THE STAR FORMATION NEWSLETTER

An electronic publication dedicated to early stellar evolution and molecular clouds

No. 221 — 26 May 2011 Editor: Bo Reipurth (reipurth@ifa.hawaii.edu)

Abstracts of recently accepted papers

Infrared and optical polarimetry around the low-mass star-forming region NGC 1333 IRAS 4A

Felipe O. Alves[1,2], José A. Acosta-Pulido[3,4], Josep M. Girart[1], Gabriel A. P. Franco[5] and Rosario López[6]

[1] Institut de Ciències de l'Espai (IEEC-CSIC), Campus UAB, Facultat de Ciències, C5 par 2ª, 08193 Bellaterra, Catalunya, Spain
[2] Argelander-Institut für Astronomie der Universität Bonn, Auf dem Hügel 71, 53121 Bonn, Germany
[3] Instituto de Astrofísica de Canarias, Vía Láctea s/n, E-38200 La Laguna, Tenerife, Spain
[4] Departamento de Astrofísica, Universidad de La Laguna, E-38205 La Laguna, Tenerife, Spain
[5] Departamento de Física – ICEx – UFMG, Caixa Postal 702, 30.123-970 Belo Horizonte, Brazil
[6] Departament d'Astronomia i Meteorologia (IEEC-UB), Institut de Ciències del Cosmos, Universitat de Barcelona, Martí i Franquès 1, E-08028 Barcelona, Spain

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

We performed J- and R-band linear polarimetry with the 4.2 m William Herschel Telescope at the Observatorio del Roque de los Muchachos and with the 1.6 m telescope at the Observatório do Pico dos Dias, respectively, to derive the magnetic field geometry of the diffuse molecular cloud surrounding the embedded protostellar system NGC 1333 IRAS 4A. We obtained interstellar polarization data for about two dozen stars. The distribution of polarization position angles has low dispersion and suggests the existence of an ordered magnetic field component at physical scales larger than the protostar. Some of the observed stars present intrinsic polarization and evidence of being young stellar objects. The estimated mean orientation of the interstellar magnetic field as derived from these data is almost perpendicular to the main direction of the magnetic field associated with the dense molecular envelope around IRAS 4A. Since the distribution of the CO emission in NGC 1333 indicates that the diffuse molecular gas has a multi-layered structure, we suggest that the observed polarization position angles are caused by the superposed projection along the line of sight of different magnetic field components.

Accepted by AJ

http://arxiv.org/abs/1105.1300

The VLT-FLAMES Tarantula Survey III: A very massive star in apparent isolation from the massive cluster R136

Joachim M. Bestenlehner[1], Jorick S. Vink[1], G. Gräfener[1], F. Najarro[2], C. J. Evans[3], N. Bastian[4,5], A. Z. Bonanos[6], E. Bressert[5,7,8], P. A. Crowther[9], E. Doran[9], K. Friedrich[10], V. Hénault-Brunet[11], A. Herrero[12,13], A. de Koter[14,15], N. Langer[10], D. J. Lennon[16], J. Maíz Apellániz[17], H. Sana[14], I. Soszynski[18] and W. D. Taylor[11]

[1] Armagh Observatory, College Hill, Armagh BT61 9DG, United Kingdom
[2] Centro de Astrobiología (CSIC-INTA), Ctra. de Torrejón a Ajalvir km-4, E-28850 Torrejón de Ardoz, Madrid, Spain
UK Astronomy Technology Centre, Royal Observatory Edinburgh, Blackford Hill, Edinburgh, EH9 3HJ, UK
[4] Excellence Cluster Universe, Boltzmannstr. 2, 85748 Garching, Germany

[5] School of Physics, University of Exeter, Stocker Road, Exeter EX4 4QL, UK
[6] Institute of Astronomy & Astrophysics, National Observatory of Athens, I. Metaxa & Vas. Pavlou Street, P. Penteli 15236, Greece
[7] European Southern Observatory, Karl-Schwarzschild-Strasse 2, D87548, Garching bei München, Germany
[8] Harvard-Smithsonian CfA, 60 Garden Street, Cambridge, MA 02138, USA
[9] Dept. of Physics & Astronomy, Hounsfield Road, University of Sheffield, S3 7RH, UK
[10] Argelander-Institut für Astronomie der Universität Bonn, Auf dem Hügel 71, 53121 Bonn, Germany
[11] SUPA, IfA, University of Edinburgh, Royal Observatory Edinburgh, Blackford Hill, Edinburgh, EH9 3HJ, UK
[12] Departamento de Astrofísica, Universidad de La Laguna, E-38205 La Laguna, Tenerife, Spain
[13] European Southern Observatory, Alonso de Cordova 1307, Casilla, 19001, Santiago 19, Chile
[14] Astronomical Institute Anton Pannekoek, University of Amsterdam, Kruislaan 403, 1098 SJ, Amsterdam, The Netherlands
[15] Astronomical Institute, Utrecht University, Princetonplein 5, 3584CC, Utrecht, The Netherlands
[16] ESA, Space Telescope Science Institute, 3700 San Martin Drive, Baltimore, MD 21218, USA
[17] Instituto de Astrofísica de Andalucía-CSIC, Glorieta de la Astronomía s/n, E-18008 Granada, Spain
[18] Warsaw University Observatory, Aleje Ujazdowskie 4, 00-478 Warsaw, Poland

E-mail contact: jbl *at* arm.ac.uk

VFTS 682 is located in an active star-forming region, at a projected distance of 29 pc from the young massive cluster R136 in the Tarantula Nebula of the Large Magellanic Cloud. It was previously reported as a candidate young stellar object, and more recently spectroscopically revealed as a hydrogen-rich Wolf-Rayet (WN5h) star. Our aim is to obtain the stellar properties, such as its intrinsic luminosity, and to investigate the origin of VFTS 682. To this purpose, we model optical spectra from the VLT-FLAMES Tarantula Survey with the non-LTE stellar atmosphere code CMFGEN, as well as the spectral energy distribution from complementary optical and infrared photometry. We find the extinction properties to be highly peculiar ($R_V \sim$4.7), and obtain a surprisingly high luminosity $\log(L/L_\odot) = 6.5 \pm 0.2$, corresponding to a present-day mass of $\sim 150 M_\odot$. The high effective temperature of 52.2 ± 2.5kK might be explained by chemically homogeneous evolution – suggested to be the key process in the path towards long gamma-ray bursts. Lightcurves of the object show variability at the 10% level on a timescale of years. Such changes are unprecedented for classical Wolf-Rayet stars, and are more reminiscent of Luminous Blue Variables. Finally, we discuss two possibilities for the origin of VFTS 682: (i) the star either formed *in situ*, which would have profound implications for the formation mechanism of massive stars, or (ii) VFTS 682 is a *slow runaway* star that originated from the dense cluster R136, which would make it the most massive runaway known to date.

Accepted by A&A Letters

http://arxiv.org/abs/1105.1775

Radiation driven implosion and triggered star formation

Thomas G. Bisbas[1,2,3], Richard Wünsch[2], Anthony P. Whitworth[3], David A. Hubber[4,5] and Stefanie Walch[3]

[1] Department of Physics & Astronomy, University College London, London WC1E 6BT, UK
[2] Astronomical Institute, Academy of Sciences of the Czech Republic, Bocní II 1401, 141 31 Prague, Czech Republic
[3] School of Physics & Astronomy, Cardiff University, Cardiff CF24 3AA, UK
[4] Department of Physics & Astronomy, University of Sheffield, Sheffield S3 7RH, UK
[5] School of Physics & Astronomy, University of Leeds, Leeds LS2 9JT, UK

E-mail contact: tb *at* star.ucl.ac.uk

We present simulations of initially stable isothermal clouds exposed to ionising radiation from a discrete external source, and identify the conditions that lead to radiatively driven implosion and star formation. We use the Smoothed Particle Hydrodynamics code SEREN and an HEALPix-based photo-ionisation algorithm to simulate the propagation of the ionising radiation and the resulting dynamical evolution of the cloud. We find that the incident ionising flux, $\Phi_{\rm LyC}$, is the critical parameter determining the cloud evolution. At moderate fluxes, a large fraction of the cloud mass is converted into stars. As the flux is increased, the fraction of the cloud mass that is converted into stars and the mean masses of the individual stars both decrease. Very high fluxes simply disperse the cloud. Newly-formed stars tend to be concentrated along the central axis of the cloud (i.e. the axis pointing in the direction of the incident flux).

For given cloud parameters, the time, $t_\star$, at which star formation starts is proportional to $\Phi_{\rm LyC}^{-1/3}$. The pattern of star formation found in the simulations is similar to that observed in bright-rimmed clouds.

Accepted by ApJ

http://arxiv.org/abs/1105.3727

A hybrid moment equation approach to gas-grain chemical modeling

Fujun Du[1] and Bérengère Parise[1]

[1] Max-Planck-Institute for Radio Astronomy, Auf dem Hugel 69, 53121 Bonn, Germany

E-mail contact: fjdu *at* mpifr.de

Context. In addition to gas phase reactions, the chemical processes on the surfaces of interstellar dust grains are important for the energy and material budget of the interstellar medium. The stochasticity of these processes requires special care in modeling. Previously methods based on the modified rate equation, the master equation, the moment equation, and Monte Carlo simulations have been used.
Aims. We attempt to develop a systematic and efficient way to model the gas-grain chemistry with a large reaction network as accurately as possible.
Methods. We present a hybrid moment equation approach which is a general and automatic method where the generating function is used to generate the moment equations. For large reaction networks, the moment equation is cut off at the second order, and a switch scheme is used when the average population of certain species reaches 1. For small networks, the third order moments can also be utilized to achieve a higher accuracy.
Results. For physical conditions in which the surface reactions are important, our method provides a major improvement over the rate equation approach, when benchmarked against the rigorous Monte Carlo results. For either very low or very high temperatures, or large grain radii, results from the rate equation are similar to those from our new approach. Our method is faster than the Monte Carlo approach, but slower than the rate equation approach.
Conclusions. The hybrid moment equation approach with a cutoff and switch scheme is a very powerful way to solve gas-grain chemistry. It is applicable to large gas-grain networks, and is demonstrated to have a degree of accuracy high enough to be used for astrochemistry studies. Further work should be done to investigate how to cut off the hybrid moment equation selectively to make the computation faster, more accurate, and more stable, how to make the switch to rate equation more mathematically sound, and how to make the errors controllable. The layered structure of the grain mantle could also be incorporated into this approach, although a full implementation of the grain micro-physics appears to be difficult.

Accepted by A&A

http://arxiv.org/abs/1104.5208

High-resolution EVLA image of dimethyl ether $(CH_3)_2O$ in Orion–KL

C. Favre[1], H. A. Wootten[2], A. J. Remijan[2], N. Brouillet[3,4], T. L. Wilson[5], D. Despois[3,4] and A. Baudry[3,4]

[1] Department of Physics and Astronomy, University of Århus, Ny Munkegade 120, DK-8000 Århus C, Denmark
[2] National Radio Astronomy Observatory, 520 Edgemont Road, Charlottesville, VA 22903-2475, USA
[3] Université de Bordeaux, OASU, 2 rue de l'Observatoire, BP 89, 33271 Floirac Cedex, France
[4] CNRS, UMR 5804, Laboratoire d'Astrophysique de Bordeaux, 2 rue de l?Observatoire, BP 89, 33271 Floirac Cedex, France
[5] Naval Research Laboratory, Code 7210, Washington, DC 20375, USA

E-mail contact: awootten *at* nrao.edu

We report the first sub-arc second (0.65 *arcsec* $\times$ 0.51 *arcsec*) image of the dimethyl ether molecule, $(CH_3)_2O$, toward the Orion Kleinmann-Low nebula (Orion–KL). The observations were carried at 43.4 GHz with the Expanded Very Large Array (EVLA). The distribution of the lower energy transition $6_{1,5} - 6_{0,6}$, EE (E_u = 21 K) mapped in this study is in excellent agreement with the published dimethyl ether emission maps imaged with a lower resolution. The main emission peaks are observed toward the Compact Ridge and Hot Core southwest components, at the northern parts of the Compact Ridge and in an intermediate position between the Compact Ridge and the Hot Core. A notable result

is that the distribution of dimethyl ether is very similar to that of another important larger O-bearing species, the methyl formate ($HCOOCH_3$), imaged at lower resolution. Our study shows that higher spectral resolution (WIDAR correlator) and increased spectral coverage provided by the EVLA offer new possibilities for imaging complex molecular species. The sensitivity improvement and the other EVLA improvements make this instrument well suited for high sensitivity, high angular resolution, molecular line imaging.

