THE STAR FORMATION NEWSLETTER

An electronic publication dedicated to early stellar evolution and molecular clouds

No. 228 — 22 Dec 2011 Editor: Bo Reipurth (reipurth@ifa.hawaii.edu)

Abstracts of recently accepted papers

AKARI observations of ice absorption bands towards edge-on YSOs

Y. Aikawa[1], D. Kamuro[1], I. Sakon[2], Y. Itoh[1], H. Terada[3], J.A. Noble[4], K.M. Pontoppidan[5], H.J. Fraser[4], M. Tamura[3], R. Kandori[3], A. Kawamura[3] and M. Ueno[6]

[1] Kobe University
[2] University of Tokyo
[3] National Astronomical Observatory of Japan
[4] University of Strathclyde
[5] Space Telescope Science Institute
[6] Japan Aerospace Exploration Agency

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

Circumstellar disks and envelopes of low-mass young stellar objects (YSOs) contain significant amounts of ice. Such icy material will evolve to become volatile components of planetary systems, such as comets in our solar system. To investigate the composition and evolution of circumstellar ice around low-mass YSOs, we observed ice absorption bands in the near infrared (NIR) towards eight YSOs ranging from class 0 to class II, among which seven are associated with edge-on disks. We performed slit-less spectroscopic observations using the grism mode of the Infrared Camera (IRC) on board AKARI, which enables us to obtain full NIR spectra from 2.5 μm to 5 μm, including the CO_2 band and the blue wing of the H_2O band, which are inaccessible from the ground. We developed procedures to carefully process the spectra of targets with nebulosity. The spectra were fitted with polynomial baselines to derive the absorption spectra. The molecular absorption bands were then fitted with the laboratory database of ice absorption bands, considering the instrumental line profile and the spectral resolution of the grism dispersion element. Towards the class 0-I sources (L1527, IRC-L1041-2, and IRAS04302), absorption bands of H_2O, CO_2, CO, and XCN are clearly detected. Column density ratios of CO_2 ice and CO ice relative to H_2O ice are $21-28$ % and $13-46$ %, respectively. If XCN is OCN^-, its column density is as high as $2-6$ % relative to H_2O ice. The HDO ice feature at 4.1 μm is tentatively detected towards the class 0-I sources and HV Tau. Non-detections of the CH-stretching mode features around 3.5 μm provide upper limits to the CH_3OH abundance of 26 % (L1527) and 42 % (IRAS04302) relative to H_2O. We tentatively detect OCS ice absorption towards IRC-L1041-2. Towards class 0-I sources, the detected features should mostly originate in the cold envelope, while CO gas and OCN^- could originate in the region close to the protostar, where there are warm temperatures and UV radiation. We detect H_2O ice band towards ASR41 and 2MASSJ1628137-243139, which are edge-on class II disks. We also detect H_2O ice and CO_2 ice towards HV Tau, HK Tau, and UY Aur, and tentatively detect CO gas features towards HK Tau and UY Aur.

Accepted by A & A

arXiv:1112.3736

The onset of high-mass star formation in the direct vicinity of the galactic mini-starburst W43

H. Beuther[1], J. Tackenberg[1], H. Linz[1], Th. Henning[1], O. Krause[1], S. Ragan[1], M. Nielbock[1], R. Launhardt[1], A. Schmiedeke[1,3], F. Schuller[2], P. Carlhoff[3], Q. Nguyen Luong[4] and T. Sakai[5]

[1] Max-Planck-Institute for Astronomy, Königstuhl 17, 69117 Heidelberg, Germany
[2] Max Planck Institute for Radioastronomy, Auf dem Hügel 69, 53121 Bonn, Germany

[3] University of Cologne, Zülpicher Strasse 77, 50937 Köln, Germany
[4] Laboratoire AIM Paris-Saclay, CEA/IRFU, CNRS/INSU, Universit Paris Diderot, Service d'Astrophysique, Bt. 709, CEA-Saclay, 91191, Gif-sur-Yvette Cedex, France
[5] Institute of Astronomy, The University of Tokyo, Osawa, Mitaka, Tokyo 181-0015, Japan

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

Context: The earliest stages of high-mass star formation are still poorly characterized. Densities, temperatures and kinematics are crucial parameters for simulations of high-mass star formation. It is also unknown whether the initial conditions vary with environment.
Aims: We want to investigate the youngest massive gas clumps in the environment of extremely active star formation.
Methods: We selected the IRDC18454 complex, directly associated with the W43 Galactic mini-starburst, and observed it in the continuum emission between 70mu and 1.2mm with Herschel, APEX and the 30m telescope, and in spectral line emission of N2H+ and 13CO with the Nobeyama 45m, the IRAM 30m and the Plateau de Bute Interferometer.
Results: The multi-wavelength continuum study allows us to identify clumps that are infrared dark even at 70mu and hence the best candidates to be genuine high-mass starless gas clumps. The spectral energy distributions reveal elevated temperatures and luminosities compared to more quiescent environments. Furthermore, we identify a temperature gradient from the W43 mini-starburst toward the starless clumps. We discuss whether the radiation impact of the nearby mini-starburst changes the fragmentation properties of the gas clumps and by that maybe favors more high-mass star formation in such an environment. The spectral line data reveal two different velocity components of the gas at 100 and 50km/s. While chance projection is a possibility to explain these components, the projected associations of the emission sources as well as the prominent location at the Galactic bar – spiral arm interface also allow the possibility that these two components may be spatially associated and even interacting.
Conclusions: High-mass starless gas clumps can exist in the close environment of very active star formation without being destroyed. The impact of the active star formation sites may even allow for more high-mass stars to form in these 2nd generation gas clumps. This particular region near the Galactic bar – spiral arm interface has a broad distribution of gas velocities, and cloud interactions may be possible.

Accepted by Astronomy & Astrophysics

http://www.mpia-hd.mpg.de/homes/beuther/papers.html

A Surprising Dynamical Mass for V773 Tau B

A. Boden[1], G. Torres[2], G. Duchene[3], Q. Konopacky[4], A. Ghez[5], R. Torres[6,7] and L. Loinard[6,7]

[1] Caltech
[2] Harvard
[3] UC Berkeley
[4] LLNL
[5] UCLA
[6] AIfA
[7] CRyA-UNAM

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

We report on new high-resolution imaging and spectroscopy on the multiple T Tauri star system V773 Tau over the 2003 – 2009 period. With these data we derive relative astrometry, photometry between the A and B components, and radial velocity (RV) of the A-subsystem components. Combining these new data with previously published astrometry and RVs, we update the relative A-B orbit model. This updated orbit model, the known system distance, and A subsystem parameters yields a dynamical mass for the B component for the first time. Remarkably the derived B dynamical mass is in the range of 1.7 – 3.0 $M_\odot$. This is much higher than previous estimates, and suggests that like A, B is also a multiple stellar system. Among these data, spatially-resolved spectroscopy provide new insight into the nature of the B component. Similar to A, these near-IR spectra indicate that the dominant source in B is of mid-K spectral type. If B is in fact a multiple star system as suggested by the dynamical mass estimate, the simplest assumption is that B is composed of similar ~ 1.2 $M_\odot$ PMS stars in a close (< 1 AU) binary system. This inference is supported by line-shape changes in near-IR spectroscopy of B, tentatively interpreted as changing RV among components in V773 Tau B. Relative photometry indicate that B is highly variable in the near-IR. The most likely explanation for this variability is circum-B material resulting in variable line-of-sight extinction. The distribution

of this material must be significantly affected by both the putative B multiplicity, and the A-B orbit.

Accepted by ApJ

http://arxiv.org/abs/1112.1018

Star Formation in the Outer Galaxy: Coronal Properties of NGC 1893

M. Caramazza[1], G. Micela[1], L. Prisinzano[1], S. Sciortino[1], F. Damiani[1], F. Favata[2], J. R. Stauffer[3], A. Vallenari[4] and S. J. Wolk[5]

[1] INAF Osservatorio Astronomico di Palermo, Piazza del Parlamento 1, 90134 Palermo, Italy
[2] European Space Agency, 8-10 rue Mario Nikis, 75015 Paris, France
[3] Spitzer Science Center, Caltech 314-6, Pasadena, CA 91125, USA
[4] INAF, Osservatorio Astronomico di Padova, Vicolo dell'Osservatorio 5, 35122 Padova, Italy
[5] Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA

E-mail contact: mcarama *at* astropa.unipa.it

The outer Galaxy, where the environmental conditions are different from the solar neighbourhood is a laboratory in which it is possible to investigate the dependence of star formation process on the environmental parameters. We investigate the X-ray properties of NGC 1893, a young cluster ($\sim 1-2$ Myr) in the outer part of the Galaxy (galactic radius ≥ 11 kpc) where we expect differences in the disk evolution and in the mass distribution of the stars, to explore the X-ray emission of its members and compare it with that of young stars in star forming regions near to the Sun. We analyze 5 deep *Chandra* ACIS-I observations with a total exposure time of 450 ks. Source events of the 1021 X-ray sources have been extracted with the IDL-based routine ACIS-Extract. Using spectral fitting and quantile analysis of X-ray spectra, we derive X-ray luminosities and compare the respective properties of Class II and Class III members. We also evaluate the variability of sources using the Kolmogorov-Smirnov test and we identify flares in the light curves. The X-ray luminosity of NGC 1893 X-ray members is in the range $10^{29.5}-10^{31.5}$ erg s^{-1}. Diskless stars are brighter in X-rays than disk-bearing stars, given the same bolometric luminosity. We found that 34% of the 1021 lightcurves appear variable and that they show 0.16 flare per source, on average. Comparing our results with those relative to the Orion Nebula Cluster, we find that, accounting for observational biases, the X-ray properties of NGC 1893 and the Orion ones are very similar. The X-ray properties in NGC 1893 are not affected by the environment and the stellar population in the outer Galaxy may have the same coronal properties of nearby star forming regions. The X-ray luminosity properties and the X-ray luminosity function appear to be universal and can therefore be used for distance estimations and for determining stellar properties as already suggested by Feigelson and collaborators.

Accepted by Astronomy & Astrophysics

Interstellar ices as witnesses of star formation: selective deuteration of water and organic molecules unveiled

S. Cazaux[1], P. Caselli[2] and M. Spaans[1]

[1] Kapteyn Astronomical Institute, P.O. Box 800, 9700AV Groningen, The Netherlands
[2] School of Physics and Astronomy, University of Leeds, LS2 9JT, Leeds, UK

E-mail contact: cazaux *at* astro.rug.nl

Observations of star-forming environments revealed that the abundances of some deuterated interstellar molecules are markedly larger than the cosmic D/H ratio of 10-5. Possible reasons for this pointed to grain surface chemistry. However, organic molecules and water, which are both ice constituents, do not enjoy the same deuteration. For example, deuterated formaldehyde is very abundant in comets and star-forming regions, while deuterated water rarely is. In this paper, we explain this selective deuteration by following the formation of ices (using the rate equation method) in translucent clouds, as well as their evolution as the cloud collapses to form a star. Ices start with the deposition of gas-phase CO and O onto dust grains. While reaction of oxygen with atoms (H or D) or molecules (H2) yields H2O (HDO), CO only reacts with atoms (H and D) to form H2CO (HDCO, D2CO). As a result, the deuteration of formaldehyde is sensitive to the gas D/H ratio as the cloud undergoes gravitational collapse, while the deuteration of water strongly depends on the dust temperature at the time of ice formation. These results reproduce well the deuterium fractionation of formaldehyde observed in comets and star-forming regions and can explain the wide spread

of deuterium fractionation of water observed in these environments.

Accepted by Astrophysical Journal Letter

http://adsabs.harvard.edu/abs/2011ApJ...741L..34C

Is the massive young cluster Westerlund I bound?

