Planet Formation and Evolution:

The Solar System and Extrasolar Planets

2nd to 6th March 2009, Tübingen, Germany

Programme
List of Posters
Abstracts
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1 Programme

Sunday, March 1	
15:00 – 19:00	Registration (at Conference Center)
18:00 – 20:00	Welcome Reception (at Conference Center)

Monday, March 2		
8:15 –	Registration (at Conference Center)	
9:00 – 9:10	W. Kley J. Jochum	Introduction, Welcome by the Vice Dean
Session 1: The Beginning (Protoplanetary Disks)		
9:10 – 9:50	S. Desch	Star Formation Environment as a Control on Planetary Growth
9:50 – 10:10	S. Andrews	High Spatial Resolution Constraints on Protoplanetary Disk Structure
10:10 – 10:30	A. Sicilia-Aguilar	Evolved Protoplanetary Disks: The Multiwavelength Picture
10:30 – 11:00	Coffee Break	
11:00 – 11:20	S. Renard	Milli-arcsecond Imaging of the Inner Regions of Protoplanetary Disks
11:20 – 11:40	S. Hügelmeyer	1D and 3D radiative transfer in protoplanetary disks
11:40 – 12:00	P. Weise	Radial-velocity planet-search survey of stars with circumstellar disks
12:00 – 14:00	Lunch Break	
Session 2: Physics and Chemistry of Disks		
14:00 – 14:40	R. Klessen	Formation and Evolution of Protostellar Disks in Star Clusters
14:40 – 15:20	L. Mayer	Formation of giant planets via disk instability; current status and new prospects
15:20 – 15:40	D. Semenov	Modeling and Observations of the Chemical Evolution in Protoplanetary Disks
15:40 – 16:40	Poster-Session and Coffee Break	
16:40 – 17:00	F. Meru	Self-gravitating disks with radiative transfer: their role in giant planet formation
17:00 – 17:20	G. Mamatsashvili	Vortices in self-gravitating gaseous disks
17:20 – 17:40	H.H. Klahr	Towards a population synthesis model for “direct imaging planets”
17:40 – 18:00	I. Thies	Enhanced coagulation in tidally perturbed protoplanetary disks

Tuesday, March 3		
Session 3: Dusty Growth		
9:00 – 9:40	G. Wurm	Experiments on dust growth
9:40 – 10:20	H. Tanaka	Growth of Dust Aggregates and Planetesimal Formation
10:20 – 10:40	A. Kospal	The relationship of debris disks and planet formation
10:40 – 11:00	Coffee Break	
11:00 – 11:20	S. Krivov	From Observations of Debris Dust to Properties of Planetesimals
11:20 – 11:40	H. Nagahara	Importance of heterogeneous condensation on dust growth and planetesimal formation
11:40 – 12:00	C. Ormel	Runaway growth processes in protoplanetary disks
12:00 – 12:20	R. Schräpler	The physics of protoplanetary dust agglomerates: Erosion by the impact of micron sized grains
12:20 – 14:00	Lunch Break	
Session 4: Radial Mixing and Transit Planets		
14:00 – 14:40	F. Ciesla	Radial Transport of Materials in Protoplanetary Disks: The Solar Nebula and Beyond
14:40 – 15:20	M. Trieloff	Radial mixing in the early solar system: Meteoritic and cometary evidence
15:20 – 15:40	N. Dzyurkevich	Conditions for planet formation in the dead-zone: 3D global MHD simulations with ZeusMP
15:40 – 16:10	Coffee Break	
16:10 – 16:30	V. Hoffmann	Martian meteorites and magnetism: do we really understand the SNC magnetic record
16:30 – 16:50	G. Laibe	3D SPH simulations of grain growth in protoplanetary disks
16:50 – 17:10	G. Wuchterl	Planet Formation and the CoRoT Planet Census
17:10 – 17:30	E. Simpson	The discovery of transiting planets from the Super-WASP survey
18:00	Reception by the Mayor in the City Hall of Tübingen	

Wednesday, March 4		
Session 5: Rapid Planetesimal Formation		
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9:40 – 10:20	Y. Amelin	Building a consistent timescale of the early Solar System
10:20 – 10:40	H. Haack	Accretion of planetesimals at different heliocentric distances – constraints and processes
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11:00 – 11:20	N. Haghighipour	Gas Drag-Induced Capture of Planetesimals in the Proto-Atmosphere of a Growing Giant Planet
11:20 – 11:40	M.-M. Mac Low	Planetesimals in Turbulent Disks
11:40 – 12:00	G. Schmidt	Planet Formation in the Inner Solar System: Origin and Nature of Impacting Projectiles
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10:00 – 10:20	R. Neuhäuser	Homogeneous comparison of planet candidates imaged directly
10:20 – 10:40	Niedzielski, Nowak, Zielinski	Current status and recent results from the Pennsylvania – Torun Planet Search
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11:00 – 11:20	B. Fegley	Chemical models of terrestial exoplanets
11:20 – 11:40	C. Helling	Cloud chemistry in cool and compact atmospheres
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11:20 – 11:40	E. Pilat-Lohinger	Resonance Phenomena in the Habitable Zone caused by Giant Planets
11:40 – 12:00	M. Mugrauer	Multiplicity study of exoplanet host stars
12:00 – 12:20	P. von Paris	Extrasolar Planets in the Gliese 581 System – Model Atmospheres and Implications for Habitability
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4 Abstracts – Oral Contributions

Invited Review:

Planetary population synthesis: fundamental properties of synthetic planets and effect of migration

Yann Alibert (1), Christoph Mordasini (2), Willy Benz (3),
(1) Observatoire de Besançon, (2) MPIA Heidelberg, (3) Universität Bern

In this talk, we present results of population synthesis models based on extended core-accretion planet formation models (taking into account disk structure and evolution and migration of the protoplanet, see Alibert et al. 2005, AA, 434, 343). For this, we calculate the evolution of many disk-forming planet systems, assuming initial conditions (in particular disk mass, disk lifetime and metallicity of the system) taken from observations. Taking into account the observational bias introduced by radial velocity surveys, we compare in a statistical way the results of our models and the population of know extrasolar planets. We show that our models are able to quantitatively reproduce the mass and semi major axis of extrasolar planets around solar type stars. We then explore the effect of recent results related to migration of low mass planets, focussing in particular on the population of short-period low mass planets, that may be discovered in the near future by (spatial) transit surveys. Finally, some correlations between disk and planetary properties will be mentioned and presented in more details in a companion presentation by C. Mordasini.

Invited Review:

Building a consistent timescale of the early Solar System

Yuri Amelin,
The Australian National University, Research School of Earth Sciences

Recent discoveries in cosmochemistry overturned the previously accepted image of the solar system formation by gradual cooling of a molecular cloud, and sequential condensation of ever larger lumps of matter: mineral grains, chondrules, planetesimals, and finally planets. Instead, it is seen as a complex assembly of hot and cold domains, differentiating small planets and pristine dust, that coexisted and interacted for a short period of less than 10 million years. Understanding the nature of their interaction is impossible without accurate knowledge of the sequence and duration of the early Solar System processes. The time markers for these events are provided by abundances of short-lived (now extinct) isotopes, by accumulation of radiogenic Pb isotopes from decay of U and Th, and by isotopic composition of Sr, which is "fossilized" in minerals and rocks.

Using multiple isotopic chronometers in which parent-daughter pairs are fractionated in different processes, greatly enhances the versatility of the timescale construction. But we have to verify the consistency of chronometer readings dating select meteorites in which the same parent-daughter nuclide pairs fractionated in the same event. Angrites, and some eucrites, are the best candidates for this consistency test. Comparative chronological studies of these meteorites using U-Pb, ^{182}W-^{182}Hf and ^{53}Mn-^{53}Cr methods show good agreement, but there are still unexplained discrepancies between chronologies of differentiated meteorites and chondritic components (chondrules and CAIs).

High Spatial Resolution Constraints on Protoplanetary Disk Structure

Sean Andrews,
Harvard-Smithsonian Center for Astrophysics

I will present some preliminary results from a high spatial resolution (0.3″) Submillimeter Array survey of protoplanetary disks in Ophiuchus and the TW Hya association. Because of their sensitivity to the amount and structure of disk solids, resolved submillimeter continuum data provide unique access to the physical conditions in disks, including in particular the spatial distribution of mass on scales relevant to the planet formation process (30 AU and 12 AU for Ophiuchus and TWA sources, respectively). A simple 2D structure prescription and radiative transfer calculations are used to simultaneously reproduce the submillimeter visibilities and broadband spectral energy distribution for each of the disks in our sample. In general, we find that the surface densities vary as $\sim 1/R$ with an exponentional taper near the outer edge; the constraints are significantly improved compared to previous lower-resolution studies. The implications of these structure measurements will be discussed in the contexts of the viscous evolution and planet-forming potential of disk material.

Gas accretion onto planetary cores: three-dimensional self-gravitating radiation hydrodynamical calculations

Ben Ayliffe,
University of Exeter, School of Physics

We have investigated gas accretion by planetary cores using three-dimensional self-gravitating radiation hydrodynamical calculations able to resolve the accretion process down to the surface of the solid core. Past calculations of this process can be separated into one of two categories. There have been one-dimensional quasi-static models that ignore the three-dimensional structure of the protoplanetary disc in which the core is embedded and neglect the complex three-dimensional hydrodynamical interaction of the core with the disc. Alternately, there have been three-dimensional hydrodynamical calculations of the process which typically neglect self-gravity, radiative transfer, and/or do not resolve the flow far inside the Hill sphere of the planetary core. Our calculations are the first to model this process self-consistently and not make any of the above approximations. The calculations are performed using a smoothed particle hydrodynamics (SPH) code that includes radiative transfer in the flux-limited diffusion approximation.

We compare our accretion rates with those obtained from past three- dimensional hydrodynamical but locally-isothermal calculations and with one-dimensional quasi-static models of core accretion. As expected, radiative transfer leads to lower accretion rates than those obtained using locally-isothermal three-dimensional hydrodynamical calculations. However, somewhat surprisingly, we find that our results are in good agreement with previous one-dimensional models, despite the additional complexity of our calculations. We also examine the effect of reduced envelope grain opacities on the gas accretion rates.

Type I planetary migration in radiative disks

Clement Baruteau,
Astronomy and Astrophysics Department, UCSC

A low-mass planet embedded in a protoplanetary gaseous disk experiences a torque from the disk that leads to its orbital decay toward the central object. This process, known as type I planetary migration, plays a major role in the building up and evolution of planetary systems. Disk-planet studies are challenging to provide accurate estimates of the migration timescale so that predictive scenarios of planetary formation and evolution may be elaborated. In this communication, I will show you how far the radiative properties of the disk can affect type I migration.

Near-infrared integral-field spectroscopy of the young AB Pic B planetary mass companion

M. Bonnefoy (1), G. Chauvin (1), P. Rojo (2), A.M. Lagrange (1), C. Dumas (3), F. Allard (4), J-L Beuzit (1),
(1) Laboratoire d'Astrophysique de Grenoble, (2) Departamento de Astronomia. Universidad de Chile, (3) ESO, Santiago Chile

In 2005, using the VLT/NACO AO spectro-imager, Chauvin et al. detected a faint and red companion candidate to the young (30 Myr), nearby (47 pc) star AB Pic, member of the Tuc-Hor association. Follow-up observations enabled them to confirm the companionship of AB Pic B and to initiate its photometric and spectroscopic characterization. Based on K band low-resolution spectroscopy, the authors derived a L1+1-2 spectral type corroborated by the red JHK colors. Evolutionary models place the object at the planet-brown dwarf boundary with a predicted temperature of $T_{\rm eff} = 1700\,{\rm K}$. At a projected physical separation of 260 AU, gravitational instabilities within a protoplanetary disk or mechanisms proposed stars and for brown dwarfs formation appear to be the more probable scenarios to explain the origin of wide planetary mass companions such as AB Pic B.

We recently obtained J, H and K band medium-resolution spectra ($R = 1500 - 2000$) of this companion with the VLT Near-Infrared Integral Field Spectrograph (SINFONI). I will present the first results on the spectral analysis conducted in the near-infrared range at medium resolution. Comparison of our spectra with libraries of young and old late dwarfs spectra confirms the previous spectral type estimation. The careful use of synthetic atmosphere spectra enabled us to determine more precisely the surface gravity and the effective temperature of AB Pic B. In addition to intermediate-gravity features confirming its youth, I will therefore present a refined analysis that lead us to firmly constrain the physical properties (mass, luminosity, radius) of AB Pic B as well as its potential origin of formation.

Invited Review:

Radial Transport of Materials in Protoplanetary Disks: The Solar Nebula and Beyond

Fred J. Ciesla,
The University of Chicago

Radial transport and mixing have long been thought to have played a role in shaping primitive materials in the solar nebula. Chondritic meteorites, the left over remnants from our solar nebula, contain materials that formed in distinct physical and chemical environments and were brought together to be intimately mixed on fine scales. These objects, however, only sample parent bodies which reside in the asteroid belt – thus the scale of mixing that was considered was relatively small. More recently, the Stardust mission has shown that the refractory grains in Comet Wild 2 have a common origin with chondritic components. This would indicate that radial transport occurred over distances of tens of AU, allowing grains that formed in the inner solar nebula to be carried outwards to the regions where comets formed. Astronomical observations of disks around young stars suggest such mixing may be a fundamental consequence of protoplanetary disk evolution, as high-temperature materials (e.g. crystalline silicates) are observed at elevated abundances in the cool outer regions around young stars. I will highlight the effects that both inward and outward transport has on primitive bodies and discuss the latest models that have be developed to explain how such transport may have occurred.

Minimum mass solar nebulae and planetary migration

Aurélien Crida,
DAMTP, University of Cambridge

The Minimum Mass Solar Nebula (MMSN) is the protoplanetary disc of smallest possible density from which the planets of the Solar System may have formed. It is built by spreading the planets material around their present positions, and adding gas to restore the Solar composition. In the Nice model, the giant planets formed in a more compact configuration than the present one, leading to a much denser MMSN.

However, planetary migration is not taken into account in the above reasoning. I show that the giant planets of the Solar system could not have survived in the dense nebula derived from the Nice model. In contrast, if they formed on a wider radial range in a less dense disc, their migration drives them to a compact configuration in which migration can be stopped.

Planetary migration therefore has a considerable impact on the MMSN. And the density profile of the MMSN determines the migration speed (and other processes of planet formation). A way out of this conundrum has to be found.

Turning Solar Systems into Extrasolar Planetary Systems

Melvyn B. Davies,
Lund Observatory

Many stars are formed in some form of cluster or association. These environments can have a much higher number density of stars than the field of the galaxy. Such crowded places are hostile environments: a large fraction of initially single stars will undergo close encounters with other stars or exchange into binaries. We describe how such close encounters and exchange encounters will affect the properties of a planetary system around a single star. We define singletons as single stars which have never suffered close encounters with other stars or spent time within a binary system. It may be that planetary systems similar to our own solar system can only survive around singletons. Close encounters or the presence of a stellar companion will perturb the planetary system, leading to strong planet–planet interactions, often leaving planets on tighter and more eccentric orbits. Thus, planetary systems which initially resembled our own solar system may later more closely resemble the observed extrasolar planetary systems.

Invited Review:

Star Formation Environment as a Control on Planetary Growth

Steve Desch,
Arizona State University

The environment in which a protostar forms has a dramatic effect on the protoplanetary disk accompanying the star, and potentially planetary growth as well. Many stars form "quiescently" in low-mass star-forming regions (like the Taurus Molecular Cloud). Their disks are large ($> 100\,\mathrm{AU}$) and are apparently well described by self-similar viscously spreading solutions. Most Sun-like stars, however, form in rich clusters and are exposed to significant UV fluxes; their disks are photoevaporated and are not allowed to spread. I will present evidence that the solar nebula fell into this latter category. I present my revision of the minimum mass solar nebula model (MMSN) that accounts for the starting positions of the giant planets as inferred from the Nice model of planetary migration. I conclude our disk was more massive than the MMSN, with a surface density that fell very steeply with heliocentric radius r, as $r^{(-2.2)}$ [from about 3 to 30 AU]. I show that this is inconsistent with a steady-state alpha accretion disk, but in fact is consistent with a steady-state alpha decretion disk that is being externally photoevaporated at an outer edge. Finally, I demonstrate that this model for a photoevaporated, truncated solar nebula disk is quite favorable for planet formation: the cores of all four giant planets can reach 10 Earth masses before the nebula gas is depleted. Paradoxically, photoevaporation of protoplanetary disks may enhance giant planet formation.

Conditions for planet formation in the dead-zone: 3D global MHD simulations with ZeusMP

Natalia Dzyurkevich,
MPIA Heidelberg

I will present the global 3D MHD simulations of the protoplanetary disk. The models are done with ZeusMP in spherical geometry, where the density stratification can be easily included. The gas is assumed to be locally isothermal, with the temperature profile decreasing with the cylindric radius. The dead zone is included by prescribing a stationary low-ionization area around the midplane. We mimic the 'snow-line' effect by introducing the jump of one order in magnitude for magnetic diffusivity. The small dust grains are described as a passive tracer. We measure the turbulent stresses and the dust diffusion coefficient for different locations in the disk.