Accepted by Astrophysical Journal (Letters) for EVLA special issue

http://arxiv.org/abs/1105.3204

Stellar Activity in the Broad-Band Ultraviolet

Krzysztof Findeisen[1], Lynne Hillenbrand[1] and David Soderblom[2]

[1] California Institute of Technology, MC 249-17, Pasadena, CA 91125, USA
[2] Space Telescope Science Institute, Baltimore, MD 21218, USA

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

The completion of the GALEX All-Sky Survey in the ultraviolet allows activity measurements to be acquired for many more stars than is possible with the limited sensitivity of ROSAT or the limited sky coverage of Chandra, XMM, or spectroscopic surveys for line emission in the optical or ultraviolet. We have explored the use of GALEX photometry as an activity indicator, using as a calibration sample stars within 50 pc, representing the field, and in selected nearby associations, representing the youngest stages of stellar evolution. We present preliminary relations between UV flux and the optical activity indicator $R'_{\rm HK}$ and between UV flux and age. We demonstrate that far-UV (FUV, 1350-1780Å) excess flux is roughly proportional to $R'_{\rm HK}$. We also detect a correlation between near-UV (NUV, 1780-2830Å) flux and activity or age, but the effect is much more subtle, particularly for stars older than than $\sim 0.5-1$ Gyr. Both the FUV and NUV relations show large scatter, ~ 0.2 mag when predicting UV flux, ~ 0.18 dex when predicting $R'_{\rm HK}$, and ~ 0.4 dex when predicting age. This scatter appears to be evenly split between observational errors in current state-of-the-art data and long-term activity variability in the sample stars.

Accepted by Astronomical Journal

http://arxiv.org/abs/1105.1377

The Highly Dynamic Behavior of the Innermost Gas and Dust in the Transition Disk Variable LRLL 31

Kevin Flaherty[1], James Muzerolle[2], George Rieke[1], Robert Gutermuth[3], Zoltan Balog[4], William Herbst[5], S. Thomas Megeath[6] and Maria Kun[7]

[1] Steward Observatory, University of Arizona, Tucson, AZ 85721, USA
[2] STSCI, 3700 San Martin Dr, Baltimore MD, 21218, USA
[3] Smith College, Northhampton, MA 01063, USA
[4] MPIA, Konigstuhl 17, D-69117 Heidelberg, Germany
[5] Department of Astronomy, Wesleyan College, Middletown, CT, USA
[6] Department of Physics and Astronomy, University of Toledo, Toledo, OH, USA
[7] Konkoly Observatory, H-1121 Budapest, Konkoly Thege ut 15-17, Hungary

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

We describe extensive synoptic multi-wavelength observations of the transition disk LRLL 31 in the young cluster IC 348. We combined 4 epochs of IRS spectra, 9 epochs of MIPS photometry, 7 epochs of cold-mission IRAC photometry, and 36 epochs of warm-mission IRAC photometry along with multi-epoch near-infrared spectra, optical spectra, and polarimetry to explore the nature of the rapid variability of this object. We find that the inner disk, as traced by the 2-5 μm excess, stays at the dust sublimation radius while the strength of the excess changes by a factor of eight on weekly timescales, and the 3.6 and 4.5 μm photometry show a drop of 0.35 mag in 1 week followed by a slow 0.5 mag increase over the next 3 weeks. The accretion rate, as measured by Paβ and Brγ emission lines, varies by a factor of five with evidence for a correlation between the accretion rate and the infrared excess. While the gas and dust in the inner disk are fluctuating, the central star stays relatively static. Our observations allow us to put constraints on

the physical mechanism responsible for the variability. The variable accretion, and wind, are unlikely to be causes of the variability, but are both effects of the same physical process that disturbs the disk. The lack of periodicity in our infrared monitoring indicates that it is unlikely that there is a companion within ∼0.4 AU that is perturbing the disk. The most likely explanation is either a companion beyond 0.4 AU or a dynamic interface between the stellar magnetic field and the disk leading to a variable scale height and/or warping of the inner disk.

Accepted by The Astrophysical Journal

http://adsabs.harvard.edu/abs/2011ApJ...732...83F

Simultaneous X-ray and radio observations of Young Stellar Objects in NGC 1333 and IC 348

Jan Forbrich[1], Rachel A. Osten[2], and Scott J. Wolk[1]

[1] Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA
[2] Space Telescope Science Institute, 3700 San Martin Drive, Baltimore, MD 21218, USA

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

Young Stellar Objects (YSOs) and in particular protostars are known to show a variety of high-energy processes. Observations in the X-ray and centimetric radio wavelength ranges are thought to constrain some of these processes, e.g., coronal-type magnetic activity. There is a well-known empirical correlation of radio and X-ray luminosities in active stars, the so-called Güdel-Benz relation. Previous evidence whether YSOs are compatible with this relation remains inconclusive for the earliest evolutionary stages. The main difficulty is that due to the extreme variability of these sources, simultaneous observations are essential. Until now, only few YSOs and only a handful of protostars have been observed simultaneously in the X-ray and radio range. To expand the sample, we have obtained such observations of two young clusters rich in protostars, NGC 1333 and IC 348. While the absolute sensitivity is lower for these regions than for more nearby clusters like CrA, we find that even in deep continuum observations carried out with the NRAO Very Large Array, the radio detection fraction for protostars in these clusters is much lower than the X-ray detection fraction. Very few YSOs are detected in both bands, and we find the radio and X-ray populations among YSOs to be largely distinct. We combine these new results with previous simultaneous *Chandra* and VLA observations of star-forming regions and find that YSOs with detections in both bands appear to be offset toward higher radio luminosities for given X-ray luminosities when compared to the Güdel-Benz relation, although even in this sensitive dataset most sources are too weak for the radio detections to provide information on the emission processes. The considerably improved sensitivity of the Expanded Very Large Array will provide a better census of the YSO radio population as well as better constraints on the emission mechanisms.

Accepted by Astrophys. J.

http://arxiv.org/abs/1105.0923

On the formation of CO_2 and other interstellar ices

R. T. Garrod[1] and T. Pauly[2]

[1] Department of Astronomy, Cornell University, Ithaca, NY 14853, USA
[2] Department of Physics and Astronomy, Iowa State University, Ames, IA 50011, USA

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

We investigate the formation and evolution of interstellar dust-grain ices under dark-cloud conditions, with a particular emphasis on CO_2. We use a three-phase model (gas/surface/mantle) to simulate the coupled gas-grain chemistry, allowing the distinction of the chemically-active surface from the ice layers preserved in the mantle beneath. The model includes a treatment of the competition between barrier-mediated surface reactions and thermal-hopping processes. The results show excellent agreement with the observed behavior of CO_2, CO and water ice in the interstellar medium. The reaction of the OH radical with CO is found to be efficient enough to account for CO_2 ice production in dark clouds. At low visual extinctions, with dust temperatures $>\sim$12 K, CO_2 is formed by direct diffusion and reaction of CO with OH; we associate the resultant CO_2-rich ice with the observational polar CO_2 signature. CH_2 ice is well correlated with this component. At higher extinctions, with lower dust temperatures, CO is relatively immobile and thus abundant; however, the reaction of H and O atop a CO molecule allows OH and CO to meet rapidly enough to produce a CO:CO_2 ratio in the range ~2-4, which we associate with apolar signatures. We suggest that the observational apolar CO_2/CO ice signatures in dark clouds result from a strongly segregated CO:H_2O ice, in which CO_2 resides almost exclusively within the CO component. Observed visual-extinction thresholds for CO_2, CO and H_2O are well reproduced by depth-dependent models. Methanol formation is found to be strongly sensitive to dynamical timescales and dust temperatures.

Accepted by Astrophysical Journal

The four-populations model: a new classification scheme for pre-planetesimal collisions

Ralf J. Geretshauser[1], Farzana Meru[1], Roland Speith[2] and Wilhelm Kley[1]

[1] Institut für Astronomie und Astrophysik, Abteilung Computational Physics, Eberhard Karls Universität Tübingen, Auf der Morgenstelle 10, 72076 Tübingen, Germany
[2] Physikalisches Institut, Eberhard Karls Universität Tübingen, Auf der Morgenstelle 14, 72076 Tübingen, Germany

E-mail contact: ralf.j.geretshauser *at* uni-tuebingen.de

Within the collision growth scenario for planetesimal formation, the growth step from centimetre sized pre-planetesimals to kilometre sized planetesimals is still unclear. The formation of larger objects from the highly porous pre-planetesimals may be halted by a combination of fragmentation in disruptive collisions and mutual rebound with compaction. However, the right amount of fragmentation is necessary to explain the observed dust features in late T Tauri discs. Therefore, detailed data on the outcome of pre-planetesimal collisions is required and has to be presented in a suitable and precise format. We wish to develop a new classification scheme broad enough to encompass all events with sticking, bouncing, and fragmentation contributions, accurate enough to capture the important collision outcome nuances, and at the same time simple enough to be implementable in global dust coagulation simulations. We furthermore wish to demonstrate the reliability of our numerical smoothed particle hydrodynamics (SPH) model and the applicability of our new collision outcome classification to previous results as well as our simulation results. We propose and apply a scheme based on the quantitative aspects of four fragment populations: the largest and second largest fragment, a power-law population, and a sub-resolution population. For the simulations of pre-planetesimal collisions, we adopt the SPH numerical scheme with extensions for the simulation of porous solid bodies. By means of laboratory benchmark experiments, this model was previously calibrated and tested for the correct simulation of the compaction, bouncing, and fragmentation behaviour of macroscopic highly porous SiO_2 dust aggregates.It is shown that previous attempts to map collision data were much too oriented on qualitatively categorising into sticking, bouncing, and fragmentation events. Intermediate categories are found in our simulations which are hard to map to existing qualitative categorisations. We show that the four-populations model encompasses all previous categorisations and in addition allows for transitions. This is because it is based on quantitative characteristic attributes of each population such as the mass, kinetic energy, and filling factor. In addition, the numerical porosity model successfully passes another benchmark test: the correct simulation of the entire list of collision outcome types yielded by laboratory experiments. As a demonstration of the applicability and the power of the four-populations model, we utilise it to present the results of a study on the influence of collision velocity in head-on collisions of intermediate porosity aggregates.

Accepted by Astronomy & Astrophysics

http://arxiv.org/abs/1105.0915

Emission Lines from the Gas Disk around TW Hydra and the Origin of the Inner Hole

Uma Gorti[1,2], David Hollenbach[2], Joan Najita[3] and Ilaria Pascucci[4]

[1] NASA Ames Research Center, Moffett Field, CA, USA
[2] SETI Institute, Mountain View, CA, USA [3] NOAO, Tucson, AZ, USA
[4] Space Telescope Science Institute, Baltimore, MD, USA

E-mail contact: uma.gorti-1 *at* nasa.gov

We compare line emission calculated from theoretical disk models with optical to sub-millimeter wavelength observational data of the gas disk surrounding TW Hya and infer the spatial distribution of mass in the gas disk. The model disk that best matches observations has a gas mass ranging from $\sim 10^{-4} - 10^{-5} M_\odot$ for $0.06AU < r < 3.5AU$ and $\sim 0.06 M_\odot$ for $3.5AU < r < 200AU$. We find that the inner dust hole ($r < 3.5AU$) in the disk must be depleted of gas by $\sim 1-2$ orders of magnitude compared to the extrapolated surface density distribution of the outer disk. Grain growth alone is therefore not a viable explanation for the dust hole. CO vibrational emission arises within $r \sim 0.5$AU from thermal excitation of gas. [OI] 6300Å and 5577Å forbidden lines and OH mid-infrared emission are mainly due to prompt emission following UV photodissociation of OH and water at $r \lesssim 0.1$AU and at $r \sim 4$AU. [NeII] emission is consistent with an origin in X-ray heated neutral gas at $r \lesssim 10$AU, and may not require the presence of a significant EUV ($h\nu > 13.6$eV) flux from TW Hya. H_2 pure rotational line emission comes primarily from $r \sim 1-30$AU. [OI]63μm, HCO^+ and CO pure rotational lines all arise from the outer disk at $r \sim 30-120$AU. We discuss planet formation and photoevaporation as causes for the decrease in surface density of gas and dust inside 4 AU. If a planet is present, our results suggest a planet mass $\sim 4-7$M$_J$ situated at ~ 3AU. Using our photoevaporation models and the best surface density profile match to observations, we estimate a current photoevaporative mass loss rate of 4×10^{-9}M$_\odot$ yr^{-1} and a remaining disk lifetime of ~ 5 million years.

