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Abstracts of recently accepted papers

Observed luminosity spread in young clusters and FU Ori stars: a unified picture

Isabelle Baraffe[1], Eduard Vorobyov[2,3] and Gilles Chabrier[4,1]

[1] University of Exeter, Astrophysics group, EX4 4QL Exeter, UK
[2] Institute of Astrophysics, The University of Vienna, Vienna, 1180, Austria
[3] Research Institute of Physics, Southern Federal University, Rostov-on-Don, Russia
[4]École Normale Supérieure, Lyon, CRAL (UMR CNRS 5574), Université de Lyon, France

E-mail contact: i.baraffe *at* ex.ac.uk

The idea that non steady accretion during the embedded phase of protostar evolution can produce the observed luminosity spread in the Herzsprung-Russell diagram (HRD) of young clusters has recently been called into question. Observations of FU Ori, for instance, suggest an expansion of the star during strong accretion events whereas the luminosity spread implies a contraction of the accreting objects, decreasing their radiating surface. In this paper, we present a global scenario based on calculations coupling episodic accretion histories derived from numerical simulations of collapsing cloud prestellar cores of various masses and subsequent protostar evolution.

Our calculations show that, assuming an initial protostar mass $M_{\rm i} \sim 1\,M_{\rm J}$, typical of the second Larson's core, both the luminosity spread in the HRD and the inferred properties of FU Ori events (mass, radius, accretion rate) can be explained by this scenario, providing two conditions. First, there must be some variation within the fraction of accretion energy absorbed by the protostar during the accretion process. Second the range of this variation should increase with increasing accretion burst intensity, and thus with the initial core mass and final star mass. The numerical hydrodynamics simulations of collapsing cloud prestellar cores indeed show that the intensity of the accretion bursts correlates with the mass and initial angular momentum of the prestellar core. Massive prestellar cores with high initial angular momentum are found to produce intense bursts characteristic of FU Ori like events. Our results thus suggest a link between the burst intensities and the fraction of accretion energy absorbed by the protostar, with some threshold in the accretion rate, of the order of $10^{-5} M_{\odot} {\rm yr}^{-1}$, delimitating the transition from "cold" to "hot" accretion. Such a transition might reflect a change in the accretion geometry with increasing accretion rate, i.e. a transition from magnetospheric or thin disk to thick disk accretion, or in the magnetospheric interaction between the star and the disk. Conversely, the luminosity spread can also be explained by a variation of the initial protostar mass within the $\sim$ 1-5 $M_{\rm J}$ range, although it is unclear for now whether such a spread among second Larson's core can be produced during the prestellar core second collapse. This unified picture confirms the idea that early accretion during protostar and proto-brown dwarf formation/evolution can explain the observed luminosity spread in young clusters without invoking any significant age spread, and that the concept of a well defined birthline does not apply for low-mass objects. Finally, we examine the impact of accretion on the determination of the IMF in young clusters.

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Preprint available on: http://arxiv.org/abs/1206.2374

Pre-main-sequence isochrones – I. The Pleiades benchmark

Cameron P. M. Bell[1], Tim Naylor[1], N. J. Mayne[1], R. D. Jeffries[2] and S. P. Littlefair[3]

[1] School of Physics, University of Exeter, Exeter, EX4 4QL, UK
[2] Astrophysics Group, Keele University, Staffordshire, ST5 5BG, UK
[3] Department of Physics and Astronomy, University of Sheffield, Sheffield, S3 7RH, UK

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

We present a critical assessment of commonly used pre-main-sequence isochrones by comparing their predictions to a set of well-calibrated colour-magnitude diagrams of the Pleiades in the wavelength range 0.4 to 2.5 μm. Our analysis shows that for temperatures less than 4000 K the models systematically overestimate the flux by a factor two at 0.5 μm, though this decreases with wavelength, becoming negligible at 2.2 μm. In optical colours this will result in the ages for stars younger than 10 Myr being underestimated by factors between two and three.
We show that using observations of standard stars to transform the data into a standard system can introduce significant errors in the positioning of pre-main-sequences in colour-magnitude diagrams. Therefore we have compared the models to the data in the natural photometric system in which the observations were taken. Thus we have constructed and tested a model of the system responses for the Wide-Field Camera on the *Isaac Newton* Telescope.
As a benchmark test for the development of pre-main-sequence models we provide both our system responses and the Pleiades sequence.

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The high-mass disk candidates NGC7538IRS1 and NGC7538S

Henrik Beuther[1], Hendrik Linz[1] and Thomas Henning[1]

[1] Max-Planck-Institute for Astronomy, Königstuhl 17, 69117 Heidelberg, Germany

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

Context: The nature of embedded accretion disks around forming high-mass stars is one of the missing puzzle pieces for a general understanding of the formation of the most massive and luminous stars.
Aims: We want to dissect the small-scale structure of the dust continuum and kinematic gas emission toward two of the most prominent high-mass disk candidates.
Methods: Using the Plateau de Bure Interferometer at ∼1.36 mm wavelengths in its most extended configuration we probe the dust and gas emission at $\sim 0.3''$, corresponding to linear resolution elements of ∼800 AU.
Results: Even at that high spatial resolution NGC7538IRS1 remains a single compact and massive gas core with extraordinarily high column densities, corresponding to visual extinctions on the order of 10^5 mag, and average densities within the central 2000 AU of $\sim 2.1 \times 10^9\,\mathrm{cm}^{-3}$ that have not been measured before. We identify a velocity gradient across in northeast-southwest direction that is consistent with the mid-infrared emission, but we do not find a gradient that corresponds to the proposed CH_3OH maser disk. The spectral line data toward NGC7538IRS1 reveal strong blue- and red-shifted absorption toward the mm continuum peak position. While the blue-shifted absorption is consistent with an outflow along the line of sight, the red-shifted absorption allows us to estimate high infall rates on the order of $10^{-2}\,\mathrm{M}_\odot\,\mathrm{yr}^{-1}$. Although we cannot prove that the gas will be accreted in the end, the data are consistent with ongoing star formation activity in a scaled-up low-mass star formation scenario. Compared to that, NGC7538S fragments in a hierarchical fashion into several sub-sources. While the kinematics of the main mm peak are dominated by the accompanying jet, we find rotational signatures from a secondary peak. Furthermore, strong spectral line differences exist between the sub-sources which is indicative of different evolutionary stages within the same large-scale gas clump.
Conclusions: NGC7538IRS1 is one of the most extreme high-mass disk candidates known today. The large concentration of mass into a small area combined with the high infall rates are unusual and likely allow continued accretion. While the absorption is interesting for the infall studies, higher-excited lines that do not suffer from the absorption are needed to better study the disk kinematics. In contrast to that, NGC7538S appears as a more typical high-mass star formation region that fragments into several sources. Many of them will form low- to intermediate-mass stars. The strongest mm continuum peak is likely capable to form a high-mass star, however, likely of lower mass than NGC7538IRS1.

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http://www.mpia.de/homes/beuther/papers.html

Gravitational Slingshot of Young Massive Stars in Orion

Sourav Chatterjee[1] and Jonathan C. Tan[1,2]

[1] Dept. of Astronomy, University of Florida, 211 Bryant Space Science Center, Gainesville, Fl 32611, USA
[2] Dept. of Physics, University of Florida, Gainesville, FL 32611, USA

E-mail contact: s.chatterjee *at* astro.ufl.edu

The Orion Nebula Cluster (ONC) is the nearest region of massive star formation and thus a crucial testing ground for theoretical models. Of particular interest amongst the ONC's ~ 1000 members are: θ^1 Ori C, the most massive binary in the cluster with stars of masses 38 and $9\,\mathrm{M}_\odot$ (Kraus et al. 2009); the Becklin-Neugebauer (BN) object, a $30\,\mathrm{km\,s}^{-1}$ runaway star of $\sim 8\,\mathrm{M}_\odot$ (Tan 2004); and the Kleinmann-Low (KL) nebula protostar, a highly-obscured, $\sim 15\,\mathrm{M}_\odot$ object still accreting gas while also driving a powerful, apparently "explosive" outflow (Allen & Burton 1993). The unusual behavior of BN and KL is much debated: How did BN acquire its high velocity? How is this related to massive star formation in the KL nebula? Here we report the results of a systematic survey using $\sim 10^7$ numerical experiments of gravitational interactions of the θ^1C and BN stars. We show that dynamical ejection of BN from this triple system at its observed velocity leaves behind a binary with total energy and eccentricity matching those observed for θ^1C. Five other observed properties of θ^1C are also consistent with it having ejected BN and altogether we estimate there is only a $\leq 10^{-5}$ probability that θ^1C has these properties by chance. We conclude that BN was dynamically ejected from the θ^1C system about 4,500 years ago. BN has then plowed through the KL massive-star-forming core within the last 1,000 years causing its recently-enhanced accretion and outflow activity.