Chemical models of terrestial exoplanets

Bruce Fegley, Laura Schaefer,
Washington University Saint Louis, Dep. of Earth & Planetary Sciences

We use thermodynamic calculations to model atmospheric chemistry on terrestrial exoplanets that are hot enough for chemical equilibria between the atmosphere and lithosphere, as on Venus. The results of our calculations place constraints on abundances of spectroscopically observable gases, the surface temperature and pressure, and the mineralogy of the planetary surface.

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

Laure Fouchet,
Physikalisches Institut, Universität Bern

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

Accretion of planetesimals at different heliocentric distances – constraints and processes

Henning Haack (1), Gerhard Wurm (2),
(1) Natural History Museum of Denmark, (2) Institute for Planetology, University of Münster

Differentiated asteroids are more common in the inner parts of the asteroid belt whereas primitive types of asteroids dominate the outer parts. Assuming that ^{26}Al was responsible for heating and melting of asteroids in the early Solar system, the observed zonation suggests that the accretion process was initiated close to the Sun and progressed outward.

The distribution of spectral types of asteroids allow us to constrain the heliocentric distances where accretion to km-sized bodies was early enough that the bodies could either melt, become metamorphosed or only experienced mild heating.

Thermal models of asteroids can be used to determine the latest accretion times where ^{26}Al will be sufficiently abundant to heat the asteroids to the observed levels. Assuming that the asteroid is sufficiently large to minimize surface heat loss the asteroid need to accrete prior to 1.2 My after CAI formation in order to melt, between 1.2 and 3 My to become metamorphosed; and later than 3 My after CAI formation in order to avoid significant heating.

A possible contributing factor to an accretion front that progresses outward from the Sun is photophoresis. Photophoresis pushes particles exposed to the Solar radiation outward. Since there is a net inward drift of particles embedded in the outer optically thick parts of the disk and photophoresis pushes particles out from the inner optically thin parts of the disk, particle densities will build up at the inner edge of the optically thick disk. When the particle density becomes high enough accretion will commence. As the particles are consumed in the accretion process at the edge, the opacity decreases and the edge moves outward.

Gas Drag-Induced Capture of Planetesimals in the Proto-Atmosphere of a Growing Giant Planet

Nader Haghighipour (1), Morris Podolak (2),
(1) IFA-University of Hawaii, (2) University of Tel Aviv

We present the results of a study of the interaction of a growing giant planet with a protoplanetary disk, and discuss the efficiency of the capture of planetesimals in the planet's contracting gaseous envelop. Both models of giant planet formation, namely the core-accretion and the disk instability scenarios, suggest that prior to the last stage of the formation of giant planets, the cores of these objects are surrounded by extended gaseous envelopes. Given that during giant planet formation, Solar System is populated by km-sized and larger bodies, many of these objects may scatter into such proto-atmospheres where their dynamics are affected by the drag force of the gas. We present the results of an extensive study of the interactions of 1 km to 100 km-sized planetesimals with a contracting proto-atmosphere at the late stage of the formation of a giant planet. Although as expected, the giant planet causes the orbits of many planetesimals in its vicinity to become unstable, our simulations show that still a large number of these objects, in particular those in the feeding zone of the proto-planet, are scattered into its gaseous envelope, where they lose a large fraction of their energies and are captured by the planet's core. Our results indicate that the efficiency of capture is size-dependent and under similar dynamical conditions, is higher for smaller (km-sized) objects. We present the results of our simulations within the context of core-accretion and disk instability models, and discuss the capture-efficiency of planetesimals, and their contribution to the growth of the proto-planet and its enrichment in heavy elements.

Cloud chemistry in cool and compact atmospheres

Christiane Helling,
SUPA, St Andrews University

Planets are surrounded by chemically active, cool atmospheres which might form clouds. The cloud formation influences the atmospheric structure due to an increased local opacity and by drastically changing the gas-phase composition. The formation efficiency depends not only on parameters like effective temperature and surface gravity, but also on the initial element abundances. This talk will address recent developments in modelling cloud formation in cool and dense atmospheres.

Martian meteorites and magnetism: do we really understand the SNC magnetic record

Viktor Hoffmann (1,2), E. Appel, M. Funaki, M. Torii,
(1) Institute for Geosciences, University of Tübingen, (2) Faculty of Geosciences, University of München

In recent years, much effort was put in the systematic investigation of the magnetic record of Martian meteorites (SNC). In this way and together with in situ studies of Martian crustal materials our knowledge about the planetary development of Mars, the potential existence of a strong dynamo field during the first $0.5-1$ Gy, the petrogenesis of Mars surface as well as the origin of the strong crustal magnetic anomalies was significantly deepened. The focus of our projects is a systematic survey of the magnetic signature / mineralogy, and petrofabric of Martian meteorites in order to shed light on the effects of shock, alteration/weathering (Martian and terrestrial). The SNC magnetic signature shows a striking variability even within specific groups of SNC's. It also has to be noted that in case of the hot-desert stony meteorite findings "magnetic pollution" caused by hand-magnets is a very serious concern. Lherzolitic shergottites show quite variable magnetic properties which contrasts with the more homogeneous magnetic signature of other shergottite groups or nakhlites. Obviously this behavior is an effect of the high shock degree, mineral neoformation (Fe-Ni metal) and terrestrial alteration. Summarizing, the SNC magnetic record is quite puzzling, and can be really understood only within systematic studies on all known SNC's.

1D and 3D radiative transfer in protoplanetary disks

Simon Hügelmeyer,
Institut für Astrophysik, Universitüt Göttingen

We present our code for the calculation of the 1D structure and synthetic spectra of accretion disks. The code is an extension of the well-tested stellar atmosphere code PHOENIX and is therefore capable of including thousands of atomic and molecular lines. We assume the standard accretion disk model for geometrically thin disks and solve the radiative transfer equation in the vertical direction for a number of disk rings with different radii. The combination of these rings yields the total disk spectrum. Comparison to observations show the capability of our code. Additionally, we will show first results of our 3D radiative transfer calculations. We plan to investigate the effect of rotating disks on the line profile by means of a two-level atom and the coupling between direct irradiation of the central star and disk structure.

Invited Review:

Formation and growth of planets in turbulent protoplanetary discs

Anders Johansen,
Leiden Observatory

Planets form in protoplanetary discs as dust grains collide together and form ever larger bodies. However a major bottleneck occurs for bodies with sizes around a few centimetres or larger. These rocks and boulders have very poor sticking properties and spiral into the star in a few hundred years due to friction with the slower rotating gas. I present the results of numerical simulations of the coupled motion of gas and rocks in protoplanetary disc mid-planes. The relative motion of gas and solids is unstable to streaming instabilities, and the saturated state of the turbulence is characterised by dense particle clumps that are fed by the radial drift of isolated rocks. The clumps are gravitationally unstable and contract on a time-scale of a few orbits to form bodies of several hundred kilometers in size. Magnetic fields may further augment the particle concentrations due to relatively long-lived high pressure bumps that form in magnetorotational turbulence. However, magnetic fields are not crucial to the gravoturbulent formation of planetesimals, rather magnetised turbulence allows collapse to occur for flows that are on the average less affected by the particles.

Towards a population synthesis model for "direct imaging planets"

Hubert Klahr,
MPIA Heidelberg

We demonstrate that direct imaging planetary candidates are plausible outcomes of disk fragmentation.

The fragmentation of massive circumstellar disks is a viable mechanism to form companions provided the cooling time of the gas is shorter than the local dynamical time-scale. We determine the minimum surface density (Toomre-density) necessary for self-gravity to become important and the maximal surface density which would allow for fast enough cooling (Gammie-density) to facilitate the collaps. For the cases where the Gammie-density is larger than the Toomre-density we determine the possibly resulting companion masses as a function of semi major axis.

We adapt 1D vertical structure models of circumstellar disks including self gravity, irradiation from the central object and flux limited diffusion of radiation energy using typical dust opacities for circumstellar disks. We also test the importance of convective energy transport. From the vertical structure models we derive cooling times and Toomre parameters. From the critical surface densities we then estimate the resulting masses of the fragments respectiveley companions.

Companion formation via fragmentation is likely to occur at distances beyond $\sim 40\,\mathrm{AU}$ resulting in companion masses of several Jupiter masses. We show that the mass and semi-major axis of these objects is determined by mass and luminosity of the central object as well as by the metallicity of the disk gas. We also show that recent direct imaging planet candidates are in the right mass range set by the gravitational instability mechanism.

Invited Review:

Formation and Evolution of Protostellar Disks in Star Clusters

Ralf Klessen,
Institut für Theoretische Astrophysik, Universität Heidelberg

The majority of stars in our Galaxy are born in clusters in the interior of turbulent magnetized clouds of molecular hydrogen. We briefly describe the current theories of star cluster formation and investigate the implications for formation and evolution of protostellar disks focusing on their main accretion phase. We report on numerical simulations of molecular cloud fragmentation and analyze the properties of the star-disk systems that build up. We discuss disk morphology and stability and speculate about the consequences for planet formation.

The relationship of debris disks and planet formation

Agnes Kospal (1), David R. Ardila (2), Peter Abraham (3), Attila Moor (3),
(1) Leiden Observatory, (2) Caltech, (3) Konkoly Observatory

The dust in debris disks is generated by collisions among planetesimals. The existence of these planetesimals is a consequence of the planet-formation process, but the relationship between these disks and planets has not been clearly established. We study this relationship by comparing the incidence of debris disks in stars with and without planets, using Spitzer 24 and 70 μm observations to look for thermal emission of cold dust. We analyze the largest sample ever assembled: 149 stars known to have planets by radial velocity methods. We use survival analysis, which allows us to take into account non-detections, to compare the two samples. We found that there is a marginal difference between the two samples: planet-bearing stars have debris disks slightly more often than stars without planets. Analysing the correlation of the excess emission (the sign of debris dust) with the stellar parameters, it seems that - similarly to the presence of planets - the incidence of debris disks is related to the stellar metallicity, supporting the theory about the common origin of planets and debris dust.

From Observations of Debris Dust to Properties of Planetesimals

Alexander V. Krivov, Sebastian Mueller, Torsten Loehne, Harald Mutschke,
Astrophysikalisches Institut, Universität Jena

Debris disks observed around main-sequence stars are believed to derive from star-orbiting planetesimal populations that have accreted at early epochs and survived over the subsequent evolutionary phases, including possible planet formation. These planetesimals bear most of the disk mass and are genetically and dynamically related to planets in the same systems. However, what is only observed is the emission of debris dust steadily produced by the planetesimals through collisional cascade. We show how the visible dust and its invisible parent bodies can be linked together via collisional and thermal emission models of debris disks. By interpreting the observational data through such models, it seems possible to constrain, to a greater or lesser extent, various planetesimal properties. These include masses, locations, and extension of planetesimal belts, the degree of their dynamical excitation, as well as their material strength and composition. We first choose several solar-type stars with infrared excesses to illustrate how this approach works in the unresolved cases. Yet better constraints on the planetesimals can be placed if a debris disk has been imaged. This is demonstrated by our analysis of the debris disk around Vega that makes use of all available unresolved data along with the resolved images of the disk from mid-IR to millimeter wavelengths.

3D SPH simulations of grain growth in protoplanetary disks

Guillaume Laibe (1), Jean-François Gonzalez (1), Laure Fouchet (2), Sarah Maddison (3),
(1) ENS Lyon, (2) ETH Zürich, (3) Swinburne Institute of Technology

We present an analysis of the treatment of grain growth in our 3D, two-fluid (gas+dust) SPH code describing protoplanetary disks. We implement a scheme able to reproduce the variation of grain sizes caused by a variety of physical processes and test it with the analytical expression of grain growth given by Stepinski & Valageas (1997) in simulations of a typical T Tauri disk around a one solar mass star. The results are in agreement with a turbulent growing process and validate the method.

We explore a large set of grain and disk parameters, and identify the relevant quantities acting on the grain size distribution. We finally discuss the implication of the combined effect of grain growth and dust vertical settling and radial migration on subsequent planetesimal formation. In particular, we present a new result showing the grain growth process in a disk with a planet.

Invited Review:

Composition of planets and properties of protoplanetary disks

Katharina Lodders,
Washington University Saint Louis, Dep. of Earth & Planetary Sciences

Aside from a central star, planets are another dense outcome of accumulated elements that were once present in a more or less homogeneous, low-density molecular cloud in the interstellar medium. An intermediate step of planet formation is accretion of condensed and gaseous materials in a planetary accretion disk. The trinity of planetary types – terrestrial planets, gas giant planets, plus the “dwarf planets” among the numerous asteroidal and Kuiperbelt objects – must reflect conditions and processes operating in the planetary accretion disk. Among each-other, the compositions of the terrestrial planets appear similar when compared to the gas giant planets, yet each planet in each quadruplet of the major planetary objects has an unique composition that also needs to be explained by chemical and physical processes during its formation. Since chemical speciation of the elements depends on usually gradual variables such as radiation field, temperature, and density, one can check bulk planetary compositions for compositional gradients with radial distance from the Sun. If these exist, they may point to compositional gradients that had developed in the accretion disk and were subsequently inherited by the planets, and we may expect to find such variations in other planetary accretion disk or planetary systems. On the other hand, obvious or apparent non-systematic variations, for example, in rock- or ice forming elements, must point to other mechanisms that endowed planets with their unique compositions, which may be related to processes within the accretion disk or to post-accretion processing. Whether such variations are random or are regular consequences of certain protoplanetary disk properties may only be possible to tell when planetary systems similar to our own become known.

Ab Initio EOS for Planetary Matter and Implications for Giant Planets

Winfried Lorenzen,
Institut für Physik, Universität Rostock

We have calculated an accurate ab initio EOS for hydrogen, helium, and water by using quantum molecular dynamics simulations. This data is used for modelling Giant Planets like Jupiter, Saturn, but also for some extrasolar planets. The planetary models reproduce all observational data and can also give additional constraints for extrasolar planets e.g. on the mass-radius-relation. An important phenomenon for giant planets and their evolution is the demixing of hydrogen and helium at high pressures. This can be used to explain the lower helium fraction in Jupiters and Saturns atmosphere compared to the protosolar value. In addition, demixing was often used to explain the high luminosity of Saturn.

Planetesimals in Turbulent Disks

Mordecai-Mark Mac Low (1), Chao-Chin Yang (1), Jeffrey S. Oishi (2), Kristen Menou (3),
(1) American Museum of Natural History, (2) University of California, Berkeley, (3) Columbia University

It appears likely that planetesimal formation is mediated by turbulent gas disks. Turbulent density fluctuations can exert gravitational torques on orbiting planetesimals causing them to execute random walks in semi-major axis. We study two aspects of this process in more detail, using shearing sheet MHDcalculations including vertical stratification. First, we examine the effect ofdead zones in the disk midplane, where low ionization fractions result in the suppression of magnetorotational instability. Although active turbulence is confined to thin active layers on the surface of the disk, we find motions throughout the disk sufficient to exert reduced, but still significant, torques at the midplane. These are sufficient to cause diffusion of planetesimals outward as well as inward, counteracting Type I migration, but probably not of full sized planets. Second, we examine how fully turbulent disks change the ellipticity and inclination of planetesimal orbits. We compare unstratified andstratified cases. In both cases, we find that turbulence causes relatively small increases in ellipticity and inclination, probably insufficient to explainthe observed wide range of ellipticities in planetary systems. This is consistent with models that produce observed ellipticities through dynamical interactions after the gas has dissipated. Our results also are relevant to thequestion of whether the magnitudes of average planetesimal collision speeds are high enough to cause breakup rather than accretion.

Vortices in self-gravitating gaseous disks

George Mamatsashvili,
Institute for Astronomy, University of Edinburgh

Vortices are believed to greatly help the formation of km sized planetesimals by collecting dust particles in their centers. However, vortex dynamics is commonly studied in non-self-gravitating disks. The main goal here is to examine the effects of disk self-gravity on the vortex dynamics via numerical simulations. In the self-gravitating case, when quasi-steady gravitoturbulent state is reached, vortices appear as transient structures undergoing recurring phases of formation, growth to sizes comparable to a local Jeans scale, and eventual shearing and destruction due to gravitational instability. Each phase lasts over 2 orbital periods or less. Vortices and density waves appear to be coupled implying that, in general, one should consider both vortex and density wave modes for a proper understanding of self-gravitating disk dynamics.

Our results suggest that given such an irregular and rapidly changing, transient character of vortex evolution in self-gravitating disks, it may be difficult for such vortices to effectively trap dust particles in their centers that is a necessary process towards planet formation.