Michiel Cottaar[1], Michael R. Meyer[1], Morten Andersen[2] and Pablo Espinoza[3]

[1] Institute for Astronomy, ETH Zurich, Wolfgang-Pauli-Strasse 27, 8093 Zurich, Switzerland
[2] European Space Agency (ESTEC), P.O. Box 299, 2200 AG Noordwijk, The Netherlands
[3] Steward Observatory, The University of Arizona, Tucson, Arizona 85721, USA

E-mail contact: MCottaar *at* phys.ethz.ch

Context. Westerlund I is the richest young cluster currently known in our Galaxy, making it one of the most massive clusters for which we can resolve the individual stars even in the crowded centre. This makes it an ideal target to assess whether massive clusters formed currently will remain bound or will disperse and contribute significantly to the stellar field population.
Aims. Here we report a measurement of the radial velocity dispersion of Westerlund I to explore whether the cluster is currently in virial equilibrium, if it is in the process of collapse or if it is expanding and dispersing into the field.
Methods. We obtained MIKE/Magellan high resolution optical spectra of 22 post main-sequence stars in Westerlund I for 2 or 3 epochs with a maximum baseline of about one year. Radial velocities variations between these spectra have been measured through cross correlation.
Results. We calculate the velocity dispersion from the cross correlation of five yellow hypergiants and one luminous blue variable, that show little radial velocity variations between epochs and have many spectral features in common. After taking into account the effect of small number statistics and undetected binaries, we estimate the velocity dispersion for the massive stars in Westerlund I to be $2.1^{+3.3}_{-2.1}$ km s^{-1}. For several different assumptions concerning possible mass segregation and the elongation of the cluster, we find that Westerlund I is subvirial at the 90% confidence level.
Conclusions: We can rule out that the cluster is significantly supervirial at the 97% confidence level, indicating that Westerlund I is currently bound. This implies that Westerlund I has survived past the point where any gas expulsion has taken place and is expected to survive for billions of years.

Accepted by Astronomy & Astrophysics

http://arxiv.org/abs/1112.4328

Resolving the Luminosity Problem in Low-Mass Star Formation

Michael M. Dunham[1] and Eduard I. Vorobyov[2,3]

[1] Department of Astronomy, Yale University, P.O. Box 208101, New Haven, CT 06520, USA
[2] Institute of Astronomy, The University of Vienna, Vienna, 1180, Austria
[3] Institute of Physics, Southern Federal University, Stachki 194, Rostov-on-Don, 344090, Russia

E-mail contact: michael.dunham *at* yale.edu

We determine the observational signatures of protostellar cores by coupling two-dimensional radiative transfer calculations with numerical hydrodynamical simulations that predict accretion rates that both decline with time and feature short-term variability and episodic bursts caused by disk gravitational instability and fragmentation. We calculate the radiative transfer of the collapsing cores throughout the full duration of the collapse, using as inputs the core, disk, and protostellar masses, radii, and mass accretion rates predicted by the hydrodynamical simulations. From the resulting spectral energy distributions, we calculate standard observational signatures (L_{bol}, T_{bol}, L_{bol}/L_{smm}) to directly compare to observations. We show that the accretion process predicted by these models reproduces the full spread of observed protostars in both $L_{bol} - T_{bol}$ and $L_{bol} - M_{core}$ space, including very low luminosity objects, provides a reasonable match to the observed protostellar luminosity distribution, and resolves the long-standing luminosity problem. These models predict an embedded phase duration shorter than recent observationally determined estimates (0.12 Myr vs. 0.44 Myr), and a fraction of total time spent in Stage 0 of 23%, consistent with the range of values determined by observations. On average, the models spend 1.3% of their total time in accretion bursts, during which 5.3% of the final stellar mass accretes, with maximum values being 11.8% and 35.5% for the total time and

accreted stellar mass, respectively. Time-averaged models that filter out the accretion variability and bursts do not provide as good of a match to the observed luminosity problem, suggesting that the bursts are required.

Accepted by ApJ

Light scattering by a multilayered spheroidal particle

Victor G. Farafonov[1] and Nikolai V. Voshchinnikov[2]

[1] State University of Aerospace Instrumentation, St. Petersburg, 190000 Russia
[2] Sobolev Astronomical Institute, St. Petersburg University, St. Petersburg, 198504 Russia

E-mail contact: nvv@astro.spbu.ru

The light scattering problem for a confocal multilayered spheroid has been solved by the extended boundary condition method (EBCM) with a corresponding spheroidal basis. The solution preserves the advantages of the approach applied previously to homogeneous and core-mantle spheroids, i.e. the separation of the radiation fields into two parts and a special choice of scalar potentials for each of the parts. The method is known to be useful in a wide range of the particle parameters. It is particularly efficient for strongly prolate and oblate spheroids. Numerical tests are described. Illustrative calculations have shown that the extinction factors to converge to average values with a growing number of layers and how the extinction vary with a growth of particle porosity.

Accepted by Applied Optics

arXiv:1110.6604]

A new method for calculating the convergent point of a moving group

P.A.B. Galli[1], R. Teixeira[1], C. Ducourant[2], C. Bertout[3] and P. Benevides-Soares[1]

[1] Instituto de Astronomia, Geofísica e Ciências Atmosféricas, Universidade de São Paulo, Rua do Matão 1226 - Cidade Universitária, 05508-900, São Paulo-SP, Brazil
[2] Observatoire Aquitain des Sciences de l'Univers, CNRS-UMR 5804, BP 89, Floirac, France
[3] Institut d'Astrophysique, 98bis, Bd. Arago, 75014 Paris, France

E-mail contact: galli *at* astro.iag.usp.br

*Context.*Convergent point (CP) search methods are important tools for studying the kinematic properties of open clusters and young associations whose members share the same spatial motion.
Aims. We present a new CP search strategy based on proper motion data. We test the new algorithm on synthetic data and compare it with previous versions of the CP search method. As an illustration and validation of the new method we also present an application to the Hyades open cluster and a comparison with independent results.
Methods. The new algorithm rests on the idea of representing the stellar proper motions by great circles over the celestial sphere and visualizing their intersections as the CP of the moving group. The new strategy combines a maximum-likelihood analysis for simultaneously determining the CP and selecting the most likely group members and a minimization procedure that returns a refined CP position and its uncertainties. The method allows one to correct for internal motions within the group and takes into account that the stars in the group lie at different distances.
Results. Based on Monte Carlo simulations, we find that the new CP search method in many cases returns a more precise solution than its previous versions. The new method is able to find and eliminate more field stars in the sample and is not biased towards distant stars. The CP solution for the Hyades open cluster is in excellent agreement with previous determinations.

Accepted by Astronomy and Astrophysics

http://arxiv.org/pdf/1112.3542

Carbon-chain Species in Warm-up Models

George E. Hassel[1,3], Nanase Harada[1] and Eric Herbst[2]

[1] Department of Physics, The Ohio State University, Columbus, OH 43210, USA
[2] Departments of Chemistry, Astronomy, and Physics, University of Virginia, Charlottesville, VA 22904, USA
[3] Department of Physics and Astronomy, Siena College, Loudonville, NY 12211, USA

E-mail contact: ghassel *at* siena.edu

In previous warm-up chemical models of the low-mass star forming region L1527, we investigated the evolution of long-chain unsaturated hydrocarbon species when the envelope temperature is slightly elevated to $T \approx 30$ K. These models demonstrated that enhanced abundances of such species could be explained by gas-phase ion-molecule chemistry following the partial sublimation of methane from grain surfaces. We also concluded that the abundances of hydrocarbon radicals such as the C_nH family should be further enhanced as the temperatures increase to higher values, but this conclusion stood in contrast with the lack of unambiguous detection of these species toward hot core and corino sources. Meanwhile, observational surveys have identified C_2H, C_4H, CH_3CCH, and CH_3OH toward hot corinos (especially IRAS 16293-2422) as well as toward L1527, with lower abundances for the carbon-chain radicals and higher abundances for the other two species toward the hot corinos. In addition, the Herschel Space Telescope has detected the bare linear chain C_3 in 50 K material surrounding young high-mass stellar objects. To understand these new results, we revisit previous warm-up models with an augmented gas-grain network that incorporated reactions from a gas-phase network that was constructed for use with increased temperature up to 800 K. Some of the newly adopted reactions between carbon-chain species and abundant H_2 possess chemical activation barriers. The revised model results now better reproduce the observed abundances of unsaturated carbon-chains under hot corino (100 K) conditions and make predictions for the abundances of bare carbon chains in the 50 K regions observed by Herschel HIFI.

Accepted by ApJ

http://arxiv.org/abs/1112.1997

Optical TiO and VO band emission in two embedded protostars: IRAS 04369+2539 and IRAS 05451+0037

Lynne A. Hillenbrand[1], Gillian R. Knapp[2], Deborah L. Padgett[3], Luisa M. Rebull[4] and Peregrine M. McGehee[3]

[1] Astrophysics Department, California Institute of Technology, Pasadena, CA 91125, USA
[2] Department of Astrophysical Sciences, Princeton University, Princeton, NJ 08544, USA
[3] Infrared Processing and Analysis Center, California Institute of Technology, Pasadena, CA 91125, USA
[4] Spitzer Science Center, California Institute of Technology, Pasadena, CA 91125, USA

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

Archival optical spectra from the Sloan Digital Sky Survey of two optically faint flat spectrum protostars, IRAS 04369+2539 and IRAS 05451+0037, show strong emission-line features including - notably - clear and broad emission across several molecular bands of TiO and VO. The molecular emission is indicative of dense, warm circumstellar gas and has been seen previously in only one object: the flat spectrum protostar IRAS 20496+4354 during a strong optical outburst (PTF 10nvg; Covey et al. 2011). The presence of broad molecular emission features in two additional objects having similar mid-infrared properties (but not known to be undergoing outbursts) could provide new insight into phases of rapid accretion / outflow at early stages of the protoplanetary disk. At present, the relevant geometry and the formation or heating mechanisms responsible for the observed TiO / VO cooling emission remain unexplained.

Accepted by The Astronomical Journal

http://arxiv.org/pdf/1111.4730

Star formation near an obscured AGN: Variations in the initial mass function

S. Hocuk[1] and M. Spaans[1]

[1] Kapteyn Astronomical Institute, P.O. Box 800, 9700AV Groningen, Netherlands

E-mail contact: seyit *at* astro.rug.nl

The conditions that affect the formation of stars in radiatively and mechanically active environments are quite different from the conditions that apply to our local interstellar neighborhood. In these galactic environments, a variety of feedback processes can play a significant role in shaping the initial mass function (IMF). Here, we present a numerical study on the effects of an accreting black hole and the influence of nearby massive stars to a collapsing, 800 $M_\odot$,

molecular cloud at 10 pc distance from the black hole. Our work focusses on the star-forming ISM in the centers of (ultra-)luminous infrared galaxies ((U)LIRGS). We therefore assume that this region is enshrouded by gas and dust and that most of the UV and soft X-ray radiation from the broad line region (BLR) is attenuated along the line of sight to the model cloud. We then parametrize and study radiative feedback effects of hard X-rays emanating from the black hole BLR, increased cosmic ray rates caused by supernovae in starbursts, and strong UV radiation produced by nearby massive stars. We also investigate the importance of shear from the supermassive, $10^6 - 10^8$ $M_\odot$, black hole as the star-forming cloud orbits around it. A grid of 42 models is created and calculated with the hydrodynamical code FLASH. We find that thermal pressure from X-rays compresses the cloud, which induces a high star-formation rate early on, but reduces the overall star-formation efficiency (SFE) to about 7% through gas depletion by evaporation. We see that the turn-over mass of the IMF increases up to a factor of 2.3, $M_{\rm turn} = 1 - 1.5$ $M_\odot$, for the model with the highest X-ray flux (160 erg s^{-1} cm^{-2}), while the high-mass slope of the IMF becomes $\Gamma \gtrsim -1$ ($\Gamma_{\rm Salpeter} = -1.35$). This results in more high-mass stars and a non-Salpeter IMF. Cosmic rays penetrate deeply into the cloud and increase the gas temperature to about 50 K for rates that are roughly 100 times Galactic and 200 K for 3000 times Galactic, which leads to a reduced formation efficiency of low-mass stars. While the shape of the mass function is preserved, high cosmic ray rates increase the average mass of stars, thereby shifting the turn-over mass to higher values, i.e., up to several solar masses. Owing to this process, the onset of star formation is also delayed. We find that UV radiation plays only a minor role. Because UV photons cannot penetrate a dense, n $\gtrsim 10^5$ cm^{-3}, cloud deep enough, they only affect the late time accretion by heating the medium where the cloud is embedded in. When we increase the black hole mass, for a cloud that is at 10 pc distance, the turbulence caused by shearing effects reduces the SFE slightly. Furthermore, shear weakens the effect of the other parameters on the slope of the IMF as well as the turn-over mass. The run with the most massive black hole, however, causes so much shear that the hydrodynamics is completely dominated by this effect and it severely inhibits star formation. We conclude that the IMF inside active galaxies is different from the one obtained from local environments. We also find that the combined effects of X-rays, cosmic rays, UV, and shear tend to drive toward a less pronounced deviation from a Salpeter IMF.

