“From Circumstellar Disks to Planetary Systems”
3-6 November 2009, Garching

ABSTRACT BOOK

Formation and properties of disks around embedded protostars

Jes K. Jørgensen[1]

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

One of the most important unanswered questions in our understanding of low-mass star formation is how circumstellar disks form and evolve. Many previous studies have focused on the properties of disks around revealed young stellar objects, yet disks are likely formed in the deeply embedded protostellar stages and their properties related to the physical and chemical structure of the innermost regions of the centrally condensed envelopes surrounding such young stars. With high angular resolution observations from present-day (sub)millimeter interferometers and high sensitivity mid-infrared observations we can start to characterize the inner envelopes and disks in their earliest evolutionary stages.

In this talk I will present a review of recent observations of disks around embedded low-mass protostars and discuss the available constraints on their physical structures and evolution. These observations for example show evidence for significant growth of disks already during the earliest embedded protostellar stages — as well as significant dust processing. I will put particular emphasis on the possibilities offered by future observations with ALMA and discuss some of the questions that we can hope to address with this ground-breaking instrument as well as some issues that we need to consider.

On the formation of disks during the collapse of magnetized prestellar cores

Patrick Hennebelle[1], Ciardi Andrea[1], Maury Anaelle[2], André Philippe[2]

[1] *Observatoire de Paris, LERMA*
[2] *Commissariat à l'énergie atomique, Saclay*

Understanding the formation of circumstellar disks is of great importance in the context of star and planet formation. Recently, 3D magnetohydrodynamical numerical simulations of the collapse of magnetized prestellar cores have been performed showing that the magnetic field has a drastic influence on: i) the formation of centrifugally supported disk, ii) the fragmentation of the core, iii) the launching of outflows. In particular, it has been found that for relatively modest magnetic intensities, the magnetic braking is sufficient to suppress the formation of disks at the early class-0 phase. In the talk, I will present and discuss numerical simulations of magnetized collapsing cores, paying particular attention to the formation of centrifugally supported disks. I will also discuss in details the physical mechanisms responsible of the dense core evolution. Finally, I will present detailed comparisons with observations performed at the IRAM plateau de Bure interferometer of young class-0 objects. These comparisons clearly exclude the presence in the observed sources, of massive and extended circumstellar disks.

Paving the way for ALMA : PdBI subarcsec observations of Class 0 protostars

Anaëlle Maury[1], Philippe André[1], Patrick Hennebelle[2]

[1] *Service d'Astrophysique, CEA Saclay*
[2] *Observatoire de Paris, LERMA*

Understanding both the formation of multiple systems and circumstellar disks is a major unsolved problem in star formation research. I will adress these questions, as seen at the earliest stages of star formation. Whether the collapse of a low mass prestellar core typically leads to the formation of a single star or a multiple system is still a matter of debate. Similarly, it is still largely unknown when, during the protostellar phase, the disk formation occurs. These two questions are closely linked since it is generally believed that multiple systems form by rotationally-driven fragmentation in the equatorial plane of the disk, at the Class 0 stage. Subarcsec imaging of young protostars observed early after point mass formation are crucially needed to provide critical tests of the models, and give insight into both the binary fragmentation and the disk formation processes. Indeed, interferometric imaging of Class 0 protostars often need a central compact component on scales of a few hundred AU to reproduce the (u,v)-amplitudes seen in the continuum data, but circumstellar disks were never resolved out around young Class 0 objects. I will present our recent 1.3 mm high-resolution PdBI observations of nearby low-mass Class 0 objects that set, for the first time, constraints on the structure and multiplicity rate on scales < 150 AU (typical of most PMS binaries) at the beginning of protostellar evolution. I will also discuss the constraints these observations provide on the properties of disks during the earliest stages of star formation, and the need for ALMA to settle these questions. Finally, thanks to detailed comparisons with numerical simulations of protostellar formation, I will show our PdBI observations of Class 0 objects favor the models of magnetized collapse againt the purely hydrodynamical ones.

Chemical evolution from cores to disks

Ruud Visser[1], Steve Doty[2], Ewine van Dishoeck[1,3], and Kees Dullemond[4]

[1] *Leiden Observatory*
[2] *Denison University*
[3] *MPE Garching*
[4] *MPIA Heidelberg*

The chemical composition of a molecular cloud changes dramatically as it collapses to form a low-mass protostar and circumstellar disk. We present the first model that can follow the entire chemical evolution from a pre-stellar core to a circumstellar disk in two spatial dimensions. It consists of a semi-analytical part to obtain 2D axisymmetric density and velocity profiles, and a full radiative transfer part to compute temperatures and UV fluxes. We follow material as it falls in from the cloud to the star and disk and we evolve a full gas-phase chemistry network – including freeze-out onto and evaporation from cold dust grains – along these trajectories. One of the key question we address is whether the chemical composition of the disk is a result of chemical processing during the collapse phase, or whether it is determined by in situ processing after the disk has formed.

Disks and the formation of the most massive stars

Harold W. Yorke[1]

[1] *Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA*

The occurance of circumstellar disks around stars in the process of forming is an inevitable consequence of the star formation process in molecular cloud cores of non-zero angular momentum. Massive stars, which must accrete a large amount of material in a relatively short period of time – thus, at high accretion rates, are no exception. Nevertheless, disks around massive stars will differ from their lower mass counterparts for a number of reasons:

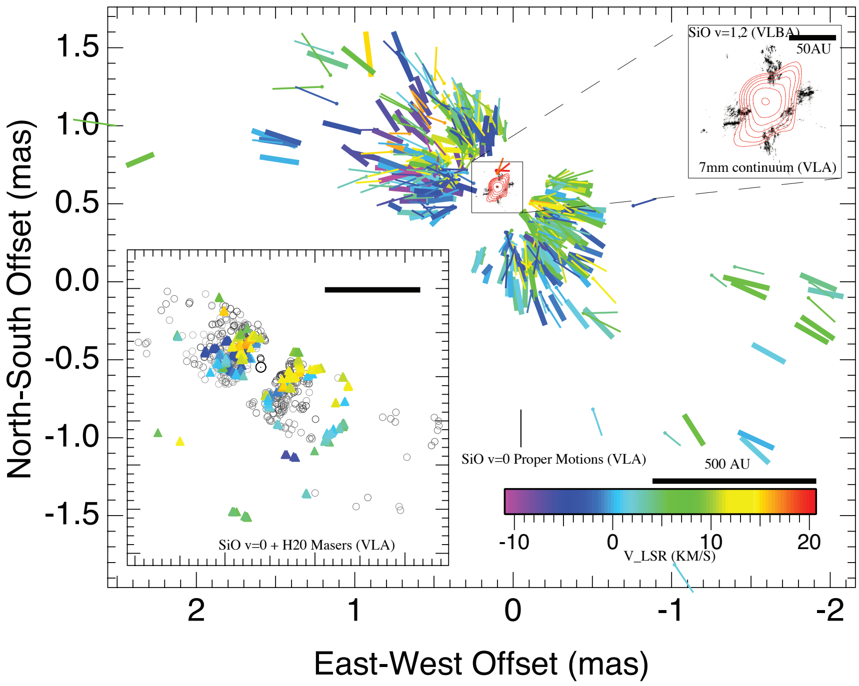
- Massive stars are significantly more luminous – radiative acceleration should play a much greater role in the disk's formation and evolution;
- The accretion rates onto massive (proto-)stars through accretion disks will be higher than their lower mass counterparts. The high accretion rates will strongly influence the evolution of the accreting object;
- Massive stars have a shorter pre-main sequence contraction timescale and will begin core hydrogen burning while still accreting material;
- Massive stars, once they have contracted to main sequence radii, are prolific emittors of ionizing UV radiation and strong stellar winds;
- Massive stars are formed in clusters and are generally members of multiple systems, resulting in complex mutual interactions;
- Disks around massive stars can expected to be short-lived $\sim 10^5$ yr;
- Planet formation around massive stars is highly unlikely.

An actual movie of accretion/ejection of material in a high-mass YSO in Orion BN/KL at radii comparable to the Solar System

Ciriaco Goddi[1]

[1] *European Southern Observatory, Karl-Schwarzschild-Strasse 2, D-85748 Garching bei Mnchen*

Around high-mass Young Stellar Objects (YSOs), outflows are expected to be launched and collimated by accretion disks inside radii of 100 AU. Strong observational constraints on disk-mediated accretion in this context have been scarce, largely owing to difficulties in probing the circumstellar gas at scales 10-100 AU around high-mass YSOs, which are on average distant (> 1 Kpc), form in clusters, and ignite quickly whilst still enshrouded in dusty envelopes. Radio Source I in Orion BN/KL is the nearest example of a high-mass YSO, and only one of three YSOs known to power SiO masers. Using VLA and VLBA observations of different SiO maser transitions, the KaLYPSO project (http://www.cfa.harvard.edu/kalypso/) aims to overcome past observational limitations by mapping the structure, 3-D velocity field, and dynamical evolution of the circumstellar gas within 1000 AU from Source I. Based on ∼20 epochs of VLBA observations of $v = 1, 2$ SiO masers over ∼2 years, I will present a movie of bulk gas flow tracing the compact disk and the base of the protostellar wind at radii < 100 AU from Source I. In addition, based on 4 epochs of VLA observations over ∼10 years, we tracked proper motions of $v = 0$ SiO masers, which trace a bipolar outflow expanding with a characteristic velocity ∼ 20 km s^{-1} at radii of 100-1000 AU from Source I, along an axis perpendicular to that of the disk traced by the $v = 1, 2$ masers. Finally, based on 4 epochs of VLA observations of the radio continuum emission spanning 10 years, we performed an evolutionary study of the ionized disk around Source I (40 AU radius) and tracked the proper motion of the central protostar. I will discuss these observational findings in the context of the large-scale outflows in the BN/KL region, and comment on implications for the structure of the global star forming region. The analysis of the complete (VLBA and VLA) dataset provides the most detailed evidence to date that high-mass star formation occurs via disk-mediated accretion.



Weighing a High Mass Protostellar Candidate: Physics and Kinematics of the M 17 Disk and its associated H_2 Jet

Dieter E. A. Nürnberger[1]

[1] *European Southern Observatory, Casilla 19001, Santiago 19, Chile; dnuernbe@eso.org*

The formation of high mass stars is still a heavily debated subject, as it is the nature of the largest ever found accretion disk in M 17. In my presentation I will focus on brand-new results obtained from high angular resolution (AO supported) and high spectral resolution observations of the M 17 disk, seen almost edge-on in silhouette against the diffuse background emission of the M 17 H II region. New CRIRES data allow to investigate in so far unmatched detail the kinematics of gas and dust within the disk plane and, by comparison of the derived rotation curve to theoretical models, to constrain the mass of the central protostellar source. New SINFONI data complement our previous studies of a collimated SouthWest jet and allow to investigate the properties of a newly discovered NorthEast counter jet. From these data a new attempt is made to constrain the mass accretion rate onto the central source and thus to further quantify the formation of a high mass star via disk accretion.

Disks statistics: IR surveys of low and high mass star forming regions

Karl R. Stapelfeldt[1]

[1] *Spitzer Project Science Office, Jet Propulsion Laboratory, California Institute of Technology*

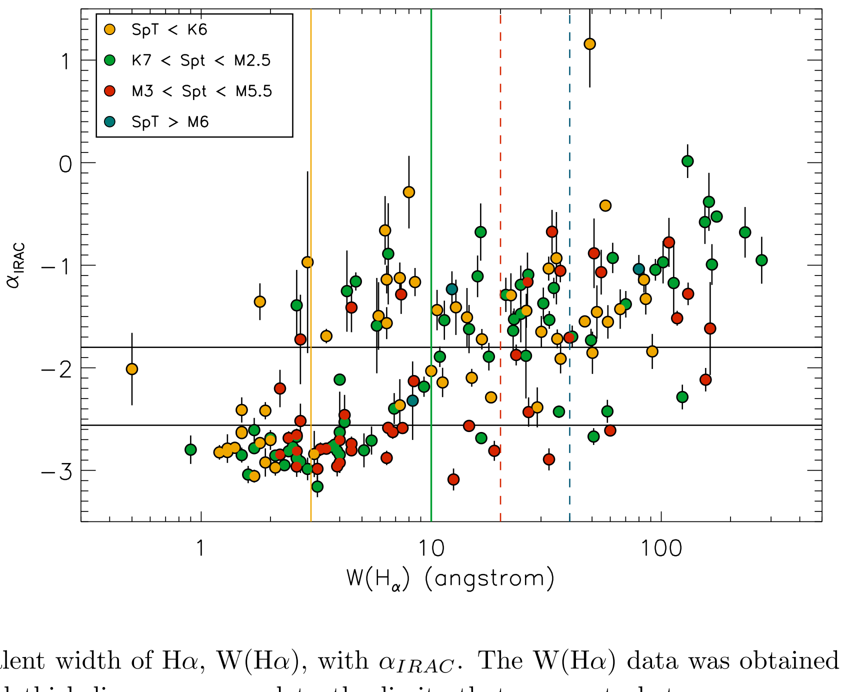
NASA's Spitzer Space Telescope completed its cryogenic mission on 15 May 2009. Surveys of star-forming regions have been a major activity, with six large legacy science projects and numerous small programs. Nearby molecular clouds such as Taurus, Ophiuchus, and Orion have been mapped in 6 or 7 infrared bands, as has much of the galactic plane. These studies have revealed new young stars with infrared excesses too faint or confused to detect in prior surveys; discovered new outflow structures tracing disk accretion history; revealed the full variety of spectral energy distributions that define the evolution of circumstellar disks and envelopes; and seeded a new generation of follow-up research at other wavelengths. This talk will review highlights of Spitzer circumstellar disk surveys, and update progress on the observatory's new "warm" mission.

***Spitzer*'s view of NGC 2264's circumstellar disk population**

Teixeira,P. S.[1], Lada, C.[2], Marengo, M.[2], Lada, E.[3],, Stolte, A[4,5], Young, E.[6]

[1] *European Southern Observatory, Karl-Swarzschild-Str. 2, D-85748 Garching bei München, Germany*
[2] *Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, M.S. 72, Cambridge, MA 02138, U.S.A.*
[3] *Department of Astronomy, University of Florida, Gainesville, FL 32611, U.S.A.*
[4] *UCLA, 430 Portola Plaza, Los Angeles, CA 90095-1547, U.S.A.*
[5] *Physikalisches Institut, Universität Köln, Zülpicher Str. 77, 50937 Köln, Germany*
[6] *Steward Observatory, University of Arizona, 933 North Cherry Avenue, Tucson, AZ 85721, U.S.A.*

We present the results of a multi-wavelength observational study of the disk population in the young cluster NGC 2264. The observations discussed here consist of data obtained with the Infrared Array Camera (IRAC) and Multiband Imaging Photometer on board the Spitzer Space Telescope, combined with deep ground-based near-infrared (NIR) FLAMINGOS imaging data and previously published optical data. We identified those sources detected in all four IRAC bands that have excess emission characteristic of circumstellar disks. We divide the disk population into 3 classes based on their spectral energy distribution shapes (measured by the IRAC slope, α_{IRAC}): (i) optically thick disks, (ii) homologously depleted anemic disks, and (iii) radially depleted transition disks. Figure 1 shows how Hα varies for sources in each of these classes. We hypothesize that there may be two distinct evolutionary paths for disks: a homologous one where the disk emission decreases uniformly in NIR and mid-infrared wavelengths (anemic disks) and throughout which most sources pass, and a radially differential one where the emission from the inner region of the disk decreases more rapidly than from the outer region (transition disks). Whether a disk evolves in a homologously or radially depleted fashion may depend on the nature of planet formation in the disk.



Variation of the equivalent width of Hα, W(Hα), with α_{IRAC}. The W(Hα) data was obtained from Dahm & Simon (2005). The horizontal thick lines correspond to the limits that segregate between sources with thick disks (-0.5 $> \alpha_{IRAC} >$-1.8), anemic disks (-1.8 $> \alpha_{IRAC} >$ -2.56), or diskless sources ($\alpha_{IRAC} <$ -2.56). The vertical colored lines represent W(Hα) limits that are used to separate accreting and non-accreting sources; these limits are a function of spectral type (White & Basri, 2003). The data are correspondingly color-coded according to the spectral type of the sources.

The Role of Multiplicity in Protoplanetary Disk Evolution

Adam L. Kraus[1], Michael J. Ireland[2]

[1] *University of Hawaii*
[2] *University of Sydney*

Interactions with close stellar or planetary companions can significantly influence the evolution and lifetime of protoplanetary disks. It has recently become possible to search for these companions, directly studying the role of multiplicity in protoplanetary disk evolution. I will describe an ongoing survey to directly detect these stellar and planetary companions in nearby star-forming regions. Our program uses adaptive optics and sparse aperture mask interferometry to achieve typical contrast limits of $\Delta K = 5-6$ at the diffraction limit (5–8 M_{Jup} at 5–30 AU), while also detecting similar-flux binary companions at separations as low as 15 mas (2.5 AU). In most cases, our survey has found no evidence of companions (planetary or binary) among the well-known "transitional disk" systems; if the inner clearings are due to planet formation, as has been previously suggested, then this paucity places an upper limit on the mass of any resulting planet. Our survey also has uncovered many new binary systems, which the majority falling among the diskless (WTTS) population. This disparity suggests that disk evolution for close (5–30 AU) binary systems is very different fom that for single stars. As we show in Figure 1, most circumbinary disks are cleared by ages of 1–2 Myr, while most circumstellar disks are not. These diskless binary systems have biased the disk frequency downward in previous studies. If we remove our new systems from those samples, we find that the disk fraction for single stars could be higher than was previously suggested.

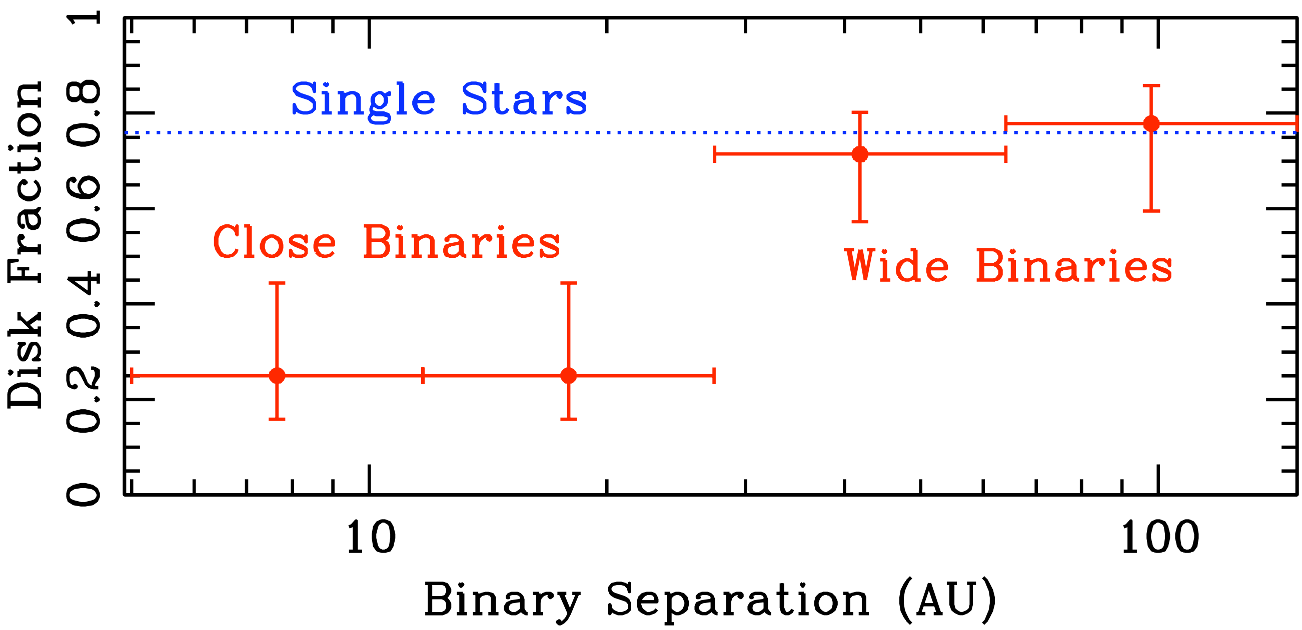


Figure: Disk fraction as a function of binary separation in Taurus-Auriga. Red points denote the disk fraction for several ranges of projected binary separations, while the blue dotted line shows the disk fraction for apparently single stars. Binary systems with separations of <30 AU have a significantly lower disk fraction than the population as a whole, whereas the disk fractions for wider binary systems and for single stars are indistinguishable.

Disk theory: disk structure and evolution, grain growth and mixing processes

K. Dullemond[1]

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

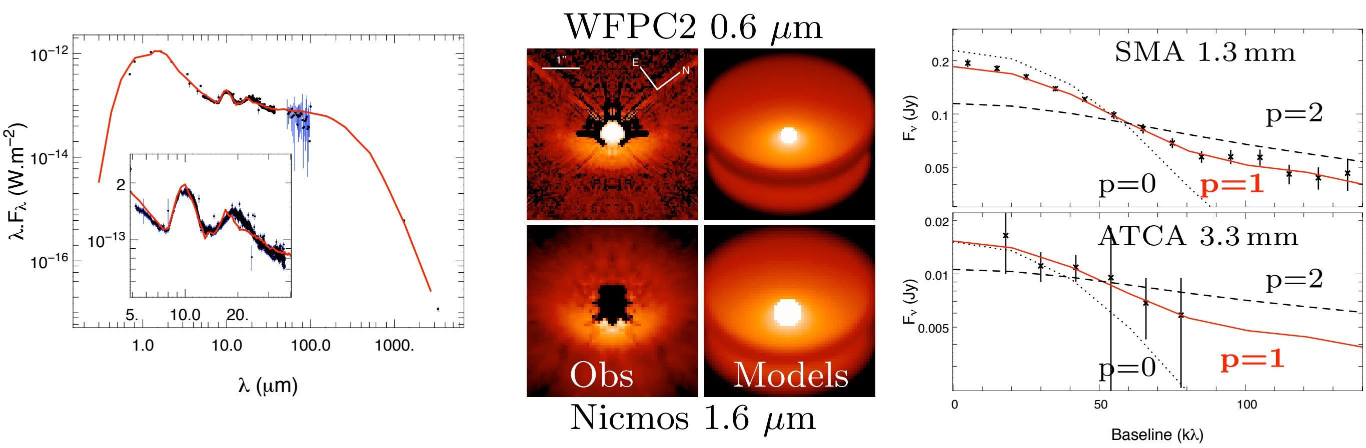
In this talk I will review where theoretical modeling of protoplanetary disks stands, putting special emphasis on disk modeling that has direct relevance to the interpretation of observations of protoplanetary disks. I will show how one can constrain issues of disk structure and evolution, as well as what we can learn of the first stages of planet formation - and what not. In addition to reviewing these topics I will present some of the work I myself am involved in related to these topics.

Muti-technique observations and modelling of the gas and dust phases of protoplanetary disks.

C. Pinte[1,2], F. Ménard[2], G. Duchêne[2,3], J.C. Augereau[2]

[1] *School of Physics, University of Exeter, Stocker Road, Exeter EX4 4QL, United Kingdom*
[2] *Laboratoire d'Astrophysique de Grenoble, CNRS/UJF UMR 5571, 414 rue de la Piscine, B.P. 53, F-38041 Grenoble Cedex 9, France*
[3] *Astronomy Dept, UC Berkeley, Berkeley CA 94720-3411, USA*

A wide range of high-quality data is becoming available for protoplanetary disks. From these data sets many issues have already been addressed, such as constraining the large scale geometry of disks, finding evidence of dust grain evolution, as well as constraining the kinematics and physico-chemical conditions of the gas phase. Most of these results are based on models that emphasise fitting observations of either the dust component (SEDs or scattered light images or, more recently, interferometric visibilities), or the gas phase (resolved maps in molecular lines). In this contribution, we will present a more global approach which aims at interpreting consistently the increasing amount of observational data in the framework of a single model, in order to to better characterize both the dust population and the gas disk properties, as well as their interactions. Results of such modeling applied to a few disks (e.g. IRAS 04158+2805, IM Lup) with large observational data-sets available (scattered light images, polarisation maps, IR spectroscopy, X-ray spectrum, CO maps) will be presented. We will discuss these results in the context of forthcoming instruments such as Herschel and ALMA.



Multiwavelength modelling of the observations of the disk surrounding IM Lupi. *Left panel:* SED. The mm spectral index indicates the presence of large mm-sized grains whereas the silicate bands indicate that micron-sized grains dominate in the disk surface, suggesting a stratified structure for the disk, with small grains at the surface and bigger grains close to the midplane. *Central panel:* the scattered light images at 0.6 and 1.6 μm give strong constraints on the disk geometry. *Right panel:* millimetre visibilities at 1.3 and 3.3 mm. In the right panel, several models with different surface density $\Sigma(r) \propto r^{-p}$ are presented, only the model with $p = 1$ reproduce the observations. The combination of these data allow strong constraints on the model parameters. From Pinte et al 2008, A&A, 489, 633.

Constraining disk models with observations of the inner and outer disk

Andrea Isella

Department of Astronomy, California Institute of Technology, MC 249-17, Pasadena, CA 91125, USA

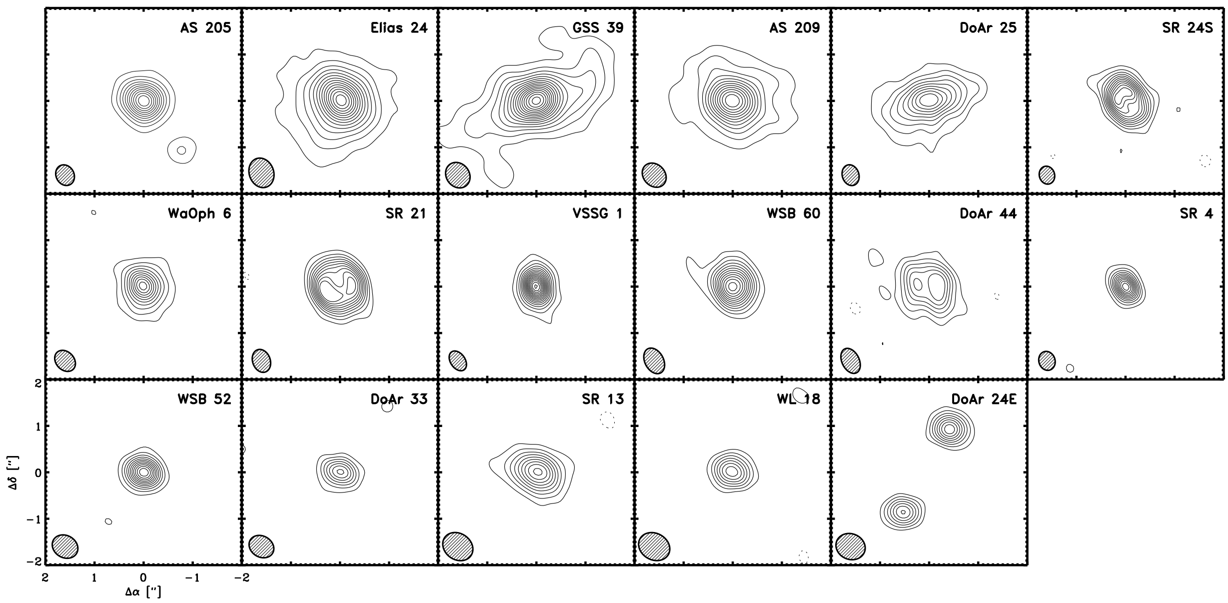
Interferometric observations at near-infrared, mid infrared and sub-millimeter wavelengths provide information on the structure of pre-main sequence circumstellar disks on spatial scales from a fraction to few hundreds of AU. Interferometers working in the infrared still produce few visibilities points and very limited information on the real morphology of the disk emission. Nevertheless, once compared with theoretical disk models they provide insight into the region where the disk interacts with the central star, where stellar jets are thought to be lunched and planets to form. Sub-millimeter interferometers maps the dust and gas emission on larger scales, leading to a better understanding of global disk properties, such as the radial dust distribution, the gas kinematics and the disk total mass. In this talk I will review the most recent interferometric results on circumstellar disks and discuss how well we can constrain disk models.

Protoplanetary Disks at High Angular Resolution with the SMA

Sean Andrews[1], David Wilner[1], Meredith Hughes[1], Chunhua Qi[1], and C. P. Dullemond[2]

[1] *Harvard-Smithsonian Center for Astrophysics, Cambridge, MA, USA*
[2] *Max Planck Institut für Astronomie, Heidelberg, Germany*

Direct observations of the primordial reservoirs of planet-building material – the disks around young stars – play a critical role in developing theoretical models of planet formation mechanisms and their efficiencies. I present a state-of-the-art high angular resolution (0.3" = 40 AU) SubMillimeter Array survey of the 345 GHz (870 microns) dust continuum emission from young protoplanetary disks in the Ophiuchus star-forming region. Two-dimensional radiative transfer calculations are used to simultaneously fit the observed continuum visibilities and broadband SED for each disk with a parametric structure model. Compared to previous work, significant upgrades in the modeling, data quality, and angular resolution for this survey provide improved constraints on key structure parameters, particularly those that describe the spatial distribution of mass. Those modeling results are used to help characterize the viscous properties and the likelihood of future (and perhaps even past) planet formation in these disks.

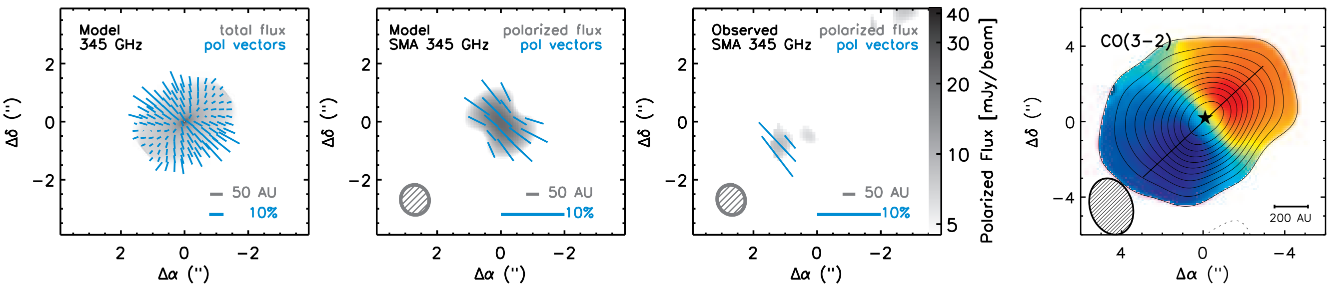


Millimeter-Wavelength Signatures of Viscosity in Protoplanetary Disks

A. M. Hughes[1], D. J. Wilner[1], et al.

[1] *Harvard-Smithsonian Center for Astrophysics*

The structure and evolution of protoplanetary disks is governed largely by the viscous transport of material through the disk, and yet remarkably few observational constraints exist on the physical mechanisms thought to drive accretion in these systems. The most commonly invoked mechanism is an anomalous viscosity generated by MHD turbulence, thought to be driven by the magnetorotational instability. These models predict significant turbulence as well as a magnetic field threading the disk. Submillimeter interferometry is a powerful tool for revealing observational signatures of these processes in two ways: (1) polarimetry is uniquely suited for constraining magnetic field strength and geometry independent of disk structure, and (2) high spectral resolution molecular line data can reveal the non-thermal broadening of spectral lines, the only directly observable quantity associated with turbulence. We present arcsecond-scale Submillimeter Array observations of the disks around the nearby young stars TW Hydrae and HD 163296, using the polarimeter to constrain the magnetic field properties and the high-resolution correlator mode to probe the CO(3-2) line at a spectral resolution of 44 m/s, well below the turbulent linewidths inferred from lower-resolution observations. We obtain the most stringent limits to date on polarized millimeter-wavelength emission from the disks around young stars, and compare the limits with realistic models of polarized emission from dust grains aligned with magnetic fields threading the disk. We find very low turbulence in the disk around TW Hya and a linewidth of order 100 m/s in the disk around HD 163296, which is resolved in the spectral domain for the first time by our observations. We discuss these results in the context of models of the viscous evolution of protoplanetary disks.



Left three panels: Comparison between the Cho & Lazarian (2007) model and the SMA 340 GHz observations of HD 163296. The top row shows the prediction for the model at full resolution (left), a simulated observation of the model with the SMA (center), and the SMA observations (right). The grayscale shows either the total flux (left) or the polarized flux (center, right), and the blue vectors indicate the percentage and direction of polarized flux at half-beam intervals. The size and orientation of the synthesized beam is indicated in the lower left of each panel. *Right panel:* Moment map of the SMA CO(3-2) emission from HD 163296 at a spectral resolution of 44 m/s. Contours indicate velocity-integrated intensity; they start at 2σ and increase by intervals of 3σ. Colors indicate intensity-weighted velocity. The high spectral resolution of this data set allows us to probe the turbulent linewidth.

Gas and Dust in Protoplanetary Disks

Thomas Henning

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

The talk will summarize recent progress in the characterization of gas and dust in protoplanetary disks with special emphasis on stellar and environmental parameters. I will discuss dust mineralogy, including a discussion of the variety of crystallization processes. Transition disks will be a special focus of the talk.

Gaps instead of Holes: How to Detect the Innermost Dust in Transition Disks and Rule out Stellar Companions with the Keck Interferometer

Jörg-Uwe Pott[1,2,3], Marshall D. Perrin[2], Elise Furlan[2,4], Stanimir Metchev[2,5], Andrea M. Ghez[2,6], Tom M. Herbst[3]

[1] *W. M. Keck Observatory, California Association for Research in Astronomy, 65-1120 Mamalahoa Hwy, Kamuela, HI 96743*
[2] *Division of Astronomy & Astrophysics , University of California, Los Angeles, CA 90095-1547*
[3] *Max-Planck-Institut für Astronomie, Königstuhl 17, D-69117 Heidelberg, Germany*
[4] *Jet Propulsion Laboratory, Caltech, Mail Stop 264-767, 4800 Oak Grove Drive, Pasadena, CA 91109*
[5] *Department of Physics and Astronomy, State University of New York, Stony Brook, NY 11794-3800*
[6] *Institute of Geophysics and Planetary Physics, University of California, Los Angeles, CA 90095-1565*

With the Keck Interferometer, we have studied the innermost regions of several nearby, young "transitional disks", which are characterized by a significant depletion of optically thick dust within a few AU of the central star. Our K-band [2 μm] observations target five of the six clearest cases of transitional disks in the Taurus/Auriga star- forming region (DM Tau, GM Aur, LkCa 15, UX Tau A, and RY Tau) and are sensitive to binary stars with separations ranging from 2.5 to 30 mas (0.35 - 4 AU), which corresponds to the range of binary star systems that could dynamically cause inner holes in the optically thick dust distributions with sizes comparable to that estimated from model fits to spectral energy distributions (SED) for these systems. At the 99.7 % confidence level, the observed visibilities exclude binaries with flux ratios of at least 20:1 over $\sim$ 95% of the area covered by our measurements. While a companion has previously been detected in the transition disk system with the largest hole size, CoKu Tau 4, we can exclude similar mass companions as the typical origin for the clearing of inner dust in transitional disks. One important difference between CoKu Tau 4 and the systems studied here is evidence for accretion; while CoKu Tau 4 shows no signatures of accretion, all the others show some evidence of accretion. Furthermore, we find that all but one of the targets are clearly spatially resolved in a way that is consistent with a simple model of hot material from a small scale (0.1 AU) circumstellar disk inside the nominal hole. Most notable is DM Tau, which shows no measurable near-infrared excess in its SED, but we find $\sim$ 5% of the K-band emission to be resolved. While in some cases, the scale of the resolved emission appears to be consistent with the SED modeling, in others it is not. Future modeling is required to resolve these detailed differences. In either case, these observations support the notion that some transitional disks have radial gaps in their optically thick material, which could be an indication for planet formation in the habitable zone ($\sim$ a few AU) of a protoplanetary disk.

The complex structure of the inner disks around Herbig AeBe stars: spectro-interferometry of HD163296 and HD100546

M. Benisty[1], A. Natta[1], E. Tatulli[2], A. Isella[3], F. Ménard[2], J-P. Berger[2], F. Massi[1], G. Duvert[2], S. Kraus[4], J-B. LeBouquin[5], F. Malbet[2,3], J. Olofsson[2], M. Swain[6], L. Testi[7]

[1] *INAF-Osservatorio Astrofisico di Arcetri, Largo Fermi, 5, 50125, Firenze, Italy*
[2] *LAOG, 414 rue de la Piscine, 38400 St Martin d'Hères, France*
[3] *Caltech, MC 105-24, 1200 East California Blvd, Pasadena, CA 91125, USA*
[4] *Max Planck Institut für Radioastronomie, Auf dem Hügel 69, 53121 Bonn, Germany*
[5] *ESO, Casilla 19001, Santiago 19, Chile*
[6] *JPL, Caltech, 4800 Oak Grove Drive, Pasadena CA 91109, USA*
[7] *ESO, Karl-Schwarzschild-Strasse 2, 85748 Garching, Germany*

The distribution of the circumstellar material surrounding Herbig AeBe stars has been widely debated. In the past decade, the general consensus has been that the observed near infrared excess is due to thermal emission from hot dust located at the sublimation radius. In this talk, I will present two cases that suggest that this description can be too simple.

First, I will show impressive long-baseline spectro-interferometric observations of the Herbig Ae star HD163296 obtained with the AMBER instrument at VLTI, resulting in the largest UV coverage achieved on a young star today. Model fitting of the SED, K and H-band visibilities and closure phases, proved that an additional component must exist inside the dust sublimation radius and that it dominates the near-infrared continuum emission. This emission is optically thin and extends from $\sim$0.1 AU to $\sim$0.45 AU. I will argue that refractory dust grains such as iron, graphite or corundum -rather than gas- could be responsible for it, a conclusion that is supported by the absence of strong molecular lines in the spectral energy distribution.

I will also present the case of HD100546, an old Herbig Be star. AMBER/VLTI spectro-interferometric observations probed the sub-AU dusty disk located inside the protoplanetary gap that was previously inferred by spectroscopy and direct imaging. Radiative transfer modelling interestingly showed that, although generally neglected, scattered light has a large contribution to the near infrared continuum emission in HD100546. In fact, models in which thermal emission is the major contribution can not explain the interferometric observations.

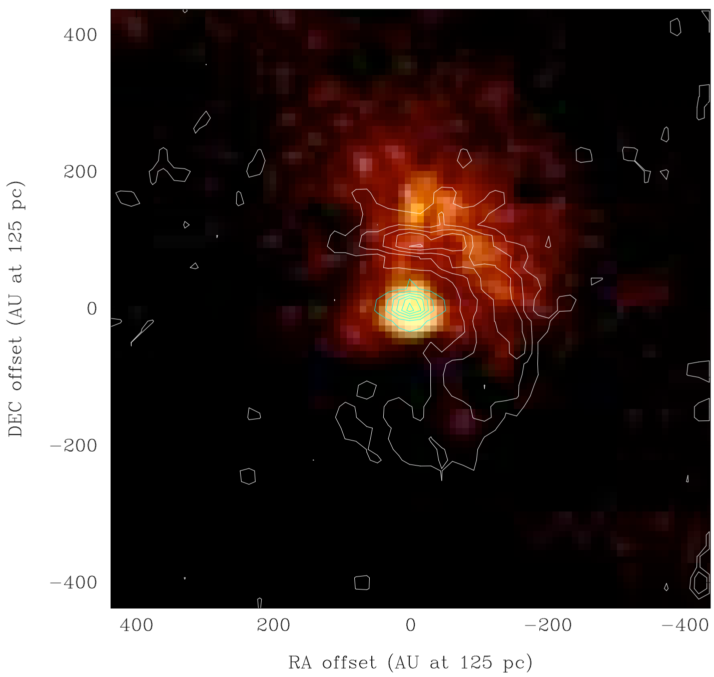
These two studies emphasize that these close environments can be very complex and could not be described by a common idea. Deeper understanding in fact requires multi-wavelength observations together with sophisticated models, including for example self-consistent treatment of gas and dust emissions.

Comparing the gas and dust spatial distribution in disks around young low-mass stars

Olja Panić[1,2], M. R. Hogerheijde[1], D. Wilner[3], C. Qi[3] and B. Merín[4]

[1] *Leiden Observatory, Leiden, The Netherlands*
[2] *European Southern Observatory, Garching, Germany*
[3] *Harvard Smithsonian Center for Astrophysics, Cambridge (MA), USA*
[4] *Herschel Science Centre, European Space Astronomy Centre (ESA), Madrid, Spain*

The recent sub-millimetre and near-infrared instrumentation allows to spatially resolve the gas and dust emission from circumstellar discs. Especially the dust distribution can be modelled in detail, to reproduce the images and the broad-band spectral energy distribution. In this contribution, we investigate how well the spatial distribution and intensity of the molecular gas lines compares to the above models. We present data on three stars, the classical T Tauri star IM Lup, the weak-line T Tauri star DoAr 21 and the Herbig Ae star HD100546. We find that the CO gas emission around IM Lup is much more extended than the dust (800 versus 400 AU radius). We speculate about possible processes that could have led to divergent evolution for the gas and the dust in the outermost disc regions, such as dust radial drift. We trace the surface of the transitional disk around DoAr 21 through ro-vibrational H_2 emission at 2.12μm, resolved with the SINFONI instrument on VLT (see Fig.1, colour scale), and the warm dust emission at 18 μm resolved with VISIR (see Fig. 1, contours). Here we find the gas and dust to reside in an arc of material extending from as much as 100 to 200 AU from the star, consistent with the lack of dust emission seen in the SED below 20 μm wavelength. The peculiar geometry suggests that we are witnessing a global perturbation of the disk. Finaly, APEX/CHAMP+ observations of CO gas towards HD100546 are shown to illustrate the relation between the spatial distribution of gas and the rotational CO line spectrum in discs around Herbig AeBe stars.



Gas and dust emission from DoAr 21 observed using SINFONI and VISIR instruments on VLT.