Invited Review:

Formation of giant planets via disk instability; current status and new prospects

Lucio Mayer,
ETH Zürich

I will review the current status of the disk instability model for giant planet formation. The possibility of fragmentation both at distances larger and smaller than 50 AU from the central star will be discussed, highlighting the importance of cooling and heating as well as the accretion of mass from the surrounding molecular envelope. I will then summarize the current predictions on the masses, orbits and migration of giant planets formed by disk instability, including new results based on simulations that, owing to a spatial resolution imroved by more than an order of magnitude, can follow the collapse of clumps down to a few Jupiter radii. Finally, I will report recent findings by more than one group on the exciting possibility of core formation and envelope enrichment in giant planets formed by gravitational instability. I will conclude by placing the disk instability model in the context of protostellar disk formation, discussing the importance of disk properties at different evolutionaey stages in deciding whether the evantual fragmentation will produce giant planets or much larger objects such as brown dwarfs.

Self-gravitating disks with radiative transfer: their role in giant planet formation

Farzana Meru,
University of Exeter, Astrophysics Group

We present new results on the fragmentation, spiral structure strength and angular momentum transport in self-gravitating accretion discs. The early evolution of massive self-gravitating discs has been considered using cooling parameters to describe the thermodynamics (e.g. Lodato & Rice 2005) and using grid-based radiative transfer calculations (e.g. Cai et al. 2008; Boss 2004). We present results from simulations using a Smoothed Particle Hydrodynamics code with radiative transfer to follow the evolution of such discs in order to simulate more realistically the physical processes of energy transfer that may occur in such massive discs, with particular focus on whether regions of these discs are able to cool sufficiently enough to fragment and form giant planets. With the hope that in the coming years ALMA will observe the evolution of protoplanetary discs undergoing planet formation as well as the presence and strengths of spiral structures in such massive discs, the need to model these discs as realistically as possible is important in order to marry the theories of giant planet formation and disc evolution with observations.

Invited Review:

Why is the Solar System as it is? Turn-points in the evolution of a planetary system

Alessandro Morbidelli,
Observatoire de la Cote d'Azur

I will discuss mechanisms that might explain why the giant planets of the solar system avoided macroscopic migration towards the Sun. I will outline a plausible history of the evolution of the planetary orbits that is consistent with hydrodynamic and N-body simulations. These evolutions are not universal. Changes in the disk parameters or in the mass distribution within the planetary system may drive totally different evolutions. This may provide hints on the origin of the diversity of planetary systems that is observed.

Multiplicity study of exoplanet host stars

Markus Mugrauer,
AIU Jena

We will present recent results of our ongoing multiplicity study of exoplanet host stars. We use seeing limited imaging in the infrared to search for widely separated companions of exoplanet host stars, carried out with SofI/ESO-NTT, and UFTI/UKIRT. In order to be sensitive also for close companions we use Lucky-Imaging with ASTRALUX/2.2m CAHA, as well as, Speckle and AO imaging with Omega-Cass/3.5m CAHA, CIAO/Subaru, and

SDI/VLT. So far, we could find several new stellar and substellar companions of exoplanet host stars of which more than 40 are known today.

We could directly detected for the first time the close companion of the exoplanet host star gamma Cep. The gamma Cep AB systems ($a \sim 20\,\mathrm{AU}$) is one of the closest exoplanet host binaries, presently known.

Beside exoplanet host binaries, we also detected triple star systems with exoplanets, e.g. HD65216A+BC which is the closest exoplanet host triple star system known today.

In addition to normal main sequence stars found as companions of exoplanet host stars, our survey also revealed HD3651B the first T dwarf companion of an exoplanet host star.

Furthermore, we identified evolved exoplanet host stellar systems with white dwarf companions, among them the HD27442AB system. With its subgiant exoplanet host star and its young and hot white dwarf companion this system is the most evolved exoplanet host stellar system presently known.

Gravitational Interaction between a Low Mass Planet and a Viscous Disk and a Possible New Mode of Type I Planetary Migration

Takayuki Muto, Shu-ichiro Inutsuka,
Kyoto University, Departm. Of Physics

We investigate the effects of the viscosity on disk-planet interaction and type I migration. We have performed a linear calculation using shearing-sheet approximation and obtained the detailed, high resolution density structure around the planet embedded in a viscous disk with a wide range of viscosity coefficients. We find that the density structure in the vicinity of the resonance is modified and the main contribution to the torque comes from this region, in contrast to inviscid case. The torque can be a factor of two or three larger than the inviscid case.

In a number of previous works, it has been believed that the torque that originates horseshoe region is important when viscosity effects are taken into account. [E.g., Masset ApJ, 558, 453 (2001)]. In an inviscid case, the distance between Lindblad resonances and the planet position is of the order of the disk scale height [Artymowicz ApJ, 419, 155 (1993)] and the density structure closer to the planet does not contribute to the torque. In this work, we have found that this picture of Lindblad resonance should be changed qualitatively when viscous effects are taken into account. We have found that the structure of Lindblad resonance is modified and the density perturbation in the vicinity of the planet can contribute to the torque. This contribution can be larger than the torque originated in the horseshoe region. This effect has not been observed in most of numerical calculations probably because relatively large softening parameter of gravitational potential tends to eliminate this effect.

Importance of heterogeneous condensation on dust growth and planetesimal formation

Hiroko Nagahara, Kazuhito Ozawa,
Tokyo University

Dust is the primary component of the solar nebula, which coagulated to grow into planetesimals. Although the conventional condensation theory *a priori* considered independent grains for various phases, homogeneous condensation requires larger degree of supercooling for condensing phases. Heterogeneous condensation, where condensing phases except for the first one grow on previously appeared phase(s), requires smaller degree of supercooling, that is, it requires smaller energy for condensation. Thus, the role of heterogeneous condensation should be evaluated quantitatively to understand dust formation and evolution in the solar nebula.

We have conducted a series of condensation experiments and model calculations for grain formation and growth with particular interests on the relationship between silicates and metallic iron, the two most major phases for terrestrial planets. Our results show that metallic iron condenses onto previously condensed forsterite unless gas cools as rapidly as the chondrule-forming event. Heterogeneous condensation of metallic iron on forsterite results in larger grain size (up to tens on cm depending on the cooling conditions) than generally assumed submicron to micron size, which enables rapid accretion of dusts and planetesimals. Heterogeneous condensation further causes chemical fractionation of the gas due to disturbance of reaction with forsterite and residual gas, and resulted in condensation of SiO_2 or Si-rich amorphous material, which has been found to be present in protoplanetary discs by IR observation. The change of phase and size of dusts affects the temperature of the disc in the radiation field, which further affects the stability of condensed phase. The larger grains with iron mantle on silicate further accelerate coagulation of the dusts to form planetesimals.

Homogeneous comparison of planet candidates imaged directly

Ralph Neuhäuser (1), Tobias Schmidt (1), and Andreas Seifahrt (2),
(1) AIU Universität Jena, (2) Universität Göttingen

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

Current status and recent results from the Pennsylvania – Torun Planet Search

Andrzej Niedzielski,
Torun Centre for Astronomy, Nicolaus Copernicus University

The Pennsylvania – Torun Planet Search is an ongoing project devoted to detection of planets around massive stars. By growing the population of known planets orbiting stars more massive than the Sun we will be able to address such issues as planet formation around massive stars and planetary systems evolution. In my talk I will present current status of the project and the most recent results.

Runaway growth processes in protoplanetary disks

Chris Ormel,
MPIA Heidelberg

Runaway growth (RG) is a coagulation process in which the rate of growth is unequally shared among the (dust) particles, ultimately resulting in the formation of a single massive body that separates from the continuous distribution. Modelling the RG stage is a challenge as several conditions have to be fulfilled: i) since RG is a discrete phenomenon the particle distribution must likewise contain discrete features; and ii) the temporal resolution of the simulation must be capable of resolving the small timescales on which RG takes place. Mathematically, RG can become instantaneous ('gelation') for systems that comprise an infinite number of particles. However, in physical systems the runaway timescale shows a dependence on finite particle number. In this contribution I present a new method for modelling general RG phenomena and test it against theoretical predictions. I further discuss cases where RG is relevant in protoplanetary disks. These include the planetesimal accretion stage, during which gravitational focussing enhances the collision cross section of planetesimals and charge-induced gelation of dust grains.

Invited Review:

New insights in planet migration

Sijme-Jan Paardekooper,
DAMTP, University of Cambridge

Young planets interact gravitationally with the gaseous disc out of which they formed. The resulting torque on the planet causes significant orbital migration, and understanding this process is therefore crucial if we want to relate the current orbit of (extrasolar) planets to their place of birth. Much theoretical work has been done on predicting the direction and magnitude of planet migration in several mass regimes.

Low-mass planets, comparable to the Earth, excite linear waves in the disc, and therefore the resulting Type I migration was thought to be understood in terms of linear theory. The obtained migration rates are very high, and directed inward, suggesting that all low-mass planets end up very close to the central star. However, recent work shows that in fact linear theory is not valid even for the lowest-mass planets, and that Type I migration can be slowed down easily due to non-linear corotation torques.

High-mass planets, comparable to Jupiter, carve deep annular gaps in the disc, which slows down migration. As a result, planets will drift inward (or, in some special cases, outward) on the viscous time scale.

Intermediate mass planets, comparable to Saturn, can migrate very fast when embedded in massive discs. This Type III migration is due to dynamical corotation torques, for which the migration gives a positive feedback on the torque.

For all migration regimes, I will discuss the most recent theoretical insights and their relation with observations.

Resonance Phenomena in the Habitable Zone caused by Giant Planets

Elke Pilat-Lohinger,
Institute for Astronomy, University of Vienna

Observations of more than 300 extra-solar planets enable a classification into

i) single-star single-planet systems,

ii) single-star multi-planet systems and

iii) planets in double star systems.

Most of the extra-solar planetary systems belong to the first class, where the motion of an additional terrestrial-like planet is mainly affected by orbital resonances with the giant planet. I will show the dynamical behavior of planetary orbits in the so-called habitable zone (HZ). This is the region around a star, where the conditions for an Earth-like planet are such that intelligent life could be possible. How the dynamical behavior in the HZ might change if more than one giant planet moves outside the zone will be discussed in this talk.

On the formation of multi-planetary systems in turbulent disks

Hanno Rein,
University of Cambridge, Dept. of Applied Maths and Theoretical Physics

Of the recently discovered 334 extrasolar planets, at least 75 are in a multiple planet systems. About 10 % of these are in or very close to a resonant configuration where two planets show a mean motion commensurability, with four systems in or near a 2:1 resonance. Resonant configurations can be established by dissipative forces acting on the planets which lead to convergent migration.

We clarify the response of those systems in a 2:1 mean motion commensurability to stochastic forcing, with planet masses ranging from the super Jovian range to the terrestrial range. The stochastic forces could result from MRI (magneto rotational instability) driven turbulence within the protoplanetary disk but our treatment is equally applicable to any other source. Although we cannot observe turbulent disks directly, stochastic forcing may have played an important role in shaping the configurations of observed systems in mean motion resonance.

We develop an analytic model of stochastically forced planets in mean motion resonance and verify it with numerical simulations. We show that stochastic forcing readily produces systems in mean motion resonance with broken apsidal corotation. As one example, we show that turbulence naturally provides an explanation of the configuration of the HD128311 system.

With the presented framework, further observations of extrasolar planetary systems with better statistics and accuracy may lead to an improved situation for assessing the role of turbulence in the early stages of planet formation.

Milli-arcsecond Imaging of the Inner Regions of Protoplanetary Disks

Stéphanie Renard (1), Fabien Malbet (2,1), Eric Thiébaut (3), Jean-Philippe Berger (1), Myriam Bénisty (4),
(1) LAOG, (2) Caltech, (3) CRAL, (4) Arcetri

Planets are believed to form in circumstellar disks around newly born stars at distances that range between 0.1 AU to 10 AU. To conduct observations of these objects at the milli-arcsecond scale, infrared interferometry will provide the right performances for T Tauri, FU Ori or Ae/Be stars.

However, the information obtained so far are scarce visibility measurements which can only constrain a priori theoretical models. With the outcome of recent multi aperture interferometers, we can now reconstruct images of the close environments of these young stars reconstructed independently of any models like what is done routinely in the radio domain.

In this contribution, we analyze the results of MIRA, an image reconstruction algorithm developed for optical interferometry, on interferometric data obtained on a variety of young stellar objects and discuss the consequences on the models which have been used so far.

Planet Formation in the Inner Solar System: Origin and Nature of Impacting Projectiles

Gerhard Schmidt,
Mainz

In early days of planetary evolution dust and small particles accumulated layer by layer. At a later stage of planet growing collisions of large impactors melt and vaporize the impactor and the growing planet it strikes. From ancient surfaces of solid planets (and the moon) we can learn that impact cratering is a major process in planet formation. Understanding the origin and the influence of impactors on the chemical composition of planets it is important to know the relative abundances of highly siderophile elements (HSE: Os, Ir, Ru, Pt, Rh, Pd) in the mantle and the crust of a planet. On Earth the element ratios of Rh/Ir, Ru/Ir, Pd/Ir, and Pt/Os derived from the primitive upper mantle (PUM) are in agreement of the ratios measured in group IV iron meteorites. The question raises if HSE in mantle rocks are added to the accreting Earth by a late bombardment of iron meteorites or some unsampled inner solar system materials from formation regions closer to the sun (Mercury-Venus region), as it is supposed for enstatite chondrites and not sampled through meteorite collections. The HSE and Ni systematics of the upper continental crust (UCC) closely resembles group IIIAB iron meteorites (many impact craters on Earth are produced by this type of iron meteorite projectiles), pallasites, and the evolved suite of Martian meteorites, possibly representing the elemental pattern of the Martian crust. Probably Martian crust and Earth crust preserves an imprint of similar materials. About 160 impacting asteroids (M-type objects) with radii of 10 km would yield the total abundances of HSE and Ni in the UCC. In fact the first meteorite of any type ever identified on another planet by NASA's Mars Exploration Rover Opportunity was an iron meteorite.

The physics of protoplanetary dust agglomerates: Erosion by the impact of micron sized grains

Rainer Schräpler, Jürgen Blum,
Institut fur Geophysik und extraterrestrische Physik, TU Braunschweig

Collisions between micron-sized grains and large agglomerates with relative velocities up to several 10 m/s are believed to be an important physical processes in protoplanetary nebulae. We present experimental results on the erosion of macroscopic agglomerates consisting of micron-sized spherical particles via the impact of micron sized particles. The experiments cover a velocity range from 15 m/s to 60 m/s. We find that after an initial phase, in which an impacting particle erodes up to 10 particles of an agglomerate, the impinging particles compact the agglomerates surface, which passivates the agglomerates against the erosion. Due to this effect the erosion halts within our error bars for impact velocities up to 30 m/s. For larger velocities the erosion is reduced by an order of magnitude. The influence of charging of the impactors and the target is discussed.

Modeling and Observations of the Chemical Evolution in Protoplanetary Disks

Dmitry A. Semenov,
MPIA Heidelberg

In my presentation, I will overview recent advances in our understanding of the chemical evolution of planet-forming disks by means of radiointerferometric observations and modeling. The freshly new results of the "Chemistry in Disks" (CID) collaboration between Heidelberg, Bordeaux and Jena groups on the disk ionization structure will be discussed. In addition, the role of high-energy stellar radiation and transport processes will be highlighted, with an emphasis on formation and destruction of organic species.

Evolved Protoplanetary Disks: The Multiwavelength Picture

Aurora Sicilia-Aguilar,
MPIA Heidelberg

Multiwavelength studies of evolved protoplanetary disks reveal a general trend of changes in the IR excesses, accretion rates, and mineralogy, suggesting grain growth/settling, photoevaporation, and maybe the formation of planets or planetesimals. Nevertheless, within the average-behaviour picture of disk evolution, we observe strong variations between individuals, which may reveal the influence of different initial conditions, different environments, different stellar and disk masses, and the presence of companions, in the evolution and fate of the disks.

The discovery of transiting planets from the SuperWASP survey

Elaine Simpson,

QUB, Department of Physics and Maths

We present results of the recent photometric and spectroscopic follow-up observations of SuperWASP transiting extra-solar planet candidates. Many secure photometric transits may be caused by several different types of stellar systems and can show behavior mimicking a planet's transit. We use photometric imaging and high resolution spectroscopy to remove these astronomical false positives and characterise the properties, including mass, radius and eccentricity, of the discovered exoplanets. We report on several observing campaigns from across the northern and southern hemisphere to reject planetary mimics and confirm new SuperWASP transiting planets.