Accepted by A&A

http://lanl.arxiv.org/abs/1109.6593

Grain charging in protoplanetary discs

Martin Ilgner[1]

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

E-mail contact: ilgner *at* mpia-hd.mpg.de

Recent work identified a growth barrier for dust coagulation that originates in the electric repulsion between colliding particles. Depending on its charge state, dust material may have the potential to control key processes towards planet formation such as MHD (magnetohydrodynamic) turbulence and grain growth which are coupled in a two-way process. We quantify the grain charging at different stages of disc evolution and differentiate between two very extreme cases: compact spherical grains and aggregates with fractal dimension $D_f = 2$. Applying a simple chemical network that accounts for collisional charging of grains, we provide a semi-analytical solution. This allowed us to calculate the equilibrium population of grain charges and the ionisation fraction efficiently. The grain charging was evaluated for different dynamical environments ranging from static to non-stationary disc configurations. The results show that the adsorption/desorption of neutral gas-phase heavy metals, such as magnesium, effects the charging state of grains. The greater the difference between the thermal velocities of the metal and the dominant molecular ion, the greater the change in the mean grain charge. Agglomerates have more negative excess charge on average than compact spherical particles of the same mass. The rise in the mean grain charge is proportional to $N^{1/6}$ in the ion-dust limit. We find that grain charging in a non-stationary disc environment is expected to lead to similar results. The results indicate that the dust growth and settling in regions where the dust growth is limited by the so-called "electro-static barrier" do not prevent the dust material from remaining the dominant charge carrier.

Accepted by Astronomy and Astrophysics

http://arxiv.org/abs/1112.2692

Adding particle collisions to the formation of asteroids and Kuiper belt objects via streaming instabilities

Anders Johansen[1], Andrew N. Youdin[2] and Yoram Lithwick[3]

[1] Lund Observatory, Department of Astronomy and Theoretical Physics, Lund University, Box 43, 221 00 Lund, Sweden
[2] Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA
[3] Center for Interdisciplinary Exploration and Research in Astrophysics (CIERA) and Dept. of Physics & Astronomy, Northwestern University, 2145 Sheridan Rd, Evanston, IL 60208, USA

E-mail contact: anders *at* astro.lu.se

Modelling the formation of super-km-sized planetesimals by gravitational collapse of regions overdense in small particles requires numerical algorithms capable of handling simultaneously hydrodynamics, particle dynamics and particle collisions. While the initial phases of radial contraction are dictated by drag forces and gravity, particle collisions become gradually more significant as filaments contract beyond Roche density. Here we present a new numerical algorithm for treating momentum and energy exchange in collisions between numerical superparticles representing a high number of physical particles. We adopt a Monte Carlo approach where superparticle pairs in a grid cell collide statistically on the physical collision time-scale. Collisions occur by enlarging particles until they touch and solving for the collision outcome, accounting for energy dissipation in inelastic collisions. We demonstrate that superparticle collisions can be consistently implemented at a modest computational cost. In protoplanetary disc turbulence driven by the streaming instability, we argue that the relative Keplerian shear velocity should be subtracted during the collision calculation. If it is not subtracted, density inhomogeneities are too rapidly diffused away, as bloated particles exaggerate collision speeds. Local particle densities reach several thousand times the mid-plane gas density. We find efficient formation of gravitationally bound clumps, with a range of masses corresponding to contracted radii from 100 to 400 km when applied to the asteroid belt and 150 to 730 km when applied to the Kuiper belt, extrapolated using a constant self-gravity parameter. The smaller planetesimals are not observed at low resolution, but the masses of the largest planetesimals are relatively independent of resolution and treatment of collisions.

Accepted by Astronomy & Astrophysics

http://arxiv.org/abs/1111.0221

Smoothed particle magnetohydrodynamics with a Riemann solver and the method of characteristic

Kazunari Iwasaki[1] and Shu-ichiro Inutsuka[1]

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

E-mail contact: iwasaki *at* nagoya-u.jp

In this paper, we develop a new method for magnetohydrodynamics (MHD) using smoothed particle hydrodynamics (SPH). To describe MHD shocks accurately, the Godunov method is applied to SPH instead of artificial dissipation terms. In the interaction between particles, we solve a nonlinear Riemann problem with magnetic pressure for compressive waves and apply the method of characteristics for Alfvén waves. An extensive series of MHD test calculations is performed. In all test calculations, we compare the results of our SPH code with those of a finite-volume method with an approximate Riemann solver, and confirm excellent agreement.

Accepted by Monthly Notices of the Royal Astronomical Society

http://jp.arxiv.org/abs/1106.3389

Looking for Outflow and Infall Signatures in High Mass Star Forming Regions

Pamela Klaassen[1,2], Leonardo Testi[1,3] and Henrik Beuther[4]

[1] European Southern Observatory
[2] Leiden Observatory
[3] NAF-Osservatorio Astrofisico di Arcetri
[4] Max Planck Institute for Astronomy

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

Many physical parameters change with time in star forming regions. Here we attempt to correlate changes in infall and outflow motions in high mass star forming regions with evolutionary stage using JCMT observations. From a sample of 45 high mass star forming regions in three phases of evolution, we investigate the presence of established infall and outflow tracers to determine whether there are any trends attributable to the age of the source. We obtained JCMT observations of $HCO^+/H^{13}CO^+$ J=4-3 to trace large scale infall, and SiO J=8-7 to trace recent outflow activity. We compare the infall and outflow detections to the evolutionary stage of the host source (high mass protostellar objects, hypercompact HII regions and ultracompact HII regions). We also note that the integrated intensity of SiO varies with the full width at half maximum of the $H^{13}CO^+$. We find a surprising lack of SiO detections in the middle stage (Hypercompact HII regions), which may be due to an observational bias. When SiO is detected, we find that the integrated intensity of the line increases with evolutionary stage. We also note that all of the sources with infall signatures onto Ultracompact HII regions have corresponding outflow signatures as well.

Accepted by A&A

http://arxiv.org/abs/1112.0928

On the stability of radiation-pressure-dominated cavities

Rolf Kuiper[1,2,3], Hubert Klahr[2], Henrik Beuther[2] and Thomas Henning[2]

[1] Argelander Institute for Astronomy, Bonn University, Auf dem Huegel 71, D-53121 Bonn, Germany
[2] Max Planck Institute for Astronomy, Koenigstuhl 17, D-69117 Heidelberg, Germany
[3] Now: Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, CA 91109, USA

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

Context: When massive stars exert a radiation pressure onto their environment that is higher than their gravitational attraction (super-Eddington condition), they launch a radiation-pressure-driven outflow, which creates cleared cavities. These cavities should prevent any further accretion onto the star from the direction of the bubble, although it has been claimed that a radiative Rayleigh-Taylor instability should lead to the collapse of the outflow cavity and foster the growth of massive stars.
Aims: We investigate the stability of idealized radiation-pressure-dominated cavities, focusing on its dependence on the radiation transport approach used in numerical simulations for the stellar radiation feedback.
Methods: We compare two different methods for stellar radiation feedback: gray flux-limited diffusion (FLD) and ray-tracing (RT). Both methods are implemented in our self-gravity radiation hydrodynamics simulations for various initial density structures of the collapsing clouds, eventually forming massive stars. We also derive simple analytical models to support our findings.
Results: Both methods lead to the launch of a radiation-pressure-dominated outflow cavity. However, only the FLD cases lead to prominent instability in the cavity shell. The RT cases do not show such instability; once the outflow has started, it precedes continuously. The FLD cases display extended epochs of marginal Eddington equilibrium in the cavity shell, making them prone to the radiative Rayleigh-Taylor instability. In the RT cases, the radiation pressure exceeds gravity by 1-2 orders of magnitude. The radiative Rayleigh-Taylor instability is then consequently suppressed. It is a fundamental property of the gray FLD method to neglect the stellar radiation temperature at the location of absorption and thus to underestimate the opacity at the location of the cavity shell.
Conclusions: Treating the stellar irradiation in the gray FLD approximation underestimates the radiative forces acting on the cavity shell. This can lead artificially to situations that are affected by the radiative Rayleigh-Taylor instability. The proper treatment of direct stellar irradiation by massive stars is crucial for the stability of radiation-pressure-dominated cavities.

Accepted by A&A

http://arxiv.org/abs/1111.5625v1

Star Formation Rates in Molecular Clouds and the Nature of the Extragalactic Scaling Relations

Charles Lada[1], Jan Forbrich[1], Marco Lombardi[2] and João Alves[3]

[1] Smithsonian Astrophysical Observatory, 60 Garden Street, Cambridge MA 02138, USA
[2] University of Milan, Department of Physics, via Celoria 16 220133 Milan, Italy
[3] Institute for Astronomy, University of Vienna, Türkenschanzstrasse 17, 1180 Vienna, Austria

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

In this paper we investigate scaling relations between star formation rates and molecular gas masses for both local Galactic clouds and a sample of external galaxies. We specifically consider relations between the star formation rates and measurements of dense, as well as total, molecular gas masses. We argue that there is a fundamental empirical scaling relation that directly connects the local star formation process with that operating globally within galaxies. Specifically, the total star formation rate in a molecular cloud or galaxy is linearly proportional to the mass of dense gas within the cloud or galaxy. This simple relation, first documented in previous studies, holds over a span of mass covering nearly nine orders of magnitude and indicates that the rate of star formation is directly controlled by the amount of dense molecular gas that can be assembled within a star formation complex. We further show that the star formation rates and total molecular masses, characterizing both local clouds and galaxies, are correlated over similarly large scales of mass and can be described by a family of linear star formation scaling laws, parameterized by f_{DG}, the fraction of dense gas contained within the clouds or galaxies. That is, the underlying star formation scaling law is always linear for clouds and galaxies with the same dense gas fraction. These considerations provide a single unified framework for understanding the relation between the standard (non-linear) extragalactic Schmidt-Kennicutt scaling law, that is typically derived from CO observations of the gas, and the linear star formation scaling law derived from HCN observations of the dense gas.