Accepted by Astrophysical Journal

Precise Orbit Solution of MML 53, a Low-Mass, Pre-Main Sequence Eclipsing Binary in Upper Centaurus Lupus

L. Hebb[1], H. M. Cegla[2,3,1], K.G. Stassun[4], H.C. Stempels[5], P.A. Cargile[1] and L.E. Palladino[1]

[1] Vanderbilt University, Nashville, TN 37235, USA
[2] Summer REU Program, Vanderbilt University, Nashville, Tennessee 37235, USA
[3] Queen's University, University Road, Belfast, BT7 1NN, UK
[4] Fisk University, Nashville, Tennessee 37208, USA
[5] Uppsala University, Box 516, SE-751 20 Uppsala, Sweden

E-mail contact: leslie.hebb *at* vanderbilt.edu

We present a double-lined orbit solution for MML 53, the recently discovered low-mass pre-main sequence eclipsing binary. Using high-resolution spectra from the SMARTS 1.5m echelle spectrograph, we measure precise radial velocities and derive the orbital parameters of the system. The 2.1 d orbit of the eclipsing pair is circular, and we find the minimum masses of the eclipsing components to be $M_1 \sin^3 i = 0.97\,\mathrm{M}_\odot$ and $M_2 \sin^3 i = 0.84\,\mathrm{M}_\odot$, with formal uncertainties of 2.0% and an additional systematic uncertainty of $\approx 2.5\%$ most likely caused by large star spots on the primary star. MML 53 has been previously identified as a member of the Upper Centaurus Lupus (UCL) star forming region (age ∼15 Myr). The systemic radial velocity from our orbit solution, $v_\gamma = +1.4 \pm 0.3 \pm 0.8$ km s^{-1} (statistical and systematic), is also consistent with kinematic membership in this association. In addition, we detect a change in v_γ between 2006 and 2009 providing further evidence for the presence of a third body in a wide (several year) orbit.

Accepted by Astronomy and Astrophysics

Detection of Two Carbon-Chain–Rich Cores; CB130-3 and L673-SMM4

Tomoya Hirota[1], Takeshi Sakai[2], Nami Sakai[3] and Satoshi Yamamoto[3]

[1] National Astronomical Observatory of Japan, Osawa 2-21-1, Mitaka, Tokyo 181-8588, Japan
[2] Institute of Astronomy, The University of Tokyo, Osawa 2-21-1, Mitaka, Tokyo 181-0015, Japan
[3] Department of Physics and Research Center for the Early Universe, The University of Tokyo, Hongo 7-3-1, Bunkyo-ku, Tokyo 113-0033, Japan

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

We have found two dense cores, CB130-3 and L673-SMM4, where the carbon-chain molecules are extremely abundant relative to NH_3, during a survey observation of radio emission lines of CCS, HC_3N, HC_5N, and NH_3 toward dark cloud cores. Judging from the low NH_3/CCS ratios, they are possible candidates for "Carbon-Chain–Producing Regions (CCPRs)" recognized as chemically young dark cloud cores. The deuterium fractionation ratios DNC/HN^{13}C in CB130-3 and L673-SMM4 are found to be $1.28^{+0.27}_{-0.05}$ and $1.96^{+0.32}_{-0.01}$, respectively, which are comparable to or slightly higher than those in CCPRs found previously. We suggest that the dense cores of CB130-3 and L673-SMM4 are analogous to CCPRs but their chemical evolutionary phase would be slightly older than those of the dense cores in the Taurus region.

Accepted by ApJ

http://jp.arxiv.org/abs/1105.0081

The standard model of low-mass star formation applied to massive stars: multiwavelength modelling of IRAS 20126+4104

Katharine G. Johnston[1,2,3], Eric Keto[1], Thomas P. Robitaille[1] and Kenneth Wood[2]

[1] Harvard-Smithsonian Center for Astrophysics, 60 Garden St, Cambridge, MA 02138, USA
[2] School of Physics & Astronomy, University of St Andrews, North Haugh, St Andrews, KY16 9SS, UK
[3] Max-Planck-Institute for Astronomy, Koenigstuhl 17, D-69117 Heidelberg, Germany

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

In order to investigate whether massive stars form similarly to their low-mass counterparts, we have used the standard envelope plus disc geometry successfully applied to low-mass protostars to model the near-IR to submillimetre spectral energy distribution (SED) and several mid-IR images of the embedded massive star IRAS 20126+4104. We have used a Monte Carlo radiative transfer dust code to model the continuum absorption, emission and scattering through two azimuthally symmetric dust geometries, the first consisting of a rotationally flattened envelope with outflow cavities, and the second which also includes a flared accretion disc. Our results show that the envelope plus disc model reproduces the observed SED and images more accurately than the model without a disc, although the latter model more closely reproduces the morphology of the mid-IR emission within a radius of 1.1 arcsec or ∼1800 au. We have put forward several possible causes of this discontinuity, including inner truncation of the disc due to stellar irradiation or precession of the outflow cavity. Our best-fitting envelope plus disc model has a disc radius of 9200 au. We find that it is unlikely that the outer regions of such a disc would be in hydrostatic or centrifugal equilibrium, however we calculate that the temperatures within the disc would keep it stable to fragmentation.

Accepted by MNRAS

http://arxiv.org/abs/1104.3580

Near-infrared spectroscopy of EX Lupi in outburst

Á. Kóspál[1], P. Ábrahám[2], M. Goto[3], Zs. Regály[2], C.P. Dullemond[3], Th. Henning[3], A. Juhász[1], A. Sicilia-Aguilar[3], and M. van den Ancker[4]

[1] Leiden Observatory, Leiden University, P.O. Box 9513, NL-2300 RA Leiden, The Netherlands
[2] Konkoly Observatory of the Hungarian Academy of Sciences, P.O. Box 67, H-1525 Budapest, Hungary
[3] Max Planck Institute for Astronomy, Königstuhl 17, D-69117 Heidelberg, Germany
[4] ESO, Karl-Schwarzschild-Straße 2, D-85748 Garching bei München, Germany

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

EX Lup is the prototype of the EXor class of young eruptive stars: objects showing repetitive brightenings due to increased accretion from the circumstellar disk to the star. In this paper, we report on medium-resolution near-infrared spectroscopy of EX Lup taken during its extreme outburst in 2008, as well as numerical modeling with the aim of determining the physical conditions around the star. We detect emission lines from atomic hydrogen, helium, and metals, as well as first overtone bandhead emission from carbon monoxide. Our results indicate that the emission lines are originating from gas located in a dust-free region within ≈0.2 AU of the star. The profile of the CO bandhead indicates that the CO gas has a temperature of 2500 K, and is located in the inner edge of the disk or in the outer parts of funnel flows. The atomic metals are probably co-located with the CO. Some metallic lines are fluorescently excited, suggesting direct exposure to ultraviolet photons. The Brackett series indicates emission from hot (10 000 K) and optically thin gas. The hydrogen lines display a strong spectro-astrometric signal, suggesting that the hydrogen emission is probably not coming from an equatorial boundary layer; a funnel flow or disk wind origin is more likely. This picture is broadly consistent with the standard magnetospheric accretion model usually assumed for normally accreting T Tauri stars. Our results also set constraints on the eruption mechanism, supporting a model where material piles up around the corotation radius and episodically falls onto the star.

Accepted by Astrophysical Journal

http://arxiv.org/abs/1105.1287

Disk Formation in Magnetized Clouds Enabled by the Hall Effect

Ruben Krasnopolsky[1], Zhi-Yun Li[2] and Hsien Shang[1]

[1] Academia Sinica, Institute of Astronomy and Astrophysics, Taipei, Taiwan
[2] University of Virginia, Astronomy Department, Charlottesville, Virginia, USA

E-mail contact: zl4h *at* virginia.edu

Stars form in dense cores of molecular clouds that are observed to be significantly magnetized. A dynamically important magnetic field presents a significant obstacle to the formation of protostellar disks. Recent studies have shown that magnetic braking is strong enough to suppress the formation of rotationally supported disks in the ideal MHD limit. Whether non-ideal MHD effects can enable disk formation remains unsettled. We carry out a first study on how disk formation in magnetic clouds is modified by the Hall effect, the least explored of the three non-ideal MHD effects in star formation (the other two being ambipolar diffusion and Ohmic dissipation). For illustrative purposes, we consider a simplified problem of a non-self-gravitating, magnetized envelope collapsing onto a central protostar of fixed mass. We find that the Hall effect can spin up the inner part of the collapsing flow to Keplerian speed, producing a rotationally supported disk. The disk is generated through a Hall-induced magnetic torque. Disk formation occurs even when the envelope is initially non-rotating, provided that the Hall coefficient is large enough. When the magnetic field orientation is flipped, the direction of disk rotation is reversed as well. The implication is that the Hall effect can in principle produce both regularly rotating and counter-rotating disks around protostars. The Hall coefficient expected in dense cores is about one order of magnitude smaller than that needed for efficient spin-up in these models. We conclude that the Hall effect is an important factor to consider in studying the angular momentum evolution of magnetized star formation in general and disk formation in particular.

Accepted by ApJ, 733, 54

http://arxiv.org/abs/1101.3018

Internal Motions in Starless Dense Cores

Chang Won Lee[1] and Philip C. Myers[2]

[1] Korea Astronomy and Space Science Institute, 776 Daedeokdae-ro, Yuseong-gu, Daejeon 305-348, Republic of Korea
[2] Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA

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

This paper discusses the statistics of internal motions in starless dense cores and the relation of these motions to core density and evolution. Four spectral lines from three molecular species are analyzed from single-pointing and mapped observations of several tens of starless cores. Blue asymmetric profiles are dominant, indicating that inward motions are prevalent in sufficiently dense starless cores. These blue profiles are found to be more abundant, and their asymmetry is bluer, at core positions with stronger N_2H^+ line emission or higher column density. Thirty three starless cores are classified into four types according to the blueshift and red shift of the lines in their molecular line maps. Among these cores, contracting motions dominate: 19 are classified as contracting, 3 as oscillating, 3 as expanding, and 8 as static. Contracting cores have inward motions all over the core with predominance of those motions near the region of peak density. Cores with the bluest asymmetry tend to have greater column density than other cores and all five cores with peak column density $> 6 \times 10^{21}$ cm^{-2} are found to be contracting. This suggests that starless cores are likely to have contracting motions if they are sufficiently condensed. Our classification of the starless cores may indicate a sequence of core evolution in the sense that column density increases from static to contracting cores: the static cores in the earliest stage, the expanding and/or the oscillating cores in the next, and the contracting cores in the latest stage.

Accepted by The Astrophysical Journal

http://arxiv.org/abs/1104.2950

Protoplanetary Disk Masses in IC348: A Rapid Decline in the Population of Small Dust Grains After 1 Myr

Nicholas Lee[1], Jonathan P. Williams[1] and Lucas A. Cieza[1]

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

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

We present a 1.3 mm continuum survey of protoplanetary disks in the 2–3 Myr old cluster, IC348, with the Submillimeter Array. We observed 85 young stellar objects and detected 10 with 1.3 mm fluxes greater than 2 mJy. The brightest source is a young embedded protostar driving a molecular outflow. The other 9 detections are dusty disks around optically visible stars. Our millimeter flux measurements translate into total disk masses ranging from 2 to 6 Jupiter masses. Each detected disk has strong mid-infrared emission in excess of the stellar photosphere and has Hα equivalent widths larger than the average in the cluster and indicative of ongoing gas accretion. The disk mass distribution, however, is shifted by about a factor of 20 to lower masses, compared to that in the ~ 1 Myr old Taurus and Ophiuchus regions. These observations reveal the rapid decline in the number of small dust grains in disks with time, and probably their concomitant growth beyond millimeter sizes. Moreover, if IC348 is to form planets in the same proportion as detected in the field, these faint millimeter detections may represent the best candidates in the cluster to study the progression from planetesimals to planets.