Invited Review:

Growth of Dust Aggregates and Planetesimal Formation

Hidekazu Tanaka,
Institute of Low Temperature Science, Hokkaido University

Dust growth by aggregation is an important process as the first step of planet formation in protoplanetary disks. Dust growth also influences the radiation field and/or the temperature structure in protoplanetary disks. However, we still have a large uncertainty in dust growth process. This uncertainty is mainly originated from unknown factors in the structure of growing dust aggregates and their collisional outcomes. It is still unclear what kind of structure dust aggregates have during their growth and how small impact velocity is required for their collisional sticking without major fragmentation. Furthermore, the collisional outcomes would be strongly dependent on the aggregate structure (the porosity, the number of connections among particles in the aggregate, etc.). In recent years, many theoretical studies on aggregate collisions have been done. In this talk, I will introduce remarkable results in these studies, mainly focusing on results by our group.

Enhanced coagulation in tidally perturbed protoplanetary disks

Ingo Thies,
Argelander-Institut für Astronomie, Universität Bonn

The very early stages of planet formation are still full of mysteries. For example, the coagulation timescales from protostellar dust grains to metre-sized planetesimals pose a challenge to the ongoing theoretical research since current models still fail to keep the timescales short enough for the protoplanet to form before the disk disperses after a few million years. Especially the formation of the outer planets of the Solar System, Uranus and Neptune, cannot easily explained by coagulation in quiet disks. As a new ansatz, tidal perturbations due to star-star encounters in young star clusters may induce local temporary overdensities suitable for vortexn trapping. In an SPH simulation I show that such semi-unstable clumps with both prograde and retrograde fast rotation can persist for several hundred years in regions beyond 20 AU, possibly allowing dust grains to be captured in their centre and thus to speed-up the coagulation of some planetesimals.

Invited Review:

Radial mixing in the early solar system: Meteoritic and cometary evidence

Mario Trieloff,
Mineralogisches Institut, Universität Heidelberg

Common arguments for radial outward transport in the protosolar accretion disk (solar nebula) comprise preaccretional high temperature products of sub-cm size in meteorites and comets, e.g. the high abundance of crystalline silicates from comet observations, and the presence of refractory grains (forsterite, Ca,Al rich grains) in dust samples returned from comet Wild-2. In primitive meteorites, both Ca,Al rich inclusions (CAIs) and chondrules are high temperature products that formed during early disk evolution in yet largely unspecified high temperature processes. However, chondrules are likely to have formed by local flash heating processes, and their chemical complementarity with micrometer sized matrix dust of chondrites requires that mm and micrometer sized particles were not dynamically separated after formation. This makes large scale radial movements unlikely, hence, high temperature processing alone is a priori not a compelling argument for radial outward transport.

For CAIs, the situation is different: they constitute an independent chemical component (concerning major, trace elements and isotopic composition, e.g. in oxygen), that adds up to bulk chondrite chemistry. Moreover, their abundance is extremely variable, and their size (cm) makes them susceptible to radial transport, and it lasted a few million years between CAI formation and incorporation into larger chondritic planetesimals, so large scale movements are likely. Nevertheless, an essential point in future modeling efforts and interpretation of observations of high temperature products is to distinguish local from global heating mechanisms. Further evidence of radial transport are the variable fractionation patterns of volatile and refractory elements in bulk chondrite chemistry, which indicates high temperature processing (independent from local chondrule flash heating) and gas-solid separation within first few Ma. The homogeneity of short-lived isotopes (e.g., 26Al) is most probably a precollapse feature, inherited from the giant molecular cloud, and hardly useful to constrain radial mixing processes.

On the other hand, there are arguments against complete mixing in the early solar nebula: the incomplete volatile-refractory equilibration, heterogeneity in oxygen (and other) isotopic compositions, and the preserved chemical complementarity within individual chondrite groups. Hence, the major task of future models will be to evaluate and quantify the relative contributions of different mechanisms capable to produce radial outward transport and solid gas-fractionations, in order to explain these observations as a whole.

Invited Review:

Extrasolar planets: an emerging population of Neptunes and super-Earths

Stephane Udry,
Geneva

High-precision radial-velocity measurements are unveiling a population of light planets with masses in the Neptune or super-Earth mass range. The emergence of this population is mainly due to the HARPS search for low-mass extrasolar planets targeting a few hundreds of G and K dwarfs of the solar neighbourhood, and which has been ongoing since 5 years on the ESO 3.6-m telescope. The published low-mass planetary systems demonstrate the sub-m/s long-term stability reached by HARPS. A preliminary analysis of our data reveals the existence of a large population of low-mass ice giants and super-Earths predicted by numerical simulations of planet formation. We indeed detect over 40 candidates having minimum masses below 30 Earth masses, and orbital periods below 50 days. These numbers are preliminary since the existence of these objects has to be confirmed by subsequent observations. However, they indicate that about 30 % of solar-type stars may have such close-in, low-mass planets. A comparison will be made with results from lower mass M dwarf primaries. Some emerging properties of this low-mass population like the period and mass distributions will be discussed, as well as the very high rate of multi-planet systems. I will also discuss the limitations of the radial-velocity method and the associated optimistic perspectives for the future detection of Earth-like planets with radial-velocities alone or in complement to space photometry.

Extrasolar planets in the Gliese 581 system – Model Atmospheres and Implications for Habitability

Philip von Paris, Mareike Godolt, J. Lee Grenfell, Pascal Hedelt, Beate Patzer, Heike Rauer, Barbara Stracke,
DLR, Institut für Planetenforschung

The planetary system around the M star Gliese 581 contains at least two close-in, potentially low-mass planets, GI 581 c and d. In order to address the very important question of their habitability, we performed detailed atmospheric modeling of GI 581 c and d for several planetary scenarios. We used a 1D radiative-convective model to calculate temperature and pressure profiles within these model atmospheres. For GI 581 c, a dry case (no surface water reservoir) and a wet case (assuming an Earth ocean reservoir of liquid water) were considered.

We show here the resulting temperature and pressure profiles within the assumed atmospheres and discuss the implications of our results for the habitability of these two planets.

In all wet case scenarios for GI 581 c except two, we found that liquid water could exist on the surface of the planet. In the dry case scenarios, calculated surface temperatures remained well below 500 K.

Thus, based on our results, we cannot exclude that habitable conditions might occur on GI 581 c.

For all scenarios considered for GI 581 d, surface temperatures were far below the freezing point of water. Thus, our modeling results suggest that GI 581 d is unlikely to be habitable.

Radial-velocity planet-search survey of stars with circumstellar disks

Patrick Weise,
MPIA Heidelberg

Young stars are often not considered as suitable targets for radial-velocity (RV) planet-search programs. The main reasons are the higher stellar activity and stellar rotation as compared to stars of solar-age. In my PhD thesis, I investigate this problem in detail and develop observation and data reduction tools and strategies that help to reveal planets around young stars with the RV technique. I will first give an overview under which circumstances young stars with ages $< 100\,\mathrm{Myr}$ are suitable for RV-surveys.

To overcome the non-flexibility and disadvantages of partially available data reduction tools, I am currently developing a new cross-correlation tool, named MACS (Max-Planck Intitute for Astronomy Cross-correlation and Spectral analysis tool). I will present the current status and advantages of MACS.

Further on, I will show how the current spectral analysis methods for old stars have to be modified and extended to be applicable to very young stars. It is necessary for young stars to analyse photospheric and chromospheric activity in detail and to measure their intrinsic variability, since high stellar activity can also cause RV variations with amplitudes of up to a few hundred m/s. I will discuss some examples for which this is the case.

To complete the overview of my thesis, I will finally show first results on target stars with sub-stellar companions orbiting their host stars within a circumstellar disk.

Planet Formation and the CoRoT Planet Census

Günther Wuchterl,
Thüringer Landessternwarte Tautenburg

To predict and understand the properties of planets in the CoRoT discovery-space we developed a new general theory of planet formation. It provides information about the masses and radii of planets for all evolutionary stages. It goes beyond the usual categorisation of core-instability versus disk-instability models by providing a general framework that contains both approaches.

First we compute all hydrostatic gas spheres that can be thermally and mechanically embedded into gravitationally stable protoplanetary nebulae. From such ensembles of planetary equilibria we derive the initial mass functions of planets for host star masses of 0.4 to 2 solar masses and orbital periods from 1 to 64 days.

Planetary masses are found to be the result of self-gravity selecting particular equilibria. The initial mass functions are generally bimodal with peaks around Jupiter's and Neptune's mass. The peak values in the mass distributions depend most strongly on the host-star mass and somewhat on orbital distance. Generally, masses near Uranus' and Neptune's occur most frequently.

In a second step we solve the quasi-hydrostatic equations of stellar evolution to obtain the planetary radii for ages up to 15 Ga for the entire ensemble of planets obtained in the first step.

Planetary evolution leads to an enhanced bi-modality in the radius-distributions with a gap between peaks near the Jupiter and Neptune values.

In a third step we check the static and quasi-hydrostatic results by fully time-dependent radiation-fluid dynamical calculations with time-dependent convection for particularly interesting cases.

Finally we compare the mass- and radii-distributions at the epoch of observation to the CoRoT-discoveries. We discuss dependencies of planetary properties on orbital distance and stellar host mass and the consequences for planet formation. Based on the results we outline a new physical approach to distinguish between sub-giant planets and super-terrestrial planets to calculate the upper limits for Super-Earths.

Invited Review:

Experiments on dust growth

Gerhard Wurm,
Institut für Planetologie, Universität Münster

Collisions between dust aggregates are the fundamental processes that shape the size distribution of particles in protoplanetary disks. Sticking, rebound, and fragmentation can produce larger bodies or replenish the reservoir of very small dust grains. Collisional evolution is therefore important for the appearance of protoplanetary disks and for the formation of planetesimals and planets. The result of an individual collision depends on the collision velocity, impact parameter and dust aggregate properties. The gaseous environment of the disk can also have an important influence on dust growth and fragmentation. Reaccretion by gas flow in individual collisions can aid growth while pure gaseous erosion in denser parts of protoplanetary disks can destroy dusty bodies. The role of electrical charging in dust growth is another topic currently under investigation. I will discuss recent laboratory work on the different aspects. Possible implications of aggregation and fragmentation to planetesimal formation and dust distributions within protoplanetary disks are still spanning a fairly wide range. Planetesimal formation by (high speed) collisions is one option, dedicated regions in protoplanetary disks for dust 'production' is another one.

5 Abstracts – Posters

Mid-infrared variability of young stellar objects: clues for disk structure and dynamics

Peter Abraham (1), Agnes Kospal (2),
(1) Konkoly Observatory, Budapest, (2) Leiden Observatory

Many young stellar objects exhibit variability at mid-infrared wavelengths. The flux changes are probably caused by variations in the disk emission, due to either changing illumination by the star or structural changes in the disk. In order to support a systematic study of the latter phenomenon, we present a mid-infrared spectral atlas containing observations of 60 young stellar objects.The atlas contains 2.5-11.6 µm low-resolution spectra obtained with the ISOPHOT-S instrument on-board the Infrared Space Observatory between 1996 and 1998, as well as 5.2-14.5 µum low-resolution and 9.9-19.6 µm high-resolution spectra obtained with the IRS instrument on-board the Spitzer Space Telescope in 2004-07. The object sample includes embedded protostars, T Tau-type and intermediate-mass PMS stars, most of them observed at more than one epochs and by both instruments. The atlas offers a large homogeneous database to identify possible variable sources at mid-infrared wavelengths. We discuss what can be learnt from mid-infrared variability about the structure and dynamics of protoplanetary disks.

Dust particle growth in evolving protoplanetary disks

Tilmann Birnstiel,
MPIA Heidelberg

Grain growth in circumstellar disks has been investigated by several authors in the context of stationary disks. Our work extends this to disks that are being build up by infall and evolving over several million years.

Important parameters influencing the evolution of a protoplanetary disks – such as initial angular momentum of the collapsing cloud, fragmentation probability and the efficiency of radial drift – are being studied. The goal of this work is to better understand the early phases of planet formation.

Planetary migration in radiative accretion disks

Bertram Bitsch,
Institut für Astronomie u. Astrophysik, Uni Tübingen

Isothermal simulations of low mass planets in discs resulted in a negative torque acting on the planet, indicating inward migration of the planet. This is the Type-I-Migration. Recent studies including radiative effects in 2D resulted in a positive torque acting on the planet, indicating outward migration. Our simulations in 3D confirm these recent results. Low mass planets in the fully radiative model tend to migrate outward, in contrast to the isothermal case. This is valid for planets smaller than about 50 earth masses. Bigger plantes open gaps

in the accretion disc, resulting in a negative torque for the fully radiative and isothermal simulations.

Binarity of Transit Host Stars

Carolina Bergfors (1), Sebastian Daemgen (1), Felix Hormuth (1), Wolfgang Brandner (1), Markus Janson (1,2), Stefan Hippler (1), Thomas Henning (1),
(1) MPIA Heidelberg, (2) Department of Astronomy, University of Toronto

Binarity characteristics of exoplanet hosts such as binary frequency and separation can provide important constraints on planet formation scenarios and dynamical system evolution. A close stellar companion will distort the circumstellar protoplanetary disk, leading to a heated and truncated environment in which to form planets. The occurrence and properties of planets formed in binary systems may provide a way to discriminate between the two most widely supported planet formation models: core accretion and disk fragmentation.

Transiting exoplanets offer a unique insight into the physical properties of planets by providing a complete set of planetary parameters. However, blending by unresolved binary companions or background stars affects the transit light curve. Finding previously unknown faint stellar companions to transit host stars therefore requires a re-evaluation of the transit light curve, resulting in revised planetary and stellar parameters.

We present initial results from our search for close stellar companions to transit host stars. The ongoing survey of all exoplanet hosts with the high-resolution AstraLux Lucky Imaging camera has so far revealed stellar companions to three of the targets: WASP-2, TrES-2 and TrES-4. For two of these, TrES-2 and TrEs-4, the stellar companions are previously unknown. We will discuss possible relations between properties of the planet, the host star and the binary separation.

The Two Modes of Gas Giant Planet Formation

Aaron C. Boley,
University of Zurich

Over the past decade, theorists have debated whether core accretion plus gas capture (e.g., Pollack et al. 1996) or direct formation by disk instability (Cameron 1978; Boss 1997) is the principal formation mechanism of gas giant planets. In order for gravitational instabilities (GIs) to form gas giants directly, the Toomre (1964) Q must approach unity and the local cooling time must be comparable to the local orbit period (Gammie 2001; Rice et al. 2005; Rafikov 2005, 2007). Whether such conditions are ever met in protoplanetary disks has been the focus of recent debate (e.g., Rafikov 2005, 2007; Boley & Durisen 2006; Boley et al. 2006, 2007a,b; Mayer et al. 2007; Boss 2008; Boley & Durisen 2008). Although a consensus has yet to be reached, analytical work (e.g., Rafikov 2007) and radiation hydrodynamics simulations (Nelson et al. 2000; Cai et al. 2006, 2008; Boley et al. 2006, 2007b; Stamatellos & Whitworth 2008; Boley & Durisen 2008) find that disk fragmentation inside $r \sim$ tens of AU is unlikely because regions with high cooling rates and low Q are rare under realistic conditions. However, disk fragmentation at $r > 100\,\mathrm{AU}$ remains a possibility, and may be a likely event in early disk evolution. The rate that Q changes in a local region of a disk is given by $\mathrm{d}\ln Q/\mathrm{d}t = 1/2\mathrm{d}\ln c_s^2/\mathrm{d}t + \mathrm{d}\ln\kappa/\mathrm{d}t - \mathrm{d}\ln\Sigma/\mathrm{d}t$. In isolated disks, the thermal energy term (c_s^2) is the only relevant term because the timescale for Σ and κ to change due to mass transport should be much larger than the local dynamical time. However, if a disk is still in its accretion phase, the Σ term can become more important than cooling. I find that accretion rates leading to fragmentation are well within plausible values, and suggest that there are two modes of gas giant planet formation. The fast mode of gas giant planet formation produces wide semi-major axis gas giants (WaGGs) within the first few 10^5 yr at $r > 100$ AU. The slow mode is standard core accretion, which forms gas giant planets in situ within tens of AU from the star.

Observational Diagnostics of Gas in Protoplanetary disks

Andres Carmona,
ISDC Geneva Observatory

Protoplanetary disks are composed primarily of gas (99 % of the mass). Nevertheless, relatively few observational constraints exist for the gas in disks. In this review, I discuss several observational diagnostics in the UV, optical, near-IR, mid-IR, and (sub)-mm wavelengths that have been employed to study the gas in the disks of young stellar objects. I concentrate in diagnostics that probe the inner 20 AU of the disk, the region where planets are expected to form. I discuss the potential and limitations of each gas tracer and present prospects for future research.

