# ABSTRACT BOOKLET

## Planet Formation & Evolution 2014

Kiel University, September 8 - 10, 2014

### Scientific Rationale

The goal of this workshop is to provide a common platform for scientists working in the fields of star and planet formation, exo-planets, astrobiology, and planetary research in general.

Most importantly, this workshop aims to stimulate and intensify the dialogue between researchers using various approaches - observations, theory, and laboratory studies.

Students and Postdocs are particularly encouraged to present their results and to use the opportunity to learn more about the main questions and most recent results in adjacent fields.

www.astrophysik.uni-kiel.de/kiel2014

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# Planet Formation & Evolution 2014

8 - 10 September 2014 – Kiel

# Abstracts

[updated: August 25, 2014]



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## Monday [September 8, 2014]

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| | Kipp | Lutz | Welcome by the President of Kiel University |

| **Session 1** | **Properties and evolution of circumstellar disks** | | |
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| 13:15-13:45 | **Woitke** | **Peter** | **Highlight talk: Gas and dust modelling in protoplanetary disks** |
| 13:45-14:00 | Broekhoven-Fiene | Hannah | Protoplanetary disks in the Auriga-California Molecular Cloud |
| 14:00-14:15 | Berger | Jean-Philippe | Protoplanetary disks at the astronomical unit scale: Results of the PIONIER-VLTI survey |
| 14:15-14:30 | Matter | Alexis | Unveiling the dust dissipation geometry and properties in the inner regions of pre-transitional disks: An interferometric view of the Herbig star HD 139614 |
| 14:30-14:45 | Menu | Jonathan | A mid-infrared interferometric survey of the disks around intermediate-mass young stars |
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| 15:15-15:30 | Keith | Sarah | Non-ideal magnetic flux transport in protoplanetary accretion zones |
| 15:30-16:00 | Coffee break | | |
| 16:00-16:15 | Paardekooper | Sijme-Jan | The stability of warped protoplanetary discs |
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| 16:30-16:45 | Laibe | Guillaume | Dust and gas mixtures with one fluid |
| 16:45-17:00 | Nagahara | Hiroko | Co-evolution of physics and chemistry of the proto-solar disk |
| 17:00-17:15 | van der Wiel | Matthijs | Warm gas in 18 protoplanetary disks: The CO ladder probed from 50 to 500 K |
| 17:15-17:30 | Kama | Mihkel | Gaseous carbon from disks to planets |
| 17:30-17:45 | Gaidos | Eric | Stellar C/O and the Building Blocks of Planets: A Perspective from the Early Solar System |
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**18:00-19:00 Poster session**

## Tuesday [September 9, 2014]

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| 09:00-09:15 | van der Marel | Nienke | Planet formation in action: The role of dust trapping in transitional disks |
| 09:15-09:30 | Drazkowska | Joanna | Pebble pile planetesimals formation |
| 09:30-09:45 | Heller | René | Water ice lines around super-Jovian planets and implications for giant moons |
| 09:45-10:15 | Coffee break | | |
| 10:15-10:45 | **Marleau** | **Gabriel-D.** | **Highlight talk: Planetary population synthesis** |
| 10:45-11:00 | Vorobyov | Eduard | How do wide-orbit planets form? |
| 11:00-11:15 | Scicluna | Peter | Old pre-main-sequence stars and a second chance for planet formation |

| **Session 3** | **Laboratory experiments** | | |
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| 11:45-12:00 | Blum | Jürgen | Comets as test cases for planetesimal-formation scenarios |
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| 13:45-14:00 | Kelling | Thorben | Experiments on Bouncing Barriers in Protoplanetary Disks |
| 14:00-14:15 | Weidling | René | Three-dimensional collision analysis of millimeter-sized dust aggregates |
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| 16:00-16:15 | Pinilla | Paola | Understanding different observed features of transition disks by modelling dust evolution with one or multiple planets interacting with the disk |
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| **Session 5** | **Exo-planets and planetary systems** | | |
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| 17:15-17:30 | Quirrenbach | Andreas | CARMENES |
| 17:30-17:45 | Alexander | Richard | Magnetospheres of hot Jupiters: Hydrodynamic models and UV transit light-curves |
| 17:45-18:00 | Dreizler | Stefan | Planets in post common envelope binaries |

**18:00-19:00 Poster session**

| **Wednesday [September 10, 2014]** | | | |
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| 09:15-09:30 | Löhne | Torsten | Collisional modelling of resolved debris: Warm components in cold discs around solar-type stars |
| 09:30-09:45 | Xu | Siyi | Elemental Compositions of Extrasolar Planetesimals |
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| | | | |
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| 11:30-11:45 | Alibert | Yann | On the radius of habitable planets |
| 11:45-12:15 | **Heng** | **Kevin** | **Highlight talk: Exoplanet Atmospheres: Theory and Simulation** |
| 12:15-12:30 | Grenfell | John Lee | Sensitivity of biosignatures on Earth-like planets orbiting in the habitable zone of cool M-dwarf Stars to varying stellar UV radiation and surface biomass emissions |
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# Oral presentations

## Overview

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## Session 1: Properties and evolution of circumstellar disks

### Highlight talk: Gas and dust modelling in protoplanetary disks

Peter Woitke
*University St. Andrews, United Kingdom*

I will discuss new efforts to consistently model the gas and the dust in protoplanetary disks. Our modelling approach has been developed in the European FP7 project DIANA "Analysis and Modelling of Multi-wavelength Observational Data from Protoplanetary Disks", which involves scientists in St Andrews (P.Woitke, J.Greaves), Amsterdam (R.Waters, C.Dominik, M.Min), Groningen (I.Kamp), Grenoble (F.Menard, C.Pinte, W.-F.Thi) and Vienna (M.Guedel), and combines the modelling software tools MCFOST, MCMax, and ProDiMo. Our ambitious aim is to simultaneously fit continuum and line observations, from near-IR to cm wavelengths, with a single 2D disk model that includes continuum radiative transfer, gas chemistry, non-LTE gas heating & cooling, and line transfer. This way, we want to establish new standards for the exploitation of multi-wavelength observational data for disk analysis.

### Protoplanetary disks in the Auriga-California Molecular Cloud

Hannah Broekhoven-Fiene
*University of Victoria, Canada*

The Auriga-California Molecular Cloud (AMC) is a recently identified (2009) giant molecular cloud. As such, it is relatively unstudied in comparison to other nearby star-forming regions. Although the AMC has a similar mass ($\sim 10^5$ Msolar), size (80 pc) and distance (450 pc) as the Orion A Molecular Cloud (OMC), its quantities and qualities of star formation more so resemble those in low-mass star-forming regions such as Taurus and Ophiuchus. This raises the question of whether similarities also exist between the disk properties and planet formation potential. Such an analysis requires observations targeted at the disk population. We have used Spitzer data to classify young stellar objects and identify candidate protoplanetary disk hosts (the Class II population) within the AMC. We complement these data with those from Herschel (from Harvey et al. 2013) and SCUBA-2 (from the JCMT Gould Belt Survey) to sample the spectral energy distribution at longer wavelengths with greater sensitivity to the total dust mass. We have followed up some of the brightest Class II sources in the Hershel maps with the Jansky VLA observations at 7 mm and 1.3 cm to probe the thermal dust emission, and at 3 cm to constrain the level of free-free contamination at shorter wavelengths. With these data, we will measure the mass in large grains and, where possible, the spectral slope to probe the degree of grain growth. These observations sample disks throughout the AMC: the densest region of star formation around the highly luminous B-star LkHa 101, the intersecting filament, and in relatively quiescent regions of the cloud,allowing us to measure disk properties in a variety of environments. I will summarize our results to date about the disk mass population and highlight the properties of the most interesting disk candidates for planet formation in the AMC relative to similar objects in the Orion,Taurus, and Ophiuchus clouds.

## Protoplanetary disks at the astronomical unit scale: Results of the PIONIER-VLTI survey

Jean-Philippe Berger
*European Southern Observatory, Chile*

I will present the results of a PIONIER-VLTI survey of the $\approx 50$ brightest southern pre-main sequence stars. At the angular resolutions of the VLTI these are probing the astronomical-unit scale near-infrared emission morphology. This unique dataset sheds a new light on the morphology of the disk inner rim and its relation with the central star. I will conclude by advertising the potential of the VLTI in planet formation studies.

## Unveiling the dust dissipation geometry and properties in the inner regions of pre-transitional disks: An interferometric view of the Herbig star HD 139614

Alexis Matter
*Institut de Planetologie et d'Astrophysique de Grenoble, France*

Protoplanetary disks are the main source of information to unveil the initial and boundary conditions for planet formation. Spatially resolving the so-called (pre-)transitional disks is then an essential key to understand the connection between the processes of planetary formation and disk dissipation. The A7 star HD139614 is of particular interest among the group of Herbig stars: its class-Ia 'featureless' SED indicates disk flaring as well as pre-transitional features, namely a noticeable near-IR excess accompanied by a dip around 6 microns, then followed a rising mid-IR part. Whether or not this object is a class-I pre-transitonal disk (Maaskant et al., 2013, A&A 555), and determining the nature of the on-going disk dissipation processes, motivated us to observe the 0.1-10 AU inner region of this disk. We present here the first analyses of near- and mid-IR interferometric data acquired with the VLTI instruments, PIONIER, AMBER, and MIDI, with the aim of constraining the spatial structure and properties of dust in the inner region and assessing whether or not it has a multi-component structure. We completed the VLTI observations by Herschel/PACS photometric measurements in the far-IR that target the outer disk properties. Based on temperature-gradient disk models including dust opacity, a first analysis of the MIDI data revealed a clear deficit in dust opacity and/or density from about 2 to 6 AU. Our modeling of the MIDI data favored a two-component structure composed an optically thin and rather extended inner dust component (  0.2 - 2 AU), a gap, and then an outer massive disk starting at about 6 AU. Notably, the outer disk temperature profile makes plausible a scenario where the inner edge of the outer disk is directly heated by the central star. In a second step, we performed a radiative transfer modeling of our whole set of data using the Monte Carlo code RADMC3D (Dullemond et al., 2004, A&A 417). We confirmed the need for a two-component disk structure to reproduce our data and constrained further the properties of the inner dust component. Notably, our modeling favors a signficant scale height coupled with a positive dust surface density radial profile for this inner component. This suggests an additional inside-out clearing mechanism acting at the same time as a possible dynamical clearing responsible for the creation of the gap farther in the disk. While already proposed for other objects, such a discontinuous disk structure observed for HD139614 can be considered as an additional argument to the idea that class-I HAeBe inner disks could already be in the 'disk-clearing' transient stage.

## A mid-infrared interferometric survey of the disks around intermediate-mass young stars

Jonathan Menu
*Institute of Astronomy, KU Leuven, Belgium*

During the past decade, the MID-infrared Interferometric instrument (VLTI/MIDI) has given us new insights in the geometry and dust composition of the disks around young stars. However, most studies focused on at most a handful of objects, which complicates the interpretation of the results of individual studies in terms of disk statistics. As an example, derived disk geometries might be model-dependent, and directly comparing geometric parameters is therefore not always possible.

The aim of this project is to investigate a statistically relevant sample of intermediate-mass young stars. We collected all archival MIDI data of more than 20 objects and reduced and calibrated the data in an automatized way.

Essentially all observations show that the disks around these objects are resolved. As a first step, we use geometric, parametrized disk models for analyzing the data. The spectrally and spatially resolved observations allow us to constrain both the geometry and composition of the disks. We determine orientations of the disks and analyze the global and local composition of the small dust grains. The model parameters are then compared with the fundamental properties of the central stars (e.g., luminosity, mass, etc.). New insights in the occurrence of gaps and the importance of disk flaring are gained.

## Small vs large dust grains in transitional disks from VLT/NACO and ALMA

Antonio Garufi
*ETH Zurich, Switzerland*

Transitional disks are a key-step of the evolution of circumstellar material, since planet formation is thought to be considerably favored during this stage. In order to better comprehend the mechanisms of planet formation, a deeper view on the interaction of (forming) planet(s) with the disk is needed. Since this interaction is predicted to differentiate the dynamics of small and large dust grains in the disk, comparisons of scattered light near-IR observations with (sub-)mm images can provide pivotal information. We present our final results of a small survey of Herbig disks (mostly transitional) imaged in Polarimetric Differential Imaging (PDI) in H and Ks bands. Images of e.g. HD169142, HD142527, SAO206462, and HD163296 revealed with unprecedented resolution diverse and complex structures such as spirals, rings, cavities, and holes. We also show similarities and differences with ALMA Cycle-0 observations of the same objects and draw some conclusions on how the interplay planet/disk is dictating the different behavior of small and large grains in transitional disks. Upcoming ALMA and VLT/SPHERE observations of these objects will improve the quality of this comparison and cast new light on the effect of forming planets on their cradles.

## Gaps, Rings, and Non-Axisymmetric Structures in the Outer Regions of Turbulent Protoplanetary Disks - From Simulations to ALMA Observations - Part I

Mario Flock
*SAP - CEA, France*

Recent ALMA observations of young stars revealed distinct asymmetries in the dust continuum emission by their embedded disks. In our work we want to study axisymmetric and non-axisymmetric structures, evocated by the magneto-rotational instability in the outer regions of protoplanetary disk. We combine the results of non-ideal global 3D MHD stratified simulations with post-processing radiation transfer to generate synthetic maps and predictions for the Atacama Large Millimeter Array (see talk by J.P. Ruge). In the first part we focus on the results from the global 3D non-ideal MHD stratified disk simulations of the dead-zone outer edge using the FARGO MHD code PLUTO. The stellar and disk parameters are taken from the current best-fit models for the systems HH30, CB26, and Butterfly-Star. The 2D temperature and density profiles are calculated consistently from a given surface density profile and Monte-Carlo radiative transfer. The 2D Ohmic resistivity profile is calculated using the dust chemistry model. All models quickly develop into a turbulent state. The fiducial model develops a large zonal flow at the outer edge of the dead-zone which is sustained. This structure is characterized by a combination of gap followed by a jump in surface density. Inside the jump, which is nearly a ring structure, we observe the generation of vortices by the Rossby-Wave instability. The lifetime of the vortices remain short as they are steadily generated and destroyed at a cycle of ten local orbits which corresponds to a lifetime of over 5000 years at this location. Our models show a new possibility to generate density gaps and enhancements which leads to vortex formation in the outer regions of protoplanetary disks.

## Non-ideal magnetic flux transport in protoplanetary accretion zones

Sarah Keith
*Macquarie University, Australia and JBCA, United Kingdom*

The growth of a giant protoplanet is likely influenced by the presence of a magnetic field. Current models of protoplanetary- and circumplanetary disks rely on magnetically-launched winds or hydromagnetic turbulence to drive inflow. However, whether the disks are able to interact sufficiently with the field for these mechanisms remains a key uncertainty. Non-ideal effect such as ohmic resistivity, the Hall effect and ambipolar diffusion cause a crucial drift between field and gas flow and so play a significant role in both the field and gas dynamics. Increased resolution has allowed recent simulations to probe the complex MHD flow surrounding the planet, but studies have only just begun to consider non-ideal effects.

Here we examine the strength and nature of magnetic coupling with the gas flow surrounding a protoplanet by quantifying non-ideal effects to characterise magnetic flux transport. We focus on two distinct regions in the accretion zone: (i) the gap in the protoplanetary disk evacuated by the protoplanet, and (ii) the circumplanetary accretion disk ringing the protoplanet. We use non-magnetised hydrodynamical simulations and models to examine whether the field is carried along with the accretion flow into the gap and to determine whether the field is strong enough to modify the accretion flow. We model the fluid flow across the gap using the Tanigawa et al. (2012) simulation and the circumplanetary disk by a standard alpha-disk with self-consistent, radially-varying viscosity parameter alpha.

We find that the field easily couples to the accretion flow which draws the field into the gap and towards the protoplanet. Strong Hall effect causes conditionally turbulent regions, suggesting the gap gas dynamics are bimodal according to the relative orientation of the rotation and field axes. The flow easily carries the field into the circumplanetary disk and strong magnetic forces at the disk surface imply that the field must be accounted for in circumplanetary disk evolution models. We find that standard, uniform accretion across the entire circumplanetary disk accretion would be powered by a combination of magnetic forces and self-gravity, and requires that the disk is massive and hot. It is unlikely that these extreme conditions met, indicating that the disk experiences outbursting accretion modes, with implications for both planet and satellite formation.

## The stability of warped protoplanetary discs

Sijme-Jan Paardekooper
*Queen Mary, University of London, United Kingdom*

The discovery of planets with orbits that are misaligned with the stellar spin has sparked renewed interest into the question of whether protoplanetary discs are always aligned with the stellar spin axis. While there are various ways of generating misalignment in the star-disc system, either in the form of a warp or a complete tilt, we focus on the subsequent evolution of the disc. How long can a warp survive in the absence of external forcing? This turns out a remarkably difficult question to answer, and we tackle the problem through numerical simulations of a newly derived local model of a warped accretion discs. We show that warped discs are hydrodynamically unstable for a wide range of parameters, and that the nonlinear, saturated state can promote warp survival. This can be of importance in the formation of misaligned planetary systems.

## Temperature Fluctuations driven by Magnetorotational Instability in Protoplanetary Disks

Colin McNally
*Niels Bohr International Academy, Niels Bohr Institute, Denmark*

The magnetorotational instability (MRI) drives magnetized turbulence in sufficiently ionized regions of protoplanetary disks, leading to mass accretion. The dissipation of the potential energy associated with this accretion is a component of the balance which determines the thermal structure of the disk. This is expected to be most significant in the inner regions, at the midplane inside the inner edge of the dead zone. To model the resulting thermal structure of the disk, it is critical to recognize that magnetized turbulence dissipates its energy intermittently in current sheet structures. I will discuss our recent study of this intermittent energy dissipation using high resolution numerical models including a constant resistivity and radiative thermal diffusion in an optically thick regime. Our models predict that these turbulent current sheets drive order unity temperature variations even where the MRI is damped strongly by

Ohmic resistivity (McNally et al. 2014). I will also discuss the impacts of variable resistivity, including the possibility of the development of 'short-circuit' modified current sheets (Hubbard et al. 2012, McNally et al. 2013). The temperature fluctuations that can be driven by magnetic dissipation have the possibility of being responsible for the remelting of CAIs, melting of chondrules, and thermal processing of other solid components of the disk.

## Dust and gas mixtures with one fluid

Guillaume Laibe
*Saint Andrews University, United Kingdom*

Simulating dust and gas mixtures with a standard two-fluids algorithm leads to unacceptable numerical artefacts in the context of planet formation. I will show how those problems can genuinely be resolved by treating the mixture as a single fluid made of two-phases!

## Co-evolution of physics and chemistry of the proto-solar disk

Hiroko Nagahara
*Dept. Earth Planet. Sci., The Univ. Tokyo, Japan*

In order to get understanding of physics and chemistry of the proto-solar disk, we have developed a numerical model that consists of fluid dynamics and chemical equilibrium calculation in order to reproduce chemical heterogeneity within 1 m.y. at the asteroidal belt. The physics of the disk is based on Ciesla (2010 and 2011), which is described by a radial advection-diffusion equation with the Lagrange method to draw drift and dispersion by turbulence with stochastic diffusion term calculated by the Monte Carlo method and which shows the diffusivity by the viscosity of the disk. The model is able to trace the movement of individual particles through time. The chemical composition of dust particles at the beginning was calculated as a function of temperature and pressure of the disk assuming chemical equilibrium. They were assumed to keep the initial value all through the evolution process. The calculation was carried out for 106 years. We trace the R-T-P (R: heliocentric distance from the porto-Sun, T: temperature, P: pressure) trajectory of individual grains, count the number of grains remained in the disk as a function of R and t (time), and sum the number of particles that keep the initial composition to obtain the chemical composition of the disk as a function of time and space[U+FF0E] Results and Discussions: The grains initially located at the inner regions have chemical composition rich in refractory components and depleted in volatile components, which is fractionated to various degrees depending on the location, on the other hand the grains at the outer regions are not fractionated, that is having the "solar abundance" composition. The dynamic evolution of the disc transports the chemically unfractionated grains from outer to inner regions, whereas diffusion by turbulence transports chemically fractionated grains outward. Because the accretion rate decreases, the total amount of disk mass decreases, and the velocity of inward and outward transports decrease with time, and therefore, the degree of mixing of fractionated and unfractionated materials changes with time and space. Mixing of inward and outward transported grains with different compositions result in the change of disk composition as a function of radial distance and time. The inner region varies continuously with time from highly refractory-rich to the unfractionated compositions, where the degree of the refractory-enrichment and volatile depletion vary independently. The results show that the compositional variation among carbonaceous chondrites was reproduced in the very early stage of the disk evolution, whereas the disk becomes homogeneous with time. If all the planetesimals of chondrite parent bodies were formed in the present asteroid belt, a plausible formation age should be a few $10^4$ years in the current model with the initial disk mass of 0.1 M(sun). The chondrite compositions and their diversity were well reproduced if the disk mass was 0.02 M(sun), but hardly reproduced.

## Warm gas in 18 protoplanetary disks: The CO ladder probed from 50 to 500 K

Matthijs van der Wiel
*NBI and StarPlan, University of Copenhagen, Denmark*

Disks around Herbig Ae/Be stars are more massive and experience more UV irradiation than their T Tauri counterparts. This contribution will present results from spectroscopic far-infrared/submillimeter observations of a sample of 12 Herbig disks and 6 T Tauri disks.

The Herschel SPIRE spectrometer, for the first time, allows us to comprehensively probe the full 200-700 micron wavelength range. I will present new detections of ten carbon monoxide (CO) lines in the energy range 50-500 K in 6 of the 18 targets. For two objects in our sample, observed CO ladders are compared with existing, published physical-chemical models. Results suggest that, in order to explain the optically thick 12CO ladder, the modeled gas heating balance in surface layers may need to be adjusted, for example by changing flaring geometry or PAH abundance. In addition – importantly – the published disk model of the Herbig object HD100546 fails to explain observed line intensities of the more optically thin lines of the 13CO isotopologue. Efforts are ongoing to treat 13CO in detail in numerical models, including effects of isotope selective photodissociation and chemical isotope fractionation.

## Gaseous carbon from disks to planets

Mihkel Kama
*Leiden Observatory, Netherlands*

There is a considerable range of variation in carbon abundance in the solid and gaseous components of planets in the Solar System and possibly around other stars. Such differences in the gas and solid abundances of elements originate in the protoplanetary disk stage. Do observations of disks show evidence for carbon depletion or enrichment in the gas, which is the raw material of giant planet atmospheres? I will present the results of an ongoing APEX survey of key carbon reservoirs, atomic carbon and carbon monoxide, in several dozen protoplanetary disks. The data are interpreted with the help of physical-chemical disk models. Finally, I will discuss the implications for our understanding of planetary atmospheres.