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Testing the Hypothesis that Methanol Maser Rings Trace Circumstellar Disks: High Resolution Near-IR and Mid-IR Imaging

James M. De Buizer[1], Anna Bartkiewicz[2] and Marian Szymczak[2]

[1] SOFIA-USRA, NASA Ames Research Center, MS N232-12, Moffett Field, CA 94035, USA
[2] Torun Centre for Astronomy, Nicolaus Copernicus University, Gagarina 11, 87-100 Torun, Poland

E-mail contact: jdebuizer *at* sofia.usra.edu

Milliarcsecond VLBI maps of regions containing 6.7 GHz methanol maser emission have lead to the recent discovery of ring-like distributions of maser spots and the plausible hypothesis that they may be tracing circumstellar disks around forming high mass stars. We aimed to test this hypothesis by imaging these regions in the near and mid-infrared at high spatial resolution and compare the observed emission to the expected infrared morphologies as inferred from the geometries of the maser rings. In the near infrared we used the Gemini North adaptive optics system of Altair/NIRI, while in the mid-infrared we used the combination of the Gemini South instrument T-ReCS and super-resolution techniques. Resultant images had a resolution of approximately 150 mas in both the near-infrared and mid-infrared. We discuss the expected distribution of circumstellar material around young and massive accreting (proto)stars and what infrared emission geometries would be expected for the different maser ring orientations under the assumption that the masers are coming from within circumstellar disks. Based upon the observed infrared emission geometries for the four targets in our sample and the results of SED modeling of the massive young stellar objects associated with the maser rings, we do not find compelling evidence in support of the hypothesis that methanol masers rings reside in circumstellar disks.

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http://www.jim-debuizer.net

Observing planet-disk interaction in debris disks

Steve Ertel[1,2], Sebastian Wolf[2] and Jens Rodmann[3,4]

[1] Université Joseph Fourier/CNRS, Laboratoire d'Astrophysique de Grenoble, UMR 5571, Grenoble, France
[2] Christian-Albrechts-Universität zu Kiel, Institut für Theoretische Physik und Astrophysik, Leibnizstraße 15, 24098 Kiel, Germany

[3] European Space Agency, Space Environment and Effects Section, Keplerlaan 1, PO Box 299, NL-2200 AG Noordwijk, The Netherlands
[4] Georg-August-Universität Göttingen, Institut für Astrophysik, Friedrich-Hund-Platz 1, 37077 Göttingen, Germany

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

Context. Debris disks are commonly considered to be a by-product of planet formation. Structures in debris disks induced by planetdisk interaction are promising to provide valuable constraints on the existence and properties of embedded planets.
Aims. We investigate the observability of structures in debris disks induced by planet-disk interaction with future facilities in a systematic way. High-sensitivity, high angular resolution observations with large (sub-)mm interferometers and large space-based telescopes operating in the near- to mid-infrared wavelength range are considered.
Methods. The observability of debris disks with the Atacama Large Millimeter/submillimeter Array (ALMA) is studied on the basis of a simple analytical disk model. Furthermore, N-body simulations are used to model the spatial dust distribution in debris disks under the influence of planet-disk interaction. From these simulations, images at optical scattered light to millimeter thermal re-emission are computed. Available information about the expected capabilities of ALMA and the James Webb Space Telescope (JWST) are used to investigate the observability of characteristic disk structures with these facilities through spatially resolved imaging.
Results. Our simulations show that planet-disk interaction can result in prominent structures in the whole considered wavelength range. The exact result depends on the configuration of the planet-disk system and on the observing wavelength which provides the opportunity of detecting and characterizing extrasolar planets in a range of masses and radial distances from the star that is not accessible to other techniques. Facilities that will be available in the near future at both considered wavelength ranges are shown to provide the capabilities to spatially resolve and characterize structures in debris disks that arise because of planet-disk interaction. Limitations are revealed and suggestions for possible instrument setups and observing strategies are given. In particular, ALMA is limited by its sensitivity to surface brightness, which requires a trade-off between sensitivity and spatial resolution. Space-based midinfrared observations will be able to detect and spatially resolve regions in debris disks even at a distance of several tens of AU from the star, where the emission from debris disks in this wavelength range is expected to be low.
Conclusions. Both ALMA and the planned space-based near- to mid-infrared telescopes will provide unprecedented capabilities to study planet-disk interaction in debris disks. In particular, a combination of observations at both wavelengths will provide very strong constraints on the planetary/planetesimal systems.

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The counterjet of HH 30: new light on its binary driving source

Robert Estalella[1], Rosario López[1], Guillem Anglada[2], Gabriel Gómez[3,4], Angels Riera[5,1] and Carlos Carrasco-González[2,6]

[1] Departament d'Astronomia i Meteorologia, Institut de Ciencies del Cosmos (ICC), Universitat de Barcelona (IEEC-UB), Martí i Franquès 1, E-08028 Barcelona, Spain
[2] Instituto de Astrofísica de Andalucía, CSIC, Glorieta de la Astronomía s/n, E-18008 Granada, Spain
[3] Instituto de Astrofísica de Canarias, E-38200 La Laguna, Tenerife, Spain
[4] GTC; GRANTECAN S.A. (CALP), E-38712 Breña Baja, La Palma, Spain
[5] Departament de Física i Enginyeria Nuclear, Escola Universitària d'Enginyeria Tècnica Industrial de Barcelona, Universitat Politècnica de Catalunya, Comte d'Urgell 187, E-08036 Barcelona, Spain
[6] Max-Planck-Institut für Radioastronomie, Auf dem Hügel 69, 53121 Bonn, Germany

E-mail contact: robert.estalella *at* am.ub.es

We present new [SII] images of the HH 30 jet and counterjet observed in 2006, 2007, and 2010 that, combined with previous data, allowed us to measure with improved accuracy the positions and proper motions of the jet and counterjet knots. Our results show that the motion of the knots is essentially ballistic, with the exception of the farthest knots, which trace the large scale "C"-shape bending of the jet. The observed bending of the jet can be produced by a relative motion of the HH 30 star with respect to its surrounding environment, caused either by a possible proper motion of the HH 30 star, or by the entrainment of environment gas by the red lobe of the nearby L1551-IRS 5 outflow. Alternatively, the bending can be produced by the stellar wind from a nearby CTTS, identified in the 2MASS catalog

as J04314418+181047. The proper motion velocities of the knots of the counterjet show more variations than those of the jet. In particular, we identify two knots of the counterjet that have the same kinematic age but whose velocities differ by almost a factor of two. Thus, it appears from our observations that counterjet knots launched simultaneously can be ejected with very different velocities. We confirm that the observed wiggling of the jet and counterjet arises from the orbital motion of the jet source in a binary system. Precession, if present at all, is of secondary importance in shaping the jet. We derive an orbital period $\tau_o = 114 \pm 2$ yr and a mass function $m\mu_c^3 = 0.014 \pm 0.006\ M_\odot$. For a mass of the system of $m = 0.45 \pm 0.04\ M_\odot$ (the value inferred from observations of the CO kinematics of the disk) we obtain a mass $m_j = 0.31 \pm 0.04\ M_\odot$ for the jet source, a mass $m_c = 0.14 \pm 0.03\ M_\odot$ for the companion, and a binary separation of $a = 18.0 \pm 0.6$ AU. This binary separation coincides with the value required to account for the size of the inner hole observed in the disk, which has been attributed to tidal truncation in a binary system.

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http://www.am.ub.edu/~robert/ISMpub.html/preprints/hh30_cj.pdf

The Formation of Young Dense Star Clusters through Mergers

M.S. Fujii[1], T.R. Saitoh[2] and S.F. Portegies Zwart[1]

[1] Leiden Observatory, Leiden University, NL-2300RA Leiden, The Netherlands
[2] Interactive Research Center of Science, Tokyo Institute of Technology, 2-12-1 Ookayama, Meguro, Tokyo 152-8551, Japan

Young star clusters such as NGC 3603 and Westerlund 1 and 2 in the Milky Way and R136 in the Large Magellanic Cloud are dynamically more evolved than expected based on their current relaxation times. In particular, the combination of a high degree of mass segregation, a relatively low central density, and the large number of massive runaway stars in their vicinity are hard to explain with the monolithic formation of these clusters. Young star clusters can achieve such a mature dynamical state if they formed through the mergers of a number of less massive clusters. The shorter relaxation times of less massive clusters cause them to dynamically evolve further by the time they merge, and the merger product preserves the memory of the dynamical evolution of its constituent clusters. With a series of N-body simulations, we study the dynamical evolution of single massive clusters and those that are assembled through merging smaller clusters together. We find that the formation of massive star clusters through the mergers of smaller clusters can reproduce the currently observed spatial distribution of massive stars, the density, and the characteristics (number and mass distribution) of the stars ejected as runaways from young dense clusters. We therefore conclude that these clusters and possibly other young massive star clusters formed through the mergers of smaller clusters.