High resolution optical spectroscopy of 35 Herbig Ae/Be star candidates

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Herbig Ae/Be stars are young pre-main sequence stars of intermediate-mass (2-8 $M_\odot$). They have spectral types B, A, or F, they present emission lines in their optical spectra (most notably Halpha) and exhibit infrared-excess in their spectral energy distribution. Herbig Ae/Be stars are surrounded by circumstellar disks. It is believed that planets are likely in formation around these stars. Here we present a high-resolution optical spectroscopy survey of 35 Herbig Ae/Be star candidates obtained with the spectrograph FEROS ($R \sim 45000$) mounted at the 2.2 m ESO-MPG telescope in la Silla Observatory. We observed a sample of relatively bright ($V < 13$) Herbig Ae/Be star candidates from tables IVa and IVb of the The et al. (1994) catalogue that have poorly constrained spectral types. Half of our sample are stars positionally coincident with star forming regions (SFR) located at a distance closer than 200 pc and half of our sample are “isolated” sources. Our goal was to confirm whether the sources belong Herbig Ae/Be stellar group, to derive their spectral types, rotational and radial velocities, and to constrain their distances employing photometry from the literature. In addition, for the sources positionally coincident with a SFR, we wanted to test whether the candidates belong to the SFR. We find that approximately half of the sample are background giant stars and half of the sample are Herbig Ae/Be stars. Only a few sources appear to be members of nearby SFRs.

Lithium Abundance Trends in ESP Host Stars

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The high metallicity of planetary host stars was one of the first clues that properties of the host stars can help constrain models for the evolution and formation of extra-solar planets (ESPs). There has also been a trend identified that ESP host stars tend to have lower lithium abundances than field stars of similar type and age. We will present results of our investigation if host stars for the shorter ESP also show systematically lower lithium abundances. We have included TESP, especially newly discovered systems from the SuperWASP survey and compare these to stars with and without planets from the literature.

Star and Disk properties in Orion's suburbs

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The disk dissipation process is neither well understood theoretically, nor well constrained observationally. It may be intimately linked to the planet formation process - a notion supported by a recent discovery of a planet orbiting a young disk-harboring star. By correlating the disk properties to those of the central stars and the environment, the physical mechanisms that govern the disk dissipation process may be revealed. To this purpose, we have conducted a large optical spectroscopic and photometric survey of two fields observed by the Spitzer Space Telescope: The Lynds 1630-North (L1641N) and Lynds 1641 clouds in Orion.

Spectral types as well as accretion and outflow characteristics are derived from our VLT/ VIMOS spectra. Optical SDSS and LAICA imaging is combined with Spitzer IRAC and MIPS imaging to obtain spectral energy distributions from 0.4 to 24 µm. Effective temperatures and bolometric luminosities are derived and used to estimate masses and ages of all young stars. The nearest-neighbor method is applied to identify stars that exist in clusters or aggregates, and those present in the distributed population. The majority of YSOs in L1630N are located in two clusters, whereas only 30% of young stars in L1641 are in small aggregates or clusters (L1641C), the remaining 70% being in a distributed population (L1641D). Within uncertainties, these populations have the same median age of $\sim$1 Myr. The disk fraction (DF) for stars in a clustered environment shows a strong decrease around 2-3 Myr, while the DF in isolation environment appears to decrease more gradually on somewhat longer time scales. We identify 28 so-called "transition disks" in our sample, accounting for 10±3%, 18±6%, and 9±3% of the disk population in L1630N, L1641C, and L1641D, respectively. These objects are thought to be in a critical evolutionary phase, with their innermost disk regions being already dissipated while their outer disks are still intact. The TD stars show significantly lower accretion activity than stars with still "complete" disks.

Solar Wind Interaction with Venus Inosphere: effects and evolutions

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Lulea Technological University

The interaction of the solar wind with the upper atmosphere of Venus is studied, based on Pioneer Venus satellite data. The solar wind interacts with planetary atmospheres and affects their chemical composition, temperature, particle density and velocity. When the solar wind approaches unmagnetized planets such as Venus, the fully-ionized charged particles interact and bombard their atmosphere (ionosphere).

Comparison of results from various Venus missions is based on the solar cycle variation, since the Venusian ionosphere is very sensitive to the EUV flux from the Sun. During solar maximum, the thermal pressure of the ionosphere is large enough to deflect the solar wind, and since the solar wind travels supersonically, a 'shock' must be formed to deflect solar wind around the planet. Formation of the bow shock is described and compared between solar maximum and minimum.

Electron density and magnetic field strength measurements by Pioneer Venus are compared between the day- and night-sides of Venusian ionosphere. These indicate the existence of ionospheric holes, where magnetic fields are strong and radiate out of the ionosphere.

Charge exchange between solar wind protons at solar minimum, and escaping hydrogen atoms from the Venus exosphere are described as the main reasons for ENAs. Some ENAs influence the Venus atmosphere, heating it up and causing hydrogen atoms to escape the atmosphere. The hydrogen and oxygen escape phenomena are described and compared between solar minimum and maximum by use of observed data from Pioneer Venus, which are also computationally modelled (QNH model).

Abbreviation: EUV: Energetic Ultra Violet, ENA: Energetic Neutral Atoms, QNH: Quasi-Neutral Hybrid

Debris disks around planet host stars

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We present our ongoing investigation of all known planet host stars for the presence of circumstellar dust, which can almost undoubtedly be ascribed to populations of leftover planetesimals within a debris disk, producing detectable dust by their collisions. The aim of this project is to uncover a link, if there is one, between stars with planets on the one hand and stars with debris disks on the other hand, which is supposed to be rooted in the process of star formation and the nearly omnipresent protoplanetary disks around recently formed young stars.

We identify infrared excess emission above the stellar photospheric continuum as an indicator for the presence of dust and compare infrared ($\sim$ 8 to $\sim$ 850 Å) data from IRAS, ISO, Spitzer, JCMT and other instruments with predicted stellar continuum emission. The determination of the predicted photospheric fluxes is done using appropriate Phoenix model atmospheres fitted to the observed spectral energy distributions in the ultraviolet, optical and near infrared spectral range. In addition to a great variety of published and archive data, also photometric data obtained with new observations are included in our investigation.

In a preliminary study we already investigated 25 multiple planetary systems and found a slightly higher disk incidence ($\sim 21\,\%$) than the average for nearby solar-type stars ($\sim 15\,\%$), although more systems have to be included to reach statistically significant results. Besides, tentative conclusions about possible correlation between the presence of dust and stellar properties like metallicity or multiplicity have been drawn, and the results strongly suggested that further investigation would be worthwhile. Now we are extending this study to all known planet host stars to perform a more comprehensive statistical analysis. In particular, we also investigate those stars with (unresolved) debris disks, where substellar companion candidates have been detected by direct imaging.

Magnetorotational Instabilities in Accretion Discs with Radiative Diffusion

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In our project, we perform numerical simulations of astrophysical accretion discs. It is generally believed that accretion discs are turbulent, and it seems most likely that the turbulence is induced via the magnetorotational instability (MRI), a linear instability found in rotating, weakly magnetised shear flows. We use direct numerical simulations to model the turbulence in a self-consistent way, where the energy in the turbulent motions is dissipated into heat at small scales, transported by radiative diffusion and ultimately radiated away.

We have implemented radiation transfer in the one-temperature flux-limited diffusion approximation suitable for protoplanetary discs. Including radiative diffusion is important in order to obtain a realistic vertical structure of the accretion disc, where the heating caused by the turbulence is compensated by radiative losses due to radiative diffusion. Furthermore, radiative diffusion affects the properties of MRI-induced turbulence, changing both the growth rates of the instability and its saturation level.

The aim of the project is to determine the key parameters for the influence of turbulence on planetesimal formation. Especially we want to determine the degree to which the precursors can be concentrated locally in protoplanetary discs in particular in flow features such as spiral arms, high pressure regions or vortex structures. This could help to answer important open questions in the theory of planet formation.

3D global MHD protoplanetary disk simulations with an high-order Godunov scheme

Mario Flock,
MPIA Heidelberg

The models of protoplanetary disk are done in spherical geometry with density stratification. Azimuthal net and zero-net flux magnetic field are applied to drive the magneto-rotational instability. For the first step, no resistivity is included. We will also compare locally isothermal with adiabatic runs including a simpified Power Law cooling. The dust in the turbulent disk is treated for the small dust grains as a passive tracer. We measure the dust diffusion coefficient for different locations in the disk for the case of ideal gas ionization.

Planet Formation in Warped Protoplanetary Discs

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Protoplanetary discs may occur in binary systems where the disc plane and the binary orbit plane are misaligned as a result of the star formation process. It is expected that the excitation of bending disturbances will lead to the formation of warped, precessing discs, as are believed to occur in numerous protoplanetary disc systems. We study these systems using a three dimensional grid-based hydrodynamics code. We examine the structure and evolution of discs whose parameters (disc thickness and viscosity) are appropriate to protoplanetary discs. We find that the disc adopts a warped and twisted configuration, and precesses uniformly at a well defined rate. We introduce planetesimals into the system which interact with the binary via gravity, and with the disc via drag forces and gravity. We find that as the planetesimal size is increased from 1 metre up to 1 km, the planetesimal orbits become increasingly inclined with respect to the disc. For sizes of approximately 1 km and above, the planetesimals essentially orbit outside of the disc. We discuss the implications of these results for planet formation in binary systems.

Progress in calibrating an SPH code for pre-planetesimal collisions

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In the early stages of planet formation the transition from metre-sized pre-planetesimals to planetesimals of kilometre size takes place potentially by collisional growth. Pre-planetesimals are rather to be thought of porous agglomerates than rocky objects. Hence the outcome of collisions between porous objects occurring between typical sizes at their typical relative velocities is crucial for the understanding of the formation of terrestrial planets and cores of giant planets. Since this size regime is not accessible to laboratory experiments we have developed a Smooth Particle Hydrodynamics (SPH) code capable of simulating the behaviour of solid and porous media. Preliminary studies have shown that the collisional outcome strongly depends on the choice of material parameters. Therefore we use realistic material parameters of SiO_2 dust which have been measured. In order to validate the code we performed a series of numerical benchmark experiments and compared them with their experimental equivalents. The results are presented here. Eventually we will use this code to determine fragmentation statistics of collisions at typical relative velocities in order to close the gap of fragmentation data for porous bodies.

Search for substellar companions around young stars with the HST

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The detection of substellar companions via direct imaging is an interesting and growing field of studies. In 2008 six new substellar objects have been discovered utilizing this method. In addition the HST data archive contains a large amount of data which is not yet analyzed homogeneously, and with the HST NICMOS and WFPC2 instruments for the search for faint cool objects are available. The goal of this project is to detect such previously not identified substellar companions around young stars, which are either isolated or located in young moving groups. Therefore, we use different methods of PSF subtraction to suppress the flux of the primary star in the images. So far, two different associations, as well as around 150 isolated young stars have been studied and several companion candidates have been found that need follow up second epoch observations.

Atmospheric biomarker and spectral responses to biogenic variations on Earth-like planets

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What is the range of spectral signals expected from terrestrial planets? We simulate the atmospheres of hypothetical worlds (e.g. water world, jungle world, desert world) using a radiative-convective model coupled with a photochemical model. The atmospheric responses to diverse surface fluxes will be presented and discussed on the basis of temperature and concentration profiles of biomarkers and related compounds.

Structure and Dynamics of Circumstellar Matter in the Neighbourhood of UX Ori Stars

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The UX Ori type stars (or UXORs) belong to the family of the photometrically most active young stars. Their variability is caused by the variable circumstellar (CS) extinction and is a result of the small inclination of the disks to the line of sight. Therefore, the investigation of the photometric activity of UXORs is the power tool for studies of the fine structure of CS disks. In this talk I summarize briefly the main observational properties of these stars. The accent is made on the properties of the cyclic variability of UXORs. The numerical modeling shows that such a variability can be caused by the periodic gas-dynamic perturbations in CS disks produced by the orbital motion of the low mass companions. The similar mechanism can also be the reason of the long-lasting eclipses observed in some exotic eclipsing systems.

Experiments on Fragmentation and Charge Separation in Pre-Planetary Dust Collisions

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Laboratory experiments of the recent years have shown that coagulation of dust is an efficient process to explain the first step of planet formation from micrometer-sized dust grains to decimeter-sized dust aggregates. However, the experiments have also shown that for collision velocities exceeding a few m/s, fragmentation dominates the collisional interaction and destroys the previously-grown aggregates. Some ideas have been developed to find a process that allows further growth despite fragmentation, some of them based on the idea of secondary agglomeration. One suggestion deals with the separation of electric charges upon a collision. If this charge separation was systematic and efficient, the reaccretion of fragments by Coulomb forces might in the end lead to further growth. Moreover, charge separation was beforehand observed in many laboratory experiments and a thorough measurement of the amount of separated charge could put many ideas dealing with charged dust in the protoplanetary nebula on a solid basis.

We present collision experiments of mm-sized dust aggregates with a porous or solid target (representing the larger aggregate) at collision velocities between 1 and 10 m/s under vacuum conditions. The fragmenting dust aggregates are observed by a high-speed camera to measure fragment sizes and trajectories. From the deflection in the electric field of a plate capacitor the charging of each fragment is deduced. Knowing the physical parameters of the fragments (size, velocity, escape angle and electric charge), the efficiency of electrostatic reaccretion in solar nebula condition can be calculated by taking realistic gas dynamics into account.

The Tautenburg survey for extrasolar planets of F-type stars

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Precise measurements of the radial velocity (RV) of stars have led to the discovery of more than 300 extrasolar planets. Since most of other RV surveys are concentrating on solar-type stars the number of known planets around intermediate mass stars is small. This limits our knowledge about how frequency and properties of planets depend on stellar mass, the most fundamental parameter of a star. In order to understand the influence of stellar mass on the process of planet formation, it is thus essential to extend planet searches over a wider range of stellar masses. As part of the Tautenburg Observatory Planet Search program (TOPS), we have been monitoring a sample of F-type main-sequence stars using the 2-m-Alfred-Jensch telescope of the Thüringer Landessternwarte Tautenburg (TLS). This program uses a coude echelle spectrograph and an iodine absorption cell as wavelength reference producing precise stellar radial velocities. We will present a status report on the program and show some recent results.

Chemical evolution of protoplanetary disks – the effect of turbulent mixing

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Protoplanetary disks are considered as a natural environment for the creation of simple and complex molecules which may ultimately lead to the evolution of life. Recent observations of the young protoplanetary disk of AA Tauri reveal a basic, active organic chemistry and important molecules such as H_20, OH, CO_2 and CO being abundant within the inner disk (Carr & Najita, 2008). These observations match existing models of the chemical evolution in protoplanetary disks that predict strong accretion flows in order to replenish the molecules, which are constantly destroyed by chemical reactions (Nomura et al., 2008).

Efficient accretion requires strong turbulence in the disk, which, through turbulent mixing, may drive the chemical composition out of equilibrium. Radial turbulent mixing may increase the abundance of the observed molecules in the inner disk region, while the effect of vertical turbulent mixing strongly depends on the timescales involved. We therefore investigate the effects of turbulence in protoplanetary disks by modeling the radial and vertical turbulent mixing and subsequently calculating the emerging molecular line emission from these systems.

Towards Radial Velocity Detections of planets around Brown Dwarfs

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A radial velocity survey based on more than six years UVES/VLT spectroscopy of a small, homogenous sample of brown dwarfs / VLMS in ChaI is presented. It is one of the first and stil one of the few RV surveys cabable of detecting giant planets orbiting brown dwarfs. The recent discovery of a low-mass RV companion in a ~ 1 AU orbit around the BD candidate ChaHa8 marks an important step towards RV detections of planets around BDs (Joergens & Mueller 2007, ApJL). New data for ChaHa8 will be presented. The capability and strategies of other RV surveys of BD/VLMS to detect planets as well as own ongoing and planned projects in the optical and near-IR (CRIRES/VLT) will be discussed.

Hybrid simulations of the stellar wind interaction with close-in extrasolar planets

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It is expected that the atmospheres of close-in extrasolar planets frequently undergo hydrodynamic expansion and produce strong ionospheres due to intensive photoionization, while at the same time being exposed to a strong stellar wind. This scenario can be expected to lead to new types of magnetospheres and interactions between stellar wind plasma and ionospheres previously unseen in the solar system. We have used a hybrid code, treating electrons as a massless, charge-neutralizing, adiabatic fluid and ions as macroparticles, to study the influence of a strongly expanding ionosphere on the stellar wind interaction for an unmagnetized close-in extrasolar terrestrial planet. We report on our attempts to apply this code to close-in extrasolar planets and results therefrom.