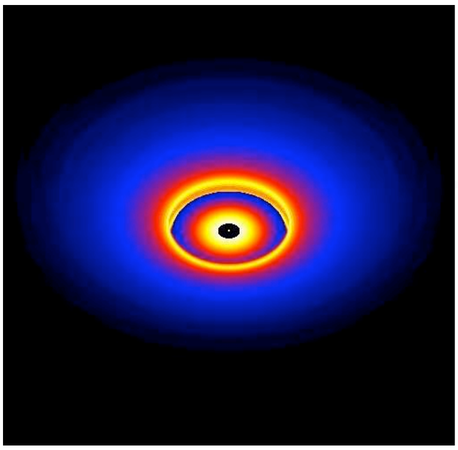
New results from infrared interferometric studies of the innermost parts of protoplanetary accretion disks

Thomas Preibisch[1], Stefan Kraus[2], Thorsten Ratzka[1], Gerd Weigelt[2]

[1] *Universitäts-Sternwarte München, Scheinerstr. 1, 81679 München, Germany*
[2] *Max-Planck-Institut für Radioastronomie, Auf dem Hügel 69, 53121 Bonn, Germany*

Long-baseline interferometry at near- and mid-infrared wavelengths can provide very high angular resolution of up to 1 milli-arcsecond, what translates to linear dimensions of less than 0.2 AU for young stellar objects in nearby star forming regions. Interferometric observations can thus spatially resolve the important innermost parts of circumstellar disks and allow to directly study the regions where disk matter is accreted onto the star, where terrestrial planets may form, and where jets and outflows are thought to be launched and collimated. With spectrally dispersed interferometric observations it is now possible to distinguish gas and dust, and thus to derive important information about the spatial distribution of each of the different constituents of the circumstellar disks.

In this talk I will present recent results of our near- and mid-infrared interferometric observations of young stellar objects with the ESO Very Large Telescope Interferometer. I will specifically address the interferometric detection of strong near-infrared emission from hot inner gas disks around some young stars. Since this gaseous material, which is located inside the dust sublimation rim (see Figure), is accreted onto the star, the interferometric observations can yield direct information about the accretion luminosity and constraints on the spatial extent of the inner gas accretion disk. Infrared interferometry can thus provide a new and very useful diagnostic of the accretion process; in combination with other accretion tracers, such as hydrogen emission lines, it can deliver important new pieces of insight into the physical processes in the innermost regions of protoplanetary accretion disks.



Radiation transfer model image of the innermost $\sim 3\,\mathrm{AU} \times 3\,\mathrm{AU}$ region of a circumstellar disk seen in the near-infrared K-band. The outer regions show emission from the dusty protoplanetary disk. The dust sublimation rim appears as a nearly vertical wall surrounding the inner dust-free gap around the central star. Inside the dust sublimation rim, emission from the inner hot gas disk can be seen.

Scattered light studies of protoplanetary and debris disks

Gaspard Duchêne[1,2]

[1] *University of California, Berkeley*
[2] *Laboratoire d'Astrophysique de Grenoble*

It has been a quarter of a century since the first image of a disk around a star other than our Sun, the debris disk surrounding Vega, has been taken. Since then, over a hundred and twenty disks have been imaged at one wavelength or another since then, covering broad ranges of stellar ages and masses. While obtaining disk images presents serious observational challenges, such datasets have proved crucial in our understanding of the properties and evolution of circumstellar disks. Gathering the spectral energy distribution (SED) of a disk is comparatively easy and its analysis remains the most immediate mean of probing its structure and dust content. However, because of its lack of spatial information, the SED leaves unanswered a number of ambiguities regarding the physical properties of any given disk. Spatially-resolved datasets provide the missing elements to solve for these ambiguities and further offer a unique opportunity to study finer details, such as the spatial structure of disks. Leaving the rich field of millimeter interferometric mapping aside, I will focus in this talk on images of disks obtained in the scattered light regime, from the optical to the mid-infrared regime. At these wavelengths, a very high angular resolution can be achieved, providing an unprecedented view of the structure of disks. Furthermore, because of the underlying physics, scattered light is a powerful tool to probe dust properties, such as the grain size distribution and, to a lesser extent, composition. After reviewing the physical parameters that such images can help constrain, I will discuss some key examples of analyses of scattered light images that have been conducted in recent years on both protoplanetary and debris disks.

Chemistry in evolving protoplanetary disks

Ewine F. van Dishoeck[1,2]

[1] *Leiden Observatory, Leiden University*
[2] *Max Planck Institut fur extraterrestrische Physik, Garching*

This talk presents an overview of recent developments in observations and models of the chemistry in protoplanetary disks at various stages of evolution. Submillimeter single-dish and interferometry data probe the chemistry of the outer disk and show the importance of photodissociation and ion-molecule reactions in the warm upper layers, with freeze-out in the cold midplane of the disk. Spitzer and ground-based infrared telescopes probe mostly the surface layers in the inner few AU of disks and reveal surprisingly strong lines of water and simple organic molecules. The observational data will be discussed in the context of physical and chemical models of flared, non-flared and transitional disks with inner holes and their evolution from protostellar regions to the debris disk phase. Special attention will put on the importance of an accurate description of the photoprocesses as grains grow and disks evolve from the gas-rich to the gas-poor phase. Laboratory experiments of key chemical processes are essential input to such models. Tools for simulating spectra of model disks will be summarized and prospects for Herschel, ALMA and ELTs to probe different aspects of disk chemistry will be illustrated.

Observations of Water and Organic Molecules in Circumstellar Disks

Salyk, C.[1], Pontoppidan, K. M.[2], Blake, G. A.[2], Najita, J.[3], Carr, J.[4]

[1] *University of Texas at Austin*
[2] *California Institute of Technology*
[3] *National Optical Astronomy Observatory*
[4] *Naval Research Laboratory*

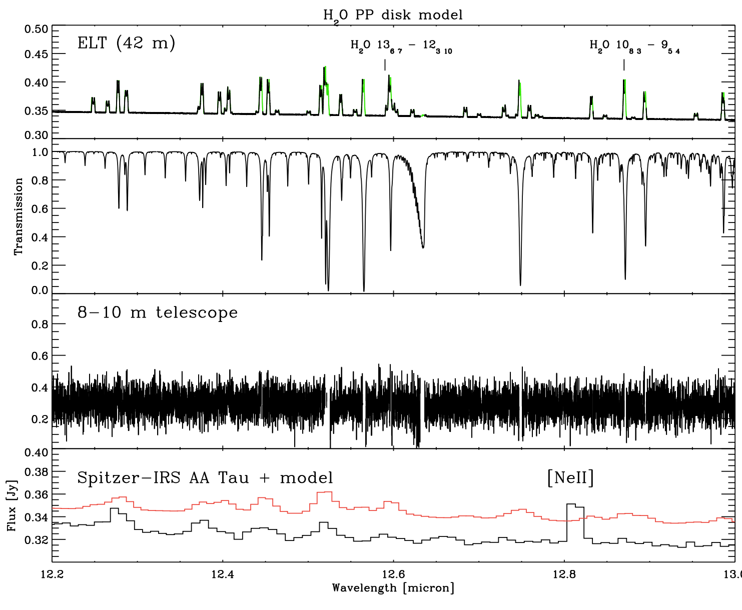
Recent Spitzer InfraRed Spectrograph (IRS) detections of water and organic molecules in protoplanetary disks (Carr & Najita 2008, Salyk et al. 2008) represent a turning point in the study of the physical and chemical development of terrestrial planet-forming regions. We will present recent results from Spitzer-IRS spectra, including data from the "cores to disks" (c2d) legacy program and other archive data, as well as from our GO-5 program "Water and Organics in Disks" (PI: J. Carr). The latter program was specifically designed to obtain the high S/N required to detect molecular emission from disks, and spans an expansive range in disk activity and physical state. Molecular emission can be influenced by a variety of factors, including condensation and radial/vertical transport of molecules, the local radiation environment, disk chemistry, dust settling and grain growth. In order to disentangle these effects, we compare molecular emission with a variety of stellar and disk parameters. In addition, we are are developing water emission models, incorporating non-LTE excitation and a variety of disk parameters, including variable gas/dust ratios, vertical and radial concentration gradients, and disk turbulence, in order to reproduce and interpret the observed spectra (Pontoppidan et al. 2009, ApJ, 704, 1482, Meijerink et al. 2009, ApJ, 704, 1471). We find that emission from water and other molecules (OH, CO_2, HCN and C_2H_2) is common in Spitzer-IRS high-resolution spectra with sufficient S/N, and that the water appears to arise from the inner few AU of the disk. The spectra show significant diversity in line strengths and molecular ratios, and detection rates strongly dependent on spectral type. We will discuss these results and our most recent analysis of this extensive dataset.

Radiative transfer modeling on AU-scales of mid-infrared water lines from protoplanetary disks

Rowin Meijerink[1], Klaus M. Pontoppidan[1], Geoffrey A. Blake[1], Cornelis P. Dullemond[2]

[1]*California Institute of Technology, Division of Geological and Planetary Sciences, MS 150-21, Pasadena, CA 91125, USA*
[2]*Max-Planck-Institut für Astronomie, Königstuhl 17, 69117 Heidelberg, Germany*

The material that formed the present-day Solar System originated in feeding zones in the inner solar disk located at distances within $\sim$ 20 AU from the Sun, known as the planet-forming zone. Meteoritic and cometary material contain abundant evidence for the presence of a rich and active chemistry in the planet-forming zone during the gas-rich phase of Solar System formation. It is a natural conjecture that analogs can be found among the zoo of protoplanetary disks around young stars. The study of the chemistry and dynamics of planet formation requires 1) tracers of dense gas at 100-1000 K and 2) imaging capabilities of such tracers with 5-100 (0.5-20 AU) milli-arcsec resolution, corresponding to the planet-forming zone at the distance of the nearest star-forming regions. We show that the rich infrared (2-200 micron) molecular spectrum recently found to be common in protoplanetary disks represents such a tracer and thus offers a unique opportunity for constraining both the structure and chemistry of planet-forming regions, beginning with current infrared imaging spectrometers and extending to the next generation of Extremely Large Telescopes and beyond. We have developed a set of non-LTE radiative transfer tools specifically designed to simulate mid-infrared line imaging observations with present and future facilities. The toolset is applied to spectroscopic observations of water vapor in protoplanetary disks with the Spitzer Space Telescope to show that the water vapor abundance in the disk surface must be truncated beyond $\sim$ 1 AU, in excess of what is possible with static chemistry models. We speculate that the depletion of water is due to vertical turbulent diffusion of water from the superheated surface to regions below the snow line, where the water can freeze out and settle to the midplane as part of the general dust settling. We suggest that such a vertical cold finger effect will be efficient due to the lack of a replenishment mechanism of water to the surface.



Simulations of ground-based observations of water lines from a typical protoplanetary disk (Pontoppidan, Meijerink et al. 2009, submitted).

Disk-star interaction: effects of the stellar radiation on the disk structure and appearance

Inga Kamp[1], Peter Woitke[2], Wing-Fai Thi[3]

[1] *Kapteyn Astronomical Institute, Rijksunversiteit Groningen, P.O. Box 800, 9700 AV Groningen, The Netherlands*
[2] *UK Astronomy Technology Centre, Royal Observatory, Edinburgh, Blackford Hill, Edinburgh EH9 3HJ, UK*
[3] *SUPA, Institute for Astronomy, Royal Observatory, Edinburgh, Blackford Hill, Edinburgh EH9 3HJ, UK*

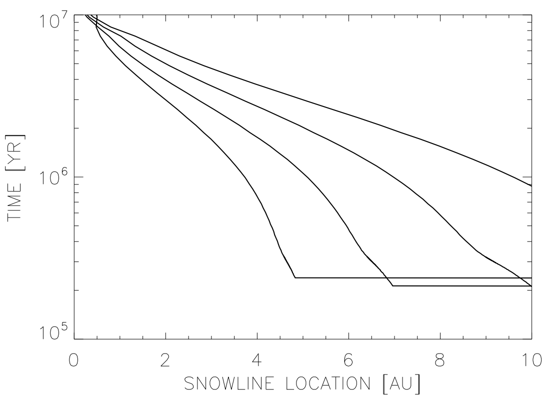
Observational evidence from the past 20 years of protoplanetary disks research, shows that disks around T Tauri stars differ from those around Herbig Ae stars in their size, mass and overall temperature. It remains to date an open question whether the reason for this are fundamental differences in the initial state of the disk or whether this is due to the vastly different luminosity and shape of radiation field from the central star. There is also observational evidence for different lifetimes of disks around low mass and high mass stars and inner holes that are substantially larger than the dust evaporation radius. The role of photoevaporation through stellar X-rays, EUV and FUV photons is one of the widely discussed explanations. I will discuss some more recent advances to understand disks across various spectral types in the framework of a single disk modeling approach. The goal is to develop the necessary physical, chemical and radiative transfer knowledge to understand the variety in disk appearance (e.g. emission lines, SEDs, dust features, lifetimes) from the basic stellar properties and radial mass distribution.

The Snow Line in Planet-Forming Disks: Location, Migration, and Implications

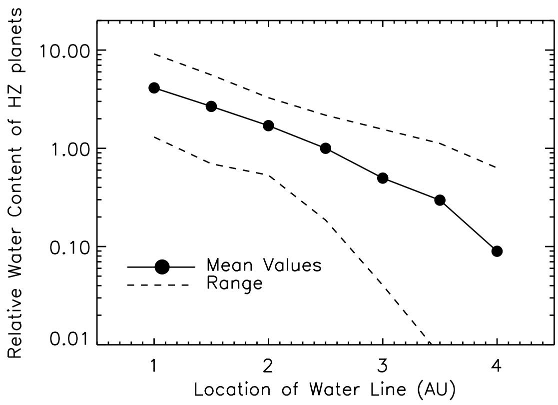
Eric Gaidos[1], Sean Raymond[2,3], Nick Moskovitz[4]

[1] *Department of Geology and Geophysics, University of Hawaii, Honolulu, USA*
[2] *CASA, University of Colorado, Boulder, USA*
[3] *Observatoire de Bordeaux, Bordeaux, France*
[4] *Department of Terrestrial Magnetism, Carnegie Institute of Washington, Washington DC, USA*

We present a self-consistent disk evolution/accretion model that describes the evolution of the water ice condensation point ("snow line") in planet-forming disks around solar-mass stars. Results from the model are used to make three salient points: First, the evolution of the snow line is sensitive to the nebular accretion rate, and the value (and time-evolution) of the latter is only grossly constrained by current observations of T Tauri stars (Hartmann 1991). Nebular accretion history is a principal governing parameter in nebular chemistry and variation between systems and should create diverse planetary outcomes. Second, for parameters relevant to the Solar nebula and for plausible accretion rates of nebular gas through the disk, during the first $2-3\times10^5$ yr, water does not condense *anywhere* in the disk (Figure 1), and in this interval accretion of Moon-sized objects can occur in the inner planetary system (Chambers 2006). These objects would form in a dry (although not necessarily reduced) state and might have included iron meteorite parent bodies. Third, migration of the snow line to the inner disk ($\sim$1 AU) is inevitable at the final stage of disk evolution (Figure 1). Introduction of substantial water ice into the inner Solar System might have been prevented if Jupiter and Saturn (or their cores) intercepted such material (Ciesla & Cuzzi 2006). We show how the abundance of water in terrestrial planets can vary by more than an order of magnitude with different snow line locations (Figure 2). Heating and devolatilization of planetesimals from the decay of ^{26}Al can influence the final volatile reservoirs of terrestrial planets (Gilmour 2008) if a significant mass remained in Vesta-sized bodies by 1 Myr. We also speculate about the role of the snow line in the formation of Jupiter (Stevenson & Lunine 1988). Our model, and those of many others, produces an enhancement in the planetesimal surface density of 2-3, too little to signficantly accelerate the formation of a Jupiter core before dissipation of nebular gas. On the other hand, the reversal in the profile of planetesimal surface density at the snow line may be sufficient to halt migration of large bodies migrating inwards as a result of planetesimal scattering (Kirsch et al. 2009), creating an "avalanche" to the snowline that may produce the required mass enhancement.



Snowline location around a solar-mass protostar with disk accretion rates of 10^{-9}-10^{-7} $M_\odot$ yr^{-1} decaying with a time constant of 1 Myr.



Mass-weighted water content of planets with final semi-major axis 0.8-1.2 AU as a function of snow line location (normalized to case of 2.7 AU).

Disk-star interaction: stellar magnetosphere and accretion

Jerome Bouvier[1]

[1] *Laboratoire dAstrophysique, Observatoire de Grenoble, Universite J. Fourier, CNRS, BP 53, 38041 Grenoble, Cedex 9, France*

I will briefly review the observational evidence for magnetospheric star-disk interaction in young stars. Recent results suggest that magnetically-channeled accretion from the inner disk edge onto the star is a very dynamical process, varying on all timescales, from hours to years. Numerical simulations support the magnetospheric accretion concept and models of accretion-powered stellar winds suggest that it is responsible for the regulation of the rotation rate of young stars. I'll show how one can relate disk accretion, rotation and lithium depletion, to estimate the minimum accretion disk lifetime required to form giant planets.

Dynamical Modelling of Outflows/Jets, Disk Formation, and Dispersal

Shu-ichiro Inutsuka[1]

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

Recent development of the resistive MHD calculations of the gravitational collapse process from the molecular cloud core is dramatical and enables us to understand early evolution of young stellar objects. I will show further development on how MHD outflows affect on the formation of protoplanetary disks and their evolutions. I will also discuss dynamical modelling of long-term evolution of magnetized disks and show that the protoplanetary disks clear up inside-out by the disk wind driven by magneto-rotational instability. Various implications to observations will be given.

Accretion Disks in the Sub-Stellar Realm: Properties and Evolution

Ray Jayawardhana[1]

[1] *University of Toronto*
[2] *Institute2*

It is now well established that young brown dwarfs harbor accretion disks –and thus undergo a T Tauri phase– similar to their low-mass stellar counterparts. The supporting evidence includes infrared and millimeter observations of the dust component as well as optical and infrared spectra with signatures of gas accretion and outflow. Recent findings suggest that disks are common even around young planetary mass objects. The ubiquity of circum-sub-stellar disks not only hints at a common formation scenario for PMOs, brown dwarfs and stars, but also offers a new regime for investigating processes such as episodic accretion, grain growth and disk clearing.

Disk Accretion in Young Stars and Brown Dwarfs with Multipole B-Fields

Subhanjoy Mohanty[1]

[1] *Imperial College London*

The manner in which young classical T Tauri stars (cTTs) accrete gas from their surrounding disks and simultaneously drive jets and outflows is central to star and planet formation, but remains an ill-understood and hotly debated subject. One of the central issues is the stellar field configuration: while analytic theories of magnetospheric accretion assume an idealized stellar dipole, T Tauri fields are observed to be complex multipolar beasts. I present here an analytic generalization of the popular X-wind theory to include such fields. Independent of the precise field geometry, the generalized model makes a a unique prediction about the relationship between various cTTs observables that is supported by recent detailed spectropolarimetric measurements. I also present numerical solutions of the theory that reproduce T Tauri hot spot and polarization features.

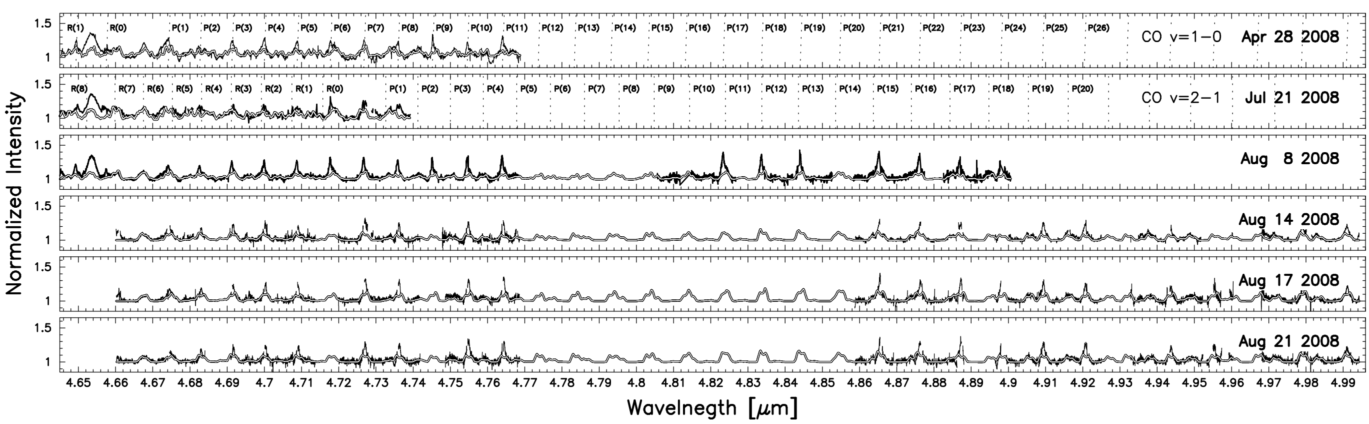
Finally, I discuss the unique insights offered by recent B-field measurements on accreting brown dwarfs: while they agree with the *accretion theory* above, they also pose a large puzzle for *magnetic field generation theory*. I propose a new possible solution, in the form of self-regulated accretion, with implications for disk-accretion in low-mass stars in general. Lastly, I touch on the significant advances anticipated in this area from recently initiated large surveys, and upcoming instruments such as CCAT and ALMA.

EX Lup Outburst in 2008 in CO Fundamental band

M. Goto[1], Z. Regaly,[2] C. P. Dullemond,[1] K. Pontoppidan,[3] M. van den Ancker,[4] A. Carmona,[5] D. Fedele,[1] A. Sicilia-Aguilar,[1] R. van Boekel,[1] Th. Henning,[1] A. Juhász,[1] P. Ábrahám,[2] L. Mosoni,[1],2 A. Kóspál,[6] E. van Dishoeck,[6] G. A. Blake,[2] J. Brown,[7] H. Terada,[8] T. Usuda[8]

[1]*Max-Planck-Institute für Astronomie*
[2]*Konkoly Observatory*
[3]*California Institute of Technology*
[4]*ESO*
[5]*ISDC*
[6]*Leiden Observatory*
[7]*Max-Planck-Institut für extraterrestrische Physik*
[8]*Subaru Telescope*

We report the monitoring of EX Lup in the CO fundamental band (4.6–4.9 μm) during its outburst in 2008. The observations were carried out at the *VLT* and the Subaru Telescope in 6 epochs from April to August 2008, covering the plateau of the outburst and the return to the quiescent state. The CO spectra consists of 2, possibly 3 components: the outburst, the quiescence, and the possible disk wind. The outburst spectrum is characterized by broad line emission ($\Delta v > 200$ km s^{-1}) from highly excited vibrational levels (v$\leq$6). The emission lines are short lived, fading on the same timescale with the optical outburst. The line profiles are double peaked, implying the emitting gas is orbiting around the central star at 0.03–0.2 AU. The quiescent emission is characterized by narrow lines ($\Delta v \approx 60$ km s^{-1}) with the equivalent width unchanged throughout the whole observing epochs. The emission lines arise at 0.3 AU from the central star if the line width represents the Keplerian rotation. These emission lines are exclusively from v=1-0 transition. The third, not well defined component, is the disk wind, which shows up as blue absorption toward the later epochs. The temporal variation of the CO spectra indicates an intriguing disconnection between the outburst and the quiescent emission. The outburst appears as if it is cut off from the outer disk, and accreted onto the star, while the outer disk is left behind, and only passively heated afterwards. EX Lup is an extreme case of rapid dissipation of gas in the inner disk, for which the gas kinematics during the dissipation is exceptionally well documented by CO spectroscopy. We will discuss which disk instability among those proposed to date best fits the picture.



Spectra of EX Lup in 6 epochs. The solid lines are the observed spectra. The gray lines are the calculated spectra for the outburst component based on a slab disk mode

From the dissipation of gas to the onset of debris: tracing the formation and evolution of planetary systems with Spitzer

Michael R. Meyer[1]

[1] *Institute for Astronomy ETH Zurich*

We will review recent observations of debris disks and what they can reveal about the formation and evolution of planetary systems with a special focus on the promise of upcoming facilities. In this presentation, we define a debris disk as one where the opacity we see is dominated by dust produced in collisions of planetesimals. We will concentrate on observed properties of disks as a function of wavelength (as a proxy for orbital radius) and compare results as a function of stellar mass when possible. We will start by summarizing the observational evidence for the appearance of dust debris and final gas disk dispersal. We then consider the observational signatures of terrestrial planet formation and giant impacts. We conclude by discussing the observational connection (or lack thereof) between known exoplanets and debris disks. If most planetary systems are dynamically full, then it may be those systems lacking signatures of debris that represent the richest planetary architectures.

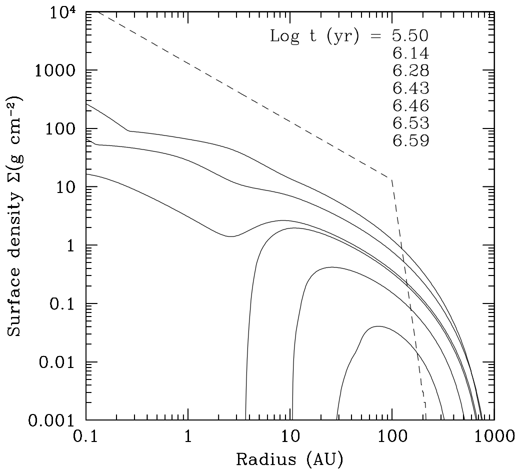
Time-Evolution of Viscous Circumstellar Disks due to Photoevaporation by FUV, EUV and X-ray Radiation from the Central Star

Uma Gorti[1], Kees Dullemond[2], & David Hollenbach[3]

[1] *NASA Ames Research Center, Moffett Field, CA*
[2] *SETI Institute, Mountain View, CA,*
[3] *Max Planck Institute for Astronomy, Heidelberg, Germany*

Abstract

We present the time evolution of viscously accreting circumstellar disks as they are irradiated by ultraviolet and X-ray photons from a low-mass central star. Our model is a hybrid of a 1D time-dependent viscous disk model coupled to a 1+1D disk vertical structure model used for calculating the disk structure and photoevaporation rates. We find that disks of initial mass 0.1 $M_\odot$ around ~ 1 $M\odot$ stars survive for $\sim 46 years, assumingaviscosityparameter \alpha = 0.01$, a time-dependent FUV luminosity $L_{FUV} \sim 10^{-2} - 10^{-3}$ ls and with X-ray and EUV luminosities $L_X \sim L_{EUV} \sim 10^{-3} L_\odot$. We find that FUV/X-ray-induced photoevaporation and viscous accretion are equally responsible for depleting disk mass. Photoevaporation rates are most significant at $\sim 1 - 10$ AU and at ~ 30 AU. Viscosity spreads the disk which causes mass loss by accretion onto the central star and feeds mass loss by photoevaporation in the outer disk. We find that FUV photons can create gaps in the inner, planet-forming regions of the disk ($\sim 1 - 10$ AU) at relatively early epochs in disk evolution while disk masses are still substantial. EUV and X-ray photons are also capable of driving gaps, but EUV can only do so at late, low accretion-rate epochs after the disk mass has already declined substantially. Disks around stars with predominantly soft X-ray fields experience enhanced photoevaporative mass loss. We follow disk evolution around stars of different masses, and find that disk survival time is relatively independent of mass for stars with 3 for 3 the disks are short-lived($\sim 10^5$ years).



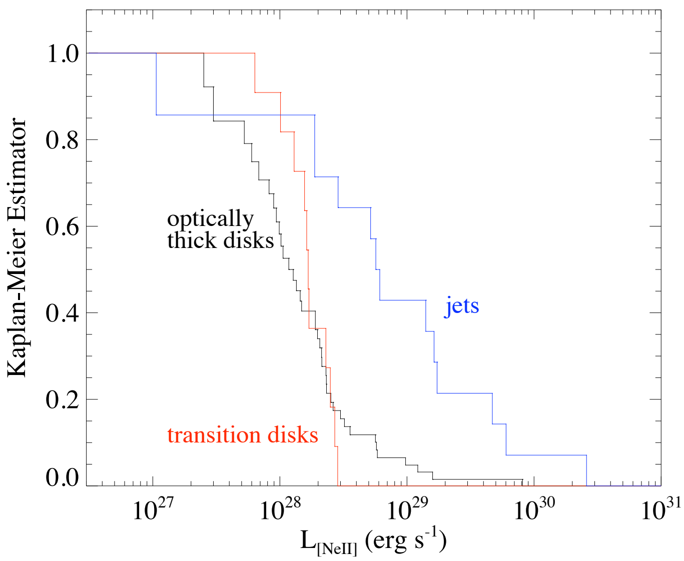
The figure shows the surface density evolution of a viscous disk around a $1M_\odot$ star with EUV, FUV and X-ray photoevaporation ($\alpha = 0.01$, initial disk mass $0.1M_\odot$). The dashed line shows Σ at the start of the simulation, $t = 0$. Σ with radius is shown for different instances of time indicated in the upper right hand corner. The disk loses mass rapidly due to a combination of accretion and photoevaporation and at $\sim 3 \times 10^6$ years, FUV/X-ray photons burn a gap at $\sim 2 - 4$ AU in the inner disk. The disk is then photoevaporated by direct illumination of the inner gap as the outer disk continues to deplete. The remaining torus-like disk is eroded at both the inner and outer regions, while the intermediate regions survive the longest. The disk survives for $\sim 10^6$ years after gap creation and is destroyed in $\sim 4 \times 10^6$ years.

[Ne II] 12.81μm line emission: What does it tell us about protoplanetary disk evolution and mass loss?

Manuel Güdel[1], Fred Lahuis[2], John Carr[3], Alfred Glassgold[4], Thomas Henning[5], Joan Najita[6], Roy van Boekel[5], Ewine van Dishoeck[7]

[1] *ETH Zurich, Switzerland*
[2] *SRON Groningen, The Netherlands*
[3] *NRL, Washington DC, USA*
[4] *University of California, Berkeley, USA*
[5] *Max-Planck-Institute for Astronomy, Heidelberg, Germany*
[6] *NOAO, Tucson, USA*
[7] *Leiden Observatory, Leiden, The Netherlands*

We present results from a study of the [Ne II] 12.81μm fine-structure line from a sample of approximately 90 classical T Tauri stars (CTTS), including several objects that drive jets. [Ne II] 12.81μm line emission may be an important indicator for disk gas, its ionization state, and disk photoevaporation, all of which are of great importance for planet formation processes. Our sample also includes about a dozen objects with transition disks. We find trends toward a correlation with the stellar X-ray luminosity, but on the other hand we report significantly enhanced emission from jet sources (see Figure); this latter trend is supported by correlations between [Ne II] emission and mass-loss indicators such as the [O I] 6300Å luminosity. We summarize the current status of [Ne II] observations from T Tauri stars, discuss new findings from numerical simulations, and try to synthesize the current view of the production of [Ne II] 12.81μm radiation (by EUV or X-ray irradiation of disks, or shocks in jets) and implications for the evolution of circumstellar disks.



Kaplan-Meier estimators (including information from upper limits) for the [Ne II] luminosities of CTTS with optically thick disks (and no jets, black), transition disks (red), and CTTS with micro-jets (blue). The excess emission from jet-driving sources is evident.

Dust and gas clearing in protoplanetary disks

Joanna Brown[1]

[1] *Max-Planck-Institut für extraterrestrische Physik*

The evolutionary processes transforming massive, gas-rich circumstellar disks into tenuous, gas-poor debris disks are still not well understood. During this crucial interval, planet(esimal)s form and the remaining disk material is accreted or dispersed. Mid-infrared spectrophotometry of proto-planetary disks has revealed a small sub-class of objects with spectral energy distributions (SEDs) suggestive of large inner gaps with low dust content, often interpreted as a signature of young planets. We present some of the first direct evidence supporting the gap hypothesis in the form of SMA 880 micron continuum maps resolving inner disk holes. The holes, first discovered through mid-IR spectroscopy, have radii in the 20-50 AU range and are in excellent agreement with predictions from SED modeling. However, spectroscopic observations are necessary to trace the gas content of the disk, with gas distribution having strong implications for mechanisms of hole formation. Despite the dust depletion, high resolution spectra from Keck NIRSPEC and VLT CRIRES reveal that CO gas is often present in the inner disk regions.

The Mechanisms Driving the Evolution and Dispersal of Protoplanetary Disks

I. Pascucci[1,2]

[1] *Space Telescope Science Institute*
[2] *Johns Hopkins University*

It is well established that most ∼1 Myr-old stars are surrounded by optically thick, actively accreting circumstellar disks. By an age of ∼10 Myr only a few percent of sun-like stars still retain an optically thick dust disk with enough gas to form Jupiter-mass planets (e.g. Meyer et al. 2007 for a review). This fast clearing of primordial disks is in accord with the fast formation time scales of chondrules, asteroids, and planets in the Solar System (Pascucci & Tachibana 2009). But what are the physical mechanisms clearing out the primordial disk mass?

In this talk, I will summarize the theoretical mechanisms that have been advanced to answer this question. Special emphasis will be on viscous accretion (e.g. Calvet et al. 2000) and star-driven photoevaporation (e.g. Gorti & Hollenbach 2009), which are expected to be the dominant dispersal mechanisms for isolated disks. I will seek constraints from observations of primordial, transition, and debris disks and from the Solar System to evaluate the role of different mechanisms in dispersing primordial gas and dust. As part of the observational body, I will also present the first evidence for photoevaporation driven by the central star (Pascucci & Sterzik 2009). I will discuss what further measurements are needed to quantify how much disk mass is cleared out via photoevaporation and the impact that photoevaporation can have on the formation of giant planets.

References:

– Calvet, N. et al. 2000, 377, Protostars and Planets IV, "Evolution of Disk Accretion"

– Gorti, U. & Hollenbach, D. 2009, ApJ, 690, 1539, "Photoevaporation of Circumstellar Disks By Far-Ultraviolet, Extreme-Ultraviolet and X-Ray Radiation from the Central Star"

– Meyer, M. R. 2007, 573, Protostars and Planets V, "Evolution of Circumstellar Disks Around Normal Stars: Placing Our Solar System in Context"

– Pascucci, I. & Sterzik, M. 2009, ApJ, in press , "Evidence for Disk Photoevaporation Driven by the Central Star"

Stellar rotation and accretion at young ages: new results from Corot's monitoring of NGC 2264

F. Favata[1], S. Alencar[2], G. Micela[3], S. Aigrain[4], K. Zwintz[5] and the Corot NGC 2264 team

[1] *European Space Agency, 8-10 rue Mario Nikis, 75015 Paris, France*
[2] *Departamento de Fsica, ICEx-UFMG, CP 702, Belo Horizonte, MG 30123-970, Brazil*
[3] *Istituto Nazionale di Astrofisica Osservatorio Astronomico di Palermo, Piazza del Parlamento 1 I-90134 Palermo, Italy*
[4] *School of Physics, University of Exeter, Exeter, EX4 4QL, UK*
[5] *Institut fr Astronomie, Universitt Wien, Trkenschanzstrasse 17, 1180 Vienna, Austria*

Angular momentum is one of the driving forces in the early evolution of stars. Issues such as the coupling between the star and the accretion disk (the so-called disk regulation paradigm), are traced by the evolution of rotational momentum, but affect the star- and planet-forming process as a whole.

We recently observed the NGC 2264 star-forming region (age ca. 3 Myr) with the Corot space telescope, obtaining an uninterrupted 24 day long high accuracy photometric series covering most known CTTS and WTTS in the region. The resulting high-quality light curves allows the determination of rotational periods for P¡12 days with high accuracy and the removal of any biases due to the coverage imposed by ground-based observational campaigns. The Corot photometric campaign on NGC 2264 unambiguously shows that stars with M¿0.25Msun have a single-peaked distribution (with a peak at 3-4 days) and no short period peak. The bimodal distribution that has been reported based on ground-based campaigns is not present in the Corot-based data, and the short-period peak in the distribution (centered around 1 day) appears to be spurious and due to aliasing effects between the actual rotational modulation and the observational window function.

We have also identified a significant number of "AA Tau"-like stars in the region, i.e. accreting stars whose light curve is modulated by the warped accretion disc. The resulting light curve modulation allows to study the dynamics of the accretion flow. This has been done from ground for the well-studied star AA Tau; the Corot photometric series are allowing us to showi that the AA Tau phenomenology is relatively common and therefore to extend the study of accretion dynamics to a large number of CTTS in NGC 2264.

We will present the Corot-based rotational period data for NGC 2264 and discuss the implications of the shift from a double-peaked to a single-peaked distribution on the angular momentum evolution in the few Myr age range, and present the first results from the mapping of the light curves presenting the AA Tau phenomenology discussing their implication in terms of the accretion dynamics at few Myr of age.

Spectroscopy of Warm Gas in Disks around Young Stars

Sean Brittain[1]

[1] *Dept. of Physics & Astronomy, Clemson University, Clemson, SC, 29634-0978, USA*

High-resolution spectroscopy of warm molecules provides an excellent view of the distribution of gas in disks and complements studies of the dusty content and structure of disks emerging from mid-infrared ground-based instruments and Spitzer. As the planet-forming region of disks is generally spatially unresolved, high-resolution spectroscopy becomes a surrogate by spectrally resolving the velocity of gas. CO in particular is well suited to probing the inner, planet-forming regions of disks because it is relatively stable and becomes self-shielding at column densities as low as 10^{14} cm^{-2}. In this talk we will discuss how the observation of ro-vibrational CO emission can be used to measure the distribution of gas in disks and complement what we learn about the disk from its spectral energy distribution.

The differences in the spectral energy distribution of young stars have led to the suggestion that they reflect an evolutionary sequence from optically thick disks to transitional disks (i.e. disks with optically thick outer disks and optically thin inner disks) to optically thin disks. The canonical interpretation of the morphology of transitional disks is that they reflect dynamical sculpting by an embedded planet. If so, then optically thick disks transition into optically thin disks on the timescale over which planet formation is thought to occur. As intriguing as this possibility is, there are other physical effects – namely grain growth and photo-evaporation – that can give rise to transitional disks with similar spectral energy distributions. In this talk we describe how these effects can be differentiated by measuring the distribution of warm gas in the disk around Herbig Ae/Be stars using high-resolution spectra of ro-vibrational CO transitions. We will show examples of spectra of several transitional Herbig Ae/Be stars and discuss what this tell us about the morphology of the spectral energy distribution. We will also discuss how these observations can be used to elucidate the geometry of disks, test model predictions of disk heating and shed light on dust settling.

A Palomar Survey of Accretion onto T Tauri stars

Gregory J. Herczeg

Max-Planck-Institut für extraterrestriche Physik

Accretion is one of the most fundamental physical processes in the formation of a young star and the evolution of its disk. However, direct measurements of accretion rate from excess Balmer continuum emission are relatively scarce. Instead, accretion is commonly measured indirectly from line shapes or luminosities, which are pinned to the few existing Balmer continuum measurements. We obtained low-resolution optical spectra with Palomar and Keck I to survey the excess Balmer continuum emission and upper limits from 300 T Tauri stars and 40 field dwarfs, with masses ranging from sub-stellar to solar. We find that excess Balmer continuum emission is the most robust and accurate probe of accretion onto K and M stars, with little potential contamination from chromospheric activity. The new accretion rates are compared with other accretion diagnostics to assess the relative mass-dependent sensitivity in each method and to provide a set of consistent relationships between line emission and accretion rate. The accretion properties of this sample is also compared with the mass and structure of disks obtained from existing IR and sub-mm observations.

Studying the sub-AU structure of protoplanetary disks and YSO accretion-/outflow-processes with VLTI spectro-interferometry

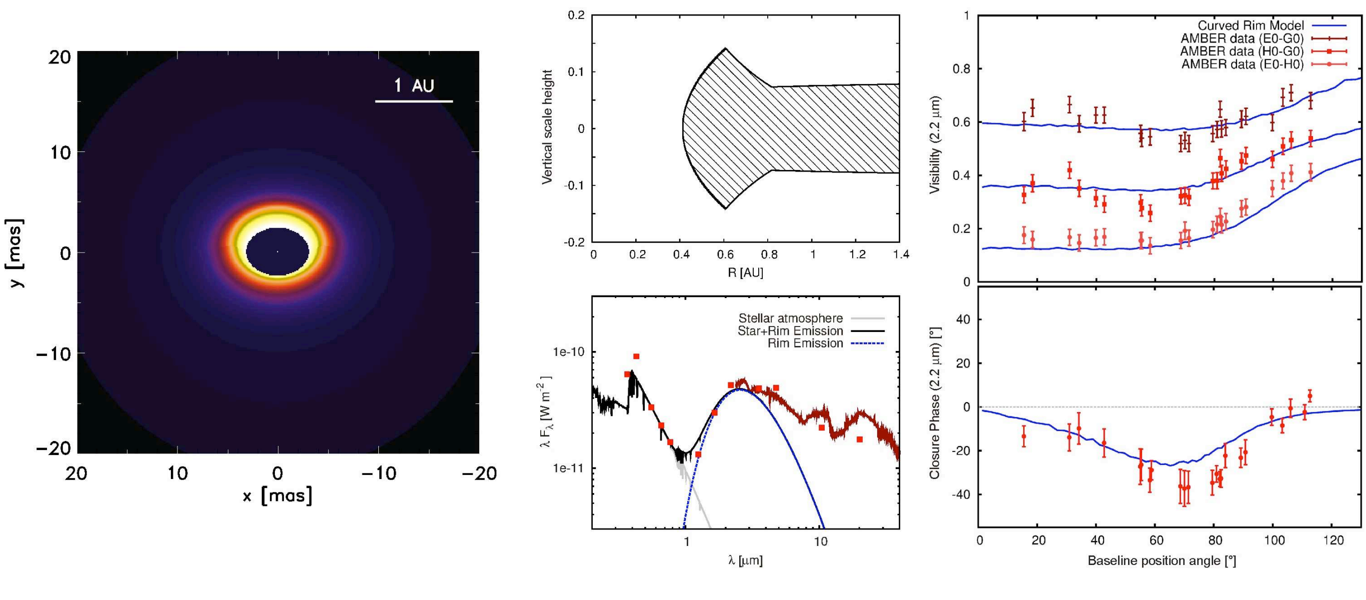
S. Kraus[1,2] and G. Weigelt[1]

Max-Planck-Institut für Radioastronomie, Auf dem Hügel 69, 53121 Bonn, Germany
NASA Sagan Fellow; University of Michigan, 500 Church Street, Ann Arbor, MI 48109, USA

Unveiling the structure of the circumstellar disks around young stars and the processes through which they interact with the central star is of fundamental importance for our understanding of the formation of stars and planetary systems. Until recently, the inner few AUs around young stars, where the accretion and outflow-launching processes are believed to take place, were not accessible to optical and infrared imaging observations. Therefore, most conclusions on the spatial distribution of the circumstellar dust and gas were based entirely on indirect methods such as the modeling of the spectral energy distribution (SED) or line profile fitting. In this talk, I will present some recent investigations, in which we employed ESO's Very Large Telescope Interferometer (VLTI) to spatially resolve the inner-most disk regions around several Herbig Ae/Be stars on a milliarcseconds scale.