## Stellar C/O and the Building Blocks of Planets: A Perspective from the Early Solar System

Eric Gaidos
*University of Hawaii at Manoa, USA*

Patterns of bulk rocky planet composition in the Solar System and their relation to elemental abundances in the Sun motivate predictions of planet composition in other planetary systems based on stellar abundance measurements. Measurements of carbon (C) and oxygen (O) in other solar-type stars stimulated the titillating prospect that C/O varies widely from the Solar value of about 0.5, and that C/O approaching or exceeding unity is possible. Under interstellar and molecular cloud conditions, carbon and oxygen form CO, a very stable and incondensible molecule, in a reaction that is effectively a sink for both elements in a 1:1 ratio. Thus whether C or O is in excess determines whether the remainder of the material is oxidizing ($C/O < 1$) or considerably reducing ($C/O > 1$). The classical condensation sequences from a gas with these two compositions are very different with water and silicates forming in the former, and organics, graphite, and carbides in the latter. This has led to numerous predictions that the 'carbon', 'diamond', or 'carbide' planets around stars with C/O approaching or >1. Subsequent analysis using high-resolution, high-signal-to-noise spectra of star has shown claims of C/O   1 to be largely erroneous, in part due to confusion with other, unrelated lines in the spectra of these stars. Moreover, the scenario of direct condensation from a hot gas of solar composition is *not* the manner in which most of the solids in the early Solar System formed, and presumably in other planetary systems. While some high-temperature condensates (e.g. CAIs) are present in meteorites, they comprise a small total fraction of solids. Isotopic anomalies and pre-solar grains show that much of solids is altered dust from the molecular cloud where oxidation states are set by different conditions and for which galactic chemical evolution data suggest $C/O < 1$. Moreover, the equilibrium oxygen fugacities of minerals in meteorites and high dust/gas ratios suggested by the abundance of volatiles, i.e. sodium and sulfur, is best understood if thermal processing took place in the very dust-rich mid-plane of the disk, not in a gas of solar composition. There are examples of more reduced building blocks, i.e. enstatite chondrites, but these still reflect an oxidation state well above that predicted for a gas of C/O   1 and may instead represent the effect of high sulfur concentration at some localized place and time in the early Solar System.

## Snowlines and C/O ratio of the planet forming regions around HAe stars

Olja Panic
*University Cambridge, United Kingdom*

The key elemental abundances of exoplanet atmospheres carry an imprint of the com- position of the protoplanetary disc gas they accreted during their formation deep in the disc midplane. The C/O ratio is strongly temperature dependent and the highest C/O ratio planets will form in the 20-40 K region of the disc midplane, between the snowlines of CO and CO 2. Because of this temperature dependence, any observations constraining C abundance or theorethical models relying on C abundance must use physically consistent temperature structures. Recently it has become possible to directly image the location of the CO snowline. The aim of this paper is to understand how disc midplane temperature and snowline locations change with the evolving gas to dust mass ratio, grain growth and other processes, and show how the existing and future observations of CO snowlines can be used as markers of disc evolutionary stage, their temperature structure and properties of the planets they may be forming. We use a 2D radiative transfer code to calculate self-consistent disc structures from a grid of models and find that the CO snowline location depends strongly on the vertical thickness of the disc. This location ranges from few tens to 200 AU in a disc around an A type star, depending on the degree of dust growth and settling. We also show how these disc properties may be discerned in the spectral energy distribution modelling thereby effectively constraining disc structure when used in combination with the CO snowline imaging.

# Tuesday [September 9, 2014]

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|---|---|---|
| **Meru** | **Farzana** | **Highlight talk: Bridging the gap between the core accretion and gravitational instability planet formation theories** |
| van der Marel | Nienke | Planet formation in action: The role of dust trapping in transitional disks |
| Drazkowska | Joanna | Pebble pile planetesimals formation |
| Heller | René | Water ice lines around super-Jovian planets and implications for giant moons |
| **Marleau** | **Gabriel-Dominique** | **Highlight talk: Planetary population synthesis** |
| Vorobyov | Eduard | How do wide-orbit planets form? |
| Scicluna | Peter | Old pre-main-sequence stars and a second chance for planet formation |
| **Teiser** | **Jens** | **Highlight talk: Laboratory experiments: Grain growth & the role of ices** |
| Blum | Jürgen | Comets as test cases for planetesimal-formation scenarios |
| Bukhari | Mohtashim | Transition between growth and fragmentation in dust-agglomerate collisions |
| Kelling | Thorben | Experiments on Bouncing Barriers in Protoplanetary Disks |
| Weidling | René | Three-dimensional collision analysis of millimeter-sized dust aggregates |
| Wurm | Gerhard | Contact Mechanics of Pre-Planetary Ice Grains |
| **Klahr** | **Hubert** | **Highlight talk: Planet-Disk interaction** |
| Ruge | Jan Philipp | Detecting young (giant) planets in circumstellar disks |
| Gonzalez | Jean-François | Particules traps at planet gap edges in disks: Effects of grain growth and fragmentation |
| Pinilla | Paola | Understanding different observed features of transition disks by modelling dust evolution with one or multiple planets interacting with the disk |
| Haghighipour | Nader | Formation and Dynamical Evolution of Circumbinary Planets: Reconciling Theory with Observation |
| **Rauer** | **Heike** | **Highlight talk: PLATO 2.0** |
| Raetz | Stefanie | Observation and analysis of the youngest transiting planet candidate |
| Quirrenbach | Andreas | CARMENES |
| Alexander | Richard | Magnetospheres of hot Jupiters: Hydrodynamic models and UV transit light-curves |
| Dreizler | Stefan | Planets in post common envelope binaries |

## Session 2: Planet formation and planet population-synthesis studies

### Highlight talk: Bridging the gap between the core accretion and gravitational instability planet formation theories

Farzana Meru
*ETH Zurich, Switzerland*

The theory of giant planet formation has developed in recent years from both the core accretion and the gravitational instability perspectives. In this talk I will discuss both theories. From the core accretion perspective, I will highlight recent numerical results on how the growth and fragmentation of dust particles depends on the aggregate mass ratio and porosity. I will also highlight a recent physically-motivated development in coagulation and fragmentation modelling that allows growth to occur to sizes that are orders of magnitude larger than obtained previously. Using this model we show that that earliest stages of planet formation by core accretion can occur in brown dwarf discs just as they do in T Tauri discs, as suggested by observations. From the gravitational instability perspective, I will discuss the advances made that show that planet formation by gravitational instability can occur at smaller radii than expected, and thus may be easier than previously thought. I will also discuss recent developments that show that the formation of a fragment in the outer disc, and resulting dynamical disc behaviour, can potentially trigger the formation of a second fragment at smaller radii.

Currently, the core accretion and gravitational instability mechanisms describe the formation of close-in and far-out planets, respectively. However, no single mechanism describes the in situ formation in the intermediate region. These recent developments may help to bridge the formation gap between these two mechanisms. Finally, once planets form they will interact with their parent disc. It is also quite likely that multiple planets will form in the same disc. The interactions between multiple planets and their parent disc are much more dynamic and complex than those between a single planet and the disc. I will briefly discuss the properties of a disc when multiple planets are interacting with it and discuss the implications for dust concentration and evolution.

## Planet formation in action: The role of dust trapping in transitional disks

Nienke van der Marel
*Leiden Observatory, Netherlands*

Planet formation by dust coagulation in protoplanetary disks is one of the long standing problems in disk evolution theory. Dust grains must grow from submicron sizes to  10 MEarth rocky cores within the  10 Myr lifetime of the circumstellar disk. However, this growth process is hindered by collisional fragmentation and rapid inward radial drift. A possible solution in dust evolution theory is dust trapping in local pressure maxima in the disk, where dust particles pile up and grow. Transitional disks with large inner dust cavities have been suggested to contain these dust traps. I present the first results of our ALMA Cycle 0 program using Band 9, imaging the Herbig Ae star Oph IRS 48 in CO(6-5), C17O(6-5) and the submillimeter continuum in the extended configuration. The resulting 0.2” spatial resolution completely resolves the cavity of this disk in the gas and the dust. Using our physical-chemical modeling tools we find that the gas distribution is consistent with a full Keplerian gas disk. However, the gas surface density contains two radial density drops, at 20 and 60 AU. These density drops directly imply the presence of companions in the disk, as they lower the gas surface density along their orbit. Similar to the gas, the micrometer-sized dust grains follow a large ring-like structure. On the other hand, the ALMA continuum emission, tracing the millimeter-sized dust, reveals an unexpected huge asymmetry at 60 AU radius and steep edges in the dust distribution along the ring. The combination of the gas and dust distribution indicates that the dust trapping mechanism is at work in this disk: at the edge of the outer density drop is a pressure bump, which traps the millimeter dust. Also other transitional disks observed in ALMA Cycle 0 show hints of dust trapping. I will present the most recent analysis of these dust traps and discuss the implications.

## Pebble pile planetesimals formation

Joanna Drazkowska
*Heidelberg University, Germany*

Dust growth in protoplanetary disks suffers from growth and drift barriers that limit the maximum size of dust aggregates and restrict the possibilities of forming planetesimals via direct coagulation. The streaming instability was proposed as an efficient way of overcoming the barriers and forming large bodies. The most interesting property of the streaming instability is the possibility of forming dense dust clumps that become gravitationally unstable and collapse directly to planetesimals or even embryos. However, the strong clumping requires relatively abundant large grains population. We investigate if such large grains can form in sufficient amount during the dust coagulation by implementing a relatively easy 'pebble pile planetesimals formation' prescription obtained from direct numerical simulations into our dust coagulation code. We check how many planetesimals can form under different conditions and what are the timescales involved. We also report how does the formation of the pebble pile planetesimals change the subsequent dust evolution and what are possible consequences of our results for the planet formation theory.

## Water ice lines around super-Jovian planets and implications for giant moons

René Heller
*McMaster University, Hamilton (ON), Canada*

The moon systems around the giant planets in the solar system provide insights into planet formation that are inaccessible by observations of the planets alone. The total satellite masses of Jupiter, Saturn, Uranus, and Neptune scale as 1/10,000 the planetary mass, respectively. While Neptune is a special case (its principal moon Triton has most likely been captured), the other satellite systems constrain the conditions in the circumplanetary disks during the planets' early accretion histories. We simulated the evolution of water ice lines around accreting super-Jovian planets at several AU from a Sun-like star and find that the mass scaling law for the solar system holds for moons around super-Jovian exoplanets. This suggests a population of water-rich moons with masses similar to Mars around the most massive planets. Due to their relatively low densities, moons larger than the smallest known exoplanet can form beyond 10 – 30 Jupiter radii around super-Jovian planets. Heat transitions, supposed to act as planet traps in circumstellar disks, are not effective as moon traps around giant planets and thereby indicate a fundamental difference between the formation of terrestrial planets and icy/terrestrial moons.

## Highlight talk: Planetary population synthesis

Gabriel-Dominique Marleau
*Max Planck Institute for Astronomy, Germany*

The large, rapidly growing amount of observational data on extrasolar planets and its diversity are making it possible to look into various statistical distributions of exoplanet properties. But going beyond bare demographics, one can translate this wealth of observational constraints into tests of planet formation scenarios with the powerful tool of planetary population synthesis. In this method, a general formation model which combines simplified descriptions of the relevant physical processes (disc evolution, orbital migration, planetary structure, etc.) is applied to an observationally-deduced distributions of input parameters (disc mass, metallicity, lifetime, etc.) to make falsifiable predictions for observable planetary properties and their correlations. Comparisons with observations can then help assess the accuracy of the descriptions or motivate developments on the theoretical side.

In this talk, after a brief review of the physical processes included in planetary population synthesis models, we discuss some predictions of the core accretion formation paradigm along with their observational constraints. We focus not only on the planets' mass and semi-major axis but also on their bulk composition and intrinsic luminosity, which lets us highlight, as examples, the effects of the accretion rate and of the accretion shock efficiency in the runaway phase.

## How do wide-orbit planets form?

Eduard Vorobyov
*University of Vienna, Austria*

Giant planets on orbital distances from tens to hundreds AU represent a rather small but ever growing class of exoplanets. The properties of wide-orbit objects and their host stars vary

significantly, making it difficult to explain their origin in the framework of a single formation mechanism. I will critically review the gravitational instability scenario for the formation of wide-orbit objects and demonstrate that disk fragmentation alone is unlikely to explain the whole observed spectrum of these objects. Other formation mechanisms, such a dynamical scattering or pebble accretion, need to be invoked to account for companions at orbital distances smaller than 150 AU and companions with the mass of the host stars $< 0.7$ Msun.

## Old pre-main-sequence stars and a second chance for planet formation

Peter Scicluna
*ITAP, Kiel University, Germany*

Young stars show evidence of accretion discs which evolve quickly and disperse with an e-folding time of $\sim$ 3Myr. This is in striking contrast with recent observations that suggest evidence for numerous $>$ 30 Myr old stars with an accretion disc in large star-forming complexes. We consider whether these observations of apparently old accretors could be explained by invoking Bondi-Hoyle accretion to rebuild a new disc around these stars during passage through a clumpy molecular cloud. We combine a simple Monte Carlo model to explore the capture of mass by such systems with a viscous evolution model to infer the levels of accretion that would be observed. We find that a significant fraction of stars may capture enough material via the Bondi-Hoyle mechanism to rebuild a disc of mass $\gtrsim 1$ minimum-mass solar nebula, and $\lesssim 10\%$ accrete at observable levels at any given time. A significant fraction of the observed old accretors may be explained with our proposed mechanism. Such accretion may provide a chance for a second epoch of planet formation, and have unpredictable consequences for planetary evolution.

### Highlight talk: Laboratory experiments: Grain growth & the role of ices

Jens Teiser
*Universität Duisburg-Essen, Germany*

Planet formation starts with coagulation, the formation of macroscopic agglomerates from small grains. While it is out of question that coagulation is an important process at the beginning of planet formation, its role for the whole process of planet formation is still a matter of debate. Various experimental and theoretical studies have investigated collisions between dust agglomerates in a wide size- and velocity range. These studies showed that the growth of planetesimals is not a straight forward process by hit-and-stick collisions, but a more complicated process consisting of direct hit-and-stick, bouncing, partial mass transfer and complete destruction of dust agglomerates. Different critical thresholds have been defined, which mark critical phases in the growth of agglomerates in protoplanetery disks. The first threshold is the so-called bouncing barrier, which is expected to be in the millimeter size range and marks a regime where the growth rate is damped by the dominance of bouncing collisions. The second threshold is the radial-drift barrier, based on the short lifetimes of large agglomerates due to their fast radial drift. The exact parameters for these thresholds strongly depend on the mechanical properties of the agglomerates, especially the cohesion forces between the grains and the porosity. These properties change completely, if silicates are replaced by ice (water, CO, CO2) particles.

The majority of experimental studies have been carried out with dust agglomerates of mostly silicates as e.g. amorphous SiO2 or quartz in the micrometer size range. Although ices are the major component in the solid material of protoplanetary disks, only few experiments have been carried out so far due to technical reasons. However, coagulation of icy grains is now in the focus of the community and work on coagulation of ice particles has become a very active field of research. Within my talk I will give a short overview over recent (mainly experimental) studies on coagulation. The focus will be on recent work on collision experiments with ice particles.

### A possible test for planetesimal-formation models

Jürgen Blum
*TU Braunschweig, Germany*

There has been vast progress in our understanding of planetesimal formation over the past decades, owing to a number of laboratory experiments as well as to refined models of dust and ice agglomeration in protoplanetary disks. Coagulation rapidly forms cm-sized 'pebbles' by direct sticking in collisions at low velocities. For the further growth, two model approaches are currently being discussed: (1) Local concentration of pebbles in nebular instabilities until gravitational instability occurs. (2) A competition between fragmentation and mass transfer in collisions among the dusty bodies, in which a few 'lucky winners' make it to planetesimal sizes. Predictions of the physical properties of the resulting bodies in both models allow a distinction of the two formation scenarios of planetesimals. In particular, the tensile strength (i.e, the inner cohesion) of the planetesimals differ widely between the two models. While model (1) predicts tensile strengths on the order of 1 Pa, model (2) results in rather compactified dusty bodies with tensile strengths in the kPa regime.

If comets are km-sized survivors of the planetesimal-formation era, they should in principle hold the secret of their formation process. Water ice is the prime volatile responsible for the activity of comets. Thermophysical models of the heat and mass transport close to the comet-nucleus surface predict water-ice sublimation temperatures that relate to maximum sublimation pressures well below the kPa regime predicted for formation scenario (2). Model (1), however, is in agreement with the observed dust and gas activity of comets. Thus, a formation scenario for cometesimals involving gravitational instability is favored.

## Transition between growth and fragmentation in dust-agglomerate collisions

Mohtashim Bukhari
*IGEP, Germany*

Whether planetesimals are formed by the so called process of sweep-up or by the mechanism of gravitational collapse,dust aggregates of cm to dm size colliding within the velocity range of 1-10 m/s play a crucial role in the evolution from dust to planetesimals.

In order to study this parameter range, we so far performed laboratory experiments in which dust aggregates of different size ratios were collided. The (larger) target dust aggregate size was kept constant at 5 cm, whereas the (smaller) projectile aggregates were varied between 1 cm and 5 cm. In the collisions, mass loss and mass gain of projectile and target were measured as a function of impact velocity and impact parameter. All experiments were conducted under micro-gravity condition in our newly built 1,5 m tall drop tower, equipped with two high-speed cameras.

We observe a transition between mass gain and mass loss of the target aggregate such that mass gain is present for large mass ratios of target and projectile and/or lower impact velocities, whereas mass loss (fragmentation) of the target aggregate occurs for relatively similar masses of target and projectile and/or high impact speeds.

## Experiments on Bouncing Barriers in Protoplanetary Disks

Thorben Kelling
*Faculty of Physics, University Duisburg-Essen, Germany*

Planet formation in protoplanetary disks begins with dust particles which sequentially grow in collisions from fluffy aggregates towards mm to cm in size. In further collision theses aggregates are compacted to higher filling factors up to 0.36. After this compaction an evolutionary phase is proposed where collisional interactions of the compacted mm aggregates are predominantly bouncing events. This so called ‘bouncing barrier’ would on one side stall growth. One the other side some larger particles (‘lucky winner’) might benefit from the barrier as they can sweep up the smaller aggregates. We carried out laboratory experiments to explicitly probe the bouncing barrier with an ensemble of about 100 equal compacted SiO2 aggregates of 1 mm in size colliding with each other at mm/s to cm/s continuously over 900 seconds. Nearly 2000 collisions were analyzed in detail and about 200.000 occurred in total. The data analysis showed no stable net growth. Temporarily, aggregates of the aggregates formed in sticking collisions (about 7% in the not excited case and about 24% in the excited case). But all these grown aggregates are separated again in further interactions. Even after 900 seconds and about 200.000 collisions in total – these are about 1000 collision per aggregate – no net growth was observed. The mean aggregate number stays constant which strongly supports the concept of the bouncing barrier (which might be better called a detachment barrier in our case).

## Three-dimensional collision analysis of millimeter-sized dust aggregates

René Weidling

*Institut für Geophysik und extraterrestrische Physik, Germany*

The first steps of planet formation require the growth of about $\mu$m-sized dust grains into km-sized planetesimals (Johansen et al., 2014). Extensive laboratory (see e.g. Blum and Wurm, 2008, and Güttler et al., 2010) and numerical work have shown that this process does not happen straightforward, but has to overcome several obstacles like the bouncing barrier. Zsom et al. (2010) showed that once the dust aggregates reach sizes of about one millimeter, they will collide with velocities that lead to bouncing and growth will stop. However, the exact velocities and masses at which bouncing will start to occur as well as whether a transition zone where both sticking and bouncing can occur exists, can greatly influence the final size of the dust aggregates. Therefore, it is necessary to investigate this part of the parameter space well enough to pin down the values.

Typical collision velocities of mm-sized particles in protoplanetary disks are on the order of millimeters per second. In order to achieve these velocities experimentally, we constructed a microgravity setup in which an ensemble of particles is slowed down over time by mutual inelastic collisions (Weidling et al., 2012). Like most of the experiments probing the transition from sticking to bouncing (see e.g. Kothe et al., 2013) the analysis of the collisions was based on two-dimensional projections of the collisions.

With our improved setup which features a prism enabling us to simultaneously capture two views of the experiment separated by an angle of 30°, we are able to obtain the full three-dimensional information of the collisions. We will present the results of the analysis and compare them with the values obtained from the two-dimensional projections. The comparison will show in which cases a faster two-dimensional analysis is sufficient and for which parameters the three-dimensional analysis is mandatory.

## Contact Mechanics of Pre-Planetary Ice Grains

Gerhard Wurm

*University Duisburg-Essen, Germany*

The forces and torques acting on small grains are fundamental for the first phases of particle aggregation. We developed the new technique of a “thermal gradient force microscope” to measure contact forces on sub-micron ice grain. First results indicate that grains are a factor 10 more resistive to twisting torques on the nm-scale than predicted. This implies that ice aggregates might grow very porous to large size.

## Session 4: Planet-disk interaction

### Highlight talk: Planet-Disk interaction

Hubert Klahr
*Max-Planck-Institut für Astronomie, Germany*

We review the current understanding of the interaction between Planets and Gas Disks they are forming in. Migration rates are not only a function of the planet and disk mass but also of the disks radial stratification and the thermal relaxation rates. Also the turbulent state and the source of turbulence, e.g. magnetic or non-magnetic seem to play a role. Gas accretion onto the planet and the phenomenon of gap-opening is also a function of the gas properties including the opacity provided by the imbedded dust grains. We conclude by linking the dynamical simulations to simulated observations and the question of observability of planets in disks.

### Detecting young (giant) planets in circumstellar disks

Jan Philipp Ruge
*ITAP, Kiel University, Germany*

The interaction of protoplanets with the circumstellar disk is supposed to result in characteristic structures, such as gaps and spiral density waves (see, e.g., talk by H. Klahr). We investigate the conditions under which these gaps can be traced in scattered light and thermal dust re-emission and thus provide indirect hints for the existence of the embedded planet (see, e.g., poster by A. Lobo Gomes). However, there are further mechanism, e.g. MRI turbulence and zonal flows (see the talk by M. Flock), that are able to perturb the disk in a similar way. In particular, we investigate the observability of gaps induced by planets and zonal flows in different star-disk-planet configurations by combining 3D (M)HD simulations with follow-up Monte-Carlo radiative transfer. Within our parameter space we consider disk sizes of $9\,\mathrm{AU} < \mathrm{R}_{\mathrm{out}} < 225\,\mathrm{AU}$ and masses of $M = 10^{-6\cdots-2}\,\mathrm{M}_{\odot}$, two typical protostars, and additional perturbations by viscous processes. We predict that ALMA will allow one to observe gaps for a large fraction of the considered star-disk-planet configurations. In contrast to this, the detectability of gaps in the scattered light at shorter wavelengths is possible only below an upper disk mass limit of about $10^{-4}\,\mathrm{M}_{\odot}$. However, based on these (simulated) observations alone it would not be possible to distinguish between the origin of gaps. For this reason, we also explore the feasibility to detect direct signals of young sub-stellar components in circumstellar disks. We find that young giant planets as well as young planets in the Earth mass regime bear the potential to be traced.