Accepted by Astrophysical Journal

http://arxiv.org/abs/1105.2046

Sequential star formation in IRAS 06084-0611 (GGD 12-15) From intermediate-mass to high-mass stars

K. M. Maaskant[1,2], A. Bik[3], L.B.F.M. Waters[4,1], L. Kaper[1], Th. Henning[3], E. Puga[5,6], M. Horrobin[7] and J. Kainulainen[3]

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

[2] Leiden Observatory, Leiden University, P.O. Box 9513, 2300 RA Leiden, The Netherlands

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

[4] SRON-Netherlands Institute for Space Research, Sorbonnelaan 2, 3584 CA Utrecht, the Netherlands

[5] Centro de Astrobiologia (CSIC-INTA), 28850 Torrejon de Ardoz, Madrid, Spain

[6] Instituut voor Sterrenkunde, Celestijnenlaan 200D, B-3001 Leuven, Belgium

[7] I.Physikalisches Institut, Universitat zu Koln, 50937 Koln, Germany

E-mail contact: kmaaskan *at* science.uva.nl

Context. The formation and early evolution of high- and intermediate-mass stars towards the main sequence involves the interplay of stars in a clustered and highly complex environment. To obtain a full census of this interaction, the Formation and Early evolution of Massive Stars (FEMS) collaboration studies a well-selected sample of 10 high-mass star-forming regions. Aims. In this study we examine the stellar content of the high-mass star-forming region centered on IRAS 06084-0611 in the Monoceros R2 cloud.
Methods. Using the near-infrared H- and K-band spectra from the VLT/SINFONI instrument on the ESO Very Large Telescope (VLT) and photometric near-infrared NTT/SOFI, 2MASS and Spitzer/IRAC data, we were able to determine the spectral types for the most luminous stars in the cluster.
Results. Two very young and reddened massive stars have been detected by SINFONI: a massive Young Stellar Object (YSO) con- sistent with an early-B spectral type and a Herbig Be star. Furthermore, stars of spectral type G and K are detected while still in the Pre-Main Sequence (PMS) phase. We derive additional properties such as temperatures, extinctions, radii and masses. We present a Hertzsprung-Russell diagram and find most objects having intermediate masses between $\sim$1.5-2.5 $M_\odot$. For these stars we derive a median cluster age of $\sim$4 Myr.
Conclusions. Using Spitzer/IRAC data we confirm earlier studies that the younger class 0/I objects are centrally located while the class II objects are spread out over a larger area, with rough scale size radii of $\sim$0.5 pc and $\sim$1.25 pc respectively. Moreover, the presence of a massive YSO, an ultracompact H ii region and highly reddened objects in the center of the cluster suggest a much younger age of ¡ 1 Myr. A possible scenario for this observation would be sequential star formation along the line of sight; from a cluster of intermediate-mass to high-mass stars.

Accepted by Astronomy & Astrophysics

http://arxiv.org/pdf/1104.5618v1

Recurrent Planet Formation and Intermittent Protostellar Outflows Induced by Episodic Mass Accretion

Masahiro N. Machida[1], **Shu-ichiro Inutsuka**[2] **and Tomoaki Matsumoto**[3]

[1] National Astronomical Observatory of Japan, Mitaka, Tokyo 181-8588, Japan
[2] Department of Physics, Nagoya University, Furo-cho, Chikusa-ku, Nagoya, Aichi 464-8602, Japan
[3] Faculty of Humanity and Environment, Hosei University, Fujimi, Chiyoda-ku, Tokyo 102-8160, Japan

E-mail contact: masahiro.machida *at* nao.ac.jp

The formation and evolution of a circumstellar disk in magnetized cloud cores is investigated from prestellar core stage until $\sim 10^4$ yr after protostar formation. In the circumstellar disk, fragmentation first occurs due to gravitational instability in a magnetically inactive region, and substellar-mass objects appear. The substellar-mass objects lose their orbital angular momenta by gravitational interaction with the massive circumstellar disk and finally fall onto the protostar. After this fall, the circumstellar disk increases its mass by mass accretion and again induces fragmentation. The formation and falling of substellar-mass objects are repeated in the circumstellar disk until the end of the main accretion phase. In this process, the mass of fragments remain small, because the circumstellar disk loses its mass by fragmentation and subsequent falling of fragments before it becomes very massive. In addition, when fragments orbit near the protostar, they disturb the inner disk region and promote mass accretion onto the protostar. The orbital motion of substellar-mass objects clearly synchronizes with the time variation of the accretion luminosity of the protostar. Moreover, as the objects fall, the protostar shows a strong brightening for a short duration. The intermittent protostellar outflows are also driven by the circumstellar disk whose magnetic field lines are highly tangled owing to the orbital motion of fragments. The time-variable protostellar luminosity and intermittent outflows may be a clue for detecting planetary-mass objects in the circumstellar disk.

Accepted by ApJ

http://jp.arxiv.org/abs/1101.1997

The Origin and Formation of the Circumstellar Disk

Masahiro N. Machida[1] **and Tomoaki Matsumoto**[2]

[1] National Astronomical Observatory of Japan, Mitaka, Tokyo 181-8588, Japan
[2] Faculty of Humanity and Environment, Hosei University, Fujimi, Chiyoda-ku, Tokyo 102-8160, Japan

E-mail contact: masahiro.machida *at* nao.ac.jp

The formation and evolution of the circumstellar disk in the collapsing molecular cloud with and without magnetic field is investigated from the prestellar stage resolving both the molecular cloud core and the protostar itself. In the collapsing cloud core, the first (adiabatic) core appears prior to the protostar formation. Reflecting the thermodynamics of the collapsing gas, the first core is much more massive than the protostar. When the molecular cloud has no angular momentum, the first core falls onto the protostar and disappears a few years after the protostar formation. On the other hand, when the molecular cloud has an angular momentum, the first core does not disappear even after the protostar formation, and directly evolves into the circumstellar disk with a Keplerian rotation. There are two paths for the formation of the circumstellar disk. When the initial cloud has a considerably small rotational energy, two nested disks appear just after the protostar formation. During the early main accretion phase, the inner disk increases its size and merges with the outer disk (i.e. first core) to form a single circumstellar disk with a Keplerian rotation. On the other hand, when the molecular cloud has a rotational energy comparable to observations, a single centrifugally supported disk that corresponds to the first core already exists prior to the protostar formation. In such a cloud, the first core density gradually increases, maintaining the Keplerian rotation and forms the protostar inside it. The magnetic field rarely affects the early formation of the circumstellar disk because the magnetic field dissipates in the high-density gas region where the circumstellar disk forms. As a result, in any case, the protostar at its formation is already surrounded by a massive circumstellar disk. The circumstellar disk is about 10-100 times more massive than the protostar in the main accretion phase. Such disks are favourable sites for the formation of binary companions and gas-giant planets.

Accepted by MNRAS

http://arxiv.org/abs/1008.0920

Accuracy of core mass estimates in simulated observations of dust emission

J. Malinen[1], M. Juvela[1], D.C. Collins[2], T. Lunttila[1] and P. Padoan[2,3]

[1] Department of Physics, University of Helsinki, P.O. Box 64, FI-00014 Helsinki, Finland
[2] Center for Astrophysics and Space Sciences, University of California, San Diego, 9500 Gilman Drive, La Jolla, CA 92093, USA
[3] ICREA & ICC, University of Barcelona, Marti i Franquès 1, E-08028 Barcelona, Spain

E-mail contact: johanna.malinen *at* helsinki.fi

We study the reliability of the mass estimates obtained for molecular cloud cores using sub-millimetre and infrared dust emission. We use magnetohydrodynamic simulations and radiative transfer to produce synthetic observations with spatial resolution and noise levels typical of Herschel surveys. We estimate dust colour temperatures using different pairs of intensities, calculate column densities with opacity at one wavelength, and compare the estimated masses with the true values. We compare these results to the case when all five Herschel wavelengths are available. We investigate the effects of spatial variations of dust properties and the influence of embedded heating sources. Wrong assumptions of dust opacity and its spectral index β can cause significant systematic errors in mass estimates. These are mainly multiplicative and leave the slope of the mass spectrum intact, unless cores with very high optical depth are included. Temperature variations bias the colour temperature estimates and, in quiescent cores with optical depths higher than for normal stable cores, masses can be underestimated by up to one order of magnitude. When heated by internal radiation sources, the dust in the core centre becomes visible and the observations recover the true mass spectra. The shape, although not the position, of the mass spectrum is reliable against observational errors and biases introduced in the analysis. This changes only if the cores have optical depths much higher than expected for basic hydrostatic equilibrium conditions. Observations underestimate the value of β whenever there are temperature variations along the line of sight. A bias can also be observed when the true β varies with wavelength. Internal heating sources produce an inverse correlation between colour temperature and β that may be difficult to separate from any intrinsic $\beta(T)$ relation of the dust grains. This suggests caution when interpreting the observed mass spectra and the spectral indices.

Accepted by Astronomy & Astrophysics

http://arxiv.org/abs/1009.4580

Mass distributions of stars and cores in young groups and clusters

Manon Michel[1], Helen Kirk[2] and Philip C. Myers[2]

[1] Physics department, Ecole Normale Superieure de Paris. 24 rue Lhomond, 75231 Paris Cedex 05, France
[2] Harvard-Smithsonian Center for Astrophysics 60 Garden Street, MS 42, Cambridge MA 02138, USA

E-mail contact: manon.michel *at* ens.fr

We investigate the relation of the stellar initial mass function (IMF) and the dense core mass function (CMF), using stellar masses and positions in 14 well-studied young groups. Initial column density maps are computed by replacing each star with a model initial core having the same star formation efficiency (SFE). For each group the SFE, core model, and observational resolution are varied to produce a realistic range of initial maps. A clumpfinding algorithm parses each initial map into derived cores, derived core masses, and a derived CMF. The main result is that projected blending of initial cores causes derived cores to be too few and too massive. The number of derived cores is fewer than the number of initial cores by a mean factor 1.4 in sparse groups and 5 in crowded groups. The mass at the peak of the derived CMF exceeds the mass at the peak of the initial CMF by a mean factor 1.0 in sparse groups and 12.1 in crowded groups. These results imply that in crowded young groups and clusters, the mass distribution of observed cores may not reliably predict the mass distribution of protostars which will form in those cores.

Accepted by Astrophysical Journal

http://arxiv.org/abs/1104.4538

Filamentary Condensations in a Young Cluster

Philip C. Myers[1]

[1] Harvard-Smithsonian Center for Astrophysics, USA

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

New models are presented for star-forming condensations in clusters. In each model, the condensation mass increases linearly with radius on small scales, and more rapidly on large scales, as in "thermal-nonthermal" models. Spherical condensations with this structure form protostars which match the IMF if their infall is subject to equally likely stopping. However such spherical models do not match the filamentary nature of cluster gas, and they are too extended to form protostars having high mass and short spacing. Two hybrid models are presented, which are spherical on small scales and filamentary on large scales. In and around clusters, cores embedded in linear filaments match the elongation of cluster gas, and the central concentration of low-mass stars. In cluster centers, condensations require a low volume filling factor to produce massive stars with short spacing. These may have stellate shape, where cores are nodes of filamentary networks, as seen in some simulations of colliding flows and of collapsing turbulent clumps. A dense configuration of such stellate condensations may be indistinguishable from a clump forming multiple protostars via filamentary flow paths.

Accepted by Astrophysical Journal

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

Molecular Outflows From the Protocluster, Serpens South

Fumitaka Nakamura[1], Koji Sugitani[2], Yoshito Shimajiri[3], Takashi Tsukagoshi[4], Aya E. Higuchi[1], Shogo Nishiyama[5], Ryohei Kawabe[3], Michihiro Takami[6], Jennifer L. Karr[6], Robert A. Gutermuth[7] and Grant Wilson[7]

[1] National Astronomical Observatory of Japan, Mitaka, Tokyo 181-8588, Japan
[2] Nagoya City University, Mizuho-ku, Nagoya 467-8501, Japan
[3] Nobeyama Radio Observatory, Nobeyama, Minamimaki, Minamisaku, Nagano, 384-1305, Japan
[4] University of Tokyo, Bunkyo, Tokyo 113-0033, Japan
[5] Kyoto University, Sakyo-ku, Kyoto 606-8502, Japan
[6] Academia Sinica Institute of Astronomy and Astrophysics, , P.O. Box 23-141, Taipei 106, Taiwan
[7] University of Massachusetts, Amherst, MA 01003, USA

E-mail contact: fumitaka.nakamura *at* nao.ac.jp

We present the results of CO ($J = 3-2$) and HCO^+ ($J = 4-3$) mapping observations toward a nearby embedded cluster, Serpens South, using the ASTE 10 m telescope. Our CO ($J = 3-2$) map reveals that many outflows are crowded in the dense cluster-forming clump that can be recognized as a HCO^+ clump with a size of ~ 0.2 pc and mass of ~ 80 $M_\odot$. The clump contains several subfragments with sizes of ~ 0.05 pc. By comparing the CO ($J = 3-2$) map with the 1.1 mm dust continuum image taken by AzTEC on ASTE, we find that the spatial extents of the outflow lobes are sometimes anti-correlated with the distribution of the dense gas and some of the outflow lobes apparently collide with the dense gas. The total outflow mass, momentum, and energy are estimated at 0.6 $M_\odot$, 8 $M_\odot$ km s^{-1}, and 64 $M_\odot$ km^2 s^{-2}, respectively. The energy injection rate due to the outflows is comparable to the turbulence dissipation rate in the clump, implying that the protostellar outflows can maintain the supersonic turbulence in this region. The total outflow energy seems only about 10 percent the clump gravitational energy. We conclude that the current outflow activity is not enough to destroy the whole cluster-forming clump, and therefore star formation is likely to continue for several or many local dynamical times.