Planetesimal formation in quasi-steady state generated by inhomogeneous MRI

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We take a magneto-hydorodynamic approach to the planetesimal formation. Planetesimals supposed to be formed via gravitational instability of dust particles when their density is somehow made to exceed a threshold. In theory, however, dust particles in a protoplanetary disk fall quickly to the central star because of the drag from the disk gas that rotates slower than the dust particles (dust in-fall problem). Be this true, there is no material left in the disk to form planets. Then, in order to see if the dust in-fall problem can be rescued and if the planetesimal formation can be realized, we study the property of the Magneto Rotational Instability (MRI) in a protoplanetary disk and the dust motion affected by the MRI. Since a protoplanetary disk is weakly-ionized, linear analyses show that a region with small vertical magnetic field has a smaller MRI growth rate and vice versa (Gammie, 1996; Sano & Miyama, 1999). We ever have studied the flow patterns produced by the non-uniformly growing MRI by situating a MRI unstable and a MRI stable annulus in the simulation box of 3D resistive MHD simulation with the local approximation. As a result, we found that the non-uniform MRI growth creates quasi-steady state and the gas rotates faster than the dust particles in some part of the disk. Then we include dusts as particles which exert the friction force on gas and followed their motion. The particles could not only be prevented from the in-fall but also be concentrated at the outer edge of the gas super-rotating zone substantially, which is a crucial process for planetesimal formation. Additionally, we will perform a global 3D simulation to cross-examine the planetesimal formation.

The Solid-State Greenhouse Effect plus Thermophoresis: Dust Recycling in Protoplanetary Disks

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Dusty bodies in protoplanetary disks might be eroded by a solid-state greenhouse effect (G) and a thermophoretic force (T). Solid-state greenhouse effects can be established in porous bodies through radiation while thermophoretic forces are triggered by temperature gradients and act on small particles (μm) in low pressure gaseous environments (mbar). The solid-state greenhouse effect creates a temperature gradient and if the resulting thermophoretic force overcomes gravity and cohesion, dust will be ejected from a surface through this interplay, named the GT-effect. Low pressure gaseous environments and also intense radiation can be found in the inner parts of protoplanetary disks. Inward drifting bodies in protoplanetary disks might therefore be (partially) eroded and escape accretion by their host star. Hence, the dust of inward drifting bodies might not be lost but recycled through this GT-effect.

Debris Disks Around Sun-like Stars from the FEPS Spitzer Legacy Program

Jinyoung Serena Kim,
MPIA Heidelberg

I will present recent results from the Spitzer Legacy science program, the Formation and Evolution of Planetary Systems (FEPS, `http://feps.as.arizona.edu`). Our goal is to help define the timescales over which terrestrial and gas giant planets are built, constrain the frequency of planetesimal collisions as a function of time, and establish the diversity of mature planetary architectures. The FEPS program samples 328 sun-like systems ($0.7\,M_\odot$ – $2.2\,M_\odot$) in age rangingfrom 3 Myr to 3 Gyr. We trace the evolution of circumstellar dust from primordial planet-building stages in young circumstellar disks through to older collisionally-generated debris disks. The FEPS team has obtained spectro-photometric observations for all our sample stars using all three science instruments (IRAC, IRS, MIPS) aboard the Spitzer Space Telescope from 3.6 micron to 70 micron. I will review recent FEPS results including: 1) complete census of 70 micron-bright debris disks; and 2) properties and evolution of disks in terrestrial and kuiper-belt planet zones around 314 solar-type stars.

Climatic effects of cloud particles in Earth-like planetary extrasolar atmospheres

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Clouds can have an important impact on the climate (and thereby also on the habitability) of terrestrial planets. It is well known, for instance, that water clouds in the lower Earth's atmosphere increase atmospheric cooling by scattering of the incoming stellar radiation, while ice clouds in the higher atmosphere can lead to an enhanced greenhouse effect, resulting in higher surface temperatures.

In this contribution we focus on the climatic effects of water and ice particle distributions in the tropospheres of Earth-like extrasolar planets. Due to the shortage of observational detail regarding the atmospheres of terrestrial extrasolar planets, particular studies of clouds are limited to basic questions about the predominant processes at work, which have to be adressed.

As a first approximation, the cloud particle distributions are assumed to be represented in terms of parametrized distribution functions. This approach for the description of cloud particles is coupled with a one-dimensional radiative-convective climate-model in order to study the basic effects on the atmospheric climate. Results for e.g. different types of central stars in conjunction with effects caused by different cloud types are presented and compared with the respective cloud-free conditions.

Evaporation studies on silicates

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Laboratory data on the physicochemical processes taking place during evaporationand condensation of silicate minerals are crucial input parameters for theoretical models of astrochemical processes in protoplanetary discs. Therefore a new Knudsen cell setup was developed to perform evaporation experiments under conditions relevant for protoplanetary discs with which it should be possible to measure even more complex and not yet investigated materials under well-defined conditions (e.g. UHV, defined oxygen fugacity) and over a broad temperature range. The first data obtained on copper (Cu) and silicon monoxide (SiO) vapour pressures will be presented.

Detecting planetary signals with Bayesian methods

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When finding solutions to statistical problems, the Bayesian methods can be seen as an alternative to the classical statistical tools. Even though these methods are generally well known, the use and practical applications of Bayesian methods in astronomy are still somewhat occasional and concentrated to quite few specific areas, gravitational lensing and lightcurve inversion being perhaps the most famous examples. Typically these applications include very complex modellings where the parameter space is high dimensional and model comparison is therefore difficult to perform via more conventional 'frequentist methods'. However, the complexity of parameter space must not be seen as any kind of limit for useful application of these methods since the explicit use of Bayesian tools may reveal important new properties from simpler systems as well.

In this poster we discuss the advantages of using Bayesian model comparison in the study of extra-solar planetary systems and present the system HD 11506 as an especially interesting example.

High-Temperature Dust Collision Experiments

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In contrast to previous laboratory experiments to investigate the first phase of planet formation, which were performed at room temperature, we study in this project the collision and sticking behavior of dust aggregates at elevated temperatures in the range of 300 to 1.300 K. Due to effects like e.g. sintering and eutectic melting, which can occur under the influence of high temperatures, we expect considerable changes in the effective growth process of colliding dust aggregates. In this work we report on laboratory studies on the mechanical and thermal properties as well as the collisional behavior of high-porosity dust aggregates.

In order to calibrate the SPH codes for the simulation of collisions between large protoplanetary dust aggregates, we performed compression experiments by impacting single glass spherules into high-porosity dust samples with subsequent density analysis by x-ray microtomography. We will present first results of the compression behavior of dust samples depending on the porosity of the dust, the impactor size and the impact velocity.

In addition to that, we have developed a novel non-invasive method to measure the thermal conductivity of fragile high-porosity dust samples. The investigation of the heat transfer of these dust samples will provide us with knowledge about the ability to melt or sinter by radioactive decay of short-lived isotopes, like e.g. 26Al. We will show results for the thermal conductivity of dust samples of different porosities, sintering stages and materials.

To investigate dust collisions at temperatures up to 1.300 K, we have constructed an experimental setup, which enables the observation of colliding mm-sized dust grains by a high-speed camera and an IR camera. Using a two-particle release mechanism we achieve collision velocities up to 1 m/s. A wide parameter study varying the temperature, grain material, grain size and collision velocity is intended for the future.

On the initial conditions of planet formation

Rolf Kuiper,
MPIA Heidelberg

The mostly used initial conditions of analytical or numerical research in disk evolution, planet formation and -migration are the Shu-, the Shu-Ulrich-model or disks in hydrostatic equilibrium.

Considering the extreme dynamical formation history of such disks, i.e. the formation during the collapse of a molecular cloud including angular momentum conservation, radiation feedback, magnetic fields and self-gravity as well as the subsequent instabilities, it is doubtful, if such simple models provide an adequate basis for realistic initial conditions.

Modeling the formation of disks in radiation hydrodynamical simulations of collapsing clouds including radiative cooling due to thermal radiation of dust and frequency-dependent radiative feedback of the newly born star offer a good alternative. Besides the density and temperature distribution of the resulting disk also dynamical properties like accretion rates and the angular momentum profile can be determined in such numerical simulations.

Here I'll present resulting disk properties of newly developed 2.5D collapse simulations of a pre-stellar solar-system-like molecular cloud.

The ESPRI project: Narrow-angle astrometry with PRIMA

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PRIMA, the instrument for Phase Referenced Imaging and Micro-arcsecond Astrometry at the VLTI, is currently being implemented and tested at the Paranal observatory. It will implement the dual-feed capability for at first two ATs or UTs to enable simultaneous interferometric observations of two objects that are separated by up to 1 arcmin. PRIMA is designed to perform narrow-angle astrometry in K-band with two ATs as well as phase-referenced aperture synthesis imaging with instruments like Amber and Midi. In order to speed up the full implementation of the astrometric capability of the VLTI and to carry out a large astrometric planet search program, a consortium lead by the Observatoire de Geneve, Max Planck Institute for Astronomy, and Landessternwarte Heidelberg, has built Differential Delay Lines for PRIMA and develops the astrometric observation preparation and data reduction software. When the facility becomes fully operational, we will use PRIMA to carry out a systematic astrometric Exoplanet Search program, called ESPRI. This poster gives an overview of the ESPRI project and its scientific goals and prospects.

Chemistry in protoplanetary discs

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Modelling of chemistry in protoplanetary discs allows us to understand, which processes in the disc are important for the disc evolution, which molecules can be produced at different distances to the protostar and which physical and chemical processes can happen in the disc. The model includes annealing of silicates, transport and combustion of carbon, evaporation and destruction of different species in the disc. The calculation of presolar SiC destruction allows us to explain the high abundance of these specie relative to presolar carbon abundance in meteorites. The modelling of PAHs in the disc shows, how many organic material were present before beginning of planet formation.

Comparison of ESP Mass Radius relations for transiting ESP

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California State University

A growing number (nearly 60!) Extra-solar planets (ESPs) have been discovered by transit photometry, and these systems are important because the transit strongly constrains their orbital inclination and allows accurate physical parameters for the planet to be derived, especially their radii. Their mass-radius relation allows us to probe their internal structure, and there are currently several models (e.g. Fortney et al. 2007). We present a comparison of these models to the current sample of transiting ESP. Although such models are nascent, it is important to establish trends for the current sample of ESP, which will further the understanding of their composition, formation, and evolution. Such studies have applications for future discoveries of lower mass planets.

The TCfA Transit Timing Survey

Gracjan Maciejewski, Andrzej Niedzielski,
Torun Centre for Astronomy, N. Copernicus University

First results of the exotransit timing survey at the Torun Centre for Astronomy are presented. The accuracy of determining the midtransit moment, transit's duration and depth are discussed in a context of utilising a 60-cm class telescope.

On the origin of eccentricities among extrasolar planets

Daniel Malmberg,
Lund Observatory

Most observed extrasolar planets have orbits which are much tighter, and often much more eccentric, than the orbits of the gas giants in the solar system. We show that some of these extrasolar planets might have formed in planetary systems resembling the solar system, i.e. in systems where the gas giants were originally on long-term stable and circular orbits with a semi-major axis of several au. If such a system is perturbed by another star, strong planet-planet interactions may be triggered, causing the ejection of several planets while leaving those remaining on much tighter and more eccentric orbits. The eccentricity distribution of these perturbed systems is very similar to that of the observed extrasolar planets with semi-major axis between 1 and 6 au if they initially consisted of planets which all had rather similar masses.

H2 emission in the disk of HD97048

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Laboratoire Astrophysique de Grenoble (LAOG)

We present high-resolution spectroscopic mid-infrared observations of the circumstellar disk around the Herbig Ae star HD97048 obtained with the VLT Imager and Spectrometer for the mid-InfraRed (VISIR). We conducted observations of mid-infrared pure rotational lines of molecular hydrogen (H2) as a tracer of warm gas in the disk surface layers. In a previous paper, we reported the detection of the S(1) pure rotational line of H2 at 17.035 μm and argued it is arising from the inner regions of the disk around the star. We used VISIR on the VLT for a more comprehensive study based on complementary observations of the other mid-infrared molecular transitions, namely S(2) and S(4) at 12.278 μm and 8.025 μm respectively, to investigate the physical properties of the molecular gas in the circumstellar disk around HD97048. We do not detect neither the S(2) line nor the S(4) H2 line from the disk of HD97048, but we derive upper limits on the integrated line fluxes which allows us to estimate an upper limit on the gas excitation temperature, $T_{ex} < 570\,K$. This limit on the temperature is consistent with the assumptions previously used in the analysis of the S(1) line, and allows us to set stronger contraints on the mass of warm gas in the inner regions of the disk. Indeed, we estimate the mass of warm gas to be lower than 0.1 Jupiter masses. We also discuss the probable physical mechanisms which could be responsible of the excitation of H2 in the disk of HD97048.

Precision Astrometry from Images Obtained with Adaptive Optics

Eva Meyer,
MPIA Heidelberg

The true masses of non-transiting substellar companions to stars are only known for a few objects so far and they have all been determined by astrometry with the HST fine guidence sensor (Benedict et al. 2006, Benedict et al. 2002). From radial velocity detections alone one does not get all orbital parameters needed to derive the true mass of a substellar companion to a star. Additional astrometric measurements are needed to calculate the inclination, i, and the longitude of the ascending node, Omega. The parallax and proper motion of the star must also be considered.

We aim to derive the true mass of a brown dwarf candidate companion to an early M dwarf with groundbased astrometry aided by adaptive optics. We found this unique brown dwarf desert object in our UVES precision radial velocity survey of M dwarfs, inferring a minimum companion mass of 27 Jupiter masses (Kuerster et al. 2008). Combining the data with HIPPARCOS astrometry, we found a probability of only 2.9 % that the companion is stellar. We are therefore observing the host star and a reference field within a monitoring program with NACO at the VLT to derive the true mass of the companion and establish its nature (BD vs. star).

A dynamical analysis of the multiple planetary system of HR 8799

Cezary Migaszewski, Krzysztof Gozdziewski,
Torun Centre for Astronomy, N. Copernicus University

We perform a dynamical analysis of available observations gathered during imaging campaigns by Marois et al. (2008). The preliminary orbital solutions of this three-planet system involving massive objects of 10 Jupiter-masses each lead to strongly unstable configurations. Although the semimajor axes are large (about of 24, 36 and 68 AU, respectively), the planets are heavily interacting and their orbits are located in a zone spanned by numerous low-order mean motion resonances. Constraining the initial conditions by the available imaging observations and the requirement of dynamical stability (the Copernican Principle), we search for the long-term stable configurations, living at least for a time comparable with the parent star life-time (100 Myr). We also test a hypothesis of yet undetected fourth planet that could be hidden in the coronagraph images and that could stabilize the whole system.

Planetary population synthesis: Correlations between disk and planetary properties

Christoph Mordasini (1), Yann Alibert (2), Willy Benz (3), Hubert Klahr (1),
(1) MPIA Heidelberg, (2) Observatoire de Besançon, (3) Universität Bern,

We vary the initial conditions of our core accretion planet formation model according to probability distributions which were derived from observed properties of protoplanetary disks, like their gas and dust content, or their lifetime. In this way we synthesize a planetary population which reproduces well many observed statistical properties of the actual extrasolar planetary population.

Here we focus on correlations between disk and planetary properties. One such correlation, namely between stellar metallicity and the likelihood of detecting a giant planet is observationally very well established and reproduced in our simulations. But many other unknown correlations exist. Examples are: (1) A positive correlation of the maximal planetary mass (core plus envelope) with [Fe/H] at subsolar metallicities. At supersolar metallicities the maximal mass is approximatively independent of [Fe/H]. (2) A positive correlation between the maximal planetary core mass with metallicity, raising from less than 40 Earth masses at [Fe/H]$= -0.5$ to about 400 Earth masses at [Fe/H]$= 0.5$. (3) A negative correlation between [Fe/H] and the extend of migration (distance between initial and final semimajor axis) of cores that finally become giant planets. At low metallicities, cores migrate typically about 6 AU, while at high metallicities giant planets-to-be migrate typically between 0 and 3 AU.

We explore the reasons for these and other correlations and examine their dependence on model parameters like the disk viscosity.

Infrared studies of Debris Disks: The Connection to Meteorites

Andreas Morlok (1), C. Lisse (2),
(1) CRPG/CNRS, Nancy, (2) Johns Hopkins University

In the debris disk stage of a evolving solar system, already accreted planetesimal bodies continue to grow by collisions. In these events, a new, second generation of circumstellar dust is created. This phase is similar to that of our own Solar System about 4.5 Gy ago. Mid- and far-infrared observations of dust in debris disks allow to determine the composition of the planetesimals involved in these collisions. Seven common chemical species make up the large majority of what is seen in the debris: olivines, pyroxenes, physllosilicates, water, PAHs, amorphus carbon, and metal sulfides.

Recent studies of archival ISO spectra by Lisse et al. (2007) indicate the involvement of un-differentiated comet-like materials in the dust orbiting the young AO star HD100546. Recent studies of archival Spitzer spectra point to more differentiated, asteroid-like warm dust close to the 12 Myr old F5 star HD113766 (Lisse et al. 2008). Morlok et al. (2007) have shown that shocked hydrated meteorite material could be the source of dust in Beta Pictoris.

We give an overview of current models for the composition of planetesimals in debris disks, and compare the results to the composition of meteorites.