For instance, using an extensive data set of 24 VLTI/AMBER observations, we resolved for the first time the near-infrared emission of the disk around the nearby Herbig Ae star R Corona Australis and determine that the dust disk is truncated at a distance of about 0.4 AU from the star, corresponding to the expected dust sublimation radius for this object. Furthermore, we detect strong non-zero closure phases, which indicate the presence of strong asymmetries in the source brightness distribution. Using detailed physical models of the inner disk structure, we find that these asymmetries can be explained with inclination effects and an increased vertical scale height of the inner dust disk, providing strong support for the existence of a pronounced "puffed-up" inner rim around the dust sublimation radius (Fig. 1; Kraus et al., subm. to A&A).

In another project we employed the unique spectro-interferometric capabilities of the VLTI/AMBER instrument to measure the spatial origin of the Brγ hydrogen line emission. Within a sample of five Herbig Ae/Be stars, we find evidence for two distinct line-emitting mechanisms, one resulting in a very compact line-emitting region (likely tracing magnetospheric accretion) and another resulting in a rather extended line-emitting region (likely tracing a stellar wind or disk wind). As we will discuss, this finding also has interesting implications on the connection between accretion and outflow processes in YSOs (Kraus et al. 2008, A&A 489, 1157).



The dynamics of solids in self-gravitating protostellar discs

G. Lodato[1]

[1] *Universita' degli Studi di Milano*

The development of instabilities and structures in the protostellar disc can have a significant impact on the dynamics of solids embedded in the disc and in the process of planetesimal formation. On the one hand, by producing local pressure maxima, such structures promote the formation of planetesimals in such agglomeration sites for meter sized objects. On the other hand, by dynamically stirring up the planeteimal population, they might induce destructive collisions and hamper further growth. In this talk I will discuss these issues in reference to structures produced by gravitational instabilities in the earliest phases of star formation. I will show that, during this phase, planetesimals preferentially form in the outer disc, beyond a few tens of AU, in a ring roughly coincident with the Kuiper belt in the Solar System. I will then discuss the implications of such model in relation to some observed properties of protostellar and debris discs.

Dust grain growth from (sub-)mm interferometry in the Taurus-Auriga and $\rho-$Oph protoplanetary disks

L. Ricci[1], L. Testi[1], A. Natta[2]

[1] *European Southern Observatory (ESO), Garching*
[2] *INAF - Osservatorio Astronomico di Arcetri*

The initial phases of planet formation involve dust grain growth and settling in the circumstellar-protoplanetary disks. These processes can be best studied at millimeter wavelengths where the disk is mostly optically thin and the emission from the dust in the disk midplane can be observed. In this talk, I will present a study on a sample of 43 protoplanetary disks in the Taurus-Auriga and $\rho-$Oph star forming regions, whose recent observative data at (sub-)mm wavelengths let us investigate the dust grain properties. In particular for 11 sources in Taurus-Auriga and 22 in $\rho-$Oph we obtained new data at $\sim$ 3mm with the IRAM Plateau de Bure Interferometer and the Australian Telescope Compact Array respectively. Thanks to the information about the disks spatial extention, we derived from the (sub-)mm spectral energy distribution constraints for the dust opacity law at these wavelengths, using two-layer flared disk models. Adopting a physical model for the dust grain, made of silicates, water ices and carbonaceous materials, we find that the observed spectral energy distributions are tipically consistent with the presence in the disk midplane of dust particles that have grown to sizes as large as a few centimeters. I will discuss about the impact of these results to the processes of dust grain growth and dust migration, that are key mechanisms in the early stages of planet formation. As part of our work I'll show preliminary results on the relation between the derived disk characteristics, e.g. disk mass and grain growth, and the properties of the central forming star, like its mass, age and mass accretion rate.

The outcome of protoplanetary dust growth: pebbles, boulders or planetesimals?

Andras Zsom[1], Chris Ormel[1], Carsten Güttler[2], Jürgen Blum[2], Cornelis Dullemond[1]

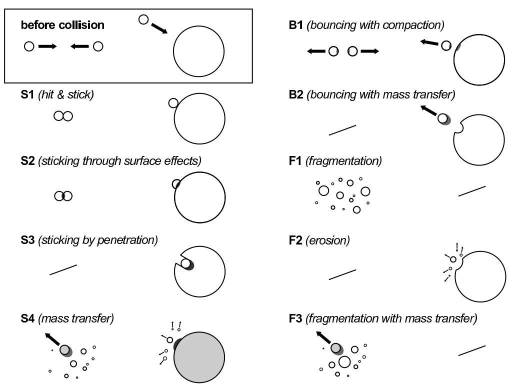
[1] *Max-Planck-Institute für Astronomie, Königstuhl 17, D-69117 Heidelberg, Germany. Email:* `zsom@mpia.de`
[2] *Institut für Geophysik und extraterrestrische Physik, Technische Universität Braunschweig, Mendelssohn-str. 3, 38106 Braunschweig, Germany. Email:* `c.guettler@tu-bs.de`

A conclusive bottom-up model on the formation of pre-planetesimal bodies has so far only been established for the very first fractal growth regime. The major reason for this drawback is that, after the restructuring and compaction of the dust aggregates, laboratory experiments show diverse results in the collisional outcomes (e.g. cratering, erosion, bouncing, etc.) which proved to be difficult to incorporate into dust collision models.

In this study we introduce a collision model which, due to its Monte Carlo nature, can handle the full complexity of aggregate collisions. We categorize dust aggregate collisions into eight regimes based on the porosity of the collision partners and their relative masses. In these regimes, aggregate masses, porosities and collision velocities determine the outcome. From experimental observations we distinguish nine classes of outcomes: 4 types of sticking, 2 types of bouncing and 3 types of fragmentation (see Figure). Although experiments are not available for all possible collisions, we are able to cover the whole parameter space by plausible extrapolations. For details, see Güttler et al., submitted.

We model the growth of dust aggregates at 1 AU at the midplane at three different gas densities. We find that the evolution of the dust does not follow the previously assumed growth-fragmentation cycles. Catastrophic fragmentation hardly occurs in the three disk models. Furthermore we see long lived, quasi-steady states in the distribution function of the aggregates due to bouncing. Particles initially grow by sticking mechanisms which is sometimes followed by a transition regime where a variety of sticking and bouncing collisions occur. The evolution of the particles is then halted by bouncing which is the dominating collision type during this phase. For details, see Zsom et al., submitted.

Typically the particles in our simulations have Stokes numbers of 10^{-4}, which is not enough to start the planetesimal formation mechanism by gravitational instability (Johansen et al., 2007). Using a 'stickier' material such as ices or particles with organic mantels may produce big enough aggregates for this mechanism to work. However, the concentration mechanism of Cuzzi et al, 2008 is an obvious successor to coagulation where it concerns the conditions adopted in this work (1 AU, silicates).



The Time History of Planet Formation: Observation Confronts Theory

Thayne Currie[1,2]

[1] *Harvard-Smithsonian Center for Astrophysics*
[2] *NASA-Goddard Space Flight Center*

In this talk, I discuss new constraints on the time history of planet formation. The combined sample draws from newly published and unpublished Spitzer and ground-based surveys of 3–30 Myr-old clusters, is 50 times larger than Spitzer Legacy surveys, and thus provides extremely robust probes of planet formation. From these data, I discuss the timescales for gas giant planet formation, the time history and frequency of terrestrial planet formation, and the time history and frequency of icy planet formation all as a function of stellar mass.

These results are compared to predictions from theory with especially heavy emphasis on the Kenyon and Bromley planet formation/debris disk evolution models, including their new and unpublished results. Specifically, I discuss the successes of and challenges for models of gas giant planet formation and describe how the data – when informed by the models – may reveal different stages of planet formation. I revisit the nature of transitional disks, showing how these new data overturn some aspects of the decade-old "canonical" picture of these disks and rule out some processes responsible for their emergence. I conclude by identifying outstanding questions that can be addressed with Herschel and JWST observations and breakthroughs in planet formation modeling.

Disk dynamics and the signatures of embedded giant planets

Philip J. Armitage[1], Richard D. Alexander[2]

[1] *JILA, University of Colorado, Boulder*
[2] *Sterrewacht Leiden, Universiteit Leiden*

Observational determination of the abundance and orbital radii of giant planets while they were still embedded within protoplanetary disks would provide critical constraints on massive planet formation theory. Such planet-bearing systems must exist, but identifying them from (unresolved) observations is challenging because ordinary disk evolution can mimic the expected signatures of planets during the phase of disk dispersal. I will discuss new calculations of disk evolution and dispersal that are coupled to models of giant planet migration. The models are calibrated against both exoplanet and disk evolution data, and yield predictions for the fraction of disks that ought to harbor planets and the nature of "transitional" disk systems. Uncertainties arising from poor knowledge of the angular momentum transport properties of disks on AU scales will also be discussed.

Direct imaging searches for young planets

Paul Kalas[1,2]

[1] *University of California, Berkeley, CA*
[2] *SETI Institute, Mountain View, CA*

A new era of advanced imaging technologies will soon increase the number of directly detected exoplanets by an order of magnitude. I will review the techniques for detecting exoplanet candidates, both as free-floating objects and as bound companions to more massive parent objects. I will summarize the properties of currently detected exoplanets and discuss how unexpected initial findings relate to theories of planet formation and evolution in circumstellar disks.

Direct detection of sub-stellar companions in young stars with disks

Ralph Neuhäuser, Tobias Schmidt, Markus Mugrauer[1]

[1] *Astrophysical Institute, University Jena, Schillergäßchen 2, D-07745 Jena, Germany*

Between April 2005 and November 2008, 12 planet candidates detected by direct imaging have been published. The first few planet candidates imaged directly were published in spring 2005; they were found around very young objects - some of them were primary objects with disks like GQ Lup and 2M1207. In falls 2008, planets were also found by direct imaging around stars with debris disks, like Fomalhaut and HR 8799. For companions imaged directly, i.e. in wide long orbits, it is difficult to constrain the mass well. Hence, it remains often unclear whether the companion is a planet or a brown dwarf. This may also depend on the exact definition of planet, in particular its upper mass limit. We will present new Sinfoni spectra of some objects and comparison with Drift-Phoenix model atmospheres. Then, we will compare all detected objects and determine their mass ranges in a homogeneous way. Based on that we will discuss their formation and nature. In this context, it is important to discuss the disk extent and disk mass of young stars with planets.

Can disks form deuterium burning planets by core accretion?

C. Mordasini[1], Y. Alibert[2,3], W. Benz[3], H. Klahr[1]

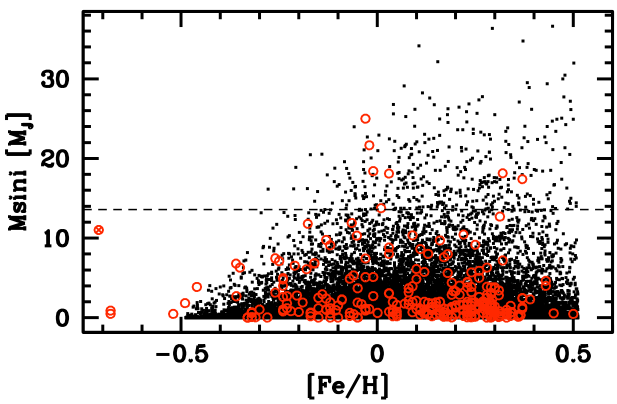
[1] *Max-Planck-Institut für Astronomie, Heidelberg*
[2] *UTINAM, Observatoire de Besançon*
[3] *Physikalisches Institut, Universität Bern*

In the standard paradigm of giant planet formation, the core accretion scenario, gap formation in the protoplanetary disk acts as a self-limiting process for planetary mass growth and limits planetary masses to about 5-10 Jupiter masses (Lubow et al. 1999). The observational finding that about 0.5 % of solar like stars have planets clearly above this limit (Marcy & Butler 2000) however indicates that some formation mechanism must exist for this mass range. Among others, one possibility is that gap formation is in fact not a hard limit for gas accretion. Indeed, numerical simulations of disk-planet interactions (Kley & Dirksen 2006) show that when a planet becomes more massive than 3-5 Jupiter masses, it can cause the disk-planet system to undergo an eccentric instability, allowing the planet to get back into the denser parts of the disk. As a consequence, the planetary gas accretion rate resumes.

We have therefore simulated giant planet formation on the assumption that gap formation does not affect the gas accretion rate. In this case it is found that core accretion can lead to the formation of planets well above the traditional planet - brown dwarf limit at 13.6 Jupiter masses (cf. the figure below). Internal structure calculations (Baraffe et al. 2008) show that despite the presence of a solid core, deuterium burning ignites in such objects, so that they form the interesting class of deuterium burning planets.

Using planetary population synthesis, it is analyze how frequent such objects are, how their mass distribution looks like and how their formation depends on disk properties, as not all disks can form them. The most important result is that planets larger than 13.6 Jupiter masses can only form for (disk) metallicities larger than -0.3. Very large objects (> 20 Jupiter masses) can only form for [Fe/H]>0.0. Above solar metallicity, no correlation exists between the planetary mass and the metallicity. As shown by the figure below, observations indicate also an absence of massive planets at clearly subsolar metallicities (Udry et al. 2002). In contrast, there exists a linear correlation between the maximal planet mass and the initial disk gas mass for all disk masses. Finally, a disk lifetime of at least 2 Myr is required to form deuterium burning planets. Another observational signature of this formation mechanism could be the presence of large amounts of heavy elements in the interior, resulting in smaller radii at a given mass (Leconte et al. 2009).

Those signatures can help to determine whether this formation mechanism is important, and distinguish it from other possibilities like direct gravitational collapse or merging of smaller planets.



Planetary mass (in Jupiter masses) as a function of metallicity [Fe/H], for synthetic planets (black dots), and actual observed extrasolar planets (red circles). Note the absence of massive objects at low [Fe/H], except for the probable late M dwarf companion seen nearly face-on around HD 114762 which is marked with a cross.

Baraffe, I., Chabrier, J. & Barman, T.S. 2008, A&A, 482, 315; Kley, W. & Dirksen, G. 2006, A&A 447, 369; Leconte, J., Baraffe, I., Chabrier, G., et al. 2009, A&A, accepted; Lubow, S. H., Seibert, M. & Artymowicz, P. 1999, ApJ, 526, 1001; Marcy, G. & Butler, R. P. 2000, PASP, 112, 137; Udry, S., Mayor, M., Naef, D., et al. 2002, A&A, 390, 267

Debris disk structures and implications for planetary systems

M. C. Wyatt[1]

[1] *Institute of Astronomy, Madingley Road, Cambridge CB3 0HA, UK*

Our understanding of the structure of debris disks now surpasses the simplest ring-like interpretation of the emission spectrum. Imaging shows that there is variety in the sharpness of the inner and outer edges of the rings, the rings have different widths, and there is a growing number of systems with dust present at multiple radii. Furthermore the structures are not axisymmetric, with disks found to be clumpy, offset and warped, and to include brightness asymmetries. These structures are exactly those expected if there are planets in the systems that perturb the debris disks, and the structures can be used to predict the presence of as yet unseen planets; in some cases the predicted planets have been detected. This talk will describe the structures imposed by planets on debris disks and how the currently known structures have been used to constrain both the presence and evolutionary history of extrasolar planetary systems, and will also consider the advances we can expect in this area with future instrumentation.

Debris Disks in the Nearest OB Association

Christine H. Chen[1], Martin Bitner[1], Kate Su[2], & Alycia Weinberger[3]

[1] *Space Telescope Science Institute*
[2] *Steward Observatory*
[3] *Carnegie Department of Terrestrial Magnetism*

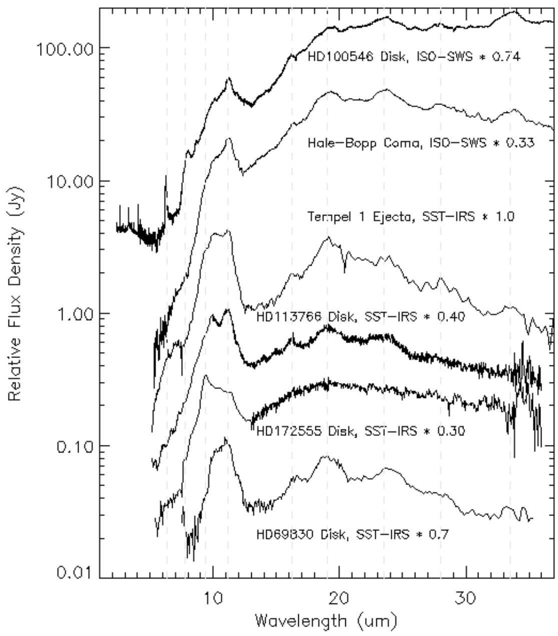
We have obtained *Spitzer Space Telescope* Multiband Imaging Photometer for *Spitzer* (MIPS) 24 μm and 70 μm photometry and high spectral resolution Magellan MIKE visual spectra (3500-9500 Å; R$\sim$50,000) of 113 nearby (within 150 pc from the sun), *Hipparcos* F- and G-type common proper motion members of the nearest OB association, Scorpius-Centaurus. We measure 24 μm disk fractions of 6/18 (33% $\pm$ 14%), 19/49 (39% $\pm$ 9%), and 8/46 (17% $\pm$ 6%) for Upper Scorpius ($\sim$5 Myr), Lower Centaurus Crux ($\sim$16 Myr), and Upper Centaurus Lupus ($\sim$17 Myr), respectively. The magnitude of these excesses (up to 200$\times$ the predicted photospheric flux) is comparable to that expected to be generated by parent bodies at distances similar to the Jovian planets during the epoch of terrestrial planet formation, consistent with the models of Kenyon & Bromley. Since young solar-like stars are expected to possess strong stellar winds, we searched for an anti-correlation between disk fractional infrared luminosity, L_{IR}/L_*, and (1) stellar fractional x-ray luminosity, L_X/L_*, (2) stellar rotational velocity, $v \sin i$, and (3) the calcium activity index, R'_{HK}, to determine whether stellar wind drag is an important grain removal mechanism. We find evidence suggesting that stellar wind drag may play an important role in grain dynamics around 5-20 Myr old solar-like stars.

Abundant Circumstellar Silica Dust and SiO Gas Created by a Giant Hypervelocity Collision in the 12 Myr HD172555 System

Carey M. Lisse[1], C. H. Chen[2], M. C. Wyatt[3], A. Morlok[4], I. Song[5], G. Bryden[6], P. Sheehan[7]

[1] *Johns Hopkins Univ., Applied Physics Lab*
[2] *Space Telescope Science Institute*
[3] *University of Cambridge, United Kingdom*
[4] *The Open University, United Kingdom*
[5] *University of Georgia*
[6] *Jet Propulsion Laboratory*
[7] *University of Rochester*

We have used the IRS Spectrograph onboard the Spitzer Space Telescope to study the warm dust orbiting around the 29 pc distant Pic analogue star HD172555. The dust mineralogy is very peculiar, composed primarily of highly refractory, non-equilibrium materials, with 3/4 of the Si atoms in silica (SiO_2) species. Tektite and obsidian lab thermal emission spectra (non-equilibrium glassy silicas found in impact and magmatic systems) are required to fit the data. The best-fit model size distribution for the observed fine dust is dn/da = $a^{-3.950.10}$. This steep a size distribution argues for a fresh source of material within the last 0.1 Myr. The location of the dust with respect to the star is at 5.8 ± 0.6 AU, within the terrestrial planet formation region but at the outer edge of any possible terrestrial habitability zone. The mass of fine dust is 4 x 10^{19} - 2 x 10^{20} kg, equivalent to a 150 - 200 km radius asteroid. Significant emission features centered at 4 and 8 um due to fluorescing SiO gas are also found. Roughly 10^{22} kg of SiO gas, formed by vaporizing silicate rock, is also present in the system, and a separate population of very large, cool grains, massing 10^{21} - 10^{22} kg and equivalent to the largest sized asteroid currently found in the Solar Systems main asteroid belt, dominates the solid circumstellar material by mass. The makeup of the observed dust and gas, and the noted lack of a dense circumstellar gas disk, strong primary x-ray activity, or an extended disk of meteroids argues that the source of the observed circumstellar materials is a giant hypervelocity (> 10 km sec^{-1}) impact between large rocky planetesimals, similar to the ones which formed the Moon and which stripped the surface crustal material off of Mercury's surface.



Planet population synthesis models

Yann Alibert[1]

[1] *Physikalisches Institut, University of Bern, Sidlerstrasse 5, 3012 Bern, Switzerland*

In this talk, we present results of population synthesis models based on extended core-accretion planet formation models For this, we calculate the evolution of many disk+forming planet systems, assuming initial conditions (in particular disk mass, disk lifetime and metallicity of the system) taken from observations. Taking into account the observational bias introduced by radial velocity surveys, we compare in a statistical way the results of our models and the population of know extrasolar planets. We show that our models are able to quantitatively reproduce the mass and semi major axis of extrasolar planets around solar type stars. In a second part, we expand our models by taking into account irradiation from the central star in the calculation of the disk structure and evolution. We compare the theoretical SEDs with observed ones for disks of different ages. Finally, we explore the effects of the the disk structure on the planet formation process.

Herschel - getting ready for the job!

Göran L. Pilbratt

European Space Agency, ESTEC/SRE-SA, Keplerlaan 1, NL-2201 AZ Noordwijk, The Netherlands

The Herschel Space Observatory is the next observatory mission in the European Space Agency (ESA) science programme, it was successfully launched on 14 May 2009.

Herschel carries a 3.5 metre diameter passively cooled Cassegrain telescope and and a science payload - consisting of two cameras/ medium resolution spectrometers (PACS and SPIRE) and a very high resolution heterodyne spectrometer (HIFI) - housed in a superfluid helium cryostat. It is the first large aperture space infrared observatory. It builds on previous infrared space missions and submillimetre ground observatories, bridging the remaining spectral gap by performing imaging photometry and spectroscopy in the far infrared and submillimetre part of the spectrum, covering approximately the 55-672 micron range and offering unique observing opportunities for a wide variety of observing programmes, including the study of disks.

I will describe the activities conducted since launch, comment on expected performance, and give an overview of the approved observing programmes, in particular wrt to disks. I will also outline future observing opportunities.

A1) AU-scale interferometric observations of the circumbinary environment of AK Sco

P. Ábrahám[1], L. Mosoni[1], A. Juhász[2]

[1] *Konkoly Observatory of the Hungarian Academy of Sciences, Budapest, Hungary*
[2] *Max-Planck-Institut für Astronomie, Heidelberg, Germany*

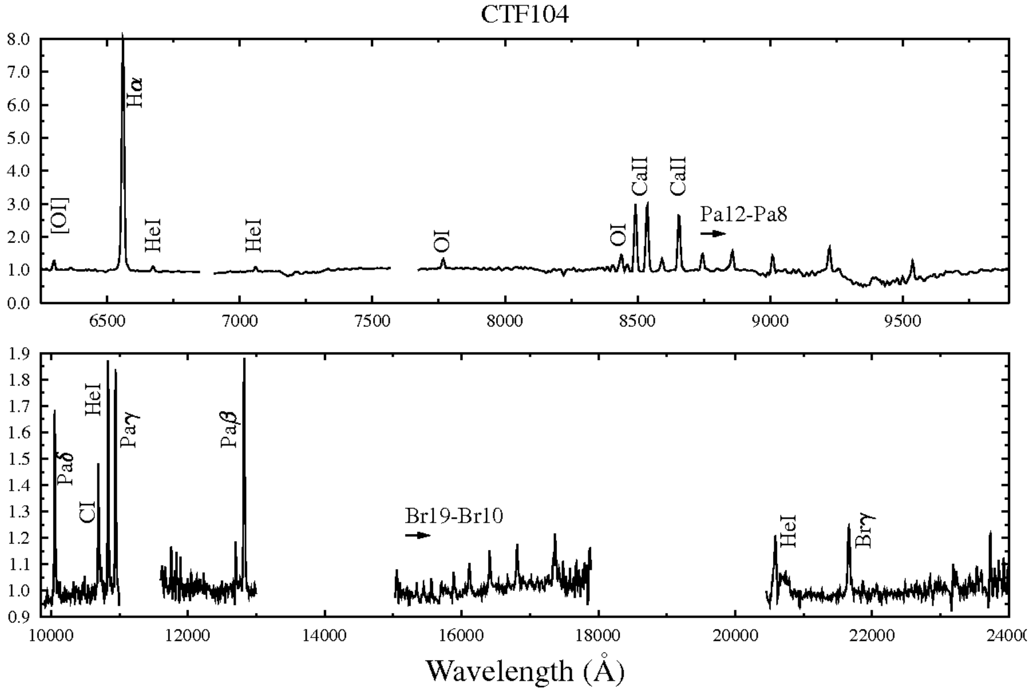
AK Sco is a pre-main sequence spectroscopic binary consisting of two identical F5V stars, at a distance of 145 pc. In order to constrain the structure of its circumbinary material, we performed interferometric observations with MIDI, the mid-infrared interferometric instrument at the Very Large Telescope Interferometer. Four measurements on three baselines were analysed, and radiative transfer calculations were performed to predict spectrally resolved visibilities for different geometrical configurations. We found that the 8−13 μm emission was clearly resolved by MIDI, and the spectrally resolved visibilities obtained on the three ∼50 m baselines suggest similar extent and structure along different position angles. The spectral energy distribution (SED), compiled from our ISO and MIDI observations as well as from archival IRAS, Spitzer and ground-based data, exhibits a near-infrared bump, strong silicate emission features at 10 and 20 μm, and a flat continuum (in νF_ν) between 7 and 60 μm. Detailed modelling of the profile of the 10 μm silicate feature revealed a dust composition consisting of almost exclusively small amorphous silicate grains both for the inner unresolved region and for the total circumstellar environment. Modelling different possible circumbinary geometries, we found that a moderately flared, partly self-shadowed (UX Orionis-type) circumbinary disk plus an optically thin envelope was consistent with both the SED and the MIDI visibilities. This is the first strong indication for the presence of an envelope in the AK Sco system. The existence of such a massive gaseous disk is unexpected in the relatively old AK Sco system (its age is estimated to be 10−16 Myrs), suggesting an evolution vastly different from the normal disk evolution trends and timescales.

A2) A new optical and near-IR spectral survey of Young Stellar Objects with ESO/NTT

S. Antoniucci[1], R. García López[1], B.Nisini[1], F. Bacciotti[2], S. Cabrit[3], A. Caratti o Garatti[4], S. Dougados[5], J. Eisloffel[6], P. Garcia[7], T. Giannini[1], D. Lorenzetti[1], T. Ray[4]

[1] *INAF - Osservatorio Astronomico di Roma*
[2] *INAF - Osservatorio Astrofisico di Arcetri*
[3] *LERMA - Observatoire de Paris, CNRS*
[4] *Dublin Institute of Advanced Studies (DIAS)*
[5] *Laboratoire d'Astrophysique de L'Observatoire de Grenoble (LAOG)*
[6] *Thüringer Landessternwarte Tautenburg*
[7] *Centro de Astrofisica Universidade do Porto (CAUP)*

We introduce a new optical/near-IR spectral survey of Young Stellar Objects (YSOs) based on NTT-SofI/EFOSC2 observations of Spitzer-selected Class I and II in nearby molecular clouds. Spectra cover the wavelength range 0.6–2.4 μm (see Fig.). The magnitude-limited (K<12) sample is composed of about 150 sources belonging to different star-forming regions (Orion-L1641, Vela-D, Cha I/II, Lupus, Serpens, R CrA) presenting a large spread of Class I/Class II number ratio (from 14/4 in Vela to 5/23 in Lupus) and covering a wide range of different star formation environments and modalities. The immediate aim of the survey is to use optical and IR emission features detected in the spectra to measure the accretion luminosity and the mass accretion and mass ejection rates of sources formed in different environments. This information will be used to classify the observed objects on the basis of quantitative indicators of their activity, refining the standard and bias-prone classification based on the shape of the Spectral Energy Distribution (SED). The measurements will also provide further information on the occurrence and properties of jets in young sources, on the accretion/ejection efficiency and on the origin of permitted line emission observed in these objects. Finally, the survey will produce the largest catalogue of optical/IR spectra available for southern YSOs, an important tool for the selection of targets to be observed with VLT/VLTI instruments and new facilities such as ALMA and ELT.



Example of a continuum-normalised spectrum of the survey (CTF104 in Orion-L1641). Several features are detected, such as permitted emission from HI, CaI and HeI and forbidden [OI] lines.

A3) The role of X-Ray radiation on Protoplanetary disks

G. Aresu[1], I. Kamp[1], R. Meijerink[2], P. Woitke[3,4], W.-F. Thi[5]

[1] *Kapteyn Astronomical Institute, Groningen*
[2] *California Institute of Technology, Pasadena*
[3] *UK Astronomy Technology Center, Royal Observatory, Edinburgh*
[4] *School of Physics and Astronomy, University of St. Andrews*
[5] *SUPA, Institute for Astronomy, University of Edinburgh*

YSOs are known to emit X-Rays due to high temperature plasma (¿1 MK) heated up by violent magnetic phenomena in the corona. XRays penetrate to large coloumn densities and potentially dominates compared to Galactic Cosmic Rays in being the most important ionization process deeper in the circumstellar disk. The ionization coming from X-Rays also influences the gas temperature through thermal processes related to the energy exchange between electrons and the surrounding medium. We investigate the role of X-Ray radiation in regulating the thermal and chemical balance in the disk using the code ProDiMo (Woitke, Kamp & Thi, 2009), by adding the relevant X-Ray processes. We present here results from a model of a TTauri star (1 MSun) with $L_x = 10^{30}$erg s^1 surrounded by a disk extending from 0.3 to 100 AU.

A4) Multi-wavelength observations of the young accreting stars V1118 Ori and V1647 Ori in outburst

Marc Audard[1], Carla Baldovin-Saavedra[1], Andres Carmona[1], Francesco Fontani[1], Nicolas Grosso[2], Manuel Güdel[3], Frédéric Gueth[4], Edward F. Guinan[5], Ryan T. Hamilton[6], Stephen L. Skinner[7], Guy S. Stringfellow[7], Frederick M. Walter[8]

[1] *ISDC & Observatoire de Genève, University of Geneva, Ch. d'Ecogia 16, 1290 Versoix, Switzerland*
[2] *Observatoire Astronomique de Strasbourg, 11 rue de l'Université, 67000 Strasbourg, France*
[3] *Institut für Astronomie, ETH Zürich, 8093 Zürich, Switzerland*
[4] *Insitut de RadioAstronomie Millimétrique, 300 rue de la Piscine, 38406 Saint Martin d'Hères, France*
[5] *Department of Astronomy and Astrophysics, Villanova University, Villanova 19085, PA, USA*
[6] *Department of Astronomy, New Mexico State University, 320 East Union Ave, Apt. 1434, Las Cruces, NM 88001, USA*
[7] *Center for Astrophysics and Space Astronomy, University of Colorado, Boulder, CO 80309-0389, USA*
[8] *Department of Physics and Astronomy, Stony Brook University, Stony Brook, NY 11794-3800, USA*

In the recent years, several young accreting stars have displayed outbursts in the optical and infrared due to increases in mass accretion rates. We have monitored the 2005–2006 outburst of the young accreting star V1118 Ori in the optical, near-infrared, mid-infrared, and X-rays, and have obtained new data of the famous V1647 Ori (and its outflow) in its new outburst of late 2008. Briefly, the V1118 Ori multi-wavelength campaign shows evidence of star-disk interactions: the X-ray flux is correlated with the optical and infrared fluxes, and the coronal temperature changed from a predominantly hot plasma temperature to a cooler plasma temperature and gradually returned to pre-outburst values. The spectral energy distribution of V1118 Ori was modeled with a star+disk+hotspot model and we found evidence of a strong increase in the hotspot coverage fraction, while the mass accretion rate increased significantly. There is further possible evidence of a change in the inner disk radius. In V1647 Ori, we have detected a CO outflow near the star. We will obtain in the coming months further IRAM data with the Plateau de Bure Interferometer and the 30m telescope to map the outflow. We will present the results from these two campaigns, while putting them into the context of the accretion history of young stars and star-disk interactions.

A5) New constraints on large grains in CQ Tau and MWC 480 protoplanetary disks.

A. Banzatti[1], L. Testi[2,3], A. Isella[4], A. Natta[3], D. Wilner[5]

[1] *ETH Zurich*
[2] *ESO*
[3] *INAF-Arcetri*
[4] *Caltech*
[5] *CfA*

We performed a deep investigation of dust properties in two protoplanetary disks in Taurus, CQ Tau and MWC 480, using new high-angular-resolution observations at mm-cm wavelengths with the VLA, PdB and SMA interferometers. Key features of our study are: accurate parametrization of dust opacity, stringent constraints on the gas contamination to the millimeter emission and resolved images at several wavelengths to better constrain disk models. We confirm the presence of evolved dust with large grains in CQ Tau and exclude a comparably advanced evolution in MWC 480. We finally present a detailed analysis of the visibility fitting at all observed wavelengths using models for passive flared two-layer disks with constant midplane dust properties at all radii. We found best fitting models with significantly different structural parameters at the different wavelengths. This apparent paradox could be a hint of the presence of radial variations of the dust properties, such as the expected radial (on top of the known vertical) stratification of grains of different sizes in the disk. New observations with higher angular resolution and more comprehensive radiation transfer models that take into account these stratifications will allow to clarify the issue.

A6) Observations of the small-amplitude brightness oscillations in the unique eclipsing system V 718 Per (HMW 15, H 187)

O. Barsunova[1], V. Grinin[1,2], A. Arkharov[1], S. Sergeev[3]

[1] *Pulkovo Observatory, St. Petersburg, Russia*
[2] *Sobolev Astronomical Institute, St. Petersburg University, Russia*
[3] *Crimean Astrophysical Observatory, Crimea, Nauchny, Ukraine*

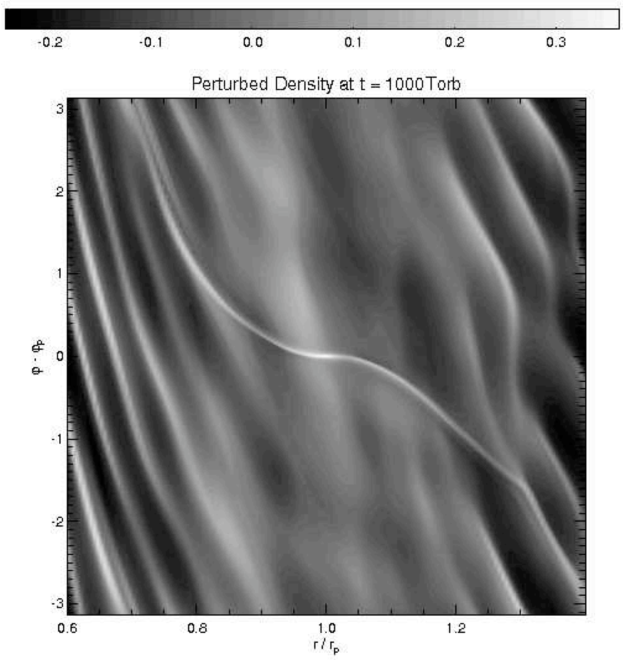
The results of new photometric observations of the unusual WTTS V718 Per in the visual (VRI) and near infrared (JHK) wavelengths are presented. They show that besides the large-scale eclipses followed one after other with the periodicity 4.7 yrs the stellar flux undergo also the low-amplitude oscillations with the period in about 8 times less than the main one. Unlike the large scale eclipses following with the star reddening, the small scale oscillations have a neutral character and are caused by the large particles. Such bi-modal photometric cycles are also observed in some UX Ori type stars. They are the result of the periodic perturbations of extinction which can be caused by the orbital motions of planets or sub-stellar companions. The star V718 Per is the first WTTS which demonstrates the similar variability that is possible only in the case of the almost edge-on orientation of CS disk.

A7) Protoplanetary migration in turbulent isothermal disks

Clément Baruteau[1], Douglas Lin[1,2]

[1] *Astronomy and Astrophysics Department, University of California at Santa Cruz, USA*
[2] *Kavli Institute of Astronomy and Astrophysics, Peking University, Beijing, China*

To reproduce the statistical properties of the observed exoplanets, population synthesis models have shown that the migration of protoplanets should be significantly slowed down, and that processes stalling migration should be at work. Much current efforts have thus been dedicated to slow down, halt or even reverse migration. Most of these studies rely on the horseshoe drag, whose long term evolution (saturated or not) is intimately related to the disk viscosity. We show in this communication how these studies are modified by a more realistic treatment of the disk turbulence.



A8) Broad single peaked CO emission from the inner regions of protoplanetary disks - Turbulent gas in disks, winds or funnel flows?

J.Bast[1], K.M. Pontoppidan[2], E.F. van Dishoeck[1,3], J. Brown[3], G. Herczeg[3]

[1] *Leiden Observatory, Leiden University, 2300-RA Leiden, Netherlands*
[2] *California Institute of Technology, CA 91125, U.S.A.*
[3] *Max Planck Institute for Extraterrestrial Physics, 857 40 Garching, Germany*

Observations of CO gas in the inner parts of protoplanetary disks are expected to give a Keplerian double peaked line profile. Our observations, using the new very high spectral resolution (R = 100 000) spectrometer CRIRES at the VLT, however shows that this is not always the case. 9 sources out of a sample of around 60 T-Tauri stars have instead a single peaked line profile with very broad wings. We present here evidence that these lines can either be described by a Keplerian rotating gas with a high turbulent velocity of ∼7 km/s or by a non-Keplerian origin. The shift from stellar velocities is small, typically < 5 km/s, excluding fast winds. The single peaked line sources have in common that they have high accretion rates and detectible v = 2-1 and 3-2 lines, in contrast with the bulk of the T-Tauri stars. We discuss whether these line profiles can be linked to an origin in the inner part of the disks, funnel flows or disk winds.

A9) GW Orionis: a young triple system revealed by infrared long-baseline interferometry

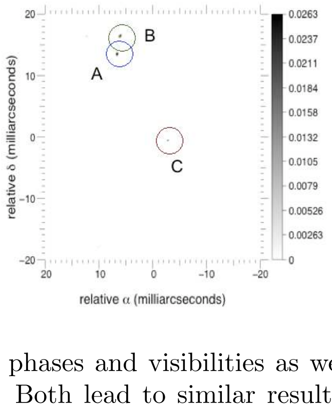
J.P-, Berger[1], J. Monnier[2], R. Millan-Gabet[3], S. Renard[1], M. Benisty[4], N. Carleton[5], P. Haguenauer[6], P. Kern[1], P. Labeye [7], M. Lacasse[5], F. Malbet[1], K. Perraut[1], E. Pedretti[8], S. Ragland[9], P. Schloerb[10], E. Thiebaut[11], W. Traub[12]

[1] *Laboratoire d'Astrophysique de Grenoble, UJF, CNRS,* [2] *University of Michigan, Astronomy department,* [3] *Caltech, NextSci,* [4] *O. Arcetri,* [5] *Harvard SAO CfA,* [6] *ESO,* [7] *CEA-LETI,* [8] *U. St Andrews,* [9]*Keck Observatory ,* [10] *Umass Amherst* [11] *CRAL Obs Lyon* [12] *JPL,*

GW Orionis is a well known bright single-line spectroscopic binary classified as a T Tauri star (Mathieu et al. 1991). The measured period is ≈ 242 days. The stars are separated by ≈ 1.1AU and have a nearly circular orbit. The analysis of the residuals have revealed the signature of a putative third companion with orbital period ≈ 1000 days and the SED's features have been interpreted as the signatures of a massive circumbinary disk with central tidal clearing. GW Orionis is one of the few solar-mass T Tauri multiple systems that offer the possibility to study the dynamics of a close multiple system formation.

We present the first direct confirmation of the presence of a third companion to the system and evidence for orbital motion.

We used the infrared long-baseline interferometer IOTA and its focal instrument IONIC-3 to observe GW Orionis at three epochs in the H band. Visibilities and closure phases were recorded (Monnier et al. 2004).



We carried out model fitting on closure phases and visibilities as well as image reconstruction using the MIRA image reconstruction software (see Figure). Both lead to similar results and clearly reveal the presence of a third companion.

These multiepochs (2003-2005) observations leads us to the observaton of an average separation of ≈ 3 ms for the close system (spectroscopic binary) and ≈ 20mas for the external companion. Our fitting leaves an incertitude of 180°

with respect to the central component flux ratio in the H band. Observations through the epochs show a clear motion of the third component. We use the H band flux ratios and spectroscopic data to discuss the mass ratios. Finally we gather in the litterature information on the photometric periodic dimmings to speculate on the spatial configuration of the system.

References

Mathieu et al., 1991, AJ, 101,2184
Shevchenko et al., 1998, AL, 24,528
DeWarf et al.,2002, BAAS, 34,1134
Artymowicz and Lubow, 1994, ApJ, 651
Monnier et al. 2004, ApJ, 602, L57-60

A10) Dust retention in protoplanetary disks

T. Birnstiel, C.P. Dullemond, and F. Brauer

Junior Research Group at the Max-Planck-Institut für Astronomie, Königstuhl 17, D-69117 Heidelberg, Germany.

Protoplanetary disks are observed to remain dust-rich for up to several million years. In most cases the dominant infrared-emitting dust consists of grains and aggregates that are less than a few microns in size. With a new and sophisticated implicitly integrated coagulation and fragmentation modeling code we show that collisional fragmentation of dust aggregates is effective enough to keep disks 'dusty' (in the sense of containing copious amounts of small grains) for several million years, firstly by replenishing the population of small grains and secondly by preventing excessive radial drift.