### 'Particules traps at planet gap edges in disks: Effects of grain growth and fragmentation

Jean-François Gonzalez
*Centre de Recherche Astrophysique de Lyon, France*

We model dust evolution in protoplanetary disks with 3D, SPH, two-phase (gas+dust) hydrodynamical simulations. The gas+dust dynamics, where aerodynamic drag leads to the vertical settling and radial migration of grains, is consistently treated. In a previous work, we characterized the spatial distribution of non-growing dust grains of different sizes in a disk containing a gap-opening planet and investigated the gap's detectability with ALMA. Here, we take into account the effects of grain growth and fragmentation and study their impact on the distribution of solids in the disk. We show that the ability of 'particle traps' at the gap edges to favor grain growth is strongly affected by fragmentation. We discuss the consequences on observations with ALMA and NOEMA.

## Understanding different observed features of transition disks by modelling dust evolution with one or multiple planets interacting with the disk

Paola Pinilla
*Leiden Observatory, Netherlands*

Transition disks are excellent candidates to investigate gas and dust evolution in protoplanetary disks and they may reveal an intermediate step of the ongoing disk dispersal process. One of the most exciting ideas to explain the observed properties of these objects is that a massive planet or multiple planets are interacting with the disk. In this talk, I will present some recent insights of dust evolution in transition disks and the comparison with observations. As an illustration, I will focus on the transition disk SR21, an object with mysterious structures imaged at different wavelengths.

## Formation and Dynamical Evolution of Circumbinary Planets: Reconciling Theory with Observation

Nader Haghighipour
*Institute for Astronomy, University of Hawaii, USA*

A survey of the currently known circumbinary planets (CBPs) points to several interesting characteristics of these objects. The detection of multiple transits in these systems points to the (almost) co-planarity of the planet-binary orbits, giving strong support to the idea that these planets formed in circumbinary protoplanetary disks. The proximity of some of these planets to the boundary of orbital instability around the binary suggests an evolutionary scenario in which planets form at large distances and either migrate to their present orbits or are scattered to their current locations. Surprisingly, all currently known CBPs are Neptune-sized or smaller, and no CBP seems to exist around very short-period binaries. These specific characteristics of circumbinary planets have raised many questions on the formation, dynamical evolution, and orbital architecture of these objects. To address these complexities, we have simulated the last stage of planet formation in circumbinary disks, and carried out extensive analysis of the dynamical evolution of the final bodies. Results of our simulations indicate that planet formation in circumbinary disks is robust and follows the same process as around single stars. As planets grow, because of their interaction with the disk, they migrate inward and settle near the inner edge of the circumbinary disk (the stability limit), in good agreement with the results of the observations. Our hydrodynamical simulations indicate that the efficiency of this process is strongly tied to the properties of the disk. Unlike around single stars, circumbinary disks are affected by the perturbation of the binary and carry specific structures such as islands of instabilities corresponding to n:1 mean-motion resonances. The results of our simulations also show that these structures have profound effects on the formation and dynamics of CBPs, and constrain their growth and final masses. We will explain how the perturbing effects of these structures combined with the migration of planets in circumbinary disk can be used to explain the possible lack of planets around very short-period binaries. We present the current state of the observation of CBPs, discuss their properties, and also discuss the implications of the results of our computational simulations for explaining the characteristics of these objects.

## Session 5 Exo-planets and planetary systems

### Highlight talk: PLATO 2.0

Heike Rauer
*Institut für Planetenforschung, DLR, Germany*

PLATO has recently been selected for ESA's M3 launch opportunity. PLATO will revolutionize our understanding of extra-solar planets through its discovery and bulk characterization of planets around hundreds of thousands of stars. With launch foreseen in early 2024, PLATO will follow the very successful space missions CoRoT and Kepler, as well as ESA's first small mission CHEOPS and NASA's mission TESS. PLATO will carry out high-precision, long-term photometric and astroseismic monitoring of up to a million of stars covering over 50% of the sky, and provide orders of magnitudes more small planets around bright stars than the previous missions. Its exquisite sensitivity will ensure that it detects hundreds of small planets at intermediate distances, up to the habitable zone around solar-like stars. PLATO will characterize planets for their radius, mass, and age. It will provide the first large-scale catalogue of well-characterized small planets at intermediate orbital periods, relevant for a meaningful comparison to planet formation theories and providing targets for future atmosphere spectroscopy. This data base of bulk characterized small planets will provide a solid basis to put the Solar System into a wider context and allow for comparative exo-planetology. Furthermore, its precise lightcurves will allow us to search for e.g. exomoons, exo-rings, and binary planets. In addition, the precise stellar parameters obtained by asteroseismic studies will open new doors to better understand stellar interiors and allow us to constrain poorly-understood physical processes, like convection, improve our understanding of stellar evolution, and determine precise ages of stars and planetary systems. The talk will provide an overview of the PLATO mission and its science goals.

### Observation and analysis of the youngest transiting planet candidate

Stefanie Raetz
*ESA, ESTEC, SRE-S, Noordwijk, Netherlands*

So far only little is known about exoplanets during the first few million years of their lives. The detailed analysis of a young transiting planet would provide important constraints on planet formation and migration time-scales and their relation to protoplanetary disc lifetimes. Therefore we started a project to monitor young stellar clusters (age $<$ 100 Myr) in order to find young transiting planets (called YETI for Young Exoplanet Transit Initiative, Neuhäuser et al. (2011)). One target of YETI is the young open cluster 25 Ori (7-10 Myrs, 323 pc, Briceno et al. 2007) in the nearby Orion OB1 association. As a result of our search for transiting planets in 25 Ori we confirm the finding of a first candidate also reported by van Eyken at al. (2012) The candidate is a possible young transiting planet orbiting a previously known weak-lined T-Tauri star. If confirmed as transiting planet it would be the youngest planet ever detected. The light curve of the young star CVSO 30 is dominated by stellar variability as expected for a PMS object. The amplitude of light variation for the R=15.2 mag star is 0.17 mag (min to max excluding occasional flares). A interesting feature of the transit light curve of CVSO 30 was first mentioned by van Eyken et al. (2012) and is confirmed by us. It can clearly be seen that there is an overall change in the transit shape between different observing seasons. Barnes et al. (2013) showed that the unusual transit light curve shapes of CVSO 30 and their variation can be explained by a precessing planet transiting a gravity-darkened star. I will report about the observations with the YETI network and compare our results with the previous published hypotheses.

# CARMENES

Andreas Quirrenbach
*Landessternwarte Heidelberg, Germany*

CARMENES (Calar Alto high-Resolution search for M dwarfs with Exo-earths with Near-infrared and optical Echelle Spectrographs) is a next-generation instrument under construction for the 3.5m telescope at the Calar Alto Observatory by a consortium of eleven Spanish and German institutions. The scientific goal of the project is conducting a 600-night exoplanet survey targeting 300 M dwarfs with the completed instrument.

The CARMENES instrument consists of two separate échelle spectrographs covering the wavelength range from 0.55 to 1.7 $\mu$m at a spectral resolution of R = 82,000, fed by fibers from the Cassegrain focus of the telescope. The spectrographs are housed in vacuum tanks providing the temperature-stabilized environments necessary to enable a 1m/s radial velocity precision employing a simultaneous calibration with an emission-line lamp or with a Fabry-Pérot etalon. For mid-M to late-M spectral types, the wavelength range around 1000 nm (Y band) is the most important wavelength region for radial velocity work. Therefore, the efficiency of CARMENES will be optimized in this range. The visible-light spectrograph is equipped with a 4k x 4k pixel CCD for the range 550-1050 nm, the NIR one with two 2k x 2k pixel HgCdTe detectors for the range from 0.9-1.7 $\mu$m. Each spectrograph will be coupled to the 3.5m telescope with its own optical fiber. The front end contains a dichroic beam splitter and an atmospheric dispersion corrector. Guiding is performed with a separate camera; on-axis as well as off-axis guiding modes are implemented. Fibers with octagonal cross-section are employed to ensure good stability of the output in the presence of residual guiding errors. The fibers are continually actuated to reduce modal noise. Additional fibers are available for simultaneous injection of light from emission line lamps or alternatively from a stabilized etalon for RV calibration. The spectrographs are mounted on benches inside vacuum tanks located in the coudé laboratory of the 3.5m dome. Each vacuum tank is equipped with a temperature stabilization system capable of keeping the temperature constant to within $\pm 0.01°$C over 24h. The visible-light spectrograph will be operated near room temperature, the NIR spectrograph will be cooled to 140K. The CARMENES instrument passed its final design review in February 2013. The MAIV phase is currently ongoing. First tests at the telescope are scheduled for mid-2014. Completion of the full instrument is planned for 2015. At least 600 useable nights have been allocated at the Calar Alto 3.5m Telescope for the CARMENES survey in the time frame from 2014 to 2018. A data base of M stars (dubbed CARMENCITA) has been compiled from which the CARMENES sample can be selected. CARMENCITA contains information on all relevant properties of the potential targets. Dedicated imaging, photometric, and spectroscopic observations are underway to provide crucial data on these stars that is not available in the literature.

## Magnetospheres of hot Jupiters: Hydrodynamic models and UV transit light-curves

Richard Alexander
*University of Leicester, United Kingdom*

We present hydrodynamic simulations of stellar wind-magnetosphere interactions in hot Jupiters such as WASP-12b. For fiducial stellar wind rates we find that a planetary magnetic field of a few G produces a large magnetospheric cavity, typically 5-10 planetary radii in size. A bow shock forms ahead of the magnetosphere, but the pre-shock gas is only mildly supersonic so the shock is invariably weak. This results in a characteristic signature in the ultraviolet light curve: a broad absorption feature that leads the optical transit by 10-20% in orbital phase. Our synthetic light-curves are consistent with existing observations of WASP-12b, but current data do not place strong limits on the model parameters. We suggest that future UV observations other hot Jupiters will provide a straightforward test to distinguish between different models of circumplanetary absorption.

## Planets in post common envelope binaries

Stefan Dreizler
*Institut für Astrophysik, Göttingen, Germany*

With nearly 1000 confirmed extrasolar planets the majority is found in solar-type single stars. Planets in wide binaries orbiting one of the binary components, however, have been found since the first exoplanet detections. In contrast, planets orbiting both stars in close binary systems, i.e. circum-binary planets, are a rather recent discovery. On the one hand the Kepler-satellite has provided several planets orbiting MS+MS binaries. Circum-binary planets have also been claimed to be detected in post-common envelope binaries. In those systems, the variation of the eclipse times of the close binary is used as indication for the presence of additional bodies in the system. Since the host binary has undergone a drastic evolution loosing about 75% of its mass, the detection of planets raises the question whether or not these planets survived the common envelope evolution or if they are formed during the common envelope ejection. In the talk I will present the status of our current knowledge about planets in post-common envelope systems and discuss the results in the context of planet and planetary system evolution.

# Wednesday [September 10, 2014]

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|---|---|---|
| **Krivov** | **Alexander** | **Highlight talk: Debris Disks - Lessons from Herschel** |
| Ertel | Steve | An unbiased near-infrared interferometric survey for exozodiacal dust |
| Löhne | Torsten | Collisional modelling of resolved debris: Warm components in cold discs around solar-type stars |
| Xu | Siyi | Elemental Compositions of Extrasolar Planetesimals |
| **Guenther** | **Eike** | **Highlight talk: Planets of hot, massive stars** |
| Deka | Beata | Spectroscopic analysis of PTPS stars |
| **Sohl** | **Frank** | **Highlight talk: Structural models of terrestrial planet interiors** |
| Alibert | Yann | On the radius of habitable planets |
| **Heng** | **Kevin** | **Highlight talk: Exoplanet Atmospheres: Theory and Simulation** |
| Grenfell | John Lee | Sensitivity of biosignatures on Earth-like planets orbiting in the habitable zone of cool M-dwarf Stars to varying stellar UV radiation and surface biomass emissions |

## Session 6: Debris disks and host stars in planetary systems

### Highlight talk: Debris Disks - Lessons from Herschel

Alexander Krivov
*AIU/FSU Jena, Germany*

Debris disks, belts of invisible planetesimals and their observable dust, are thought to be remnants of the planet formation process. These disks have been observed at far-infrared wavelengths in various large-scale and smaller programs of the Herschel Space Observatory. Herschel observations have revealed the presence of debris disks around at least 20% of stars across the main sequence and discovered disks around subgiants. More exotic systems such as circumbinary and even circumpolar debris rings have also been found. Thanks to Herschel, the number of spatially resolved disks increased from about two dozens to approximately one hundred. Resolved images along with densely sampled SEDs allow the disk properties to be tightly constrained. Analyses of Herschel-resolved disks suggest a two-component structure, i.e. a Kuiper-like belt plus an asteroid-like belt, to be more common than a single-component architecture. The radii of the Kuiper-belt analogs exhibit a large scatter and do not appear to correlate with the stellar luminosity, which might pose additional constraints on the planetesimal formation mechanisms. The disks are typically aligned with the stellar equator and, in systems with known radial velocity planets, also with their orbital planes. There is an emerging sense that disks of A-type stars (e.g., Vega, beta Pic, HR 8799) appear to be compatible with an active collisional cascade in a narrow, massive, Kuiper-like planetesimal belt, whereas the disks of solar-type stars (e.g., q1 Eri, HD 207129, HIP 17439) tend to be more quiescent collisionally. This might reflect systematic differences between the planetesimal belts around earlier- and later-type stars. It remains unclear, however, whether presumed planets in the disks are also different and to what extent they are responsible for the observed disk properties.

### An unbiased near-infrared interferometric survey for exozodiacal dust

Steve Ertel
*ESO Santiago, Chile*

Exozodiacal dust around main sequence stars is expected to be the analog of the zodiacal dust in our own Solar system. Detecting this hot dust close to other main sequence stars remained elusive until the FLUOR instrument at the CHARA interferometer detected for the first time a 1% excess in the near-infrared around the prominent debris disk host star Vega in 2006. Studying exozodiacal dust can give insights into the dynamics and evolution of the innermost regions of planetary systems, close to the habitable zone. First studies revealed the

extreme nature of the systems detected, being more massive and hotter than our own zodiacal dust. On the other hand, the presence of such dust around other stars may represent a major obstacle for future terrestrial planet finding missions. The possible presence of diffuse emission adds uncertainty to the observations and clumpy structures in the dust distribution may point toward dynamical interaction with planets but a clump may also be misinterpreted as an actual planet.

We are carrying out the first large, statistical survey for exozodiacal dust in the near-infrared using CHARA/FLUOR in the northern and VLTI/PIONIER in the southern hemisphere. We observed 134 stars in total so far, the majority of targets observed as a magnitude limited sample with PIONIER. We will present the strategy and results of our survey. We draw statistical conclusions on the incidence of exozodiacal dust with different parameters of the system and by that on the potential mechanisms being responsible for the dust production. For the excesses detected with PIONIER, we also present the first spectrally dispersed observations allowing us to constrain the dust properties and to distinguish between thermal emission and scattered light as the dominant emission process. Finally, based on our results we discuss the impact of the presence of exozodiacal dust on future earth-like planet finding missions using direct imaging and discuss potential target selection strategies to optimize the outcome of such missions.

## Collisional modelling of resolved debris: Warm components in cold discs around solar-type stars

Torsten Löhne
*AIU/FSU Jena, Germany*

Observations at optical and far-infrared wavelengths reveal the presence of debris discs around at least 20 percent of stars across the main sequence. For a growing number of observed systems with debris discs, spatial resolution and densely sampled SEDs allow us to more tightly constrain the properties of the discs. Being remnants of the planet formation process, debris discs consist of (invisible) planetesimals and collisionally replenished dust. To link observational data with potential scenarios for their formation and dynamical history, we performed in-depth collisional modelling for a handful of discs around solar-type stars. The simulations started from a distribution of planetesimals and followed the production and loss of material in a collisional cascade, including the dynamical effects of direct radiation pressure and drag forces. One characteristic feature common to the discs is the presence of additional emission closer to the star, incompatible with a pure ring-like disc. We show that this emission can be explained by (a) drag of dust into an inner region devoid of planetesimals, (b) an extended, self-stirred and self-cleared debris disc, and/or (c) a separate inner disc. In all cases, the models suggest low dynamical excitation, i.e. discs that are quiescent rather than very active.

## Elemental Compositions of Extrasolar Planetesimals

Siyi Xu
*ESO, Germany*

The composition of extrasolar rocky planets is essential for understanding the formation and evolution of these alien worlds. Studying heavy-element-enriched white dwarfs, which are accreting from their own minor planets, provides a unique method to measure the elemental compositions of extrasolar planetesimals, the building blocks of planets. We report results from a high-resolution spectroscopic study with Keck/HIRES and HST/COS on a number of heavy-element-enriched white dwarfs. The main conclusions are: (i) Four elements, O, Mg, Si and Fe are always dominant in extrasolar planetesimals while volatiles, such as carbon and water, are typically trace constituents. (ii) Post-nebular processing, such as differentiation, collision and melting, must have occurred in a large number of extrasolar planetesimals. We find that extrasolar planetesimals are very similar to solar system asteroids in a lot of aspects.

## Highlight talk: Planets of hot, massive stars

Eike Guenther
*Thüringer Landessternwarte Tautenburg, Germany*

In contrast to planets of solar-like stars, very little is known about planets of intermediate mass (1.3-2.1 Msun) stars (IMSs). Spitzer observations have shown that the disk of young IMSs are more massive than those of solar-like stars. It is thus not surprising that radial-velocity surveys of giant stars have shown that IMSs have a large number of very massive planets. However, because giant stars have only planets at large orbital distances, we do not know whether IMSs can also have close-in planets. The interesting aspect is that the lifetime of the disks of IMSs is half as long as that of lower-mass stars. Thus, if IMSs would have close-in planets, it would mean that these planets must have formed and migrated inwards through planet-disk interaction within about one Myr. The determination of the frequency of close-in planets of IMSs thus is an important constrain theories of planet formation and migration. Another interesting aspect is that close-in planets of IMSs are exposed to the radiation field of a hot star. By observing close-in planets of IMSs we can thus constrain the evaporation rate of planets. In here I report on the outcome of a survey for planets of IMSs with orbital periods of less than 5 days.

## Spectroscopic analysis of PTPS stars

Beata Deka
*Toruń Centre for Astronomy Nicolaus Copernicus University, Poland*

The most efficient planet search techniques, precise radial velocity measurements and photometric transits critically rely on basic data on the observed stars.

Both radial velocity and transit planet searches require precise radii and masses that are best determined from detailed spectral analysis which delivers gravitational accelerations, metallicities and effective temperatures. Additional photometric data and parallaxes allow to estimate stellar luminosities and in turn complete data on observed stars become available. It is therefore of crucial importance to deliver as precise as possible stellar data on planet search targets that in turn, result in detailed planet description.

We present basic atmospheric parameters, masses, radii and ages for 716 stars, giants and subgiants from the complete sample of 1000 stars monitored for radial velocity variation in the ongoing PennState-Torun Centre for Astronomy Planet Search (PTPS). In addition to 348 stars studied by Zieliński et al. (2012) we present new results for another 368 subgiants and giants. The atmospheric parameters were determined from purely spectroscopic analysis of high resolution (R=60000) Hobby-Eberly Telescope High Resolution Spectrograph spectra.

References: Zielinski, P., et al. 2012, A&A, 547, 91

## Highlight talk: Structural models of terrestrial planet interiors

Frank Sohl
*DLR Institute of Planetary Research, Berlin, Germany*

The thermal and chemical evolutions of terrestrial or Earth-like planets are predominated by endogenic processes, often retained as individual geological and tectonic surface features. Endogenic planetary dynamics is mainly driven by solid-state convection in the deep interiors, at which thermal energy is converted into gravitational, magnetic field, and deformational energy. Structural models of planetary interiors are chemically layered, including subsurface water oceans and high-pressure ice layers in case of icy bodies, and composed of volatile constituents, rock-forming elements, and metals such as iron and nickel, the latter concentrated in central cores. Valuable information on the interior structure of the Earth and, to a lesser extent, for the Earth's Moon has been obtained from a vast amount of seismological observations. The successful construction of chemically layered interior structure models invokes the knowledge of thermodynamic state variables, petrology and geochemistry of planetary materials, equation-of-state parameters for the local density, compaction of porous materials, thermal and electrical material properties, intrinsic energy sources, chemical reactions, and pressure-induced phase transformations. Since there are usually fewer constraints than unknowns, even basic interior structure models that would involve only two or three chemically homogeneous layers of constant density suffer from inherent non-uniqueness. In the case of the terrestrial planets and satellites within the solar system the resultant radial profiles of density and related material properties are required to be consistent with geophysical observations and cosmochemical evidence as obtained from spacecraft multi-spectral imaging, in-situ monitoring of neutral and charged particles, and gravitational and magnetic field data. These observations indicate that terrestrial planet interiors usually are strongly differentiated and subdivided like that of the Earth into a partly or entirely liquid metallic core, a silicate mantle and an outermost magmatic crust derived from partial melting of the mantle below. Unfortunately, such data are not available yet for many other solar system bodies and terrestrial extrasolar planets. The latter are thought to reveal similar interior structures and bulk compositions like the terrestrial-type bodies in the solar system. Structural models of low-mass solid exoplanets are required to be consistent with the observed planetary masses and radii measured from ground-based observations and space missions. Calculated models can be used to derive mass-radius relationships for low-mass solid exoplanets, assuming a range of different chemical compositions to gain insight in the interior structure and possible bulk compositions of these planets. Furthermore, scaling laws for key physical and chemical properties are essential to better understand global planetary processes controlling planetary evolution and habitable potential. Current detection limits of ground-based observational methods have limited the discovery of low-mass solid exoplanets to only a few, although, according to predictions of planet formation models, those should be quite abundant. The future detection of hot (super-) Earths up to one AU distance from their host stars will provide important information to better constrain the diversity of these planets in terms of bulk composition. In this paper, I will present an overview of interior models of selected terrestrial planets and confirmed rocky exoplanets.

## On the radius of habitable planets

Yann Alibert
*University of Bern, Switzerland*

The conditions that a planet must fulfill in order to be habitable are not precisely known. However, it is comparatively easier to define conditions under which a planet is very likely not habitable. Finding such conditions is moreover important as it can help to select, in an ensemble of potentially observable planets, which ones should be observed in more details for characterization studies. Assuming, as in the case of the Earth, that the presence of a C-cycle is a necessary condition for long-term habitability, we derive, as a function of the planetary mass, a radius above which a planet is likely not habitable. For this, we compute the maximum radius a planet can have in order to fulfill two constraints: surface conditions compatible with the existence of liquid water, and no ice layer at the bottom of a putative global ocean. We demonstrate that, above a given radius, these two constraints cannot be met. For this, we compute internal structure models of planets, using a 5-layer model (core, inner mantle, outer mantle, ocean and atmosphere), for different masses and composition of the planets (in particular Fe/Si ratio of the planet). Our results show that for planets in the Super-Earth mass range (1-12 Mearth), the overall maximum that a planet can have varies between 1.8 and 2.3 Rearth. This radius is reduced when considering planets with higher Fe/Si ratios, and taking into account irradiation when computing the gas envelope structure.