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Remnant gas in evolved circumstellar disks: Herschel PACS observations of 10–100 Myr old disk systems

Vincent C. Geers[1], Uma Gorti[2,3], Michael R. Meyer[1], Eric Mamajek[4,5], Arnold O. Benz[1] and David Hollenbach[3]

[1] ETH Zurich, Institute for Astronomy, Wolfgang-Pauli-strasse 27, 8093 Zurich, Switzerland
[2] NASA Ames Research Center, Moffett Field, CA 94035, USA
[3] SETI Institute, 189 Bernardo Ave., Mountain View, CA 94043, USA
[4] University of Rochester, Department of Physics & Astronomy, Rochester, NY 14627-0171, USA
[5] Cerro-Tololo Inter-American Observatory, Casilla 603, La Serena, Chile

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

We present *Herschel* PACS spectroscopy of the [OI] 63 μm gas-line for three circumstellar disk systems showing signs of significant disk evolution and/or planet formation: HR 8799, HD 377 and RX J1852.3-3700. [OI] is undetected toward HR 8799 and HD 377 with 3σ upper limits of 6.8×10^{-18} W m^{-2} and 9.9×10^{-18} W m^{-2} respectively. We find an [OI] detection for RX J1852.3-3700 at $12.3 \pm 1.8 \times 10^{-18}$ W m^{-2}. We use thermo-chemical disk models to model the gas emission, using constraints on the [OI] 63 μm, and ancillary data to derive gas mass upper limits and constrain gas-to-dust ratios. For HD 377 and HR 8799, we find $3\,\sigma$ upper limits on the gas mass of 0.1–20 $M_\oplus$. For RX J1852.3-3700, we find two distinct disk scenarios that could explain the detection of [OI] 63 μm and CO(2–1) upper limits reported from the literature: (i) a large disk with gas co-located with the dust (16–500 AU), resulting in a large tenuous disk with ~ 16 $M_\oplus$ of gas, or (ii) an optically thick gas disk, truncated at ~ 70 AU, with a gas mass of 150 $M_\oplus$. We discuss the implications of these results for the formation and evolution of planets in these three systems.

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Dynamical friction in an isentropic gas

Fazeleh Khajenabi[1] and Sami Dib[2]

[1] Faculty of Science, Golestan University, UK
[2] Blackett Laboratory, Imperial College London, UK

E-mail contact: f.khajenabi *at* gu.ac.ir

When a gravitating object moves across a given mass distribution, it creates an overdense wake behind it. Here, we performed an analytical study of the structure of the flow far from object when the flow is isentropic and the object moves subsonically within it. We show that the dynamical friction force is the main drag force on the object and by using a perturbation theory, we obtain the density, velocity and pressure of the perturbed flow far from the mass. We derive the expression of the dynamical friction force in an isentropic flow and show its dependence on the Mach number of the flow and on the adiabatic index. We find that the dynamical friction force becomes lower as the adiabatic index increases. We show analytically that the wakes are less dense in our isentropic case in comparison to the isothermal ones.

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http://arxiv.org/abs/1203.0629

Towards the field binary population: Influence of orbital decay on close binaries

Christina Korntreff[1], Thomas Kaczmarek[2] and Susanne Pfalzner[2]

[1] Juelich Supercomputing Centre, Forschungszentrum Juelich GmbH, 52425 Juelich
[2] Max-Planck-Institut fr Radioastronomie, Auf dem Huegel 69, 53121 Bonn

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

Surveys of the binary populations in the solar neighbourhood have shown that the periods of G- and M-type stars are log-normally distributed. However, observations of young binary populations suggest a log-uniform distribution. Clearly some process(es) change the period distribution over time. Most stars form in star clusters, in which two important dynamical processes occur: i) gas-induced orbital decay of embedded binary systems and ii) destruction of soft binaries in three-body interactions. The emphasis here is on orbital decay which has been largely neglected so far. Using a combination of Monte-Carlo and dynamical nbody modelling it is demonstrated here that the cluster dynamics destroys the number of wide binaries, but leaves short-period binaries basically undisturbed even for a initially log-uniform distribution. By contrast orbital decay significantly reduces the number and changes the properties of short-period binaries, but leaves wide binaries largely uneffected. Until now it was unclear whether the short period distribution of the field is unaltered since its formation. It is shown here, that orbital decay is a prime candidate for such a task. In combination the dynamics of these two processes, convert an initial log-uniform distribution to a log-normal period distribution. The probability is 94% that the evolved and observed period distribution were sampled from the same parent distribution. This means binaries can be formed with periods that are sampled from the log-uniform distribution. As the cluster evolves, short-period binaries are merged to single stars by the gas-induced orbital decay while the dynamical evolution in the cluster destroys wide binaries. The combination of these two equally important processes reshapes a initial log-uniform period distribution to the log-normal period distribution, that is observed in the field (abridged).

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The dusty environment of HD 97300 as seen by Herschel and Spitzer

Á. Kóspál[1], T. Prusti[1], N. L. J. Cox[2], G. L. Pilbratt[1], Ph. André[3], C. Alves de Oliveira[4], E. Winston[1], B. Merín[4], A. Ribas[4], P. Royer[2], R. Vavrek[4] and C. Waelkens[2]

[1] Research and Scientific Support Department, European Space Agency (ESA-ESTEC, SRE-SA), PO Box 299, 2200 AG Noordwijk, The Netherlands
[2] Instituut voor Sterrenkunde, KU Leuven, Celestijnenlaan 200D, 3001 Leuven, Belgium
[3] Laboratoire AIM Paris–Saclay, CEA/DSM–CNRS–Université Paris Diderot, IRFU, Service d'Astrophysique, Centre d'Etudes de Saclay, Orme des Merisiers, 91191 Gif-sur-Yvette, France
[4] Herschel Science Centre, ESA-ESAC, PO Box 78, E-28691 Villanueva de la Cañada, Madrid, Spain

E-mail contact: akospal *at* rssd.esa.int

We analyze the surroundings of HD 97300, one of two intermediate-mass stars in the Chamaeleon I star-forming region. The star is known to be surrounded by a conspicuous ring of polycyclic aromatic hydrocarbons (PAHs). We present infrared images taken with *Herschel* and *Spitzer* using 11 different broad-band filters between 3.6 μm and 500 μm. We compare the morphology of the emission using cuts along different position angles. We construct spectral energy distributions, which we compare to different dust models, and calculate dust temperatures. We also derive opacity maps and analyze the density structure of the environment of HD 97300. We find that HD 97300 has no infrared excess at or below 24 μm, confirming its zero-age main sequence nature. The morphology of the ring is very similar between 3.6 μm and 24 μm. The emission at these wavelengths is dominated by either PAH features or PAH continuum. At longer wavelengths, only the northwestern part of the ring is visible. A fit to the 100–500 μm observations suggests that the emission is due to relatively warm ($\approx$26 K) dust. The temperature gradually decreases with increasing distance from the ring. We find a general decrease in the density from north to south, and an approximate 10% density increase at the northeastern part of the ring. Our results are consistent with the theory that the ring around HD 97300 is essentially a bubble blown into the surrounding interstellar matter and heated by the star.

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HST Observations of the HD 202628 Debris Disk

John Krist[1], Karl Stapelfeldt[2], Geoffrey Bryden[1], and Peter Plavchan[3]

[1] Jet Propulsion Laboratory, 4800 Oak Grove Dr., Pasadena, CA 91109, USA
[2] NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA
[3] NASA Exoplanet Science Institute, California Institute of Technology, Pasadena, CA 91125, USA

E-mail contact: john.krist *at* jpl.nasa.gov

A ring-shaped debris disk around the G2V star HD 202628 (d = 24.4 pc) was imaged in scattered light at visible wavelengths using the coronagraphic mode of the Space Telescope Imaging Spectrograph on the *Hubble Space Telescope*. The ring is inclined by $\sim$64° from face-on, based on the apparent major/minor axis ratio, with the major axis aligned along PA = 130°. It has inner and outer radii (> 50% maximum surface brightness) of 139 AU and 193 AU in the northwest ansae and 161 AU and 223 AU in the southeast ($\Delta r/r \approx 0.4$). The maximum visible radial extent is $\sim$ 254 AU. With a mean surface brightnesses of V $\approx$ 24 mag arcsec^{-2}, this is the faintest debris disk observed to date in reflected light. The center of the ring appears offset from the star by $\sim$28 AU (deprojected). An ellipse fit to the inner edge has an eccentricity of 0.18 and a = 158 AU. This offset, along with the relatively sharp inner edge of the ring, suggests the influence of a planetary-mass companion. There is a strong similarity with the debris ring around Fomalhaut, though HD 202628 is a more mature star with an estimated age of about 2 Gyr.
We also provide surface brightness limits for nine other stars in our study with strong *Spitzer* excesses around which no debris disks were detected in scattered light (HD 377, HD 7590, HD 38858, HD 45184, HD 73350, HD 135599, HD 145229, HD 187897, and HD 201219).