Accepted by ApJ

arXiv:1105.4481

Effects of magnetic fields on the cosmic-ray ionization of molecular cloud cores

Marco Padovani[1,2] and Daniele Galli[2]

[1] Institut de Ciències de l'Espai (CSIC–IEEC), Campus UAB, Facultat de Ciències, Torre C5–parell 2^a, 08193 Bellaterra, Spain

[2] INAF–Osservatorio Astrofisico di Arcetri, Largo E. Fermi 5, 50125 Firenze, Italy

E-mail contact: padovani *at* ieec.uab.es

Low-energy cosmic rays are the dominant source of ionization for molecular cloud cores. The ionization fraction, in turn, controls the coupling of the magnetic field to the gas and hence the dynamical evolution of the cores. The purpose of this work is to compute the attenuation of the cosmic-ray flux rate in a cloud core taking into account magnetic focusing, magnetic mirroring, and all relevant energy loss processes. We adopt a standard cloud model characterized by a mass-to-flux ratio supercritical by a factor of ~ 2 to describe the density and magnetic field distribution of a low-mass starless core, and we follow the propagation of cosmic rays through the core along flux tubes enclosing different amount of mass. We then extend our analysis to cores with different mass-to-flux ratios. We find that mirroring always dominates over focusing, implying a reduction of the cosmic-ray ionization rate by a factor of $\sim$ 2–3 over most of a solar-mass core with respect to the value in the intercloud medium outside the core. For flux tubes enclosing larger masses the reduction factor is smaller, since the field becomes increasingly uniform at larger radii and lower densities. We also find that the cosmic-ray ionization rate is further reduced in clouds with stronger magnetic field, e.g. by a factor ~ 4 for a marginally critical cloud. The magnetic field threading molecular cloud cores affects the penetration of low-energy cosmic rays and reduces the ionization rate by a factor 3–4 depending on the position inside the core and the magnetization of the core.

Accepted by Astronomy & Astrophysics

http://arxiv.org/abs/1104.5445

The Photoevaporative Wind from the Disk of TW Hya

Ilaria Pascucci[1], Michael Sterzik[2], Richard Alexander[3], Silvia Alencar[4], Uma Gorti[5], David Hollenbach[5], James Owen[6], Barbara Ercolano[7] and Suzan Edwards[8]

[1] LPL, The University of Arizona, USA [2] ESO Santiago, Chile
[3] Department of Physics and Astronomy, University of Leicester, UK
[4] Departamento de Fisica - ICEx UFMG, Brazil
[5] SETI Institute, California, USA
[5] SETI Institute, California, USA
[6] Institute of Astronomy, Cambridge, UK
[7] University Observatory Munich, Germany
[8] Astronomy Department, Smith College, USA

E-mail contact: pascucci *at* lpl.arizona.edu

Photoevaporation driven by the central star is expected to be a ubiquitous and important mechanism to disperse the circumstellar dust and gas from which planets form. Here, we present a detailed study of the circumstellar disk surrounding the nearby star TW Hya and provide observational constraints to its photoevaporative wind. Our new high-resolution ($R \sim 30,000$) mid-infrared spectroscopy in the [Ne II] 12.81 micron line confirms that this gas diagnostic traces the unbound wind component within 10 AU from the star. From the blueshift and asymmetry in the line profile, we estimate that most (>80%) of the [Ne II] emission arises from disk radii where the midplane is optically thick to the redshifted outflowing gas, meaning beyond the 1 or 4 AU dust rim inferred from other observations. We re-analyze high-resolution ($R \sim 48,000$) archival optical spectra searching for additional transitions that may trace the photoevaporative flow. Unlike the [Ne II] line, optical forbidden lines from OI, SII, and MgI are centered at the stellar velocity and have symmetric profiles. The only way these lines could trace the photoevaporative flow is if they arise from a disk region physically distinct from that traced by the [Ne II] line, specifically from within the optically thin dust gap. However, the small (~10 km/s) FWHM of these lines suggest that most of the emitting gas traced at optical wavelengths is bound to the system rather than unbound. We discuss the implications of our results for a planet-induced versus a photoevaporation-induced gap.

Accepted by The Astrophysical Journal

http://arxiv.org/pdf/1105.0045v1

The *Spitzer* Survey of Interstellar Clouds in the Gould Belt. III. A Multi-Wavelength View of Corona Australis

Dawn E Peterson[1], Alessio Caratti o Garatti[2], Tyler L. Bourke[1], Jan Forbrich[1], Robert A. Gutermuth[3], Jes K. Jørgensen[4], Lori E. Allen[5], Brian M. Patten[1], Michael M. Dunham[6], Paul M. Harvey[6], Bruno Merín[7], Nicholas L. Chapman[8], Lucas A. Cieza[9], Tracy L. Huard[10], Claudia Knez[10], Brian Prager[10] and Neal J. Evans II[6]

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

[2] Dublin Institute for Advanced Studies, 31 Fitzwilliam Place, Dublin 2, Ireland

[3] Five College Astronomy Dept., Smith College, Northampton, MA 01063, USA; Department of Astronomy, University of Massachusetts, Amherst, MA 01002, USA

[4] Centre for Star and Planet Formation, Natural History Museum of Denmark, University of Copenhagen, Øster Voldgade 5-7, DK-1350 Copenhagen K., Denmark

[5] National Optical Astronomy Observatory, 950 N. Cherry Avenue, Tucson, AZ 85719, USA

[6] Department of Astronomy, University of Texas at Austin, 1 University Station, C1400, Austin, TX 78712-0259, USA

[7] Herschel Science Centre, European Space Astronomy Centre (ESA), P.O. Box 78, 28691, Villanueva de la Cañada, Madrid, Spain

[8] Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, MS 301-429, Pasadena, CA 91109, USA

[9] Institute for Astronomy, University of Hawaii at Manoa, Honolulu, HI 96822, USA

[10] Department of Astronomy, University of Maryland, College Park, MD 20742, USA

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

We present *Spitzer Space Telescope* IRAC and MIPS observations of a 0.85 deg^2 field including the Corona Australis (CrA) star-forming region. At a distance of 130 pc, CrA is one of the closest regions known to be actively forming stars, particularly within its embedded association, the Coronet. Using the *Spitzer* data, we identify 51 young stellar objects (YSOs) in CrA which include sources in the well-studied Coronet cluster as well as distributed throughout the molecular cloud. Twelve of the YSOs discussed are new candidates, one of which is located in the Coronet. Known YSOs retrieved from the literature are also added to the list, and a total of 116 candidate YSOs in CrA are compiled. Based on these YSO candidates, the star formation rate is computed to be 12 $M_\odot Myr^{-1}$, similar to that of the Lupus clouds. A clustering analysis was also performed, finding that the main cluster core, consisting of 68 members, is elongated (having an aspect ratio of 2.36), with a circular radius of 0.59 pc and mean surface density of 150 pc^{-2}.

In addition, we analyze outflows and jets in CrA by means of new CO and H_2 data. We present 1.3 mm interferometric continuum observations made with the Submillimeter Array (SMA) covering R CrA, IRS 5, IRS 7, and IRAS 18595-3712 (IRAS 32). We also present multi-epoch H_2 maps and detect jets and outflows, study their proper motions, and identify exciting sources. The *Spitzer* and *ISAAC*/VLT observations of IRAS 32 show a bipolar precessing jet, which drives a CO (2-1) outflow detected in the SMA observations. There is also clear evidence for a parsec-scale precessing outflow, E-W oriented, and originating in the SMA 2 region, likely driven by SMA 2 or IRS 7A.

Accepted by ApJ Supplements

High resolution version of the paper can be found here: http://www.cfa.harvard.edu/∼dpeterson/CrA/CrA_highres.pdf

A *Spitzer*-IRS Detection of Crystalline Silicates in a Protostellar Envelope

Charles A. Poteet[1], S. Thomas Megeath[1], Dan M. Watson[2], Nuria Calvet[3], Ian S. Remming[2], Melissa K. McClure[2,3], Benjamin A. Sargent[4], William J. Fischer[1], Elise Furlan[5], Lori E. Allen[6], Jon E. Bjorkman[1], Lee Hartmann[3], James Muzerolle[4], John J. Tobin[3] and Babar Ali[7]

[1] Department of Physics and Astronomy, The University of Toledo, 2801 West Bancroft Street, Toledo, OH 43606, USA

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

[3] Department of Astronomy, University of Michigan, 830 Dennison Building, 500 Church Street, Ann Arbor, MI 48109, USA

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

[5] Jet Propulsion Laboratory, California Institute of Technology, Mail Stop 264-723, 4800 Oak Grove Drive, Pasadena,

CA 91109, USA
[6] National Optical Astronomy Observatory, 950 North Cherry Avenue, Tucson, AZ 85719, USA
[7] NHSC/IPAC, California Institute of Technology, 770 South Wilson Avenue, Pasadena, CA 91125, USA

E-mail contact: charles.poteet *at* gmail.com

We present the *Spitzer Space Telescope* Infrared Spectrograph spectrum of the Orion A protostar HOPS-68. The mid-infrared spectrum reveals crystalline substructure at 11.1, 16.1, 18.8, 23.6, 27.9, and 33.6 μm superimposed on the broad 9.7 and 18 μm amorphous silicate features; the substructure is well matched by the presence of the olivine end-member forsterite (Mg_2SiO_4). Crystalline silicates are often observed as infrared emission features around the circumstellar disks of Herbig Ae/Be stars and T Tauri stars. However, this is the first unambiguous detection of crystalline silicate absorption in a cold, infalling, protostellar envelope. We estimate the crystalline mass fraction along the line-of-sight by first assuming that the crystalline silicates are located in a cold absorbing screen and secondly by utilizing radiative transfer models. The resulting crystalline mass fractions of 0.14 and 0.17, respectively, are significantly greater than the upper limit found in the interstellar medium ($< 0.02-0.05$). We propose that the amorphous silicates were annealed within the hot inner disk and/or envelope regions and subsequently transported outward into the envelope by entrainment in a protostellar outflow.