## Highlight talk: Exoplanet Atmospheres: Theory and Simulation

Kevin Heng
*University of Bern, Switzerland*

I will review the state of the art of theory and simulation in the study of exoplanetary atmospheres, focusing on the objects for which we can currently obtain data (hot Earths/Neptunes/ Jupiters). I will organize the review around key questions. Some of the material is based on an upcoming review by Heng & Showman (2015) in AREPS (Annual Reviews of Earth and Planetary Science).

## Sensitivity of biosignatures on Earth-like planets orbiting in the habitable zone of cool M-dwarf Stars to varying stellar UV radiation and surface biomass emissions

John Lee Grenfell
*Inst. Planetary Research, DLR Berlin, Germany*

We find that variations in the UV emissions of cool M-dwarf stars have a potentially large impact upon atmospheric biosignatures in simulations of Earth-like exoplanets i.e. planets with Earth's development, and biomass and a molecular nitrogen–oxygen dominated atmosphere. Starting with an assumed blackbody stellar emission for an M7 class dwarf star, the stellar UV irradiation was increased stepwise and the resulting climate-photochemical response of the planetary atmosphere was calculated. Results suggest a "Goldilocks" effect with respect to the spectral detection of ozone. At weak UV levels, the ozone column was weak (due to weaker production from the Chapman mechanism) hence its spectral detection was challenging. At strong UV levels, ozone formation is stronger but its associated stratospheric heating leads to a weakening in temperature gradients between the stratosphere and troposphere, which results in weakened spectral bands. Also, increased UV levels can lead to enhanced abundances of hydrogen oxides which oppose the ozone formation effect. At intermediate UV (i.e. with 10 $\times$ the stellar UV radiative flux of black body Planck curves corresponding to spectral class M7) the conditions are "just right" for spectral detection. Results suggest that the planetary ozone profile is sensitive to the UV output of the star from 200–350 nm. We also investigated the effect of increasing the top-of-atmosphere incoming Lyman-$\alpha$ radiation but this had only a minimal effect on the biosignatures since it was efficiently absorbed in the uppermost planetary atmospheric layer, mainly by abundant methane. Earlier studies have suggested that the planetary methane is an important stratospheric heater which critically affects the vertical temperature gradient, hence the strength of spectral emission bands. We therefore varied methane and nitrous oxide biomass emissions, finding e.g. that a lowering in methane emissions by 100 compared with the Earth can influence temperature hence have a significant effect on biosignature spectral bands such as those of nitrous oxide. Our work emphasises the need for future missions to characterise the UV of cool M-dwarf stars in order to understand potential biosignature signals.

# Posters

## Abstracts

| Name | | Poster-ID | Poster title |
|---|---|---|---|
| Abdulmyanov | Tagir | PF-1 | Initial formation of bodies in the proto-planetary disks |
| Baillie | Kevin | CD-1 | Viscous Evolution of Protoplanetary Disks: Influence of the Geometry on Planetary Cores Migration |
| Bauer | Florian | T-1 | High accuracy wavelength solution with the use of a Fabry Perot Interferometer |
| Bertrang | Gesa | CD-2 | Magnetic fields in circumstellar disks traced with spectro-polarimetry |
| Beutel | Moritz | CD-3 | Vortex amplification through thermal relaxation in a baroclinically stratified disk |
| Bhatt | Jayesh | LE-1 | The role of statistical fluctuations in heterogeneous dust mantle growth |
| Caceres | Claudio | PF-2 | Planet formation in action? Studying a planet forming candidate in Lupus |
| Capelo | Holly | PF-3 | Gas-particle Interaction and the Connection to Planetesimal Formation |
| Charnoz | Sebastien | PF-4 | Formation of compact exoplanet systems from viscous spreading of dense circumstellar disks |
| Clausen | Niels | CD-4 | Growth rates of the elliptical instability within the anelastic approximation |
| Coleman | Gavin | PF-5 | On the formation of planetary systems via oligarchic growth in thermally evolving viscous discs |
| Cuello | Nicolas | CD-5 | Photophoresis in protoplanetary disks: A numerical approach |
| de Boer | Joszua | CD-6 | Why disks around Herbig Ae stars appear different for various differential imaging techniques |
| de Beule | Caroline | PF-6 | Planetesimal Formation in the warm inner Disk |
| Deckers | Johannes | LE-2 | Collision Dynamics of Decimetre Ice and Dust |
| Demidova | Tatiana | CD-7 | The variable circumstellar extinction in the models of protoplanetary disks with embedded companions |
| Diehl | Christiane | EP-1 | Extrasolar planets around post-common envelope binaries |
| Dorfi | Ernst | IA-1 | Early evolution of atmospheres of earth-like planets |
| Dürmann | Christoph | PD-1 | Massive planets migrating faster than type-II |
| Erikson | Anders | EP-2 | NGTS: Next Generation Transit Survey |
| Feiler | Anna | CD-8 | Radiative heating of circumstellar disks |
| Fendyke | Stephen | PD-2 | On the corotation torque for low-mass eccentric planets |
| Gellissen | Marko | LE-3 | Depletion of volatile lithophile elements in the inner solar system: Clues from evaporation experiments |
| Górecka | Michalina | DD-1 | Bayesian analysis of stellar parameters in PTPS |
| Gressel | Oliver | PD-3 | Core accretion in MHD simulations of layered protoplanetary discs |
| Hands | Tom | EP-3 | Understanding the assembly of Kepler's compact planetary systems |
| Ioannidis | Panos | EP-4 | On the influence of stellar activity on transit timing variations |
| Ismailov | Nariman | PF-7 | Planet formation processes in the spectrum of AB Aur |
| Jamialahmadi | Narges | CD-9 | Resolving the inner disk of the Herbig star MWC480 at mid-infrared wavelengths Suspected a vortex in the inner disk part |
| Jankowski | Tim | LE-4 | Experimental investigation of small ice particles in the context of planet formation |
| Khaibrakhmanov | Sergey | CD-10 | MHD model of accretion disks of young stars |
| Kirchschlager | Florian | CD-11 | The impact of dust grain porosity on the appearance of protoplanetary disks |
| Kitze | Manfred | EP-5 | Planetary transit search in young open clusters |
| Koester | Detlev | DD-2 | Chemical composition of extrasolar planetary systems |
| Köhler | Rainer | T-2 | Image reconstruction of circumstellar disks with MATISSE |
| Köster | Marc | PF-8 | Driving Planetesimals by Knudsen Engines |
| Kothe | Stefan | LE-5 | Abrasion of cm-sized dust agglomerates: A source of small dust agglomerates in the protoplanetary disk |
| Küffmeier | Michael | CD-12 | Zooming in on Protoplanetary Disk Formation |
| Küpper | Markus | LE-6 | Microgravity experiment on photophoresis of micro-particles |
| Lichtenberg | Tim | CD-13 | Modeling of gravitational instabilities in compact and massive protoplanetary disks with adaptive mesh refinement techniques |
| Lobo Gomes | Aiara | PD-4 | Vortex formation and evolution in discs under thermal relaxation and with a high mass planet embedded |
| Loren | Pablo | CD-14 | Gas and dust mixtures in the two fluid Smoothed Particle Hydrodynamics scheme |
| Lösche | Christoph | LE-7 | Photophoretic Strength on Chondrules |
| Marvin | Christopher | DD-3 | A Re-Analysis of Activity in the HARPS M dwarf Sample |
| Miotello | Anna | CD-15 | Protoplanetary disks masses from CO isotopologues line emission |

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|---|---|---|---|
| Montesinos | Matias | PD-5 | Protoplanetary disks including radiative feedback from accreting planets |
| Mutter | Matthew | PD-6 | The Role of Disc Self-Gravity on the Orbital Evolution of Circumbinary Planets |
| Ober | Florian | CD-16 | Tracing planet-induced structures in molecular lines |
| Pawellek | Nicole | DD-4 | Disc radii and grain sizes in Herschel-resolved debris discs |
| Picogna | Giovanni | PD-7 | Gas dynamics near giant planetary cores in 3D global simulations. |
| Pignatale | Francesco C. | CD-17 | Sorting grains in protoplanetary disks: Species sorting and grains porosity |
| Pohl | Adriana | CD-18 | Analyzing spiral structures in protoplanetary disks |
| Püstow | Robert | IA-2 | The influence of Hydrogen - Helium demixing on Saturn's cooling behaviour and evolution |
| Ramírez Reyes | Ricardo | DD-5 | A Spectro-Astrometric study of bracket gamma emission in Young Stars |
| Razdoburdin | Dmitry | CD-19 | A study of transient dynamics of perturbations in Keplerian discs using a variational approach |
| Regaly | Zsolt | PD-8 | Interpreting brightness asymmetries in transitional disks: Vortex at dead zone or planet carved gap edges? |
| Reiners | Ansgar | EP-6 | CARMENES: A new window into exoplanets and their stars |
| Reißl | Stefan | CD-20 | Tracing magnetic fields in star-forming regions on multiple scales |
| Rosotti | Giovanni | PF-9 | X-ray photoevaporation and planet formation in the dispersal of protoplanetary discs |
| Salz | Michael | IA-3 | X-ray/EUV evaporation of hot Jupiter atmospheres |
| Sándor | Zsolt | EP-7 | Formation of a Solar System analogue in a gamma Cephei-type binary system |
| Schleicher | Dominik | PF-10 | Planet formation in the close binary system NN Serpentis |
| Schmidt | Tobias | EP-8 | Young directly imaged planet candidates and their age independent mass determination |
| Schywek | Mathias | LE-8 | Collisions between viscous particles and compound chondrule formation |
| Sebastian | Daniel | EP-9 | Transiting sub-stellar companions of Intermediate-mass stars |
| Seemann | Ulf | EP-10 | CRIRES+: The 3m/s Planet Finder in the near-infrared |
| Shevchenko | Ivan | CD-21 | Spiral patterns in circumbinary planetesimal disks |
| Snytnikov | Valeriy | CD-22 | Cosmochemical and Physical Condition on the Initial Stage of Circumsolar Disc Formation |
| Sotiriadis | Sotiris | PF-11 | Influence of the inclination damping on the formation of planetary systems |
| Stammler | Sebastian | LE-9 | Dust coagulation simulations including water ice |
| Stoll | Moritz | CD-23 | Long time evolution of the vertical shear instability with radiation transport |
| Stoyanovskaya | Olga | CD-24 | Wandering boulders in the process of gravitational instability development in massive circumstellar disc |
| Surville | Clement | CD-25 | Can vortices effectively contribute to grain grow? |
| Tarnopolski | Mariusz | EP-11 | Nonlinear Time Series Analysis of Hyperion's Lightcurves |
| Tazzari | Marco | CD-26 | Constraining dust grains size and disc properties with ALMA and EVLA observations |
| Thies | Ingo | CD-27 | Transient induced vorticity in protoplanetary discs |
| Trova | Audrey | CD-28 | New prescription for the softening length in discs simulations |
| Ulbrich | Kathrin | CD-29 | Synthetic spectra of protoplanetary disks |
| Venturini | Julia | PF-12 | Critical core mass for enriched envelopes: The role of H2O condensation |
| Völschow | Marcel | PF-13 | Second generation planet formation in NN Ser? |
| Yamada | Ko | PD-9 | Effect of Dust Particles on the Type I Migration |
| Yang | Chao-Chin | PF-14 | On the Feeding Zone of Planetesimal Formation by the Streaming Instability |
| Zechmeister | Mathias | T-3 | The CARMENES pipeline |

# Posters by topic

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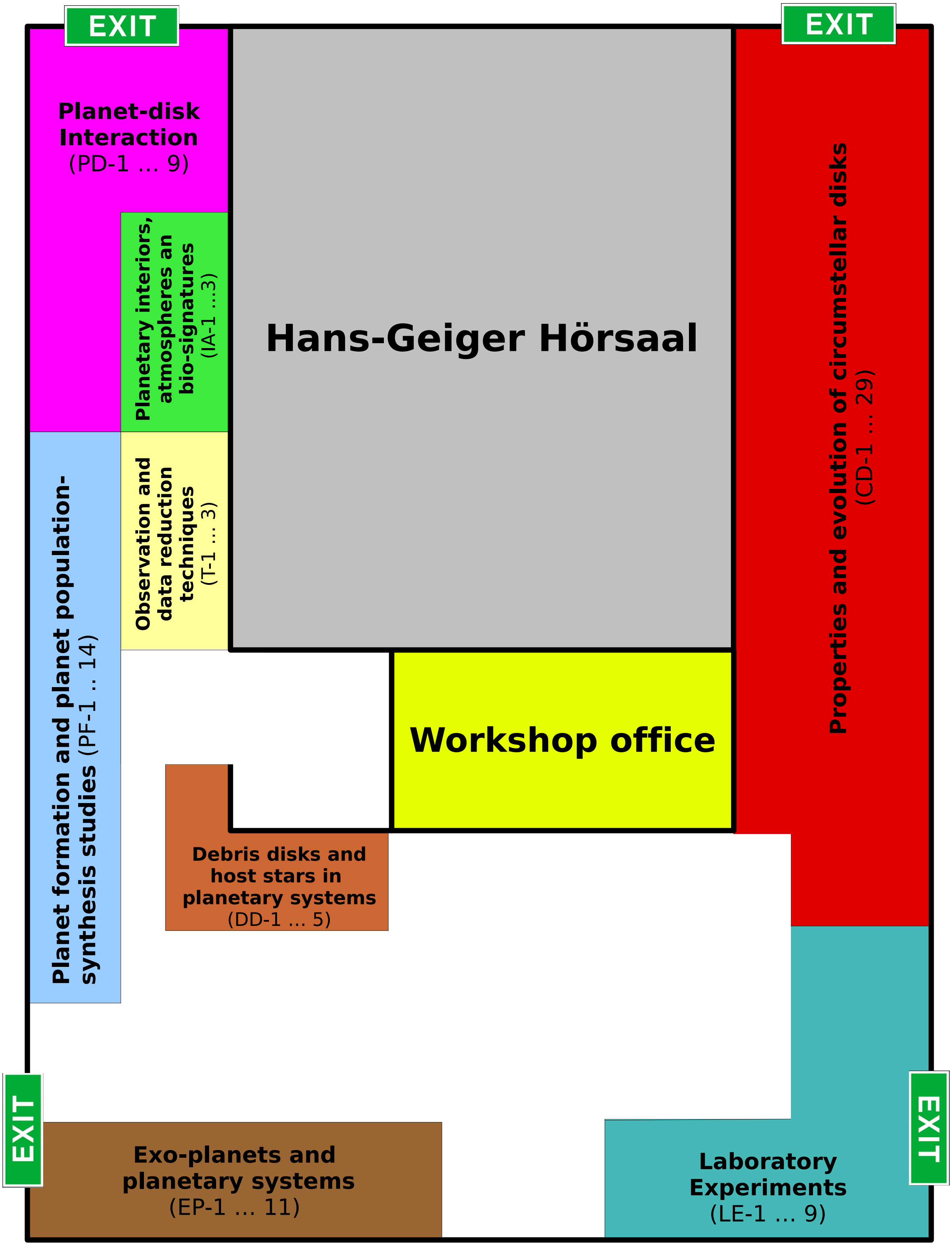
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## Properties and evolution of circumstellar disks

Poster-ID: CD-1

### Viscous Evolution of Protoplanetary Disks: Influence of the Geometry on Planetary Cores Migration

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In order to model the favorable conditions for planetary formation, we have designed a hydrodynamical numerical model for the spreading of protoplanetary disks based on a self-consistent coupling between the disk thermodynamics, photosphere geometry and dynamics (Baillié & Charnoz., 2014, ApJ 786, 35). We retrieved the recurrent observational properties of protoplanetary disks around young Classical T Tauri type stars. One of the novelty of our approach lies in the proper treatment of the disk geometry, leading to the presence of non-irradiated zones. In addition, we show the importance of the physical composition of the disk: using a full-opacity model, our disk temperature takes into account the various changes of states experienced by the different components of our gas-dust disk. This is crucial for estimating the resonant torques that a potential planet would experience in an evolved disk: these corotation and Lindblad torques are very sensitive to the discontinuities in surface-mass density and temperature gradients. From these torques, we show that there are some preferential zones for planetary embryos to accumulate and some regions could be totally depleted in planetary cores.

Poster-ID: CD-2

### Magnetic fields in circumstellar disks traced with spectro-polarimetry

Gesa Bertrang
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Observations of submillimeter polarization from T-Tauri disks enable us to study their magnetic fields. In this contex, recent studies show that the anisotropy of the radiation field may have a major influence on the polarized reemission radiation of these disks (Lazarian & Hoang, 2007). Based on polarized radiative transfer simulations we aim at modeling, characterizing, and explaining polarimetric observations of T-Tauri disks. For this purpose we apply a modified version of the 3D continuum radiative transfer code MC3D that takes the anisotropy of the radiation field into account. We extended the code to allow us to consider dust grain alignment of non-spherical dust grains due to magnetic fields (3D). As grain alignment mechanism, we assume radiative torques within a wavelength range of $0.2 - 1000\,\mu$m. With this sophisticated polarized radiative transfer code, we are able to model polarized spectral energy distributions and spatially resolved polarization maps of the thermal dust emission of circumstellar disks.

Poster-ID: CD-3

## Vortex amplification through thermal relaxation in a baroclinically stratified disk

Moritz Beutel
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The baroclinic amplification of vortices by radial buoyancy in circumstellar accretion disks is known to be influenced by the global entropy gradient and thermal and diffusive relaxation. Recent studies have manifested the insight that the presence of both is not only helpful but a requirement for a subcritical baroclinic instability, and that the amplifying effects are essentially non-linear. It is difficult to study vortex amplification at Reynolds numbers in the magnitude of $10^{10}$ numerically. Hence, the approach presented here builds on several well-known approximations like a vertically integrated accretion disk and a constant pressure profile, and then uses an analytical description of the local temperature profile in terms of aspect ratio and radial extent to predict the further growth of the perturbation. The thermodynamic structure leads directly to an effective torque that amplifies the vortex against viscous processes. Radiative diffusion and viscosity are added in a subsequent step. The inclusion of viscosity yields a combined growth/damping rate from which we determine the minimal spatial extent of the initial perturbation which is sufficient to overcome the dissipation processes of molecular viscosity permanently and thereby triggers vortex growth.

Poster-ID: CD-4

## Growth rates of the elliptical instability within the anelastic approximation

Niels Clausen
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We use the anelastic approximation to include compressibility for the calculation of the growth rates of the elliptical instability in a slightly elliptical deformed sphere. In addition, the influence of the Coriolis force and viscosity are taken into account. Semianalytical methods are used to solve the equations which is feasible because we assume a power law for the radial dependence of the background density. The main result is that the compressibility essentially does not change the stability limits if the viscosity is low enough. The elliptical instability typically leads to three-dimensional turbulence. The associated turbulent dissipation together with the dissipation of the large scale mode may be important in the synchronization process in stellar and planetary binary systems.

Poster-ID: CD-5

## Photophoresis in protoplanetary disks: A numerical approach

Nicolas Cuello
*Centre de Recherche Astrophysique de Lyon, France*

It is thought that rocky planets form in the inner regions of protoplanetary disks (PPD) at about 1-10 AU. However, theoretical models and numerical simulations show that in this region the grains tend to fall onto the star due to the gas drag. Even if rocks could reach large sizes near to the host star, they will then follow the same fate of smaller grains. Several theories have

been proposed and investigated in order to stop or invert the radial-drift of grains (dead-zones, meridional flow, turbulence, etc.) and overcome this major difficulty to build up rocky cores in the inner region of PPD.
In this work we explore the effects of the motion induced by the irradiation of the star on the dust grains, namely photophoresis. Photophoresis is a phenomenon which has been poorly explored from the numerical point of view. Previous experiments suggest that photophoresis may be a good candidate to revert the radial-drift of the grains. Moreover, theoretical calculations show that it could revert the inward movement of up to meter-sized rocks in a protoplanetary disk at 1 AU from the central star (Duermann et al. 2013). We perform 3D simulations of PPD using our two-fluid (gas+dust) SPH code and study the impact of photophoresis on its structure and dynamics. We find a radial sorting of dust which is due to the different chemistry, size and porosity of the grain species.

`Poster-ID: CD-6`

## Why disks around Herbig Ae stars appear different for various differential imaging techniques

Jos de Boer
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The proto-planetary disks (PPDs) around the Herbig Ae stars HD 163296 and HD 135344B have both been detected in scattered light multiple times with varying facilities and techniques. The PPD of HD 163296 turns out to be much more elusive than that of HD 135344B, but both have features that either disappear or look distinct, when we vary our observing methods. In this study, we analyze the possible origins for differences between NaCo polarimetric differential imaging (PDI) observations and MagAO angular- and reference star differential imaging (ADI & RDI) observations. In the PPD of HD163296, a ring like feature at 0.5" from the star appears in the PDI observations, which is not detected with the ADI & RDI observations. The PPD of HD 135344B shows a strong asymmetry between its northern and southern sides in the ADI & RDI observations. This asymmetry is strongly diminished in the PDI observations. We perform a quantitative analysis of the observed differences, which help us to determine the most likely scenarios that can explain both the ring like structure in the PPD of HD 163296, and the spiral pattern in the disk around HD 135344B.

`Poster-ID: CD-7`

## The variable circumstellar extinction in the models of protoplanetary disks with embedded companions

Tatiana Demidova
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The model of an young star surrounded by an extended protoplanetary disk with an embedded secondary component or low-mass companion are considered. The hydrodynamic flows produced by the motion of the companion are simulated using our modification of GADGET 2 code. The column density of the circumstellar dust on the line between the star and an observer is calculated. We intersect the disk matter in a number of directions to estimate effect of the disk orientation on the light curves. It allows us to explore the contribution of the different parts of the disk to the extinction of the star luminosity. The results of the simulation are applied to explain the brightness curves of UX Ori stars, which circumstellar disks are observed almost edge-on.

Poster-ID: CD-8

## Radiative heating of circumstellar disks

Anna Feiler
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Stellar irradiation plays a crucial role in the evolution of circumstellar disks. For this purpose we developed a model to parameterize the radiative heating of an optically thick disk in the hydrodynamics code Fosite (Illenseer & Duschl, 2009). It is based on the seminal work of Kenyon & Hartmann (1987) but uses a new method to calculate the illuminated surface of the disks depending on a well tested model of dust absorption properties (Weingartner & Draine 2003). It is sensitive to the chemical composition and the size distribution of the dust grains. Part of the incoming radiation is scattered out of the disk and cannot contribute to the heating which is also included in the model. The possibility of self shadowing is taken into account.
The model has been tested by comparison with the Monte Carlo radiative transfer code MC3D ( Wolf et.al. 1999, Wolf 2003). To this end we ran fosite simulations of disks with different masses, density distributions, and dust types and used snapshots of the evolving density distribution as input models for MC3D. The resulting scale height, midplane temperature and the energy absorbed by the disk are in very good agreement with the results obtained through full radiative transfer simulations.