Accepted by The Astrophysical Journal (to appear February 2012)

https://www.cfa.harvard.edu/~clada/pubs_html/SFRII.html

An icy Kuiper-Belt around the young solar-type star HD 181327

J. Lebreton[1], J.-C. Augereau[1], W.-F. Thi[1], A. Roberge[2], J. Donaldson[3], G. Schneider[4], S. T. Maddison[5], F. Ménard[1], P. Riviere-Marichalar[6], G.S. Mathews[7], I. Kamp[8], C. Pinte[1], W. R. F. Dent[9], D. Barrado[6],[1]0, G. Duchêne[1],[11], J.-F. Gonzalez[12], C. A. Grady[13], G. Meeus[14], E. Pantin[15], J. P. Williams[7], P. Woitke[16],[17],[18]

[1]UJF-Grenoble 1 / CNRS-INSU, Institut de Planétologie et d'Astrophysique de Grenoble (IPAG) UMR 5274, Grenoble, F-38041, France
[2]Exoplanets and Stellar Astrophysics Lab, NASA Goddard Space Flight Center, Code 667, Greenbelt, MD, 20771, USA
[3]Department of Astronomy, University of Maryland, College Park, MD 20742, USA
[4]Steward Observatory, The University of Arizona, 933 North Cherry Avenue, Tucson, AZ 85721, USA
[5]Centre for Astrophysics & Supercomputing, Swinburne University, PO, Box 218, Hawthorn, VIC 3122, Australia
[6]LAEX, Depto. Astrofísica, Centro de Astrobiología (INTA-CSIC), P.O. Box 78, E-28691 Villanueva de la Cañada, Spain
[7]Institute for Astronomy, University of Hawaii at Manoa, Honolulu, HI 96822, USA
[8]Kapteyn Astronomical Institute, P.O. Box 800, 9700 AV Groningen, The Netherlands
[9]ESO-ALMA, Avda Apoquindo 3846, Piso 19, Edificio Alsacia, Las Condes, Santiago, Chile
[10]Calar Alto Observatory, Centro Astronómico Hispano-Alemán C/Jesús Durbán Remón, 2-2, 04004 Almería, Spain
[11]Astronomy Department, University of California, Berkeley CA 94720-3411 USA
[12]Université de Lyon, Lyon, F-69003, France ; Université Lyon 1, Observatoire de Lyon, 9 avenue Charles André, Saint-Genis Laval, F-69230, France ; CNRS, UMR 5574, Centre de Recherche Astrophysique de Lyon ; École Normale Supérieure de Lyon, Lyon, F-69007, France
[13]Eureka Scientific and Exoplanets and Stellar Astrophysics Lab, NASA Goddard Space Flight Center, Code 667, Greenbelt, MD, 20771, USA
[14]Dep. de Física Teórica, Fac. de Ciencias, UAM Campus Cantoblanco, 28049 Madrid, Spain
[15]CEA/IRFU/SAp, AIM UMR 7158, 91191 Gif-sur-Yvette, France
[16]SUPA, Institute for Astronomy, University of Edinburgh, Royal Observatory Edinburgh, UK

[17]School of Physics & Astronomy, University of St. Andrews, North Haugh, St. Andrews KY16 9SS, UK
[18]UK Astronomy Technology Centre, Royal Observatory, Edinburgh, Blackford Hill, Edinburgh EH9 3HJ, UK

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

HD 181327 is a young Main Sequence F5/F6 V star belonging to the β Pictoris moving group (age $\sim$ 12 Myr). It harbors an optically thin belt of circumstellar material at radius ∼90 AU, presumed to result from collisions in a population of unseen planetesimals.
We aim to study the dust properties in the belt in details, and to constrain the gas-to-dust ratio.
We obtained far-infrared photometric observations of HD 181327 with the PACS instrument onboard the Herschel Space Observatory, complemented by 3.2 mm observations carried with the ATCA array. The geometry of the belt is constrained with newly reduced HST/NICMOS scattered light images that allow the degeneracy between the disk geometry and the dust properties to be broken. We use the radiative transfer code GRaTer to compute a large grid of models, and we identify the grain models that best reproduce the Spectral Energy Distribution (SED) through a Bayesian analysis. We attempt to detect the oxygen and ionized carbon fine-structure lines with Herschel/PACS spectroscopy, providing observables to our photochemical code ProDiMo.
The HST observations confirm that the dust is confined in a narrow belt. The continuum is detected with Herschel/PACS completing nicely the SED in the far-infrared. The disk is marginally resolved with both PACS and ATCA. A medium integration of the gas spectral lines only provides upper limits on the [OI] and [CII] line fluxes. We show that the HD 181327 dust disk consists of micron-sized grains of porous amorphous silicates and carbonaceous material surrounded by an important layer of ice, for a total dust mass of $\sim 0.05 M_\oplus$ (in grains up to 1 mm). We discuss evidences that the grains consists of fluffy aggregates. The upper limits on the gas atomic lines do not provide unambiguous constraints: only if the PAH abundance is high, the gas mass must be lower than $\sim 17 M_\oplus$.
Despite the weak constraints on the gas disk, the age of HD 181327 and the properties of the dust disk suggest that it has passed the stage of gaseous planets formation. The dust reveals a population of icy planetesimals, similar to the primitive Edgeworth-Kuiper Belt, that may be a source for the future delivery of water and volatiles onto forming terrestrial planets.

Accepted by Astronomy and Astrophysics

http://arxiv.org/abs/1112.3398

Distances to dense cores that contain very low luminosity objects

G. Maheswar[1,2], Lee Chang-Won[2] and Sami Dib[3]

[1] Aryabhatta Research Institute of Observational Sciences, Manora Peak, Nainital, 263 129, India
[2] Korea Astronomy & Space Science Institute, 61-1 Hwaam-dong, Yusung-gu, Daejeon, 305-348, Korea
[3] Astrophysics Group, Blackett Laboratory, Imperial College, London, SW7 2AZ, UK

E-mail contact: maheswar *at* aries.res.in

Aims: We estimate the distances to dense molecular cores that harbour very low luminosity objects (VeLLOs) detected by the Spitzer Space Telescope and attempt to confirm their VeLLO nature.
Methods: The cloud distances are estimated using a near-IR photometric method. We use a technique that performs a spectral classification of stars lying towards the fields containing the clouds as either main-sequence stars or giants. In this technique, the observed (J - H) and (H - Ks) colours are dereddened simultaneously using trial values of AV and a normal interstellar extinction law. The best fit of the dereddened colours to the intrinsic colours giving a minimum value of chisq2 then yields the corresponding spectral type and AV for the star. The main-sequence stars, thus classified, are then utilized in an AV versus distance plot to bracket the cloud distances. The typical error in the estimation of distances to the clouds are found to be 18%.
Results: We estimate distances to seven cloud cores, IRAM 04191, L1521F, BHR 111, L328, L673-7, L1014, and L1148 using the above method. These clouds contain VeLLO candidates. The estimated distances to the cores are found to be 127 ± 25 pc (IRAM 04191), 136 ± 36 pc (L1521F), 355 ± 65 pc (BHR 111), 217 ± 30 pc (L328), 240 ± 45 pc (L673-7), 258 ± 50 pc (L1014), and 301 ± 55 pc (L1148). We re-evaluated the internal luminosities of the VeLLOs discovered in these seven clouds using the distances estimated from this work. Except for L1014 - IRS ($L_{int} = 0.15\ L_\odot$), all other VeLLO candidates are found to be consistent with the definition of a VeLLO ($Lint \leq 0.1$ Lsun). In addition to the cores that harbour VeLLO candidates, we also obtained distances to the clouds L323, L675, L676, CB 188, L1122, L1152, L1155, L1157, and L1158, which are located in the directions of the above seven cores. Towards L1521F and

L1148, we found evidence of multiple dust layers.

Accepted by Astronomy & Astrophysics,

http://arxiv.org/abs/1110.1704

Close Companions to Young Stars. I. A Large Spectroscopic Survey in Chamaeleon I and Taurus-Auriga

Duy Cuong Nguyen[1,2,3], Alexis Brandeker[1,2], Marten H. van Kerkwijk[1] and Ray Jayawardhana[1]

[1] Department of Astronomy and Astrophysics, University of Toronto, 50 St. George Street, Toronto, Ontario, M5S 3H4, Canada

[2] Department of Astronomy, Stockholm University, SE-106 91 Stockholm, Sweden

[3] Department of Physics and Astronomy, University of Rochester, Rochester, NY 14627-0171, USA

E-mail contact: dcnguyen *at* pas.rochester.edu

We present the results of a multiplicity survey of 212 T Tauri stars in the Chamaeleon I and Taurus-Auriga star-forming regions, based on high-resolution spectra from the Magellan Clay 6.5 m telescope. From these data, we achieved a typical radial velocity precision of ∼80 m/s with slower rotators yielding better precision, in general. For 174 of these stars, we obtained multi-epoch data with sufficient time baselines to identify binaries based on radial velocity variations. We identified eight close binaries and four close triples, of which three and two, respectively, are new discoveries. The spectroscopic multiplicity fractions we find for Cha I (7%) and Tau-Aur (6%) are similar to each other, and to the results of field star surveys in the same mass and period regime. However, unlike the results from imaging surveys, the frequency of systems with close companions in our sample is not seen to depend on primary mass. Additionally, we do not find a strong correlation between accretion and close multiplicity. This implies that close companions are not likely the main source of the accretion shut down observed in weak-lined T Tauri stars. Our results also suggest that sufficient radial velocity precision can be achieved for at least a subset of slowly rotating young stars to search for hot Jupiter planets.

Accepted by Astrophysical Journal

http://arxiv.org/abs/1112.0002

Molecule survival in magnetized protostellar disk winds. I. Chemical model and first results

D. Panoglou[1,2], S. Cabrit[2], G. Pineau des Forets[3,2], P.J.V. Garcia[4,5], J. Ferreira[5] and F. Casse[6]

[1] Centro de Astrofisica, Universidade do Porto, 4150-752 Porto, Portugal

[2] LERMA, Observatoire de Paris, ENS, UPMC, UCP, CNRS, 61 Avenue de l'Observatoire, 75014 Paris, France

[3] IAS, UMR 8617 du CNRS, Universite de Paris-Sud, 91405 Orsay, France

[4] Universidade do Porto, Faculdade de Engenharia, Laboratorio SIM Unidade FCT #4006, Portugal

[5] Institut de Planetologie et d'Astrophysique de Grenoble, UMR 5521 du CNRS, 38041 Grenoble Cedex, France

[6] Laboratoire Astroparticule & Cosmologie, Universite Paris 7, UMR 7164 du CNRS, 75205 Paris Cedex 13, France

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

Context: Molecular counterparts to atomic jets have recently been detected within 1000 AU of young stars at early evolutionary stages. Reproducing these counterparts is an important new challenge for proposed ejection models.
Aims: We explore whether molecules may survive in the magneto-hydrodynamic (MHD) disk wind solution currently invoked to reproduce the kinematics and tentative rotation signatures of atomic jets in T Tauri stars.
Methods: The coupled ionization, chemical, and thermal evolution along dusty flow streamlines is computed for the prescribed MHD disk wind solution, using a method developed for magnetized shocks in the interstellar medium. Irradiation by (wind-attenuated) coronal X-rays and far-ultraviolet photons from accretion hot spots is included, with an approximate self-shielding of H_2 and CO. Disk accretion rates of 5×10^{-6}, 10^{-6} and $10^{-7} M_\odot \mathrm{yr}^{-1}$ are considered, representative of low-mass young protostars (so-called 'Class 0'), evolved protostars ('Class I') and very active T Tauri stars ('Class II') respectively.
Results: The disk wind has an "onion-like" thermo-chemical structure, with streamlines launched from larger radii having lower temperature and ionisation, and higher H_2 abundance. The coupling between charged and neutral fluids

is sufficient to eject molecules from the disk out to at least 9 AU. The launch radius beyond which most H_2 survives moves outward with evolutionary stage, from $\simeq 0.2$ AU (sublimation radius) in the Class 0 disk wind, to $\simeq 1$ AU in the Class I, and > 1 AU in the Class II. In this molecular wind region, CO survives in the Class 0 but is significantly photodissociated in the Class I/II. Balance between ambipolar heating and molecular cooling establishes a moderate asymptotic temperature $\simeq 700 - 3000$ K, with cooler jets at earlier protostellar stages. As a result, endothermic formation of H_2O is efficient, with abundances up to $\simeq 10^{-4}$, while CH^+ and SH^+ can reach $\geq 10^{-6}$ in the hotter and more ionised Class I/II winds.
Conclusions: A centrifugal MHD disk wind launched from beyond $0.2 - 1$ AU can produce molecular jets/winds up to speeds $\simeq 100$ km s^{-1} in young low-mass stars ranging from Class 0 to active Class II. The model predicts a high ratio of H_2 to CO and an increase of molecular launch radius, temperature, and flow width as the source evolves, in promising agreement with current observed trends. Calculations of synthetic maps and line profiles in H_2, CO and H_2O will allow detailed tests of the model against observations.

