequency, structure, and theory of debris disks

The meeting should be a milestone for our community in assessing how Spitzer has impacted these areas of astronomy. The program will consist of invited reviews, contributed talks, and posters. The conference talks and posters will be posted online as a permanent record of the meeting. A more detailed agenda and list of confirmed speakers can be found on the conference website (see above). The conference will open with registration, poster session, and a reception on Sunday afternoon Oct 26. Four full days of scientific sessions will follow Oct 27-30.

REGISTRATION is now open on the conference website. The registration fee covers the opening reception, conference materials, coffee breaks, and the conference banquet. The fee schedule is US\$250 for early registration (by Aug. 8), US\$300 for late registration (by Oct. 17), and US\$350 for onsite registration (no credit cards accepted).

ABSTRACTS for posters and contributed talks should be submitted at the time of registration. Contributed talks will have a duration of 15 min plus 5 minutes of discussion. The number of contributed talks will be limited: from the expected oversubscription of proposed talks, the SOC will select the final schedule. Selected speakers will be notified by Sep. 10. Talk requests that cannot be accommodated will revert to posters.

SUPPORT funding for a very limited number of student attendees will be available. See the conference website for further information on how to apply. The application deadline is July 18.

LODGING is available at the prevailing government rate (currently US\$118 per night plus taxes) at both the Pasadena Hilton and the Pasadena Sheraton hotels. The latter is located a short walk from the conference hotel. Links to the hotel reservation pages can be found on the conference website. These business-class lodgings are located adjacent to the Paseo shopping plaza which hosts a variety of dining and entertainment options. They are also located 15 min walking distance from Old Town Pasadena, one of the most popular restaurant districts in Southern California. Room reservations must be made by Sep. 25 (Hilton) or Oct. 06 (Sheraton) to get the conference room rate. The number of rooms available to our attendees is limited, so reserve early to avoid the possibility of higher rates or more distant accommodations.

Requests to be added to the conference mailing list, or any questions about the meeting should be directed to [spitzer08@ipac.caltech.edu](mailto:spitzer08@ipac.caltech.edu).

SOC: Deborah Padgett (chair), Ted Bergin, Sean Carey, Neal Evans, Lynne Hillenbrand, Karl Stapelfeldt, Jonathan Tan, Ewine van Dishoeck

LOC: Karl Stapelfeldt (chair), Babar Ali, Mary Ellen Barba, Sergio Fajardo-Acosta, Caer-Eve McCabe, Peregrine McGehee, Helga Mycroft, Deborah Padgett, Peter Plavchan, Rosanne Scholey, Inseok Song, John Stauffer

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).

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