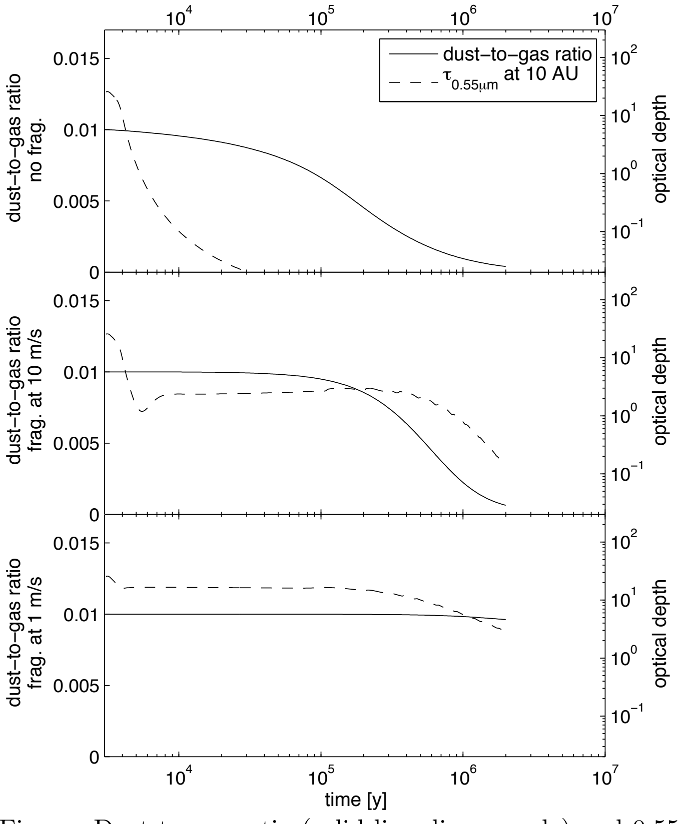


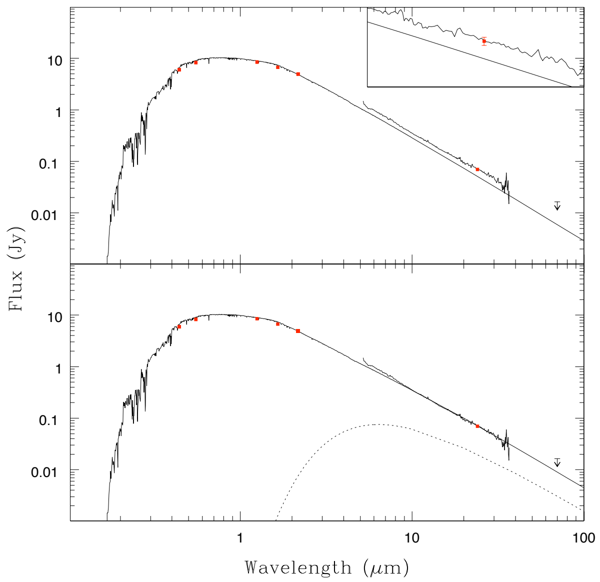
Figure: Dust-to-gas ratio (solid line, linear scale) and 0.55 μm optical depth at 10 AU (dashed line, logarithmic scale) as function of time for growth without fragmentation (top), with fragmentation at a relative velocity of 10 m/s (center) and fragmentation at 1 m/s (bottom).

A11) HD101088, A 5 Myr Old Accreting Close Binary in the Sco Cen OB Association

Martin A. Bitner[1], James Muzerolle[1], Christine H. Chen[1], Alycia J. Weinberger[2]

[1] *Space Telescope Science Institute, Baltimore, MD, USA*
[2] *Department of Terrestrial Magnetism, Carnegie Institution of Washington, Washington, DC, USA*

We present high resolution (R∼70,000) optical spectroscopy obtained with MIKE on the 6.5 m Magellan Clay Telescope and *Spitzer* MIPS photometry and IRS low resolution (R∼ 60) spectroscopy of the ∼5 Myr old close (14 AU separation) binary, HD 101088, a member of the Lower Centaurus Crux (LCC) subgroup of the Scorpius-Centaurus OB association. We find that the primary and/or secondary is accreting from a tenuous circumprimary and/or circumsecondary disk despite the lack of a massive circumbinary disk. We estimate an accretion rate of $\sim 10^{-8}$ $M_\odot$ yr^{-1}, which our multiple observation epochs show varies over a timescale of months. The *Spitzer* IRS spectrum reveals a weak infrared excess throughout its 5-35 μm range. If the emitting dust grains are large, we estimate a temperature range of 500-2000 K. We conclude that the classification of disks into either protoplanetary or debris disks based on fractional infrared luminosity alone may be inaccurate.



A12) The Protostellar Population of the Auriga Molecular Cloud

Tyler Bourke[1], Brenda Matthews[2], Dawn Peterson[1], Lori Allen[3], Jes Jørgensen[4], and the Spitzer Gould's Belt Legacy Team

[1] *Harvard-Smithsonian Center for Astrophysics*
[2] *Herzberg Institute of Astrophysics*
[3] *National Optical Astronomy Observatory*
[4] *Argelander Institut für Astronomie*

The Auriga molecular cloud region has received much less attention than its more famous neighbours in Taurus and Perseus, although at 300 pc it is at a similar distance to Perseus. As part of the Gould's Belt (GB) legacy survey with Spitzer, we have mapped a large region within Auriga having extinctions $A_V > 3$ over the wavelengths $3.6 - 160$ μm. Candidate young stellar objects (YSOs) have been identified through near-infrared spectral colours between $2 - 24$ μm, following well developed procedures used for other Spitzer studies (Harvey et al. 2007). A total of 18 candidates Class 0/I YSOs have been identified that are also detected at 70 μm, none of which have been observed at sub-millimetre wavelengths. With the Submillimeter Array (SMA) we have imaged 10 of the Auriga candidate YSOs, detecting compact emission associated with all of them in the continuum at 1.3 mm, most likely due to disks. Clear bipolar CO outflows are identified originating from most of the YSOs. In this presentation the Spitzer and SMA results will be discussed in more detail, and compared to results from other regions.

A13) SMA observations of the disk around Class I protostar B5 IRS1

Erin B. Brassfield[1], Tyler L. Bourke[2]

[1] *Smithsonian Astrophysical Observatory, Submillimeter Array Project, 645 Aohoku Place, Hilo, HI 96720*
[2] *Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138*

Although the process for low-mass star formation is generally known, some important details are not well understood. In particular, the accretion process is poorly constrained by observations, and determining the mass distribution during the embedded protostellar stage allows models to be critically tested.

It has been recently shown that, in some cases, HCO^+ J=3-2 is a good tracer for compact disk emission around nearby protostars at the typical spatial resolution of the Submillimeter Array. Such observations show a velocity gradient in the compact emission indicative of Keplerian rotation allowing the central mass to be determined, while dust continuum observations provide an estimate of the surrounding disk mass.

Here we present Submillimeter Array results of prototypical Class I young stellar object B5 IRS1. These observations show Keplerian disk motions, thus adding to the small sample of Class I objects for which separate masses for the envelope, disk, and protostar are attainable.

A14) Warm and hot gas in the circumstellar environment of V1647 Ori during the 2008-2009 outburst.

Andres Carmona[1], Marc Audard[1] , Mario van den Ancker[2] , Davide Fedele[3], Miwa Goto[3], Gerrit van der Plas[2,4]

[1] *ISDC & Geneva Observatory, University of Geneva, chemin d'Ecogia 16, 1290 Versoix, Switzerland*
[2] *European Southern Observatory, Karl Schwarzschild Str 2 , 85748 Garching bei München, Germany*
[3] *Max-Planck Institute for Astronomy, Königstuhl 17, 69117 Heidelberg, Germany*
[4] *Astronomical Institute, University of Amsterdam, Kruislaan 403, NL-1098 SJ Amsterdam, The Netherlands*

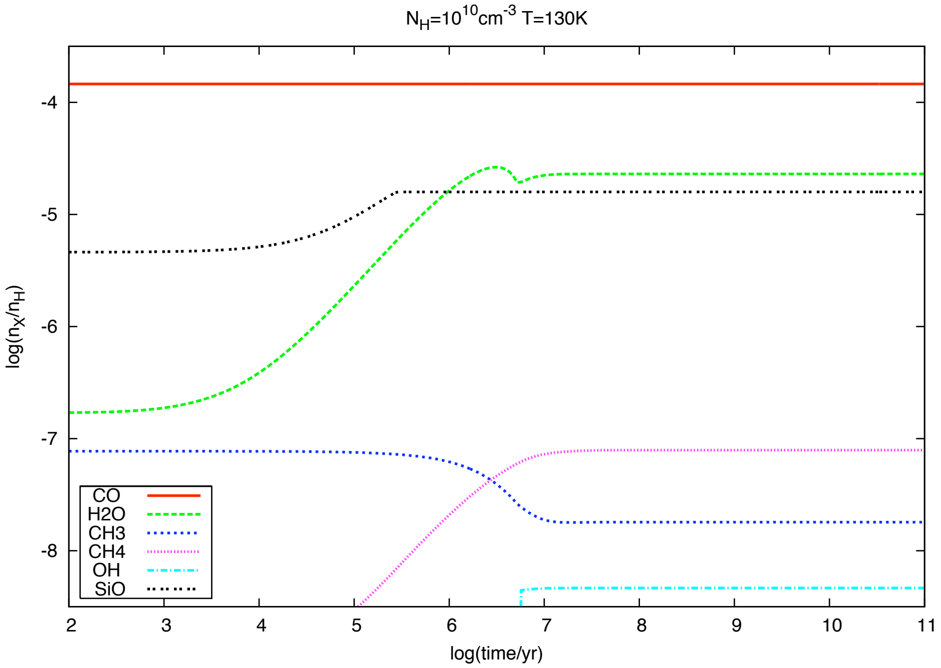
The pre-main sequence star (PMS) V1647 Ori started a new outburst in late August 2008. Here we report on the temporal evolution of the circumstellar gas during the outburst phase of V1647 Ori from October 2008 to February 2009. We observed V1647 Ori with the ESO's VLT high-resolution near-IR spectrometer CRIRES, the ESO's VLT high-resolution mid-IR spectrometer VISIR, and the ESO's VLT low resolution optical spectrometer FORS2. We monitored the evolution of CO, H_2, and [OI], [SII], [Fe II] emission line profiles in a time scale of 4.5 months obtaining data every 1.5±0.5 months starting on October 2008. We describe the changes on the temperature and spatial distribution of hot and warm gas surrounding V1647 Ori and discuss how they are related to the source luminosity change. Finally, we describe the inner disk dynamics of the V1647 Ori's disk and discuss the observational evidence for molecular outflows/winds associated with the outburst. PMS outbursts events are a unique opportunity to understand the physical processes that occur in the inner disk, from the region coupling star to the disk, to the disk's planet forming region.

A15) Time evolution of H_2O/CO has-grain chemistry in protoplanetary disks (Midplane)

Germán Chaparro[1], Inga Kamp[1], ...

[1] *Kapteyn Astronomical Institute, Postbus 800, 9700AV Groningen, The Netherlands*

Time evolution of on-the-spot gas-grain chemistry in protoplanetary disks is the main source of information about the layered structure of species deposited onto the surface of grains during the first few million years of a protoplanetary disk's life. Gas chemistry is strongly affected by the presence of adsorption-desorption processes onto grains and the time evolution of the abundances of significant species. Grains, specially in the cold midplane of the disk can quickly deplete important species such as CO and H_2O from the gas phase. The history of trapping important quantities of carbon and oxygen in the grain is of special significance for the study of grain surface chemistry and the formation of more complex (organic) molecules on the surface of grains. The focus of this study is the role of cosmic-ray induced UV photons on the gas-grain chemistry. At 10AU from the star it is possible to find water vapor at an abundance of 10^{-5} molecules per hydrogen atom, which is a high value in comparison to previous analysis that do not fully account for the grain extinction cross section. This is a first step in laying out a base for an in-depth study of grain surface chemistry using a multi-layered analysis.



A16) CN and HCN in Proto-planetary Disks

Chapillon,E.[1], Guilloteau,S.[2], Dutrey,A.[2], Piétu,V.[3]

[1] *MPIfR Max-Planck-Institut für Radioastronomie, Auf dem Hügel 69, 53121 Bonn, Germany*
[2] *LAB Laboratoire d'astrophysique de Bordeaux, 2 rue de l'observatoire, BP 89, 33271 Floirac, France*
[3] *IRAM Institut de Radioastronomie Millimétrique, 300 rue de la piscine, 38406 Saint Martin d'Héres, France*

Understanding the structure of the disks around young stars is one of the key issues for understanding the process of planet formation. Nevertheless the overall properties of these disks are not yet well constrained by observations.

Theoretical studies of chemistry in disks lead to a three layers vertical structure of the outer disk: a upper layer directly illuminated by the stellar UV and dominated by photodissociation reactions (PDR), a warm molecular layer and a cold mid-plane dominated by molecular depletion on dust grains.

In order to confront theory with observations, we use the PdBI to obtain spatially resolved images of two key molecules for dissociation processes CN J=2-1 and HCN J=1-0 in three disks surrounding 2 T-Tauris stars (DM Tau and LkCa 15) and 1 Herbig Ae star (MWC 480). The data analysis is performed using our standard parametric model. The geometric parameters (such as inclination and position angle) are in good agreement with previous CO observations. We find surprising low excitation temperature (∼10 K) for both transitions in the 2 T-Tauris stars.

A17) Study of transitory disks between the protoplanetary and debris phases

Carolina Chavero[1] and Ramiro de la Reza[1]

[1] *Observatório Nacional – Rio de Janeiro*

Detection of low mass stars with transitory disks between the primordial, or protoplanetary, and the debris phases, is an important step towards the understanding of their evolutionary physical processes. On the one hand, these hybrid disks must present signs in their inner disk regions of the terminal processes of formation of larger planetoids . On the other hand, show signs of the first collisional cascade processes characterizing the initial debris phase. Because during these processes the disk is beginning to lose all of its gas, it is supposed that this happens during the first 10 Myr of the lifetime of the disks. By using a global evolution study of IR sources corresponding to primordial and debris disks, we found that the transitory interval occurs between ∼ 2 and 11 Myr . This result was obtained by using ages of stars whose disks belong to the transitory phase being that these stars are members of coeval stellar groups. For these groups, precise ages have been found by means of stellar Galactic dynamics methods to determine the behavior of their 3D past orbits. We show that whereas the upper limit of 10 - 11 Myr seems to be quite well established, this is not completely the case of the lower limit.

A18) Evidence for a disk around the massive young star NGC 7538 IRS1

Stuartt Corder[1], Melvyn Wright[2], Goran Sandell[3]

[1] *National Radio Astronomy Observatory, Joint ALMA Observatory, Santiago, Chile*
[2] *Radio Astronomy Laboratory, University of California, Berkeley, California, USA*
[3] *NASA Ames, Mountain View, California, USA*

While there is clear evidence for circumstellar disks around intermediate and low mass young stars, there are very few definitive examples of disks around young B-type stars and none to date around young O-type stars. We present observations of the young, likely O-type star NGC 7538 IRS1. We have obtained high- resolution (¡1 arcsec resolution) images in 1mm and 3mm continuum emission with the Combined Array for Research in Millimeter-wave Astronomy (CARMA). We also have similar resolution images in $HCO^+(J = 1 - 0)$ and various CO isotopologues, spanning ^{12}CO to $C^{17}O$ in opacity. We also mapped a wide-field ($3'$ by $4'$) region at modest resolution (about 3 arcsec) to eliminate biasing interpretations because of restricted field of view. There are several indicators of the presence of a disk, including out ow and infall, and evidence that there is a resolved, flattened structure perpendicular to the out ow direction. In this poster, we present the CARMA images and discuss the status of on-going studies of this star and the surrounding region.

A19) A Systematic Survey to Detect Young Gas Giants

Kevin R. Covey[1], James P. Lloyd[1], Philip Muirhead[1]

[1] *Cornell University*

From the large number of exoplanets discovered in orbit around main sequence stars, we have learned a great deal about the frequency and properties of mature planetary systems. Our understanding of the formation and early evolution of these systems is significantly poorer, as we lack empirical detections of young planets with which to confront theoretical models.

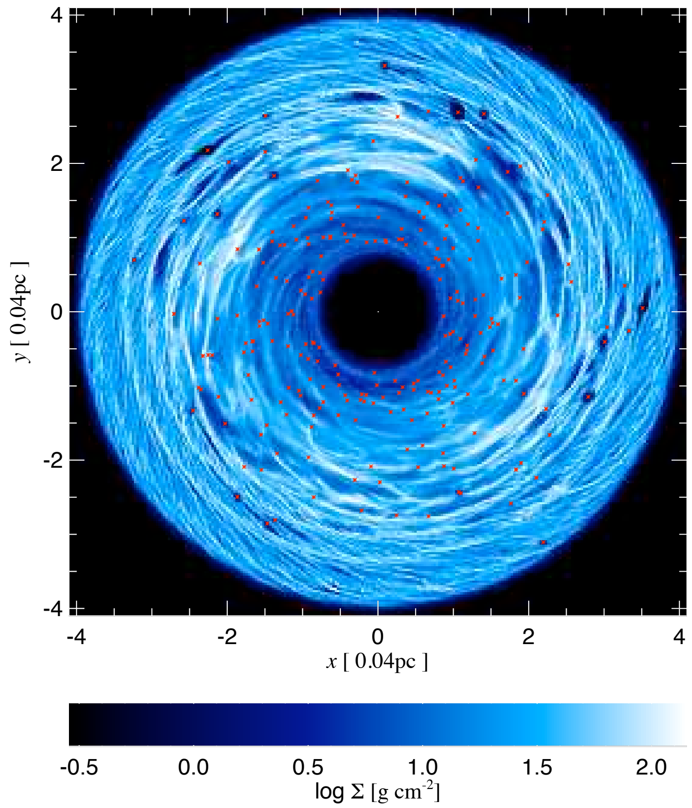
Recent observations by Huélamo et al. (2008), however, indicate that young stars are sufficiently stable in the near-infrared that Doppler surveys with 35 m s^{-1} precision can detect gas giants. We have begun a systematic ($\sim$150 target) survey to robustly measure the frequency of giant planets around young stars. This survey is being conducted with the TripleSpec Exoplanet Discovery Instrument (TEDI), whose novel design provides high precision near-infrared Doppler measurements. Cornell University has committed 50 nights in 2010-2011 to Doppler planet searches with TEDI, of which this survey is one component. This survey will reveal how planet formation affects the structure of circumstellar disks, and produce the first statistically robust measurement of planetary frequency around young stars. The timescales indicated by these measurements will therefore place direct, empirical constraints on models of planet formation and migration.

A20) Origin and evolution of stellar discs in the Galactic centre

Jorge Cuadra[1]

[1] *Max-Planck-Institut für Astrophysik, D-85741 Garching*

Sgr A*, the massive black hole at the centre of the Milky Way, is surrounded by young stars, most of which orbit Sgr A* in a planetary-like disc. The presence of these stars is puzzling, as the huge tidal field around the black hole prevents 'standard' star formation. Instead, we propose that the stars were formed as the result of gravitational instabilities in an accretion disc that existed around Sgr A* in the past, and present numerical models of this process. We then show how the observed stellar dynamics constrain the properties of the gaseous system from which the stars formed. Finally, we investigate the origin of the so-called S-stars, whose low age and extreme proximity ($< 0.01\,\mathrm{pc}$) to the massive black hole rule out any *in situ* formation scenario. Analogous to the case of hot Jupiters, we study their formation in a disc and their subsequent migration as a result of satellite–disc tidal interactions.



Snapshot of a gravitationally-unstable disc simulation, showing the gas surface density. In the inner part, where the time-scales are short, stars (red asterisks) have already formed and accreted a large fraction of the gas. In the outer part only a few stars have been formed at this stage. The spiral pattern shows the presence of gravitational instabilities. (Nayakshin, Cuadra, Springel, 2007, MNRAS, 379, 21)

A21) Protoplanetary Disks of TTauri Binaries in Orion

S. Daemgen[1], M. Petr-Gotzens[1], S. Correia[2]

[1] *ESO Garching, Germany*
[2] *Astrophysikalisches Institut Potsdam, Germany*

Since more than a decade it is known that the process of low-mass star formation leads, almost exclusively, to the formation of binary or multiple systems. Another inevitable consequence of the star formation process is the formation of a dusty protoplanetary disk surrounding each young star, the birthplace of planets. However, apparently not every protoplanetary disk induces planet formation. Intriguingly, extra-solar planets discovered in binary systems so far are found only around one star, never around both stars of the binary system (considering systems with component separation $\sim 100\,\mathrm{AU}$). The cause of this may be a very discriminative early evolution of the binary components' disks. In order to trace protoplanetary disks and their properties in young binary systems we have carried out spatially resolved spectroscopy as well as spectral energy distribution analysis for several low-mass binaries in the well-known Orion Nebula Cluster. We report on the first results of this detailed investigation or protoplanetary disks of the ONC binary population in this presentation.

A22) Polarization Signatures Due To Transiting Exoplanets

James W. Davidson Jr.[1], Karen S. Bjorkman[1], Antonio M. Magalhães[2], Alex C. Carciofi[2], Jon E. Bjorkman[1], Daiane B. Seriacopi[2], John P. Wisniewski[3]

[1] *The University of Toledo, Dept. of Physics & Astronomy, Toledo, OH 43606, USA*
[2] *Universidade de São Paulo, Inst. de Astronomia, Geofisica e Ciências Atmosféricas, São Paulo, Brazil*
[3] *University of Washington, Dept. of Astronomy, Seattle, WA 98195, USA*

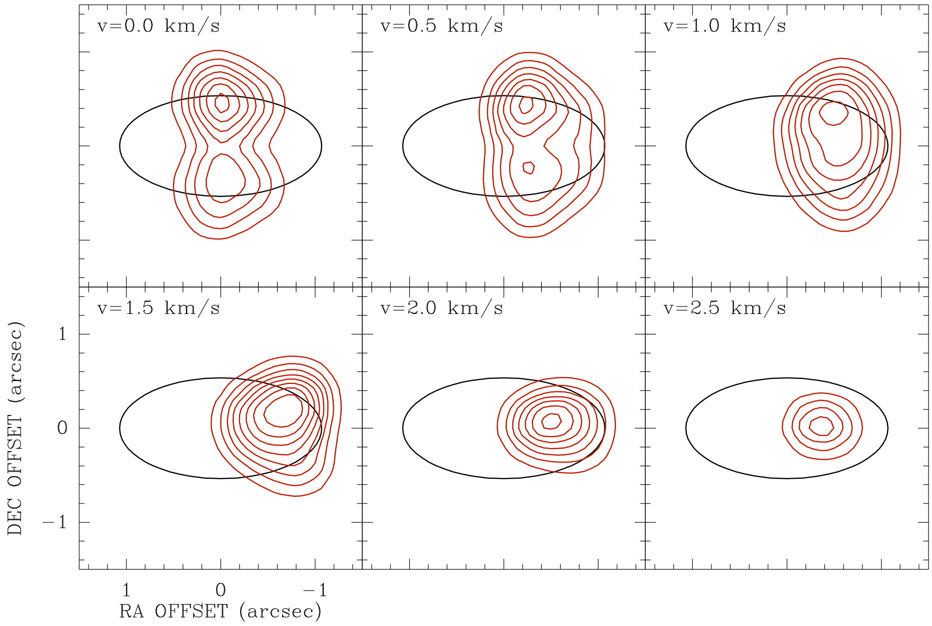
Many different techniques are being used to discover and characterize exoplanets. One diagnostic which has been underutilized, surprisingly, in exoplanet studies is polarimetry. Most theoretical models have focused on using the technique of polarimetry to detect exoplanets by means of the light they scatter from their atmospheres. However, the polarization levels which are predicted from this effect are well below the sensitivity of modern polarimeters. In this project we will observationally test the alternative theory presented by Carciofi & Magalhães (2005) that provides a means of detecting exoplanets occulting their host stars by polarimetry. Instead of looking for the scattered light from the exoplanet, we will focus on the polarimetric signatures produced when exoplanets occult their host stars. During the occultation the exoplanet will block some of the light from the stellar disk. The symmetry of the stellar disk will thus be broken, producing a net linear polarization which is predicted to be within the detectable range of modern polarimeters. Measuring the occultation polarization gives us important information about the planet and the star. In particular, this technique allows for the determination of the stellar limb polarization, a quantity that is very difficult to measure and is essentially unknown to stars other than the Sun. Current and future space based missions such as *CoRoT*, *Kepler* and others will significantly increase the number of known exoplanets, providing addition prospective targets to investigate. Observations will be carried out with the use of the University of Wisconsin's Halfwave Polarimeter (HPOL). Several of us are involved in a collaboration to relocate HPOL to the Mt. Lemmon Observing Facility in Fall 2009, and this will provide us with guaranteed observing time to conduct this study.

A23) Statistical Analysis of Molecular Line Emission From T TAURI Disk Models

de Gregorio-Monsalvo, I.[1], D'Alessio, P.[2], Gómez, J. F.[3]

[1] *European Southern Observatory, Chile*
[2] *Centro de Radioastronomía y Astrofísica, Universidad Nacional Autónoma de México.*
[3] *Instituto de Astrofísica de Andalucía (CSIC), Spain*

In this work we model the expected emission from the molecular line $C^{17}O(J=3 \rightarrow 2)$ in protoplanetary disks (see Fig 1), modifying different physical parameters to obtain distinctive observational signatures. Our aim is to determine the kind of observations that will allow us to extract information about the physical parameters of disks. With this purpose we perform a statistical analysis of principal components and a multiple linear correlation on our set of results from the models. We also present prospects for future molecular line observations of protoplanetary disks using SMA and ALMA.



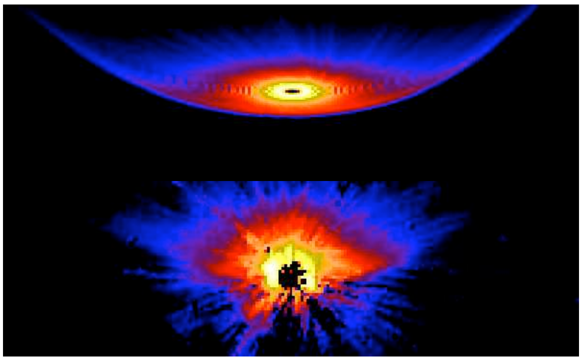
$C^{17}O$(J=3 →2) emission maps at different velocities for a disk with radius = 150 AU, a_{max} = 10 μm, i = 60°, $\alpha = 0.01$ and mass accretion rate = $10^{-7} M_{\odot}$ year^{-1} (where a_{max} is the maximum radius of dust grains, i is the inclination angle of the disk, and α is the viscosity parameter). Maps have been convolved with a 0.″4 beam. The lowest contour and the increment step are 20 mJy beam^{-1}. The ellipse traces the outer edge of the disk.

A24) Debris Disks Blowing in the Wind: ISM Sculpting of the HD 32297 Debris Disk

J.H. Debes[1,2], A.J. Weinberger[3],M.J. Kuchner[1]

[1] *NASA Goddard Space Flight Center Greenbelt, MD 20771*
[2] *NASA Postdoctoral Program Fellow*
[3] *Department of Terrestrial Magnetism, Carnegie Institution of Washington, Washington, DC 20015*

Many nearby debris disks that have been resolved in scattered light show a variety of twists, warps, or asymmetries. Often these features are noted and the presence of unseen planetary companions is inferred. However, the outer regions of debris disks can be impacted by the surrounding interstellar environment. In this talk, I present scattered light observations of the edge-on debris disk HD 32297, which shows warping at distances beyond a few tens of AU. I also present a simple model involving supersonic gas drag on debris disk dust particles that explains these observations and the strange morphologies of two other debris disks, HD 61005 and HD 15115.



Comparison between an F110W image of HD 61005's disk (kindly provided by G. Schneider) and a model of a disk interacting with a cloud of ISM gas. The image is at the bottom.

A25) Investigating Timescales for Planet Formation in Ophiuchus

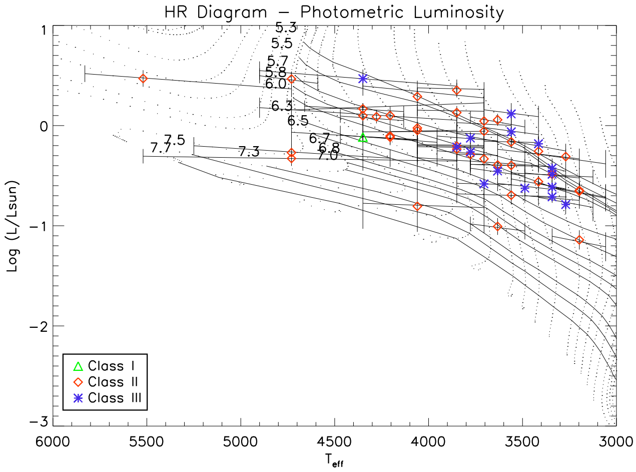
Casey P. Deen[1], Daniel T. Jaffe[2], ...

[1] *University of Texas at Austin, Department of Astronomy*

The Ophiuchus cloud is an ideal laboratory to study the process of star and planet formation, as it is one of the youngest ($\sim 1 - 3$ Myr) and closest (120 pc) regions actively forming stars. We present results of a magnitude limited near IR spectroscopic study of the L1688 core. Using medium resolution ($R \sim 2000$) $0.8 - 2.4\mu$m spectra, we thoroughly characterize the photospheres in our sample, in anticipation of studying how the properties of disks around these objects evolve with age. Our study uses higher resolution spectra and a wider near IR wavelength range than previous studies to determine spectral types independent of reddening, and veiling in a consistent way for class II and III objects. Spectral types allow us to determine effective temperatures, luminosities, extinctions, K-band veilings, and accretion rates for most objects in our sample. We confirm one candidate class III object as a YSO, and reject another as a background giant. We then place the objects on the HR Diagram (see Figure 13) to determine masses and ages. Even at the young age of Ophiuchus, there is no apparent difference in distribution of photospheric luminosities between class II and class III objects of the same spectral types.

References

S. Bontemps et al. 2001, A&A, 372, 173
F. D'Antona and I. Mazzitelli, 1997, Mem. Soc. Astr. It., 68, 807



HR Diagram of the Ophiuchus sources with the tracks of D'Antona & Mazzitelli (1997) overlaid. Green dots are class I objects, red dots are class II objects, and blue dots are class III objects, as determined by Bontemps et al. (2001). The class II sources at ages greater than 10 Myr are likely seen in scattered light, suggesting uncertainties in the A_V determination. Isochrones are labeled by $\log_{10}$ (Age), while masses tracks range from $3.0 M_{sun}$ to $0.01 M_{sun}$. Note that the red class II sources and blue class III sources inhabit the same region in the HR diagram, suggesting a parameter other than stellar age drives the evolution and dissipation of circumstellar disks.

A26) Emission from CO bandhead and hot water lines in disks around low-mass stars.

W.R.F. Dent[1], W.-F. Thi[2], S.K. Ramsay[3], C.J. Davis[4]

[1] *ALMA JAO, Santiago, Chile*
[2] *SUPA, Univ. of Edinburgh, Scotland*
[3] *ESO, Garching, Germany*
[4] *Joint Astronomy Centre, Hilo, Hawaii*

We describe high spectral resolution observations of the v=2-0 CO bandhead and nearby water lines in 10 low-mass young stellar objects. The aim was to investigate the CO bandhead spectral shape, variability and possible polarisation, and to look for emission from hot water lines at K-band. The results show a very wide range of underlying CO spectral profiles, from narrow emission with a width of $< 18 kms^{-1}$, through to broad profiles with a width of $150 kms^{-1}$. In most cases, the profiles can be fitted by simple inclined disk models, with radii of order ∼1 AU. However, it is difficult to account for the very narrow lines seen in a few objects, unless the disks are very close to face-on.

In 7/10 objects, we also detect emission at $2.2913 \mu m$, which is attributed to the 13 4 10(001)-12 2 11(000) transition of H_2O. The intensity of this water line is closely correlated with the K-band continuum flux, suggesting that the line and continuum arise from the same region of the disk. The flux of the H_2O line is 9% ±5% of the $2.3 \mu m$ continuum flux, and is not correlated with the CO bandhead emission: it is seen in objects exhibiting both bandhead emission and absorption. Emission in this line implies gas densities of $\sim 10^8 cm^{-3}$ and temperatures of ∼ 1500K. The H_2O linewidth is typically 15-30 kms^{-1}, which is 2-6 times narrower than the CO line. Assuming rotational broadening, this indicates that the H_2O-emitting region lies at ∼10 larger radii than the CO bandhead-emitting region, ie typically ∼10 AU. This line is relatively spectrally isolated, making it a good tracer of hot water in this region of the disks.

Two objects - DG Tau and V1647 Ori - show highly-variable CO bandhead fluxes, changing from absorption to emission on timescales of months. The CO bandhead emission profile of V1647 Ori is complex, with multiple emission components. A deep blue-shifted absorption component observed in the quiescent phase is thought to be a dense clump of outflowing gas ejected by the previous outburst. The appearance of emission in the CO bandhead from this object is delayed behind the continuum flaring event by a period of order a few weeks. However, the water line in both objects remains single-peaked at all times, and tracks the K-band continuum flux.

A27) Exoplanets around G–K giants

M.P. Döllinger[1], A.P. Hatzes[2], L. Pasquini[1], E.W. Guenther[2], M. Hartmann[2], J. Setiawan[3], Leo Girardi[4], J.R. de Medeiros[5], L. da Silva[6]

[1] *European Southern Observatory, Garching bei München, Germany*
[2] *Thüringer Landessternwarte, Tautenburg, Germany*
[3] *Max-Planck-Institut für Astronomie, Heidelberg, Germany*
[4] *Observatorio Astronomico di Padova-INAF, Padova, Italy*
[5] *Departamento de Fisica, Universidade Federal do Rio Grande do Norte, Natal, Brazil*
[6] *Observatorio Nacional, Rio de Janeiro, Brazil*

Planetary companions orbiting G–K giants are indicated by radial velocity (RV) variations. The northern sample consists of 62 very bright K giants. The spectra in the visual range were obtained with the high resolution coudé échelle spectrograph mounted on the 2m telescope of the Thüringer Landessternwarte Tautenburg (TLS). In the South around 300 G and K giants were monitored with $HARPS$ mounted on the 3.6m telescope on La Silla. The Tautenburg survey contains at least 6 stars (around 10 %) which show low-amplitude, long-period RV variations most likely due to planetary companions. The first preliminary results of the HARPS study confirm this high planet frequency. Moreover the TLS survey seems to indicate, that planets around giant stars do not favour metal-rich stars, are more massive and have longer periods than those found around solar type stars.

A28) Chemistry of disks seen with the IRAM array: the CID project

Anne Dutrey[1]

[1] *LAB, UMR 5804, Observatoire de Bordeaux, 2 rue de lObservatoire, 33270 Floirac, France*

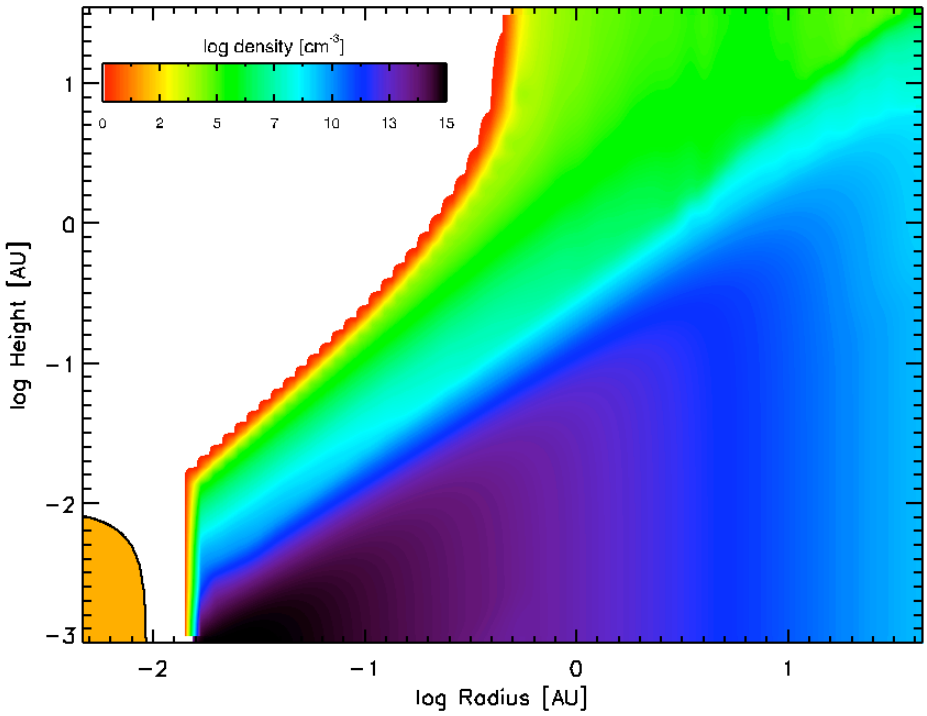
A29) Metallicity dependence of T-Tauri disk lifetimes and effects on the formation of giant planets

Barbara Ercolano[1,2]

[1] *Institute of Astronomy, Madingley Rd, Cambridge, CB3 0HA, UK*
[2] *Department of Physics and Astronomy, University College London, WC1E 6BT, UK*

The lifetime of protoplanetary disks is intimately linked to the mechanism responsible for their dispersal. Photoevaporation by energetic radiation from the central young stellar object has been proposed as the dominant dispersal mechanism. Contrary to what would be expected by a dispersal mechanism based on planet formation, photoevaporation predicts a positive correlation between the dispersal timescale τ_{dis} and the metallicity (Z) of the disk. In this talk I will discuss the effects of Z on τ_{dis} in the context of a photoevaporation model, by means of detailed thermal calculations of a disk in hydrostatic equilibrium irradiated by EUV and X-ray radiation from the central source (see Figure 1). The models show $\tau_{dis} \propto Z^{0.64}$. Future observational studies of disk frequencies in clusters of different ages and metallicity may be used to differentiate between the two dispersal mechanisms if sufficiently large number statistics can be achieved.

In this talk I will also discuss an analytical framework to study the effects of the $\tau_{dis} - Z$ correlation on the formation of gas giants in the core accretion scenario. It is found that photoevaporation only plays a secondary role in this scenario, with the strongest effect being the positive correlation between the mass of the core formed and the density of solids in the disk.



A30) Star and protoplanetary disk properties in Orion's suburbs

M. Fang[1], R. van Boekel[1], W. Wang[1], A. Carmona[2,3,1], A. Sicilia-Aguilar[1], Th. Henning[1]

[1] *Max-Planck Institute for Astronomy, Königstuhl 17, D-69117 Heidelberg, Germany*
[2] *ISDC Data Centre for Astrophysics, University of Geneva, chemin d'Ecogia 16, CH-1290 Versoix, Switzerland*
[3] *Observatoire de Genève, University of Geneva, chemin des Maillettes 51, CH-1290 Sauverny, Switzerland*

Knowledge of the evolution of circumstellar accretion disks is pivotal to our understanding of star and planet formation; and yet despite intensive theoretical and observational studies, the disk dissipation process is not well understood. Infrared observations of large numbers of young stars, as performed by the *Spitzer Space Telescope*, may advance our knowledge of this inherently complex process. While infrared data reveal the evolutionary status of the disk, they hold little information on the properties of the central star and the accretion characteristics. Existing 2MASS and Spitzer archive data of the Lynds 1630N and 1641 clouds in the Orion GMC provide disk properties of a large number of young stars. We wish to complement these data with optical data that provide the physical stellar parameters and accretion characteristics. Therefore, we performed a large optical spectroscopic and photometric survey of the aforementioned clouds. Spectral types, as well as accretion and outflow characteristics, are derived from our VLT/VIMOS spectra. Optical SDSS and CAHA/LAICA imaging was combined with 2MASS, Spitzer IRAC, and MIPS imaging to obtain spectral energy distributions from 0.4 to 24 μm. Reddened model atmospheres were fitted to the optical/NIR photometric data, keeping $T_{\rm eff}$ fixed at the spectroscopic value. Mass and age estimates of individual objects were made through placement in the HR diagram and comparison to several sets of pre-main sequence evolutionary tracks.

From this survey, we provide a catalog of 132 confirmed young stars in L1630N and 267 such objects in L1641. We identify 28 transition disk systems, 20 of which were previously unknown, as well as 42 new transition disk candidates for which we have broad-band photometry but no optical spectroscopy. We give mass and age estimates for the individual stars, as well as equivalent widths of optical emission lines, the extinction, and measures of the evolutionary state of the circumstellar dusty disk. We estimate mass accretion rates $\dot{M}_{\rm acc}$ from the equivalent widths of the Hα, Hβ, and He I 5876Å emission lines, and find a dependence of $\dot{M}_{\rm acc} \propto M_*^{\alpha}$, with $\alpha \sim$3.1 in the subsolar mass range that we probe. An investigation of a large literature sample of mass accretion rate estimates yields a similar slope of $\alpha \sim$2.8 in the subsolar regime, but a shallower slope of $\alpha \sim$2.0 if the whole mass range of $0.04\,{\rm M}_\odot \leq M_* \leq 5\,{\rm M}_\odot$ is included. The fraction of stars with transition disks that show significant accretion activity is relatively low compared to stars with still optically thick disks (26±11% vs. 57±6%, respectively). However, those transition disks that *do* show significant accretion have the same median accretion rate as normal optically thick disks of 3-4$\times10^{-9}$ $M_\odot$ yr^{-1}. Analyzing the age distribution of various populations, we find that the ages of the CTTSs and the WTTSs with disks are statistically indistinguishable, the WTTSs without disks are significantly older than the CTTSs, and the ages of the transition disks and the WTTSs without disks are statistically indistinguishable. These results argue against disk-binary interaction or gravitational instability as mechanisms causing a transition disk appearance. Our observations indicate that disk lifetimes in the clustered population are shorter than in the distributed population.

A31) Timescale of Mass Accretion in Pre-Main-Sequence Stars

D. Fedele[1], M. E. van den Ancker[2], Th. Henning[1] R. Jayawardhana[3] & J. M. Oliveira[4]

[1] *Max Planck Institut für Astronomie, Königstuhl 17, D-69117 Heidelberg, Germany*
[2] *European Southern Observatory, Karl Schwarzschild Strasse 2, D-85748 Garching bei München, Germany*
[3] *Department of Astronomy and Astrophysics, University of Toronto, 50 St. George Street, Toronto, ON, M5S 3H4, Canada*
[4] *Lennard-Jones Laboratories, School of Physical & Geographical Sciences, Keele University, Staffordshire ST5 5BG, UK*

We present initial result of a large spectroscopic survey aimed at measuring the timescale of mass accretion in young, pre-main-sequence stars with spectral type between K0 – M5. Using multi-object spectroscopy with VIMOS at the VLT we identified the fraction of accreting stars in a number of young stellar clusters and associations of ages between 1 – 30 Myr. The fraction of accreting stars decreases from ~ 70 % at 1 Myr to ~ 2 % at 10 Myr. No accreting stars are found after 10 Myr at a sensitivity limit of 10^{-11} $M_{\odot} yr^{-1}$. We compared the fraction of stars showing ongoing accretion (f_{acc}) to the fraction of stars with Spitzer/IRAC infrared excess (f_{irac}, signature of optically thick dusty inner disk). In most cases we find $f_{acc} < f_{irac}$, *i.e.*, mass accretion appears to cease (or drop below detectable level) earlier than the dust is dissipated in the inner disk. At 5 Myr, 95 % of the stellar population has stopped accreting material at a rate of $> 10^{-11}$ $M_{\odot} yr^{-1}$, while ~ 20 % of the stars show near-infrared excess emission. Assuming an exponential decay, we measure a mass accretion timescale (τ_{acc}) of 2.3 Myr, compared to an (IRAC) infrared excess timescale (τ_{irac}) of 2.9 Myr. We discuss this difference in terms of disk evolutionary models and planet formation.