Poster-ID: CD-9

## Resolving the inner disk of the Herbig star MWC480 at mid-infrared wavelengths Suspected a vortex in the inner disk part

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Studying the physical conditions in circumstellar disks is crucial for understanding the planet formation and the disk evolution. Of particular interest is the case of MWC480, a Herbig Ae star surrounded by a Keplerian disk (Mannings et al. 1997; Simon et al. 2000; Pitu et al. 2007). The inner structure and properties (temperature, mass, opacity) of the circumstellar disk of MWC480 are studied by optical interferometry and are interpreted using semi-analytical models. From these models, the SED (Spectral Energy Distribution) and multi-wavelength intensity map of the source were calculated. The intensity map provides the input for modeling the Keck Interferometer (KI) data in the near- infrared (NIR) and the Very Large Telescope Interferometer (VLTI) with the mid-infrared instrument MIDI. We conclude that the simple symetrical models (one or two disks) can not reproduce the SED and interferomet- ric visibilites simultaneously. The only way to reproduce all the measurements is to consider an azimuthal asymmetric structure. We successfully tested in our models a vortex like structure in the inner component of the two attached disk model. We found this vortex could be located at $\sim$ 6.5 AU at a position angle of 175[U+25E6]. Some constrains are derived for the possible size of the vortex. In order to reproduce our observations, a clump, which mimic a vortex in the inner disk of the attached disks model is required. More observations providing high resolution imaging in the mid-infrared e.g. MATISSE would be needed to confirm this model.

Poster-ID: CD-10

## MHD model of accretion disks of young stars

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We elaborate kinematic MHD model of stationary accretion disks of young stars. The model equations include equations of the Shakura and Synuaev $\alpha$-model, induction equation and equations of ionization balance. Magnetic field is calculated taking into account Ohmic, magnetic ambipolar diffusion and buoyancy. Ionization equations take into account cosmic rays, X-rays and thermal ionization, radiative and dust grain recombinations, as well as dust evaporation. Model equations have analytical solution for the radial profiles of ionization fraction and magnetic field components in case of power-law dependence of ionization fraction on density.
We investigate intensity and geometry of the large-scale fossil magnetic field of young stars' accretion disks in frame of the model. Analytical estimations and numerical calculations show that, in presence of dust, magnetic field is quasi-azimuthal close to the accretion disk inner edge and quasi-poloidal in the "dead" zones with low ionization fraction and efficient magnetic diffusion. Magnetic field is either quasi-radial or quasi-azimuthal in the outer regions of the accretion disk depending on dust and ionization parameters. In absence of dust, magnetic field is frozen-in in the disk and it is quasi-azimuthal in the inner accretion disk regions and quasi-radial in the outer regions.
Calculations show that inner boundary of the dusty "dead" zone is placed at 0.1-0.6 AU depending on stellar mass. Outer boundary of the "dead" zone is placed at 3-21 AU from the star and it is determined by magnetic ambipolar diffusion. Mass of solid material inside "dead" zones is more than 3 $M_\oplus$ for stars with $M \geq 1\,M_\odot$.

Poster-ID: CD-11

## The impact of dust grain porosity on the appearance of protoplanetary disks

Florian Kirchschlager
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We present a theoretical study of porous dust grains in protoplanetary disks (Kirchschlager & Wolf 2014, submitted). In the analysis of observations of protoplanetary disks the dust phase is often assumed to consist of spherical grains, allowing one to apply the Mie scattering formalism. However, in reality the shape of dust grains is expected to deviate strongly from a sphere. We investigate the impact of porous dust grains on the temperature distribution and observable appearance of protoplanetary disks for dust grain porosities up to 60%. Therefore, we perform radiative transfer modeling to simulate the spectral energy distribution, temperature distribution, and spatially resolved intensity and polarization maps. The optical properties of porous grains are calculated using the method of discrete dipole approximation. We find that grain porosity has a strong impact on the spectral energy distribution and scattered light maps. If compared to the case of compact, spherical grains, the flux in the optical wavelength range is increased for porous grains. The profile of the silicate peak at $\sim 9.7\,\mu$m strongly depends on the degree of grain porosity. Moreover, the temperature distribution shows significant changes in the direction perpendicular to the midplane which might have an effect on the processes of grain growth and disk evolution. Furthermore, simulated polarization maps reveal an increase of the polarization degree by a factor of $\sim$ four when porous grains are considered, regardless of the disk inclination. The polarization direction is reversed in selected disk regions, depending on the wavelength, grain porosity, and disk inclination. Several possible explanations of this effect are discussed with the result that the multiple scattering explains the effect best. Moreover, a correlation between the polarization reversal and the scattering properties of single dust grains is derived.

`Poster-ID: CD-12`

## Zooming in on Protoplanetary Disk Formation

Michael Küffmeier
*Niels Bohr Institute/ StarPlan, Denmark*

Planet formation is tightly connected to the formation process of stars via protoplanetary disks, which are widely observed for young stars. Protoplanetary disks are a natural consequence of star formation and they are considered as the region of planetary birth and evolution. While disk dynamics have been modeled for decades with a standard accretion disk approach considering a viscosity parameter $\alpha$, the question of initial disk formation and the influence of the stellar environment has been ignored. Recent studies of the standard accretion disc scenario lead to the discernment that the huge amount of angular momentum cannot be transported radially sufficiently rapidly through mechanisms such as the magnetorotational instability. In this poster, I will present results of zoom simulations of disk formation, obtained by using a highly modified local version of the adaptive mesh refinement code RAMSES, starting from first principles at giant molecular cloud scales of 40 pc and going down to minimum cell sizes of less than 0.02 AU. These simulations encourage an ongoing paradigm shift in the disk community. In fact, there is growing appreciation that realistic protoplanetary disks form due to a combined effect of omnipresent turbulence and the occurrence of large-scale magnetic fields, through a process of 'chaotic magnetic braking'. Soon after the birth of a star, the magnetic field becomes strongly toroidal, passing first through a phase where it is hour-glass shaped. These toroidal fields then efficiently remove the angular momentum of gas accreting to the disk, while the effect of turbulence avoids total disk quenching via the magnetic braking catastrophe. With respect to turbulence and the strong dependency of the stellar environment, our simulations demonstrate that stars show diverse histories of asymmetric accretion, also yielding less homogeneous disks and different strengths and evolution of jets as well as outflows collimated by magnetic towers at the center of the disk perpendicular to the disk plane. The jets and outflows are important in the sense that they eject a significant amount of mass out of the system. Angular momentum is mainly transported out of the system due to two mechanisms: On the one hand Poynting-flux can efficiently cause a transfer of angular momentum potentially related to bipolar jet launching, and on the other hand, magneto-centrifugal disk winds work efficiently in the sense of vertical angular momentum transfer.

Poster-ID: CD-13

## Modeling of gravitational instabilities in compact and massive protoplanetary disks with adaptive mesh refinement techniques

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The astonishing diversity in the observed (exo-)planetary population necessitate theoretical efforts and advances in planet formation theories. The use of numerical approaches provides a method to tackle the weaknesses of current models and is a major tool to slowly close gaps in poorly constrained areas such as the rapid formation of giant planets in highly evolved systems (Schleicher & Dreizler 2014). So far, most numerical approaches make use of Lagrangian-based smoothed-particle hydrodynamic (SPH) techniques or grid-based 2D axisymmetric simulations. Here, we present a new setup to model gravitational instabilities in 3 dimensions with the adaptive mesh refinement (AMR) code Enzo. We explore the potential impact of AMR techniques to model the first stages of giant planet formation via gravitational instabilities (GI), in particular the fragmentation and clumping due to large-scale instabilities using different numerical setups. As our reference model, we consider the temporal evolution of a compact ($r = 10$ AU) and massive ($M_{\rm disk} \approx 0.05 M_\odot$) protoplanetary disk around a central object of subsolar mass ($M_\star = 0.646 M_\odot$). Implying a simple thermodynamical profile sufficient for the onset of GI, we show that fragmentation and clumping can be observed in the disk structure. In the numerical model, clumps are formed due to the GI but eventually vanish due to tidal disruptions. The latter may reflect the absence of radiative feedback from the central star, which may stabilize the clumps on larger scales. Our simulations illustrate the capabilities of AMR-based modeling techniques for planet formation simulations. We expect that the inclusion of additional physics like radiative feedback and the formation of sink particles will provide a detailed framework to study the formation of planets via gravitational instabilities.

Poster-ID: CD-14

## Gas and dust mixtures in the two fluid Smoothed Particle Hydrodynamics scheme

Pablo Loren

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The study of dust dynamics becomes essential in order to correctly understand the process of planetary formation. However, numerical simulations of gas and dust mixtures in protoplanetary disks are very complex, due to the presence of an extremely wide range of dynamical time scales. Dust dynamical evolution in protoplanetary disks is mainly driven by drag forces, whose intensity depends amongst other things, on the size of the dust particles. Because the size of dust particles in protoplanetary disks ranges from micron-sized grains, up to kilometre-sized planetesimals, dust dynamical evolution time scales range from a few seconds, up to several thousand years. This large range of dynamical time scales can make numerical simulations very computationally intensive. In order to ease this problem, a new algorithm is presented in the two fluid Smoothed Particle Hydrodynamics context. By using approximated analytical solutions for the evolution of the smallest dust grains, one can simulate dust and gas evolution with arbitrary grain sizes, without a significant increase in computational time. A series of tests are presented, showing the accuracy of the present method.

Poster-ID: CD-15

## Protoplanetary disks masses from CO isotopologues line emission

Anna Miotello
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An accurate measurement of disk masses is a key point for understanding disk evolution all the way up to planet formation. The disk's mass is the initial reservoir of material made available to build planets. So far, virtually all disk mass determinations are based on millimeter continuum observations of large dust grains. To derive the total gas + dust disk mass from these data involves however some assumptions on the dust opacity and the gas-to-dust ratio, usually taken to be constant across the disk at 100, with gas the main disk constituent.

The alternative method for deriving disk masses relies on direct observations of the gas, whose bulk mass is in the outer cold (T$\sim$ 30 K) regions. This zone can be well traced by sub-mm lines of CO. However, $^{12}$CO is not a good mass tracer because its lines become optically thick at the disk surface. Less abundant CO isotopologues such as $^{13}$CO, C$^{18}$O and C$^{17}$O have optically thin lines and as a consequence probe the gas down to the midplane. In the standard approach, the total gas mass is then obtained with the isotopologue ratios taken to be constant at the isotope values found in the local ISM. This approach is however imprecise, because isotope selective processes are ignored and more detailed analysis should be carried out (Visser et al. 2009).

We present here for the first time full disk models that properly treat the isotope-selective photodissociation, the main process controlling the abundances of CO isotopologues, using the code DALI (Bruderer et al. 2012). The chemistry, thermal balance, line and continuum radiative transfer are all considered together with a chemical network that treats $^{13}$CO, C$^{18}$O, C$^{17}$O, isotopes of all included atoms, and molecules, as independent species. Our results show that taking isotopologue ratios as constants leads to an underestimate of disk masses by up to one order of magnitude. Isotope selective processes indeed lead to regions where the isotopologues abundance ratio e.g. of C$^{18}$O/$^{12}$CO is considerably different from the atomic $^{18}$O/$^{16}$O ratio.

The focus of our work is on the emission of the various isotopologues and their dependence on stellar and disk parameters, to set the framework for the analysis of ALMA data. We can employ ALMA to its full potential only if we have the correct tools to analyze its data.

Poster-ID: CD-16

## Tracing planet-induced structures in molecular lines

Florian Ober
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We investigated the feasibility to use molecular lines to trace planet-induced structures in circumstellar disks. Based on hydrodynamic simlations of planet-disk interaction obtained with the PLUTO code, we performed self-consistent temperature calculations and produced N-LTE molecular line velocity-channel maps and spectra of these disks. Subsequently, we simulated ALMA observations using the CASA simulator. We considered two near face-on inclinations, five disk masses, seven disk radii, and two different typical pre-main-sequence host stars (TTauri, Herbig AE) in a distance of 140 pc. We calculated up to 141 individual CO 3-2 and HCO+ 4-3 velocity channel maps to investigate the frequency dependence of the structures indicated above. We find that the major fraction of protoplanetary disks in our parameter space could be detected in the considered molecular lines. However, unlike the continuum case, gap detection is not straightforward in lines. Gaps are not seen in symmetric rings, mainly due to the (Keplerian-) global velocity field. Even for undisturbed, smooth disks the individual channel maps reveal complex asymmetric pattern. By comparing with simulated observations of undisturbed disks we are able to identify specific regions in the velocity channel maps, which are most characteristic for the planet-induced structures. These simulations of high-angular resolution molecular line observation demonstrate the potential of ALMA to significantly improve our understanding of the physical and chemical environment in which planets form.

`Poster-ID: CD-17`

## Sorting grains in protoplanetary disks: Species sorting and grains porosity

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Vertical and radial transport of grains clearly played an important role in determining the composition of the dust aggregates in the early stages of planets formation. This is also seen by the chemical and structural analysis of meteorites. In particular, the composition of the rare enstatite chondrites suggests that dust removal might have altered the chemical environment in which these chondrites formed. It is thought that together with size sorting, species-sorting can also contribute to alter the dust distribution in protoplanetary disks. In order to get more clues on this process we model simultaneously the dynamics of multiple dust species together with their porosity using a 3D two-phases (gas+dust) SPH code. We then explore the effect of these parameters on the sedimentation and radial migration of the dust in disks. Our results show that grains sorting caused by different chemical species and porosity is a very efficient process and can dramatically alter the chemical distribution of the dust in disks.

`Poster-ID: CD-18`

## Analyzing spiral structures in protoplanetary disks

Adriana Pohl
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In recent observations of protoplanetary disks characteristic large-scale structures, mainly of non-axisymmetric shape like spirals, are discovered in the disk density profile. These structures could be induced by the perturbation of additional gravitating objects (e.g. planets, companions). We analyze whether and how the large contrast between spiral arms and background seen in the observations can be reproduced by simulations. It is tested if surface density perturbations and/or temperature/pressure scale height changes are responsible for such spiral arms. In order to investigate their nature and to distinguish between different models of spiral arm formation, we calculate synthetic scattered light images using the radiative transfer code RADMC-3D. Special attention is given to both the comparison of our results with Subaru/HiCIAO data and to making predictions about the performance of upcoming instruments like VLT/SPHERE.

Poster-ID: CD-19

## A study of transient dynamics of perturbations in Keplerian discs using a variational approach

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The behaviour of hydrodynamical fluctuations in gaseous component of young protoplanetary disks is of primary importance for planetary system formation and evolution. It is also related to the major problem of the enhanced angular momentum transfer and nature of the effective viscosity in protoplanetary disks and, more generally, in Keplerian disks. Having a significant gradient of angular velocity, these disks are capable of a substantial transient effects in dynamics of perturbations. In our study we consider such effects employing a variational formulation of the optimisation problem what allows one to obtain an optimal initial perturbations that exhibit the highest possible growth at a specified time interval. In particular, we use our method to study the transient dynamics in a shearing sheet approximation. It is shown that the most rapidly growing shearing harmonic has azimuthal wavelength of order of the disc thickness. Moreover, its initial shape is always nearly identical to vortical perturbation having the same potential vorticity. We also extend our study to a global spatial scale taking into account the background vorticity gradient and the disc cylindrical geometry. It is shown that global vortices with azimuthal wavelengths more than an order of magnitude greater than the disc thickness still are able to attain the growth of dozens of times in a few Keplerian periods at the inner disk boundary. We estimate that if disc is already in a turbulent state with small effective viscosity, these large scale vortices have the most favorable conditions to be transiently amplified before they are damped. At the same time, turbulence is a natural source of the potential vorticity for this transient activity. Thus, we conclude that transiently growing vortical structures on scales above the disc thickness should provide an additional angular momentum transfer in discs and should affect their variability properties as well. The results we present here have been published in http://adsabs.harvard.edu/abs/2014MNRAS.442..870Z

Poster-ID: CD-20

## Tracing magnetic fields in star-forming regions on multiple scales

Stefan Reißl
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*Motivation:* Magnetic fields are crucial to many astrophysical phenomena in the interstellar medium (ISM) such as the formation of stars, circumstellar disks, and planets. In addition, dust also play a central role in the ISM because of polarization effects of dust grains aligned with the direction of the magnetic field. The potential of polarized light by interstellar dust to trace the magnetic fields in the ISM is still far from being exhausted.
*Goal:* We evaluate the potential of continuum polarization measurements on multiple scales to constrain the impact of magnetic fields on star formation. For this purpose we post-process magnetic fields, temperature, and density distributions as well as velocity fields resulting from complex MHD simulations to create synthetic polarization maps. The analysis of polarization measurements depends on a detailed understanding of the dominating grain alignment mechanisms inside the ISM. Revealing the underlying magnetic field morphology with the help of polarization measurements requires dust radiative transfer (RT) calculations in arbitrary 3D geometries.

*Our approach:* We developed an adaptive grid 3D Monte-Carlo RT code for continuum polarization simulations. The code solves the RT problem combined with the polarization effects of dichroic extinction, thermal reemission, and scattering using an algorithm similar to the one in Whitney & Wolff (2002). The optical properties of the dust grains are calculated with the well tested program DDSCAT 7.2 (Draine & Flatau 2012).
Dust grains align with their shorter axis parallel to the magnetic field direction (Voshchinnikov 2012). To investigate the impact of imperfectly aligned dust grains we go beyond previous approaches in this field and combine RT and polarization algorithms with state of the art dust grain alignment theories. Here, we implement the classical imperfect Davis-Greenstein (IDG) alignment due to paramagnetic relaxation (Davis and Greenstein 1951; Voshchinnikov 2010), the radiative torque alignment (RAT) because of radiation-dust interaction (Lazarian 2007) and considered the effects of mechanical alignment (Gold 1951; Lazarian 1996) as a result of gas streams.
*Results:* We demonstrate the potential of polarization maps resulting from multi-scale MHD simulations. Various dust grain parameter are considered to offer maps for a broad variety of configurations. Here, we conclude that:

- Dust alignment mechanisms influence the patterns of linear polarization in a unique way allowing to identify the dominant alignment mechanism in star forming regions on multiple scales.

- Circumstellar disk models considering RAT alignment are consistent with observations and can bridge the gap between observational data and theoretical predictions.

The result of this study provides insight in the effects of grain alignment on polarization measurements and constraints the accuracy and spatial resolution of polarization measurements required to trace the magnetic field morphology in star-forming regions.

`Poster-ID: CD-21`

## Spiral patterns in circumbinary planetesimal disks

Ivan Shevchenko
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The dynamical stirring of a circumbinary planetesimal disk, when the gas component is depleted, is studied. In a gas-free case, we extend and refine the theory by Moriwaki and Nakagawa (2004) for the secular dynamics of planetesimals in circumbinary disks. We demonstrate how a circumbinary spiral pattern forms. We study the spiral pattern evolution analytically and numerically, as it spreads over the disk on a secular timescale. An analytical expression for the spiral is derived; it turns out to be a “power-law” one, and matches the numeric results perfectly. We use the SPH scheme to explore how the residual gas affects the wave propagation.

Poster-ID: CD-22

## Cosmochemical and Physical Condition on the Initial Stage of Circumsolar Disc Formation

Valeriy Snytnikov
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CM carbonaceous chondrites meteorites have ages about 50 million years from the beginning of the formation of the Solar system. Scanning electron microscopic examination of carbonaceous chondrites meteorites Migey, Murchison, Staroe Boriskino, Orgueil carried out by three groups confirmed the conclusion of Hoover R., Rozanov A. and other researchers about the presence of microfossils of bacterial origin in the matrix of these meteorites . Since the time of the Solar system formation is 60 - 100 million years, the primary biocenosis emerged in the protoplanetary disc of the Solar system before meteorites or simultaneously with them. It means that prebiological processes and RNA world appeared even earlier in the circumsolar protoplanetary disc. Most likely, this appearance of prebiotic chemistry takes place nowday in massive and medium-massive discs of the observed young stellar objects (YSO) class 0 and I. The timescale of the transition from chemical to biological evolution took less than 50 million years for the Solar system. Further evolution of individual biocenosis in a protoplanetary disc associated with varying physico-chemical conditions during the formation of the Solar system bodies. Biocenosis on these bodies could remove or develop under the influence of many cosmic factors and geological processes in the case of Earth.

To complete the primary biosphere formation in short evolution time - millions of years - requires highly efficient chemical syntheses. In industrial chemistry for the efficient synthesis of ammonia, hydrogen cyanide, methanol and other organic species, that are the precursors to obtain prebiotic compounds, catalytic reactors of high pressure are used. Thus (1) necessary amount of the proper catalyst in (2) high pressure areas of the disc can trigger these intense syntheses. The disc contains the solids with the size from nanoparticle to pebble. Iron and magnesium is catalytically active ingredient for such solids. The puzzle is a way to provide hydrogen pressure inside the disc from tens to hundred atmospheres.

We simulated unsteady processes in massive circumstellar discs around YSO class O and I. In the computational experiments, we have shown that at a certain stage of its evolution the circumstellar discs of gas and solids produces local areas of high pressure. According to the classical heterogeneous catalysis, a wide range of organic and prebiotic compounds could have been synthesized in these areas.

Can we capture these areas of high pressure synthesis in observation of circumstellar discs? Due to the small sizes of such areas they can be hardly ever resolved even with the modern telescopes such as ALMA. However, we can try to detect their signatures in the disc, since the gas of the disc keep the set of organic synthesis products. The idea is to define the signature of the process using laboratory experiments.

Poster-ID: CD-23

## Long time evolution of the vertical shear instability with radiation transport

Moritz Stoll
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The origin of turbulence in accretion discs is still not fully understood. While the magneto-rotational instability is considered to operate in sufficiently ionized discs, its role in the poorly ionized protoplanetary disc is questionable. Recently, the vertical shear instability (VSI) has been has been suggested as a possible alternative. Our goal is to study the characteristics of this instability and the efficiency of angular momentum transport, in extended discs, under the influence of radiative transport and irradiation from the central star. We use multi-dimensional hydrodynamic simulations to model a larger section of an accretion disc. First we study inviscid and weakly viscous discs using a fixed radial temperature profile in two and three spatial dimensions. The simulations are then extended to include radiative transport and irradiation from the central star. In agreement with previous studies we find for the isothermal disc a sustained unstable state with a weak positive angular momentum transport of the order of $\alpha \approx 10^{-4}$. Under the inclusion of radiative transport the disc cools off and the turbulence terminates. For discs irradiated from the central star we find again a persistent instability with a similar $\alpha$ value as for the isothermal case. We find that that the VSI can indeed generate sustained turbulence in discs albeit at a relatively low level with $\alpha$ about few times $10^{-4}$.