Accepted by The Astrophysical Journal Letters

http://arxiv.org/pdf/1104.4498v1

Detection of a large massive circumstellar disk around a high-mass young stellar object in the Carina Nebula

Thomas Preibisch[1], Thorsten Ratzka[1], Tiago Gehring[1], Henrike Ohlendorf[1], Hans Zinnecker[2,3,4], Robert R. King[5], Mark J. McCaughrean[5,6] and James R. Lewis[7]

[1] Universitäts-Sternwarte München, Ludwig-Maximilians-Universität, Scheinerstr. 1, 81679 München, Germany
[2] Astrophysikalisches Institut Potsdam, An der Sternwarte 16, 14482 Potsdam, Germany
[3] Deutsches SOFIA Institut, Universität Stuttgart, Pfaffenwaldring 31, 70569 Stuttgart, Germany
[4] NASA-Ames Research Center, MS 211-3, Moffett Field, CA 94035, USA
[5] Astrophysics Group, College of Engineering, Mathematics and Physical Sciences, University of Exeter, Exeter EX4 4QL, UK
[6] European Space Agency, Research & Scientific Support Department, ESTEC, Postbus 299, 2200 AG Noordwijk, The Netherlands
[7] Cambridge Astronomical Survey Unit, Institute of Astronomy, Madingley Road, Cambridge, CB3 0HA, UK

E-mail contact: preibisch *at* usm.uni-muenchen.de

Context: The characterization of circumstellar disks around young stellar objects can provide important information about the process of star formation and the possible formation of planetary systems.
Aims: We investigate the spatial structure and the spectral energy distribution of a newly discovered edge-on circumstellar disk around an optically invisible young stellar object that is embedded in a dark cloud in the Carina Nebula.
Methods: The disk object was serendipitously discovered in our deep near-IR imaging survey of the Carina Nebula obtained with HAWK-I at the ESO VLT. Whereas the object was detected as an apparently point-like source in earlier infrared observations, only the superb image quality (FWHM $\approx 0.5''$) of the HAWK-I data could reveal, for the first time, the peculiar morphology of the object. It consists of a very red point-like central source that is surrounded by a roughly spherical nebula, which is intersected by a remarkable dark lane through the center. We construct the spectral energy distribution of the object from $1\,\mu$m to $870\,\mu$m and perform a detailed radiative transfer modeling of the spectral energy distribution and the source morphology.
Results: The observed object morphology in the near-IR images clearly suggests a young stellar object that is embedded in an extended, roughly spherical envelope and surrounded by a large circumstellar disk with a diameter of $\approx$ 5500 AU that is seen nearly edge-on. The radiative transfer modeling shows that the central object is highly luminous and thus must be a massive young stellar object, most likely in the range $10 - 15\,M_{\odot}$. The circumstellar disk has a mass of about $2\,M_{\odot}$.
Conclusions: The disk object in Carina is one of the most massive young stellar objects for which a circumstellar disk has been detected so far. The size and mass of the disk are very large compared to the corresponding values found for most other similar objects. These results support the assumption that $10 - 15\,M_{\odot}$ stars can form via accretion from

a circumstellar disk.

Accepted by Astronomy & Astrophysics (530, A40)

Preprints can be obtained from http://www.usm.uni-muenchen.de/people/preibisch/publications.html

Deep wide-field near-infrared survey of the Carina Nebula

Thomas Preibisch[1], Thorsten Ratzka[1], Benjamin Kuderna[1], Henrike Ohlendorf[1], Robert R. King[2], Simon Hodgkin[3], Mike Irwin[3], James R. Lewis[3], Mark J. McCaughrean[2,4], Hans Zinnecker[5,6,7]

[1] Universitäts-Sternwarte München, Ludwig-Maximilians-Universität, Scheinerstr. 1, 81679 München, Germany
[2] Astrophysics Group, College of Engineering, Mathematics and Physical Sciences, University of Exeter, Exeter EX4 4QL, UK
[3] Cambridge Astronomical Survey Unit, Institute of Astronomy, Madingley Road, Cambridge, CB3 0HA, UK
[4] European Space Agency, Research & Scientific Support Department, ESTEC, Postbus 299, 2200 AG Noordwijk, The Netherlands
[5] Astrophysikalisches Institut Potsdam, An der Sternwarte 16, 14482 Potsdam, Germany
[6] Deutsches SOFIA Institut, Universität Stuttgart, Pfaffenwaldring 31, 70569 Stuttgart, Germany
[7] NASA-Ames Research Center, MS 211-3, Moffett Field, CA 94035, USA

E-mail contact: preibisch *at* usm.uni-muenchen.de

Context: The Great Nebula in Carina is a giant HII region and a superb location in which to study the physics of violent massive star formation, but the population of the young low-mass stars remained very poorly studied until recently.
Aims: Our aim was to produce a near-infrared survey that is deep enough to detect the full low-mass stellar population (i.e. down to $\approx 0.1\,M_\odot$ and for extinctions up to $A_V \approx 15$ mag) and wide enough to cover all important parts of the Carina Nebula complex (CNC), including the clusters Tr 14, 15, and 16 as well as the South Pillars region.
Methods: We used HAWK-I at the ESO VLT to survey of the central $\approx 0.36\,\mathrm{deg}^2$ area of the Carina Nebula. These data reveal more than 600 000 individual infrared sources down to magnitudes as faint as $J \approx 23$, $H \approx 22$, and $K_s \approx 21$. The results of a recent deep X-ray survey (which is complete down to stellar masses of $\sim 0.5 - 1\,M_\odot$) are used to distinguish between young stars in Carina and background contaminants. We analyze color-magnitude diagrams (CMDs) to derive information about the ages and masses of the low-mass stars.
Results: The ages of the low-mass stars agree with previous age estimates for the massive stars. The CMD suggests that ≈ 3200 of the X-ray selected stars have masses of $M_* \geq 1\,M_\odot$; this number is in good agreement with extrapolations of the field IMF based on the number of high-mass ($M_* \geq 20\,M_\odot$) stars and shows that there is no deficit of low-mass stars in the CNC. The HAWK-I images confirm that about 50% of all young stars in Carina are in a widely distributed, non-clustered spatial configuration. Narrow-band images reveal six molecular hydrogen emission objects (MHOs) that trace jets from embedded protostars. However, none of the optical HH objects shows molecular hydrogen emission, suggesting that the jet-driving protostars are located very close to the edges of the globules in which they are embedded.
Conclusions: The near-infrared excess fractions for the stellar population in Carina are lower than typical for other, less massive clusters of similar age, suggesting that the process of circumstellar disk dispersal proceeds on a faster timescale in the CNC than in the more quiescent regions, most likely due to the very high level of massive star feedback in the CNC. The location of all but one of the known jet-driving protostars at the edges of the globules adds strong support to the scenario that their formation was triggered by the advancing ionization fronts.

Accepted by Astronomy & Astrophysics (530, A34)

Preprints can be obtained from http://www.usm.uni-muenchen.de/people/preibisch/publications.html

Submillimeter continuum observations of Sagittarius B2 at subarcsecond spatial resolution

S.-L. Qin[1], P. Schilke[1], R. Rolffs[1,2], C. Comito[2], D.C. Lis[3] and Q. Zhang[4]

[1] I. Physikalisches Institut, Universität zu Köln, Zülpicher Str. 77, 50937 Köln, Germany
[2] Max-Planck-Institut für Radioastronomie, Auf dem Hügel 69, 53121 Bonn, Germany

[3]California Institute of Technology, Cahill Center for Astronomy and Astrophysics 301-17, Pasadena, CA 91125 USA
[4] Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge MA 02138, USA

E-mail contact: qin *at* ph1.uni-koeln.de

We report the first high spatial resolution submillimeter continuum observations of the Sagittarius B2 cloud complex using the Submillimeter Array (SMA). With the subarcsecond resolution provided by the SMA, the two massive star-forming clumps Sgr B2(N) and Sgr B2(M) are resolved into multiple compact sources. In total, twelve submillimeter cores are identified in the Sgr B2(M) region, while only two components are observed in the Sgr B2(N) clump. The gas mass and column density are estimated from the dust continuum emission. We find that most of the cores have gas masses in excess of 100 $M_\odot$ and column densities above 10^{25} cm^{-2}. The very fragmented appearance of Sgr B2(M), in contrast to the monolithic structure of Sgr B2 (N), suggests that the former is more evolved. The density profile of the Sgr B2(N)-SMA1 core is well fitted by a Plummer density distribution. This would lead one to believe that in the evolutionary sequence of the Sgr B2 cloud complex, a massive star forms first in an homogeneous core, and the rest of the cluster forms subsequently in the then fragmenting structure.

Accepted by A&A Letters

http://adsabs.harvard.edu/abs/2011arXiv1105.0344Q

New Young Star Candidates in CG4 and Sa101

L. M. Rebull[1], C. H. Johnson[2], V. Hoette[3], J. S. Kim[4], S. Laine[1], M. Foster[4], R. Laher[1], M. Legassie[1,5], C. R. Mallory[6], K. McCarron[7] and W. H. Sherry[8]

[1] Spitzer Science Center/Caltech, M/S 220-6, 1200 E. California Blvd., Pasadena, CA 91125, USA
[2] Breck School, Minneapolis, MN, USA
[3] Yerkes Observatory, University of Chicago, USA
[4] University of Arizona, Tucson, AZ, USA
[5] Raytheon, Pasadena, CA, USA
[6] Pierce College, Woodland Hills, CA, USA
[7] Oak Park and River Forest High School, Oak Park, IL, USA
[8] NOAO/NSO, Tucson, AZ, USA

E-mail contact: rebull *at* ipac.caltech.edu

The CG4 and Sa101 regions together cover a region of ∼0.5 square degree in the vicinity of a "cometary globule" that is part of the Gum Nebula. There are seven previously identified young stars in this region; we have searched for new young stars using mid- and far-infrared data (3.6 to 70 microns) from the Spitzer Space Telescope, combined with ground-based optical data and near-infrared data from the Two-Micron All-Sky Survey (2MASS). We find infrared excesses in all 6 of the previously identified young stars in our maps, and we identify 16 more candidate young stars based on apparent infrared excesses. Most (73%) of the new young stars are Class II objects. There is a tighter grouping of young stars and young star candidates in the Sa101 region, in contrast to the CG4 region, where there are fewer young stars and young star candidates, and they are more dispersed. Few likely young objects are found in the "fingers" of the dust being disturbed by the ionization front from the heart of the Gum Nebula.

Accepted by AJ

http://web.ipac.caltech.edu/staff/rebull/research.html

The Structure of Molecular Clouds: III - A link between cloud structure and star formation mode

J. H. Rowles[1] and D. Froebrich[1]

[1] University of Kent

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

We analyse extinction maps of nearby Giant Molecular Clouds to forge a link between driving processes of turbulence and modes of star formation. Our investigation focuses on cloud structure in the column density range above the self shielding threshold of 1 mag A_V and below the star formation threshold – the regime in which turbulence is expected

to dominate.
We identify clouds with shallow mass distributions as cluster forming. Clouds that form stars in a less clustered or isolated mode show a steeper mass distribution. Structure functions prove inadequate to distinguish between clouds of different star formation mode. They may, however, suggest that the turbulence in the average cloud is governed by solenoidal forcing. The same is found using the Δ-variance analysis which also indicates that clouds with a clustered mode of star formation show an enhanced component of compressive driving in the turbulent field. Thus, while star formation occurs in each cloud, independent of the turbulent driving mechanism, compressive forcing appears to be associated with the formation of stellar clusters.

Accepted by MNRAS

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

Protostars and stars in the Coronet cluster: Age, evolution, and cluster structure

Aurora Sicilia-Aguilar[1], Thomas Henning[1], Jouni Kainulainen[1] and Veronica Roccatagliata[2]

[1] Max-Planck-Institut fuer Astronomie, Koenigstuhl 17, 69117 Heidelberg, Germany
[2] Space Telescope Science Institute, Baltimore, MD 21218, USA

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

We present new optical spectroscopy with FLAMES/VLT, near-IR imaging with HAWK-I/VLT, and 870μm mapping with APEX/LABOCA of the Coronet cluster. The optical data allow to estimate spectral types, extinction and the presence of accretion in 6 more M-type members, in addition to the 12 that we had previously studied. The submillimeter maps and near-IR data reveal the presence of nebular structures and high extinction regions, which are in some cases associated to known IR, optical, and X-ray sources. Most star formation is associated to two elongated structures crossing in the central part of the cluster. Placing all the 18 objects with known spectral types and extinction in the HR diagram suggests that the cluster is younger than previously thought (<2 Myr, and probably ∼0.5-1 Myr). The new age estimate is in agreement with the evolutionary status of the various protostars in the region and with its compactness (<1.3 pc across), but results in a conflict with the low disk and accretion fraction (only 50-65% of low-mass stars appear to have protoplanetary disks, and most transitional and homologously depleted disks are consistent with no accretion) and with the evolutionary features observed in the mid-IR spectra and spectral energy distributions of the disks.