A32) Effects of the disk inclination angle of classical T Tauri stars on their accretion and mass loss signatures

M.Fernández[1], Th.Henning[2]

[1] *Instituto de Astrofísica de Andalucía, CSIC, Granada, Spain*
[2] *Max-Planck-Institut für Astronomie, Heidelberg, Germany*

From the study of a small sample of classical T Tauri stars, Appenzeller, Bertout & Stahl (2005) suggested that the disk inclination, together with the mass accretion rate, dominates the emission properties of these stars. If the inclination notoriously affects the spectral features considered to be indicators of the mass accretion and mass loss processes, this effect needs to be taken into account before accretion rates and other physical properties are derived from them.

We have started an observational project with UVES to test how much the disk inclination angle influences the line profiles. We have selected a sample of 18 T Tauri stars, with known rotational periods, for which we would like carry out high resolution spectroscopy in order to measure their $v \cdot sini$, veiling and the equivalent width and line profile of the emission lines included in the 3260 - 6840 Å wavelength range. Here we will present the first results of our observations, carried out on a small group of stars of our sample.

A33) Chemistry of a protoplanetary disk with grain settling and Lyα radiation

Jeffrey K. J. Fogel[1], Thomas J. Bethell[1], Edwin A. Bergin[1], Nuria Calvet[1]

[1] *University of Michigan*

A critical component to calculate the correct chemistry of protoplanetary disks is the proper treatment of the incident UV field on these disks. We present results from a new model where we directly calculate the changing propagation and penetration of the high energy radiation field as the dust grains evolve. We also have explored the

effect of Lyα photons on the disk chemistry, an important component that has been left out of other disk chemistry models. In some T Tauri stars, Lyα radiation has been shown to dominate the UV fields, carrying up to 75% of the UV flux. The dust grains evolution plays a large role in determining how deep the UV radiation penetrates into the disk. Significant grain settling at the midplane leads to much smaller freeze-out regions near the midplane and shifts the warm molecular layer deeper into the disk while raising the temperature of the disk. The inclusion of Lyα radiation impacts the disk chemistry through specific species that have large photodissociation cross sections at 1216 Å. H_2O and SO_2 are two species where the column densities in the disk are decreased by factors of 10 or more due to the presence of Lyα radiation in the UV spectrum. At all radii beyond about 20 AU, the presence of H_2O vapor in the disk is significantly limited by the presence of Lyα radiation in the UV field.

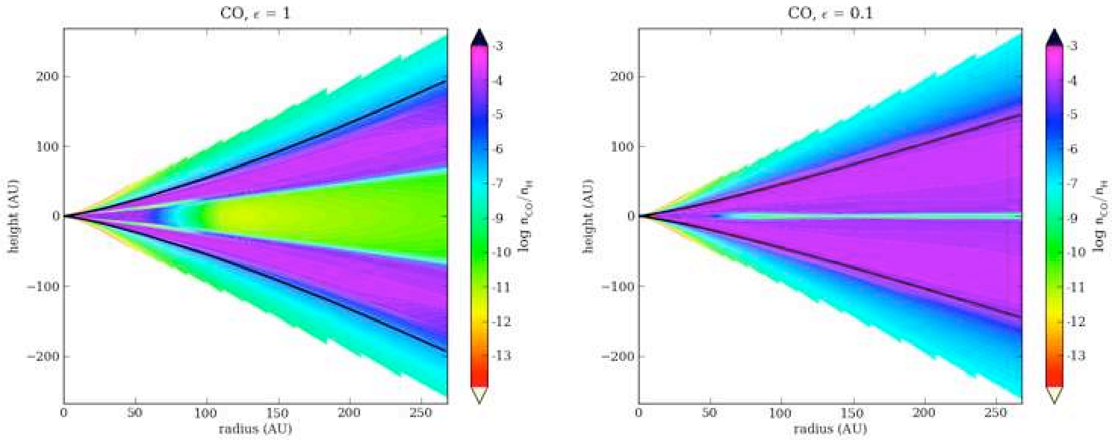


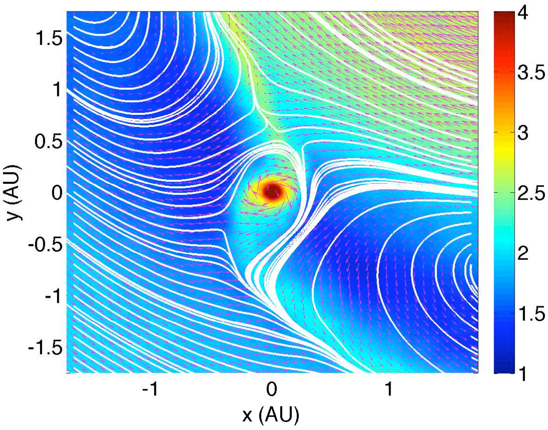
Figure: Abundance of CO relative to H_2 in protoplanetary disks with UV radiation field penetration included. Figure on the right includes the effects of dust settling.

A34) Migration and growth of giant planets in self-gravitating disks with varied thermodynamics

Fouchet, L.[1], Mayer, L.[2,3]

[1] *Physikalisches Institut, University of Bern, Sidlerstrasse 5, 3012 Bern, Switzerland*
[2] *Institut für Theoretische Physik, University of Zürich, CH-8057 Zürich, (Switzerland)*
[3] *Department of Physics, Institut für Astronomie, ETH Zürich, CH-8093 Zürich, (Switzerland)*

We report on the results of novel global high-resolution three-dimensional simulations of disk-planet interaction which incorporate simultaneously realistic radiation physics and the self-gravity of the gas, as well as allowing the planet to move in a viscous disk. We find that both self-gravity and thermodynamics have a significant effect on the character and magnitude of migration of Jupiter mass planets as well as on the amount of gas available for accretion. Self-gravity increases migration rates by about $\sim 50\%$. In simulations with radiative transfer adopting flux-limited diffusion, inward migration can be decreased by about 30% relative to the isothermal case, while in adiabatic runs migration nearly shuts off after a few tens of orbits. Similar strong effects of thermodynamics on planet migration have been recently found for the case of low mass planets. Gas feeding rates on the planet can be reduced by more than an order of magnitude going from isothermal to radiative transfer and adiabatic simulations. A circumplanetary disk always forms except in adiabatic runs. With radiative transfer the disk is sub-keplerian ($v_{rot}/v_{kep} \sim 0.7$) owing to significant pressure support, but large boulders with sizes larger than $10 - 100$ m should drift slow enough to allow the formation of rocky satellites.



A35) Variability in Scattered Light from the Protoplanetary Disk around HD 163296

M. Fukagawa[1], E. Katoh[1], M. Shimoura[1], A. F. Kowalski[2], J. P. Wisniewski[2], C. A. Grady[3], M. L. Sitko[4], H. Shibai[1]

[1] *Osaka University*
[2] *University of Washington*
[3] *NASA GSFC*
[4] *University of Cincinatti and Space Science Institute*

Primordial disks provide the initial conditions of planet formation, and hence observations of disks are of primary importance to understand planet building mechanisms. HD 163296, a well-studied Herbig Ae star, harbors an extended disk and the multi-epoch observations of HD 163296 recently brought us a new insight into the disk structure. Sitko et al. (2008) reported the variability of the thermal emission from the inner disk by the near-infrared spectroscopy, while Wisniewski et al. (2008) confirmed the temporal change of the surface brightness of the outer disk in the optical with *HST*. These observations suggest that the HD 163296 disk experiences variable self-shadowing. The thermal variation in near-infrared can be interpreted by structural change in the dust sublimation zone, possibly inflating of the inner wall of the dusty disk, which induces variable illumination in the outer region, and which can be detected through imaging observations. In order to test the hypothesis and to understand physical process causing the variation, we have been conducting the multi-epoch observing campaign to investigate the period, amplitude, morphological change, and correlation between inner and outer disks.

We present the H-band images of the disk around HD 163296 obtained as part of the monitoring campaign in 2008 and 2009, along with those in 2004, with the Subaru Telescope. The coronagraphic imaging observations reveal the disk with the radius of approximately 400 AU. The disk is noticeably brighter and less structured in scattered light in 2008 than in 2004. The structure like the dark inner region and the ansa in south-east seen in the faint phase (in 2004) is much more ambiguous in the brighter phase (in 2008), and this tendency is consistent with the *HST* results at previous epochs. The preliminary analysis of the images in 2009 is also reported. The ongoing efforts to compile literature and to carry out photometric monitoring for pre-main-sequence stars suggest that HD 163296 is not peculiar and variable thermal emission could be common. Such variability should be one of the clues to understand how disks evolve in million years, during the era of the planet formation.

A36) Disk Dissipation at an Age of 1-2 Myr

Elise Furlan[1], Manoj Puravankara[2], Dan M. Watson[2], William J. Forrest[2]

[1] *Spitzer Fellow; JPL, Caltech, Pasadena, CA*
[2] *Department of Physics and Astronomy, University of Rochester, Rochester, NY*

We present an analysis of young (1-2 Myr old) protoplanetary disks that show signs that their disk material has already started to disperse. Their low infrared excess emission suggests that the inner disk regions are depleted in small dust grains compared to typical protoplanetary accretion disks. Using mid-infrared spectra obtained with the *Spitzer Space Telescope*, we characterize the infrared excess and quantify the degree of dust depletion in these systems, as well as the distribution and composition of the remaining dust. This information will be used to assess to which extent processes such as photoevaporation or planet formation play a role in clearing the inner disks.

A37) Dust amorphization in protoplanetary disks

A. M. Glauser[1,2], M. Güdel[1], D. Watson[3], T. Henning[4], P. Woitke[2,5], A. A. Schegerer[6], S. Wolf[7], M. Audard[8,9], C. Baldovin-Saavedra[8,9]

[1] *Institute of Astronomy, ETH Zurich, 8093 Zurich, Switzerland*
[2] *UK Astronomy Technology Centre, Blackford Hill, Edinburgh EH9 3HJ, United Kingdom*
[3] *University of Rochester, Department of Physics and Astronomy, Rochester, NY, USA*
[4] *Max Planck Institute for Astronomy, Königstuhl 17, 69117 Heidelberg, Germany*
[5] *School of Physics & Astronomy, University of St. Andrews, North Haugh, St. Andrews KY16 9SS, UK*
[6] *Helmholtz Zentrum München, German Research Center for Environmental Health, Ingolstädter Landstraße 1, 85758 Neuherberg, Germany*
[7] *University of Kiel, Institute for Theoretical Physics and Astrophysics, Leibnizstr. 15, 24098 Kiel, Germany*
[8] *Observatoire de Genève, University of Geneva, Ch. de Maillettes 51, 1290 Sauverny, Switzerland*
[9] *ISDC Data Center for Astrophysics, University of Geneva, Ch. d'Ecogia 16, 1290 Versoix, Switzerland*

During star and planet formation, the structure of circumstellar dust grains evolves from purely amorphous (interstellar medium) to highly crystalline (debris disks). The underlying processes may be thermal annealing as well as dust evaporation and re-condensation on colder grains. For both processes, direct relations between the dust structure and the disk evolution or the stellar properties are expected. It is therefore surprising that until now, no such correlation has been found.

We present a possible explanation by introducing a model of an amorphization process caused by the stellar radiation, mainly the stellar wind. We use both observations and simulations to strengthen the plausibility of this model.

Our observational study focuses on a sample of class II T Tauri stars and is extended further to transitional disks. Since the stellar wind is not directly observable, we use X-rays as an indicator of the stellar activity and the high energy particle irradiation of the circumstellar dust. We measure the dust crystallinity using the 10 μm silicate feature, measured with the Spitzer IRS instrument. We then correlate the X-ray luminosity and the X-ray hardness of the central object with the crystalline mass fraction of the circumstellar dust and find a significant anti-correlation. Consequently, we interpret this result as an indication for an amorphization process caused by stellar irradiation.

We show that the fluxes around 1 AU and ion energies of the present solar wind are sufficient to amorphize the upper layer of dust grains very efficiently, leading to an observable reduction of the crystalline mass fraction of the circumstellar dust. We extend this modeling using a Monte Carlo simulation of stellar wind ions penetrating the protoplanetary disk, taking physical disk properties into account. This allows the study of disk-self-shielding effects which are crucial for the determination of the efficiency of the proposed amorphization mechanism.

A38) Dust growth and planet gaps in protoplanetary disks

J.-F. Gonzalez[1], G. Laibe[1], L. Fouchet[2], S.T. Maddison[3], C. Pinte[4], F. Ménard[4]

[1] *Centre de Recherche Astrophysique de Lyon, Université de Lyon, France*
[2] *Physikalisches Institut, Universität Bern, Switzerland*
[3] *Centre for Astrophysics and Supercomputing, Swinburne University of Technology, Melbourne, Australia*
[4] *Laboratoire d'AstrOphysique de Grenoble, Université Joseph Fourier, Grenoble, France*

In order to understand the first stages of planet formation, when tiny grains aggregate to form planetesimals, one needs to simultaneously model grain growth, vertical settling and radial migration of dust in protoplanetary disks. We have implemented an analytical prescription for grain growth by coagulation, which assumes that grains stick perfectly upon collision, into our 3D, two-phase (gas and dust, interacting via aerodynamic drag) SPH code. This allows us to follow the evolution of the size and spatial distribution of a dust population in a Classical T Tauri star (CTTS) disk. We find that the grains go through various stages of growth due to the complex interplay between gas drag, dust dynamics, and growth. Grains initially grow rapidly as they settle to the mid-plane, then experience a fast radial migration with little growth through the bulk of the disk, and finally pile-up in the inner disk where they grow more efficiently. We find that grains reach decimetric sizes in 10^5 years in the inner disk and survive the fast migration phase. We present a suite of simulations covering a wide range of disk and grain parameters (varying the disk's mass, thermal and density profiles, and initial size and density of the grains). We find that the gas density profile determines the region of the most efficient coupling between the gas and dust for a given grain size, which strongly affects the shape of the grain size distribution in the disk. Thus the gas density profile determines the grain dynamics and hence is crucial in planet formation.

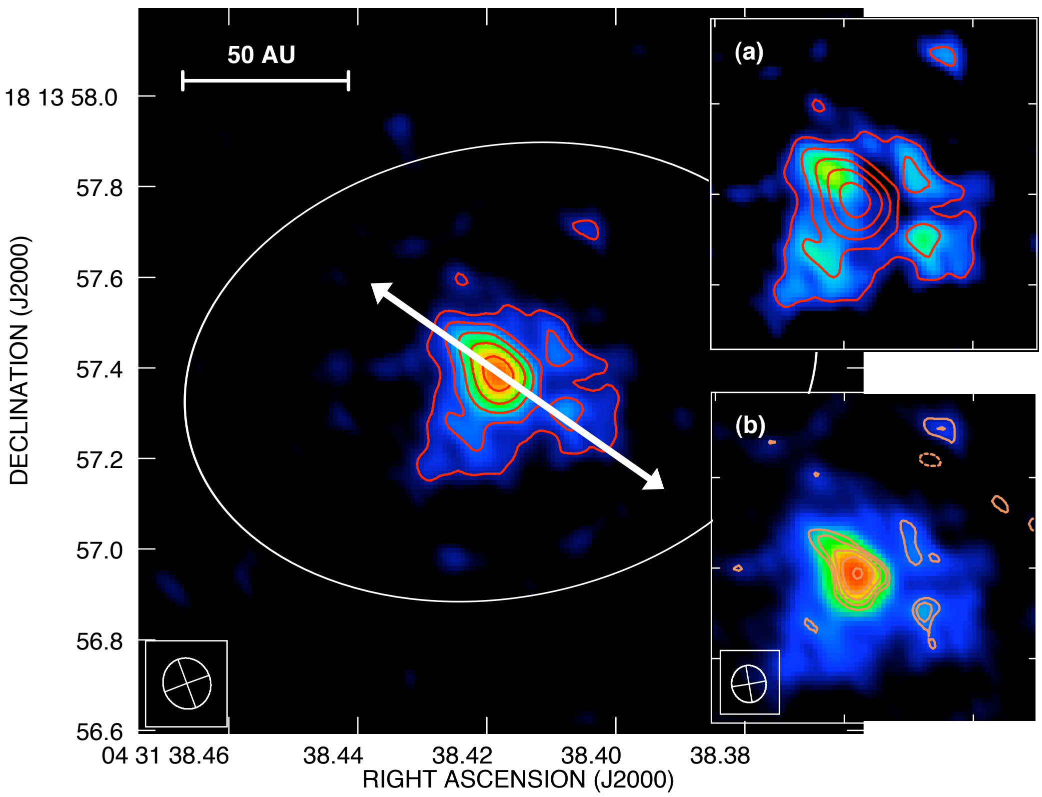
We also present the evolution of a CTTS disk in the presence of an embedded planet for different masses (0.1 to 5 $M_{\rm Jup}$), and for various grain sizes (100 μm to 10 cm, growth being neglected at first) to see how they affect the resulting disk structure. We find that gap formation is much more rapid and striking in the dust layer than in the gaseous disk and that a system with a given stellar, disk and planetary mass will have a completely different appearance depending on the grain size. We produce synthetic images and show that such differences will be detectable in the millimetre domain with ALMA. Dust accumulates at the edges of the planetary gap where its density exceeds that of the gas phase. In new simulations including grain growth, we find that particles grow most efficiently in these high density regions. Gap edges therefore appear as potential sites for the formation of additional planets.

A39) Radio imaging of proto-planets and their host disks

J.S. Greaves[1] and the PEBBLES Consortium

[1] *SUPA, University of St Andrews, Physics & Astronomy, North Haugh, St Andrews, Fife KY16 9SS, UK*

Rocky circumstellar particles must build into larger bodies in order for planetary cores to form. At the cm-sized stage, such bodies will be weak emitters of radio emission, in the long-wavelength tail of the blackbody spectrum, and this steep-spectrum signal is a characteristic signpost of these 'pebbles'. Such emission has been detectable for only a few years, and here we present the first high resolution study, with VLA and MERLIN, of the Class 0 star HL Tau. As well as a few-AU central condensation of pebbles, we find a secondary source in the outer disk (upper right in the figure). In conjunction with dynamical simulations, we show that HL Tau b is a candidate proto-planetary clump, which can have formed by gravitational instability in the host disk. Plans for future ultra-high-resolution observations with eMERLIN are also presented - the PEBBLES project will be able to discriminate for the first time between the formation zones of gas-giant and terrestrial planets in nearby star-forming regions.



A40) Spitzer Observations of an Extreme Protostellar Outflow

Green,J.D.[1], Watson,D.M.[2], Neufeld, D.A., Bergin, E.A.

[1] *Department of Astronomy, University of Texas at Austin*
[2] *Department of Physics and Astronomy, University of Rochester*
[3] *Department of Astronomy, The Johns Hopkins University*
[4] *Department of Astronomy, University of Michigan*

GGD 37 (Cepheus A West) is a collection of Herbig Haro objects – small emission nebulae that signify the interaction between both broad and collimated outflows from young stellar objects and the ambient molecular cloud material. Although it has been well-studied at millimeter and longer wavelengths, the relationship of this flow to its companion Cepheus A East is not well understood. The Outflows GO program utilized the Infrared Spectrograph onboard the Spitzer Space Telescope to map several outflow regions, including GGD 37 in the mid-infrared. With this data we have spatially resolved weaker shocks (less than $\sim$ 10000 K) that excite the molecular hydrogen into various rotational states detectable at IRS wavelengths, from strong shocks that completely destroy the molecules and illuminate the ions. The dataset contains a rich array of chemical species, allowing us to analyze the energetics of a multi-phase shock as it impacts the surrounding molecular cloud. How does the instability of driving sources of Herbig Haro jets affect their surrounding medium? By studying the pre-and post-shock gas, we can determine whether outflows from young stars have greater clumping or dispersive effects on their environment. Do outflows trigger or suppress star formation in the neighborhood? We present evidence that powerful flows such as HH 168 can unbind a protostar in its early stages of development, opening a 10000 AU cavity of ionized material. We provide evidence that the progenitor source of the HH 168 flow is at the radio source W2, rather than the more distant HW3c, and is among the hottest and most intense protostellar outflows. As a result we may have the opportunity to observe a high mass protostar in its initial stages of formation.

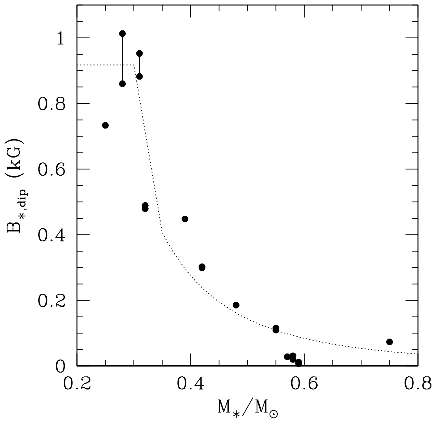
A41) The star-disk interaction as a function of spectral type

S. G. Gregory[1,2], M. Jardine[2], J. Morin[3] and J.-F. Donati[3]

[1] *University of Exeter, United Kingdom*
[2] *University of St Andrews, United Kingdom*
[3] *LATT - CNRS/Université de Toulouse, France*

The large-scale magnetic topologies of classical T Tauri stars can now be probed in unprecedented detail through Zeeman-Doppler imaging. To date, magnetic maps of four accreting T Tauri stars have been published. Initial results suggest that the magnetic topologies of high mass T Tauri stars ($> 1\,\mathrm{M}_\odot$) are significantly more complex than those of intermediate mass stars ($0.5 - 1\,\mathrm{M}_\odot$). The intermediate mass star BP Tau, which is wholly convective, has a simple large scale magnetic topology with a strong dipole component. In contrast, the high mass stars V2129 Oph, CR Cha and CV Cha, which have already developed radiative cores, have complex magnetic fields with many strong high order f ield components, and weak dipole components. More data is required to confirm if this rapid increase in field complexity, and decay in the strength of the dipole component, with increasing stellar mass, is a general result. However, it is si milar to what is found in studies of the magnetic fields of low-mass main-sequence (MS) stars.

We examine the star-disc interaction across the fully convective - radiative core divide. The stellar mass at which a radiative core develops decreases with increasing stellar age. We consider a large sample of intermediate and high mass classical T Tau ri stars for which mass accretion rate estimates are available. We re-derive masses and ages using the Siess et al., the D'Antona & Mazzitelli, and the Baraffe et al. stellar evolution models, by applying a consistent technique to convert spectral typ es to effective temperatures, and using the latest estimates of distances to various star-forming regions to update luminosity estimates. We assume that each star in the sample has a large scale magnetosphere consisting of only axial ($m = 0$) field modes, with the field complexity and the strength of the dipole component increasing and decreasing respectively with increasing stellar mass, following a similar trend to MS M-dwarf stars. By assuming that discs are truncated where the magnetic torque from the stellar magnetosphere is comparable to the viscous torque in the disc, we find that only intermediate mass stars can truncate their discs out to the corotation radius. The discs of high mass accreting T Tauri stars are always found to be truncated well within corotation. We conclude that the star-disc interaction is more strongly mass dependent than previously anticipated by dipolar accretion models, and the angular momentum remova l mechanism that must operate in order to explain the slow rotation of accreting T Tauri stars is more efficient for earlier spectral types.



The rapid change in the strength of the dipole component for MS M-dwarfs stars across the fully convective - radiative core divide ($\sim 0.35\,M_\odot$). Vertical bars denote stars observed at two different epochs.

A42) Mid-Infrared Interferometry of the massive YSO NGC 2264 IRS 1

Rebekka Grellmann[1], Stefan Kraus[2], Thomas Preibisch[1], Thorsten Ratzka[1], Gerd Weigelt[2]

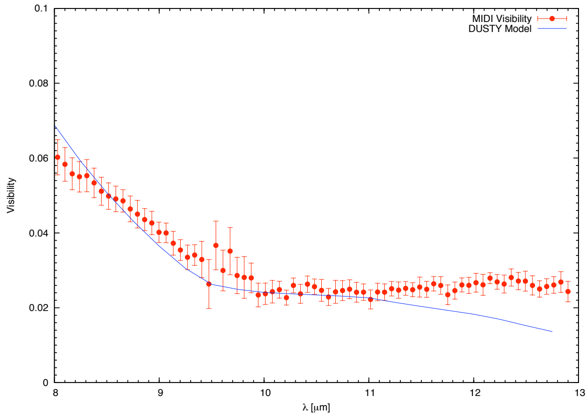
[1] *Universitätssternwarte München, Scheinerstr. 1, 81679 München*
[2] *Max-Planck-Institut für Radioastronomie, Auf dem Hügel 69, 53121 Bonn*

The question how massive stars ($> 8M_\odot$) form is still highly debated as observations of adequate objects are rare. This is due to several reasons: First of all, these objects are surrounded by high amounts of gas and dust, which absorb almost all the radiation coming from the central star, thus making a direct observation very difficult. Second, the large distances of the massive young stellar objects (MYSO) require a high spatial resolution. Other difficulties are the fast evolution of MYSO and the fact, that they are rarely found in isolation. Until recently, conclusions drawn on the spatial distribution of the surrounding dust were based only on the modeling of the spectral energy distribution (SED). Such SED model fits are highly ambigous, therefore more information is required to obtain the real geometry of the circumstellar material.

The MYSO NGC 2264 IRS 1 was discovered in 1972 by D. Allen (ApJ, 172, 55, therefore also called Allen's Source) as an infrared source without optical counterpart. It is believed to be a young massive star at a distance of 760 pc with a mass of 9.5 $M_\odot$, a luminosity of $4.7 \cdot 10^3 L_\odot$ and the spectral type B2.

NGC 2264 IRS 1 was observed with the Mid-Infrared Instrument (MIDI) at the VLTI at a projected baseline of 89 m and a position angle of 81°. The observation was done with the grism, which has a spectral resolution of 230, and in the SCI-PHOT mode, in which the photometric data are recorded simultaneously to the interferometric data. With this data we first tried to find out the approximate size of the dust distribution by fitting some simple geometrical models (Gaussian, uniform disk, ring) to the observed visibility curve. As expectet the diameter of the source increases with increasing wavelength and for the size of the dust distribution in the mid-infrared we get values from 20 to 30 mas, equivalent to 19 to 24 AU. This is considerably larger than typical sizes for Herbig Ae/Be stars (Leinert et al. 2004, A& A, 423, 537).

As the circumstellar material of the object seems to be relatively extended we employed the 1-D radiative transfer code DUSTY to test spherical models for the circumstellar dust distribution. In the figure below the visibility vs. wavelength curve can be seen together with the best-fit DUSTY model, which can reproduce the visibility up to 11 micron, but fails to reproduce it between 11 and 13 micron. In this contribution we therefore will also present 2-D radiative transfer models which are in progress at the moment. Another possible geometry of the dust is a circumstellar disk, often seen in low-mass YSO. For this possibility to test we also used a temperature-gradient model. Furthermore we will investigate the silicate absorbtion feature in more detail.



A43) High-velocity gas in the young high-mass star MWC 297

J. H. Groh[1], T. Driebe[1], K.-H. Hofmann[1], S. Kraus[1], A. Moises[2], D. Schertl[1], M. Teodoro[2], and G. Weigelt[1]

[1] *Max-Planck-Institut für Radioastronomie, Auf dem Hügel 69, D-53121 Bonn, Germany*
[2] *Instituto de Astronomia, Geofísica e Ciências Atmosféricas, Universidade de São Paulo, Rua do Matão 1226, Cidade Universitária, 05508-090, São Paulo, SP, Brazil*

Young stellar objects are characterized by the simultaneous presence of outflows and accretion, which are widely recognized to play a key role in the star formation process and angular momentum evolution. The origin, dynamics, and physical processes governing the outflow are still subject of debate, in particular for luminous high-mass Herbig Be stars where both the intense radiation and magnetic fields are expected to affect the wind. To study the properties of the outflow, we obtained multi-epoch near-infrared spectroscopy of the Herbig Be star MWC 297 with the 1.6-m telescope of the Brazilian Observatório Pico dos Dias, with a resolving power of R=10 000 around the spectral line of He I 10833 Å. We report the detection of a strong blueshifted absorption associated with He I 10833 Å around -420 km s^{-1} in the 2009 Apr 21 spectrum. Data recorded in 2009 Jun 06 shows that the radial velocity of the blueshifted absorption changed to -340 km s^{-1}, while all other emission lines present in our the near-infrared spectrum, such as Paschen γ, do not show radial velocity variability within ±5 km s^{-1}. The short spectral coverage of previous spectroscopic observations around the He I 10833 Å line from Drew et al. 1997 did not allow these authors to clearly decide between the presence of high-velocity absorption around -400 km s^{-1} or of emission from -400 to -200 km s^{-1}. Our spectroscopy of MWC 297 unambiguously shows a strong, time-dependent, high-velocity absorption in He I 10833 Å, with velocity at least 3 times higher than the typical velocity of the material which is presumably outflowing from a disk wind (~ 100 km s^{-1}). We interpret that the high-velocity material seen in He I 10833 Å is coming from a stellar wind located much closer to the central star, preferentially at high latitudes.

A44) Dust disk at 0.3 arcsec resolution: the PdBI view

Guilloteau, S.[1,2]

[1] *Universit Bordeaux 1; Laboratoire dAstrophysique de Bordeaux (LAB), France*
[2] *CNRS/INSU UMR5804, BP 89, 33270 Floirac, France*

A45) A CO survey in Planet-Forming disks: Characterizing the Gas Content in the Epoch of Planet Formation.

Hales, A.[1]

[1] *ALMA Institute, Apoquindo 3946 Piso 19, Santiago*

We present preliminary results from our ongoing CO survey of protoplanetary disks using southern single-dish sub-mm facilities (APEX+ASTE). The survey aims to 1) characterize the evolution of the molecular gas and dust in

protoplanetary disks systems through the ratio of infrared excess and integrated CO emission, 2) identify new gas-rich systems and build up a southern sample of gaseous protoplanetary disks that can be targeted with ALMA, and 3) extract statistics on the physical conditions inferred in the disks through radiative transfer models of the CO line profiles. In this poster we present our current detections and briefly discuss non-detections and their implicances.

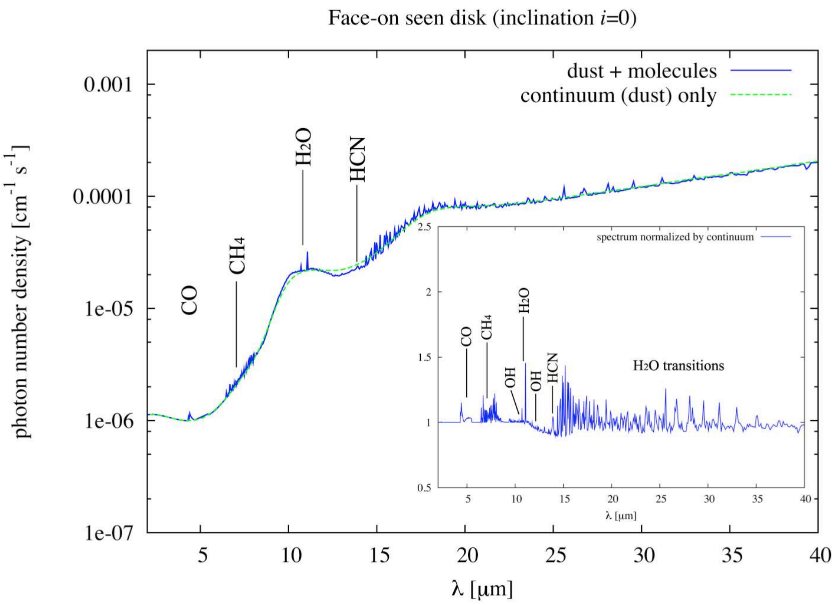
A46) CEPD – Chemical Evolution of Protoplanetary Disks

Dominikus Heinzeller[1], Hideko Nomura[1], Tom J. Millar[2]

[1] *Department of Astronomy, Graduate School of Science, Kyoto University, Kyoto, Japan*
[2] *School of Mathematics and Physics, The Queens University Belfast, UK*

Protoplanetary disks undergo a significant evolution from their early phase around a hot, protostellar core to their dispersal phase after planet formation. We present a new project on the physical and chemical evolution of protoplanetary disks in their intermediate phase. Thereby, we plan to focus especially on the effects of turbulent mixing and accretion motion on the chemical composition in the disk. Strong turbulence might drive the disk chemistry out of equilibrium and replenish the abundances of molecules in the inner disk regions and in the upper disk layers, where they are continuously destroyed by UV- and X-ray irradiation from, e. g., the central star. Likewise, inward accretion may supply the inner disk with molecules from the outer regions where they are frozen onto dust grains.

To address the complex problem of modeling the combined evolution of the disks' physical and chemical state and to confront it with observations, we propose a step-by-step approach. Here, we calculate the molecular line emission of the inner regions of protoplanetary disks. The disk is taken to be stationary and based on an extended, irradiated α-viscosity disk model, while the chemical abundances are calculated as a function of time. Our first results of the radiative transfer analysis suggest that molecules such as H_2O, CO and CH_4 indeed can be detected in the inner 20 AU of the disk (see figure below). Further improvements of the physical and chemical modeling, for example an accurate determination of the UV- and X-ray irradation field and the consideration for adsorption of molecules onto dust grains close to the disk mid-plane, are discussed. Finally, necessary future extensions are presented which will allow us to constrain further the relevance of turbulent mixing and accretion motion for the chemical and physical evolution of protoplanetary disks.



A47) An arc of gas and dust around the young star DoAr 21

Michiel Hogerheijde[1], Olja Panić[1], Hester Schouten[1], and Bruno Merín[2]

[1] *Leiden Observatory, Leiden University, The Netherlands*
[2] *herschel Science Center, ESA/ESAC, Madrid, Spain*

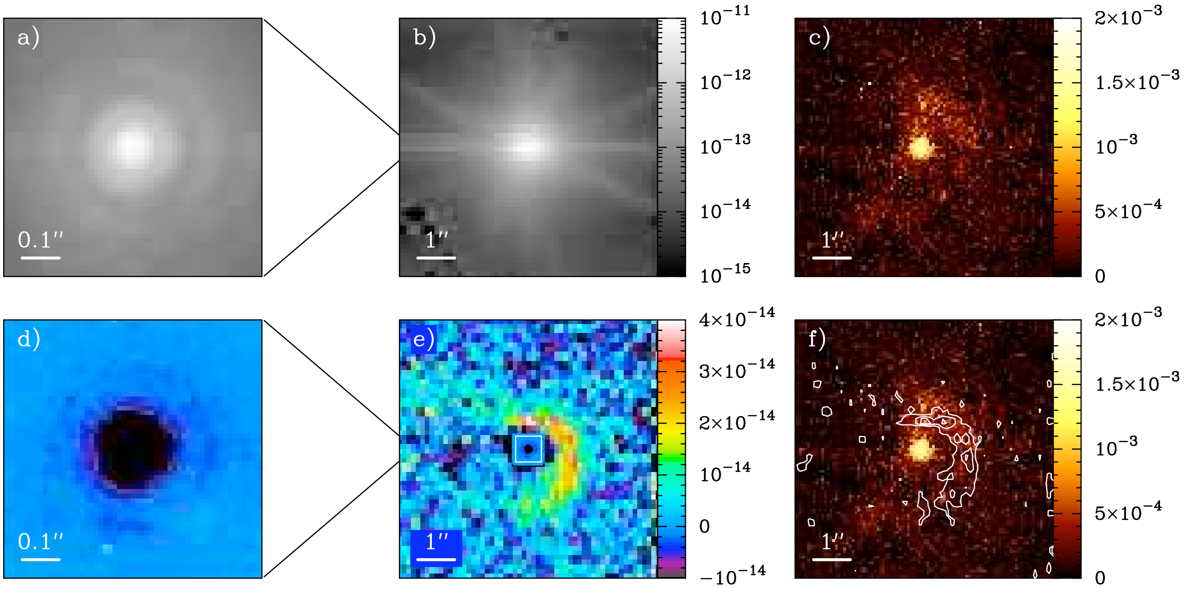
The dissipation of protoplanetary disks is currently thought to occur inside-out, either through photoevaporation or gap formation following giant-planet formation. So-called 'transitional' disks, with cleared-out inner regions, are characterized by nearly photospheric near-infrared fluxes and strong mid-infrared excess.

We investigate the spatial distribution of circumstellar material around the ~ 0.3 Myr old, weak-line T Tauri star DoAr 21, which has a 'transitional' SED.

We resolve the emission of the H_2 1–0 S(1) line at a resolution of ~ 250 mas using adaptive-optics assisted Integral Field Unit spectroscopic measurements with SINFONI on VLT. We also detect the H_2 1–0 S(0) line, but at insufficient signal-to-noise to spatial resolve the emission; and we obtain upper limits to several other H_2 lines. Diffraction limited imaging with VISIR on VLT at $\lambda = 18.72$ μm shows the emission from warm (~ 50–100 K) dust at a resolution of $0.48''$.

The H_2 line emission and the 18.72 μm dust continuum reveal a 230° arc of emission located on the northwest side of the star at 73–219 AU distances. The mass of the circumstellar material is estimated at $> 1 \times 10^{-4}$ $M_\odot$ of gas and dust. We conclude that this arc may be the result of swept-up unrelated cloud material or may be caused by an unseen companion of no more than a few Jupiter masses interacting with disk material; perturbation of the disk by a stellar fly-by is considered unlikely. Our results illustrate that the presence of a cleared-out disk cannot be inferred from spatially unresolved observations alone. At the same time, they suggest that detectable ro-vibrational H_2 lines arise when X-rays are not confined to the immediate surroundings of the star.

Figure: **(a)** *Image of the 2.20 μm emission of DoAr 21 plotted using a logarithmic stretch ranging from 10^{-15} to 10^{-11} erg s^{-1} cm^{-2} μm^{-1} pixel^{-1}.* **(b)** *Same as (a), recorded over a larger region, under-resolving the PSF.* **(c)** *Image of the 18.72 μm emission, plotted on a linear stretch ranging from 0 to 2 mJy pixel^{-1}.* **(d)** *Continuum subtracted image of the H_2 1–0 S(1) line,. The intensity is plotted with a linear stretch ranging from -1×10^{-14} to 4×10^{-14} erg s^{-1} cm^{-2} μm^{-1} pixel^{-1}. Note the negative residual of the stellar continuum subtraction possibly due to absorption by H_2 located along the line-of-sight.* **(e)** *Same as (d), over a larger region* **(f)** *Overlay of the H_2 1–0 S(1) line emission (contours, at 1, 2, 3... times 1.2×10^{-14} erg s^{-1} cm^{-2} μm^{-1} pixel^{-1}) on the 18.72 μm continuum emission.*

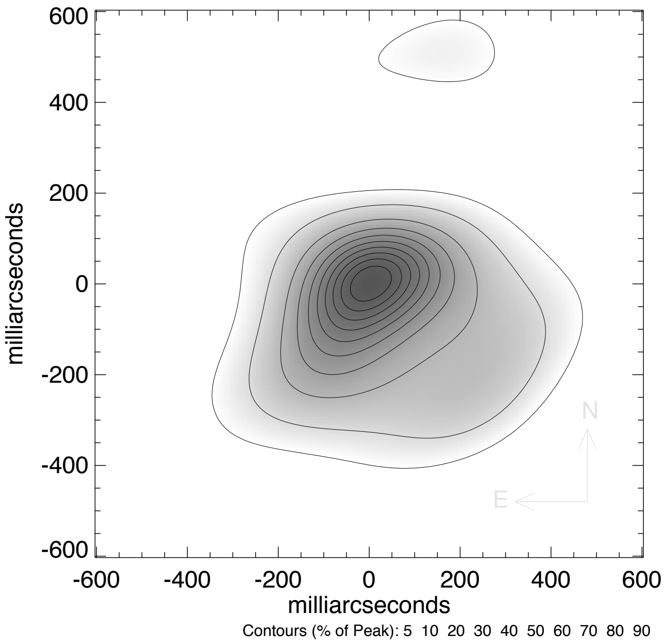


A48) Detection of a disk by mid-infrared interferometry in the massive young stellar object NGC3603-IRS9A.

Christian Hummel[1], Stefan Vehoff[2], Dieter Nürnberger[1]

[1] *European Southern Observatory*
[2] *Insitute for Theoretical Astrophysics, Heidelberg*

We present results from our high angular resolution observations of the high-mass young stellar object IRS 9A in NGC 3603. Both MIDI at the VLTI and T-ReCS equipped with an aperture mask at Gemini have resolved the mid-infrared dust emission on scales of 30 mas to 300 mas, corresponding to scales of 200 AU to 2000 AU. We have modeled the structure using disks and envelopes, and find reasonable agreement with the visibility measurements and the SED as measured by Spitzer. We conclude that this model, which has been very successful at describing low and intermediate mass star formation, also appears to be applicable to the high-mass case.



A49) Resolving the circumstellar environment of V921 Sco in the near-infrared with VLTI/AMBER

A. Kreplin[1], S. Kraus[1], T. Driebe[1], and G. Weigelt [1]

[1] *Max-Planck-Institut für Radioastronomie, Auf dem Hügel 69, 53121 Bonn*

We resolved the innermost region of dust sublimation of the unclassified B[e] - star V921 Sco using near-infrared interferometric observations. The VLTI near-infrared beam combiner instrument AMBER obtained spectrally dispersed interferogramms in the H and K band simultaneously. The spatial distribution of circumstellar dust near the inner disk rim could be derived. Applying temperature-gradient models and radiative transfer models we studied possible circumstellar dust geometries. The characteristic size of the near-infrared emitting region was found to be more compact than the expected dust sublimation radius. The simultaneous modeling of both the H and K band revealed a more compact size of the object in the H band than in the K band which could be attributed to the presence of a gaseous inner disk.