Variability among Pleiades Stars

Mohammad Moualla, Ralph Neuhäuser, Tobias Schmidt, Stefanie Rätz, Thomas Eisenbeiss, Markus Mugrauer, Alexandra Költzsch, Claudia Marka, Christian Ginski, Markus Hohle, Tristan Röll, Wissam Rammo, Annegret Reithe, Christopher Broeg, Martin Vanko,
AIU Jena

In this photometric search we try to find variable stars (and new eclipsing binaries) in one field among the Pleiades cluster, for that we have conducted a CCD R-band survey using our telescope in Großschwabhausen near Jena.

The area covered by our telescope and CCD camera has 0.4 square deg within the region of the cluster (RA: 3h 42m 20.6s, Dec: 25d 36’ 45”). First observations were done in March and April 2007 and again between January and March and September 2008.

In order to reduce our data we first do the basic bias and flat field calibration with MIDAS and then we do the illuminationn Corrections. Then we use three programs:

- Source detection with GAIA (Global Astrometric Interferometer for the Astrophysics), usually around 600 stars in our field
- Aperture photometry for all stars in all images with MIDAS (Munich Image Data Analysis System)
- Relative photometry program (software based on ADA from Broeg et al. 2005), yielding typical precision of few milli-mag.

We first search for constant stars in the field, then create an artifical comparison star, then obtain magnitudes of all other stars relative to this comparison star. Then we have light curves for all stars in the field, which we can plot (JD time against the brightness).

We can also add up all images taken to obtain a very deep image of his field, e.g. to seach for new faint Pleiades members: The Pleiades star cluster is an ideal hunting ground for substellar objects due to its richness of members, young age, proximity, and scarce interstellar absorption.

Interior models for Jupiter, Saturn, and Neptune

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Institut für Physik, Uni Rostock

We have determined accurate EOS data for hydrogen, helium, and water by using quantum molecular dynamics simulations. We apply this new data table LM-REOS to model the interior structure of Jupiter, Saturn, and Neptune. We assume the standard three-layer structure: a solid isothermal core of rocks or ices and two convective fluid envelopes. The outer and inner fluid envelopes have different abundancies of helium and metals. The respective layer boundary is usually associated with the pressure-driven metalization transition in hydrogen which induces also demixing of hydrogen and helium. The phase diagram of water includes a superionic phase (proton conductor) at several megabars which is relevant for states deep in the interior of giant planets, especially in Neptune. We present interior structure models based on these accurate material properties which are consistent with observational constraints.

Photometric activity and RV scatter in PTPS stars

A. Niedzielski, M. Adamow, G. Maciejewski, P. Bereznicka, A. Wolszczan,
Torun Centre for Astronomy, Nicolaus Copernicus University

The Pennsylvania - Torun Planet Search (PTPS) is aiming at detection and characterization of planetary systems around evolved stars. The hosts of such systems may exhibit detectable intrinsic variability that in some cases mimics substellar components. For proper interpretation of our high precision radial velocity observations we collected all archival multi-epoch photometric observations from various surveys (Hipparcos, NSVS, ASAS). In this paper we present global characteristic of photometric variability and the scatter observed in high precission radial velocities versus stellar parametrs ($T_{\rm eff}$, luminosity, $\log g$) for our subsample of the red giant clump stars.

Pennsylvania-Torun Planet Search: V sin(i) measurements of 1000 red giants

Grzegorz Nowak, Andrzej Niedzielski, Monika Adamow, Aleksander Wolszczan,
Torun Centre for Astronomy, Nicolaus Copernicus University

The main objective of the Pennsylvania-Torun Planet Search is detection of planetary systems around evolved stars. Searches for planets around G-K giants are essential for developing general understanding of planet formation and evolution of the planetary systems.

Precise radial velocity (RV) measurements of red giants have lead to the discovery of more than ten planets around such stars. However, the long period radial velocity variations of giants may also have other than planetary nature. Rotational modulation due to starspots can also induce RV variations, thereby mimicking the gravitational influence of low-mass companions. For this reason, precise determinations of projected rotational velocities and rotation periods of stars from our survey are very important. In this work we present the method and results of our projected rotational velocities (Vsin(i)) measurements of 1000 red giants from our survey obtained from the cross-correlation function (CCF) constructed from high signal to noise spectra.

Planets or atmospheric variability: activity indicators of red giants

Grzegorz Nowak, Andrzej Niedzielski, Aleksander Wolszczan,
Torun Centre for Astronomy, Nicolaus Copernicus University

The targets of first extrasolar planet search programs were solar like stars. That was the natural first choice given the fact that we know that the Sun harbors planetary system. The objects of the second generation of the exoplanet surveys were late-type stars, especially red dwarfs. Such stars are numerous, less massive, and numerous, little rotational broadened absorption lines are present in their spectra. They also display much smaller intrinsic radial velocity variations. All this caused these stars to be very good targets for the most effective extrasolar planets searching method, that is, radial velocity technique. The targets of another generation of exoplanet search programs were massive, early-type stars. However, the technique could not be applied to early-type main sequence stars due to their large effective temperatures, decreasing a number of absorption lines in their spectra, and fast rotation, causing substantial rotational broadening of its lines. All these factors result in precision of the radial velocity measurements on the level only a few dozen m/s. The solution to that unfortunate situation was to search for planets around red giant stars.

Red giants are later phase of evolution of the main sequence stars. The planet induced Doppler effects are easy to detect in this stars due to cooler effective temperatures and lower rotational velocities. Taken Galaxy lifetime into consideration, we can observe in the solar neighbourhood red giants with masses larger than 1 solar mass. In such way, we can search planets around massive stars. Red giants offer a way to investigate planet formation around massive stars. They also offer a way to investigate dynamicalal evolution of planetary systems with aging of the central stars. However, searching for planets around red giant stars with the radial velocity technique are not free from traps. These stars have active atmospheres, they can pulsate, or have spots rotating with their surfaces. Such phenomena can mimic planetary signatures in radial velocity measurements. In this talk I would like to present methods used in Pensylvania-Torun Planet Search, that allow us to distinguish the effects in radial velocity caused by planets

N-body Simulations of Planetary Accretion around M Dwarf Stars

Masahiro Ogihara, Shigeru Ida

Tokyo Institute of Technology

We have investigated planetary accretion from planetesimals in terrestrial planet regions around M dwarf stars through N-body simulations including tidal interactions with disk gas. Because of low luminosity of M dwarfs, habitable zones (HZs) are located in inner regions. In the close-in HZ, type-I migration and the orbital decay induced by eccentricity damping are efficient according to the high disk gas density. In the case of full efficiency of type-I migration predicted by the linear theory, we found that protoplanets that migrate to the vicinity of the host star undergo close scatterings and collisions, and 4 to 6 planets eventually remain in mutual mean motion resonances and their orbits have small eccentricities and they are stable both before and after disk gas decays. In the case of slow migration, the resonant capture is so efficient that densely-packed small protoplanets remain in mutual mean motion resonances. In this case, they start orbit crossing, after the disk gas decays and eccentricity damping due to tidal interaction with gas is no more effective. Through merging of the protoplanets, several planets in widely-separated non-resonant orbits with relatively large eccentricities are formed. Thus, the final orbital configurations (separations, resonant or nonresonant, eccentricity, distribution) of the terrestrial planets around M dwarfs sensitively depend on strength of type-I migration. We also found that large amount of water-ice is delivered by type-I migration from outer regions and final planets near the inner disk edge around M dwarfs are generally abundant in water-ice except for the innermost one that is shielded by the outer planets.

Effects of extinction by icy dust particles on the location of the snowline in an optically-thick protoplanetary disk

Akinori Oka, Taishi Nakamoto, Shigeru Ida,
Tokyo Institute of Technology

The inner boundary of the condensation region of water ice in protoplanetary disks is called the "snowline". The location of the snowline is very important for understanding the formation of planets because water ice dominates solid materials in the disk.

Recent papers, e.g., Garaud and Lin (2007) and Davis (2005), calculated the location of the snowline, but they considered only silicate dust particles as the opacity source even in the region outside the snowline where icy particles contribute to the opacity too. In this study, we obtain the location of the snowline in an optically-thick protoplanetary disk as a function of mass accretion rate taking into account extinction by silicate dust particles and icy dust particles as well.

We consider an optically-thick steady-accretion disk around a T Tauri star. To obtain the structure of the disk, we employ the 1-D plane-parallel radiative transfer method in Dullemond et al. (2002). We modify it to take into account the viscous heating, the opacity by icy dust particles, and scattering.

We found that the location of the snowline with both ice and silicate opacity is farther than the location of the snowline without ice opacity. This is because icy dust particles condensed in the atmosphere prevent energy generated by viscous heating around the midplane from escaping to the space and enhance the temperature. We also found that the ratio of the radii of the snowline is constant and depends on the amount of the dust particles at the snowline.

This fact indicates that if some mechanisms enhance the amount of the water ice at the snowline, the snowline may be located farther.

Electric charging of dust aggregates and its effect on their coagulation in protoplanetary disks

Satoshi Okuzumi,
Kyoto University

Mutual sticking of small dust aggregates is the first step toward planetesimal formation in protoplanetary disks. In spite that the electric charging of dust particles is well recognized in some contexts, it has been largely ignored in the current modeling of collisional dust growth. This study presents the general solution to the charge state of dust aggregates in nonthermally ionized gases, and demonstrates how the charging could change the current scenarios of dust coagulation. It is shown that the self-consistent solution of the dust charging state and gas ionization state can be written in analytical forms depending on a single master parameter. The equation for the master parameter is derived from the conditions for the ionization-recombination equilibrium. This equation is easily solved numerically, and thus gives the semianalytical solution of the dust charging state. The semianalytical solutions agree with full numerical solutions obtained by a charge reaction scheme. As an illustrative example, the effect of dust charging on the early stage of dust coagulation is examined. It is found for a wide range of model parameters that the ballistic cluster-cluster aggregation (BCCA) "freezes out" at a certain aggregate size, which is because Coulomb repulsion barrier between aggregates quickly increase with dust evolution while their relative velocity hardly increase in BCCA. It is also suggested that the "freeze-out" of uniform BCCA growth might be followed by oligarchic growth where a small population of relatively compact aggregates sweep up a large population of frozen-out BCCA clusters.

Zirkonium and Hafnium in meteorites

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Zr and Hf are incompatible, lithophile, and refractory trace elements. With respect to meteorites, they may help decipher condensation conditions and sequences during the early stages of solar system formation.

We analyzed 34 bulk samples via laser ablation ICP-MS. Our objective was the identification of possible systematic fine-scale variations among different meteorite classes.

Recent work defined a chondritic Zr/Hf ratio of 34.2 ± 0.3 as based on 2 carbonaceous chondrites and 5 monomict eucrites [1]. Another investigation examining 34 different meteoritic samples returned a similar result (34.3 ± 0.1 [2]).

We normalized our Zr/Hf data to the chondrite-only ratio (Orgueil, CI1) of [1] (34.1 ± 0.6). We then obtained relative values in percent deviation from this reference point (gamma values). Deviations appear to be systematic and include a negative trend for EL6 chondrites and a positive trend for H chondrites. All carbonaceous chondrites yield ratios equal to Orgueil.

[1] Weyer, S. et al. (2002) Chem. Geol. 187, 295-313. [2] Shima, M. (1979) GCA 43, 353-362.

On the gravitational settling of cloud particles under the atmospheric conditions of the Super-Earth Gl 581d

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The presence of particles of likely condensates in extrasolar terrestrial planet atmospheres is of particular interest, especially in view of the recently discovered low mass planets – so called Super-Earths. Consequences regarding the condensation of major gaseous constituents of the planetary atmospheres have to be considered in detail to account for e.g. a possible atmospheric collapse.

In this contribution the results of gravitational settling studies of (potential) solid CO_2 particles under the atmospheric conditions of the Super-Earth Gl 581d is, therefore, presented and compared with the findings of corresponding calculations for liquid water particles in Earth's atmosphere.

Supernova Bullets Impinging upon Molecular Clouds

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We analyze supernova ejecta in the form of distinct clumps, "bullets", impinging upon molecular clouds at the peripheries of HII regions surrounding the supernova explosion. We have carried out preliminary 3D simulations with sample bullets denser than the molecular cloud by one to two orders of magnitude, a radius of a few tens to a few hundreds AU and a velocity of a few thousands of km/s using the FLASH code to solve the hydrodynamic equations and accurately capture the strong shock. We show the depth at which the mass is deposited inside the cloud, the mixing of bullet material with molecular cloud components due to Kelvin-Helmholtz instabilities, and the distribution of the mass deposited along the trajectory of the ejecta. We compare our preliminary results with previous studies and suggest the implications for star formation and protoplanetary disks.

Particle Accretion onto Planets in a Protoplanetary Disc

Natalie Raettig,
MPIA Heidelberg

We follow the trajectories of individual particles in an accretion disk. This is done with a restricted 3-body code. The motion of the particles is due to two effects. Gravitational attraction of star and planet and coupling to the disk gas. Disk gas is slightly sub-keplerian while unperturbed dust particles move on exact Kepler orbits. Depending on particle size coupling to the gas is more or less efficient. Therefore particle drag also depends on its size.

For varying Stokes-numbers we find accretion-rates on different size planets. Also the location within a disk from where accreted particles originate is looked at.

Planetary transit observations at the University Observatory Jena: TrES-2

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AIU Jena

We have started high precision photometric observations at the Jena University Observatory in Großschwabhausen near Jena in fall 2006. To test the obtainable photometric precision, we observed stars with known transiting planets. For our transit observations we used a 25 cm Cassegrain telescope mounted picky-pack on the tube of a 90 cm telescope equipped with the optical CCD-camera.

Here, we report on observations of several transit events of the transiting planet TrES-2. Between March 2007 and July 2008 eight different transits and almost a complete orbital period were observed. Overall, in 37 nights of observation 4052 exposures (in total 65.08 h of observation) of the TrES-2 parent star were taken. With the transit timings for TrES-2 from the four events published by the TrES and Transit Light Curve projects plus our own eight transits, we find that the orbital period is slightly smaller ($\sim 0.3\,\mathrm{s}$) than the previously published value. We present new ephemeris for this transiting planet.

Furthermore, we found a second dip after the transit which could either be due to a blended variable star or occultation of a second star or even an additional object in the system.

Our observations will be useful for future investigations of timing variations caused by additional perturbing planets and/or stellar spots and/or moons.

In early 2009, we will start to use our 90 cm telescope with a new CCD-camera for the transit observations.

Laboratory Experiments on the Kinetics of Thermal Annealing of Dust in Proto-Planetary Disks – First Results

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The measurements taken by the ISO mission revealed a considerable amount of crystalline dust in proto-planetary disks. A widespread assumption is that the crystallisation of the amorphous cosmic dust particles occurs via thermal annealing. In this project we investigate the crystallisation kinetics of Magnesium-rich silicates in the laboratory with the aim of relating them to astronomical data.

We have started our investigations with forsterite (Mg_2SiO_4). As a consequence of the contradictory results of previous studies we have developed new strategies in regard to sample preparation and annealing. We essentially use amorphous thin films of stoichiometric composition with a constant and accurate adjustable thickness deposited on a silicon-wafer via PLD (Pulsed Laser Deposition). We have developed a simple annealing sequence in a vertical quench furnace. Before and after annealing, the sample is characterized not only by IR spectroscopy but also by AFM (Atomic Force Microscopy), SEM (Scanning Electron Microscopy) and TEM (Transmission Electron Microscopy).

First annealing experiments were performed at 800°C and 1080°C with various run durations in the range from 6 to 260 hours. The IR spectra (mid and far IR) of the annealed samples show the development of characteristic forsterite peaks. Additional characterizations with SEM and AFM reveal a roughening and dewetting of the annealed thin film from the surface of the carrier material which indicates an internal restructuring of the film in relation to volume decrease during the crystallisation process. Experimental series with different annealing times and temperatures are on the way.

Grain growth in Taurus-Auriga protoplanetary disks from millimetre wavelengths

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We present a preliminary study on a sample of nearly 30 protoplanetary disks around low-mass pre-main-sequence stars in the Taurus-Auriga star forming region. For 18 of these objects we obtained new data at 3 mm with the IRAM Plateau de Bure Interferometer with 0.3 rms sensitivity. Since many of the disks in our sample have been spatially resolved at millimetre wavelengths indicating outer disk radii typically larger than 100 AU, this suggests that the disk emission is mostly optically thin at these wavelenths. One can therefore directly derive from the shape of the (sub-)millimeter spectral energy distribution an estimate of the dust opacity law. We use a two-layer flared disk model to interpret the observed fluxes in the sub-mm and mm spectral region. Using an opacity law produced by compact spherical grains of silicates, H_2O-ices and carbonaceous materials we find that the observed spectral energy distributions are tipically consistent with the presence in the disk midplane of dust particles that have grown to sizes as large as a few centimeters. As part of our work we show preliminary results on the relation between the derived disk characteristics, like the disk mass and the maximum dust grain size, and the protostar properties, like its mass and mass accretion rate.