Poster-ID: CD-24

## Wandering boulders in the process of gravitational instability development in massive circumstellar disc

Olga Stoyanovskaya

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Due to new opportunities provided by ALMA it is becoming possible to explore the earliest stages (Young Stellar Objects class O-I) of disc evolution. These objects are promising in discovery of observational signatures of planet formation mechanism. We suggest that disc instability and self-gravitation clumps formation can leave chemical signatures in the disc atmosphere. Clump chemistry is different from the disc chemistry, as clumps have high pressure gas and increased solids concentration. Such conditions facilitate chemical reaction of CO, ammonia, formaldehyde, cyanide hydrogen and other species. So if we manage to specify the set of products of homogeneous or heterogeneous (gas-phase catalytic) reactions for clumps condition, the observation of the set can be evidence of the instability of the disc. Species transport from clump to disc atmosphere can be provided by diffusion or adsobtion-desorbtion mechanism if there are bodies that can go through the clump.

We simulated gas flow and dynamics of metre-sized solid clusters in massive self-gravitating circumstellar disc. Our computer simulations demonstrated that numerous solitary clumps of gas and boulders can be formed in the massive disc. Some metre-sized clusters was found to be wandering, it means that they were captured by one clump, than ejected and captured by the next clump. Such wandering boulders can provide efficient species transport between clumps and from clump to disc atmosphere as well as periodically changing physical conditions for the species adsorbed by the boulder. We found the correlation between initial velocity dispersion of metre-sized solids and the total mass of wandering boulders in the disc.

Poster-ID: CD-25

## Can vortices effectively contribute to grain grow?

Clement Surville
*MPIA Heidelberg, Germany*

Since almost 20 years, anticyclonic vortices are considered as a good way to concentrate dust in protoplanetary disks. Numerical simulations as well as analytical studies, based on Kida vortex model, show that they capture particles on few tens of orbits. However long term evolution of dusty vortices, taking the back reaction of drags forces on the gas, is not well constrained. In this work, I will present a new study of this problem, with both analytical and numerical approach, and show that even if dusty vortices can be unstable, the dust density enhancement obtained could be sufficient for new planetesimal formation scenarios.

Poster-ID: CD-26

## Constraining dust grains size and disc properties with ALMA and EVLA observations

Marco Tazzari
*ESO*

The growth of solids from micron-size particles to planetesimals is a critical stage in the formation of planetary systems (including Our own). Observations at millimetre and submillimetre wavelengths allow us to probe the solids on the disk midplane where the bulk of the material is located and where planets are expected to form. The distribution of grain sizes in different regions of the disk is a powerful probe of the physical mechanisms related to grain growth and ultimately on how solids can overcome the various growth barriers on the way to form planetesimals and planetary cores. The upgraded VLA and, especially, the ALMA observatories provide new powerful tools to resolve grain growth in disks, but they also provide huge datasets that require new and more efficient methods of data analysis. I will present a novel approach to extract the dust properties in disks that I have developed and will show the preliminary results of applying this method to young protoplanetary disks.

Poster-ID: CD-27

## Transient induced vorticity in protoplanetary discs

Ingo Thies
*AIfA, University of Bonn, Germany*

Planet formation is not an isolated phenomenon, but is closely related to the star-forming environment through perturbations and material exchange. There is also significant evidence that the Solar System has formed in a dense star-forming environment like the Orion Nebula Cluster. Furthermore, vortices inside protoplanetary discs may play an important role for planet formation. Here we present the recent results of our research project on the effects of the perturbations by the environment of the Sun's birth cluster on the proto-Solar System. We find that the perturbations induce transient vortices in circumstellar discs, and we address their possible role in the young Solar system. The results will be discussed in the context of recently published competing models of planet formation by multiple shock passages through protostellar clouds.

Poster-ID: CD-28

## New prescription for the softening length in discs simulations

Audrey Trova
*Astronomical Institute of the Academy of Sciences, Czech Republic*

In numerical simulations of discs, self-gravitating forces/potentials are traditionally computed from softened gravity. For thin discs, the softening length $\lambda$ is commonly estimated to a fraction of the disk local thickness h. Here, we present a novel prescription that preserves the Newtonian property of the numerical grid cells. Our analysis shows that, at long-range, the nominal $\lambda$-parameter can be a purely imaginary number. This new formula, discussed in a concrete case as a flared disc, improves the accuracy by 2-3 digits on the gravitational potential. It would be interesting to see how this result impacts on hydrodynamical simulations, in particular for secular evolutions and gravitational instabilities.

Poster-ID: CD-29

## Synthetic spectra of protoplanetary disks

Kathrin Ulbrich
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Protoplanetary disks, which are believed to be the birthplaces of planets, draw more and more attention since the discovery of the first exoplanets. The inner gaseous regions are of special interest for the formation and evolution of planets and stars. To gain a better understanding of the dynamics, the physical and chemical structure and gas content of this region we developed a 1D disk package for the well established multi-purpose stellar atmosphere code PHOENIX.
Based on this previous work we calculated synthetic spectra for a wide range of parameters ($R_* = 0.3 - 1R_\odot$, $M_* = 1.6 - 2.9M_\odot$, $T_{eff} = 3100 - 5500K$, $\dot{M} = 1 \cdot 10^{-7} - 1 \cdot 10^{-9} M_\odot/yr$, $Re = 10^4 - 10^5$) investigating the effect on the spectra of inner regions of protoplanetary disks around 0.03-0.5AU. We also tested the influence of different height-dependent viscosity distributions on the spectra. First results and comparisons to high resolution CRIRES observations will be presented.

## Planet formation and planet population-synthesis studies

Poster-ID: PF-1

### Initial formation of bodies in the proto-planetary disks

Tagir Abdulmyanov
*Kazan State Power Engineering University, Russia*

In this paper the initial stage of formation of bodies in the proto-planetary disks is considered. It is shown that the redistribution of gas and dust particles in proto-planetary disks could be the cause of disks inside the singular points of the gravitational interaction of the whole disk with dust particles. At these points could be the primary accumulation and the formation of bodies. Growth in the size and mass of the bodies could be due to the influx of new dust particles in the singular points of the neighborhoods of these points.

Poster-ID: PF-2

### Planet formation in action? Studying a planet forming candidate in Lupus

Claudio Caceres
*University of Valparaiso, Chile*

Circumstellar disks are sites where giant planets are expected to form. The direct detection of forming planets still embedded in a ptotoplanetary disk would provide the most direct observational test for current theories of giant planet formation. Here we present a many-fold approach for the study of a protoplanetary disk in Lupus that presents evidence of planet formation, including multi-epoch Sparse Aperture Masking (NACO/VLT) and ALMA observations.

Poster-ID: PF-3

### Gas-particle Interaction and the Connection to Planetesimal Formation

Holly Capelo
*MPI-DS, Germany*

In proto-planetary systems, differential motion between the gas-dominated main disc and the dust-rich subdisk results in aerodynamic drag on the dust grains. The resultant dust-particle dynamics depend upon how well coupled the particles are to the gas and what the dust-to-gas mass-density ratio is. One of the outstanding matters in the earliest stages of the core-accretion planet formation scenario is that poorly coupled dust agglomerates (i.e. long friction times) will suffer from radial drift, thus becoming unavailable as the raw material for later stages of planetary growth. It has previously been shown that this problem can be alleviated by considering the aerodynamic coupling between the gas and particle velocity fields, and in particular that, for dust-to-gas ratios around unity or greater, a two-stream instability develops which produces sufficiently high particle concentrations to result in a gravitational instability and rapidly form planetesimal-size bodies. A feature of this mechanism is that clusters of particles travel faster collectively than they would individually, when subject to the relevant drag laws (e.g. in the Stokes, or Epstein regimes). We show that when the reduced system of equations for the particles and the incompressible fluid are recast in a non-rotating center-of-mass frame, the result is an instability exhibiting the same outcomes (clustering and collective drag reduction) as in prior studies of the rotating case. The mechanism is therefore general enough to apply to a host of contexts and we emphasize our studies conducted in the laboratory. By analogy to the relative velocity that gas and dust particles experience in a pre-planetesimal scenario, we are studying a low-pressure gas stream that is laden with solid, spherical, inertial particles. For the sizes and material densities of our particles, our apparatus is operating at pressures that bracket the transition from the Stokes to the Epstein drag regime. We record the particle motion using high-resolution cameras, yielding three-dimensional particle velocities, accelerations and local concentrations. Previous analytical and numerical studies traced the evolution of the particle velocities and densities as volume averaged or cell-averaged quantities. However, for the first time, using our experimental facility, we explore more explicitly the relative motions between individual particles. We supplement the experimental results with high-resolution numerical simulations and discuss how this effect may be applicable to various phases of planetesimal formation.

Poster-ID: PF-4

## Formation of compact exoplanet systems from viscous spreading of dense circumstellar disks

Sebastien Charnoz
*Université Paris Diderot, France*

The Kepler and Corot missions have unveiled the presence of several systems of exoplanets systems on very compact orbits, contained within tens of stellar radii only. Understand their formation still challenges all formation model and migration only in a protoplanetary disk, or multiple planets scattering does not seem able to build such systems. To several respects these system share similarities with satellite systems of giants planets in term of mass ratios and orbital architectures as noted by several authors.

In the present work we explore an alternative planet formation model, inspired from recent works on satellite formation (suggesting that some of giant planet's satellites may have formed from the viscous spreading of rings). We propose that some of these compact exoplanet systems could have formed through the viscous spreading of a dense circumstellar disk of material, fed by planet migration in the protoplanetary disk and shattered by tids. The debris disk then spread outward and becomes gravitationally unstable. If the masse ratio of the disk to the star is small, then we show than a retinue of planet can form, and with a specific orbital architecture that is similar to what is found for giant planet's satellites system. We will present this model in details and show results of numerous numerical simulations. These planets then evolve outwards due to stellar tides and mutual interactions. In this model, such compact planet systems may be called of 2nd generation, since a first generation of planets may form, maybe in a more classical way, in order to feed the circumstellar disk. An complex interplay exist between the sublimation distance of silicates and the Roche Limit of the star that may lead to different types of systems, that have kept or not the memory of the chemical composition of the first generation of planets in the system. However, this scenarios still have problems to explain the distance of the most distant planets observed in some systems, an issued that may be potentially solved via a better description of the star's dissipation factor (k2/Q) as a function of frequency.

Poster-ID: PF-5

## On the formation of planetary systems via oligarchic growth in thermally evolving viscous discs

Gavin Coleman
*Queen Mary, University of London, United Kingdom*

The question of how planetary systems form within protoplanetary discs still remains largely unanswered. In this talk I will present the results of N-body simulations, coupled to 1D thermally evolving viscous disc models, that we have run to examine the formation of planets via oligarchic growth. The simulations include type I and II planet migration (including the effects of corotation torques), gas accretion onto planetary cores, and disc dispersal through photoevaporation. The simulations display a number of outcomes that correlate with the initial disc mass and solids-to-gas ratio. Compact systems of terrestrial, super-Earth and Neptune-mass planets arise naturally from the runs, but a significant failing of the models is that gas giant planets that form are unable to survive migration into the central star. During the talk I will discuss the results of the simulations, compare them with observations, and present an analysis of the conditions required for gas giant planets to form and survive within the context of our model.

Poster-ID: PF-6

## Planetesimal Formation in the warm inner Disk

Caroline de Beule
*University Duisburg-Essen, Germany*

Our recent investigations approach the question how elevated temperatures in inner parts of protoplanetary disks influence the formation of planetesimals. We find in laboratory experiments that changes in composition of dust aggregates with increasing temperature are correlated to a strong increase in cohesive forces within the dust aggregates. We studied dust samples of palagonite (JSC Mars-1a) which were tempered for 1 hour at different temperatures and applied a (photophoretic) tensile stress to the dust grains. Above 500 K the force per mass necessary to break contacts increases steadily. This change is well matched by mineral transformations which can be traced e.g. by x-ray diffraction or Mössbauer spectroscopy. These results suggest a strong change in the collisional evolution towards larger bodies with increasing temperature as collisional growth is fundamentally based on cohesion. It likely enhances the possibility to grow planetesimals which might lead to a preferred in-situ formation of inner planets and explain the observed presence of dense inner planetary systems.

Poster-ID: PF-7

## Planet formation processes in the spectrum of AB Aur

Nariman Ismailov
*Shamakhy Astrophysical Observatory, Azerbaijan*

On the UV spectrograms of Herbig Ae/Be type star AB Aur obtained for 1978-1992 (IUE archive) for the first time have discovered a periodical variability of intensities of some lines as MgII $\lambda$2800, FeII $\lambda\lambda$2600, 2742 etc. with period 6.1$\pm$0.1 days. Moreover, the results of last measurements of spectral parameters of emission lines – equivalent widths, the displacement

of separate components of H$\alpha$, H$\beta$, HeI $\lambda$5876, D1, D2 NaI were presented. Equivalent widths of hydrogen and helium emission lines in the optical region are varied with the same period, but radial velocities of these lines shows inverse phase variability with the same period. It is possible that there are other periods in the variability of the spectrum AB Aur. Hydrogen lines of H$\alpha$ and H$\beta$ show the active variation in the blue wing, while the line HeI $\lambda$5876 on the red wing. Obtained results can be explained with complex structure of the circumstellar disk and planet formation processes in this system.

`Poster-ID: PF-8`

## Driving Planetesimals by Knudsen Engines

Marc Köster
*Faculty of Physics, University Duisburg-Essen, Germany*

It was just recently discovered that dusty (pre)-planetary bodies, non uniformly heated, effectively transport gas through their pores. As Knudsen compressor thermal creep efficiently pumps gas from cooler to hotter dust layers. Applied to protoplanetary disks, this gas flow can act as an engine and contribute to the transport of pre-planetary matter which is heated one way or the other (radioactive decay, radiation, ...). We carried out first laboratory experiments to quantify these gas flows. We measured the pressure differences in two chambers connected by a dust filled tube. The dust is heated at one side by radiation. We probed different size distributions in the micrometer range at varying ambient pressure and heat rates.

`Poster-ID: PF-9`

## X-ray photoevaporation and planet formation in the dispersal of protoplanetary discs

Giovanni Rosotti
*MPE, IoA, Germany*

Planet formation is a race between the processes aggregating the material in the protoplanetary disc and the ones removing it, dispersing the disc. The so-called transition discs show evidence for an inner hole and are interpreted as discs caught in the final act of dispersal. Photoevaporation and planet formation itself have been proposed as mechanisms responsible for their creation. However, both scenarios have problems in explaining the measured hole sizes and mass accretion rates. I have studied the combined effect of the two processes, finding that it can significantly alter the picture. In particular, I find that the formation of a giant planet can trigger the creation of a short-lived transitional disc and its final dispersal by photoevaporation. I will show results from a suite of 2d simulations of protoplanetary discs undergoing X-ray photoevaporation with an embedded giant planet. I have expanded the parameter space investigated by previous simulations with the goal of making comparisons with observations (e.g., more massive discs). In addition, while before the simulations were run only up to hole opening, the updated model includes thermal sweeping, needed for studying the complete dispersal of the disc. The suite of simulations allows me to construct predictions about the gas content in the cavities of transitional discs, that can be compared against the upcoming ALMA observations.

Poster-ID: PF-10

## Planet formation in the close binary system NN Serpentis

Dominik Schleicher
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The close binary system NN Serpentis must have gone through a common envelope phase before the formation of its white dwarf. During this phase, a substantial amount of mass was lost from the envelope. The recently detected orbits of circumbinary planets are likely inconsistent with planet formation before the mass loss. We explore whether new planets may have formed from the ejecta of the common envelope and derive the expected planetary mass as a function of radius. We employed the Kashi & Soker model to estimate the amount of mass that is retained during the ejection event and inferred the properties of the resulting disk from the conservation of mass and angular momentum. The resulting planetary masses were estimated from models with and without radiative feedback. We show that the observed planetary masses can be reproduced for appropriate model parameters. Photoheating can stabilize the disks in the interior, potentially explaining the observed planetary orbits on scales of a few AU. We compare the expected mass scale of planets for 11 additional systems with observational results and find hints of two populations, one consistent with planet formation from the ejecta of common envelopes and the other a separate population that may have formed earlier. The model proposed here can be tested through refined observations of additional post-common envelope systems.

Poster-ID: PF-11

## Influence of the inclination damping on the formation of planetary systems

Sotiris Sotiriadis
*naXys, Department of Mathematics,University of Namur, Belgium*

Highly non-coplanar extrasolar systems (e.g. Upsilon Andromedae) and unexpected spin-orbit misalignment of some exoplanets have been discovered. In Thommes & Lissauer (2003) and Libert & Tsiganis (2009, 2011), resonant planet-planet interactions during (Type II) migration of giant planets in the protoplanetary disc have been invoked to explain the inclined orbits of extrasolar systems. Here we investigate the effect of the inclination damping due to planet-disk interactions on the previous results, for a variety of planetary systems with different initial configurations and mass ratios. Using the damping formulae for eccentricity and inclination provided by the numerical hydrodynamic simulations of Bitsch et al. (2013), we examine their impact on the possible multiple resonances between the planets and how the growth in eccentricity and inclination are affected.

Poster-ID: PF-12

## Critical core mass for enriched envelopes: The role of H2O condensation

Julia Venturini
*University of Bern, Germany*

During the formation of a planet, once the core reaches a lunar mass, it can start to bound some gas from the protoplanetary disk. The planetesimals that are accreted from this stage on, undergo thermal ablation and physical disruption when crossing the atmosphere. Thus, the primordial H-He atmosphere gets enriched in volatiles and silicates from the planetesimals. This change of composition affects the thermal structure of the atmosphere. In particular, if the planet is located in a region where the temperature and pressure are suited for water condensation to take place, the release of latent heat modifies drastically the adiabatic temperature gradient. We will discuss how this effect reduces the critical core mass and the implications on the type of planets that can be formed.

Poster-ID: PF-13

## Second generation planet formation in NN Ser?

Marcel Völschow
*Hamburger Sternwarte, Germany*

In our work, we study the general impact of stellar mass-ejection events in planetary orbits in post-common envelope binaries with circumbinary planets like those around NN Serpentis. We discuss a set of simple equations that determine upper and lower limits for orbital expansion and investigate the effect of initial eccentricity. We deduce the range of possible semi-major axes and initial eccentricity values of the planets prior to the common-envelope event. In addition to spherically-symmetric mass-ejection events, we consider planetary dynamics under the influence of an expanding disk. In order to have survived, we suggest that the present planets in NN Ser must have had semi-major axes $\sim 10$ AU and high eccentricity values which is in conflict with current observations. Consequently, we argue that these planets were not formed together with their hosting stellar system, but rather originated from the fraction of matter of the envelope that remained bound to the binary. According to the cooling age of the white dwarf primary of $10^6$ yr, the planets around NN Ser might be the youngest known so far and open up a wide range of further study of second generation planet formation.

Poster-ID: PF-14

## On the Feeding Zone of Planetesimal Formation by the Streaming Instability

Chao-Chin Yang
*Lund University, Sweden*

The streaming instability is a promising mechanism to overcome the barriers in direct dust growth and lead to the formation of planetesimals. Most previous studies of the streaming instability, however, were focused on a local region of a protoplanetary disk with a limited simulation domain such that only one filamentary concentration of solids has been observed. The characteristic separation between filaments is therefore not known. To address this, we conduct the largest-scale simulations of the streaming instability to date, with computational domains up to 1.6 gas scale heights both horizontally and vertically. The large dynamical range allows the effect of vertical gas stratification become prominent. We observe more frequent merging and splitting of filaments in simulation boxes of high vertical extent. We find multiple filamentary concentrations of solids with an average separation of about 0.2 local gas scale heights, much higher than the most unstable wavelength from linear stability analysis. This measures the characteristic separation of planetesimal forming events driven by the streaming instability and thus the initial feeding zone of planetesimals.

## Laboratory experiments

Poster-ID: LE-1

### The role of statistical fluctuations in heterogeneous dust mantle growth

Jayesh Bhatt
*University College London, United Kingdom*

Heterogeneous mantle growth of dust in planet forming regions occurs when gas phase molecules adsorb onto the surface of already existing grains. In general, grain growth involves four processes: (1) the adsorption of gas phase molecules, (2) the desorption of these molecules without participating in any reaction on the grain surface, (3) the thermal walk of the adsorbed molecules on the surface and (4) the evaporation or disintegration of a molecular cluster on the grain surface before it is energetically stable. Traditionally, the dynamical interplay among these competing processes are described through population balance equations that involve mean concentrations of the reacting molecules and molecular clusters on the grain surface. The solution of these equations leads to the mean growth rate of the dust grains. However, when the dust grains are very small and the gas concentration is comparatively low, statistical fluctuations in the populations must be taken into account. A fully stochastic treatment of this process has been developed which predicts significantly lower growth rates of dust particles in certain environments.

Poster-ID: LE-2

### Collision Dynamics of Decimetre Ice and Dust

Johannes Deckers
*Fakultät Physik, Universität Duisburg-Essen, Germany*

Decimetre bodies play an important role in the different models for the growth of km-sized objects, the so-called planetesimals. Planets are formed from these planetesimals by accretion. The formation processes involved in the growth of the planetesimals is not understood in detail, yet. Different models have been developed to describe planetesimal growth, which one can roughly divide into two main groups. One group considers growth by coagulation in mutual collisions and the other group gravitational collapse in regions of high particle concentrations. Collision dynamics of decimetre bodies are important for both these groups as these bodies are the direct precursors to metre-sized bodies and are believed to be strongly effected by particle concentration mechanisms. Previous experiments on mutual collisions of decimetre dust showed that the threshold between bouncing and fragmentation lies at a specific kinetic energy of 5 mJ/kg. We performed collisions of centimetre dust projectiles onto decimetre dust targets in order to expand these experiments and investigate the threshold to catastrophic disruption. In these experiments we found, that the fragmentation strength of decimetre dust agglomerates lies at 190 mJ/kg. Furthermore, we found mass gain of the target for lower collision energies and analyse the dependency of the accretion efficiency on collision parameters. Analysis of the projectile fragments lead to a power law size distribution with exponent -3.77, which is in good agreement with simulations as well as other experiments. In addition to that we will show preliminary results of collision experiments of icy bodies in the decimetre range. Here, we will analyse the threshold conditions for fragmentation and the collision dynamics of solid ice bodies.