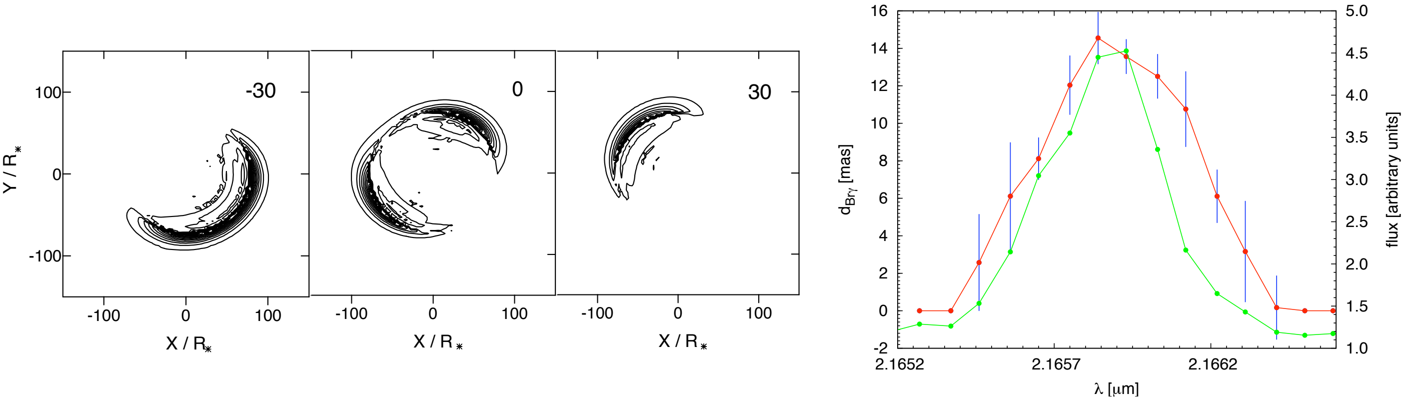
A50) First VLTI spectro-interferometry of a YSO with a spectral resolution of 12000: studies of the dust and gas distribution around the Herbig Be star MWC 297

G. Weigelt[1], T. Driebe[1], V. Grinin[2], J.H. Groh[1], K.-H. Hofmann[1], S. Kraus[1], A.S. Miroshnichenko[3], D. Schertl[1], L. Tambovtseva[2], and the AMBER Consortium

[1] *Max-Planck-Institut für Radioastronomie, Auf dem Hügel 69, D-53121 Bonn, Germany*
[2] *Main Astronomical Observatory Pulkovo, Pulkovskoe shosse 65, St. Petersburg 196140, Russia*
[3] *University of North Carolina at Greensboro, P.O. Box 26170, Greensboro, NC 27402, USA*

Circumstellar disks play a fundamental role in the formation of stars and planets. The inner circumstellar region hosts fascinating astrophysical phenomena such as inner gaseous accretion disks, disk winds, jets, dust sublimation, etc. To obtain spatially resolved observations of these phenomena, milli-arcsecond angular resolution with high spectral resolution is needed. Near-infrared interferometric observations with high spectral resolution are able to spatially resolve the gas and dust distribution in the innermost regions of disks and constrain their physical properties. Therefore, such observations will allow us to probe the nature of the accretion process and the launching of jets and winds. For the more luminous Herbig Be stars, optically thick gaseous disks, which extend well inside the dust sublimation radius, seem to play an important role. Some of the observed emission lines are possibly emitted by matter which is either accreting or being ejected from the system, rather than from the gaseous disk itself.

We report the first spectro-interferometric observations of the massive Herbig Be star MWC 297 with a spectral resolution of 12000 using VLTI/AMBER. This high spectral resolution is crucial for studying the visibilities and closure phases in several spectral channels within different Doppler-shifted parts of emission lines. The fringe tracker FINITO allowed us to use exposure times up to 8 seconds and to obtain a sufficiently high SNR. Our VLTI/AMBER interferometry of MWC 297 shows, for the first time, the detailed wavelength dependence of the visibilities measured at different baselines as well as the wavelength dependence of the closure and differential phases within the Brγ emission line. From these measurements, we derived the size and asymmetry of both the continuum- and the line-emitting region in several (~ 10) spectral channels within the Brγ line (e.g., a Gaussian FWHM diameter of 14 mas at the center of the Brγ line; see figure). The measurements clearly unveil a disk with an inner continuum radius that is much smaller than the dust sublimation radius and a line-emitting region which is three times larger than the continuum-emitting region. To explain the strong wavelength dependence of the visibilities and closure phase, we performed detailed 2D radiative transfer modeling of our data using a magnetocentrifugally driven disk-wind model of a compact disk inside the dust sublimation radius. The figure shows 2-D intensity maps of one of the models at the center of the Brγ line and at velocities of $\pm 30\ \mathrm{km\,s^{-1}}$ (left) and the Gaussian FWHM diameters of the Brγ line-emitting region for ~ 10 individual spectral channels across the emission line (right; bullets with error bars). The AMBER spectrum is shown for comparison.



B1) X-ray induced variable mass ejection in jets from young stars

P.J.V. Garcia[1,2], J. Ferreira[1], S. Cabrit[3], C. Bertout[4], L. Binette[5], F. Casse[6]

[1] *Laboratoire d'Astrophysique, Observatoire de Grenoble, BP 53, F-38041 Grenoble Cédex 9, France*
[2] *SIM and Faculdade de Engenharia, Universidade do Porto, Porto, Portugal*
[3] *Observatoire de Paris, LERMA, UMR 8112 du CNRS, 61 avenue de l'Observatoire, F-75014 Paris, France*
[4] *Institut d'Astrophysique de Paris, 98bis Bd Arago, 75014 Paris, France*
[5] *Instituto de Astronomía, UNAM, Ap. 70-264, 04510 D. F., México*
[6] *Université Paris Diderot, 10 rue Alice Domon et Lónie Duquet, 75205 Paris Cedex 13, France*

Circumstellar disks are complex systems of several interacting components. Magnetic loops in the magnetosphere of the central star create strong X-ray emission and flares, some of these loops connect to the circumstellar disk allowing accretion to take place. It is not clear how the accreting angular momentum is liberated, winds from the star, the disk or magnetic loops connecting to outer disk regions are proposed possibilities. The inner disk sometimes drives a power-full jet in an onion like structure with the inner hot atomic jet being surrounded by slower molecular material. Jet rotation is sometimes observed, either in the same sense of the disk, or more puzzling, in opposite sense.

In this work we start by presenting a disk driving a wind/jet. Such a disk is very different from a standard α accretion disk, we highlight its differences, in particular a transonic accretion rate and correspondingly much smaller density. We tie these properties to observations of inner disks.

A crucial aspect of this work is the connection of the jet properties to the source X-ray emission. We compute the heating of the disk surfacical layers from X-rays and find that it is dominated by collisional de-excitation from the level $n = 2$ of Hydrogen. This is due to the combination of severe optical thickness of the Lyα line and the low temperatures arising by the expansion cooling of the disk wind. The key result is that although the energy input from X-rays is small it is enough to increase the mass loss and lower the ejection velocity. The strong effects of such a small energy input can be intuitively understood by the very small potential well matter in an keplerian disk has to cross. This connection shows that X-rays, which are variable, are able to drive variable mass ejection and therefore shocks that light up the jet.

We then proceed by discussing the implications of disk winds and jets to overall disk evolution, in particular for theories of photoevaporation. We show that the disk wind/jet is an efficient screen to any UV and X-ray radiation, the photoionized wind layer width scaling as $\dot{M}_{\rm acc}^{-2}$. We speculate that long lived disks are related to disk wind/jet screening of the photoevaporating radiation. We also present typical column densities of disk winds useful for the calculation of the attenuation of UV to X-ray radiation field in disk chemistry and disk ionization studies.

We finalize by underlining the importance of observational disk studies in building samples of accretion disks where the effects of jets on disk structure can be studied and accurate disk structure diagnostics can be identified. A particular recent example is the attribution of [Ne II] emission to outflow when it is generally thought to be an irradiated disk surface diagnostic.

B2) Observing on-going crystal formation in real time in the disk of EX Lup

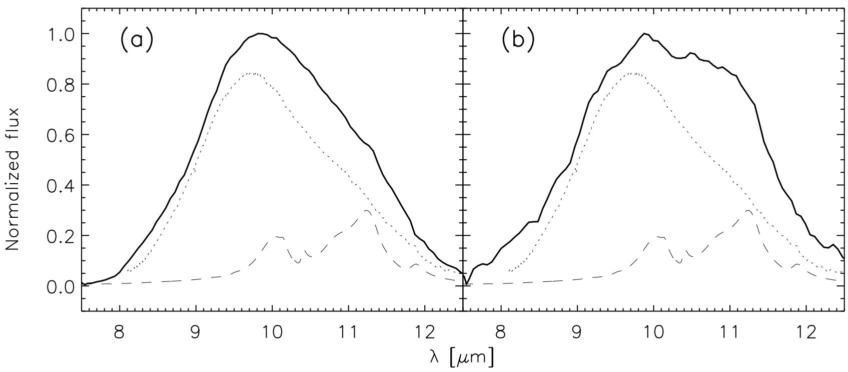
Juhász, A.[1], Ábrahám, P.[2], Bouwman, J.[1], Dullemond, C.P.[1], Henning, Th.[1], Kóspál, Á.[4], Moór, A.[2], Mosoni, L.[2], Regaly, Zs.[2], Sipos, N.[2], Sicilia-Aguilar, A.[1], van Boekel, R.[1]

[1] *Max-Planck-Institute for Astronomy, Königstuhl 17, D-69117 Heidelberg, Germany*
[2] *Konkoly Observatory of the Hungarian Academy of Sciences, PO Box 67, H-1525, Budapest, Hungary*
[3] *31 Ranui Road, Stoke, Nelson, New Zealand*
[4] *Leiden Observatory, Leiden University, Niels Bohrweg 2, NL-2333 CA, Leiden, The Netherlands*

Crystalline silicates, which are the building blocks of planetesimals and cometary bodies, are thought to form in the disk of young stars, but it was unknown when and where exactly. Large amount of crystalline silicates is expected to form during the FUor- and EXor-type outbursts of young stars. These eruptions are related to increased accretion rate in the disk. Due to the enhanced luminosity, amorphous grains which are heated above 1000 K should crystallise.

The recent outburst of EX Lup, starting in January 2008, gave us an opportunity to proof this hypothesis. Mid-infrared spectrum of EX Lup was taken in April 2008 with the IRS instrument on-board the Spitzer Space Telescope. The comparison of the outburst spectrum with the pre-outburst spectrum from the Spitzer Archive (taken in 2005) revealed the signatures of crystalline forsterite in the outburst spectrum, which were not present before. The modeling showed that the only possible explanation for the appearance of crystalline features is the in situ formation of crystalline forsterite via thermal annealing in the upper layers of the disk. In the Spitzer IRS spectra, taken after the end of the outburst, crystalline features appeared also at 24 μm and 28 μm, indicating that the temperature of the crystals significantly decreased (Juhász et al., in prep). Historical records of EX Lup show that an outburst, similar in amplitude to that in 2008, occured also in the 1950s (Herbig 1977). Assuming that similar amount of crystals was produced in the 1950s to that in 2008 it is puzzling that no crystalline features are seen in the pre-outburst spectrum (taken in 2005). A possible explanation for the lack of crystalline features can be strong vertical mixing in the disk and/or X-ray/ion amorphization of the freshly produced crystals.

The crystallinity in the disk atmosphere of an EXor is strongly affected by the number and the strength of outbursts the star went through before. Given the random, unpredictable nature of EXor outbursts, the assumption that most of the young stars go through an EXor phase during their evolution, predicts a strongly variable crystallinity among young stars even in systems with similar stellar/disk parameters.



Spitzer IRS spectra of EX Lup in the quiescent phase (a) and in the outburst (b). The spectra are continuum-subtracted and normalized to their maximum values. The mass-absorption coefficients of forsterite (Koike et al. 2003, dashed line) and the 10 μm silicate feature of the ISM (Kemper et al. 2004, dotted line) are shown for comparison.

B3) Importance of fragmentation for final masses of planetary embryos

Hiroshi Kobayashi[1,2] and Hidekazu Tanaka[2]

[1] *Astrophysical Institute and University Observatory, Friedrich Schiller University, GERMANY*
[2] *Institute of Low Temperature Science, Hokkaido University, JAPAN*

At a final stage of planet formation, planetary embryos grow through collisions with planetesimals. Gravitational scattering by larger embryos induces destructive collisions between planetesimals. Fragments produced by the collisions get smaller and smaller by successive collisions until the smallest fragments are removed by the gas drag (in protoplanetary disks) or by radiation pressure (in debris disks). As a result, the final planetary mass is determined by the equilibrium between the growth of the embryos and the depletion of planetesimals by collisional fragmentation.

Fragmenting collisions are divided into two types, catastrophic disruption and cratering. Although some studies neglected the effect of cratering, it is unclear which of the two collision types makes a dominant contribution to the collision cascades. We construct a simple outcome model describing both catastrophic disruption and cratering, with the total ejecta mass, the mass of the largest fragment, and the power-law exponent of the size distribution of fragments as parameters. Using this model, we examine the mass depletion time in collision cascades. We find the cratering collisions to be much more efficient than disruptive ones over a wide range of the model parameters. It is also found that the mass depletion time in collision cascades is mainly governed by the total ejecta mass and is almost insensitive to the mass of the largest fragment and the size distribution of fragments for a realistic parameter region. The total ejecta mass is usually determined by the ratio of the impact energy per unit target mass Q to its threshold value $Q_{\rm D}^{\star}$ for catastrophic disruption. We derive a mass depletion time in collision cascades, which is determined by $Q_{\rm D}^{\star}$ of the high-mass end of collision cascades.

Using the mass depletion time, we estimate the final masses of embryos to be about 0.1-1 Earth mass. Although the final mass becomes larger farther out from the star, the formation timescale of embryos in the outer region is longer. Thus, embryos become the largest at intermediate distances. They may grow further by another effect, which is an enhancement of the collisional cross section by a gaseous planetary "atmosphere" (Inaba et al. 2003, Icarus 166, 46–62), until the embryo becomes massive enough to enable gas accretion and ultimately a gas giant formation. Therefore, we show a possibility for gas giants to form at intermediate distances from a central star.

B4) Infrared variability as disk diagnostics

Ágnes Kóspál[1], Péter Ábrahám[2], Nikoletta Sipos[2]

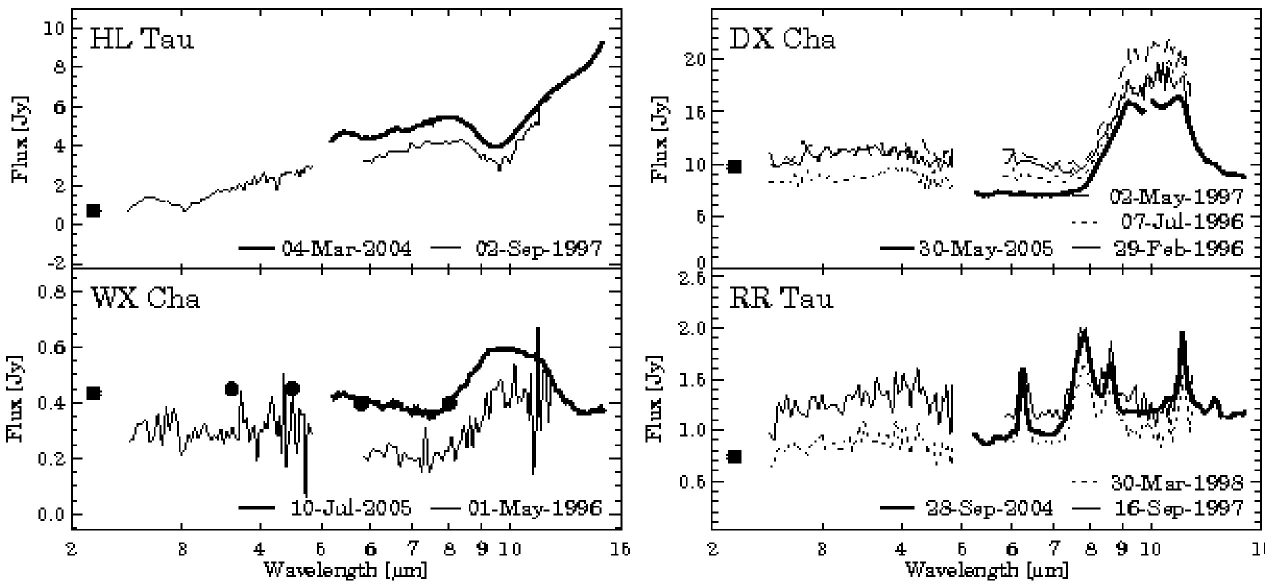
[1] *Leiden Observatory, Leiden University*
[2] *Konkoly Observatory of the Hungarian Academy of Sciences*

Optical variability is a long-known general characteristics of pre-main sequence stars. The growing number of ground-based observations and satellite missions at longer wavelengths make it increasingly evident that infrared variability is also widespread during early stellar evolution. The observed infrared flux changes may partly be linked to the central star (e.g. hot or cold starspots). However, to a larger part they are related to the circumstellar matter, either to its varying extinction along the line-of-sight, or to its changing thermal emission.

We will present the first results of our on-going *Spitzer* warm phase monitoring program, in which we obtain light curves of 38 T Tauri and Hebrig stars. We utilize the *Spitzer*/IRAC 3.6 and 4.5 μm channels, and we complement these with ground-based optical (V, R, I) and near-infrared (J, H, K) observations. Each of our targets is being monitored for about 2 weeks with a cadence of one day, enabling us to study day-to-day variability and its color dependence.

We will also present highlights from our mid-infrared variability spectral atlas of young stellar objects, in which we compare low-resolution multi-epoch 5–12 μm spectra for 60 low and intermediate mass young stars. The spectra were obtained with the *Infrared Space Observatory* in 1996–1998 and with the *Spitzer Space Telescope* in 2004–2007. Most of the objects show flux changes between these two epochs, both in the continuum and in the 10 μm silicate feature (see the examples below). This spectral atlas was used to select the list of candidate infrared variable targets for our Spitzer monitoring program.

Preliminary modelling with a radiative transfer code will be used to explore the effect of changing model parameters on the infarared spectral energy distribution.



Mid-infrared observations of pre-main sequence stars. Thin lines: ISO/ISOPHOT-S, thick lines: Spitzer/IRS, dots: Spitzer/IRAC, squares: 2MASS.

B5) The elusive inner disk molecules of IRS 46

Fred Lahuis[1,2]

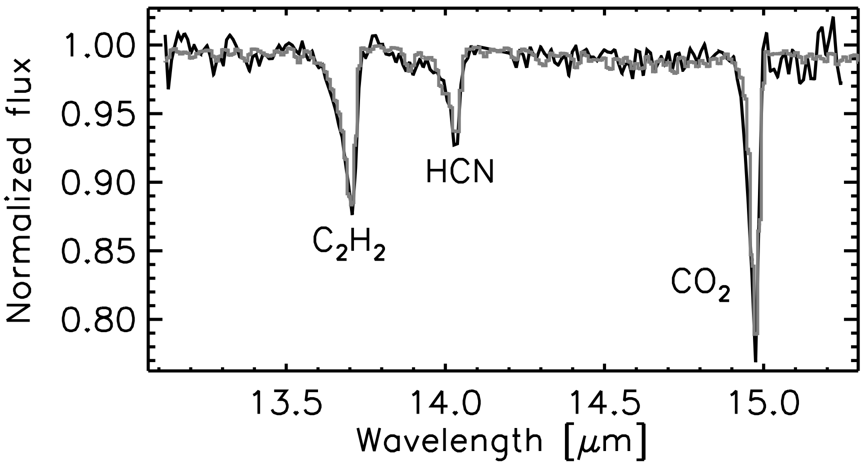
[1] *SRON Netherlands Institute for Space Research*
[2] *Leiden Observatory*

Spitzer-IRS detections of highly abundant hot ($T_{ex} > 400$ K) molecular gas toward the low-mass star IRS 46 (Lahuis et al. 2006) were cause for great excitement. The detection of strong absorption bands of gas-phase C_2H_2, HCN and CO_2 was the first observational test of chemical models in the planet-forming zone of a circumstellar disk and provided a direct measure of the temperature and density in this zone. Since, the same molecules have been observed in absorption toward the young star GV Tau (Gibb et al. 2007) and in emission (together with hot abundant H_2O and OH) toward a number of T Tauri stars (Carr & Najita 2008 and Salyk et al. 2008).

Interestingly, multi-epoch *Spitzer*-IRS observations of IRS 46 taken during 2008 and 2009 produced a big surprise. The strength of the molecular absorption features decreased by a factor of five or more while at the same time the mid-IR continuum gradually increased up to a factor of two, however both changes are not proportional. At the same time GV Tau does not show similar dramatic changes and its flux levels and molecular absorption bands show little change.

What lies at the bottom of these changes? Are we witnessing changes in the physical and/or chemical structure of the inner disk of IRS 46 or could these changes be related to variations in an inner disk wind. It has been proposed earlier, based on blue-shifted near-IR 3μm HCN $\nu_3 = 1-0$ absorption lines, that the molecular absorptions may have its origin at the footprint of a wind launched from the inner disk.

Carr, J. S. and Najita, J. R. 2008, Science, 319, 1504
Gibb, E. L. et al. 2007, ApJ, 660, 1572
Lahuis, F., et al. 2006, ApJL, 636, L145
Salyk, C., et al. 2008, ApJL, 676, L49



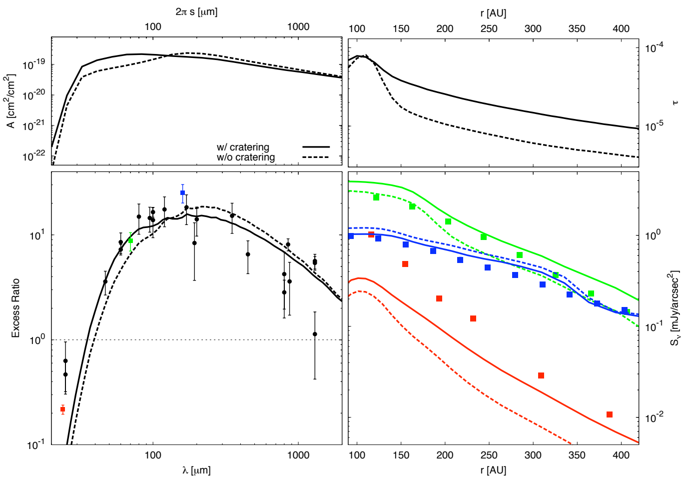
Gas-phase molecular absorption features observed toward IRS 46 (Lahuis et al. 2006). Shown is part of the normalized *Spitzer*-IRS high resolution spectrum with overplotted in gray a single component LTE model.

B6) The Taming of the Shrew: Understanding the Dust Disk of Vega

Torsten Löhne, Sebastian Müller, Alexander V. Krivov

Astrophysikalisches Institut und Universitätssternwarte Jena, Schillergässchen 2–3, 07745 Jena, Germany

The archetypical debris disk around Vega has been observed at many wavelengths from the near-infrared to millimeter range over the past twenty-five years. This wealth of photometric data and images has put enough constraints to exclude simplistic disk models. In particular, the emission in the mid-infrared seems to be in excess of what is expected from a "Kuiper belt" at ≈100 AU evident in the sub-millimeter images and inferred from the majority of photometric points. Assuming that this belt continuously produces dust through a collisional cascade, we employed our collisional and radiative transfer codes to consistently model the size and radial distribution as well as thermal emission of dust. In doing so, we varied a broad set of model parameters, ranging from stellar properties and exact location of the planetesimal belt to intrinsic dust properties and the collisional prescription. We are able to reproduce the overall shape of the spectral energy distribution and the radial brightness profiles and to put important constraints on the parameters. We show, in particular, that including cratering collisions into the model is mandatory. Still, the strong mid-infrared emission problem seems more persistent, possibly suggesting an "asteroid belt" deeply inside the known "Kuiper belt" as a source of additional hot dust.



B7) High Resolution Imaging with CARMA: The Case of HL Tauri

Leslie W. Looney[1], Woojin Kwon[1], Lee Mundy[2], and Jack Welch[3]

[1] *University of Illinois*
[2] *University of Maryland*
[3] *University of California, Berkeley*

We present 0.1 arcsecond resolution dust continuum imaging of HL Tauri at $\lambda = 1$ mm using the CARMA array (see figure). Contrary to previous suggestions, we do not see any evidence of a companion or proto-planet. We show various models of the dust emission fit to multi-configuration CARMA data at both $\lambda = 1$ mm (*uv* coverage from 15 kλ to 1450 kλ) and 3 mm (*uv* coverage from 8 kλ to 360 kλ). This wide range of data allows us to model the HL Tauri disk simultaneously at two frequencies, providing better physical constraints. In addition, we compare the models of HL Tauri with 5 other T Tauri stars observed with the CARMA array at lower resolution.

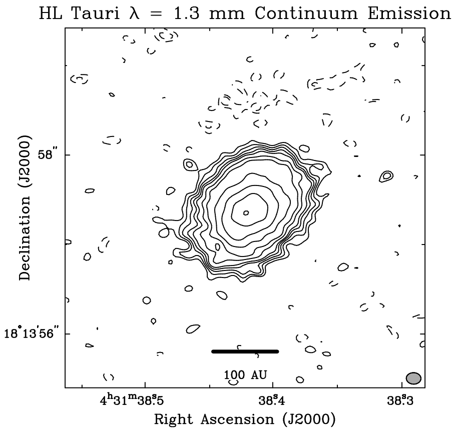


Figure 1: CARMA observations of HL Tauri at $\lambda = 1$ mm using A, B, and C array data. The contours are 2,3,4,5,6,8,10,14.14,20,28.8,and 40 $\times$ σ, where $\sigma = 0.8$ mJy/beam. The synthesized beam is illustrated in the bottom right corner, 0.16 $\times$ 0.13 arcseconds.

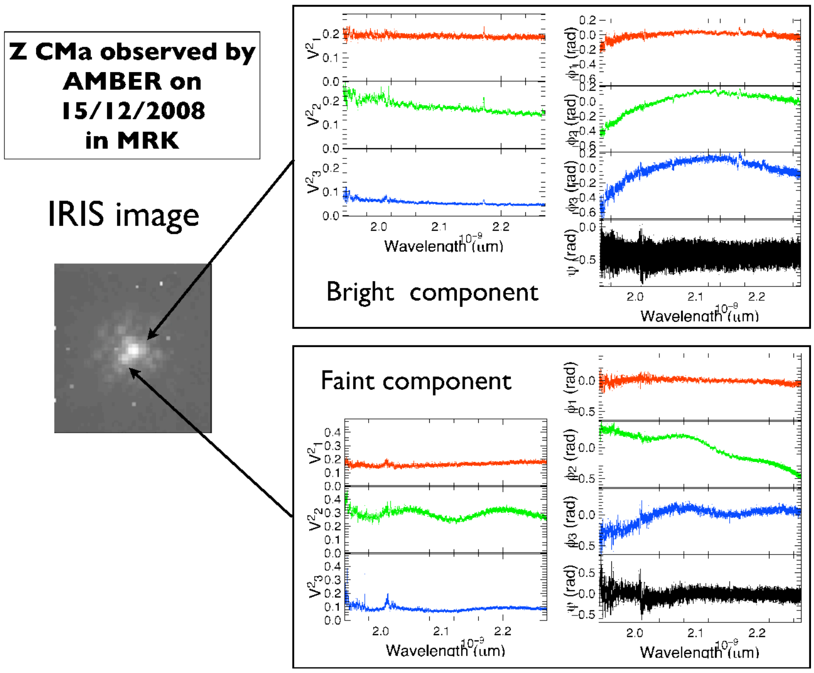
B8) Probing disk sub-AU scale instabilities in the young stellar object Z CMa with the VLTI during the outburst phase.

F. Malbet[1], M. Benisty[2], J.-B. Le Bouquin[3], J.-P. Berger[1], S. Renard[1], T. Ratzka[4], J. Bouvier[1], K. Grankin[5]

[1] *Laboratoire d'Astrophysique de Grenoble, universit J. Fourier/CNRS, France*
[2] *Osservatorio Astrofisico di Arcetri/INAF, Italy*
[3] *European Southern Observatory, Chile*
[4] *Universitäts-Sternwarte München, Germany*
[5] *Crimean Astrophysical Observatory, Nauchny, Crimea, Ukraine*

FU Orionis objects (FUors) are young stellar objects that undergo photometric outbursts of 4-6 mag in less than 1 year. FUors exhibit large IR excesses, double-peaked line profiles, apparent spectral types that vary with wavelength, broad, blue-shifted Balmer line absorption, and they are often associated with powerful mass outflows. All these features are well explained by the presence of a massive accretion disk which radiates mostly in the infrared. The origin of the outburst, although believed to originate from thermal instabilities resulting in a outburst state, is still mostly unknown.

Z CMa is a young stellar system consisting of a 16 $M_\odot$ B0 primary and a 3 $M_\odot$ FU Ori companion at an age of 0.3 Myr. Both components are surrounded by active accretion disks. The photometric variations of the system have been monitored for the last 25 years by K. Grankin at Mt Maidanak (Uzbekistan) and Crimean Astrophysical Observatory (Ukraine). The magnitude of the system has been continuously decreasing from 1982 to 1998, from V$\sim$9 to V$\sim$10.5, and then remained nearly constant since then except for a short duration ($\sim$6 month) outburst in 1999 with an amplitude of 1 magnitude. Based on high resolution spectroscopy, this outburst was identified as resulting from a large scale accretion instability in the circumstellar disk of the massive primary. After this outburst, the system returned to its faint state. On November 19, 2008, K. Grankin, who continues to monitor the photometric variations of the system year after year, discovered that Z CMa is again exhibiting an extreme outburst with an amplitude of nearly 2 magnitudes, i.e., larger than any photometric variations recorded in the last 25 years.



We report here high resolution spatial interferometric observations of Z CMa taken during this unprecedented outburst state. These observations taken with AMBER in medium spectral resolution in addition to low spetral resolution ones allow us to investigate the origin and evolution of the outburst. This is the first time that interferometric observations were possible during such an outburst.

B9) New NIR Tracers of Warm Gas in the Planet-Forming Regions of Gas-Rich Circumstellar Disks

Avi M. Mandell[1], Michael J. Mumma[1], Geoffrey A. Blake[2], Colette Salyk[2], Klaus M. Pontopiddan[2], Ewine F. van Dishoeck[3], and Jeanette Bast[3]

[1] *NASA GSFC*
[2] *CalTech*
[3] *Leiden Observatory*

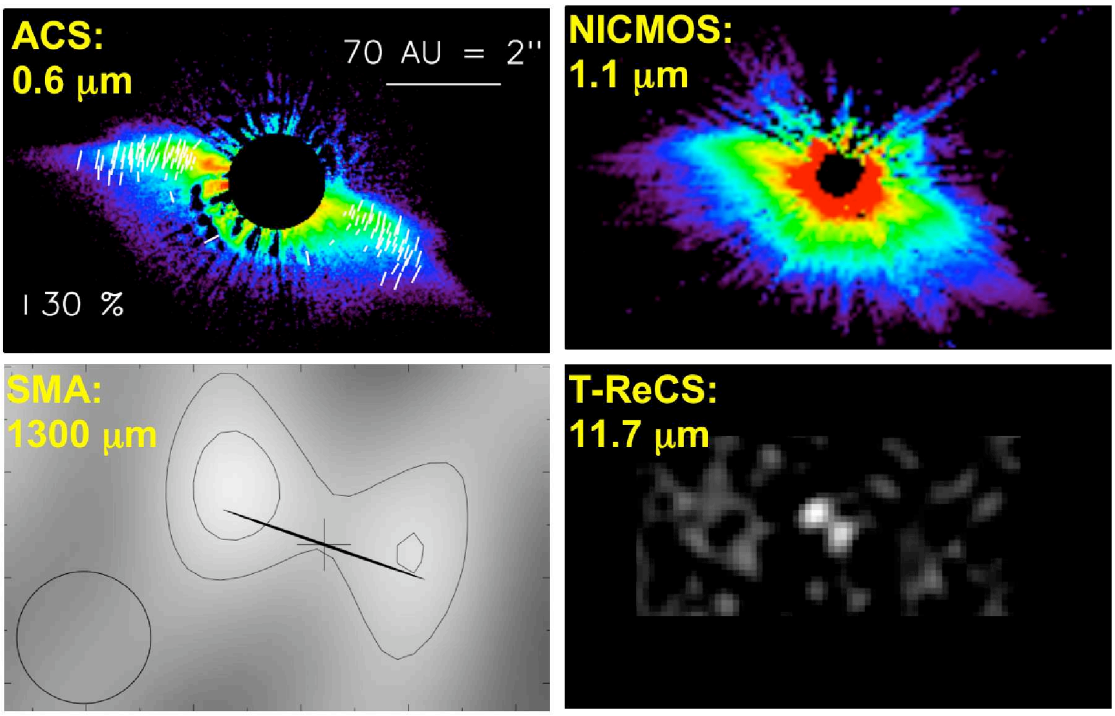
Characterizing the gas chemistry in the planet-forming regions of young circumstellar disks is essential to understanding the origins of planetary systems. Near-infrared spectroscopy (1 - 5 μm) covers both low-energy and high-energy ro-vibrational transitions for a large variety of molecules, allowing accurate measurements of the excitation state and kinematics of the warm gas in the inner disk. Detection of new tracers of molecular chemistry can provide new insight into the thermodynamic and kinematic processes occurring in the inner disk. We have developed new reduction techniques to allow very accurate spectroscopic observations of Herbig Ae and T Tauri stars in the 3.0 - 3.7 μm wavelength range (L-band); our results reveal emission from multiple ro-vibrational transitions of OH, as well as lines of highly excited H_2O and evidence of other simple CNO-based molecular tracers. Initial results reveal a lack of molecular signatures from molecules other than OH in spectra from higher-mass stars (Mandell et al. 2008), while water and simple volatiles are relatively easy to detect in TT stars (see Figure 1); constraining the reasons for this disparity may provide important clues to the processes driving chemical balance in disks of different masses. Detailed investigations of the formation and excitation of these inner-disk constituents will help to expand our understanding of the chemistry occurring in the warm gas surrounding young protoplanets and how it may affect the final composition of fully-formed planets and planetary atmospheres.

B10) Debris Disk Erosion by the ISM: The Case of HD 61005

H. L. Maness[1], P. Kalas[1], M. P. Fitzgerald[2], J. P. Williams[3], E. I. Chiang[1], James R. Graham[1], K. Scherer[4], K. M. G. Peek[1], D. C. Hines[5], G. Schneider[6], S. A. Metchev[7]

[1]*Department of Astronomy, University of California at Berkeley*
[2]*Lawrence Livermore National Laboratory*
[3]*Institute for Astronomy, University of Hawaii*
[4]*Institut für Theoretische Physik IV, Ruhr Universität Bochum*
[5]*Space Science Institute*
[6]*Steward Observatory, University of Arizona*
[7]*Department of Physics and Astronomy, State University of New York – Stony Brook*

HD 61005 is the first resolved debris disk to show clear evidence for interaction with the interstellar medium and thus presents a unique testbed for probing environmental theories of disk evolution, including sandblasting, interstellar gas drag, and ram pressure stripping of disk gas. I will present results of our new multi-wavelength program initiated to characterize this source. Results to date include (1) optical coronagraphic polarization images, which resolve the source into two distinct morphological components, (2) scattered-light colors, which constrain the grain size distribution, (3) 1.3-mm interferometric observations, which reveal a ring of large grains near the outer edge of the swept back structure, (4) mid-infrared images, which resolve a warm interior asteroid belt, and (5) a high-resolution optical echelle spectrum, which limits the ambient ISM density to that typical of local interstellar clouds. The latter result suggests that the evolutionary state of HD 61005 represents a commonplace, intermittent stage of debris disk evolution driven by interaction with typical, low-density clouds. I will discuss the implications of this result in the context of models of interaction with low-density interstellar gas developed for the Solar System. The models predict the relative flow direction is oriented along the disk midplane in the plane of the sky; scheduled near-UV absorption spectroscopy observations will test this prediction. In addition to presenting our specific results for HD 61005, I will discuss the morphological features these models can produce in general, and suggest a few additional systems in which they may be relevant.



B11) Searching for molecular hydrogen mid-infrared emission in the circumstellar environments of Herbig Ae/Be stars

C. Martin-Zaïdi[1], J-.C. Augereau[1], F. Ménard[1], E.F. van Dishoeck[2,3], E. Habart[4], P-.O. Lagage[5], E. Pantin[5], J. Olofsson[1]

[1] *Université Joseph Fourier - Grenoble 1 / CNRS, Laboratoire d'Astrophysique de Grenoble (LAOG) UMR 5571, BP 53, 38041 Grenoble Cedex 09, France*
[2] *Leiden Observatory, Leiden University PO Box 9513, 2300 RA Leiden, The Netherlands*
[3] *Max Planck Institut für Extraterrestrische Physik, Giessenbachstrasse 1, 85748 Garching, Germany*
[4] *Institut d'Astrophysique Spatiale, Université Paris-Sud, 91405 Orsay Cedex, France*
[5] *Laboratoire AIM, CEA/DSM - DAPNIA/Service d'Astrophysique CEA/Saclay, 91191 Gif-sur-Yvette Cedex, France.*

Disks around young stars are a natural outcome of the star formation process and the place for planet formation. At the present time, signicant effort has been put into the study of the dust in disks. However, the dust only represents a tiny fraction of the disk mass (~1%), and it is thus mandatory to deeply study the gas phase in disks in order to set stronger constraints on the giant planets formation process. Molecular hydrogen (H_2) is the most abundant molecule in the circumstellar (CS) environments of young stars and is supposed to be the key element of giant planet formation; thus its diagnostics are promising. Indeed, the detection of H_2 provides the most direct information about the gaseous content of disks, setting limits on the timescales for the dissipation of CS matter and possibly planet building. Molecular hydrogen has been observed in CS environments at ultraviolet (e.g., Johns-Krull et al. 2000; Martin-Zaïdi et al. 2008a) and near-infrared (e.g., Bary et al. 2003) wavelengths. These observations trace hot CS gas, or gas excited by fluorescent processes, or require specific spatial distributions for the gas to be detectable. They are therefore difficult to translate into gas masses. The pure rotational mid-infrared H_2 lines are useful probes because the level populations are expected to be in local thermodynamic equilibrium at the local gas temperature, and so line ratios allow the determination of the excitation temperature and mass of the warm gas.

We present here a review of high-resolution spectroscopic mid-infrared observations of the pure rotational lines of H_2, as a tracer of warm gas in the surface layers of circumstellar disks around Herbig Ae/Be stars with the VLT Imager and Spectrometer for the mid-InfraRed (*VISIR*). All these results are detailed in papers by Martin-Zaïdi et al. (2007, 2008b, 2009)

References:

Bary, J. S., et al. 2003, ApJ, 586, 1136
Johns-Krull, C. M., et al. 2000, ApJ, 539, 815
Martin-Zaïdi C., et al. 2007, ApJ, 666, L117
Martin-Zaïdi C., et al. 2008a, A&A, 484, 225
Martin-Zaïdi C., et al. 2008b, A&A, 489, 601
Martin-Zaïdi C., et al. 2009, ApJ, 695, 1302

B12) The inner disk structure of the Herbig stars HD 97048 and HD 100546: puffed-up rim or not?

François Ménard

Laboratoire d'Astrophysique de Grenoble, CNRS/UJF UMR 5571, France

Based on the shape of their SED's, in particular the near- and mid-infrared excesses, it has been proposed that the inner disks of some Herbig stars is puffed-up, i.e., inflated in the vertical direction a factor of a few more than what is expected from hydrostatic equilibrium, in particular if the bulk of the gas is at the same temperature as the dust. However, SED's are indirect tracers of disk shapes and little direct evidence of the shape of inner disks is available. Long baseline near-infrared interferometry measurements of the disks of HD 97048 and HD 100546 will be presented and results will be discussed. Together with simultaneous fits of the SEDs, these results will be discussed in the context of the necessity (or not) of a puffed-up rim. We will show that at least one other solution exists that cannot be ruled out with the current data sets available. These results will be discussed in the broader context of "how general" they are.

B13) Optical Spectroscopic Variability of HAeBe stars

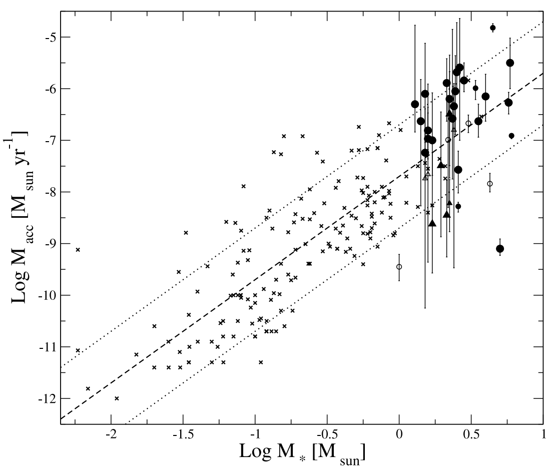
I. Mendigutía[1] et al.

[1] *Laboratorio de Astrofísica Estelar y Exoplanetas, Centro de Astrobiología (INTA-CSIC), Madrid, Spain.*

The EXPORT consortium carried out simultaneous photo-polarimetric and spectroscopic monitoring of 38 intermediate-mass Pre-Main-Sequence (PMS) stars (mass range 1-6 $M_\odot$, age range 1-15 Myr) showing the Hα emission line. Their spectroscopic variability has been studied from the analysis of 337 multi-epoch (timescales of hours-months) intermediate resolution optical spectra. For each spectrum, the Hα emission line has been characterized by means of the equivalent width (EW), the line width at 10% of peak intensity (W_{10}), and classifying the profile shapes. Mean values and amplitudes of the accretion rates ($\dot{M}_{acc}$) have been derived from W_{10}(Hα). EWs of the [OI]6300, HeI5876, NaI $D_2$5890 and $D_1$5896 lines have been obtained. The simultaneous optical and nIR photometry is being used to derive line fluxes and to compare the spectroscopic and photometric behaviours to each other.

The main results derived from this study will be presented, which can be summarized as follows: Most of the stars analysed are variable in the different spectral lines studied. Their typical spectroscopic EW and W_{10} mean values and variations will be presented, showing different timescale variability and quantitative variations depending on the line. When $\dot{M}_{acc}$ is derived from W_{10}(Hα) the M_*–$\dot{M}_{acc}$ relationship (Fig. 1) is extended to the 1–6 $M_\odot$ range and the $\sim$ 2 orders of magnitude scatter can be partially explained -if not totally in several stars- by accretion variability. These variations drop at $M_* > 2.8$ $M_\odot$, probably reflecting that different physical scenarios control accretion in Herbig Ae and Herbig Be stars, as has been proposed before. The mean strength of the lines tend to decrease with the stellar age, although with an important scatter for the youngest objects. The upper envelopes fitting that evolution suggest different disipation timescales for the atomic gas traced by the different spectroscopic lines studied.

The complex variability characterizing both the emission and absorption features of HAeBe stars is analysed from multi-epoch spectra, allowing for the first time to study it from homogeneous observations of a wide enough sample of intermediate-mass stars. Considering also the information provided by the simultaneous photo-polarimetry, these data constitute a unique data-set to understand the evolution and properties of intermediate-mass-PMS stars and their CS disks.



Mass accretion rate for a wide range of stellar masses. The crosses are from the literature. Filled and open symbols represent our results, corresponding to the objects with EW(Hα) > 10 Å and < 10 Å, respectively. Small filled symbols represent the objects with less than five spectra available. The remaining have between 5 and 18 spectra/object. Triangles are lower limits. The bars spread out from the minimum to the maximum value of $\dot{M}_{acc}$ derived from the corresponding values of W_{10}(Hα). The dashed line is $\dot{M}_{acc} \propto M_*^2$, and the dotted lines are $\pm$ 1 dex.