Accepted by Astronomy & Astrophysics

http://arxiv.org/abs/1112.3248

Resolving the inner regions of the HD97048 circumstellar disk with VLT/NACO polarimetric differential imaging

Sascha P. Quanz[1], Stephan M. Birkmann[2], Daniel Apai[3], Sebastian Wolf[4] and Thomas Henning[5]

[1] Institute for Astronomy, ETH Zurich, Wolfgang-Pauli-Strasse 27, 8093 Zurich, Switzerland
[2] ESA/ESTEC
[3] Department of Astronomy/Department of Planetary Sciences, University of Arizona
[4] University of Kiel, Institute of Theoretical Physics and Astrophysics
[5] Max Planck Institute for Astronomy

E-mail contact: quanz *at* astro.phys.ethz.ch

Circumstellar disks are the cradles of planetary systems and their physical and chemical properties directly influence the planet formation process. As most planets supposedly form in the inner disk regions, i.e., within a few tens of AU, it is crucial to study circumstellar disk on these scales to constrain the conditions for planet formation. Our aims are to characterize the inner regions of the circumstellar disk around the young Herbig Ae/Be star HD97048 in polarized light. We use VLT/NACO to observe HD97048 in polarimetric differential imaging (PDI) mode in the H and Ks band. We spatially resolve the disk around HD97048 in polarized flux in both filters on scales between ∼0.1″–1.0″ corresponding to the inner ∼16–160 AU. Fitting isophots to the flux calibrated H-band image between 13 – 14 mag/arcsec^2 and 14 – 15 mag/arcsec^2 we derive a apparent disk inclination angle of 34±5 ° and 47±2°, respectively. The disk position angle in both brightness regimes is almost identical and roughly 80°. Along the disk major axis the surface brightness of the polarized flux drops from ∼11 mag/arcsec^2 at ∼0.1″ (∼16 AU) to ∼15.3 mag/arcsec^2 at ∼1.0″ (∼160 AU). The brightness profiles along the major axis are fitted with power-laws falling off as $\sim r^{-1.78\pm0.02}$ in H and $\sim r^{-2.34\pm0.04}$ in Ks. As the surface brightness drops off more rapidly in Ks compared to H the disks becomes relatively bluer at larger separations possibly indicating changing dust grain properties as a function of radius. For the first time the inner ∼0.1″–1.0″ (∼16–160 AU) of the surface layer of the HD97048 circumstellar disk have been imaged in scattered light demonstrating the power of ground-based imaging polarimetry. Our data fill an important gap in a large collection of existing data including resolved thermal dust and PAH emission images as well as resolved gas emission lines.

Accepted by Astronomy & Astrophysics

http://xxx.lanl.gov/abs/1112.1953

Spectroscopic Confirmation of the Dragonfish Association: The Galaxy's Most Luminous OB Association

Mubdi Rahman[1], Dae-Sik Moon[1] and Christopher D. Matzner[1]

[1] Department of Astronomy & Astrophysics, University of Toronto, 50 St. George Street, Toronto, ON, M5S 3H4

E-mail contact: rahman *at* astro.utoronto.ca

Young OB associations with masses greater than 10^4 $M_\odot$ have been inferred to exist in the Galaxy but have largely evaded detection. Recently, a candidate OB association has been identified within the most luminous star forming complex in the Galaxy, the Dragonfish Nebula. We identify 18 young, massive stars with near-infrared spectroscopy from a sample of 50 members within the candidate OB association, including 15 O-type, and three Luminous Blue Variables or Wolf-Rayet stars. This number matches the expected yield of massive stars from the candidate association, confirming its existence and ability to power the parent star forming complex. These results demonstrate the existence of a 10^5 $M_\odot$ OB association, more powerful than any previously known in the Galaxy, comparable in mass only to Westerlund 1. Further, the results also validate the color selection method used to identify the association, adding credence to others discovered in the same way.

Accepted by Astrophysical Journal Letters

http://arxiv.org/abs/1111.3362

Radius Dependent Angular Momentum Evolution in Low-Mass Stars. I

Ansgar Reiners[1] and Subhanjoy Mohanty[2]

[1] Institut fur Astrophysik, Georg-August-Universitat, Gottingen, Germany
[2] Imperial College London, UK

E-mail contact: Ansgar.Reiners *at* phys.uni-goettingen.de

Angular momentum evolution in low-mass stars is determined by initial conditions during star formation, stellar structure evolution, and the behaviour of stellar magnetic fields. Here we show that the empirical picture of angular momentum evolution arises naturally if rotation is related to magnetic field strength instead of to magnetic flux, and formulate a corrected braking law based on this. Angular momentum evolution then becomes a strong function of stellar radius, explaining the main trends observed in open clusters and field stars at a few Gyr: the steep transition in rotation at the boundary to full convection arises primarily from the large change in radius across this boundary, and does not require changes in dynamo mode or field topology. Additionally, the data suggest transient core-envelope decoupling among solar-type stars, and field saturation at longer periods in very low mass stars. For solar-type stars, our model is also in good agreement with the empirical Skumanich law. Finally, in further support of the theory, we show that the predicted age at which low mass stars spin down from the saturated to unsaturated field regimes in our model corresponds remarkably well to the observed lifetime of magnetic activity in these stars.

Accepted by ApJ

HYPERION: An open-source parallelized three-dimensional dust continuum radiative transfer code

Thomas P. Robitaille[1]

[1] Max Planck Institute for Astronomy

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

Hyperion is a new three-dimensional dust continuum Monte-Carlo radiative transfer code that is designed to be as generic as possible, allowing radiative transfer to be computed through a variety of three-dimensional grids. The main part of the code is problem-independent, and only requires an arbitrary three-dimensional density structure, dust properties, the position and properties of the illuminating sources, and parameters controlling the running and output of the code. Hyperion is parallelized, and is shown to scale well to thousands of processes. Two common benchmark models for protoplanetary disks were computed, and the results are found to be in excellent agreement with those from other codes. Finally, to demonstrate the capabilities of the code, dust temperatures, SEDs, and synthetic multi-wavelength images were computed for a dynamical simulation of a low-mass star formation region. Hyperion is being actively developed to include new features, and is publicly available (*http://www.hyperion-rt.org*).

Accepted by Astronomy and Astrophysics

http://arxiv.org/abs/1112.1071

Parallaxes and proper motions of interstellar masers toward the Cygnus X star-forming complex. I. Membership of the Cygnus X region

K.L.J. Rygl[1,2], A. Brunthaler[2,3], A. Sanna[2], K.M. Menten[2], M.J. Reid[4], H.J. van Langevelde[5,6], M. Honma[7], K.J.E. Torstensson[6,5] and K. Fujisawa[8]

[1] Istituto di Fisica dello Spazio Interplanetario (INAF-IFSI), Via del fosso del cavaliere 100, 00133 Roma, Italy
[2] Max-Planck-Institut fuer Radioastronomie (MPIfR), Auf dem Huegel 69, 53121 Bonn, Germany
[3] National Radio Astronomy Observatory, 1003 Lopezville Road, Socorro 87801, USA
[4] Harvard Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA
[5] Joint Institute for VLBI in Europe, Postbus 2, 7990 AA Dwingeloo, the Netherlands
[6] Sterrewacht Leiden, Leiden University, Postbus 9513, 2300 RA Leiden, the Netherlands
[7] Mizusawa VLBI Observatory, National Astronomical Observatory of Japan, 2-21-1, Osawa, Mitaka, Tokyo 181-8588, Japan
[8] Faculty of Science, Yamaguchi University, 1677-1 Yoshida,Yamaguchi 753-8512, Japan

E-mail contact: kazi.rygl *at* ifsi-roma.inaf.it

Whether the Cygnus X complex consists of one physically connected region of star formation or multiple independent regions projected close together on the sky has been debated for decades. The main reason for this puzzling scenario is the lack of trustworthy distance measurements. We aim to understand the structure and dynamics of the star-forming regions toward Cygnus X by accurate distance and proper motion measurements. In order to measure trigonometric parallaxes, we observed 6.7 GHz methanol and 22 GHz water masers with the European VLBI Network and the Very Long Baseline Array. We measured the trigonometric parallaxes and proper motions of five massive star-forming regions toward the Cygnus X complex and report the following distances within a 10% accuracy: $1.30^{+0.07}_{-0.07}$ kpc for W 75N, $1.46^{+0.09}_{-0.08}$ kpc for DR 20, $1.50^{+0.08}_{-0.07}$ kpc for DR 21, $1.36^{+0.12}_{-0.11}$ kpc for IRAS 20290+4052, and $3.33^{+0.11}_{-0.11}$ kpc for AFGL 2591. While the distances of W 75N, DR 20, DR 21, and IRAS 20290+4052 are consistent with a single distance of 1.40 ± 0.08 kpc for the Cygnus X complex, AFGL 2591 is located at a much larger distance than previously assumed. The space velocities of these four star-forming regions in the Cygnus X complex do not suggest an expanding Strömgren sphere.

Accepted by Astronomy and Astrophysics

http://arxiv.org/abs/1111.7023

Clustered star formation and outflows in AFGL 2591

A. Sanna[1], M. J. Reid[2], C. Carrasco-González[1], K. M. Menten[1], A. Brunthaler[1], L. Moscadelli[3] and K.L.J. Rygl[4]

[1] Max-Planck-Institut für Radioastronomie, Auf dem Hügel 69, 53121 Bonn, Germany
[2] Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA
[3] INAF, Osservatorio Astrofisico di Arcetri, Largo E. Fermi 5, 50125 Firenze, Italy
[4] IFSI-INAF, Istituto di Fisica dello Spazio Interplanetario, Via del Fosso del Cavaliere 100, 00133 Roma, Italy

E-mail contact: asanna*at*mpifr-bonn.mpg.de

We report on a detailed study of the water maser kinematics and radio continuum emission toward the most massive and young object in the star-forming region AFGL 2591. Our analysis shows at least two spatial scales of multiple star formation, one projected across 0.1 pc on the sky and another one at about 2000 AU from a ZAMS star of about 38 $M_{\odot}$. This young stellar object drives a powerful jet- and wind-driven outflow system with the water masers associated to the outflow walls, previously detected as a limb-brightened cavity in the NIR band. At about 1300 AU to the north of this object a younger protostar drives two bow shocks, outlined by arc-like water maser emission, at 200 AU either side of the source. We have traced the velocity profile of the gas that expands along these arc-like maser structures and compared it with the jet-driven outflow model. This analysis suggests that the ambient medium around the northern protostar is swept up by a jet-driven shock (> 66 km s^{-1}) and perhaps a lower-velocity (~ 10 km s^{-1}) wind with an opening angle of about 20° from the jet axis.