Poster-ID: LE-3

## Depletion of volatile lithophile elements in the inner solar system: Clues from evaporation experiments

Marko Gellissen
*Institut für Geowissenschaften, CAU Kiel, Germany*

Depletion of volatile lithophile elements like Na, K or Mn is typical of solid matter in the inner solar system and occurs at all scales from large planets to tiny chondrules, a major component of undifferentiated bodies. There are two extreme possibilities: evaporation of volatiles from solids or liquids or incomplete condensation from a gas of solar composition. The present experiments are designed to shed light on the evaporation mechanism. For this purpose we have performed a large number of evaporation experiments with solid and liquid silicates at controlled temperature (T), pressure (p) and oxygen fugacity (fO2). Early results showed that heating experiments with initially compositionally different samples in one furnace led to a uniform level of volatiles in all samples, after a few hours of run duration, apparently mediated through the ambient gas phase with evaporation and recondensation processes. The total losses of volatiles increase with run duration and T, and decrease with p and fO2. Na losses exceed K losses and all samples show surface depletion within the first 200 micrometers. The depletion of volatiles in bulk meteorites is more likely the result of incomplete condensation as similar depletions of Na and Mn observed in many meteorites cannot be the result of evaporation according to the results of our experiments.

Poster-ID: LE-4

## Experimental investigation of small ice particles in the context of planet formation

Tim Jankowski
*University of Duisburg-Essen, Germany*

In the past years the role of ice particles in the process of planet formation drew more and more interest. Theoretical studies of ice supported growth near or beyond the snow line often lack in models with experimentally determined properties of ice and ice-coated dust particles. We developed an experimental setup to create small ice particles by injecting water into a vacuum chamber with pressures below the triplet point pressure of around 6 mbars. The freeze desalination results from (partly) evaporation of the injected water droplets. Depending on the setup variables used, the particle size can be varied and a continuous flow of ice particles can be produced. On the basis of the 'lighthouse' experiment by Teiser et al. we can investigate the produced ice aggregates in terms of e.g. structure and porosity. In this talk we like to present first results of our ice studies.

Poster-ID: LE-5

## Abrasion of cm-sized dust agglomerates: A source of small dust agglomerates in the protoplanetary disk

Stefan Kothe

*Institut für Geophysik und extraterrestrische Physik, Germany*

The ongoing progress of laboratory experiments and simulations in the field of protoplanetary dust growth has enabled us to draw a better picture of the very first steps of planet formation. Current experiment-based models predict the outcome of collisions between agglomerates, depending on their collision velocities, masses, and porosities. They basically distinguish between collisions which lead to mass gain and loss, and can be neutral in terms of growth as well. Recent simulations have shown that the growth beyond agglomerates of cm-size can be suppressed by the latter effect. This is often referred to as the "bouncing-barrier". However, the behavior of rebounding cm-sized dust agglomerates has only been studied in individual or a rather small numbers of consecutive collisions. To improve our current knowledge of this important collision type, we performed parabolic flight experiments to study the outcome of a large number of successive collisions at velocities of approx. 6 - 17 cm/s. We found that individual collisions appear to be neutral in terms of growth, whereas the average agglomerate size is decreasing over time. This result requires the introduction of a new abrasive effect into our dust collision model to describe collisions between the bouncing and fragmentation regime. Since this effect produces a large number of small dust fragments, it represents a source of small particles which can grow new agglomerates by direct sticking or add to the mass of existing agglomerates by mass transfer. However, abrasion only affects the surface of the agglomerates and estimates show that the particles will not be destroyed entirely. Furthermore, abrasion might be a source of small dust agglomerates ($\leq 100$ $\mu$m) visible in the observed spectral energy distribution of protoplanetary disks.

Poster-ID: LE-6

## Microgravity experiment on photophoresis of micro-particles

Markus Küpper

*Universität Duisburg Essen, Germany*

Illuminated aerosols in low pressure environments experience photophoretical forces, which can dominate the motion of these particles in planetary atmospheres and protoplanetary disks. Here we present the results of drop tower experiments measuring the photophoretic force for micrometer-sized basalt grains and aggregates. It is found that the particles preferentially move along the direction of the illumination, even in the absence of gravitational aligning torques. This implies that delta-T-photophoresis is dominating in the micrometer size range and delta-alpha-photophoresis was not observed. However, some particles also move sidewards or towards the light source. This offers different possibilities for the absolute and relative motion of dust and its evolution at the surface or inner edge of protoplanetary disks.

Poster-ID: LE-7

## Photophoretic Strength on Chondrules

Christoph Lösche
*Universität Duisburg-Essen, Germany*

Photophoresis can transport particles in optical thin parts of a protoplanetary disk such as the inner edge and optical surface region. For improved transport models we quantified the equilibrated strength of photophoresis in the free molecular flow regime for a set of chondrules as a basic input. Here, x-ray tomography provided all necessary data of surface morophology and composition. We found that the expectation value of the force is a function of the radius of a volume-equivalent sphere and a material parameter specified by the two main components of the chondrule. Particle orientation and inhomogeneity have only small influence. Also results of microgravity experiments carried out in a drop tower are part of the work presented here. As supplement time-dependent studies for spheres are discussed and compared to the drop tower experiements leading to possible Yarkovsky and YORP analogues.

Poster-ID: LE-8

## Collisions between viscous particles and compound chondrule formation

Mathias Schywek
*University Duisburg-Essen, Germany*

Compound chondrules provide evidence that collisions in protoplanetary disks also occurred between solids which were hot and viscous but little is known about this regime. The contact forces, plastic deformation, and viscous relaxation will strongly differ from the conditions during cooler collisions. We started to set up collision experiments of mm-size particles close to the melting point to answer under what conditions viscous particles stick together, bounce of each other or fragment.

Poster-ID: LE-9

## Dust coagulation simulations including water ice

Sebastian Stammler
*Institute of Theoretical Astrophysics, Heidelberg University, Germany*

In recent years a huge progress has been made in the field of dust coagulation. Both, on the side of experiments and in simulations. However, there are still some unresolved issues in creating large planets by coagulation of micrometer-sized dust particles alone, known as various barriers in the scientific community. Simulations so far only implemented dust as silicate particles with their material and collision properties known from experiments. But since there was also a reasonable amount of water in the solar nebula, water ice also has to be taken into account. Water is able to build hydrogen bonds, increasing the sticking probability of ice particles as compared to the pure van der Waals bonds of silicate dust. Furthermore, the presence of water ice increases the surface density of solids outside the ice line leading to a faster growth of particles. I will show some first results of simulations solving the Smoluchowski equation for dust coagulation including water ice and talk about the difficulties that arise by including additional parameters in this method.

## Planet-disk interaction

Poster-ID: PD-1

### Massive planets migrating faster than type-II

Christoph Dürmann
*Universität Tübingen, Germany*

Commonly the migration of planets in protoplanetary disks is distinguished in two different regimes called type-I and type-II migration. Type-I migration occurs for planets with mass less than about 50 $M_{\mathrm{Earth}}$ and type-II migration acts on heavy planets with masses comparable to $M_{\mathrm{J}}$. These planets open a gap in the density profile of the protoplanetary disk in which the density can be rarefied by some orders of magnitude. It is thought that the gap moves with the viscous accretion velocity and that the planet is locked in the middle of the gap. Thus the planet migrates with the viscous accretion velocity. We found in 2-dimensional calculations that massive planets migrate with a rate independent of their mass as expected for type-II migration, but several times faster. Because the gap is deformed while it moves through the disk faster than the viscous accretion velocity, the torques from the inner and the outer disk do no longer cancel out to keep the planet in the middle of the gap. Thus the viscous accretion velocity is no limit to the migration rate of massive planets.

Poster-ID: PD-2

### On the corotation torque for low-mass eccentric planets

Stephen Fendyke
*Queen Mary, University of London, United Kingdom*

Poster-ID: PD-3

### Core accretion in MHD simulations of layered protoplanetary discs

Oliver Gressel
*Niels Bohr International Academy, Denmark*

We perform magnetohydrodynamic simulations of a protoplanetary disc section with an embedded planet core. The disc model assumes a self-consistent and dynamically evolving Ohmic resistivity, which is derived from a sophisticated ionisation model. Before the insertion of the planet core, the resulting configuration consists of a magnetically inactive dead zone and turbulent surface layers. When the embedded planet core of initially 100 earth masses has opened a gap in the disc, we study the ionisation structure and turbulent state of this region, including the circumplanetary disc which has formed around the planet. By determining accretion rates and analysing the flow structure in the vicinity of the planet, we address the important question of what limits the growth of gas giant planets in the classic core-accretion picture.

Poster-ID: PD-4

## Vortex formation and evolution in discs under thermal relaxation and with a high mass planet embedded

Aiara Lobo Gomes
*Max-Planck-Institut für Astronomie, Germany*

Vortices are structures that can be formed in several fluid systems. In the particular case of a protoplanetary disc they are known to play a role for planet formation, angular momentum transport, and type I migration. In this project we study the formation and evolution of vortices induced by a high mass planet embedded in a disc under thermal relaxation. For this purpose we perform 2D-HD simulations of planet-disc interaction using the PLUTO code. We study the lifetime of vortices as a function of the cooling timescale, as well as the migration behavior of both vortices and the high mass planet. Additionally we model the Oph IRS 48 system, a place where a vortex is claimed to be detected by ALMA data.

Poster-ID: PD-5

## Protoplanetary disks including radiative feedback from accreting planets

Matias Montesinos
*Instituto de Astrofisica Santiago de Chile, Chile*

While recent observational progress is converging on the detection of compact regions of thermal emission due to embedded protoplanets, further theoretical predictions are needed to understand the response of the parent disk to the planet formation feedback. Particular attention is required on the observability of the circumplanetary environment. Here we follow the evolution of a luminous Jupiter-mass planet embedded in a viscous protoplanetary disk using 2-D hydrodynamic simulations. We use an energy equation which includes the radiative heating of the planet as an additional mechanism for planet formation feedback. A grid of models is computed for different viscosity prescriptions, and planet luminosities ranging from $\sim 10^{-5}$ to $\sim 10^{-3}$ solar luminosities. We estimate the spectral signature of this feedback, depending on the position of the planet and its luminosity. The emitted spectrum of the disk can be appreciably modified in the infrared region when comparing with simulations without feedback. Particularly, a Jupiter-mass planet emitting at $L_p \gtrsim 10^{-3} \mathrm{L}_\odot$ and initially placed at 10 au modifies significantly the cavity and the spectrum of the disk,making the luminosity of the disk almost 18 times more brighter than the case without feedback ($L_p = 0$). The changes produced by the radiative feedback are mainly due to the extra pressure work done by the planet radiation onto the gas, enhancing the accretion rate across the protoplanetary gap. The conversion of gravitational energy into radiation is more efficient and the disk becomes more hotter and luminous in a region close to the planet. The model is independent of the viscosity prescription, similar results are found for alpha disks, constant viscosity and inviscid models.

Poster-ID: PD-6

## The Role of Disc Self-Gravity on the Orbital Evolution of Circumbinary Planets

Matthew Mutter

*Queen Mary University of London, United Kingdom*

The on-going discovery of planets orbiting two stars by Kepler, has prompted numerous investigations into binary-disc-planet interactions. The picture building-up is that these planets formed further out in these circumbinary discs and migrated inwards, whilst the interactions with the binary causes the disc to become eccentric and the inner region to truncate. The migration of the planets is then halted at this disc-cavity.
The importance of the disc structure and dynamics in shaping the planetary system has been noted in these past works, and understanding the processes which shape the disc are paramount in explaining the observed Kepler circumbinary systems. Our aim in this work is to investigate the role of disc self-gravity and mass play in disc evolution, and the impact on orbital evolution of embedded planets.

Poster-ID: PD-7

## Gas dynamics near giant planetary cores in 3D global simulations.

Giovanni Picogna

*Universität Tübingen, Institut für Astronomie & Astrophysik, Germany*

The time constraint to build up a core of a giant planet before the gas disk removal is very tight in the core accretion scenario. Thus, high accretion rates are necessary to reach the critical mass just in time for the rapid gas envelope accretion to burst in. The most accepted theory is that of planetesimal accretion, which is possibly sped up by the presence of a gaseous atmosphere near the planetary core. However, recently, Lambrechts & Johansen (2012) have proposed also the pebble accretion scenario, which may take place on a much shorter timescale, if the replenishment of pebbles is fast enough to balance their fast inward drift. In order to address this problem and find a more comprehensive solution, it is firstly necessary to understand the gas dynamics near the planetary core location, the planet envelope, and the envelope-disk interactions, since the pebble dynamics and the planetesimal accretion rate strongly depends on them. In particular, we are now able to model global 3D disks where small cores are embedded, which is of paramount importance since the flow becomes inherently three-dimensional as it approaches the planet location. Studying the evolution of low mass cores ($< 3$ Earth masses) in 3D radiative disks, Lega et al. (2013) have found that a 'cold dense finger' develops ahead of the planet just inside of its orbit, and behind the planet just outside of its orbit. This phenomena could have important consequences on the planet orbital evolution favoring its inward migration (Lega et al., 2013), but it could also have an impact on the dust and planetesimal evolution around small mass cores. Moreover, in the low mass regime, the core is not able to carve a gap in the disk; however, it could be sufficiently massive to modify the local gas density profile creating an effective dust gap (Zhu et al., 2014, Goodman & Rafikov, 2001), thus preventing the replenishment of dust to the planet. Finally, as shown by D'Angelo & Bodenheimer (2013), the 3D structure of gaseous envelopes bound to small planetary cores is non–trivial. They found that the interaction of the external flow with the envelope can produce asymmetries in its outer layers, increasing its oblateness. Furthermore, the accretion flow is not spherical, but it enters the envelope preferentially at mid- to high latitudes. The impact of those processes has a strong dependence on the core mass, the disk viscosity, the grain opacities, and the equation of state adopted. I modeled the gas evolution in isothermal and fully-radiative 3D disk with the PLUTO code (Mignone et al., 2012), focusing on the planet location in order to study in detail the gas dynamics, and its dependence on the initial planetary core mass. I present here some preliminary result of my analysis.

Poster-ID: PD-8

## Interpreting brightness asymmetries in transitional disks: Vortex at dead zone or planet carved gap edges?

Zsolt Regaly
*Konkoly Observatory, Hungary*

Recent sub-millimeter observations show non-axisymmetric brightness distribution (with a horseshoe-like morphology) for more than dozen of transitional disks. As of today, two competing scenarios exist to explain this observational phenomenon. Both scenarios assume non-axisymmetric dust accumulation in a large-scale vortex. Vortices can form by the excitation of Rossby wave instability (RWI) in the vicinity of steep pressure gradients, which can develop at the edges of a giant planet carved gap or at the outer edge of accretionally inactive region, called dead zone. An investigation on both scenarios are presented in order to test their viability by means of locally isothermal hydrodynamical simulations. Assuming that the spatial distribution of mm-sized dust particles follow that of the gas given by hydrodynamical simulations, synthetic sub-millimeter images for ALMA interferometer are presented. We found that the vortex formed at the gap outer edge is short-lived (only $\sim 10 - 20 \times 10^3$ yr) due to the viscous evolution of gap edge, unless the disk is not inviscid. Contrary, for dead zone bearing disks, the large-scale vortex are found to be existed for the disk lifetime. Based on the synthetic ALMA images calculated in the planet carved gap (in inviscid case) and dead zone bearing disk models, we conclude that sub-millimeter observations can be better explained by the latter models. Since the presence of a large-scale vortex in protoplanetary disks presumably assists planet formation, sub-millimeter images of non-axisymmetric transitional disks may reveal on-going planet formation. If this scenario is confirmed, construction of a novel theory, 'vortex-aided planet formation' can be supported.

Poster-ID: PD-9

## Effect of Dust Particles on the Type I Migration

Ko Yamada
*School of Political Science and Economics, Waseda University, Japan*

Migration of a low-mass protoplanet in a protoplanetary disc is one of the most important processes to determine the final spatial structure of a planetary system around a star. A protoplanet excites spiral density waves in a protopnateary disc and interacts with them gravitationally. The protoplanet loses the angular momentum and migrates toward a central star. This migration process is called the Type I migration. Recent numerical simulations show that the gravitational interactions of a protoplanet with gas in a horseshoe orbit of the protoplanet become large enough to decrease the migration rate of the protoplanet in a disc. The Type I migration is dependent on the thermal structure of a protoplanetary disc. A protoplanet migrates even outward in a disc with the negative entropy gradient. Dust particles also migrate toward a central star in a disc due to the gas drag in a disc. The migrating dust particles enhance the dust/gas ratio in an inner disc, in which a protoplanet is formed. Dust particles accumulate in the vicinity of a protoplanet and gravitationally interact with the protoplanet. Dust particles could also modify the gas flow around a protoplanet due to the exchange of the angular momentum between the gas and the dust particles. It is essential to take into account the additional torque exerted on the protoplanet by dust particles. In the present study, we examine the effect of dust particles on the Type I migration. We consider a disc consisted of gas and dust in the nearly Keplerian motion around a star. We adopt dust particles that are non-growing spheres and interact with the protoplanet gravitationally. We include the radiative cooling that is responsible for the thermal structure of a disc. We find that (1) the torque exerted on a protoplanet by dust particles becomes positive and (2) the torque increases with an increase in the size of dust particles and/or the gas/dust ratio. This result indicates the significant decrease of the migration rate of the protoplanet. A protoplanet might migrate outward in a dust rich disc.

## Exo-planets and planetary systems

Poster-ID: EP-1

### Extrasolar planets around post-common envelope binaries

Christiane Diehl
*Hamburger Sternwarte, Germany*

We perform hydrodynamical simulations of planets around close binary stars during the common envelope phase. Our goal is to put further constraints on the survival of first-generation planets and discuss the formation of circumstellar disks where second-generation planet formation might occur.

Poster-ID: EP-2

### NGTS: Next Generation Transit Survey

Anders Erikson
*DLR PF, Germany*

NGTS: Next Generation Transit Survey, A. Erikson on behalf of the NGTS Team

The Next Generation Transit Survey (NGTS) is a new ground-based transit survey designed to detect transiting exoplanets down to sub-Neptune size around bright stars. NGTS consist of twelve individual telescopes, each with an aperture of 20cm and a field of view of eight square degrees. It operates in a wavelength range between 550-900nm to maximize its sensitivity to stars of K and early M spectral type. The brightness of the host stars (<13 Vmag) will allow for follow up observations of the detected planets, not only to confirm their planetary nature, but also for further characterization. The system is located at the ESO Paranal site in order to benefit from the excellent photometric conditions as well as follow-up synergy with the VLT and E-ELT. Science operations are due to begin in late 2014.

Poster-ID: EP-3

### Understanding the assembly of Kepler's compact planetary systems

Tom Hands
*University of Leicester, United Kingdom*

The Kepler mission has recently discovered a number of exoplanetary systems, such as Kepler-11 and Kepler-32, in which ensembles of several planets are found in very closely packed orbits (often within a few percent of an AU of one another). These systems present a challenge for traditional formation and migration scenarios, since these planets presumably formed at larger orbital radii before migrating inwards. In particular, it is difficult to understand how some planets in such systems could have migrated across strong mean-motion resonances without becoming trapped, and remaining relatively well-spaced. It is also difficult to explain how such systems remain dynamically cold, as resonant interactions tend to excite orbital eccentricity and lead to close encounters. We present a dynamical study of the formation of these systems, using an N-body method which incorporates a parametrized model of planet migration in a turbulent protoplanetary disc. We explore a wide parameter space, and find that under suitable conditions it is possible to form compact, close-packed planetary systems (such as Kepler-11) via traditional disc-driven migration.

Poster-ID: EP-4

## On the influence of stellar activity on transit timing variations

Panos Ioannidis
*Hamburger Sternwarte, Germany*

We report the results of our study on the effects of stellar activity on the transit timing variations measurements of the planets orbiting around them. As one planet is transiting in front of the parent star, may cross over spots. This can cause deformation of the transit lightcurve, which can lead to miscalculation of the mid-transit time. We investigate the dependence of the measurement from the orbital ratio between the planetary orbit and the stellar rotation period and the type of the star.

Poster-ID: EP-5

## Planetary transit search in young open clusters

Manfred Kitze
*Astrophysikalisches Institut und Universitätssternwarte Jena, Germany*

We present first results of the Young Exoplanet Transitting Initiative (YETI), where we monitor young open clusters in collaboration with small telescopes around the world to detect signals of young transitting planets. Within in total 9 observing campaigns, each selected cluster is observed continously by the telescopes of different geographical longitudes to overcome the disadvantage of long observational gaps, accompanied by ground based observations. The detection of young exoplanets enables us to study consistency of evolutionary models for a very early state (less than 10Myr), which time span is currently not well covered by observational data.

Poster-ID: EP-6

## CARMENES: A new window into exoplanets and their stars

Ansgar Reiners
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Within a few months, the CARMENES project will start surveying 300+ low-mass stars to look for their population of exoplanets. It will be the first instrument to collect time series of high-resolution spectra covering the wavelength range from visual to near-infrared (550-1700nm). The data will allow to find planets of only a few Earth-masses around stars in our immediate neighborhood. The unprecedented wavelength coverage and high data quality will provide information on fundamental stellar parameters, stellar activity, magnetic fields, and star-planet interactions. I will review the potential of the CARMENES survey for exoplanet and stellar research, and summarize the extensive scientific activities carried out in preparation of the CARMENES target sample.

Poster-ID: EP-7

## Formation of a Solar System analogue in a gamma Cephei-type binary system

Zsolt Sándor
*Institut für Astrophysik, Universität Wien, Austria*

The existence of terrestrial planets in the habitable zone of binary stars is of a great importance, since stars are born not alone but as members of binary and multiple systems. Therefore it is worth investigating the formation of terrestrial planets in binary and even in multiple star systems. The formation process is investigated in various configurations of the binary star systems. The main aim of our work is to investigate those orbital configurations, also including a giant planet, which may lead to the formation of terrestrial planets in the habitable zone of one of the stellar components. It has been found that once a large embryo population develops as the end-result of the oligarchic growth, terrestrial planet formation takes place even in mid-separation $\gamma$-Cephei-like binary systems.

Poster-ID: EP-8

## Young directly imaged planet candidates and their age independent mass determination

Tobias Schmidt
*Hamburger Sternwarte, Germany*

About 30 sub-stellar companions with large separations ($>$ 10 AU) to their young primary stars and brown dwarfs are confirmed by both common proper motion and late-M to early-T type spectra. The origin and early evolution of these objects is still under debate. While often these sub-stellar companions are regarded as brown dwarfs, they could possibly also be massive planets, the mass estimates are very uncertain so far. They are companions to primary stars or brown dwarfs in young associations and star forming regions like Taurus, Upper Scorpius, the TW Hya association, Beta Pic moving group, Columba association, TucHor association, Lupus, Ophiuchus, and Chamaeleon, hence their ages and distances are well known, in contrast to free-floating brown dwarfs. Here we present how mass estimates of such young directly imaged companions can be derived, using e.g. evolutionary models, which are however currently almost uncalibrated by direct mass measurements of young objects. An empirical classification by medium-resolution spectroscopy is currently not possible, because a spectral sequence that is taking the lower gravity into account, is only existing for few points in the big temperature, surface gravity regime. This problem leads to an apparent mismatch between spectra of old field type objects and young low-mass companions at the same effective temperature, hampering a determination of temperature and surface gravity independent from models. We show that from spectra of the objects, using the advantages of light concentration by an AO-assisted integral field spectrograph, temperature, extinction, metallicity and surface gravity can be derived using non-equilibrium radiative transfer atmosphere models as comparison and that this procedure as well allows an age independent mass determination in combination with the luminosities found by the direct observations, as has recently been done by us for several young sub-stellar companions, as e.g. around UScoCTIO 108 and PZ Tel. Particularly, however, we would like to present a new sub-stellar companion, found within one of our surveyed associations, whose analysis is currently under way, but will be finished in September, right in time for Planet Formation and Evolution 2014.