B14) Spitzer c2d results on disk types, time-scales and evolution from 1 to 10 Myrs

Bruno Merín[1], Loredana Spezzi[2], Isa Oliveira[3], Joanna M. Brown[4], Ewine F. van Dishoeck[3,4], Neal J. Evans II[5], Lucas Cieza[6], C.P. Dullemond[7], Karl Stapelfeldt[8], Juan M. Alcalá[9], Paul M. Harvey[5], David W. Koerner[10], Lori E. Allen[11], Luisa M. Rebull[12]

[1] *Herschel Science Centre, European Space Agency (ESAC, Madrid, Spain)*
[2] *Research and Scientific Support Dept., European Space Agency (ESTEC, Noordwijk, The Netherlands)*
[3] *Leiden Observatory, Leiden University (Leiden, The Netherlands)*
[4] *Max-Plank Insitut Für Extraterrestrial Physik (Munich, Germany)*
[5] *Department of Astronomy, University of Texas at Austin (Austin, USA)*
[6] *Institute for Astronomy, University of Hawaii (Honolulu, USA)*
[7] *Max-Plank Insitut Für Astronomie (Heidelberg, Germany)*
[8] *Jet Propulsion Laboratory, California Institute of Technology (Pasadena, USA)*
[9] *INAF - Osservatorio Astronomico di Capodimonte, (Naples, Italy)*
[10] *Department of Astronomy, Northern Arizona University (Flagstaff, USA)*
[11] *Department of Astronomy, University of Arizona, (Tucson, USA)*
[12] *Spitzer Science Center, California Institute of Technology (Pasadena, USA)*

The Spitzer data, due to its wavelength coverage and sensitivity, offers an exceptional tool for studying the status and evolution of the inner several AUs of the disks around young stars, were planets could eventually form. The 'Cores to Disks' (c2d) Spitzer Legacy Program (Evans et al. 2009) observed five large, nearby young molecular clouds with IRAC and MIPS and produced a large and homogeneous magnitude-limited sample of 1024 Young Stellar Objects, out of which 773 are Class II or III objects. The estimated ages of these objects range between 1 to 10 Myrs, which encompasses nicely the observed time-scale for disk dissipation around low-mass stars. In this contribution we will classify this sample in disk types (primordial, settled and transitional) and will study their dependence with the stellar mass and age. Their numbers and time-scales will also be studied statistically with the aim of finding constraints to the different disk dispersal mechanisms, including the formation of planetary systems.

B15) The Asymmetric Warm Dust Ring of HR 4796A as a Companion Signature

Margaret Moerchen[1]

[1] *European Southern Observatory*

We have obtained new resolved images of the well-studied HR 4796A dust ring at 18 and 25 μm with the 8-meter Gemini telescopes. These images confirm the previously observed spatial extent seen in MIR, NIR, and optical images of the source. We again detect a brightness asymmetry where one ansa (northeast) is brighter than the other (southwest). Through spatially-resolved images at two wavelengths, we have used color temperature profiles to conclude that the dust in the brighter ansa is also significantly warmer. Our models explain the apparent brightness and temperature asymmetry with the effect of pericenter glow. In this scenario, the center of the dust ring is offset by a companion with an eccentric orbit that has induced a forced eccentricity on the dust particle orbits. Recent *HST* images also show evidence for an offset between the star and the disk center. We find that these MIR observations are well approximated by a ring of 2-μm dust particles with a forced eccentricity of 0.06, implying the presence of a perturbing companion (whose mass remains unconstrained by this analysis).

B16) Metallicities of 10-30 Myr Open Clusters with Debris Disks

TalaWanda Monroe[1], Catherine Pilachowski[1], Nuria Calvet[2], Aki Roberge[3]

[1] *Indiana University*
[2] *University of Michigan*
[3] *NASA Goddard Space Flight Center*

We present an analysis of moderate-resolution WIYN-Hydra spectra of F and G stars in two 10-30 Myr old open clusters, NGC 7160 and NGC 2232, observed at 24 microns with Spitzer Space Telescope. Metallicities were

determined for each cluster member differentially with respect to the Sun to determine global cluster abundances on an uniform scale with reduced systematic effects. Our multi-object spectrograph observations from WIYN-Hydra (and also Magellan-MMFS) are part of a larger project to complement MIPS 24 micron observations of 18 northern and southern clusters in the age range of 3 to 200 Myr, which were examined for excess MIR emission. The aim of this program is to consider the role that stellar metallicity may play in debris disk frequency and longevity for B and A cluster stars.

B17) Traps and pitfalls in modelling transitional disks: the case of LkCa 15

G.D.Mulders[1,3], C. Dominik[1,4], M. Min[2]

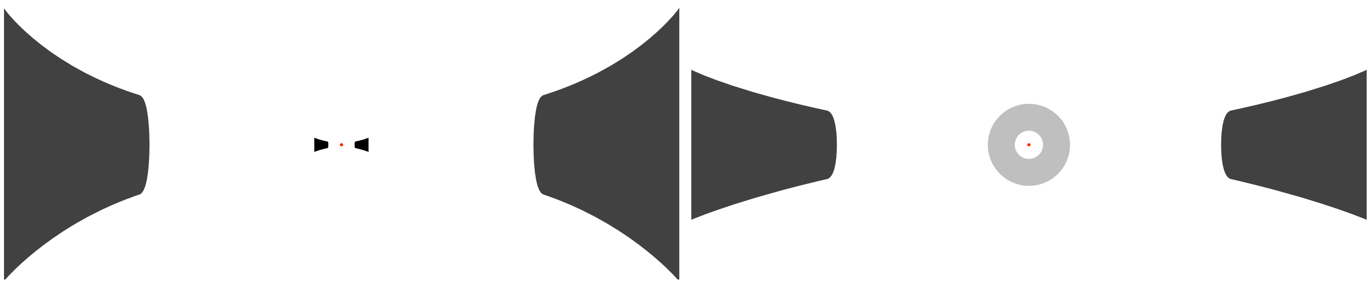
[1] *Astronomical Institute "Anton Pannekoek", University of Amsterdam, PO Box 94249, 1090 GE Amsterdam, The Netherlands*
[2] *Astronomical institute Utrecht, University of Utrecht, P.O. Box 80000, NL-3508 TA Utrecht, The Netherlands*
[3] *SRON Netherlands Institute for Space Research, PO Box 800, 9700 AV, Groningen, The Netherlands*
[4] *Afdeling Sterrenkunde, Radboud Universiteit Nijmegen, Postbus 9010, 6500 GL Nijmegen, The Netherlands*

With the legacy of Spitzer and current advances in (sub)mm astronomy, a large number of so-called 'transitional' disks has been identified which are believed to contain gaps or have developped large inner holes, some filled with dust. This may indicate that complex geometries may be a key feature in disk evolution that has to be understood and modelled correctly. We will use the gapped disk of LkCa 15 as a showcase to illustrate the importance of 2D radiative transfer in transitional disks, by showing how the vertical dust distribution in dust filled inner holes determines not only the radial optical depth but also the outer disk geometry.

The disk around LkCa 15 has a large gap ranging from ∼5 - 50 AU, as identified by Espaillat et al. (2007) using 1+1D radiative transfer modelling. To fit the SED, they propose 2 possible scenarios for the inner (<5 AU) disk - optically thick or optically thin - and one scenario for the outer disk. In this poster we focus on the radial optical depth of the inner disk using a full 2D radiative transfer code, and identify two geometries for the inner *and* outer disk, that are both different from those in Espaillat et al. (2007).

An optically thick inner disk in vertical hydrostatic equilibrium reprocesses enough stellar radiation to fit the near and mid infrared flux. Because the radial optical depth of such a disk is non-negigable, it casts a shadow on the inner rim of the outer disk. This prevents the rim from puffing up as much as a fully exposed rim. In order for an inner disk to become radially optically thin, but still reprocces the same amount of stellar radiation as an optically thick inner disk, its vertical scaleheight needs to be much larger. In the case of LkCa 15, the scaleheight has to be so large that the inner disk effectively becomes a dust shell that also contributes to the reddening of the star. Because the inner rim is fully illuminated, the outer disk scaleheight has to be reduced to fit the far infrared flux.

We will also discuss the feasibility of having a dust shell so close to the star, and compare the physical properties of the outer disk between both scenarios.



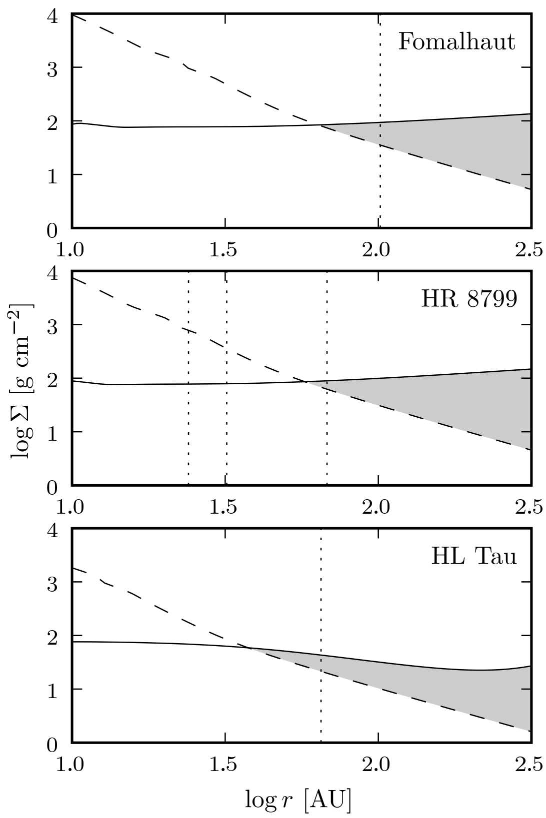
Sketch of the two possible geometries for LkCa 15. The left panel shows a model with a 1 AU optically thick inner disk, that casts a shadow on the inner rim of the outer disk. The right panel shows a 5 AU spherical dust shell that is optically thin, and a fully illuminated outer disk. If the inner rim of the outer disk is not shadowed, the outer disk is much flatter.

B18) Disk Mass Required to Form Planets via the Gravitational Instability

D. Nero[1], J. E. Bjorkman[1]

[1] *University of Toledo*

We explore the viability of forming giant planets via the gravitational instability. This mechanism favors the production of giant planets at large radii, since a disk would need to be both gravitationally unstable (as characterized by the Toomre Q parameter) as well as posses the ability to radiate away the energy released by fragment formation (as characterized by the disk cooling time). The planet Fomalhaut b, the outermost planet of HR 8799, and the potential protoplanet associated with HL Tau are, to date, some of the best examples of planetary systems that we would expect the gravitational instability to produce. Using a new technique to more accurately calculate cooling times, we can place upper and lower limits on disk surface density—or equivalently disk mass—required to form these observed planets. We find that the required mass interior to the planet's orbital radius is ~ 0.1 $M_\odot$ for Fomalhaut b, the outermost planet of HR 8799, and the potential protoplanet associated with HL Tau. We also investigate how dust settling can reduce the cooling time, and the effects this has on the viability of the gravitational instability in the inner disk.



Surface density limits for disk fragmentation. The solid line denotes $\Sigma_{\rm max}$, which is the maximum surface density for the cooling time constraint. The dashed line denotes the minimum surface density for fragmentation, $\Sigma_{\rm min}$, which is the locus Toomre $Q = 1$. Disk fragmentation is only allowed in the region $\Sigma_{\rm max} > \Sigma_{\rm min}$, which is shaded gray. The locations of known planets are plotted as vertical dotted lines. From Nero & Bjorkman 2009, ApJ, 702, L163.

B19) Observations of near-infrared line ratios of molecular hydrogen emission from protoplanetary disks

H. Nomura[1], Y. Takagi[2], Y. Itoh[2], K. Sugitani[3], M. Watanabe[4], J.S. Bary[5], D.A. Weintraub[6], Y. Aikawa[2], M. Tsujimoto[7], Y. Nakagawa[2], T.J. Millar[8]

[1] *Dept. of Astronomy, Graduate School of Science, Kyoto Univ., Sakyo-ku, Kyoto 606-8502, Japan*
[2] *Dept. of Earth and Planetary Sciences, Kobe Univ., 1-1 Rokkodai-cho, Nada, Kobe 657-8501, Japan*
[3] *School of Natural Sciences, Nagoya City University, Mizuho, Nagoya 467-8501, Japan*
[4] *Subaru Telescope, NAOJ, 650 North A'ohoku Place, Hilo, HI 96720, USA*
[5] *Dept. of Physics & Astronomy, Colgate Univ. Hamilton NY 13346, USA*
[6] *Dept. of Physics and Astronomy, Vanderbilt Univ., Nashville, TN 37235, USA*
[7] *JAXA/ISAS, 3-1-1 Yoshino-dai, Sagamihara, Kanagawa 229-8510, Japan*
[8] *ARC, School of Mathematics & Physics, Queen's Univ. Belfast, Belfast BT7 1NN, UK*

It is believed that planets are being formed from dust and gas in protoplanetary disks. Recent high spectral resolution and high sensitivity observations have made it possible to detect various transition lines of molecular hydrogen in the disks around T Tauri and Herbig Ae/Be stars. Historically, near-infrared H_2 line ratios have been used as a tool to derive the physical properties of various astronomical objects.

In this work we have measured the 2-1 S(1)/1-0 S(1) H_2 line ratios towards T Tauri stars to diagnose the H_2 excitation mechanisms and the evolutionary status of dust grains in protoplanetary disks. By using Subaru/IRCS+AO188, we observed the 2-1 S(1), 1-0 S(0), and 1-0 S(1) lines simultaneously with sufficiently high sensitivity and high spectral resolution. As a result, we have succeeded in constraining an upper limit of 0.14 for the 2-1 S(1)/1-0 S(1) H_2 line ratio. Our result suggests that the molecular hydrogen is excited by thermal collisions, that is, the gas temperature is sufficiently high in the disk surface. The high gas temperature means that there will be enough amount of small dust grains which heat the gas via photoelectric effect induced by FUV photons. Since the dust settling towards the midplane is efficient in the disk surface, our result suggests continuous supply of small dust grains from the surrounding molecular cloud or by the accretion flow. More detailed analysis of the observed data together with model calculations will be shown in the poster.

B20) Evolution of young stars and their disks in Serpens

Isa Oliveira[1], Bruno Merín[2], Klaus Pontoppidan[3], Ewine van Dishoeck[1,4]

[1] *Leiden Observatory*
[2] *ESAC*
[3] *Caltech*
[4] *MPE*

Unbiased, flux-limited surveys of protoplanetary disks and their parent stars curently exist for only a few clouds, primarily Taurus and IC 348. Such surveys are essential to address questions of disk evolution with stellar parameters such as spectral type, age, accretion activity and environment. Using the 'Cores to Disks' (c2d) Spitzer Legacy Program, we discovered a new population of young stellar objects (YSO) in a region of only 0.5 sq^2 in the Serpens Molecular Cloud. This sample contains 150 bright YSOs with infrared excess, having a broad range of SED types and luminosities, making Serpens a unique target region for obtaining a complete, well-defined sample of multi-wavelength observations of young stars in a possible evolutionary sequence. Compared with other clouds such as Taurus and Chamaeleon, Serpens has an exceptionally high star-formation rate. Follow-up complimentary observations in the optical, near- and mid-infrared (Spitzer/IRS GO3) have allowed us to characterize the both central stars and the surrounding disks, down to the brown dwarf regime. The shape and slope of the mid-infrared excess provide information on the flaring geometry of the disks. The spectral features give constraints on grain growth and mineralogy, which in turn probes heating and radial mixing. The presence of PAH features traces UV radiation, whereas Hα and Brγ are used as diagnostics of accretion. Assuming that all stars within a sufficiently small region are nearly coeval, this provides direct constraints on the importance of environment and initial conditions on disk evolution. We will present our latest results on this rich population of YSOs, attempting to connect the evolution of the disks with that of their harboring stars, and to establish the mechanisms that determine the evolutionary sequence of protoplanetary disks.

B21) Modelling Disc Destruction via Photoevaportation

James E. Owen[1]

[1] *Institute of Astronomy, Madingley Rd, Cambridge, CB3 0HA, UK*

The evolution of protoplanetary discs, which contain the reservoir of material available for planet formation, is heavily influenced by heating and irradiation from the central star - from IR to X-ray. Indeed X-ray photoevaporation has been suggested as the leading dispersal mechanism. However so far only a rough treatment of the photoevaporative flow has been possible. In this talk I will present the first self-consistent hydrodynamical (ZEUS-2D) and radiative transfer (MOCASSIN) calculations of a T-Tauri disc heated and ionised by extreme ultraviolet and X-ray radiation from the stellar chromosphere (see Figure1) . The mass-loss profile obtained was then combined to a viscous evolution model to determine the evolution and dispersal of the disc structure. We find that the disc opens a gap at 1AU after a few Myr, the inner disc then quickly drains onto the central star followed by the rapid dispersal of the outer disc in approximately 10^5 years. Finally I will discuss the models it the context of available observational data.

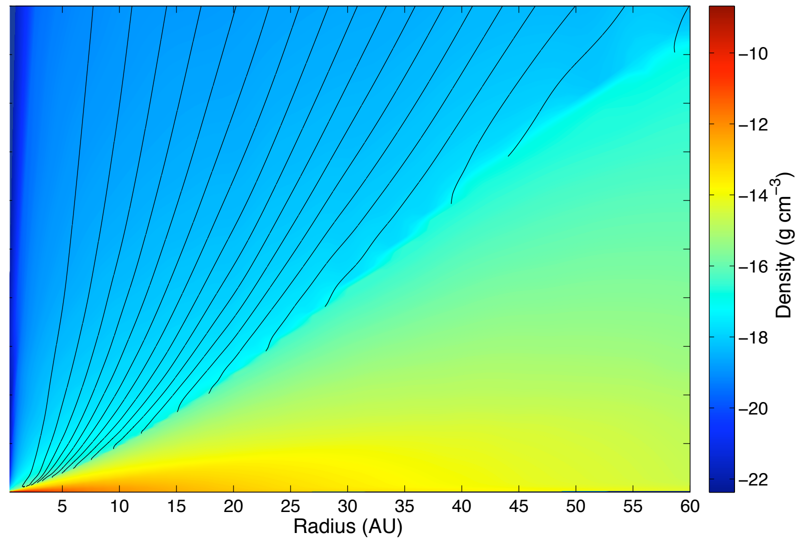


Figure showing wind/disc structure, streamlines plotted at 5% mass loss intervals

B22) Remember the ejected protoplanet TMR-1C?

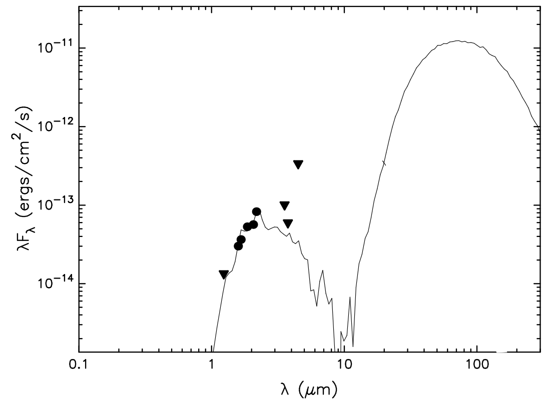
M. G. Petr-Gotzens[1], J.-G. Cuby[2], M. D. Smith[3], M. F. Sterzik[4]

[1] *European Southern Observatory, Karl-Schwarzschild-Str. 2, D-85748 Garching, Germany*
[2] *Laboratoire d'Astrophysique de Marseille, OAMP, Université Aix-Marseille & CNRS, 38 rue Frédéric Joliot Curie, 13388 Marseille, France*
[3] *Centre for Astrophysics and Planetary Science, University of Kent, Canterbury, Kent CT2 7NR, England*
[4] *European Southern Observatory, Casilla 19001, Santiago 19, Chile*

TMR-1 (IRAS 04361+2547) is a class I proto-stellar source located in the nearby Taurus star-forming region. Its circumstellar environment is characterized by extended dust emission with complex structures and conspicuous filaments. A faint companion, called TMR-1C, located near the proto-star had been detected in previous studies, but its nature as a very young substellar, possibly planetary mass, object remained inconclusive.

Using very sensitive infrared imaging observations of the TMR-1 system as well as near-infrared spectroscopy, we construct the spectral energy distribution of TMR-1C over a much larger wavelength range as had been possible in previous work, and compare it with models of extincted background stars, young sub-stellar objects, and very low-mass stars with circumstellar disk and envelope emission. We also search for additional low-luminosity sources in the immediate environment of the TMR-1 proto-stellar source. Furthermore, we study the surrounding near-infrared dust morphology, and analyse the emission line spectrum of a filamentary structure in the physical context of a bow-shock model.

We find that the observed spectral energy distribution of TMR-1C is inconsistent with an extincted background star, nor can be fitted with available models for a young extremely low-mass ($\leq 12 M_J$) object. Our near-infrared spectrum indicates an effective temperature $\geq$3000K. Based on a good match of TMR-1C's spectral energy distribution with radiation transfer models of young stellar objects with circumstellar protoplanetary disk, we propose that TMR-1C is most likely a very low-mass star with M$\approx$ 0.1M$_{\odot}$ surrounded by a circumstellar disk with high inclination, $i > 80°$ (see Figure below). Interestingly, we detect an additional very faint source, which we call TMR-1D, and that shows a quite striking symmetry in position with TMR-1C. TMR-1C and TMR-1D may have been formed from a common triggered star-formation event, caused by a powerful outflow or by the collision of primordial proto-stellar disks. The impact of an outflow is traced by molecular hydrogen emission that we detect from a distinct filament pointing towards TMR-1C. A comparison with C-type bow shock models confirms that the emission is caused by shock excitation.



Spectral energy distribution of TMR-1C (indicated by filled dots, triangles represent upper limits) compared to a model SED for a central source of 0.13M$_{\odot}$ with a circumstellar disk inclined to our line of sight by $i = 87$ deg, an outer disk radius of 94 AU, an age of $\approx 4 \times 10^5$yr, and located at a distance of 138 pc seen through an interstellar extinction of A_V=18.0mag.

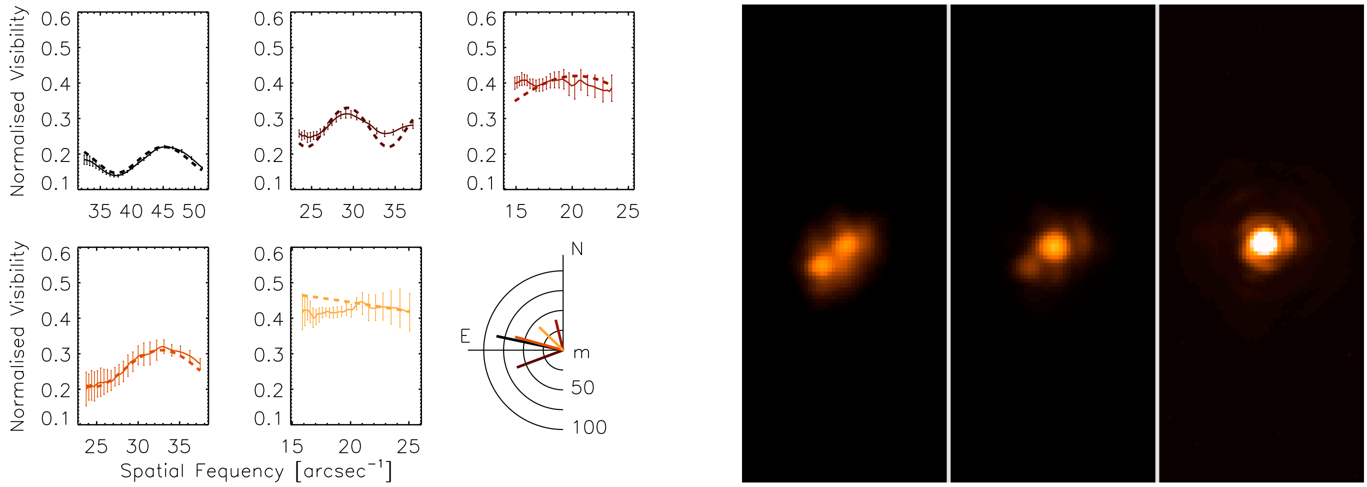
B23) Z CMa - Characterising an Unequal Binary in the Mid-Infrared with MIDI

Thorsten Ratzka[1], Laszlo Mosoni[2], Fabien Malbet[3], Myriam Benisty[4], Rebekka Grellmann[1], Christoph Leinert[5], and Thomas Preibisch[1]

[1] *Universitäts-Sternwarte München, Scheinerstr. 1, 81679 München, Germany*
[2] *Konkoly Observatory of the Hungarian Academy of Sciences, P.O. Box 67, 1525 Budapest, Hungary*
[3] *Laboratoire d'Astrophysique de Grenoble, 414, Rue de la Piscine, BP 53, 38041 Grenoble cedex 9, France*
[4] *INAF - Osservatorio Astrofisico di Arcetri, Largo E. Fermi 5, 50125 Firenze, Italy*
[5] *Max-Planck-Institute for Astronomy, Königstuhl 17, 69117 Heidelberg, Germany*

Z CMa is a pre-main sequence binary separated by only about 100 mas. The emission of both components is characterised by circumstellar material. No signs of stellar photospheres have been detected. The south-eastern component was classified as FU-Ori type variable. Its absorption spectrum can be interpreted as that of an optically thick accretion disc surrounding the star. While this source is the brighter one in the visible wavelength range, the north-western component dominates at infrared wavelengths. It is most likely a Herbig Be star surrounded by an asymmetric dust envelope. The observable visible and near-infrared light from this source is escaping from the envelope probably by scattering off the walls of a jet-blown cavity.

With the aim to spatially resolve the circumstellar material around the indiviual components, Z CMa has been studied in the N-band with the two-telescope interferometric instrument MIDI at the VLTI in the years 2004 to 2006. These measurements immediately allowed a reliable determination of the relative positions and the flux ratio of the two binary components in the mid-infrared for the first time [1]. During the recent outburst, that led to a brightening of 2 mag in the visual, Z CMa was again observed with AMBER and MIDI at the VLTI to study changes in the circumstellar environment of the two sources. Here we want to present a first interpretation of the complete sample of mid-infrared interferometric data.



Left: Five of the 21 visibilities (solid lines) measured with MIDI in GTO and DDT. Overplotted is a preliminary, simple binary model (dashed lines). The projected baselines are indicated. *Right:* Images in the J-, Ks, and L′-band taken with NACO in 2002. North is up and East is left.

References

[1] Ratzka, Th. & Leinert, Ch. 2008. *Observing T Tauri Stars in the Mid-Infrared with MIDI.* The Power of Optical/IR Interferometry: Recent Scientific Results and 2nd Generation Instrumentation, ESO Astrophysics Symposia.

B24) Discovery of accretion in a nearby, young brown dwarf

Ansgar Reiners[1]

[1] *Georg-August-Universität, Institut für Astrophysik, Friedrich-Hund-Platz 1, 37077, Göttingen, Germany*

Observations of disks and accretion around brown dwarfs have shown that brown dwarf and star formation are probably very similar, and in particular that disk lifetimes of stars and brown dwarfs are comparable. Only very few brown dwarfs at the end of the disk accretion phase are known, they are usually relatively far away which makes observations of the disks, the search for planets, and spectroscopy of the disks very difficult. I present the discovery of an accreting, nearby, young brown dwarf that probably is at the end of the disk accretion phase. The brown dwarf is only about 35 pc away and may be a member of Tuc Hor ($\sim$ 20 Myr), or a remote member of the β Pic association ($\sim$ 12 Myr). Both would imply that the accreting brown dwarf is as old as 10 Myr or older, which provides first evidence that in brown dwarfs the disk accretion phase – and hence the planet formation phase – can last as long as in stars, perhaps even longer. The object is the closest accreting brown dwarf known so far and can become a benchmark object for observational tests of brown dwarf accretion and planet formation.

B25) Milli-arcsecond Imaging of the Inner Regions of Protoplanetary Disks

S. Renard[1], F. Malbet[1], E. Thiébaut[2], J.-P. Berger[1], M. Benisty[3]

[1] *Laboratoire d'AstrOphysique de Grenoble (LAOG), France*
[2] *Centre de Recherche Atrophysique de Lyon (CRAL), France*
[3] *Osservatorio Astrofisico di Arcetri INAF, Italy*

Planets are believed to form in circumstellar disks around newly born stars at distances ranging from 0.1 to 10 AUs. To conduct observations of such disks at the milli-arcsecond scale, infrared interferometry is a suitable tool for observing T Tauri, FU Ori and Ae/Be stars.

However, the data obtained so far consist of a small number of visibility measurements which may or may not confirm a priori theoretical models. With the advent of recent multi-aperture interferometers, images of the close environments of young stars can be reconstructed independently of any model, as is routinely done in the radio frequency range.

In this contribution, the results of MIRA, an image reconstruction algorithm developed for optical interferometry, are analyzed via interferometric data obtained from a variety of young stellar objects. Finally, we discuss the consequences for models used so far.

B26) The Ongoing Outbursts from V1647 Ori

Terrence W. Rettig[1], Sean Brittain[2], Theodore Simon[3], Erika Gibb[4], Joe Liskowsky[1]

[1] *University of Notre Dame, Notre Dame, IN 46556*
[2] *Clemson University, Department of Physics and Astronomy, Clemson, SC 29634*
[3] *Institute for Astronomy, University of Hawaii, 2680 Woodlawn Dr, Honolulu, HI 96822*
[4] *University of Missouri at St. Louis, 8001 Natural Bridge Road, St. Louis, MO, 63121*

We present new high-resolution infrared observations of V1647 Ori, the young star that illuminates McNeils nebula. From the 2003 outburst and subsequent fading through early 2008 to the current brightening in late 2008, V1647 Ori has been an enigmatic source that has defied classification. In these observations we concentrate on the near IR CO emission lines to monitor the temperature and structure of the inner disk and use several atomic lines to provide a measure of the wind velocities and accretion rate. In this most recent episode, the fundamental CO lines returned to near their 2004 brightness but our spectra provide no indication of the prominent CO overtone emission bandheads that were seen in 2004 or the later absorption bandheads that were seen as the object returned to pre-outburst brightness in 2007. The prominent outflow that was seen as an absorption component in the CO lines during the return to quiescence in 2006/7 (Brittain et al 2007) has now faded and cooled so that it can only be marginally detected in the low J lines. This outflow provides a unique insight into the early phase of the star and disk evolution and if the current brightening fades similar to the previous event, it will be important to search for the resulting outflow.

B27) Silicate Evolution in Brown Dwarf Disks

B. Riaz[1]

[1] *Instituto de Astrofsica de Canarias, Tenerife, Spain*

We present a compositional analysis of the 10 μm silicate spectra for brown dwarf disks in the Taurus and Upper Scorpius (UppSco) star-forming regions, using *Spitzer*/IRS observations. Flatter features are observed for the brown dwarfs compared to higher mass T Tauri and Herbig Ae/Be stars, consistent with previous findings of heightened flattening in lower-mass objects. While the “strength” in the feature is not correlated with either the large-grain or the crystalline mass fractions, the “shape” is found to be affected by both processes. For most objects, we find nearly equal fractions for the large-grain and crystalline mass fractions, indicating both processes to be active in these disks. No strong correlation is observed between the mass fractions for the large and crystalline grains, and the degree to which the disk has sedimented. We find a trend of increasing large-grain mass fractions with an increasing strength in the X-ray emission, while the opposite trend is observed for the crystallinity levels. The median crystalline mass fraction for the Taurus brown dwarfs is found to be 20%, a factor of $\sim$2 higher than the median reported for the higher mass stars in Taurus. A comparison with the Chamaeleon I brown dwarfs suggests a trend of increasing crystallinity with age. A small 5% of the Taurus brown dwarfs are still found to be dominated by pristine ISM-like dust, with an amorphous sub-micron grain mass fraction of $\sim$90%. For 15% of the objects, we find a negligible large-grain mass fraction, but a >60% small amorphous silicate fraction. These may be the cases where substantial grain growth and dust sedimentation has occurred in the disks, resulting in a high fraction of amorphous sub-micron grains in the disk surface. The detection rate for emission in the 10 μm silicate feature shows a dependence on the age of the system, such that the rate drops from $\sim$75% in Taurus to only $\sim$23% among the older UppSco brown dwarfs.

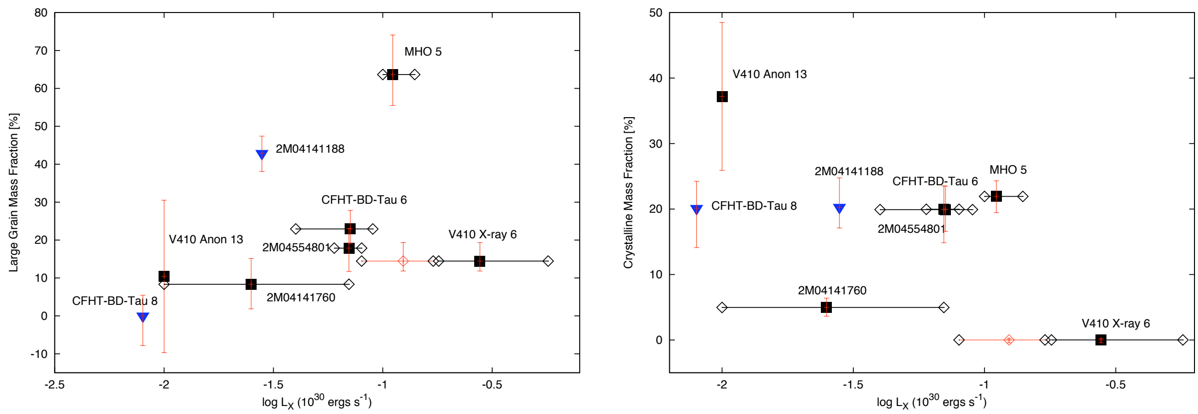


Figure 2: X-ray emission versus the large-grain and crystalline mass fractions.

B28) Disks and activity around low-mass stars in the sigma-Ori star forming region

Elisabetta Rigliaco[1]

[1] *Osservatorio Astrofisico di Arcetri*

Circumstellar disks are observed around pre-main sequence objects of masses from few Msun to brown dwarfs, and the correlation with the accretion properties is crucial to understand the disk evolution. We present here a study aimed to investigate the accretion properties of a sample of low-mass stars (ranging in mass from ~1 Msun to 0.1 Msun) in the intermediate age star forming region sigma-Orionis (~ 3Myr) based on the U-band photometry. The mass accretion rate derived from the U-band photometry for our sample will be compared with the mass accretion rate derived with other methods and in other samples. Moreover the Spectral Energy Distribution (SED) will be considered in comparison with the accretion properties of the stars.

B29) Disk evolution in OB associations: the case of IC1795

Veronica Roccatagliata[1], J. Bouwman[1], Th. Henning[1], E. Feigelson[2], A. Sicilia-Aguilar[1]

[1] *Max-Planck-Institut für Astronomie, Königstuhl 17, 69117 Heidelberg, Germany*
[2] *Department of Astronomy and Astrophysics, Pennsylvania State University, University Park, PA 16802, USA*

The IC1795 cluster belongs to the diffuse HII region in the W3 giant molecular cloud complex, situated in the Perseus arm at 2kpc, and it contains several spectacular regions of high and low mass star formation, W3 North, W3-Main and W3-OH. IC 1795 has been observed with IRAC/Spitzer and with Chandra.

Sources detected in both the survey are classified as 'cluster members' and sources with excess with infrared excess and without Xray emission as 'cluster member candidates'.

Pre-main sequence isochrones in the IRAC color have been computed to fit the sources without infrared excess. The age of the cluster is confirmed to be between 3 and 5 Myr.

The disk fraction has been determined using the different magnitudes as tracers of the stellar photosphere: the J, V and 3.6μm magnitudes. Source with a 3.6-4.5 μm color $>$ 0.1 have been classified with disk. The disk fraction is found to increase from 0.2 until 0.7 as the stellar mass decrease from 8 until 0.4 $M_\odot$.

The disk fraction has been found to be not dependent on the spatial distribution of the cluster.

For solar type stars the disk fraction has been found to be ~40% which is in agreement with the evolution timescale in "quiescent" environment drown from Haisch et al. (2001) for a ~4 Myr cluster.

B30) Bayesian analysis and parameter estimation based on observed SEDs of class II/III systems.

L. Sarro[1], A. Delgado[2], B. Montesinos [2], B. Merin[3], E. Solano [2], R. Gutierrez[2], C. Rodrigo [2]

[1] *Dpt. Artificial Intelligence, UNED, Spain*
[2] *LAEX/CAB, INTA/CSIC, Spain*
[3] *Herschel Science Centre, ESAC, ESA*

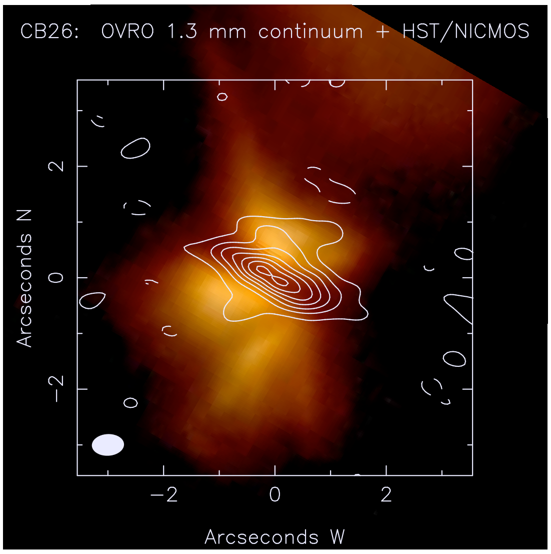
In this poster we report on current efforts to carry out bayesian parameter inference based on model grids of Class II/III systems spectral energy distributions. In particular, we show how we can reproduce parameter estimates made with the usual trial and error approach for two systems with well studied SEDs: HD34282 & HD141569. Furthermore, we address the question of the optimal complexity of models as justified by the data, i.e., the question of how many dust components are needed for a satisfactory fit to the observed SED. Finally, we stress the advantage to work all along the analysis process with probability density distributions and their suitability as tools for the tackling of common scientific tasks.

B31) The circumstellar disc in the Bok globule CB 26 Multi-wavelength observations and modelling of the dust disc and envelope

Jürgen Sauter[1,2], Sebastian Wolf[1], Ralf Launhardt[2], Deborah L. Padgett[3], Karl R. Stapelfeldt[4], Christophe Pinte[5,6], Gaspard Duchêne[7,6], François Ménard[6], Caer-Eve McCabe[3], Klaus Pontoppidan[8], Michael Dunham[9], Tyler L. Bourke[10], and Jo-Hsin Chen[9].

[1] *Christian-Albrechts-Universität zu Kiel, Institut für Theoretische Physik und Astrophysik, Leibnizstr. 15, 24098 Kiel, Germany*
[2] *Max-Planck-Institut für Astronomie, Königstuhl 17, 69117 Heidelberg, Germany*
[3] *California Institute of Technology, 1200 E California Blvd, Mail code 220-6, Pasadena, CA 91125, USA*
[4] *JPL, 4800 Oak Grove Drive, Mail Stop 183-900, Pasadena, CA 91109, USA*
[5] *School of Physics, University of Exeter, Stocker Road, Exeter EX4 4QL, UK*
[6] *Laboratoire d'Astrophysique de Grenoble, CNRS/UJF UMR 5571, B.P. 53, F-38041 Grenoble Cedex 9, France*
[7] *Astronomy Department, University of California Berkeley, 601 Campbell Hall, Berkeley CA 94720-3411 USA*
[8] *California Institute of Technology, Division of Geological and Planetary Sciences, MS 150-21, Pasadena, CA 91125, USA*
[9] *Department of Astronomy, University of Texas at Austin, 1 University Station C1400, Austin, TX 78712, USA*
[10] *Harvard-Smithonian Center for Astrophysics, 60 Garden St., Cambridge MA02138, USA*

Circumstellar discs are understood to be the nursery of planets. Grain growth within such discs is the first step in the planet formation process. The Bok globule CB 26 harbours such a young disc. We present a detailed model of the edge-on circumstellar disc and its envelope in the Bok globule CB 26. The model is based on HST images in the I, J, H, and K bands, OVRO and SMA radio maps at $1.1mm$, $1.3mm$ and $2.7mm$, and the spectral energy distribution (SED) from $0.9\mu m$ to $3mm$. New photometric and spectroscopic data from the Spitzer Space Telescope and the Caltech Submilimeter Observatory have been obtained and are part of our analysis. Figure 1 shows an overlay of the NIR images and the OVRO map. Using the self-consistent radiative transfer code MC3D, the model we construct is able to discriminate parameter sets and dust properties of both its parts, namely envelope and disc. We find that the disc has an inner hole with a radius of 45 ± 5 AU. Based on a dust model including silicate and graphite the maximum grain size needed to reproduce the spectral millimetre index is $2.5\mu m$. Features seen in the near-infrared images, dominated by scattered light, can be described as a result of a rotating envelope. Our modeling excludes the substantial presence of grains much larger than those found in the ISM dust in both, disc and envelope, and thus hints that grain growth may not yet play a significant role for the appearance of this system. A larger inner hole gives rise to the assumption that CB 26 is a circumbinary disc.



Overlay of the OVRO 1.3*mm* continuum map and the HST NICMOS images of CB26. The NICMOS colour image is a 3-colour composite of F205W, F160 W, and F110W (in the RGB colour planes, respectively), shown in log stretch. The contour levels are linear, with the lowest contour at about the 2.5 σ-level, the others at the 6, 10, 14, 22, and 25 σ-level, respectively. *From:* Sauter et al. 2009, A&A, 505, 1167.

B32) A multiwavelength picture of evolved and transitional protoplanetary disks

A. Sicilia-Aguilar[1], Th. Henning[1], A. Juhász[1], J. Bouwman[1], L.Hartmann[2], D.Watson[3], N.Patel[4]

[1] *Max-Planck-Institut für Astronomie*
[2] *University of Michigan*
[3] *University of Rochester*
[4] *Harvard-Smithsonian Center for Astrophysics*

Protoplanetary disks are complex systems. Multiwavelength observations of large numbers of disk-bearing stars in clusters with different ages reveal evolution of the IR excesses, accretion rates, and silicate features. The changes in the disks are consistent with grain growth/settling, photoevaporation, and maybe the formation of planets and planetesimals. However, within the average-behavior picture of disk evolution, we observe strong variations between objects with similar ages and masses, which suggests that not all disks are dispersed in the same way: The various dispersal mechanisms (photoevaporation, grain growth, planet formation) do not seem to be equally efficient in all systems. In addition, the comparison of different star-forming regions suggests that other parameters, related to the initial conditions (disk masses, presence of companions) and the cluster environment, also play an important role in disk evolution and dissipation.