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Rapid growth of gas-giant cores by pebble accretion

Michiel Lambrechts[1] and Anders Johansen[1]

[1] Lund University, Box 22100, Lund, Sweden

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

The observed lifetimes of gaseous protoplanetary discs place strong constraints on gas and ice giant formation in the core accretion scenario. The approximately 10-Earth-mass solid core responsible for the attraction of the gaseous envelope has to form before gas dissipation in the protoplanetary disc is completed within 1-10 million years. Building up the core by collisions between km-sized planetesimals fails to meet this time-scale constraint, especially at wide stellar separations. Nonetheless, gas-giant planets are detected by direct imaging at wide orbital distances. In this paper, we numerically study the growth of cores by the accretion of cm-sized pebbles loosely coupled to the gas. We measure the accretion rate onto seed masses ranging from a large planetesimal to a fully grown 10-Earth-mass core and test different particle sizes. The numerical results are in good agreement with our analytic expressions, indicating the existence of two accretion regimes, one set by the azimuthal and radial particle drift for the lower seed masses and the other, for higher masses, by the velocity at the edge of the Hill sphere. In the former, the optimally accreted particle size increases with core mass, while in the latter the optimal size is centimeters, independent of core mass. We discuss the implications for rapid core growth of gas-giant and ice-giant cores. We conclude that pebble accretion can resolve the long-standing core accretion time-scale conflict. This requires a near-unity dust-to-gas ratio in the midplane, particle growth to mm and cm and the formation of massive planetesimals or low radial pressure support. The core growth time-scale is shortened by a factor 30-1,000 at 5 AU and by a factor 100-10,000 at 50 AU, compared to the gravitationally focused accretion of, respectively, low-scale-height planetesimal fragments or standard km-sized planetesimals.

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Dynamical Measurements of the Young Upper Scorpius Triple NTTS 155808−2219

G. N. Mace[1], L. Prato[2], G. Torres[3], L. H. Wasserman[2], R. D. Mathieu[4] and I. S. McLean[1]

[1] UCLA Division of Astronomy and Astrophysics, Los Angeles, CA 90095-1562, USA
[2] Lowell Observatory, 1400 West Mars Hill Road, Flagstaff, AZ 86001, USA
[3] Harvard-Smithsonian Center for Astrophysics, 60 Garden St., Cambridge, MA 02138, USA
[4] Department of Astronomy, University of Wisconsin - Madison, Madison WI 53726, USA

E-mail contact: gmace *at* astro.ucla.edu

The young, low-mass, triple system NTTS 155808−2219 (ScoPMS 20) was previously identified as a ∼17-day period single-lined spectroscopic binary with a tertiary component at 0.21 arcseconds. Using high-resolution infrared spectra, acquired with NIRSPEC on Keck II, both with and without adaptive optics, we measured radial velocities of all three components. Reanalysis of the single-lined visible light observations, made from 1987 to 1993, also yielded radial velocity detections of the three stars. Combining visible light and infrared data to compute the orbital solution produces orbital parameters consistent with the single-lined solution and a mass ratio of $q = 0.78 \pm 0.01$ for the SB. We discuss the consistency between our results and previously published data on this system, our radial-velocity analysis with both observed and synthetic templates, and the possibility that this system is eclipsing, providing a potential method for the determination of the stars' absolute masses. Over the ∼20 year baseline of our observations, we have measured the acceleration of the SB's center-of-mass in its orbit with the tertiary. Long-term, adaptive optics imaging of the tertiary will eventually yield dynamical data useful for component mass estimates.

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The circumstellar disk of HH 30. Searching for signs of disk evolution with multi-wavelength modeling

D. Madlener[1], S. Wolf[1], A. Dutrey[2,3] and S. Guilloteau[2,3]

[1] Christian-Albrechts-Universität zu Kiel, Institut für Theoretische Physik und Astrophysik (ITAP), Leibnizstr. 15,

24118 Kiel, Germany
[2] Université de Bordeaux, Observatoire Aquitain des Sciences de l'Univers, 2 rue de l'Observatoire, BP 89, F-33271 Floirac Cedex, France
[3] CNRS, UMR 5804, Laboratoire d'Astrophysique de Bordeaux, 2 rue de l'Observatoire, BP 89, F-33271 Floirac Cedex, France

E-mail contact: dmadlener *at* astrophysik.uni-kiel.de

Context. Circumstellar disks are characteristic for star formation and vanish during the first few Myr of stellar evolution. During this time planets are believed to form in the dense midplane by growth, sedimentation and aggregation of dust. Indicators of disk evolution, such as holes and gaps, can be traced in the spectral energy distribution (SED) and spatially resolved images.

Aims. We aim to construct a self-consistent model of HH 30 by fitting all available continuum observations simultaneously. New data sets not available in previous studies, such as high-resolution interferometric imaging with the Plateau de Bure Interferometer (PdBI) at $\lambda = 1.3$mm and SED measured with IRS on the *Spitzer Space Telescope* in the mid-infrared, put strong constraints on predictions and are likely to provide new insights into the evolutionary state of this object.
Methods. A parameter study based on simulated annealing was performed to find unbiased best-fit models for independent observations made in the wavelength domain $\lambda \sim 1\mu$m...4mm. The method essentially creates a Markov chain through parameter space by comparing predictions generated by our self-consistent continuum radiation transfer code `MC3D` with observations.
Results. We present models of the edge-on circumstellar disk of HH 30 based on observations from the near-infrared to mm-wavelengths that suggest the presence of an inner depletion zone with about 45AU radius and a steep decline of mm opacity beyond 140AU. Our modeling indicates that several modes of dust evolution such as growth, settling, and radial migration are taking place in this object.
Conclusions. High-resolution observations of HH 30 at different wavelengths with next-generation observatories such as ALMA and JWST will enable the modeling of inhomogeneous dust properties and significantly expand our understanding of circumstellar disk evolution.

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GASPS observations of Herbig Ae/Be stars with PACS/Herschel. The atomic and molecular content of their protoplanetary discs.

G. Meeus[1], B. Montesinos[2], I. Mendiguta[1], I. Kamp[3], W.F. Thi[4] et al.

[1] Universidad Autonoma de Madrid, Dpt. Fisica Teorica, Campus Cantoblanco, Spain
[2] Dept. of Astrophysics, CAB (CSIC-INTA), ESAC Campus, P.O. Box 78, 28691 Villanueva de la Cañada, Spain
[3] Kapteyn Astronomical Institute, Postbus 800, 9700 AV Groningen, The Netherlands
[4] UJF-Grenoble 1 / CNRS-INSU, Institut de Planétologie et d'Astrophysique (IPAG), Grenoble, 38041, France

E-mail contact: gwendolyn.meeus *at* uam.es

We observed a sample of 20 representative Herbig Ae/Be stars and five A-type debris discs with PACS onboard of *Herschel*. The observations were done in spectroscopic mode, and cover far-IR lines of [OI], [CII], CO, CH^+, H_2O and OH. We have a [OI]63 μm detection rate of 100% for the Herbig Ae/Be and 0% for the debris discs. [OI]145 μm is only detected in 25%, CO J=18-17 in 45% (and less for higher J transitions) of the Herbig Ae/Be stars and for [CII] 157 μm, we often found spatially variable background contamination. We show the first detection of water in a Herbig Ae disc, HD 163296, which has a settled disc. Hydroxyl is detected as well in this disc. CH^+, first seen in HD 100546, is now detected for the second time in a Herbig Ae star, HD 97048. We report fluxes for each line and use the observations as line diagnostics of the gas properties. Furthermore, we look for correlations between the strength of the emission lines and stellar or disc parameters, such as stellar luminosity, UV and X-ray flux, accretion rate, PAH band strength, and flaring. We find that the stellar UV flux is the dominant excitation mechanism of [OI]63 μm, with the highest line fluxes found in those objects with a large amount of flaring and greatest PAH strength. Neither the amount of accretion nor the X-ray luminosity has an influence on the line strength. We find correlations between the line flux of [OI]63 μm and [OI]145 μm, CO J = 18-17 and [OI]6300 Å, and between the continuum flux at 63 μm and

at 1.3 mm, while we find weak correlations between the line flux of [OI]63 μm and the PAH luminosity, the line flux of CO J = 3-2, the continuum flux at 63 μm, the stellar effective temperature and the Brγ luminosity. Finally, we use a combination of the [OI]63 μm and ^{12}CO J = 2-1 line fluxes to obtain order of magnitude estimates of the disc gas masses, in agreement of the values we found from detailed modelling of 2 HAEBEs, HD 163296 and HD 169142.