Poster-ID: EP-9

## Transiting sub-stellar companions of Intermediate-mass stars

Daniel Sebastian

*Thüringer Landessternwarte Tautenburg, Germany*

We use the CoRoT-survey to search for transiting close-in planets of intermediate-mass stars ($M_* = 1.3 - 2.1 M_\odot$). In this talk we will be presenting the statistics of the transiting companions, found as result of our survey. RV-surveys and direct imaging campaigns showed, that intermediate-mass main-sequence stars have more massive planets then solar-like stars. Even brown dwarfs have been found and many of these stars have planets with masses near the border between planets and brown dwarfs. In our study we concentrated on short-period planets for which a mass-determination is possible. Determining the fraction of close-in planets of intermediate-mass stars is important, because Spitzer observations show that the life-time of the proto-planetary disks of such stars is half as long as the life-time of disks of solar-like stars. The detection of close-in planets of intermediate-mass stars therefore would puts strong constraints on the timescales of the formation and migration. Furthermore while determining the physical parameters of such close-in objects we can study the evaporation rate of planets. We already have identified transiting Jupiter-like planet candidates with short orbital periods and observed these candidates with high-resolution echelle-spectrographs at various Telescopes.

Poster-ID: EP-10

## CRIRES+: The 3m/s Planet Finder in the near-infrared

Ulf Seemann

*Institut für Astrophysik Göttingen, Germany*

CRIRES at the ESO/VLT is one of the few adaptive optics enabled near-IR instruments that offer a resolving power of R=100.000 from $1 - 5\mu$m. An instrument upgrade ("CRIRES+") has commenced to implement cross-dispersion capabilities, spectro-polarimetry modes, a new detector mosaic, and a new gas absorption cell. CRIRES+ will boost the simultaneous wavelength coverage of the current instrument ($\sim \lambda/70$ in a single-order) by a factor of >10 in the cross-dispersed configuration, while still retaining a 10 arcsec slit suitable for long-slit spectroscopy. CRIRES+ dramatically enhances the instrument's observing efficiency, and opens new scientific opportunities. These include high-precision radial-velocity studies on the 3m/s level to characterize extra-solar planets and their atmospheres, which demand for specialized, highly accurate wavelength calibration techniques. CRIRES+ thus offers the community to spectroscopically adress a manifold of open questions concerning planet formation and evolution.

This talk outlines the CRIRES+ project opportunities and the instrument upgrade, and discusses the CRIRES+ wavelength calibration strategies to cover the full operational spectral range ($1 - 5\mu$m; absorption gas-cells, hollow-cathode emission lamps, Fabry-Perot étalons) The development of a new absorption gas-cell for high-precision radial velocimetry is highlighted. This cell delivers a dense forest of molecular absorption lines in the H and K bands, and can be used simultaneously or off-line for wavelength calibration.

Poster-ID: EP-11

## Nonlinear Time Series Analysis of Hyperion's Lightcurves

Mariusz Tarnopolski
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Many minor bodies in the Solar System are of irregular shape, i.e. have a non-zero oblateness parameter, e.g. asteroids or some moons. The oblateness, also called the ellipticity, is defined as $\omega^2 = \frac{3(B-A)}{C}$, where $A$¡$B$¡$C$ are the body's principal moments of inertia. These can be estimated based on an image of the body or by means of the lightcurve inversion techniques. An oblateness high enough to exceed the critical value given by the Chirikov Overlapping Criterion, allows the body to be in a chaotic rotational state. This is connected to the existence of a positive maximal Lyapunov Exponent (mLE). Many theoretical works showed that the Lyapunov Time for Hyperion (the biggest known celestial body of such a highly aspherical shape, $\omega^2 = 0.79$, with an orbit of $e \approx 0.1$ around Saturn) is from 1.5 the orbital period $P_{\rm orb}$ ($\approx 21$ d) up to $\approx 7P_{\rm orb}$. However, these results were obtained by means of solving the differential equations describing the satellite's rotation for given initial conditions. We explore the existing in literature photometric observations treating them as experimental time-series in order to estimate the mLE using the Wolf *et al.* and Kantz & Schreiber algorithms. We perform numerical experiments to answer the question how to perform the ground-based observations to obtain the temporal mLE as acccurately as possible.

## Debris disks and host stars in planetary systems

Poster-ID: DD-1

### Bayesian analysis of stellar parameters in PTPS

Michalina Górecka
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Mass is the most important parameter which determines internal structure and evolution of a star. In case of planet searches with the precise radial velocity measurements technique the stellar mass is required to estimate the minimum mass of a planetary companion. Precise mass determinations for stars are not simple, though. Best stellar mass measurements come form the Third Kepler Law which describes motion of two orbiting bodies. In the case of eclipsing binaries masses can be measured with an accuracy that depends on the quality of observational data only. Unfortunately for planet search targets, typically single stars, astronomers have to apply other methods. Indirect stellar mass estimates usually use other characteristics adequate to the evolutionary stage i.e.: for the main sequence star the Eddington mass-luminosity relation, for white dwarfs the mass-radius relation and so on. Another approach to estimate stellar mass is to compare stellar evolutionary models with available observational data delivered: detailed spectroscopically determined atmospheric parameters, photometry and parallaxes. One can choose between interpolation between stallar tracks (isochrones) or statistical methods based on bayesian probability. Here I will present estimates of masses, luminosities,radii and ages for 348 stars from the ongoing PennState-Torun Centre for Astronomy Planet Search based on bayesian analysis.

Poster-ID: DD-2

### Chemical composition of extrasolar planetary systems

Detlev Koester
*ITAP, Kiel University, Germany*

Approximately 25% of white dwarfs show heavy elements in their atmospheres. Because of very short gravitational settling times these cannot be primordial, but must be provided from an external source. Current consensus is that this source is a debris disk resulting from the tidal disruption of rocky material like asteroids. The analysis of the elements in the white dwarf photosphere thus provides direct evidence of the composition of the planetary system around the progenitor star. The current results indicate compositions similar to bulk Earth, but significant individual differences exist.

Poster-ID: DD-3

### A Re-Analysis of Activity in the HARPS M dwarf Sample

Christopher Marvin
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While FGK stars have well-established activity indices such as the Mt. Wilson S-Index and R'HK, M dwarfs lack such a well-defined index primarily due to their lack of flux in the visible and near-UV wavelengths. We re-analyze the HARPS M dwarf sample using a different

technique for measuring chromospheric emission lines. This technique normalizes high S/N template spectra to PHOENIX stellar atmosphere models to obtain measurements of chromospheric lines in physical units. We obtain an activity index for M dwarfs using these chromospheric line measurements. Such an index provides typical activity values of M dwarfs which is suitable for direct comparison with activity values of FGK stars. We also establish an empirical relation of typical radial velocity jitter to activity. Stars with jitter exceeding typical values for their known activity level could possibly harbor planets. An activity index of M dwarfs, similar to R'HK in FGK stars, can be a useful tool for distinguishing between stellar activity and planetary signals.

`Poster-ID: DD-4`

## Disc radii and grain sizes in Herschel-resolved debris discs

Nicole Pawellek
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The radii of debris discs and the sizes of their dust grains are tracers of the formation mechanisms and physical processes operating in these systems. We use a sample of 34 debris discs spatially resolved in various Herschel programmes to constrain them. We focus exclusively on the cold outer discs and exclude warm inner discs (that we identified around about two-thirds of the stars) from our analysis. The disc radii derived from the resolved images reveal a large dispersion, but no significant trend with the stellar luminosity, which argues against ice lines as a dominant player in setting the debris disc sizes. Fixing the disc radii to those inferred from the resolved images, we model the spectral energy distributions to determine the dust temperatures and the size distributions. While the dust temperature systematically increases towards earlier spectral types, its ratio to the blackbody temperature at the disk radius decreases with the stellar luminosity. This is explained by an increase of typical grain sizes towards more luminous stars. The sizes are compared to the radiation pressure blowout limit $s_{blow}$ that is proportional to the stellar luminosity-to-mass ratio and thus also increases towards earlier spectral classes. The grain sizes in the discs of K- to A-stars are inferred to be several times $s_{blow}$ at all stellar luminosities, in agreement with collisional models of debris discs. The sizes, measured in the units of $s_{blow}$, appear to decrease with the luminosity. We discuss possible explanations for this effect.

`Poster-ID: DD-5`

## A Spectro-Astrometric study of bracket gamma emission in Young Stars

Ricardo Ramírez Reyes
*Universidad de Chile, Chile*

Unlike the case of T Tauri stars, the mass accretion onto higher mass young stars (Herbig Ae/Be) and in particular the origin of the HI lines is not completely understood. The HI bracket gamma line is well correlated with accretion luminosity in T Tauri stars, and while the same relation holds for Herbig Ae stars, in Herbig Be the bracket gamma line flux often overestimates the accretion luminosity. HD 100546 is an Herbig Be star with a transitional disk. We observed it with the VLT/SINFONI integral field spectrograph in K band. We have applied the spectro-astrometric technique to the SINFONI observations of the HI bracket gamma emission line in this source. Spectro-Astrometry is a technique used to calculate small variations in the position of the emission as a function of wavelength, with the aim to constrain

the origin of the spectral line in study. We have reached a positional accuracy (rms) of 10-30 micro arcseconds (0.01-0.03 milli-arcseconds), corresponding to the size scale of the stellar radius. We find an asymmetric signal in RA and a S pattern in Dec of amplitude around 0.2 mas. This signal doesn't follow the expectations from a keplerian accretion disk with the same PA as the large scale disk around this source, suggesting an origin either in a stellar outflow or accretion funnels. I will also show preliminary results on a larger sample of sources.

## Planetary interiors, atmospheres and bio-signatures

Poster-ID: IA-1

### Early evolution of atmospheres of earth-like planets

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Evaluating different time-scales for young Earth-like planets we see that the evolution is strongly affected by changes within the protoplanetary disk. Such planets are still embedded in the protoplanetary disk and accumulate gravitationally disk gas and dust particles into planetary atmospheres. Usually, such atmospheres are investigated by hydrostatic models, even though in many cases the assumption of stationarity is unlikely to be fulfilled. Most models rely on the specification of a planetary luminosity, attributed to a continuous accretion of planetesimals onto the surface of the solid core. The atmospheres extend up to the Hill-radius and typically only km-sized bodies can reach the planetary surface to deposit there the remaining kinetic energy, smaller sized bodies are destroyed during their infall through the atmosphere. We present time-dependent, dynamic simulations of the accretion of nebula gas into an atmosphere around a proto-planet and the evolution of such embedded atmospheres while integrating the thermal energy budget of the solid core. Our spherical symmetric models computed with the TAPIR-Code (short for The adaptive, implicit RHD-Code) range from the surface of the rocky core up to the Hill radius where the surrounding protoplanetary disk provides more natural boundary conditions. The TAPIR-Code includes the hydrodynamics equations, radiative transport together with convective energy transport. The results indicate that disk-embedded planetary atmospheres evolve along comparatively simple outlines and in particular settle, dependent on the mass of the solid core, at a characteristic surface temperature and planetary luminosity, quite independent on numerical parameters and initial conditions. For sufficiently massive cores, this evolution ultimately also leads to runaway accretion and the formation of a gas planet.

Poster-ID: IA-2

### The influence of Hydrogen - Helium demixing on Saturn's cooling behaviour and evolution

Robert Püstow
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Despite the enormous progress in undestanding the interior structure of the solar giant planets, the correct description of their evolution remains a serious challenge. The most prominent example is Saturn for which the simplest model of homogeneous evolution yields an age between 2 and 3 billion years (Gyr), i.e. much shorter than the age of the solar system of 4.56 Gyr. It has long been argued that H-He demixing should occur in the interior of Saturn after the planet has cooled off sufficiently. This incident would mark the begin of an inhomogeneousl evolution period in which He droplets sink down and accumulate above the planetary core. Thereby gravitational energy is released which would contribute to the intrinsic luminosity of the planet and prolong its age, perhaps towards the correct value. Such scenarios have been studied in the past (see, e.g.,Stevenson, Salpeter (77), Stevenson et al.(82), Fortney, Hubbard (03), Fortney, Hubbard (04)) on the basis of assumptions for the H-He phase diagram that was unknown for a long time. Recently, various ab initio simulations have revealed details of

the H-He phase diagram (Morales et al. (09), Lorenzen, Holst, Redmer (09), Lorenzen, Holst, Redmer (11), Morales et al. (13)). These new predictions can now be used to study the interior structure and the inhomogeneous evolution period of Saturn in a consistent way. We construct a model to describe the cooling behavior of an inhomogeneously evolving Saturn considering the demixing of hydrogen and helium. Our calculations are performed using both the chemical model equation of state SCvHi-EOS (Saumon, Chabrier, Van Horn (95)) and the ab initio equation of state data tables LMREOS (Nettelmann (12)). We give results for the onset of H-He separation in Saturn, for the first time by using the ab initio EOS data of Lorenzen, Holst, Redmer (11) and Morales et al. (13). We calculate its further thermal evolution considering the descent of He towards the planetary core. The new cooling models yield considerably longer ages of about 3.6-5.25 Gyr. Furthermore, we give predictions for the He concentrations in the fluid layers and their variation with time.

Poster-ID: IA-3

## X-ray/EUV evaporation of hot Jupiter atmospheres

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Intense X-ray and extreme ultraviolet radiation (EUV) of host stars cause strong heating and expansion of the atmospheres of close-in extrasolar planets. This results in a planetary mass-loss. In the most extreme cases a complete evaporation of giant gas planets is possible. Expanded planetary atmospheres have been detected in three nearby systems. However, no commonly accepted model for the absorption signals exists. In an effort to understand planetary mass-loss, we composed a sample of eight systems, in which expanded atmospheres could be detectable by Ly$\alpha$ transit spectroscopy with the Hubble Space Telescope. For these targets we obtained Chandra and XMM-Newton X-ray observations to quantify the high energy irradiation of the planetary atmosphere and the expected mass-loss rates. Furthermore, the observations show that based on the relation between X-ray and Ly$\alpha$ luminosities our targets are suitable for HST Ly$\alpha$ transit observations.

## Observation and data reduction techniques

Poster-ID: T-1

### High accuracy wavelength solution with the use of a Fabry Perot Interferometer

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Accurate wavelength calibration is a cornerstone for any measurement with high resolution spectrographs as it translates the pixel grid of the raw observation into an absolute wavelength scale. Fabry Perot Interferometers provide about 10 times more lines than standard hollow cathode lamps do but give no absolute wavelength scale. However, the dispersion solution of the hollow cathode lamp provides the wavelength for each Fabry Perot peak with a low accuracy of about 100m/s. We count the ?exact? interference number of individual Fabry Perot peaks which allows us to measure the cavity width between the two mirrors as a function of wavelength. This property is expected to be a smooth function and can therefore serve as a calibration curve between hollow cathode lamp and Fabry Perot Interferometer. The calculated Fabry Perot wavelengths from this calibration provide a robust interpolation of the sparse hollow cathode lamp peaks and should improve our knowledge about the dispersion function. By the use of this method we expect to correct the wavelength solution for physical detector defects and tie together the solutions for consecutive spectral orders.

Poster-ID: T-2

### Image reconstruction of circumstellar disks with MATISSE

Rainer Köhler
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MATISSE is a mid-infrared spectro-interferometer at the VLTI that will combine beams from four Unit Telescopes (UTs) or Auxiliary Telescopes (ATs). It will measure closure phases, thus offering the capability for image reconstruction. This will allow us to obtain mid-infrared images with unprecedented resolution, on the order of 20 milli-arcseconds, or a few AU at the distance of the next star-forming regions. With MATISSE, we will be able to observe the regions where planets are forming and image the structure of the disk.

However, interferometric image reconstruction requires many observations to fill the uv-plane. The VLTI offers the possibility to position the ATs at several different stations, which gives much better uv-coverage than fixed telescopes. Since relocating an AT is a time-consuming process, the number of relocations should be kept to a minimum. Observations for image reconstruction therefore require careful planning, to avoid configuration changes that are not really necessary.

We carried out simulated observations with MATISSE, in order to find out the requirements for efficient image reconstruction. We study how many different telescope configurations are needed to obtain sufficient coverage of the uv-plane. We also examine which measurement precision is necessary to reconstruct images suitable for the science goals of MATISSE.

Poster-ID: T-3

# The CARMENES pipeline

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The CARMENES consortium constructs two high-resolution spectrographs (550–1000 nm and 1.0–1.7 $\mu$m) which will start its operation in 2015 at the 3.6 m telescope in Calar Alto (Spain). Designed for an radial velocity precision of 1 m/s, CARMENES will target about 300 M dwarfs to search for low-mass exoplanets in the habitable zone. Our pipeline automatises the image processing and includes calibration, spectrum extraction and radial velocity computation aiming for highest possible precision. We have developed a simplified optimal extraction algorithm for stabilised spectrographs. The radial velocities are calculated with least square template matching. To evaluate the pipeline performance in advance, we run end-to-end tests using forward simulated CARMENES spectra as well as real observations from the HARPS spectrograph. For both, we achieve a precision at the level 1 m/s. The precision might be further improved by combining emission lamp and Fabry Perot etalon spectra to compute the wavelength solution. The spectrum extraction quality might be increased when accounting for the two dimensional shape of the spectrograph point spread function which is neglected in optimal extraction algorithms.

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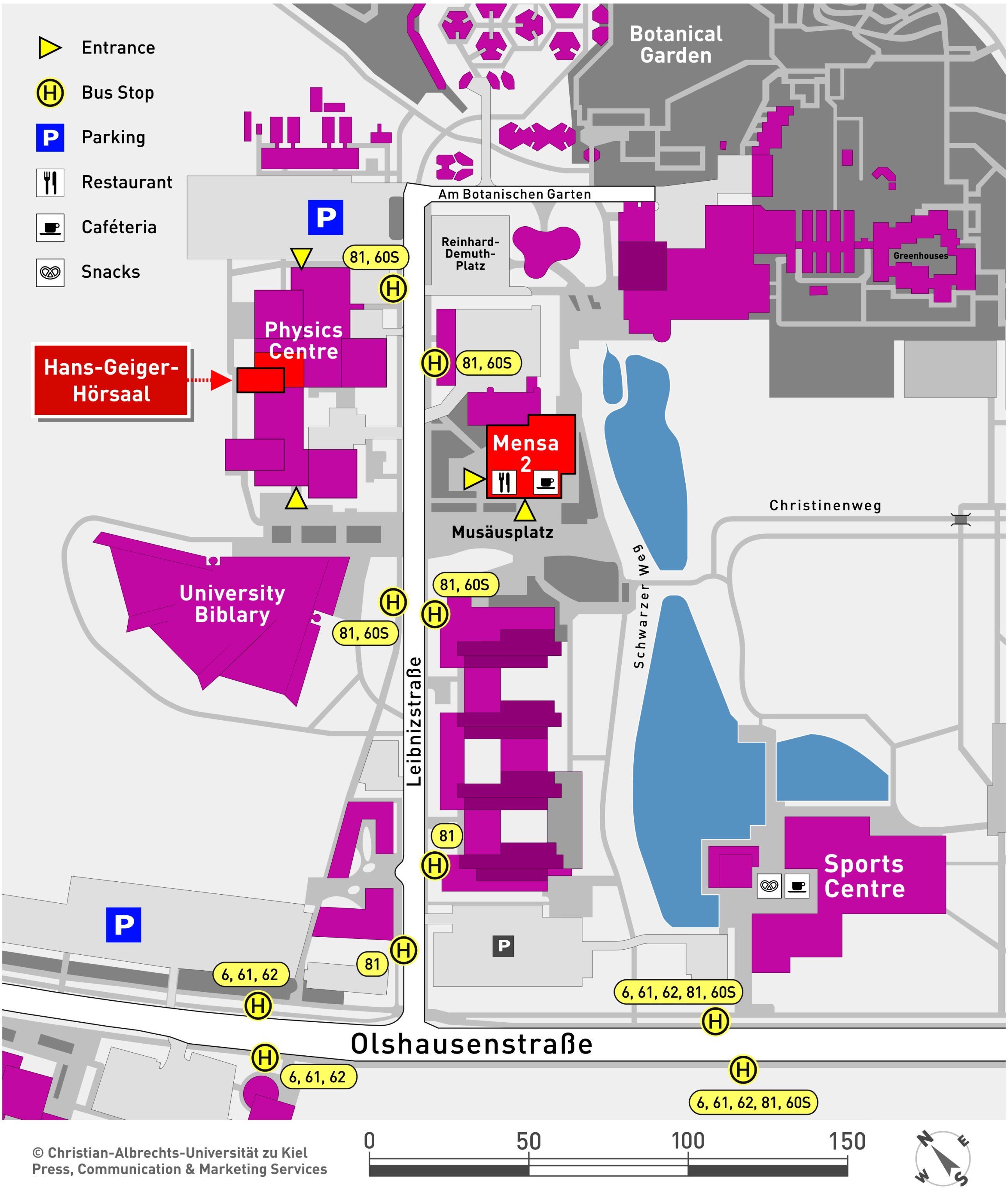
# Campus map



Entrance
Bus Stop
Parking
Restaurant
Caféteria
Snacks
Botanical Garden
Am Botanischen Garten
Reinhard-Demuth-Platz
Greenhouses
81, 60S
Physics Centre
Hans-Geiger-Hörsaal
Mensa 2
Musäusplatz
Christinenweg
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81
Sports Centre
6, 61, 62
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**Bus:** For timetables see **Your Kiel Guide** or following webpage: http://www.kvg.de/en

**LOC:** You can find members of the LOC by looking for their red name tags.

**Lunch break:** We suggest you have lunch at *Mensa 2*, which is located near the Physikzentrum. The campus map will guide you to the building.

**Meeting rooms:** If you need a meeting room, please contact the workshop office.

**Taxi:** Vineta Taxi: +49-431-77070; Taxi Kiel: +49-431-680101

**Webpage of the workshop:** http://www.astrophysik.uni-kiel.de/kiel2014/

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**Workshop office:** The workshop office is located in the Foyer of the Hans-Geiger Hörsaal. It offers a computer workstation with printer and scanner as well as a copier. You may call the workshop office anytime at: **+49-1575-0661235**.