Accepted by The Astrophysical Journal

http://arxiv.org/abs/1111.0843

The frequency of large variations in the near-infrared fluxes of T Tauri stars

Aleks Scholz[1]

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

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

Variability is a characteristic feature of young stellar objects (YSOs) and could contribute to the large scatter observed in HR diagrams for star forming regions. For typical YSOs, however, the long-term effects of variability are poorly constrained. Here I use archived near-infrared photometry from 2MASS, UKIDSS, and DENIS to investigate the long-term variability of high-confidence members of the four star forming regions ρ-Oph, ONC, IC348, and NGC1333. The total sample comprises more than 600 objects, from which ~ 320 are considered to have a disk. The dataset covers timescales up to 8 yr. About half of the YSOs are variable on a 2σ level, with median amplitudes of 5-20%. The fraction of highly variable objects with amplitudes > 0.5 mag in at least two near-infrared bands is very low – 2% for the entire sample and 3% for objects with disks. These sources with strong variability are mostly objects with disks and are prime targets for follow-up studies. A transition disk candidate in IC348 is found to have strong K-band variations, likely originating in the disk. The variability amplitudes are largest in NGC1333, presumably because it is the youngest sample of YSOs. The frequency of highly variable objects also increases with the time window of the observations (from weeks to years). These results have three implications: 1) When deriving luminosities for YSOs from near-infrared magnitudes, the typical error introduced by variability is in the range of 5-20% percent and depends on disk fraction and possibly age. 2) Variability is a negligible contribution to the scatter in HR diagrams of star forming regions (except for a small number of extreme objects), if luminosities are derived from near-infrared magnitudes. 3) Accretion outbursts with an increase in mass accretion rate by several order of magnitudes, as required in scenarios for episodic accretion, occur with a duty cycle of $> 2000 - 2500$ yr in the Class II phase.

Accepted by MNRAS

http://arxiv.org/abs/1111.1940

The Extremely High-Velocity Outflow from the Luminous Young Stellar Object G5.89-0.39

Yu-Nung Su[1], **Sheng-Yuan Liu**[1], **Huei-Ru Chen**[1,2] **and Ya-Wen Tang**[3,4]

[1] Institute of Astronomy and Astrophysics, Academia Sinica, P.O. Box 23-141, Taipei 106, Taiwan
[2] Institute of Astronomy and Department of Physics, National Tsing Hua University, Hsinchu, Taiwan
[3] Observatoire Aquitain des Sciences de l′Univers, Université de Bordeaux, BP 89, 33271 Floirac, France
[4] CNRS/INSU-UMR5804, Laboratoire d′Astrophysique de Bordeaux, BP 89, 33271 Floirac, France

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

We have imaged the extremely high-velocity outflowing gas in CO (2−1) and (3−2) associated with the shell-like ultracompact H II region G5.89−0.39 at a resolution of ∼3 arcseconds (corresponding to ∼4000 AU) with the Submillimeter Array. The integrated high-velocity (>45 km s^{-1}) CO emission reveals at least three blueshifted lobes and two redshifted lobes. These lobes belong to two outflows, one oriented N-S, the other NW-SE. The NW-SE outflow is likely identical to the previously detected Brγ outflow. Furthermore, these outflow lobes all clearly show a Hubble-like kinematic structure. For the first time, we estimate the temperature of the outflowing gas as a function of velocity with the large velocity gradient calculations. Our results reveal a clear increasing trend of temperature with gas velocity. The observational features of the extremely high-velocity gas associated with G5.89−0.39 qualitatively favor the jet-driven bow shock model.

Accepted by ApJL

http://arxiv.org/abs/1112.2041

The statistics of triggered star formation: an overdensity of massive YSOs around Spitzer bubbles

M.A. Thompson[1], **J.S. Urquhart**[2,3], **T.J.T. Moore**[4] **and L.K. Morgan**[4]

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

[2] Australia Telescope National Facility, CSIRO Astronomy and Space Science, PO Box 76, Epping NSW 1710
[3] Max Planck Institut fuer Radioastronomie, Auf dem Huegel 69, 53121 Bonn, Germany
[4] Astrophysics Research Institute, Liverpool John Moores University, Twelve Quays House, Egerton Wharf, Birkenhead, CH41 1LD, UK

E-mail contact: m.a.thompson *at* herts.ac.uk

We present a detailed statistical study of massive star formation in the environment of 322 *Spitzer* mid-infrared bubbles by using the RMS survey for massive Young Stellar Objects (YSOs). Using a combination of simple surface density plots and a more sophisticated angular cross-correlation function analysis we show that there is a statistically significant overdensity of RMS YSOs towards the bubbles. There is a clear peak in the surface density and angular cross-correlation function of YSOs projected against the rim of the bubbles. By investigating the autocorrelation function of the RMS YSOs we show that this is not due to intrinsic clustering of the RMS YSO sample. RMS YSOs and *Spitzer* bubbles are essentially uncorrelated with each other beyond a normalised angular distance of two bubble radii. The bubbles associated with RMS YSOs tend to be both smaller and thinner than those that are not associated with YSOs. We interpret this tendency to be due to an age effect, with YSOs being preferentially found around smaller and younger bubbles. We find no evidence to suggest that the YSOs associated with the bubbles are any more luminous than the rest of the RMS YSO population, which suggests that the triggering process does not produce a top heavy luminosity function or initial mass function. We suggest that it is likely that the YSOs were triggered by the expansion of the bubbles and estimate that the fraction of massive stars in the Milky Way formed by this process could be between 14 and 30%.

Accepted by MNRAS

http://arxiv.org/abs/1111.0972

VLBA determination of the distance to nearby star-forming regions V. Dynamical mass, distance and radio structure of V773 Tau A

R. Torres[1,5], L. Loinard[2,5], A. Mioduszewski[3], A. Boden[4], R. Franco-Hernandez[1], W. Vlemmings[1] and L. Rodriguez[5]

[1] AIfA
[2] MPIfR
[3] NRAO
[4] Caltech
[5] CRyA-UNAM

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

(ABRIDGED) We present multi-epoch Very Long Baseline Array (VLBA) observations of V773 Tau A, the 51-day binary subsystem in the multiple young stellar system V773 Tau. Combined with previous interferometric and radial velocity measurements, these new data enable us to improve the characterization of the physical orbit of the A subsystem. In particular, we infer updated dynamical masses for the primary and the secondary components of 1.55 pm 0.11 $M_\odot$, and 1.293 $\pm$ 0.068 Msun, respectively, and an updated orbital parallax distance to the system of 135.7 $\pm$ 3.2 pc, all consistent with previous estimates. Using the improved orbit, we can calculate the absolute coordinates of the barycenter of V773 Tau A at each epoch of our VLBA observations, and fit for its trigonometric parallax and proper motion. This provides a direct measurement of the distance to the system almost entirely independent of the orbit modeling. The best fit yields a distance of 129.9 pm 3.2 pc, in good agreement (i.e. within 1 sigma) with the distance estimate based on the orbital fit. Taking the mean value of the orbital and trigonometric parallaxes, we conclude that V773 Tau is located at d =132.8 pm 2.3 pc. The accuracy of this determination is nearly one order of magnitude better than that of previous estimates. In projection, V773 Tau and two other young stars (Hubble 4 and HDE 283572) recently observed with the VLBA are located toward the dark cloud Lynds 1495, in the central region of Taurus. These three stars appear to have similar trigonometric parallaxes, radial velocities, and proper motions, and we argue that the weighted mean and dispersion of their distances (d = 131.4 pc and sigma-d = 2.4 pc) provide a good estimate of the distance to and depth of Lynds 1495 and its associated stellar population.

Accepted by ApJ

http://arxiv.org/abs/1112.0114

Detection of HF emission from the Orion Bar

F.F.S. van der Tak[1], V. Ossenkopf[2], Z. Nagy[1], A. Faure[3], M. Röllig[2] and E.A. Bergin[4]

[1] SRON & Kapteyn Institute, Groningen, The Netherlands
[2] KOSMA, I. Physik. Inst., Universität zu Köln, Germany
[3] UJF-Grenoble 1/CNRS, Institut de Planétologie et d'Astrophysique de Grenoble, France
[4] Dept. of Astronomy, University of Michigan, Ann Arbor, USA

E-mail contact: vdtak *at* sron.nl

Context The clumpy density structure of photon-dominated regions is well established, but the physical properties of the clumps and of the surrounding interclump medium are only approximately known.
Aims The aim of this paper is to constrain the physical and chemical conditions in the Orion Bar, a prototypical nearby photon-dominated region.
Methods We present observations of the HF J=1–0 line, which appears in emission toward the Orion Bar, and compare the brightness of the line to non-LTE radiative transfer calculations.
Results The large width of the HF line suggests an origin of the emission in the interclump gas, but collisional excitation by H_2 in the interclump gas underpredicts the observed line intensity by factors of 3–5. In contrast, an origin of the line in the dense clumps requires a density of $\sim 10^9\,\mathrm{cm}^{-3}$, 10–100 times higher than previous estimates, which is unlikely. However, electron impact excitation reproduces our observations for T=100 K and n_e=10 cm^{-3}, as expected for the interclump gas.
Conclusions We conclude that HF emission is a signpost of molecular gas with a high electron density. Similar conditions may apply to active galactic nuclei where HF also appears in emission.

Accepted by A&A

Preprint at http://arxiv.org/abs/1112.3860

Protostellar Outflow Heating in a Growing Massive Protocluster

Ke Wang[1,2], Qizhou Zhang[2], Yuefang Wu[1], Hua-bai Li[3] 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
[3] Max-Planck Institute for Astronomy, Königstuhl 17, D-69117 Heidelberg, Germany

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

The dense molecular clump P1 in the infrared dark cloud (IRDC) complex G28.34+0.06 harbors a massive protostellar cluster at its extreme youth. Our previous Submillimeter Array (SMA) observations revealed several jet-like CO outflows emanating from the protostars, indicative of intense accretion and potential interaction with ambient natal materials. Here we present the Expanded Very Large Array (EVLA) spectral line observations toward P1 in the NH_3 (J,K) = (1,1), (2,2), (3,3) lines, as well as H_2O and class I CH_3OH masers. Multiple NH_3 transitions reveal the heated gas widely spread in the 1 pc clump. The temperature distribution is highly structured; the heated gas is offset from the protostars, and morphologically matches the outflows very well. Hot spots of spatially compact, spectrally broad NH_3 (3,3) emission are also found coincident with the outflows. A weak NH_3 (3,3) maser is discovered at the interface between an outflow jet and the ambient gas. These findings suggest that protostellar heating may not be effective in suppressing fragmentation during the formation of massive cores.

Accepted by The Astrophysical Journal Letters

http://arxiv.org/abs/1112.1885

Near-infrared and Millimeter-wavelength Observations of Mol 160: A Massive Young Protostellar Core

Grace Wolf-Chase[1,2], Michael Smutko[1,3,4], Reid Sherman[2], Doyal A. Harper[2] and Michael Medford[3]

[1] Adler Planetarium, Astronomy Department, 1300 S. Lake Shore Drive, Chicago, IL 60605, USA
[2] University of Chicago, Department of Astronomy & Astrophysics, 5640 S. Ellis Ave., Chicago, IL 60637, USA
[3] Northwestern University, Department of Physics & Astronomy, 2145 Sheridan Rd., Evanston, IL 60208, USA

[4] Northwestern University, Center for Interdisciplinary Exploration and Research in Astrophysics (CIERA), 2145 Sheridan Rd., Evanston, IL 60208, USA

E-mail contact: gwolfchase *at* adlerplanetarium.org

We have discovered two compact sources of shocked H_2 2.12-μm emission coincident with Mol 160 (IRAS 23385+6053), a massive star-forming core thought to be a precursor to an ultracompact HII region. The 2.12-μm sources lie within $2''$ (0.05 pc) of a millimeter-wavelength continuum peak where the column density is $\geq 10^{24}$ cm^{-2}. We estimate that the ratio of molecular hydrogen luminosity to bolometric luminosity is $> 0.2\%$, indicating a high ratio of mechanical to radiant luminosity. CS J=2→1 and HCO^+ J=1→0 observations with CARMA indicate that the protostellar molecular core has a peculiar velocity of ~ 2 km s^{-1} with respect to its parent molecular cloud. We also observed 95 GHz CH_3OH J=8→7 Class I maser emission from several locations within the core. Comparison with previous observations of 44-GHz CH_3OH maser emission shows the maser sources have a high mean ratio of 95-GHz to 44-GHz intensity. Our observations strengthen the case that Mol 160 (IRAS 23385+6053) is a rapidly accreting massive protostellar system in a very early phase of its evolution.