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The rapid dispersal of low-mass virialised clusters

Nickolas Moeckel[1], Christopher Holland[1], Cathie J. Clarke[1] and Ian A. Bonnell[2]

[1] IoA, Cambridge, UK
[2] University of St Andrews, UK

E-mail contact: nickolas1 *at* gmail.com

Infant mortality brought about by the expulsion of a star cluster's natal gas is widely invoked to explain cluster statistics at different ages. While a well studied problem, most recent studies of gas expulsion's effect on a cluster have focused on massive clusters, with stellar counts of order 10^4. Here we argue that the evolutionary timescales associated with the compact low-mass clusters typical of the median cluster in the Solar neighborhood are short enough that significant dynamical evolution can take place over the ages usually associated with gas expulsion. To test this we perform N-body simulations of the dynamics of a very young star forming region, with initial conditions drawn from a large-scale hydrodynamic simulation of gravitational collapse and fragmentation. The subclusters we analyse, with populations of a few hundred stars, have high local star formation efficiencies and are roughly virialised even after the gas is removed. Over 10 Myr they expand to a similar degree as would be expected from gas expulsion if they were initially gas-rich, but the expansion is purely due to the internal stellar dynamics of the young clusters. The expansion is such that the stellar densities at 2 Myr match those of YSOs in the Solar neighborhood. We argue that at the low-mass end of the cluster mass spectrum, a deficit of clusters at 10s of Myr does not necessarily imply gas expulsion as a disruption mechanism.

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Probing the physical and chemical structure of the CS core in LDN 673. Multitransitional and continuum observations

Oscar Morata[1], Josep Miquel Girart[2], Robert Estalella[3] and Robin T. Garrod[4]

[1] Institute of Astronomy & Astrophysics, Academia Sinica, P.O. Box 23-141, Taipei 10617, Taiwan
[2] Institut de Ciències de l'Espai (CSIC-IEEC), Campus UAB, Facultat de Ciències, C5 par 2a, E-08193, Bellaterra, Catalunya, Spain
[3] Departament d'Astronomia i Meteorologia (IEEC-UB), Institut de Ciències del Cosmos, Universitat de Barcelona, Martí i Franquès 1, E-08028 Barcelona, Catalunya, Spain
[4] Department of Astronomy, Cornell University, Ithaca, NY 14853, USA

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

High-angular resolution observations of dense molecular cores show that these cores can be clumpier at smaller scales, and that some of these clumps can also be unbound or transient. The use of chemical models of the evolution of the molecular gas provides a way to probe the physical properties of the clouds. We study the properties of the clump and inter-clump medium in the starless CS core in LDN 673 by carrying out a molecular line survey with the IRAM 30-m telescope toward two clumps and two inter-clump positions. We also observed the 1.2-mm continuum with the MAMBO-II bolometer at IRAM. The dust continuum map shows four condensations, three of them centrally peaked, coinciding with previously identified sub-millimetre sources. We confirm that the denser clump of the region, $n \sim 3.6 \times 10^5$ cm^{-3}, is also the more chemically evolved, and it could still undergo further fragmentation. The inter-clump medium positions are denser than previously expected, likely $n \sim 1 \times 10^3$–$1{\times}10^4$ cm^{-3} due to contamination, and are chemically young, similar to the gas in the lower density clump position. We argue that the density contrast between these positions and their general young chemical age would support the existence of transient clumps in the lower density material of the core. We were also able to find reasonable fits of the observationally derived chemical

abundances to models of the chemistry of transient clumps.

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Searching for young Jupiter analogs around AP Col: L-band high-contrast imaging of the closest pre-main sequence star

Sascha P. Quanz[1], Justin R. Crepp[2], Markus Janson[3], Henning Avenhaus[1], Michael R. Meyer[1] and Lynne A. Hillenbrand[2]

[1] Institute for Astronomy, ETH Zurich, Wolfgang-Pauli-Strasse 27, 8093 Zurich, Switzerland
[2] Department of Astrophysics, California Institute of Technology, 1200 E. California Blvd., Pasadena, CA 91125, USA
[3] Department of Astrophysical Sciences, Princeton University, Princeton, NJ, USA

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

The nearby M-dwarf AP Col was recently identified by Riedel et al. 2011 as a pre-main-sequence star (age 12 – 50 Myr) situated only 8.4 pc from the Sun. The combination of its youth, distance, and intrinsically low luminosity make it an ideal target to search for extrasolar planets using direct imaging. We report deep adaptive optics observations of AP Col taken with VLT/NACO and Keck/NIRC2 in the L-band. Using aggressive speckle suppression and background subtraction techniques, we are able to rule out companions with mass $m \geq 0.5 - 1 M_{Jup}$ for projected separations $a > 4.5$ AU, and $m \geq 2\,M_{Jup}$ for projected separations as small as 3 AU, assuming an age of 40 Myr using the COND theoretical evolutionary models. Using a different set of models the mass limits increase by a factor of $\gtrsim$2. The observations presented here are the deepest mass-sensitivity limits yet achieved within 20 AU on a star with direct imaging. While Doppler radial velocity surveys have shown that Jovian bodies with close-in orbits are rare around M-dwarfs, gravitational microlensing studies predict that 17^{+6}_{-9}% of these stars host massive planets with orbital separations of 1-10 AU. Sensitive high-contrast imaging observations, like those presented here, will help to validate results from complementary detection techniques by determining the frequency of gas giant planets on wide orbits around M-dwarfs.

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Near-IR Variability in Young Stars in Cygnus OB7

Thomas S. Rice[1], Scott J. Wolk[2] and Colin Aspin[3]

[1] Harvard University, 60 Garden St. Cambridge MA, USA
[2] Harvard-Smithsonian Center for Astrophysics, 60 Garden St. Cambridge MA, USA
[3] University of Hawaii Institute for Astronomy, 640 N. Aohoku Place, Hilo, HI 96720, USA

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

We present the first results from a 124 night J, H, K near-infrared monitoring campaign of the dark cloud L 1003 in Cygnus OB7, an active star-forming region. Using 3 seasons of UKIRT observations spanning 1.5 years, we obtained high-quality photometry on 9,200 stars down to J=17 mag, with photometric uncertainty better than 0.04 mag. On the basis of near-infrared excesses from disks, we identify 30 pre-main sequence stars, including 24 which are newly discovered. We analyze those stars and find the NIR excesses are significantly variable. All 9,200 stars were monitored for photometric variability; among the field star population, about 160 exhibited near-infrared variability (1.7% of the sample). Of the 30 YSOs (young stellar objects), 28 of them (93%) are variable at a significant level. 25 of the 30 YSOs have near-infrared excess consistent with simple disk-plus-star classical T Tauri models. Nine of these (36%) drift in color space over the course of these observations and/or since 2MASS observations such that they cross the boundary defining the NIR excess criteria; effectively, they have a transient near-infrared excess. About half of the YSOs have color-space variations parallel to either the classical T Tauri star locus or a hybrid track which includes the dust reddening trajectory. This indicates that the NIR variability in YSOs that possess accretion disks arises from a combination of variable extinction and changes in the inner accretion disk: either in accretion rate, central hole size and/or the inclination of the inner disk. While some variability may be due to stellar rotation, the level of variability on the individual stars can exceed a magnitude. This is a strong empirical suggestion that protoplanetary disks are

quite dynamic and exhibit more complex activity on short timescales than is attributable to rotation alone or captured in static disk models.

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Fragmentation in the Massive Star-Forming Region IRAS 19410+2336

J. A. Rodón[1], H. Beuther[2] and P. Schilke[3]

[1] European Southern Observatory, Casilla 19001, Santiago 19, Chile
[2] Max-Planck-Institut für Astronomie, Königstuhl 17, 69117 Heidelberg, Germany
[3] I. Physikalisches Institut, Universität zu Köln, Zülpicherstr. 77, 50937 Köln, Germany

E-mail contact: jrodon *at* eso.org

The Core Mass Functions (CMFs) of low-mass star-forming regions are found to resemble the shape of the Initial Mass Function (IMF). A similar result is observed for the dust clumps in high-mass star forming regions, although at spatial scales of clusters that do not resolve the substructure found in them. The region IRAS 19410+2336 is one exception, having been observed at spatial scales on the order of ~ 2500 AU, resolving the clump substructure into individual cores.
We mapped that region with the PdBI in the 1.4 mm and 3 mm continuum and several transitions of H_2CO and CH_3CN. The H_2CO transitions were also observed with the IRAM 30 m Telescope. We detected 26 continuum sources at 1.4 mm with a spatial resolution down to ~ 2200 AU, distributed in two protoclusters. With the lines emission we derived the temperature structure of the region, ranging from 35 to 90 K. With them we calculated the core masses of the detected sources, ranging from ~ 0.7 to ~ 8 $M_\odot$. These masses were strongly ($\sim 90\%$) affected by the interferometer spatial filtering. Considering only the detected dense cores we derived a CMF with a power-law index $\beta = -2.3 \pm 0.2$. We resolve the Jeans length of the protoclusters by one order of magnitude, and only find little velocity dispersion between the different subsources.
Since we cannot unambiguously differentiate protostellar and prestellar cores, the derived CMF is not prestellar. Also, because of the large missing flux, we cannot establish a firm link between the CMF and the IMF. This implies that future high-mass CMF studies will need to complement the interferometer continuum data with the short spacing data, a task suitable for ALMA. We note that the method of extracting temperatures using H_2CO lines becomes less applicable when reaching the dense core scales of the interferometric observations because most of the H_2CO appears to originate in the envelope structure.