Accepted by ApJ

http://www.mpia.de/homes/sicilia/aurora_publications.html
http://de.arxiv.org/abs/1105.2702

Skewed Distributions and Opposite Velocity Gradients of Submillimeter Molecular Lines in Low-Mass Protostellar Envelopes

Shigehisa Takakuwa[1] and Takeshi Kamazaki[2]

[1] Academia Sinica Institute of Astronomy and Astrophysics, P.O. Box 23-141, Taipei 10617, Taiwan
[2] Joint ALMA Observatory, Av. Alonso de Cordova 3107, Vitacura, Santiago, Chile

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

We have made mapping observations of L1551 IRS 5, L1551NE, L723, and L43 and single-point observations of IRAS 16293-2422 in the submillimeter CS (J = 7–6) and HCN (J = 4–3) lines with ASTE. Including our previous ASTE observations of L483 and B335, we found a clear linear correlation between the source bolometric luminosities and the total integrated intensities of the submillimeter lines ($I_{CS} \propto L_{bol}^{0.92}$). The combined ASTE + SMA CS (7–6) image of L1551 IRS 5 exhibits an extended (∼2000 AU) component tracing the associated reflection nebula at the west and southwest, as well as a compact ($\lesssim$500 AU) component centered on the protostellar position. The emission peaks of the CS and HCN emissions in L1551 NE are not located at the protostellar position but offset (∼1400 AU) toward the associated reflection nebula at the west. With the statistical analyses, we confirmed the opposite velocity gradients of the CS (7–6) emission to those of the millimeter lines along the outflow direction, which we reported in our early paper. The magnitudes of the submillimeter velocity gradients are estimated to be (9.7±1.7) × 10^{-3} km s^{-1} arcsec^{-1} in L1551 IRS 5 and (7.6±2.4) × 10^{-3} km s^{-1} arcsec^{-1} in L483. We suggest that the "skewed" submillimeter molecular

emissions toward the associated reflection nebulae at a few thousands AU scale trace the warm ($\gtrsim$40 K) walls of the envelope cavities, excavated by the associated outflows and irradiated by the central protostars directly. The opposite velocity gradients along the outflow direction likely reflect the dispersing gas motion at the wall of the cavity in the envelopes perpendicular to the outflow.

Accepted by PASJ

http://arxiv.org/abs/1105.3787

A New Recipe for Obtaining Central Volume Densities of Prestellar Cores from Size Measurements

Konstantinos Tassis[1] and Harold W. Yorke[1]

[1] Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive Pasadena, CA 91109, USA

E-mail contact: ktassis *at* jpl.nasa.gov

We propose a simple analytical method for estimating the central volume density of prestellar molecular cloud cores from their column density profiles. Prestellar cores feature a flat central part of the column density and volume density profiles of the same size indicating the existence of a uniform density inner region. The size of this region is set by the thermal pressure force which depends only on the central volume density and temperature of the core, and can provide a direct measurement of the central volume density. Thus a simple length measurement can immediately yield a central density estimate independent of any dynamical model for the core and without the need for fitting. Using the radius at which the column density is 90% of the central value as an estimate of the size of the flat inner part of the column density profile yields an estimate of the central volume density within a factor of 2 for well resolved cores.

Accepted by ApJL

http://arxiv.org/abs/1105.2560

Constraining the structure of the planet-forming region in the disk of the Herbig Be star HD 100546

E. Tatulli[1], M. Benisty[2], F. Ménard[1], P. Varnière[3], C. Martin-Zaidi[1], W.-F. Thi[1], C. Pinte[1], F. Massi[4], G. Weigelt[5], K.-H. Hofmann[5] and R. G. Petrov[6]

[1] UJF-Grenoble1, Institut de Planétologie et d'Astrophysique de Grenoble, 38041 Grenoble Cedex 9, France
[2] Max-Planck-Institut für Astronomie, Königstuhl 17, 69117 Heidelberg, Germany
[3] AstroParticule & Cosmologie, 10 rue Alice Domon et Leonie Duquet, 75205 Paris Cedex 13, France
[4] INAF-Osservatorio Astrofisico di Arcetri, Largo E. Fermi 5, 50125 Firenze, Italy
[5] Max-Planck-Institut für Radioastronomie, Auf dem Hugel 69, 53121 Bonn, Germany
[6] Laboratoire H. Fizeau, Université de Nice Sophia-Antipolis, 06108, Nice Cedex 2, France

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

Studying the physical conditions in circumstellar disks is a crucial step toward understanding planet formation and disk evolution. Of particular interest is the case of HD 100546, a Herbig Be star that presents a gap within the first 13 AU of its protoplanetary disk, a gap that may originate in the dynamical interactions of a forming planet with its hosting disk. We seek a more detailed understanding of the structure of the circumstellar environment of HD 100546 and refine our previous disk model that is composed of a tenuous inner disk, a gap and a massive outer disk (see Benisty et al. 2010b). We also investigate whether planetary formation processes can explain the complex density structure observed in the disk.
We gathered a large amount of new interferometric data using the AMBER / VLTI instrument in the H- and K-bands to spatially resolve the warm inner disk and constrain its structure. Then, combining these measurements with photometric observations, we analyze the circumstellar environment of HD 100546 in the light of a passive disk model based on 3D Monte-Carlo radiative transfer. Finally, we use hydrodynamical simulations of gap formation by planets to predict the radial surface density profile of the disk and test the hypothesis of ongoing planet formation.
The SED (spectral energy distribution) from the UV to the millimeter range, and the NIR (near-infrared) interferometric data are adequately reproduced by our model. We show that the H- and K-band emissions are coming mostly from the inner edge of the internal dust disk, located near 0.24 AU from the star, i.e., at the dust sublimation radius

in our model. At such a short distance, the survival of hot (silicate) dust requires the presence of micron-sized grains, heated at ~ 1750K. We directly measure an inclination of $33° \pm 11°$ and a position angle of $140° \pm 16°$ for the inner disk. This is similar to the values found for the outer disk ($i \simeq 42°$, $PA \simeq 145°$), suggesting that both disks may be coplanar. We finally show that 1 to 8 Jupiter mass planets located at ~ 8 AU from the star would have enough time to create the gap and the required surface density jump of three orders of magnitude between the inner and outer disk. However, no information on the amount of matter left in the gap is available, which precludes us from setting precise limits on the planet mass, for now.

Accepted by Astronomy & Astrophysics

http://arxiv.org/abs/1104.0905

The H_2O southern Galactic Plane Survey (HOPS): I. Techniques and H_2O maser data

A. J. Walsh[1], S. L. Breen [2], T. Britton[2], K. J. Brooks[2], M. G. Burton[3], M. R. Cunningham[3], J. A. Green[2], L. Harvey-Smith[2], L. Hindson[2,4], M. G. Hoare[5], B. Indermuehle[2], P. A. Jones[2,6], N. Lo[6,7], S. N. Longmore[8], V. Lowe[2,3], C. J. Phillips[2], C. R. Purcell[5], M. A. Thompson [4], J. S. Urquhart[2], M. A. Voronkov[2] G. L. White[1] and M. T. Whiting[2]

[1]Centre for Astronomy, School of Engineering and Physical Sciences, James Cook University, Townsville, QLD 4811, Australia

[2]CSIRO Astronomy and Space Science, PO BOX 76, Epping, NSW 1710, Australia

[3]School of Physics, University of New South Wales, Sydney, NSW 2052, Australia

[4]Centre for Astrophysics Research, Science and Technology Research Institute, University of Hertfordshire, AL10 9AB, UK

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

[6]Departamento de Astronomía, Universidad de Chile, Casilla 36-D, Santiago, Chile

[7]Laboratoire AIM Paris-Saclay, CEA/Irfu - Uni. Paris Didérot - CNRS/INSU, 91191 Gif-sur-Yvette, France

[8]Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA

E-mail contact: andrew.walsh *at* jcu.edu.au

We present first results of the **H_2O** Southern Galactic **P**lane **S**urvey (HOPS), using the Mopra radiotelescope with a broad band backend and a beam size of about 2′. We have observed 100 square degrees of the southern Galactic plane at 12 mm (19.5 to 27.5 GHz), including spectral line emission from H_2O masers, multiple metastable transitions of ammonia, cyanoacetylene, methanol and radio recombination lines. In this paper, we report on the characteristics of the survey and H_2O maser emission. We find 540 H_2O masers, of which 334 are new detections. The strongest maser is 3933 Jy and the weakest is 0.7 Jy, with 62 masers over 100 Jy. In 14 maser sites, the spread in velocity of the H_2O maser emission exceeds 100 km s^{-1}. In one region, the H_2O maser velocities are separated by 351.3 km s^{-1}. The rms noise levels are typically between 1-2 Jy, with 95% of the survey under 2 Jy. We estimate completeness limits of 98% at around 8.4 Jy and 50% at around 5.5 Jy. We estimate that there are between 800 and 1500 H_2O masers in the Galaxy that are detectable in a survey with similar completeness limits to HOPS. We report possible masers in NH_3 (11,9) and (8,6) emission towards G19.61-0.23 and in the NH_3 (3,3) line towards G23.33-0.30.

Accepted by MNRAS

Hierarchical Fragmentation and Jet-like Outflows in IRDC G28.34+0.06, a Growing Massive Protostar Cluster

Ke Wang[1,2], Qizhou Zhang[2], Yuefang Wu[1] and Huawei Zhang[1]

[1] Department of Astronomy, School of Physics, Peking University, Beijing 100871, China

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

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

We present Submillimeter Array (SMA) $\lambda = 0.88$ mm observations of an infrared dark cloud G28.34+0.06. Located in the quiescent southern part of the G28.34 cloud, the region of interest is a massive ($> 10^3\, M_\odot$) molecular clump P1 with a luminosity of $\sim 10^3\, L_\odot$, where our previous SMA observations at 1.3 mm have revealed a string of five dust cores of 22–64 $M_\odot$ along the 1 pc IR-dark filament. The cores are well aligned at a position angle of 48° and regularly spaced at an average projected separation of 0.16 pc. The new high-resolution, high-sensitivity 0.88 mm image further resolves the five cores into ten compact condensations of 1.4–10.6 $M_\odot$, with sizes a few thousands AU. The spatial structure at clump (~ 1 pc) and core (~ 0.1 pc) scales indicates a hierarchical fragmentation. While the clump fragmentation is consistent with a cylindrical collapse, the observed fragment masses are much larger than the expected thermal Jeans masses. All the cores are driving CO (3–2) outflows up to 38 km s^{-1}, majority of which are bipolar, jet-like outflows. The moderate luminosity of the P1 clump sets a limit on the mass of protostars of 3–7 $M_\odot$. Because of the large reservoir of dense molecular gas in the immediate medium and ongoing accretion as evident by the jet-like outflows, we speculate that P1 will grow and eventually form a massive star cluster. This study provides a first glimpse of massive, clustered star formation that currently undergoes through an intermediate-mass stage.

Accepted by ApJ

http://arxiv.org/abs/1105.4559

IRDC G030.88+00.13: A Tale of Two Massive Clumps

Qizhou Zhang[1] and Ke Wang[1,2]

[1] Harvard-Smithsonian Center for Astrophysics, 60 Garden St, Cambridge, MA 02138, USA
[2] Department of Astronomy, Peking University, Beijing 100871, China

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

Massive stars form from collapse of parsec-scale molecular clumps. How molecular clumps fragment to give rise to massive stars in a cluster with a distribution of masses is unclear. We search for cold cores that may lead to future formation of massive stars in a massive ($> 10^3\ M_\odot$), low luminosity ($4.6 \times 10^2 L_\odot$) infrared dark cloud (IRDC) G030.88+00.13. The NH_3 data from VLA and GBT reveal that the extinction feature seen in the infrared consists of two distinctive clumps along the same line of sight: The C1 clump at 97 km/s coincides with the extinction in the Spitzer 8 and 24 μm. Therefore, it is responsible for the majority of the IRDC. The C2 clump at 107 km/s is more compact and has a peak temperature of 45 K. Compact dust cores and H_2O masers revealed in the SMA and VLA observations are mostly associated with C2, and none is within the IRDC in C1. The luminosity indicates that neither the C1 nor C2 clump has yet to form massive protostars. But C1 might be at a precluster forming stage. The simulated observations rule out 0.1pc cold cores with masses above 8 $M_\odot$ within the IRDC. The core masses in C1 and C2, and those in high-mass protostellar objects suggest an evolutionary trend that the mass of cold cores increases over time. Based on our findings, we propose an empirical picture of massive star formation that protostellar cores and the embedded protostars undergo simultaneous mass growth during the protostellar evolution.

Accepted by ApJ

http://arxiv.org/abs/1103.5092

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.

Dissertation Abstracts

Warm Gas in Protoplanetary Disks

G. van der Plas

Thesis work conducted at: ESO / Garching bei Muenchen, Germany *and* the Anton Pannekoek Institute, University of Amsterdam, the Netherlands.