Accepted by The Astrophysical Journal

http://arxiv.org/abs/1112.2237

Challenges in Forming Planets by Gravitational Instability: Disk Irradiation and Clump Migration, Accretion & Tidal Destruction

Zhaohuan Zhu[1,2], Lee Hartmann[2], Richard P. Nelson[3] and Charles F. Gammie[4]

[1] Department of Astrophysical Sciences, Princeton University, 4 Ivy Lane Peyton Hall, Princeton, NJ 08544, USA
[2] Dept. of Astronomy, University of Michigan, 500 Church St., Ann Arbor, MI 48109, USA
[3] Astronomy Unit, Queen Mary, University of London, Mile End Road, London E1 4NS, UK
[4] Dept. of Astronomy, University of Illinois at Urbana- Champaign, 1002 W. Green St., Urbana, IL 61801, USA
[5] Dept. of Physics, University of Illinois at Urbana-Champaign, USA

E-mail contact: zhzhu *at* astro.princeton.edu

We present two-dimensional hydrodynamic simulations of self-gravitating protostellar disks subject to axisymmetric, continuing mass loading from an infalling envelope and irradiation from the central star, to explore the growth of gravitational instability (GI) and disk fragmentation. We assume that the disk is built gradually and smoothly by the infall, resulting in good numerical convergence. We confirm that for disks around solar-mass stars, infall at high rates at radii beyond ~ 50 AU leads to disk fragmentation. At lower infall rates, however, irradiation suppresses fragmentation. We find that, once formed, the fragments or clumps migrate inward on typical type I time scales of $\sim 2 \times 10^3$ yr initially, but with a stochastic component superimposed due to their interaction with the GI-induced spiral arms. Migration begins to deviate from the type I time scale when the clump becomes more massive than the local disk mass, and/or when the clump begins to form a gap in the disk. As they migrate, clumps accrete from the disk at a rate between 10^{-3} to 10^{-1} $M_{Jupiter}$ yr^{-1}, consistent with analytic estimates that assume a 1-2 Hill radii cross section. The eventual fates of these clumps, however, diverges depending on the migration speed: 3 out of 13 clumps in our simulations become massive enough (brown dwarf mass range) to open gaps in the disk and essentially stop migrating; 4 out of 13 are tidally destroyed during inward migration; 6 out of 13 migrate across the inner boundary of the simulated disks. A simple analytic model for clump evolution explains the different fates of the clumps and reveals some limitations of 2-D simulations. Overall, our results indicate that fast migration, accretion, and tidal destruction of the clumps pose challenges to the scenario of giant planet formation by GI in situ, although we cannot address whether or not remnant solid cores can survive after tidal stripping. The models where the massive clumps are not disrupted and open gaps may be relevant to the formation of close binary systems similar to Kepler 16. A clump formed by GI-induced fragmentation can be as large as 10 AU and as luminous as $2\times10^{-3}L_{\odot}$, which will be easily detectable with ALMA, but its lifetime before dynamically collapsing is only ~ 1000 years.

Accepted by ApJ

http://arxiv.org/abs/1111.6943

The stellar and sub-stellar IMF of simple and composite populations

Pavel Kroupa[1], Carsten Weidner[2], Jan Pflamm-Altenburg[1], Ingo Thies[1], Joerg Dabringhausen[1], Michael Marks[1] and Thomas Maschberger[3]

[1] Argelander Institute for Astronomy, Bonn, Germany
[2] IAC, La Laguna, Spain
[3] IPA, Grenoble, France

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

The current knowledge on the stellar IMF is documented. It is usually described as being invariant, but evidence to the contrary has emerged: it appears to become top-heavy when the star-formation rate density surpasses about 0.1 Msun/(yr pc pc pc) on a pc scale and it may become increasingly bottom-heavy with increasing metallicity. It ends quite abruptly below about 0.1 Msun with brown dwarfs (BDs) and very low mass stars having their own IMFs. The most massive star of mass mmax formed in an embedded cluster with stellar mass Mecl correlates strongly with Mecl being a result of gravitation-driven but resource limited growth and fragmentation induced starvation. There is no convincing evidence whatsoever that massive stars do form in isolation. Massive stars form above a density threshold in embedded clusters which become saturated when mmax approx.150Msun which appears to be the canonical physical upper mass limit of stars. Super-canonical massive stars arise naturally due to stellar mergers induced by stellar-dynamical encounters in very young dense clusters. Various methods of discretising a stellar population are introduced: optimal sampling leads to a mass distribution that perfectly represents the exact form of the desired IMF and the mmax-Mecl relation, while random sampling results in statistical variations of the shape of the IMF. The observed mmax-Mecl correlation and the small spread of IMF power-law indices together suggest that optimally sampling the IMF may be the more realistic description of star formation than random sampling. Composite populations on galaxy scales, which are formed from many pc scale star formatiom events, need to be described by the integrated galactic IMF. This IGIMF varies systematically in dependence of galaxy type and star formation rate, with dramatic implications for theories of galaxy formation and evolution.

Accepted by Stellar Systems and Galactic Structure, Vol.V, Springer

http://xxx.uni-augsburg.de/abs/1112.3340

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.

The Origin of Stars: Tales from the Unexpected in Extreme Environments

Seyit Hocuk

Kapteyn Astronomical Institute, University of Groningen, Netherlands

P.O. Box 800, 9700AV Groningen, Netherlands

Electronic mail: seyit *at* astro.rug.nl

Ph.D dissertation directed by: M. Spaans

Ph.D degree awarded: November 2011

The research in this thesis focuses on gaining insight into the formation of stars in extreme environments. In particular, the dependence of the renowned initial mass function (IMF) is considered. The initial mass function gives the relative distribution of stellar masses in a given volume of space. It is an empirically derived function that behaves as a power law according to observations. This distribution has become an important diagnostic tool for astronomers and is of fundamental importance in many research areas. The idea is that the IMF should be a universal function. However, it is uncertain whether stars in extreme environments form in the same way and if the IMF is similar to those in our Galaxy. In this thesis, the universality of this debated function is tested under different conditions, using detailed numerical simulations. Each chapter focuses on a different aspect of star formation. Chapter 2 focuses on the fragmentation properties of giant molecular clouds, Chapter 3 to the formation of stars in X-ray dominated molecular clouds and the resulting stellar mass functions and Chapter 4 on the formation of stars in molecular clouds under different, but strong feedback effects from black holes. All the results of the various studies in this thesis lead to the same outcome. If the environmental conditions are extreme enough, chemically, mechanically or radiatively, then the initial mass function differs from the IMF as observed in our galaxy and it deviates from the theorized universal form.

http://dissertations.ub.rug.nl/faculties/science/2011/s.hocuk/

&

http://adsabs.harvard.edu/abs/2011PhDT........16H

Postdoctoral position on the formation and evolution of exoplanets

Lund University invites applicants to a postdoc position within the topic of planet formation and orbital evolution of planetary systems. The successful applicant will work within the PEBBLE2PLANET project funded by a Starting Grant from the European Research Council.

The postdoctoral research will focus on theoretical/computational models of planet formation and/or orbital evolution. Together with the current group members and three new PhD students who will start in 2012, the postdoc will work in an inspiring environment towards the common goal of formulating and testing a new planet formation theory framework that is self-consistent as well as consistent with observational constraints.

Part of the postdoctoral research can consist of own, independent research. Please contact Anders Johansen (anders *at* astro.lu.se) for details.

For details on how to apply go to http://www.astro.lu.se/vacancies/.

Closing date: 01 February 2012

Postdoctoral Position in Theoretical/Computational Astrophysics (University of Exeter)

Applications are invited for a postdoctoral position in the Astrophysics group at the University of Exeter. The successful candidate will be expected to work with Dr Clare Dobbs on an ERC funded project studying molecular cloud formation and evolution, and star formation on galactic scales. The research carried out by the applicant will focus on modeling the ISM on the scales of individual galaxies, modeling localized cloud formation for example in spiral arms, and / or performing radiative transfer simulations in order to compare the results of numerical calculations with observations.

The University of Exeter Astrophysics group has a strong emphasis on star formation, with both theorists and observers working on star formation and molecular clouds. The successful candidate will be expected to use the university supercomputer, which has recently been upgraded.

The position will be for 3 years, starting in the fall of 2012. The salary will be in the range 24,370 to 30,870 depending on qualifications and experience. There are also funds for travel and computing.

Applicants will possess a relevant PhD, and have experience in astrophysical hydrodynamical, magnetohydrodynamical and/or radiative transfer calculations. Applicants should send a CV, list of publications, the details of three referees, and a three page research statement by email to dobbs@astro.ex.ac.uk by 14th February 2012.

Postdoctoral Research and Doctoral Student Positions in National Key Research Program on Protoplanetary Disks, Planet Formation, and Habitability

University of Vienna, IWF Graz, Austria

The University of Vienna and the Space Research Institute in Graz, Austria, announce the availability of up to 6 postdoctoral research positions (2- to 4-year contracts) and up to 5 graduate student positions in a large key national research program dedicated to the study of conditions for habitability in planetary systems. The project, led by Prof. Manuel Guedel at Vienna, is anticipated to run for 8 years and is supported by national members and international collaborators. Co-leads are Profs. E. Pilat-Lohinger, E. Dorfi, R. Dvorak (Vienna), H. Lammer and M. Khodachenko (Graz).

Successful candidates will work in one of six specialist teams, addressing hydrodynamic and chemical modeling of protoplanetary disks during their entire evolution, water transport during planet formation, evolution of the stellar radiative and particle environment, wind-magnetosphere interactions, radiative+particle interactions with upper planetary atmospheres, and related processes in binary systems. A more detailed summary of the research fields/options is available on request. Work can be observational, numerical or theoretical. For numerical work, high-performance computer clusters will be accessible. Strong scientific interactions and collaborations between the groups will be emphasized. An early starting date is encouraged, but no earlier than 1 March 2012.

Applications include a CV, a publication list, a summary of past research (for postdoc positions, max 3 pages) resp. a summary of undergraduate studies (for graduate student positions) and a brief description of the preferred research area or proposed topics the candidate would like to contribute. These documents must be submitted electronically as a PDF file to manuel.guedel *at* univie.ac.at.

Review starts 1 February 2012; applications submitted thereafter will be considered until the posts are filled. Applicants should arrange for three letters of reference sent by the referees directly to the same address. For inquiries, contact Prof. M. Guedel (manuel.guedel *at* univie.ac.at).

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

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

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

The faint Early Sun: Problem, paradox, or distraction?