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Search for Circumstellar Disks and Radio Jets in the Massive Star-formation Region IRAS 23033+5951

Tatiana Rodriguez[1], Miguel A. Trinidad[1] and Victor Migenes[2]

[1] Universidad de Guanajuato, Department of Astronomy, P.O. Box 144, Guanajuato, GTO. 36000. Mexico
[2] Brigham Young University, Department of Physics and Astronomy, ESC-N145, Provo, UT. 84602. USA

E-mail contact: vmigenes *at* byu.edu

We present radio continuum (1.3 and 3.6 cm) and H_2O maser observations toward the high-mass star-forming region IRAS 23033+5951 carried out with the VLA-EVLA (in transition phase) in the A configuration. Three radio continuum sources are detected at 3.6 cm, which are aligned in the east-west direction. However, no continuum emission is detected in the region at 1.3 cm. Based on the continuum information, we find that the two continuum sources detected in the region could be consistent with ultracompact H II regions harboring ZAMS B2 and B2.5 stars, however, we don't rule out that they could be associated with a radio jet. In addition, nine water maser spots are detected toward IRAS 23033+5951, which are clustered in two groups and located about 2" to the south of the continuum sources. The spatio-kinematical distribution of the water masers suggest that they are tracing a circumstellar disk associated with a central star ZAMS B0, which could be the least evolved source in the region and has not developed an H II region yet. Moreover, as the circumstellar disk seems to be associated with the CO molecular outflow observed in the region,

this conforms a disk-YSO-outflow system, similar to that found in low-mass stars.

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Shocked and Scorched: The Tail of a Tadpole in an Interstellar Pond

Raghvendra Sahai[1], Mark R. Morris[2] and Mark Claussen[3]

[1] Jet Propulsion Laboratory, Caltech
[2] UCLA
[3] NRAO

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

We report multi-wavelength observations of the far-infrared source IRAS 20324+4057, including high-resolution optical imaging with HST, and ground-based near-infrared, millimeter-wave and radio observations. These data show an extended, limb-brightened, tadpole-shaped nebula with a bright, compact, cometary nebula located inside the tadpole head. Our molecular line observations indicate that the Tadpole is predominantly molecular, with a total gas mass exceeding $3.7\,M_{\odot}$. Our radio continuum imaging, and archival Spitzer IRAC images, show the presence of additional tadpole-shaped objects in the vicinity of IRAS 20324+4057 that share a common E-W head-tail orientation: we propose that these structures are small, dense molecular cores that originated in the Cygnus cloud and are now being (i) photoevaporated by the ultraviolet radiation field of the Cyg OB2 No. 8 cluster located to the North-West, and (ii) shaped by ram pressure of a distant wind source or sources located to the West, blowing ablated and photoevaporated material from their heads eastwards. The ripples in the tail of the Tadpole are interpreted in terms of instabilities at the interface between the ambient wind and the dense medium of the former.

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Optical spectroscopy of EX Lupi during quiescence and outburst: Infall, wind, and dynamics in the accretion flow

Aurora Sicilia-Aguilar[1], Ágnes Kóspal[2,3], Johny Setiawan[4], Péter Ábrahám[5], Cornelis Dullemond[4,6], Carlos Eiroa[1], Miwa Goto[4], Thomas Henning[4] and Attila Júhasz[2]

[1] Departamento de Física Teórica, Facultad de Ciencias, Universidad Autónoma de Madrid, 28049 Cantoblanco, Madrid, Spain
[2] Leiden Observatory, Leiden University, PO Box 9513, 2300RA Leiden, The Netherlands
[3] Research and Scientific Support Department, European Space Agency, ESA/ESTEC, SRE-SA, PO Box 299, 2200 AG, Noordwijk, The Netherlands
[4] Max-Planck-Institut für Astronomie, Königstuhl 17, 69117 Heidelberg, Germany
[5] Konkoly Observatory of the Hungarian Academy of Sciences, PO Box 67, 1525 Budapest, Hungary
[6] Institut für Theoretische Astrophysik, Zentrum für Astronomie, Universität Heidelberg, Albert-Ueberle-Str. 2, 69120 Heidelberg, Germany

E-mail contact: aurora.sicilia *at* uam.es

EX Lupi is the prototype of EXor variables. After 50 years of mild variability and smaller outbursts, the object again experienced a large outburst in 2008. We explore the accretion mechanisms in EX Lupi during its pre-outburst, outburst, and post-outburst phases. We analyze 10 high-resolution optical spectra of EX Lupi, taken before, during, and after the 2008 outburst. In both quiescence and outburst, the star presents many permitted emission lines. These include lines typical of accreting T Tauri stars, plus a large number of neutral and ionized metallic lines (mostly Fe I and Fe II). During the outburst, the number of emission lines increases to about a thousand, and their structure shows a narrow and a broad component (NC and BC). We study thestructure of the BC, which is highly variable on short timescales (24-72h). An active chromosphere can explain the metallic lines in quiescence and the outburst NC. The dynamics of the BC line profiles suggest that these profiles originate in a hot, dense, non-axisymmetric, and non-uniform accretion column that suffers velocity variations along the line-of-sight on timescales of days. Assuming Keplerian rotation, the emitting region would be located at ∼0.1-0.2 AU, which is consistent with the location of the inner disk rim,but the velocity profiles of the lines reveal a combination ofrotation and infall. Line ratios of ions and neutrals can be reproduced assuming a temperature of T∼6500 K for electron densities of a few times 10^{12}cm^{-3} in

the line-emitting region.The line profiles also indicate that there is an accretion-related inner disk wind. The data confirm that the 2008 outburst was an episode of increased accretion, albeit much stronger than previous EX Lupi and typical EXors outbursts. The line profiles are consistentwith the infall/rotation of a non-axisymmetric structure thatcould be produced by clumpy accretion during the outburst phase. A strong inner disk wind appears in the epochs of higher accretion.The rapid recovery of the system after theoutburst and the similarity between the pre-outburst and post-outburststates suggest that the accretion channels are similar during the wholeperiod, and only the accretion rate varies, providing a superb environment for studying the accretion processes.

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Toward Understanding the Origin of Turbulence in Molecular Clouds: Small Scale Structures as Units of Dynamical Multi-Phase Interstellar Medium

Kengo Tachihara[1,2], Kazuya Saigo[2], Aya E. Higuchi[1,2], Tsuyohshi Inoue[3], Shu-ichiro Inutsuka[4], Moritz Hackstein[5], Martin Haas[5] and Markus Mugrauer[6]

[1] Joint ALMA Observatory, Alonso de Córdova 3107, Vitacura, Santiago, Chile
[2] National Astronomical Observatory of Japan, 2-21-1, Osawa, Miaka, Tokyo, 181-8588, Japan
[3] Department of Physics and Mathematics, Aoyama Gakuin University, Fuchinobe, Sagamihara 229-8558, Japan
[4] Department of Astrophysics, Nagoya University, Chikusa-ku, Nagoya, 464-8602, Japan
[5] Astronomisches Institut, Ruhr-Universität Bochum, Universitätsstr. 150, D-44801, Bochum, Germany
[6] Astrophysikalisches Institut und Universitäts-Sternwarte Jena, Schillergäßchen 2-3, D-07745, Jena, Germany

E-mail contact: k.tachihara *at* nao.ac.jp

In order to investigate the origin of the interstellar turbulence, detailed observations in the CO J = 1–0 and 3–2 lines have been carried out in an interacting region of a molecular cloud with an H II region. As a result, several 1,000 to 10,000 AU scale cloudlets with small velocity dispersion are detected, whose systemic velocities have a relatively large scatter of a few km s^{-1}. It is suggested that the cloud is composed of small-scale dense and cold structures and their overlapping effect makes it appear to be a turbulent entity as a whole. This picture strongly supports the two-phase model of turbulent medium driven by thermal instability proposed previously. On the surface of the present cloud, the turbulence is likely to be driven by thermal instability following ionization shock compression and UV irradiation. Those small scale structures with line width of $\sim$ 0.6 km s^{-1} have a relatively high CO line ratio of J =3–2 to 1–0, $1 \leq R_{3-2/1-0} \leq 2$. The large velocity gradient analysis implies that the 0.6 km s^{-1} width component cloudlets have an average density of 10$^{3-4}$ cm^{-3}, which is relatively high at cloud edges, but their masses are only $\lesssim$0.05 $M_{\odot}$.