Current address: Anton Pannekoek Institute, University of Amsterdam, PO Box 94249, 1090 GE Amsterdam, the Netherlands

gerrit.vanderplas *at* gmail.com

L.B.F.M. Waters

Ph.D degree awarded: Dec 2010

In my thesis I have investigated the surface of ProtoPlanetary (PP) disks around Herbig Ae/Be (HAEBE) stars via different gas emission lines that each trace a different physical (temperature, pressure, radiation field) regime. HAEBE stars are the more massive (1.5 - 8 solar mass, all HAEBE stars studied in my thesis are between 1.5 and 3 solar mass) siblings of the solar type T Tauri pre main sequence stars.

Observationally, passive disks around HAEBE stars can be split in two geometries: so-called gflaringh and gself-shadowedh disks (Meeus et al. 2001, Dullemond and Dominik 2004). This classification is based on the Spectral Energy Distribution (SED) of the star, and especially on the amount of reprocessed stellar light that is emitted by the dust in the disk as IR emission, and reflects the disk geometry. One possible connection suggested by observations and modeling is that flared disks evolve into self-shadowed disks due to grain growth and subsequent dust settling. Within these disks, holes (star-hole-disk) and gaps (star-disk-gap-disk) may form. Disk holes are characterized by an inner disk radius that lies farther away from the central star than the dust destruction radius, and can form under influence of e.g. disk dissipation or tidal interaction with a binary companion or planet. Disk gaps are opened due to tidal interactions. The objective of my research is to gain a better understanding of the different geometries seen in disks around HAEBE stars. Relevant questions are, for exampe: are these different geometries linked evolutionary? and how do gas tracers react to disk-geometry? To investigate this, I collect high angular and spectral resolution optical (VLT UVES) and IR (VLT CRIRES) data from flaring and self-shadowed disks, including disks with gaps and holes.

The gas tracers I use are: [1] the optical [OI] (630 nm) emission line, which traces the disk surface that is illuminated by the stellar UV flux from the dust evaporation radius out to tens of AU, and which is stronger and spatially more extended in flaring disks compared to self-shadowed disks (van der Plas et al. 2008; chapter 2 of my thesis). [2] Near-IR H2 emission, which we only detect at large (>5 AU) radius in flaring disks (Carmona, van der Plas et al. (submitted); chapter 5 of my thesis). [3] IR CO lines that trace the warm (200 - 2000K) inner disk surface. The CO emission in the flaring disks is spatially resolved and originates between 10 - 50 AU, and is excited mainly through UV pumping, whereas the CO emission from self shadowed disks is spatially unresolved, originates from more modest radii, and most likely is excited collisionally (van der Plas et al. 2009, van der Plas et al. (submitted), van der Plas et al.(in prep.); chapters 3, 4 and 6 of my thesis).

From the work described above a picture of PP disks around HAEBE disks arises. In the surface layers of this disk the gas and dust are decoupled. The different gas tracers each diagnose a different radius, temperature, pressure and chemical environment. For the PP disks surveyed, the disk geometry as traced by the SED is a deciding factor for the emission properties of the gas.

To understand this dependence of gas tracers on disk geometry, I am working on a parameter study using the disk code ProDiMo (Woitke et al. 2009). ProDiMo is a 2D state-of-the-art disk code that calculates the disk dust and gas structure simultaneously, and self-consistently calculates the disk chemistry, temperature and vertical structure. In this study, I vary the PAH content and dust-to-gas ratio of the disks (van der Plas et al. (in prep.); chapter 6 of my thesis). By changing these two parameters, the self-consistently calculated disk structure can mimic both a flaring and self-shadowed disk geometry, each with a specific thermal and chemical composition. The CO emission in these models traces the PP disk wherever temperatures are high enough and the disk is optically thick so it can shield the CO molecules from dissociation. This is consistent with the CO emission from self-shadowed disks, but inconsistent with the lack of observed CO emission at small radii in flaring disks.

Post doc and Ph.D. positions at University of Copenhagen: Observations of the Earliest Stages of Star Formation

One graduate student and one post doc position are available in the group of Jes Jørgensen at Centre for Star and Planet Formation the Niels Bohr Institute and the Natural History Museum of Denmark, University of Copenhagen. The successful candidates will be join an active research group dedicated to studies of the earliest stages of low-mass star formation.

We are looking for two enthusiastic candidates with a particular interest in observations of star forming regions. The topic for the Ph.D. student will be on the earliest stages of low-mass protostars and their chemistry. The post doc will focus on observations and radiative transfer modeling with a particular emphasis on understanding the link between the formation of circumstellar disks and the kinematics and structure of the inner regions of protostellar cores. He/She will furthermore have ample time to carry out an independent research program in collaboration with other members of the group. Both candidates will have good opportunities in helping to define and carrying out programs using facilities available to Danish astronomers (e.g., through ESO and ESA), which includes the Atacama Large Millimeter Array (ALMA) beginning early science observations later this year. For both positions, previous experience in infrared/submillimeter observations and/or radiative transfer modeling is a plus.

For the graduate position, a Master's degree in astronomy, physics or equivalent is required. The position is for three years and expected to lead to a Ph.D. degree at University of Copenhagen. The application should contain a curriculum vitae (including a certified list of university courses and grades) and a description of the applicant's research experience and interests. The application should include the names and E-mail addresses of two academic referees familiar with the work of the applicant.

For the post doc position, the candidate should have finished his/her doctoral thesis before taking up the position. The position is initially for two years with an extension possible depending on progress and funding. The application should contain a curriculum vitae, a list of publications, a description of the applicant?s experience and proposed research. In addition, the applicant should arrange for three letters of reference sent separately.

Salary, pension and terms of employment are in accordance with the agreement between the Ministry of Finance and the Danish Confederation of Professional Associations on Academics in the State. Currently, starting salaries are about 29,330 DKK (3,940 Euro) per month for Ph.D. students and 36,750 DKK (4,937 Euro) per month for post docs - including a mandatory 17% pension contribution. Note for the post doc position: non-Danish candidates coming from abroad may be eligible for tax reductions. The positions carry the full benefits in terms of enrollment in the public Danish health care system. The positions are open for candidates of all nationalities. The University of Copenhagen wishes to reflect the surrounding society and encourage all qualified applicants regardless of personal background to apply for the positions.

Review of applications will start on July 1st and continue until the positions have been filled. Requests for further information as well as applications and reference letters should be sent per E-mail (preferred) or regular mail to:

Dr. Jes Jørgensen (jeskj *at* nbi.dk)
Centre for Star and Planet Formation
Niels Bohr Institute, University of Copenhagen
Juliane Maries Vej 30
DK-2100 Copenhagen Ø, Denmark.

Senior Lecturer in Star Formation and Exoplanets at Stockholm University

The Department of Astronomy at Stockholm University announces a tenured position as Senior Lecturer in Astronomy in the area of Star Formation and Exoplanets. Research at the department covers a broad range, from solar physics, exo-planets, the formation and death of stars, galaxies, to the distant and early Universe. The Swedish memberships in ESO and ESA allow access to first-class observing facilities.

We are looking for a person with a research background in star formation and/or exoplanets. We welcome applications from theoreticians, observers, as well as instrumentalists. The research at the department in this area forms part of the astrobiology activities at the Faculty of Sciences, Stockholm University.

The main tasks of the appointee will be research, teaching and supervision of students. To qualify the applicant should have a PhD or equivalent scientific qualifications, as well as demonstrated teaching proficiency. In the evaluation equal and special weight will be given to scientific and teaching qualities. Some weight will also be given to experience with public outreach. Fluency in Swedish is not a requirement. Stockholm University strives towards gender balance and applications from women are particularly welcome.

The formal announcement (reference number SU 612-0838-11) can be found at the department's website
`http://www.astro.su.se/new_pos.en.html`
and at Stockholm University's page for vacancies
`http://www.su.se/english/about/vacancies/lecturers-researchers`.
The deadline for applications is May 31st, 2011.

Please refer to the formal announcement for details of the electronic application procedure. Further information can be obtained from the head of department, Professor Göran Östlin, e-mail: ostlin *at* astro.su.se, tel. +46-8-5537 8513.

Physical Processes in Circumstellar Disks around Young Stars

Edited by Paulo J. V. Garcia

This volume brings together a team of leading experts to distill the most up-to-date knowledge of circumstellar disks into a clear introductory volume. Understanding circumstellar disks requires a broad range of scientific knowledge, including chemical processes, the properties of dust and gases, hydrodynamics and magnetohydrodynamics, radiation transfer, and stellar evolution - all of which are covered in this comprehensive work, which will be indispensable for graduate students, seasoned researchers, or even advanced undergrads setting out on the study of the origins of stars and planets.

Contents

Review quotes

"Written by some of the leading experts in the field, *Physical Processes in Circumstellar Disks around Young Stars* provides a comprehensive explanation of the basic physics of planet-forming disks. It serves both as a valuable introduction and as a thoroughly researched sourcebook for all those in the field." – James E. Pringle, University of Cambridge

"The authors have provided a rigorous presentation of many aspects of a topic that is certain to become of increasing interest to astronomers as our inventory of extra-solar-system planets and types of planets continues to grow. The stimulating last chapter, by Cathie Clarke, leaves the reader with a number of questions to work on in the future, the most notable and surprising of which is, How do stars get rid of their disks as fast as observations say they must, and still have time to form planets?!" – Virginia Trimble, University of California, Irvine

"These essays provide a deep, insightful presentation of the key theoretical issues relevant to understanding the protoplanetary disks that are likely sites for future planet formation. *Physical Processes in Circumstellar Disks around Young Stars* will certainly be a fundamental contribution to astrophysical literature." – Suzan Edwards, Smith College

Chicago University Press, ISBN: 9780226282305
440 pages, 12 color plates, 15 halftones, 78 line drawings, 5 tables — 6 x 9, paperback US$55.00
Available from http://www.press.uchicago.edu/ucp/books/book/chicago/P/bo11105735.html

Recent Advances in Star Formation: Observations and Theory
(Part of the Silver Jubilee celebration of the Vainu Bappu Telescope)

Star forming regions are replete with dense pockets of molecular hydrogen. Proto stellar systems form in some of the densest regions of these pockets, with a number of star-forming clouds having a filamentary appearance. Extensive multi-wavelength studies of star-forming regions have led to better understanding of the physics of star formation and proto-stellar evolution. Theoretical understanding of star-formation too, has improved enormously to encompass different modes of triggering the star-forming cycle. This workshop will cover some of the crucial topics in star-formation : (1)Structure and dynamics of molecular clouds (2)Triggered star-formation (3)Low and high-mass star forming regions, and HII regions (4)Protostellar evolution, jets and outflows (5)Star-clusters, binaries, initial mass function (IMF)

Dates : 28^{th} June to 01^{st} July 2011, Venue : Indian Institute of Astrophysics, Bangalore,

url : http://www.iiap.res.in/meet/star/index.htm

Scientific organising committee:
H.C.Bhatt,
Annapurni Subramaniam,
Sumedh Anathpindika,
Padmakar Parihar,
Mousumi Das

Contact: purni *at* iiap.res.in, Sumedh_a *at* iiap.res.in

Formation, atmospheres and evolution of brown dwarfs

Workshop at the 'Tagung der Astronomischen Gesellschaft 2011', Sept. 20-23, 2011, Heidelberg

Scientific Rationale:

The exploration of brown dwarfs, which fill the gap in mass between stars and planets, has seen tremendous progress over the past years. Steadily improving instrumental performance led to the discovery of e.g. companions around them down to planetary masses, of disk material, of accretion and activity phenomena, and of molecular-rich atmospheres. The monitoring of brown dwarfs in binary systems yields dynamical mass estimates. The statistical properties of brown dwarf (binary) populations provide clues on their origin. Studies of their atmospheres provide unique benchmarks for the modeling of atmospheres dominated by molecular opacities and clouds. These detailed empirical characterizations of brown dwarfs meet with increasingly sophisticated substellar atmosphere and formation models. This allows us to address fundamental questions concerning their evolution and origin; e.g. the question of how do brown dwarfs form, which is one of the main open questions in the theory of star formation. This splinter meeting aims at an overview on the current state of brown dwarf studies.

Invited review speakers: France Allard; Paul Clark (tbc); Fernando Comeron; Christiane Helling; Pavel Kroupa; Emma Whelan

Location: Heidelberg, Germany

Time: two afternoons between Sept 20 and 23, 2011

SOC: Viki Joergens (ITA, MPIA), Beth Biller (MPIA), Wolfgang Brandner (MPIA)

Further information: www.mpia.de/homes/joergens/ag2011_bdsplinter.html

Contact: ag2011_bd *at* mpia.de