B33) PAH destruction in protoplanetary disks

Ralf Siebenmorgen[1] and Endrik Krügel[2]

[1] *ESO, Karl-Schwarzschildstr.2, D-85748 Garching*
[2] *MPIfR, Auf dem Hügel 69, D-53001 Bonn*

In Spitzer observations of Tauri stars and their disks, PAH features are detected in less than 10% of the objects, although the stellar photosphere is sufficiently hot to excite PAHs. To explain the deficiency, we discuss PAH destruction by photons assuming that the star has beside its photospheric emission also a FUV, an EUV and an X–ray component with fractional luminosity of 1%, 0.1% and 0.025%, respectively. Two conditions for PAH destruction are required: Super-heating, which assumes steady state and in which a certain fraction of PAHs is brought by photon absorption above the evaporation temperature. It is relevant for EUV and soft photons, but only up to $\sim 2\,$AU, and fails for energetic photons which impinge rarely. As a second criterion the expulsion of atoms by hard photons (EUV and X–ray) is discussed. It requires time considerations and works independently of the distance to the star and is so efficient that it would destroy all PAHs. As a possible path for PAH survival we suggest turbulent motions in the disk. They can replenish PAHs or remove them from the reach of hard photons. For standard disk models, where the surface density changes like r^{-1} and the mid plane temperature like $r^{-0.5}$, the critical vertical velocity for PAH survival is proportional to $r^{-3/4}$ and equals $\sim$5 m/s at 10 AU which is in the range of expected velocities in the surface layer. The uncertainty in the parameters is large enough to explain both detection and non-detection of PAHs. Our approximate treatment also takes into account the presence of gas which, at the top of the disk, is ionized and at lower levels neutral.

B34) X-ray Observations of Accreting Star-Disk Systems

S.L. Skinner[1], K.R. Sokal[1], M. Güdel[2], M. Audard[3]

[1] *Univ. of Colorado, Boulder, CO USA*
[2] *ETH, Zürich, Switzerland*
[3] *ISDC and Univ. of Geneva, Switzerland*

X-ray observations of accreting young stars are capable of providing information on gas column densities through the disk, plasma temperatures in accretion shocks or shocked outflows, and star-disk geometry inferred from fluorescent emission line analysis. We summarize recent X-ray observations of several different accreting systems. These include rapidly-accreting FU Orionis stars, as well as class I/II outflow sources located in heavily-obscured star-forming regions (e.g. NGC 2071-IR in Orion, and Lynds 1228 in the Cepheus Flare). We will provide examples of X-ray spectra of accreting systems that show unusual features such as broad fluorescent Fe emission lines and two different absorption components. We will discuss and interpret these spectra in the context of accretion, jets, and outflows. We will also present *Chandra* images revealing an X-ray detection of the probable driving source of the giant Herbig-Haro flow HH 200 in L1228.

B35) Observations of Unusually High $^{12}C/^{13}C$ Fractionation in Protostars Using VLT-CRIRES

Rachel L. Smith[1], Klaus M. Pontoppidan[2], Gregory J. Herczeg[3], and Edward D. Young[1,4]

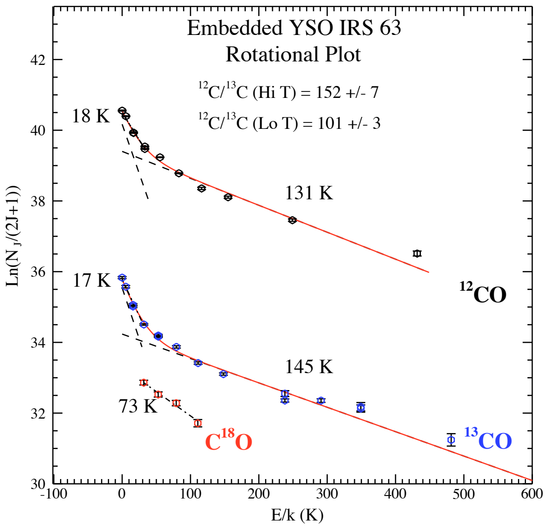
[1] *Department of Earth and Space Sciences, University of California Los Angeles, 595 Charles E. Young Drive East, Geology Building, Los Angeles, CA 90095-1567 (rsmith@ess.ucla.edu)*
[2] *Hubble Fellow, Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena, CA 91125 (pontoppi@gps.caltech.edu)*
[3] *Max Planck Institut für extraterrestrische Physik, Postfach 1312, 85741 Garching, Germany (gregoryh@mpe.mpg.de)*
[4] *Institute of Geophysics and Planetary Physics, University of California Los Angeles (eyoung@ess.ucla.edu)*

In the study of meteorites, sensitive measurements of isotope ratios are a powerful tool for tracing the early history of the solar system. We are extending such studies by making accurate measurements of isotope ratios in extra-solar protoplanetary disks, thus providing a much needed direct comparison to the solar system. Here we present new $^{12}CO/^{13}CO$ ratios for a Stage I - II YSO (IRS 63) and a foreground cloud (IRS 51) in the ρ Ophiuchus star forming region obtained at very high resolution ($R \approx 95\,000$) with the Cryogenic Infrared Echelle Spectrograph (CRIRES) at the Very Large Telescope (VLT) in Chile. Initial results for IRS 63 indicate warm ($\sim$ 150 K) and cold ($\sim$ 20 K) regions, with the warm gas likely representing the region close to the central protostar or the photoactive regions of the outer disk, and the cold gas characterizing the surrounding envelope (Figure). A single, cold regime is found for the extincted source IRS 51, which traces the Ophiuchus ridge. Preliminary results for the warm, well-sampled gas in IRS 63 reveal a $^{12}CO/^{13}CO$ ratio that is significantly higher ($\sim$ 150) than the ambient parent cloud ($\sim$ 65); the high value obtained for IRS 51 ($\sim$ 160) may trace photolyzed CO in the Ophiuchus ridge. These high carbon isotope ratios for both sources and two-temperature structure for IRS 63 are consistent with our report for the Stage I YSO Reipurth 50 in Orion and Stage II VV CrA disk in Corona Australis (Smith et al. 2009), each of which reveal a $^{12}CO/^{13}CO$ ratio of $\sim$ 100, significantly higher than the local ISM ($\sim 67 - 79$). The interesting mystery in early solar system chemistry presented by these ratios cannot be explained by spectral systematics, and photochemical fractionation of CO may be a viable explanation; isotope-selective photodissociation of CO has been used to explain similarly high $^{12}CO/^{13}CO$ ratios observed in molecular cloud cores such as in ρ Ophiuchus (i.e., Federman et al. 2003), and in the VV CrA disk by virtue of the significant mass-independent deficit of $C^{18}O$ and $C^{17}O$ relative to $C^{16}O$ (Smith et al. 2009).

References:

Federman, S. R., Lambert, D. L., Sheffer, Y., Cardelli, J. A., Andersson, B.-G., van Dishoeck, E. F., & Zsargo J. 2003, ApJ, 591, 986.

Smith, R. L., Pontoppidan, K. M., Young, E. D., Morris, M. R., & van Dishoeck, E. F. 2009, ApJ, 701, 163.



Rotational plot for CO isotopologues in IRS 63 from the initial analysis of the fundamental and overtone rovibrational absorption bands. Simultaneous fits to the two-temperature model and derived high and low temperatures for ^{12}CO and ^{13}CO are indicated by the red curves and dashed lines, respectively. A single-temperature fit was used for the C^{18}O lines. Error bars are 1σ propagated from the Gaussian fits to the lines.

B36) Exploring the bottom of the IMF in NGC3603

L. Spezzi[1], G. Beccari[2], E. Young[3], G. De Marchi[1], F. Paresce[4], M. Andersen

[1] *European Space Agency*
[2] *Dipartimento di Astronomia, Universita' di Bologna*
[3] *Steward Observatory, University of Arizona*
[4] *Istituto Nazionale di Astrofisica (INAF)*

The new Wide Field Camera 3 (WFC3) on board the HST is optimized at both UV and IR wavelengths and brings unique capabilities to star formations studies. To fully exploit this new instrument, the WFC3 Scientific Oversight Committee is conducting a wide multi-wavelength imaging program that includes well-resolved star forming regions in the Milky Way, the Large Magellanic Cloud and other nearby galaxies that sample a wide range of star-formation rates and environments. This program is aimed at studying young stellar populations, revealing stars that are still hidden by dust at optical wavelengths, and showing the deriving properties of star clusters.

One of the targets included in this program is the NGC3603 cluster powering HII region. Its relative proximity (7.2 kpc) and young age (2-3 Myr) give us a unique opportunity to study the dense stellar cores that are not accessible in more distant, unresolved regions and represent our window into the giant HII regions seen in other galaxies. In this contribution we focus, in particular, on the search for very low-mass stars and brown dwarfs in NGC3603, with the aim of obtaining new insights into the very low-mass IMF of an intense star-burst environment. We show the possibilities offered by the WFC3 panchromatic capabilities for the identification and characterization of brown dwarfs.

This paper is based on Early Release Science observations made by the WFC3 Scientific Oversight Committee. We are grateful to the Director of the Space Telescope Science Institute for awarding Director's Discretionary time for this program.

B37) Age Determination Method of Pre-Main Sequence Stars with High-Resolution Spectroscopy

Yuhei Takagi[1], Yoichi Itoh[1], Yumiko Oasa[2]

[1] *Graduate School of Science, Kobe University*
[2] *Faculty of Education, Saitama University*

Age of a pre-main sequence star is one of the most fundamental stellar parameters to study the evolution of young stars. Generally, the age of a young star is determined by estimating the luminosity and the effective temperature of the star (Strom et al. 1989, Kenyon and Hartmann 1995). However, the luminosity of the young star is very uncertain, due to the distance indefiniteness, extinction, and veiling, a continuum excess caused from accretion shock and the heated circumstellar disk. Therefore, the age of a young star estimated by the photometric method may contain errors.

We construct a new age-determining method by estimating the surface gravity of a pre-main sequence star. Since a star contracts in the early evolutional stage, its age is able to be estimated by deriving the surface gravity. High-resolution spectroscopy is suitable for determining the surface gravity, because the equivalent width of an atomic absorption line is sensitive to metal abundance, effective temperature, and pressure of the stellar atmosphere. In addition, we used the "equivalent width ratio" of the nearby absorption lines to estimate the surface gravity. The effect of veiling such as "filling-up" of the lines is able to be canceled by calculating the ratio (Meyer et al. 2008), and also the difference of metal abundance will be eliminated assuming that the abundance ratio of the elements are equal. However, a fine line pair is yet to be established in a long wavelength range which is suitable for observing pre-main sequence stars.

We selected the Sc (22057$\AA$) an Na (22062$\AA$, 22090$\AA$) lines in the K-band for the surface gravity indicator. The Na lines are reached to the limiting depth, therefore the equivalent width increases in high surface gravity stars. On the other hand, the Sc line is not reached to the limiting depth. The equivalent width of Sc decreases with the increase of the continuum opacity, i.e., the increase of the surface gravity.

In order to derive the relation between the equivalent width ratio (Sc/Na) and the surface gravity, we obtained high-resolution near-infrared spectra of dwarfs, T Tauri, and giants. The effective temperature of each object is nearly 3800K. We found that the Sc/Na is a good indicator of surface gravity. It is expected that the age of pre-main sequence stars can be determined with a precision of a factor of 1.5 by our new method.

References
Kenyon, S. J. & Hartmann, L. 1995, ApJS, 101, 117
Meyer, M. R., Edwards, S., Hinkle, K. H., & Strom, S. E. 1998, ApJ, 508, 397
Strom, K. M., Strom, S. E., Edwards, S., Cabrit, S. & Skrutskie, M. F. 1989, AJ, 97, 1451

B38) Formation of the hydrogen emission lines in the disk winds of the young hot stars

L.V. Tambovtseva, V.P. Grinin

Main Pulkovo Astronomical Observatory, Pulkovskoe shosse 65, 196140 St. Petersburg, Russia

We consider the formation of the hydrogen emission spectra (Balmer, Paschen and Brackett lines) in Ae and late Be Herbig stars. They form mainly in the inner regions of the accretion disks and disk winds of these stars. It is shown that all types of the line profiles can be obtained under the different orientation of the stellar disks to the line of sight. We discuss constraints on the physical parameters of the emitting region.

B39) Modeling Spectro-astrometry in Circumstellar Disks

Matthew Troutman[1,2], Sean Brittain[1]

[1] *Clemson University*
[2] *Michelson Graduate Fellow*

We present models of a circumstellar disk observed using spectro-astrometry. This technique provides ultra-high spatial resolution data using a high resolution spectrograph, providing unique insights into the planet-forming regions of a circumstellar disk. Given a disk size, inclination, and orientation, the model produces a spectro-astrometric signal. This signal can be adjusted given an instrument resolution, to fit observations from CRIRES on the VLT or

PHOENIX at Gemini South. When the disk inclination and orientation are known, this can be used to determine the best orientations of the slit position angle to maximize the signal. When the disk inclination or orientation are not known, it can be used to fit observed data to extract those values. Also, disk asymmetries are explored to determine what, if any, the observational effect will be.

B40) The variability mechanism of the T Tau infrared companion

Roy van Boekel[1], Attila Juhasz[1], Kees Dullemond[1], Thomas Henning[1], Tom Herbst[1], Rainer Koehler[2], Willy Kley[3], Thorsten Ratzka[4]

[1] *MPIA Heidelberg, Königstuhl 17, D-69117 Heidelberg, Germany*
[2] *Landessternwarte, Königstuhl 12, D-69117 Heidelberg, Germany*
[3] *Institut für Astronomie & Astrophysik, Auf der Morgenstelle 10, D-72076 Tübingen, Germany*
[4] *Universitäts-Sternwarte München, Scheinerstrasse 1, D-81679 München, Germany*

T Tauri has traditionally served as the prototype of young, low-mass stars, and has been extraordinarily well studied. It has an "infrared companion" located ≈0.7 arcseconds south of the optically visible star (Dyck et al. 1982). The infrared source itself is a close binary (Koresko 2000), making the whole system at least a triplet. The masses of the components T Tau N, Sa and Sb are estimated at ≈2.1, ≈2.2 and ≈0.7 $M_\odot$, respectively (Koehler et al. 2008).

The apparent brightness of the southern infrared companion was found to vary strongly in time, ≈2−3 magnitudes, at near- and mid-infrared wavelengths (Ghez et al. 1991). High spatial resolution observations have identified Sa as the main variable component. Initially, these brightness fluctuations were attributed to variations in the intrinsic luminosity of the system, caused by a variable accretion rate. However, intensive multi-band photometric monitoring over a number of years has led to a paradigm shift: in recent years the variability of T Tau S has been attributed to variable extinction due to inhomegeneous dust clouds passing through our sightline (Beck et al. 2004).

Based on the rapidity of the brightness variations that we detected at relatively long wavelengths in VLT/VISIR observations of the T Tau system (a brightening of ≈0.25 mag at 12.8 μm within 4 days), we argue that simple variable extinction *cannot* be the mechanism resposible for photometric fluctuations of T Tau S. Instead, rapid and substantial changes in the illumination of the disk surface are required. In a strongly accreting system with a variable accretion rate, this can readily be achieved.

We present updated light curves of the system at near- and mid-infrared wavelengths. We show that, contrary to previous claims, the observed "bluer when brighter" infrared color-brightness behavior of the variability *can* in fact be qualitatively reproduced using a disk model with a variable mass accretion rate. We speculate that the period of high and variable brightness that T Tau S has shown from the early 1990s to the early 2000s is due to gravitational perturbation of the Sa disk during the periastron passage of Sb around ≈1995. If this is so, we predict T Tau S to return to its "low" state soon, and remain there until the highly eccentric orbit of Sb takes it close to Sa once more, in ≈40−100 years.

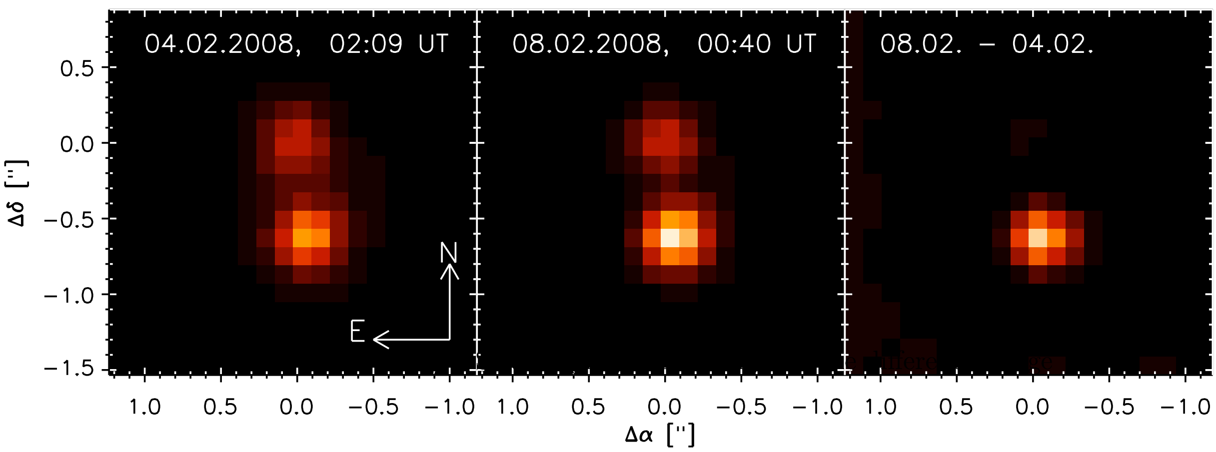


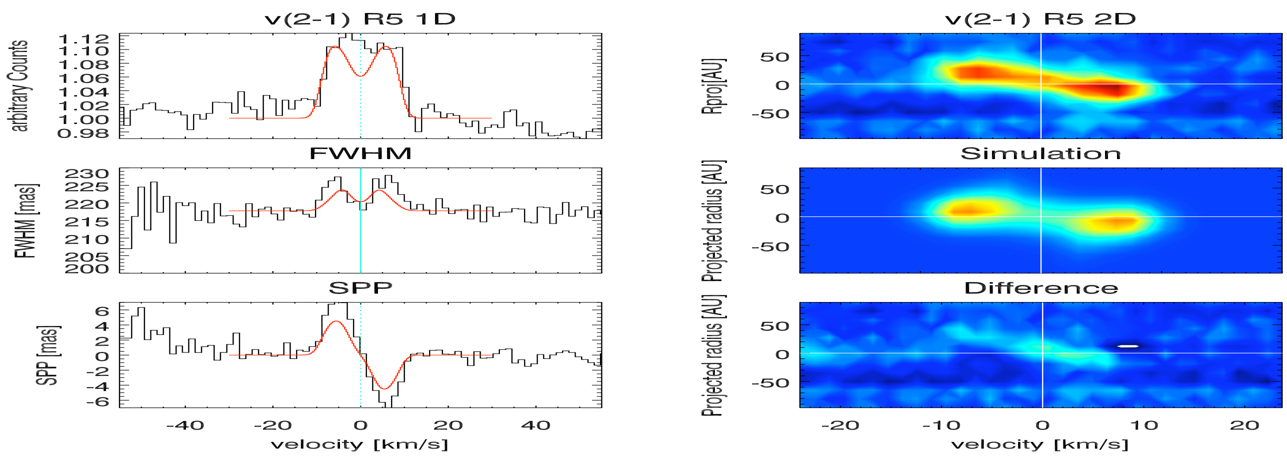
Fig.1:

B41) Spatially and spectrally resolved CO emission from disks around Herbig AeBe stars: a non-LTE excitation mechanism, disk geometry, and CO depletion

G. van der Plas[1,2], Mario van den Ancker[2], Carsten Dominik[1,3], L.B.F.M. Waters[1,4], I. Kamp[5], E. Pantin[6]

[1] *Astronomical Institute Anton Pannekoek, University of Amsterdam, PO box 94249, 1090 GE, Amsterdam, The Netherlands*
[2] *European Southern Observatory, Karl-Schwarzschild-Str.2, D 85748 Garching bei München, Germany*
[3] *Institute for Astrophysics, Radbout University, Heyendaalseweg 135, 6525 AJ Nijmegen, The Netherlands*
[4] *Department of Physics and Astronomy, KU Leuven, Celestijnenlaan 200D, 3001 Leuven, Belgium*
[5] *Kapteyn Astronomical Institute, Rijksunversiteit Groningen, P.O. Box 800, 9700 AV Groningen, The Netherlands*
[6] *CEA/Saclay, DSM/DAPNIA/Service d'Astrophysique, 91191 Gif-sur-Yvette, France*

We have studied Carbon Monoxide (CO) gas in a sample of 14 nearby, relatively isolated, intermediate mass pre-main-sequence stars with CRIRES at the VLT and with the RXA3 receiver at the JCMT. We use both the Δ v = 0 (rotational, JCMT), Δ v = 1 (fundamental, CRIRES) and Δ v = 2 (First overtone, CRIRES) transitions probing the distribution of CO gas at spatial scales reaching from within the inner AU to the outer disk. We find CO emission with CRIRES up to very highly excited vibrational energy levels in four disks, but surprisingly little variation in the line shape of individual rotational lines in these vibrational bands. This excludes LTE excitation. In three stars we find the CO ro-vibrational line emission to be spatially resolved (figure 1). We study the relation between the presence of ro-vibrational CO emission and the geometry of the disk (flaring versus self-shadowed, disk gaps, inner hole), and with other gas indicators such as Polycyclic Aromatic Hydrocarbons and [OI]. The fact that the latter, which requires comparable excitation conditions as ro-vibrational CO emission, is found in almost half our targets, at significantly smaller radii than the CO, suggests that at least in some protoplanetary disks, CO may be efficiently depleted in the innermost parts of the disk.



Comparison of the ^{12}CO v = 2-1 R5 *spatially and spectrally resolved* spectral line (black) to a model (orange). We show on the left panels the spectral line (top), spatial FWHM (middle), and astrometric signal (lower left, SPP, see van der Plas et al. (2009) for a description). On the right we show the continuum subtracted 2D spatial profile (top), our scaled best fit model of CO emission in the disk around HD 97048 (middle), and at the bottom the difference between both. Contour levels for all plots are the same.

B42) The fate of HAeBe star disks: Photoevaporation versus planet formation.

A.P. Verhoeff[1], L.B.F.M. Waters[1,2], M. van den Ancker[3], A.G.G.M. Tielens[4], M. Min[5], F.A. Stap[1], E. Pantin[6], R. van Boekel[7], A. de Koter[1,5]

[1] *Astronomical Institute "Anton Pannekoek", University of Amsterdam, The Netherlands*
[2] *Institute for Astronomy, KU Leuven, Belgium*
[3] *European Southern Observatory, Garching, Germany*
[4] *Leiden Observatory, Leiden University, The Netherlands*
[5] *Astronomical Institute Utrecht, University of Utrecht, The Netherlands*
[6] *CEA/DSM/DAPNIA/Service d'Astrophysique, Saclay, France*
[7] *Max Planck Institut für Astronomie, Heidelberg, Germany*

The formation of low mass stars has been pretty well mapped and the number of indications are growing that star formation at higher masses follows a similar sequence of events. Star formation proceeds by the accretion of matter through a disk, which remains in place after the accretion has stopped. Our knowledge of the fate of these passive disks is also biased toward the low mass end. Now that we have the spatial resolution in the mid IR to zoom in to disk scales and filter out the natal clouds surrounding the higher mass stars we can start to compare the disks.

We studied two samples of young stars in the mass range 1-3 and 3-30 $M_\odot$ in the mid IR using VISIR at the VLT. We mapped the spatial distribution and composition of their circumstellar dust. We found that over the entire mass range the circumstellar matter can be characterized by a circumstellar disk that reprocesses a substantial portion of the stellar flux. Also the composition of the emitting dust does not vary greatly. However, in the lower mass range we find a significant number of disks that show indications of disk gaps and/or inner holes. The stars in the higher mass range typically have a lower IR reprocessing power. Furthermore, these disks lack signs of an extended flaring disk geometry, from which we deduce that they have been truncated. We recognized the former as the signature of planet formation and the latter as a sign of photoevaporation.

B43) The Spitzer Gould's Belt survey in Lupus: First results

Pierre Vernazza[1], Loredana Spezzi[1], Bruno Merín[2], Tracy L. Huard[3], Dawn Peterson[4], Paul M. Harvey[5], Lori E. Allen[6], Neal J. Evans II[5] & Goulds Belt Team

[1] *Research and Scientific Support Dept., ESTEC (ESA), Keplerlaan, 1, PO Box 299, 2200 AG Noordwijk, The Netherlands*
[2] *Herschel Science Centre, ESAC (ESA), P.O. Box 78, 28691 Villanueva de la Canada (Madrid), Spain*
[3] *Astronomy Department, University of Maryland, College Park, MD 20742, USA*
[4] *Smithsonian Astrophysical Observatory, 60 Garden Street, Cambridge, MA 02138, USA*
[5] *Department of Astronomy, University of Texas at Austin, 1 University Station C1400 Austin, TX 78712-0259, USA*
[6] *Department of Astronomy, University of Arizona, 933 N Cherry Ave., Tucson AZ 85721-0065, USA*

We will present Gould's Belt (GB) Spitzer IRAC and MIPS observations of the Lupus V and VI clouds and discuss them in combination with near-infrared (2MASS) data. Our observations complement those obtained for other Lupus sub-clouds within the frame of the Spitzer c2d survey (Lupus I, III and IV, Merín et al. 2008). We found 46 Young Stellar Object candidates in each cloud using the standard c2d/GB selection method. A large majority of these objects appear to be surrounded by thin disks (Class III objects; 76 % in Lupus V, 87 % in Lupus VI). These Class III abundances differ significantly from those observed for the other Lupus sub-clouds where objects with optically thick disks dominated the distribution (Class II objects; 55 %). We investigate various scenarios that can explain this discrepancy.

B44) Revealing the inner-disk structure of the T Tauri star S CrA N with the VLTI

J. Vural[1], S. Kraus[1], T. Driebe[1], G. Weigelt[1]

[1] *Max-Planck-Institut für Radioastronomie, Auf dem Hügel 69, 53121 Bonn*

We probed the circumstellar disk of the T Tauri star S CrA N with both VLTI instruments: MIDI, the two-beam combiner in the mid-infrared and AMBER, the three-beam combiner in the near-infrared. We applied a temperature

gradient model to both visibility and spectral energy distribution and found an almost face-on disk consisting of two components. The outer component is a disk extending from approximately 2 AU to 30 AU. The inner component is a geometrically thin ring with a radius of approximately 0.1 AU. This finding is consistent with the existence of the so-called puffed-up rim located at the dust sublimation radius. This rim might in addition explain the gap between the two components, which can be considered as a part of the disk shadowed from the stellar light and thus not seen in mid- or near-infrared.

B45) The planet forming capability of circumstellar disks in Orion

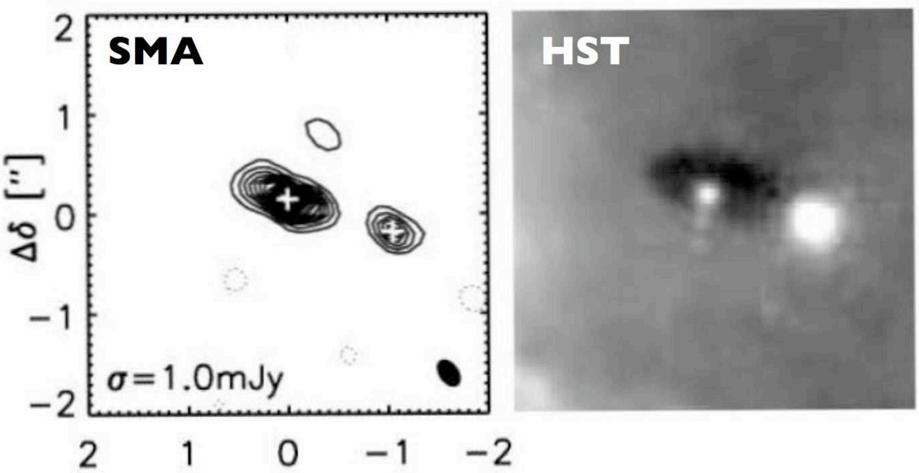
Jonathan P. Williams[1], Rita K. Mann[1]

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

Most stars, likely including our Sun, formed in large clusters within about a parsec of a massive star. The ultraviolet radiation from O stars warms and evaporates the outer parts of nearby circumstellar disks, as dramatically evidenced by HST observations of the Trapezium Cluster. We have carried out a submillimeter interferometric survey with the SMA to measure the distribution of disk masses in Orion and assess the likelihood for Solar System scale planet formation. We find that, compared to Taurus and ρ Ophiuchus, there is a dearth of massive disks in the central ~ 0.2 pc of the Trapezium Cluster but that more massive disks exist in the neighboring M43 region, over 1 pc away from the O stars.

The inner regions of disks can survive photoevaporation for many Myr. We estimate that the fraction of disks with masses greater than $0.01\,M_\odot$ and radii less than 60 AU, that have the potential to form planetary systems on the scale of our own, is a similar $\sim 11-13\%$ in Orion and Taurus and comparable to the detection frequency of hot Jupiters.

Finally we present high resolution ($0.2''$) SMA observations of a binary system showing two massive disks. The disks differ in size and mass by about a factor of 3 and provide a benchmark to the effect of stellar mass on disk formation and early evolution.



B46) X-ray and IR spectral Properties of YSOs in Serpens North and NGC 1333.

Elaine Winston[1]

[1] *School of Physics, University of Exeter, U.K.*

I will present spectral observations of 140 young stellar objects (YSOs) in the Serpens Cloud Core and NGC 1333 star forming regions, using near-IR spectra in the J, H, and K-bands, from SpeX on the IRTF and far-red spectra, (6000 - 9000 Å), from Hectospec on the MMT. These YSOs were identified in previous *Spitzer* and *Chandra* observations, and the evolutionary classes of the YSOs were determined from the *Spitzer* mid-IR photometry.

I will then detail new, deeper observations of NGC 1333 with *Chandra ACIS-I* and combine these with existing *Spitzer IRAC* observations of the region. In NGC 1333, 86 cluster members are detected in X-rays, of which 54 were previously identified in the *IRAC* data. Thirty-two new Class III members of the cluster are identified, bringing the total identified YSO population to 169.

The X-ray Luminosity Functions (XLFs) of the NGC 1333 and Serpens clusters are compared to each other and the Orion Nebula Cluster. For the Serpens Cloud Core, a new distance of 360 pc was found to best fit the X-ray data.

Using the spectral data I will then present an analysis of the dependence of the X-ray emission on the measured stellar properties. The X-ray luminosity is found to depend on the calculated bolometric luminosity as in previous studies of other clusters. The dependence of L_X on stellar surface area and effective temperature is examined, for the YSOs that L_X depends primarily on the stellar surface area. The variation in X-ray luminosity, L_X , with evolutionary class indicates that, for a given stellar surface area, the Class III sources in both clusters are slightly more luminous than the Class II stars.

B47) The DENT Grid – 300 000 Disk Models for GASPS

P. Woitke[1,2], I. Kamp[3], W.-F. Thi[4], I. Tilling[4], C. Pinte[5], F. Ménard[6], G. Duchêne[6], J.-C. Augereau[6], M. R. Hogerheijde[7]

[1] *UK Astronomy Technology Centre, Royal Observatory, Edinburgh, Blackford Hill, EH9 3HJ, UK*
[2] *School of Physics & Astronomy, University of St. Andrews, North Haugh, St. Andrews KY16 9SS, UK*
[3] *Kapteyn Astronomical Institute, Postbus 800, 9700 AV Groningen, The Netherlands*
[4] *Institute for Astronomy, University of Edinburgh, Royal Observatory, Blackford Hill, EH9 3HJ, UK*
[5] *School of Physics, University of Exeter, Stocker Road, Exeter EX4 4QL,UK*
[6] *Laboratoire d'Astrophysique, Université Joseph Fourier, BP 53, 38041 Grenoble cedex 9, France*
[7] *Leiden Observatory, Leiden University, PO Box 9513, 2300 RA Leiden, The Netherlands*

The Herschel open time key programme GASPS will observe far IR gas emission lines of OI, CII, CO and H_2O from about 250 circumstellar disks covering an ages range between slightly less than 10^6 and more than 10^7 years. This systematic survey will provide a new molecular inventory of circumstellar disks, allowing for new constraints about the chemistry, the temperature structure, disk evolution from class II to debris disks, and the disappearance of the gas component.

The observed line fluxes and SED data will be analyzed by the Monte Carlo dust radiative transfer code MCFOST (Pinte et al. 2006) and the newly developed thermo-chemical disk code ProDiMo (Woitke et al. 2009a,b). See Fig. 1 for an exemplary result of ProDiMo for the water concentration in a Herbig Ae disk. In this combined application, we only use ProDiMo's kinetic gas-phase and UV photo-chemistry, ice formation, and detailed non-LTE heating & cooling modules. The level populations are calculated with escape probability treatment as basis of the line transfer calculations.

A grid of ∼320 000 disk models, combining the theoretical power of MCFOST and ProDiMo, has been computed, systematically varying 10 stellar and disk parameters including Misk mass, disk shape parameters and the dust-to-gas ratio. For each model, line transfer calculations are performed for 30 lines under 5 inclinations. Our aim is to simultaneously fit SED (dust) and line flux (gas) observations for a profound analysis of dust and gas properties in circumstellar disks. The model grid, comprising the computed SED and line flux data, will be made available to the scientific community.

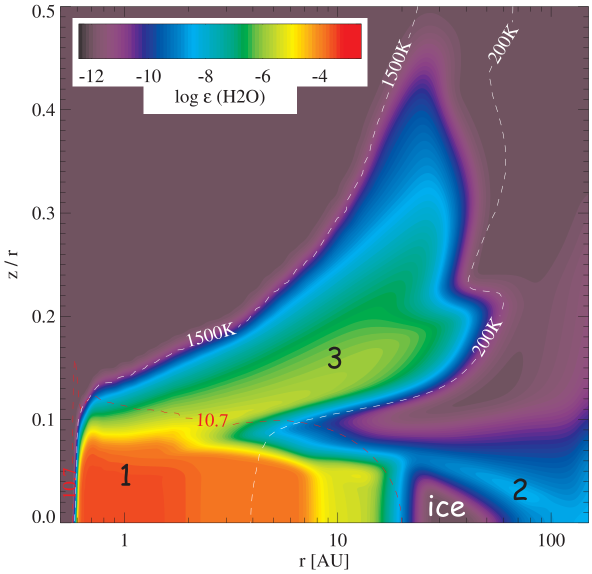


Figure: Concentration of water molecules $\epsilon_{H_2O} = n_{H_2O}/n_{\langle H \rangle}$ as function of radius r and relative height above the midplane z/r for a Herbig Ae disk model. Three different regions with high water concentrations can be distinguished. 1) A big water reservoir behind the inner rim with large H_2O concentrations. 2) A belt of cold water around the icy midplane beyond 20 AU where water has mainly condensed into water ice. 3) A layer of hot water at high altitudes $z/r = 0.1 \ldots 0.3$ where the kinetic gas temperature ranges between $T_{gas} = 200$ K and 1500 K (white contours). The red contour line marks total hydrogen nuclei particle density $n_{\langle H \rangle} = 10^{10.7}$ cm^{-3}.

Woitke P., Kamp I., Thi W.-F., 2009a, A&A 501, 383
Woitke P., Thi W.-F., Kamp I., Hogerheijde M.R., 2009b, A&A 501, L5
Kamp I., Tilling I., Woitke P., Thi W.-F., Hogerheijde M.R., A&A submitted
Pinte C., Ménard F., Duchêne G., Bastien P., 2006, A&A 459, 797

B48) Resolving structure in the HD100546 disk at millimetre and centimetre wavelengths

C.M. Wright[1], S.T. Maddison[2], D. Lommen[3], M.G. Burton[4], D.J. Wilner[5], T.L. Bourke[5]

[1] *School of Physical, Environmental and Mathematical Sciences, UNSW@ADFA, Canberra ACT 2600, Australia*
[2] *Centre for Astrophysics & Supercomputing, Swinburne University, PO Box 218, Hawthorn, VIC 3122, Australia*
[3] *Leiden Observatory, Leiden University, P.O. Box 9513, 2300 RA Leiden, The Netherlands*
[4] *School of Physics, University of New South Wales, Sydney, NSW 2000, Australia*
[5] *Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA*

Several lines of evidence demonstrate the existence of a circumstellar disk around the enigmatic Herbig Be star HD100546. Structure within the disk, such as an inner cavity and spiral pattern, as well as similar mineralogy of the dust grains to those seen in our own solar system, further suggest that the growth to planets may be well underway.

To learn more about the processes occurring in this disk we have conducted a multi-frequency observing program with the Australia Telescope Compact Array (ATCA). At 3, 7 and 16 mm we have resolved the emission region, which probably consists of a compact disk of FWHM $\sim$ 50 AU and an envelope of FWHM $\geq$ 100 AU. Temporal stability over timescales of days, months and years at all wavelengths suggests that the flux is dominated by thermal emission from probably cm-sized dust grains. An extrapolation of the 3.5 and 6.2 cm radio fluxes to 16 mm does however indicate that a minor fraction of the 16 mm flux may arise from free-free emission. When corrected for this the spectral index of the dust emission (integrated over the whole region) is $\alpha \sim 2.3 \pm 0.2$, and thus the dust opacity index $\beta \sim 0.3$. When compared to dust models in the literature this suggests a maximum size of a few tens of centimetre and an index $q \leq 3$ for the power law distribution of grain sizes.

The emission at longer wavelengths of 3.5 and 6.2 cm is dominated by free-free processes, likely a stellar wind which we have resolved to be elongated othogonal to the disk major axis. Along with the IR hydrogen recombination lines detected by ISO–SWS, the data indicate the mass loss rate of the wind is $\sim 10^{-8}$ M$_\odot$ yr^{-1}. Assuming a canonical factor of 10 difference between outflow and accretion rates then the latter is $\sim 10^{-7}$ M$_\odot$ yr^{-1}, in agreement with the rate inferred from IUE data in the literature.

At all millimetre wavelengths the peak emission is centred on or near the HD100546 stellar position. But there is structure to the emission on a spatial scale broadly resembling the spiral pattern seen in scattered light images. At 3 mm we also tentatively resolve an inner disk clearing on the scale of a few tens of AU, also known from published scattered light and mid-IR images.

We also present HCO$^+$ J=1–0 line data which demonstrates the presence of dense molecular gas in the disk. The line profile is double-peaked, with component velocities at $\sim$ 3.5 and 7.0 km s^{-1}. Each component is coincident with the position of HD100546, but with a slight spatial offset approximately along the disk major axis. If interpreted as Keplerian rotation the radius of the emission is $\sim$ 350 AU, with the south-east side approaching and the north-west side receding from Earth.

Overall our results suggest that HD100546 is probably younger than hitherto thought, perhaps less than 5 Myr instead of $\geq$ 10 Myr as generally assumed.

B49) The catalog of circumstellar disks, whose IR spectra can be approximated by Plank's emission law

Zakhozhay O.V.[1], Zkhozhay V.A.[2]

[1] *Main Astronomical Observatory NAS of Ukraine*
[2] *V.N. Karazin Kharkiv National University*

The catalog of approximately 150 stars is compiled, whose energy distribution can be approximate by two Plank's laws of emission. The results are: stars numbers according to catalogs HD, SAO, HR, Gl, Zkh, etc.; equatorial coordinates per epoch 2000.0; spectra; magnitude of a stars in bands U, B, V, R, I, J, H, K; parallaxes; physical parameters of substellar disks that were calculated from their energy spectra (effective temperature, dimensions, mass). For all objects the dependence of energy distribution in spectra from apparent to millimeter wavelengths are represented and also the references on the literature, published during the period from 1984 to 2009 are stated.

B50) Gas tracers in Spitzer IRS spectra of young stars in the Taurus Molecular Cloud.

Carla Baldovin-Saavedra[1], Marc Audard[1], Manuel Güdel[2], Deborah Padgett[3],Kevin Briggs[2], Sergio Fajardo-Acosta[4], Adrian Glauser[3],Luisa Rebull[3], Stephen Skinner[6], Caer Mc Cabe[3], Sebastian Wolf[7]

[1] *ISDC & Observatoire de Genève, University of Geneva, Ch. d'Ecogia 16, 1290, Versoix, Switzerland*
[2] *Institut für Astronomie, ETH Zürich, 8093 Zürich, Switzerland*
[3]*Spitzer Science Center/Caltech, M/S 220-6, 1200 E. California Blvd., Pasadena, CA 91125*
[5] *UK Astronomy Technology Centre, Royal Observatory, Edinburgh EH9 3HJ, UK*
[6] *Center for Astrophysics and Space Astronomy, University of Colorado, Boulder, CO 80309-0389, USA*
[7] *University of Kiel, Institute of Theoretical Physics and Astrophysics, Leibnizstrasse 15, 24098 Kiel, Germany*

Our knowledge of circumstellar disks is based mainly on the study of the dust. However, the main consistuent, gas (99%) remains difficult to trace. Usually, the presence of gas in circumstellar disks is probed by CO and H2 rotational lines at near-infrared, mid-infrared, and mm wavelengths. Theoretical studies suggest that the irradiation of the circumstellar disks from high energy photons can heat up the circumstellar material, ionizing and exciting the gas forming emission lines. In the mid-infrared, we have detected [NeII] (12.81 μm), [NeIII] (15.55 μm), H_2 rotational lines (12.27, 17.04 μm), [FeII] (17.94 μm) and S[III] (18.71 μm). The origin these lines is not yet clear; the absorption of stellar X-rays is an obvious candidate, but alternative models include the ionization by extreme UV photons, strong shocks, or cosmic rays. In the last years several authors have reported detections, specially of the [NeII] line from selected pre-main sequence stars.

In this work, we present a search for gas emission lines in a sample of young stellar objects in the Taurus Molecular Cloud (TMC), one of the best studied star forming regions mainly thanks to its nearby distance (140 pc). Our study is based on archival observations of pre-main sequence stars done by the Spitzer space telescope with the IRS spectrometer. Our sample contains approximately 70 spectra. We have detected [Ne II] in 11 objects of our sample, we further obtained 2 [Ne III] detections, 5 detections of H_2 and [Fe II] detected in 2 cases. We will present our results looking for correlations between the line fluxes and stellar parameters such as L_X, mass accretion rates and stellar masses.