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Discovery of Crystallized Water Ice in a Silhouette Disk in the M43 Region

Hiroshi Terada[1] and Alan Tokunaga[2]

[1] Subaru Telescope, National Astronomical Observatory of Japan, 650 North A'ohoku Place, Hilo, HI 96720, USA
[2] Institute for Astronomy, University of Hawaii, 2680 Woodlawn Drive, Honolulu 96822, USA

E-mail contact: terada *at* subaru.naoj.org

We present the 1.9-4.2 μm spectra of the five bright (L < 11.2) young stars associated with silhouette disks with a moderate to high inclination angle of 39°-80° in the M42 and M43 regions. The water ice absorption is seen toward d121-1925 and d216-0939, while the spectra of d182-316, d183-405, and d218-354 show no water ice feature around 3.1 μm within the detection limits. By comparing the water ice features toward nearby stars, we find that the water ice absorption toward d121-1925 and d216-0939 most likely originates from the foreground material and the surrounding disk, respectively. The angle of the disk inclination is found to be mainly responsible for the difference of the optical depth of the water ice among the five young stars. Our results suggest that there is a critical inclination angle between 65 μm and 75 μm for the circumstellar disk where the water ice absorption becomes strong. The average density at the disk surface of d216-0939 was found to be 6.38 10^{-18} g cm^{-3}. The water ice absorption band in the d216-0939 disk is remarkable in that the maximum optical depth of the water ice band is at a longer wavelength than detected before.

It indicates that the primary carrier of the feature is purely crystallized water ice at the surface of the d216-0939 disk with characteristic size of 0.8 μm, which suggests grain growth. This is the first direct detection of purely crystallized water ice in a silhouette disk.

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Different Evolutionary Stages in the Massive Star Forming Region W3 Main Complex

Yuan Wang[1,2,7], Henrik Beuther[2], Qizhou Zhang[3], Arjan Bik[2], Javier A. Rodón[4], Zhibo Jiang[1] and Cassandra Fallscheer[5,6]

[1] Purple Mountain Observatory & Key Laboratory for Radio Astronomy, Chinese Academy of Sciences, Nanjing 210008, China
[2] Max-Plank-Institute for Astronomy, Königstuhl 17, Heidelberg 69117, Germany
[3] Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA
[4] European Southern Observatory, Alonso de Córdova 3107, Vitacura, Casilla 19001, Santiago 19, Chile
[5] Department of Physics and Astronomy, University of Victoria, PO Box 355, STN CSC, Victoria BC, V8W 3P6, Canada
[6] National Research Council, 5071 West Saanich Rd., Victoria, BC, V9E2E7, Canada
[7] Graduate University of the Chinese Academy of Sciences, 19A Yuquan Road, Shijingshan District, Beijing 100049, China

E-mail contact: ywang *at* pmo.ac.cn

We observed three high-mass star-forming regions in the W3 high-mass star formation complex with the Submillimeter Array and IRAM 30 m telescope. These regions, i.e. W3 SMS1 (W3 IRS5), SMS2 (W3 IRS4) and SMS3, are in different evolutionary stages and are located within the same large-scale environment, which allows us to study rotation and outflows as well as chemical properties in an evolutionary sense. While we find multiple mm continuum sources toward all regions, these three sub-regions exhibit different dynamical and chemical properties, which indicates that they are in different evolutionary stages. Even within each subregion, massive cores of different ages are found, e.g. in SMS2, sub-sources from the most evolved UCHii region to potential starless cores exist within 30 000 AU of each other. Outflows and rotational structures are found in SMS1 and SMS2. Evidence for interactions between the molecular cloud and the Hii regions is found in the ^{13}CO channel maps, which may indicate triggered star formation.

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Herschel imaging of 61 Vir: implications for the prevalence of debris in low-mass planetary systems

M. C. Wyatt[1], G. Kennedy[1], B. Sibthorpe[2], A. Moro-Martín[3], J.-F. Lestrade[4], B. Matthews[5], S. Udry[6], J. S. Greaves[7], P. Kalas[8,9], S. Lawler[10], K. Y. L. Su[11], G. H. Rieke[11], M. Booth[12,5], G. Bryden[13], J. Horner[14], J. J. Kavelaars[5] and D. Wilner[15]

[1] Institute of Astronomy, University of Cambridge, Madingley Road, Cambridge CB3 0HA, UK
[2] UK Astronomy Technology Centre, Royal Observatory, Blackford Hill, Edinburgh EH9 3HJ, UK
[3] Centro de Astrobiología (CSIC-INTA), 28850 Torrejón de Ardoz, Madrid, Spain
[4] Observatoire de Paris, 77 Avenue Denfert Rochereau, 75014, Paris, France
[5] Herzberg Institute of Astrophysics, 5072 West Saanich Road, Victoria V9E 2E7, BC, Canada
[6] Observatoire de l'Université de Genève, 51 Ch. des Maillettes, CH-1290 Versoix, Switzerland
[7] Scottish Universities Physics Alliance, University of St. Andrews, Physics & Astronomy, North Haugh, St Andrews KY16 9SS, UK
[8] Department of Astromomy, University of California, 601 Campbell Hall, Berkeley, CA 94720, USA
[9] SETI Institute, 515 North Whisman Road, Mountain View, CA 94043, USA
[10] University of British Columbia, Department of Physics and Astronomy, 6244 Agricultural Road, Vancouver, BC V6T 1Z1, Canada
[11] Steward Observatory, University of Arizona, Tucson, AZ 85721, USA
[12] Department of Physics & Astronomy, University of Victoria, Elliott Building, 3800 Finnerty Rd, Victoria, BC, V8P

5C2, Canada
[13] Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, CA 91109, USA
[14] Department of Astrophysics and Optics, School of Physics, University of New South Wales, Sydney 2052, Australia
[15] Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA

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

This paper describes Herschel observations of the nearby (8.5pc) G5V multi-exoplanet host star 61 Vir at 70, 100, 160, 250, 350 and 500 μm carried out as part of the DEBRIS survey. These observations reveal emission that is significantly extended out to a distance of > 15arcsec with a morphology that can be fitted by a nearly edge-on (77° inclination) radially broad (from 30AU out to at least 100AU) debris disk of fractional luminosity 2.7×10^{-5}, with two additional (presumably unrelated) sources nearby that become more prominent at longer wavelengths. Chance alignment with a background object seen at 1.4GHz provides potential for confusion, however the star's 1.4arcsec/year proper motion allows archival Spitzer 70μm images to confirm that what we are interpreting as *disk* emission really is circumstellar. Although the exact shape of the disk's inner edge is not well constrained, the region inside 30AU must be significantly depleted in planetesimals. This is readily explained if there are additional planets outside those already known (i.e., in the 0.5-30AU region), but is also consistent with collisional erosion. We also find tentative evidence that the presence of detectable debris around nearby stars correlates with the presence of the lowest mass planets that are detectable in current radial velocity surveys. Out of an unbiased sample of the nearest 60 G stars, 11 are known to have planets, of which 6 (including 61 Vir) have planets that are all less massive than Saturn, and 4 of these have evidence for debris. The debris toward one of these planet-hosts (HD20794) is reported here for the first time. This fraction (4/6) is higher than that expected for nearby field stars (15%), and implies that systems that form low-mass planets are also able to retain bright debris disks. We suggest that this correlation could arise because such planetary systems are dynamically stable and include regions that are populated with planetesimals in the formation process where the planetesimals can remain unperturbed over Gyr timescales.

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Dust Filtration by Planet-Induced Gap Edges: Implications for Transitional Disks

Zhaohuan Zhu[1,2], Richard P. Nelson[3], Ruobing Dong[1], Catherine Espaillat[4] and Lee Hartmann[2]

[1] Department of Astrophysical Sciences, 4 Ivy Lane, Peyton Hall, Princeton University, 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] Center for Astrophysics, 60 Garden St., Cambridge, MA 02138, USA

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

23 Pages, 11 figures

By carrying out two-dimensional two-fluid global simulations, we have studied the response of dust to gap formation by a single planet in the gaseous component of a protoplanetary disk - the so-called "dust filtration" mechanism. We have found that a gap opened by a giant planet at 20 AU in a α=0.01, $\dot{M} = 10^{-8}$ $M_{\odot}$ yr^{-1} disk can effectively stop dust particles larger than 0.1 mm drifting inwards, leaving a sub-millimeter dust cavity/hole. However, smaller particles are difficult to filter by a planet-induced gap due to 1) dust diffusion, and 2) a high gas accretion velocity at the gap edge. Based on these simulations, an analytic model is derived to understand what size particles can be filtered by the planet-induced gap edge. We show that a dimensionless parameter T_s/α, which is the ratio between the dimensionless dust stopping time and the disk viscosity parameter, is important for the dust filtration process. Finally, with our updated understanding of dust filtration, we have computed Monte-Carlo radiative transfer models with variable dust size distributions to generate the spectral energy distributions (SEDs) of disks with gaps. By comparing with transitional disk observations (e.g. GM Aur), we have found that dust filtration alone has difficulties to deplete small particles sufficiently to explain the near-IR deficit of moderate $\dot{M}$ transitional disks, except under some extreme circumstances. The scenario of gap opening by multiple planets studied previously suffers the same difficulty. One possible solution is by invoking both dust filtration and dust growth in the inner disk. In this scenario, a planet induced gap filters large dust particles in the disk, and the remaining small dust particles passing to the inner disk can grow efficiently without replenishment from fragmentation of large grains. Predictions for ALMA have also

been made based on all these scenarios. We conclude that dust filtration with planet(s) in the disk is a promising mechanism to explain submm observations of transitional disks but it may need to be combined with other processes (e.g. dust growth) to explain the near-IR deficit of some systems.