The toroidal topology of 3D steady flow of ideal compressible fluid in description of Solar System formation

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We have used stereographic projection of Hopf field on the 3-sphere into Euclidean 3-space as a model of 3D steady flow of ideal compressible fluid in accordance with Arnold's structural theorem. In such case, flow lines are Villarceau circles lying on tori corresponding to the levels of Bernoulli function. Existence of an "optimal torus" with minimal relative surface free energy was shown. Corresponding optimal torus formfactor $g = \frac{1}{\sqrt{2}} \approx 0.701...$, and Villarceau circles inclination $\theta = \arcsin(g) = \pi/4$. We call Villarceau circles inclination as "stream inclination". Beat of oscillations with wave numbers corresponding to structural radii of torus intersection with accretion plain leads to scaling of optimal tori with scaling factor $K = 1 + g = 1 + \sin(\theta)$. Scaled tori are considered as precursors of planetary orbits.

We found that scaling factor of Solar System and HR 8799 system precisely corresponds to an optimal torus. We have shown that scaling factors of satellite systems had deviations depending on central body axial tilt and local ratio of semi-major axes of neighbor planets. Large axial-tilt of Uranus is well explained with the suggested model. Spatial intersection of homothetic tori within one torus results in formation of cluster with the size depending on a scaling factor. First threshold corresponding to transition from the cluster size 3 to the size 4 at scaling factor is $K \approx 1.3894...$, being in agreement with stream inclination $\theta = 22.917°$. We found that the cluster size of solar, HR 8799, Galilean, Uranus' systems $C = 4$, but for Saturn's, Neptune's, Pluto's and Mars' systems is $C = 3$ where omitting of two orbits was found.

At least two stages of toroidal flow development have been determined in primordial nebula. At first stage, nebula was uniform, and tori separation brought about linear dependence of logarithm of relative volumes of planets on logarithm of relative semi-major axes. All regular satellites of giant planets with increasing volumes at increasing semi-major axes have distribution approximated by linear dependence with high degree of correlation. In suggestion on absence of dissipation of particles involved in toroidal flow around planets, high correlation confirms that density of particles in all satellite systems was similar. Moon has close parameters to concerned distribution, thereby suggesting that its formation has been processed by common mechanism. We found that Triton's parameters fit well the dependence of logarithm of relative volumes on logarithm of relative semi-major axes of regular Neptune's satellites. This means that formation of Triton and regular Neptune's satellites was simultaneous. We have shown that orbit inclination of Triton corresponded to its formation in opposite phase to regular satellites being similar to Pluto's system. Explanation of lack of two clusters with size $C = 3$ between the Proteus' and Triton's orbits is done. At second stage, main stream of toroidal flow located on tori has resulted in formation of paired planets with neighbor orbits and equal volumes. Number of pairs depended on a value of cluster size. If cluster size was $C = 4$, two pairs could be observed, while one pair could be seen when $C = 3$. Also, linear dependence of relative volumes of paired planets on relative semi-major axes was found.

Eccentricity damping during the formation of terrestrial planets

Zsolt Sandor,
MPIA Heidelberg

In the final stage of planet formation isolated planetesimals form terrestrial planets and planetary cores by collisional accretion. This process has already been investigated thoroughly by N-body simulations, however, the eccentricities of the formed planets are slightly larger than that observed in the case of Solar System.

In this work we investigate the long term effects of different mechanisms which might act during the formation process. These mechanisms can be:

i) drag force of the ambient gas of the protoplanetary disk,

ii) interaction of the planetary embryos with a planetesimal disk, and

iii) dynamical friction induced by fragmentation of the larger planetesimals.

Modelling the protoplanetary disc CB26

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A model of the edge-on seen circumstellar disc in the Bok globule CB26 is presented. The model is based on spectral data from Spitzer/IRAS and photometric data from HST, CSO and millimetre observations. Furthermore, we reproduce HST/NICMOS near-infradred maps in the JHK-Bands as well as OVRO and SMA radio maps at 1.1 mm, 1.3 mm and 2.7 mm. Both wavelength regimes trace different physical processes and different spatial regions of the system such as scattered stellar light from the disc's surface and envelope on the one hand side and reemitted radiation from the dust in the central parts of the disc on the other hand side, respectively. Using the self-consistent radiative transfer code MC3D, the model we construct is able to discriminate parameter sets and dust properties of both its parts, namely envelope and disc. We find that the disc features a large inner void of $r = 45\,\mathrm{AU}$ and can be described using the same dust properties as found in the interstellar medium and grain growth does not play a significant role for the appearance of this system.

Global Simulations of the Collapse of Molecular Cloud Cores

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The talk will give an overview of recent global radiation-hydrodynamics (RHD) simulations of the collapse of a rotating molecular cloud core. A Bonnor-Ebert-Sphere in hydrostatic equilibrium and uniform rotation, being on the verge of gravitational instability, is slightly perturbed and starts to contract. After about one free fall time the first adiabatic central core with the shape of an oblate spheroid forms, surrounded by an accretion shock front. After the dissociation of molecular hydrogen in this first core, the second central collapse starts and forms the second core which is the seed of the protostar. At the same time, material continues to fall to the equator of the system, forming the protoplanetary disk. Our simulation covers for the first time the whole range of spatial scales necessary to describe this process from about 0.2 light years (diameter of the initial cloud core of one solar mass) down to stellar scales. The dependence of the results on the total angular momentum and its initial distribution will be discussed.

Planetary systems around evolved stars

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The majority of extrasolar planets are found around hydrogen core burning main sequence stars since this is the longest-lived phase in the live of a star, and the radial velocity method is most readily applied to these host stars. The investigation of formation processes implies a focus on the observations of the much rarer very young planetary systems. Beyond the main sequence phase, planets have been found around subgiant stars at the beginning of the red giant branch, and the first planet-like objects ever discovered were in fact found around pulsars. In between the highly evolved pulsars, and stars evolved just beyond the main sequence, planetary systems found around extreme horizontal branch stars allow to separate the effects of the red giant branch from those of the asymptotic giant branch evolution. This contribution presents the current census of extra-solar planets around horizontal branch stars and reports on our on-going search program and the timing method used for detection.

The Inner Boundary of the Habitable Zone for Earth-like Planets

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Liquid water is a commonly accepted, fundamental requirement for the development of life. Based on this condition the Habitable Zone (HZ) is defined as the region of possible orbits around a star where liquid water exists on the surface of a terrestrial planet. The inner boundary of the HZ can be defined in different ways. The "water loss limit" occurs where an Earth-like planet loses its entire water content within the planet's lifetime. The "runaway greenhouse" limit marks the point where the greenhouse effect becomes unstable via water evaporation. In this study we present a self-consistent determination of the inner boundaries of the HZ applying a one-dimensional radiative-convective model of the atmosphere. Our approach involves the step-by-step increase of the incoming stellar flux and the subsequent calculation of resulting changes in the atmospheric composition and the radiative properties. To achieve this, the infrared radiative transfer scheme was improved to be suitable for such high temperature and pressure conditions. Modelling results are presented for the influence of various planetary and atmospheric conditions on the inner boundaries of the HZ.

Collisions – From Dust Puppies to Planets

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The growth of planetesimals from dust aggregates in protplanetary disks is still a matter of discussions. The growth of cm to dm size bodies by collisions of highly porous dust agglomerates has been subject to several theoretical and experimental studies and is well understood so far. However, for growth to larger sizes (especially overcoming the m-size barrier) the outcome of collisions with impact velocities of several 10 m/s is crucial, independent from the growth model (gravitational instability or growth via collisions). In this work we performed experiments with (mm to cm size) compact dust aggregates impacting into dm-size targets (of equal properties) with velocities between 20 and 60 m/s. Projectiles smaller than 1 mm were found to lead to growth at impact velocities of up to $\sim$60 m/s. In the studied velocity range collisions produce large amounts of small fragments which are smaller than the impacting aggregate. After several collisions cm-size aggregates will be grinded to sub-mm size and can be (re-) accreted in a following collision. The experimental results suggest, that preplanetesimal growth by collisions in the high velocity range is possible.

Laboratory experiments towards heterogeneous accretion

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This contribution reports the experimental results on the aggregation of ferrimagnetic grains by an imposed impulse magnetic field. The sample chosen was a ferrimagnetic block, which was first thermally demagnetized and then broken into grains of mm to cm size. The sample was exposed to lighting impulse, generated by a 38 kV rectangular pulse of 150 ns duration supplied from the Marx impulse generator. A series of photographs of the state of sample under the applied electromagnetic forcing was taken by a high-speed (600 frames per second) camera. The individual grains get magnetically bonded, forming a cluster which exhibits a permanent magnetic moment. The implications regarding the heterogenous accretion in planetary formation are discussed.

Observations of planets orbiting within disks around young stars

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Planets are thought to form inside gas-rich circumstellar disks around forming stars during the first several Myr of their evolution, after which the disks – and thus the material reservoir for making (gaseous) planets – are gone. The disk dissipation and planet formation process may be intimately related.

Since the first announcement of a planet orbiting a star other than our sun in 1995, over 300 exo-planets have been identified, mostly using the radial velocity technique. The vast majority of exo-planet host stars are ordinary main sequence stars that formed long before our time and for which we cannot study the formation process. For a better understanding of the relation between planet formation and the disks dissipation processes, planets around young, forming stars must be found.

Recently, a giant gas planet was found orbiting within the disk of TW Hya, a young star whose "transition" disk is currently being dissipated (Setiawan et al. 2008). We will discuss the prospects of further such observations, and show a candidate planet orbiting a star that is substantially younger and more massive than TW Hya, and is still surrounded by a massive gas-rich disk.

Implication of activity of late-type stars for Darwin mission

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Because of high energetic activity of M-type stars, their quality as habitable planet hosts is still discussed. Nevertheless, a detailed knowledge of theactivity characteristics of possible target stars is important for design planet finding missions like Darwin (ESA) and TPF (NASA). Our investigation is aimed at the CMEs (Coronal Mass Ejections)- and flaring-activity of nearby single M dwarfs based on analogy of decameter radio type II bursts and CMEs on the Sun. The radio observations were carried out at the UTR-2, the World's largest decameter array, of the Radioastronomical Institute of the Ukrainan Academy of Sciences in Kharkov. Similtaneous observations in the optical range (B,V photometry) were performed at the Astrophysical Institute and University Observatory in Jena. A general description of our project and the short report on the last observational campaigns is presented.

Formation of Planet System OGLE-06-109L

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Gas giant planets are ubiquitous in the detected extrasolar systems. So the presence of gas giants is crucial to the formation and dynamics of a proto-planet system. In this paper we investigate the formation of planetary system OGLE-06-109L which is the first multiple planetary system discovered by gravitational microlensing with N-body simulation, including gas accretion and type-II migration of gas giants during their formation. First we find that under the perturbation of the two giants, the planet embryos in the inner part of the system will be excited leading them merge and scatter. Among our simulations, Earth-mass planets survival in the habitable zone. The two giants in the system will undergo near-separatrix motion and the eccentricities of them are comparable to the observation data. Then considering the accretion process we find due to type II migration on 1 Myr time scale, the existence of gas giant planets on short period orbits is common. A system similar to OGLE-06-109L is formed during our simulations.

Estimating the masses of the extra-solar planets

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The majority of extra-solar planet masses that have been derived spectroscopically represent lower limits to their true masses since the inclination of the planetary orbit is unknown except for transiting systems. In theory, however, it is possible to determine the inclination angle between the rotation axis of a star and an observer's line-of-sight from measurements of the projected equatorial velocity, the stellar rotation period and the stellar radius. This allows the removal of the inclination dependency of extra-solar planet masses under the assumption that the planetary orbits lie perpendicular to the stellar rotation axis.

We present and discuss the results of applying this methodology to a large sample of stars hosting extra-solar planets, and estimate the true masses of 135 planets. In addition, by applying a Markov-chain Monte Carlo analysis we are able to determine transit probabilities for extra-solar planets based on the spectroscopic properties of their host stars alone.

Condensation of SiO and SiO2 studied by infrared spectroscopy

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For a better understanding of the formation of silicate compounds in protoplanetary discs and their observed infrared (IR) emission, the condensation processes of thermally evaporated SiO and SiO_2 were studied under ultra high vacuum (UHV) conditions by IR spectroscopy. For both the materials the IR spectra of the condensed films show the features of amorphous SiO and can be described by a dielectric function model with four Brendel oscillators. The optical properties obtained from transmission measurements will be presented and compared to latest literature data.

Chemistry in brown dwarf discs

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Using the model of an accretion disc physical structure and extensive set of gas-phase chemical reactions as well as dust-gas interactions, we compare the chemical evolution in a protoplanetary disc around a brown dwarf and a low-mass T Tau star. It is shown that discs of substellar objects of lower luminosity are in general colder and less dense than discs around T Tau stars. Also, less dense brown dwarf discs have greater fractional ionisation in the midplane as they are more transparent to ionising radiation. Nevertheless, in both cases, most molecules are concentrated in the so called warm molecular layer between the ionised atmosphere and cold midplane, where icy dust mantles are abundant. Differences in the chemical composition of discs around brown dwarfs are mainly caused by the disc thermal structure. In addition to the warm molecular layer, there is another specific layer (an 'icy mantle zone') where some molecules are significantly depleted even in comparison with the midplane.

Collision Condition for Compound Chondrule Formation

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Some compound chondrules seem to be formed by collisions of two independent particles during heating events in the solar nebula. Although some researchers noticed collision probability of particles so far, they seldom noticed the collision conditions. If two drops experience the high-speed or grazing collision, they cannot coalesce. Or if the viscosities of both drops are too low, they cannot keep their shape and will fuse together by surface tension. In this study, we examined the collision conditions for compound chondrule formation with three-dimensional hydrodynamics simulation.

Firstly, we examined "condition for coalescence" for various parameters; the collision velocity, angle, the diameters and viscosities of drops. We can categorize the results of drops" collisions into three groups; "Stretching separation", "Disruption", and "Coalescence" and we found that these boundaries can be expressed by comparing the kinetic energy, surface energy, viscous dissipation, and rotational energy.

Secondly, we examined “condition for keeping shape”. In order to keep their shape, the deformation timescale has to be longer than the cooling timescale. When the relative velocity is relatively low, the deformation is controlled by ram pressure of collision and the deformation time can be understood by the timescale of transit time of two drops. On the other hand, when the relative velocity is relatively high, it is controlled by the surface tension and the deformation time can be understood by damped oscillation.

Now, we obtain the collision condition for compound chondrule formation quantitatively and then we can verify formation models.

The M dwarf planet search program with the VLT+UVES

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We present results from the precision radial velocity survey of M dwarfs with the VLT+ UVES in search for planetary companions. They include the first genuine brown dwarf desert object and several low-mass companion candidates around early-type M dwarfs. The lack of Jupiter-mass companions in this survey is comparable with results from other search programs. Upper limits to the mass of hypothetical planets can be placed down to the Earth mass regime in the habitable zones of our better observed stars.

The Pennsylvania - Torun Planets Search. Stellar parameters determination

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Proper interpretation of high-precision radial velocity (RV) observations requires knowledge of precise stellar fundamental parameters with highest possible accuracy. These parameters not only allow for planetary components mass determination but also allow to estimate stellar evolutionary status including age. These data are crucial for statistical considerations of planetary systems evolution. In the case of the Pennsylvania - Torun Planets Search (PTPS) determination of stellar parameters it is carried out through spectroscopic study assuming LTE and observational data obtained with the 9.2 m Hobby-Eberly Telescope. In this poster we present the results of physical parameters determinations with two numerical algorithms: TGVIT (Y. Takeda et al.) and MOOG (C. Sneden). We present the observational material that we use, the reduction/measurement technique and compare effective temperatures, gravities and metallicities obtained with both codes for a sample of stars.

Metallicity of evolved stars with planets

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The main goal of the Pennsylvania - Torun Planets Search is planets detection around evolved stars using the high-precision radial velocity (RV) technique. The project is performed with the the 9.2 m Hobby-Eberly Telescope. To determine stellar parameters and evolutionary status for targets observed in the survey complete spectral analysis is required. The most important is knowledge of such fundamental parameters as effective temperatures, metallicities and luminosities that allow us to estimate stellar ages and masses. In this talk I will present the results of metallicity determinations for late-type evolved stars showing significant RV variations and for a control sample of relatively RV-stable stars. By comparing this results with literature data it is possible to address the planet occurence frequency vs. metallicity relation for giants.

Circumstellar disks and dust aggregates: the biggest billiard table with the smallest balls

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

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

Based on this recipe we ran a growth simulation in a disk model introduced by Brauer et al. (2008) and found that bouncing slows down the initial growth of particles. When, however, the aggregate masses reach a critical value, new ways of growth become available (e.g. growth by penetration). After a sudden transition in the mass distribution function, the compacted aggregates do nothing but bounce without further growth or fragmentation. The maximum mass of the particles is two orders of magnitude lower compared to previous dust models, such as Brauer et al. (2008) and Zsom & Dullemond (2008).

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