A workshop to be held at the Space Telescope Science Institute in Baltimore MD, April 9-10, 2012

MEETING WEB SITE:
http://www.stsci.edu/institute/conference/faint-sun

MOTIVATION:
The problem of the faint early Sun has been around for many years, and it boils down to this: We presume that the Sun started its life on the zero-age main sequence (ZAMS) with essentially the same mass that it has today, given the low flux of the solar wind, and we presume that our understanding of the physics of the Sun at that stage is reasonably good. Evolutionary models of the ZAMS Sun then predict that it had about 70% of its current luminosity.
That low luminosity is a problem when combined with what we know about the early atmosphere of the Earth because if the Earth s surface were to become covered in ice then the albedo would be high enough to prevent the young planet from recovering. The usual way out of this dead-end is to provide the early Earth with a reducing atmosphere that leads to a strong greenhouse effect, keeping the surface fairly toasty, or at least non-frozen.

We know the early Earth had liquid water on its surface, and we know that the young Mars did as well. Of course both planets may have had greenhouse atmospheres, but perhaps our understanding of the ZAMS Sun is incomplete.

The purpose of this workshop is to bring together scientists from a number of disciplines to discuss the state of knowledge of the young Sun and the young solar system. We will involve leading experts from geochemistry, geophysics, planetary science, solar physics, and stellar astronomy. Among the questions to be addressed are:

How much do we know of the early Earth's atmosphere and the planet's surface?
Was there a reducing atmosphere sufficient to produce a greenhouse effect?
How much glaciation occurred at those early epochs?
What other effects related to the Earth itself can account for liquid water?
What limits can we set on the state at different times of the atmosphere and surface of early Mars?
What limits on the state of the ZAMS Sun can be set from observing stars, from the solar system, and from the Sun itself?

SCHEDULE:: Registration deadline: March 15, 2012
Registration fee: $100 until March 15, $150 after.

PROGRAM:
The program of invited speakers is shown at the above web site. Contributed talks and posters are welcome and encouraged. Please contact D. Soderblom at drs@stsci.edu to request to present a contributed talk.

NRAO-NAASC 2012 Workshop

Outflows, Winds and Jets: From Young Stars to Supermassive Black Holes

March 3-6, 2012 Charlottesville, Virginia

The North American ALMA Science Center (NAASC) will host its 6th annual science workshop entitled "Outflows, Winds and Jets: from Young Stars to Supermassive Black Holes" in Charlottesville, Virginia, March 3-6, 2012. The venue is the Omni Hotel, conveniently located on the downtown mall in the heart of Charlottesville.

2012 is a special year for radio wavelength science. In addition to the much anticipated operation of ALMA Early Science, newly upgraded NRAO facilities – EVLA, GBT and VLBA – are joining forces to offer the astronomy community unprecedented access to instruments of superb imaging capabilities, highest angular resolution and sensitivity, broad spectral coverage, and highest precision. These telescopes together will transform the science of jets and outflows from young stars to super massive black holes. This workshop is an exciting opportunity to bring together active researchers interested in outflow-bearing systems spanning a wide range of mass and size scales for a refreshing view of the spectacular phenomena.

Workshop focus items include:

* Probing the driving engines deep with the upgraded facilities

* Emission and absorption properties of outflows, winds, and jets

* Structures and chemistry of the outflow systems on various scales

* Cross-talk among the participating communities

* Synergy programs with the featured facilities and other large telescopes

The approach adopted by this workshop is interdisciplinary. Science from different mass and size scales will be naturally blended. We hope to promote interactions among the various communities from young stars to the active galactic nuclei, and to facilitate mutual exchanges and joint efforts at this unique time.

https://science.nrao.edu/facilities/alma/naasc-workshops/jets2012

CPS 9th International School of Planetary Sciences

CPS 9th International School of Planetary Sciences
https://www.cps-jp.org/~pschool/pub/2012-06-24/index.html

Date: 24-29 June 2012
Venue: Seapal Suma, a casual seaside resort located in the west part of Kobe, Japan
Address: 1-1-1 Sumaura-dori, Suma, Kobe 654-0055 Japan
Phone: +81 78 731 6815 / Fax: +81 78 734 1896
Japanese site: http://www.seapalsuma.com/
English site: http://web.travel.rakuten.co.jp/portal/my/info_page_e.Eng?f_no=13907&f_ptn1=&f_teikei=

Objective and Scope: The objective of the school is to promote education and research in planetary sciences for highly motivated graduate students and young researchers by providing them with an opportunity to interact with leading scientists in a specific field. Note that the term 'Planetary Sciences' is used in a broader sense to include astronomy, astrophysics, astrochemistry, astrobiology, astromineralogy, geosciences, space science, cosmology, and other related fields.

Topic of the coming school: Across the Earth into Exoplanets

Recent wonderful discovery of exoplanets requires us to rethink the earth and generalize our understandings of the planet. For the sake of doing so, we should first absorb up-to-date knowledge about the structure of the earth from the deep interior to the surface and dynamics producing various geological and geophysical phenomena. We could then apply the knowledge to various conditions of planets such as the early earth, the other planets in the solar system, and exoplanets. This application enables us to better understand the coevolution of a solid planet's interior and its surface in terms of a search for a habitable exoplanet.

Lectures: Internationally well-established experts in various fields will review recent progress in our understandings of those fields. The lecturers and their topics (tentative) are listed below:

- David J. Stevenson: Theoretical overview of structure and dynamics of the Earth: its particularity and universality
- Shun-ichiro Karato: Earth mantle dynamics from planetary perspective
- Francis Nimmo: Evolution of rocky and icy planets in the solar system
- Philippe Lognonne: Planetary seismology and geophysics
- Taku Tsuchiya: High pressure physics of the Earth and beyond

• Diana Valencia: Earth-like exoplanets: predictions and observations
• TBD: Coupled evolution of the interior and surface environment of the Earth and planets
• TBD: Earth and planetary magnetism

Who are the target participants?
- PhD students, postdocs, and young research/academic staff who have a good command of English
- This school is not intended for bachelor, diploma, and master's students

How to apply?
The application for participation in the school is currently open for submission. An abstract of one page A4 size should be uploaded to the CPS server for evaluation. To fill out the application form and to upload the abstract, please go to the following webpage for registration:
https://www.cps-jp.org/signup/pschool9?ml_lang=en
First, create your CPS account at this page. Then, go to CPS website https://www.cps-jp.org/ and login with your CPS User ID you have registered. Click "CPS 9th International School of Planetary Sciences" at the right column and start registration.
- Registration and abstract submission must be completed by 15 February 2012
- To apply for the CPS travel grant, both the application form (incl. of an abstract) and the letter of recommendation must reach us by 07 February 2012

How are participants selected and who makes the final decision?
- SOC will evaluate the level and suitability of applicant's works and interests to the school
- The school chair will make the final decision and applicants are notified accordingly

Need a travel grant?
- Indicate your intention in the application form
- Do arrange a letter of recommendation and send it by email to us <pschool-9rgst@cps-jp.org>; the letter has to reach us no later than 07 February 2012
- Successful applicants are obliged to present a poster in the poster session and to contribute in archiving lecture materials
- Note that the available funds are limited and the grant may not cover ALL of your expenses
- The final decision for travel grant application and the amount will be at the LOC's discretion
- The deadline for travel grant application is 07 February 2012

Short Talk and Poster Presentation:
- If you wish to present a poster, do indicate your intention upon registration.
- Successful applicants for registration will be given 1 minute, without discussion time, each for a short oral presentation of the poster. Please upload your slide file for the 1-minute talk by 06 June 2012.
- The short talks are video-recorded and open to the public through the CPS website.
- Your poster PDF file should be uploaded to the CPS server by 10 July 2012.

Accommodation:
Participants:
- 4 persons share one traditional Japanese-style tatami room
- The room charge is 47,000 JPY per person
- The room has a toilet but no bathtub and shower
- Ocean view public bath is located at the top floor and it is open until 23:00 daily
Lecturers:
- Western style twin rooms with a shower are available for single use
- The room charge is 62,000 JPY per person
- Please let us know should you prefer to stay in a Japanese-style room

Access:
Please refer to
https://www.cps-jp.org/~pschool/pub/2012-06-24/index.html

Important Dates:

All deadline times are 23:59 Japanese Standard Time, UTC+9
07 February 2012 Travel Grant Application Deadline
15 February 2012 Registration Application Deadline
15 February 2012 Abstract Submission Deadline
29 February 2012 Result Notification
06 June 2012 Short Talk Slide File Upload Deadline
24-29 June 2012 CPS Int'l Sch. of Planet. Sci.
10 July 2012 Poster PDF File Upload Deadline

Science Organizing Committee:
Kei Kurita (The University of Tokyo)
Yoshi-Yuki Hayashi (CPS)
Masahiro Ikoma (Tokyo Institute of Technology)
Jun Kimura (CPS)
Naoki Kobayashi (ISAS/JAXA)
Kiyoshi Kuramoto (CPS/Hokkaido University)
Takashi Nakagawa (JAMSTEC)

Contact us:
E-mail: pschool-9info@cps-jp.org
Center for Planetary Science

The Origins of Stars and Planetary Systems

The Origins Institute at McMaster University is pleased to announce that registration is now open for an interdisciplinary conference on

The Origins of Stars and Planetary Systems

http://origins.physics.mcmaster.ca/oi_planets/

The conference will take place 10-15 June 2012 at McMaster University in Hamilton, Ontario, Canada.

This interdisciplinary conference will explore the deep links between the processes of star and planet formation, highlighting recent advances in observations (Kepler, Herschell), theory, and computation.

The conference features 9 interdisciplinary and interleaved sessions, each with an invited Review Speaker, who will set up the session with a true review of the current state of that field, as well a Keynote Speaker who will focus more on their own contributions to the subject. The 9 sessions are

1. Star Formation in Clusters
2. Planets-Statistical Properties
3. Planets in Cluster Context
4. Young, Gas-Rich Disks
5. Atmospheres and Evolutionary Models
6. Cores and Small Scale Collapse
7. Planet Formation-Early Stages in Disks
8. Planet Formation-Late Stages
9. Brown Dwarfs and Lower Mass End of IMF

About 60% of the talks will be contributed, so please submit your abstract as early as you can. The SOC will make decisions about the contributed talks schedule soon after April 15, 2012. Three days will also feature Discussion sessions at day's end, meant to provide a stimulating forum for the key results and issues raised in the presentations.

Ralph Pudritz, James Wadsley, and Chris Wilson (for the SOC)

The Chemical Composition of Comets - Emerging Taxonomies and Natal Heritage

In the October edition of the Newsletter, the abstract appeared for the Annual Review of Astronomy and Astrophysics article "The Chemical Composition of Comets - Emerging Taxonomies and Natal Heritage" by Mike Mumma and Steve Charnley. The following link is an alternative to that previously supplied and will allow readers a one-time download of this article free of charge:

http://arjournals.annualreviews.org/eprint/2sVdmBK5SPYJgEVahySH/full/10.1146/annurev-astro-081309-130811

(Any further/multiple distribution, publication, or commercial usage of this copyrighted material requires submission of a permission request addressed to the Annual Reviews Permissions Department, email permissions@AnnualReviews.org.)

Steve Charnley

The Public Radiative Transfer Program Radex

The public radiative transfer program Radex has recently been updated. By using a linearized version of the rate equations, the new version converges much faster than before, especially at high optical depth. We thank Simon Bruderer for this suggestion and encourage all users to update to the latest (30nov2011) version of Radex.

On-line version: http://www.sron.rug.nl/~vdtak/radex/radex.php

Off-line version: http://www.sron.rug.nl/~vdtak/radex/index.shtml

The on-line version is suitable for quick estimates of line intensities, such as for the time estimate in an observing proposal. For more extensive calculations such as for in a refereed journal or a PhD thesis, we recommend to always use the off-line version which gives full control over input parameters and molecular datafiles.

Happy modeling,

Floris van der Tak, John Black, Ewine van Dishoeck