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Dynamical fingerprints of star cluster formation

Michael Marks

Argelander Institut für Astronomie, Rheinische Friedrich-Wilhelms-Universität Bonn, Auf dem Hügel 71, 53121 Bonn
Max-Planck-Institut für Radioastronomie, Auf dem Hügel 69, 53121 Bonn

Member of the International Max-Planck Research School (IMPRS) for Astronomy and Astrophysics at the Universities of Bonn and Cologne

Electronic mail: mmarks *at* astro.uni-bonn.de

Ph.D dissertation directed by: Prof. Dr. Pavel Kroupa

Ph.D degree awarded: March 2012

The vast majority of stars forms in embedded star clusters. Therefore an understanding of the birth conditions of star clusters is desirable. This thesis employs the imprint of dynamical evolutionary processes early in the life of a cluster in present-day observational data in order to learn about those ancient conditions. The results presented are manifold, ranging from the formation of stars and binaries - *scale*: a few solar radii ($R_{\rm sun}$) to thousands of astronomical units (AU) - to the properties of whole galaxies - *scale*: many kiloparsecs (kpc) - all of them obtained by investigating star cluster dynamics - *scale*: a fraction of, up to a few parsecs (pc, note 1 kpc= 1000 pc= 206264806 AU= $4.44\times10^{10}R_{\rm sun}$ = 3.09×10^{16} km). In particular the main findings of my thesis are summarised as follows.

I demonstrated previously in my diploma thesis (the results published in Marks, Kroupa & Baumgardt 2008) that the violent phase of residual-gas expulsion, i.e. the removal of the gas that is left-over from star formation, depletes the low-mass stellar initial mass function in a way that is consistent with observations of the present-day mass function. In the first part of this thesis, these data are used to constrain for the first time parameters determining the residual-gas expulsion process which allows to infer initial masses, sizes and densities for a sample of twenty Galactic globular clusters. The constrained quantities lead to novel insights into the formation process of star clusters, in particular uncovering cluster metallicity as the potential driving physical quantity of residual-gas expulsion and star cluster formation (Marks & Kroupa 2010). If the residual-gas is assumed to be removed over some given time-scale, it is shown that the derived initial conditions require globular clusters to have formed with a non-standard stellar initial mass function at the high-mass end depending on cluster metallicity and birth density for stars more massive than the Sun. The deduced variation of the IMF is consistent qualitatively with the theoretically predicted variation of the IMF with physical conditions of star formation (Marks, Kroupa, Dabringhausen & Pawlowski 2012).

The second part of this thesis deals with the evolution of initially binary star dominated star clusters. It is shown that a population of binaries with initially invariant properties changes its characteristics on a dynamical crossing time-scale. This finding allows to devise an analytical method to describe the dynamically induced evolution of the distributions of binary orbital parameters in N-body computations depending on the initial cluster density (Marks, Kroupa & Oh 2011). This novel method is subsequently used to compare observed binary orbital-parameter distributions in young star clusters with those expected from the model. All of the investigated regions can be explained within the framework of the dynamical modification of the initially invariant binary star distribution into the observed ones. The model delivers initial cluster densities for the sample of young clusters and predicts present-day overall binary-fractions in them as well as the shape of their distribution functions. The derived initial densities compare excellently with observed pre-cluster cloud core densities (Marks & Kroupa 2012). The same analytical method is employed to calculate the single and binary star populations in galactic fields by summing up the individual stellar populations in star clusters. The model results in binary star distributions consistent with those observed in the Milky Way if clusters formed compact. Having adjusted the parameters determining a galaxy-wide population for other galaxies allows for the first time the prediction of the single and binary star content for elliptical, spiral and dwarf galaxies (Marks & Kroupa 2011).

The low-metallicity ISM: Chemistry, Turbulence and Magnetic Fields

This is the second announcement of our workshop **"The low-metallicity ISM: Chemistry, Turbulence and Magnetic Fields"**, which will take place October 8-12 at the University of Goettingen.

The ISM at low metallicity is a very prospective area of research, with potential applications in the field of **high-redshift galaxies, the first generations of stars, as well as the local Universe**, in particular with respect to nearby dwarf galaxies. In light of new theoretical results as well as new and upcoming observational data, the investigation of the ISM in this regime becomes increasingly more complex. In particular, the necessity of modeling the chemistry at low metallicity has been realized since a long time, although only now people start modeling the full complexity in a three-dimensional framework. Only in this way, the interaction of chemistry with turbulence and feedback processes can be explored.

For nearby dwarf galaxies, **Herschel** is providing a wealth of data revealing the conditions in low-metallicity systems, and higher-resolution, spectral information can be expected from **ALMA**. Magnetic fields have been detected in nearby dwarf galaxies, while simultaneously, theoretical efforts aim at exploring magnetic field amplification by turbulence or cosmic-ray driven dynamos. Their existence has further been inferred in distant starburst galaxies via their synchrotron emission as well as the validity of the **radio-IR correlation** at least up to $z = 3$.

In light of such developments, it is important to provide a platform connecting the different experts to stimulate an exchange of ideas, and to work towards a coherent understanding of low-metallicity environments. For this purpose, we are planning a workshop aimed at experts for **ISM chemistry, turbulence and magnetic fields** to explore their interaction at low metallicity. The scope of this workshop comprises systems in the nearby Universe as well as at high redshift, in order to stimulate the interaction in these fields.

For the participation in our workshop, we would like to remind you of the following deadlines:
May 31: Application for **travel support**
June 30: Registration deadlines for **talks / posters**
August 1: Expiry of **hotel block reservations**

For further information, registration and abstract submission, please visit **http://low-met.uni-goettingen.de/** .

Hope to see you in October,

Dominik Schleicher on behalf of the SOC

Frontiers of Star Formation

August 15-17, 2012, European Space Agency, ESTEC, Noordwijk, The Netherlands

http://www.sciops.esa.int/index.php?project=CONF2012&page=FSF2012

Research into the fundamental topic of star formation has come of age in recent years, with the era of major spaced-based facilities such as the Herschel, Chandra, and Spitzer observatories. Such facilities have aided in the investigation of important questions in star formation, such as: how is the formation and evolution of stellar clusters effected by their initial conditions and environment? what are the effects of cluster environment on the processing of circumstellar material of young stars? and more recently with Herschel, what is the relation of core mass to the initial mass function and the filamentary structure observed in molecular clouds? Though we have made great headway in recent times, yet these puzzles remain unsolved.

The future missions and telescope facilities, expected to come online in the next decade, will open new avenues of research, and help answer some of these outstanding questions while also providing new avenues of inquiry and new puzzles to pursue. With Gaia and ALMA due to come online over the next two years, and JWST and SPICA planned to replace the current space missions in the coming decade, this workshop aims to discuss such missions and how they will impact future research on the frontiers of star formation.

The workshop will bring together young researchers at postdoctoral and PhD level with established researchers in the field to share their current work and to foster new collaborations for future projects. Overviews of currently operating and planned future missions will be provided and complimented by review talks on the major scientific questions under discussion. Ample time for open discussion will be provided in each of the sessions, with an hour given over to the discussion of ideas raised in the preceding talks.

The workshop aims to explore the unanswered questions in star formation. There will be four broad sessions:

- Filaments to Cores, including a Herschel review talk.
- Stellar Clusters: Importance of Environment, including review talks on Gaia and JWST.
- Circumstellar Disks: from T Tauri to Debris Disks, including review talks on ALMA and SKA.
- Brown Dwarfs and ExoPlanets: Low Mass Frontiers, including a E-ELT review talk.

Each session will include relevant scientific contributed talk(s) to review the current status of our knowledge and to point the way to new avenues of research. Ample discussion time in each session will encourage healthy debate and foster an environment where young researchers can interact with both their peers and more established researchers to create and further collaborations.

Invited Speakers

Joana Ascenso (ESO Garching)
Guido de Marchi (ESA/ESTEC)
Thomas Henning (MPIA, Heidelberg)
Michiel Hogerheijde (Leiden Observatory)
Kate Isaak (ESA/ESTEC)
Vera Könyves (CEA Saclay)
Pavel Kroupa (Argelander Institute for Astronomy, Bonn)
Huib Jan van Langevelde (JIVE, Dwingeloo)
Mark McCaughrean (ESA/ESTEC)
Göran Pilbratt (ESA/ESTEC)
Timo Prusti (ESA/ESTEC)

Scientific Organizing Committee

E. Winston, N. Leigh, N. Da Rio, Á. Kóspál (ESA/ESTEC), M. Andersen (IPAG Grenoble)

Abstract submission deadline : July 15, 2012