Planet Formation and Evolution 2017

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Abstracts

Talks

TTauri disks with SPHERE Polarimetric Differential Imaging

Avenhaus, Henning (havenhaus[at]phys.ethz.ch)

ETH Zürich

Abstract: In 2016 and 2017, we have started to observe a larger sample of TTauri disks with VLT SPHERE IRDIS Polarimetric Differential Imaging (PDI) in an effort to expand the sample of disks imaged at high resolution and signal-to-noise ratio in scattered light. We have targeted a total of 29 TTauri stars, and were able to detect the disks for a significant fraction (>50%) of these. During my presentation, I will go into detail on the results for our 2016 campaign and will present some early results from our 2017 observations.

HD169142 seen with new eyes

Bertrang, Gesa H.-M. (bertrang[at]das.uchile.cl)

Universidad de Chile

Abstract: The circumstellar disk around the Herbig Ae/Be star HD169142 is a well-studied object which shows structures on multiple wavelength ranges (e.g., Quanz+2013, Osorio+2014). Moreover, HD169142 harbors the most promising proto-planet candidate (Reggiani+2014, Biller+2014).
We present new SPHERE/ZIMPOL data which distinctly deviate from the established picture developed for this object (Osorio+2014). Based on these new observations as well as high-resolution ALMA observations and further archival data, we built a new model for this disk. These new eyes, namely SPHERE and ALMA, in combination with 3D radiative transfer simulations show that we are witness to previously undetected planet-disk interactions in HD169142.

On pebble isolation mass and its influence on planet growth

Bitsch, Bertram (bert[at]astro.lu.se)

Lund University

Abstract: Planetary growth can be greatly accelerated by the accretion of pebbles, which in contrast to planetesimals feel gas drag and drift inwards in the disc. As they approach

the Hill sphere of a growing planet they can spiral down towards it and are accreted. However, as the planet grows, it pushes away material from its orbit due to the exchange of angular momentum. This allows the planet to open up a partial gap in the disc, generating a pressure bump outside of its orbit, which stops the inward flow of pebbles. Pebble accretion thus self terminates.
In this talk, I will present new results to constrain the pebble isolation mass in more detail and show the influence on planet growth models. In particular, the pebble isolation mass depends on the disc's aspect ratio, viscosity and pressure gradient. This results in different final masses planets can reach by pebble accretion and can explain the dichotomy between ice and gas giants.

Yet more evidence that comet 67P formed by gravitational instability of a pebble cloud

Blum, Jürgen (j.blum[at]tu-bs.de)

IGeP, TU Braunschweig

Abstract: After Rosetta has finished its observations of comet 67P, participating scientists have started to publish more and more results. From a first analysis of the published data, the hypothesized picture of 67P's formation by gravitational instability of a pebble cloud receives further support. Data on dust release, thermal properties, cliff collapse, or day/night activity can readily be understood if the comet nucleus is composed of cm-sized dust pebbles. I will present the latest evidence and modeling efforts.

Direct imaging of exoplanetary systems with current and future facilities

Boccaletti, Anthony (anthony.boccaletti[at]obspm.fr)

LESIA - Paris Observatory

Abstract: In the last two decades the knowledge on exoplanetary systems has a lot progressed triggered by many discoveries with various techniques as well as theoretical works. One obvious priority is the investigation of exoplanets atmospheres which requires a direct detection. Two families of techniques have emerged, one is targeting close-in transiting systems while direct imaging is appropriate for rather long-period planets.

The technique of high contrast imaging provides a number of capabilities of great interest to study exoplanetary systems. Not only it allows for photometric or spectroscopic characterization of exoplanets but also provides a snapshot image where all components of a system can be identified. Depending on the performances and the spectral range it corresponds to planetary mass bodies as well as dust which essentially scatters the starlight at visible and near IR wavelengths. The ultimate goal is clearly to characterize exoplanetary systems that are similar to our Solar System with the ambition to place it in context for a better understanding of planetary formation. Currently, whatever the technique of detection, the knowledge of the population of planets at separations larger than 5-10 au is not complete, while giant planets in this separation range are believed to shape the planetary systems and hence determine their evolution as proposed in the Grand Track model for the case of the Solar System.
Direct imaging has an critical role to play in this general context but naturally comes with some difficulties. In this presentation, I will introduce the limitations and the technical aspects

Discovery and characterization of substellar companions observed during the SHINE (SPHERE) exoplanet survey

Bonnefoy, Mickaël (mickael.bonnefoy[at]univ-grenoble-alpes.fr)

Institut de Planétologie et d'Astrophysique de Grenoble (IPAG/CNRS)

Abstract: The SHINE survey conducted on the SPHERE high contrast imager aims to characterize the giant planet population beyond 5 AU around 400-600 nearby stars. Once a companion is resolved, the collection of sub-instruments of SPHERE can uniquely provide spectra and photometry of known exoplanet and brown-dwarf companions from 0.5 to 2.5 µm. Those spectro-photometric informations are used to better understand their orbital, physical, and chemical properties of the objects, and in turn to access the formation modes and dynamical evolution of planetary systems.
During the past two years, we have achieved with SPHERE a complete characterization of all known bona-fide planets discovered so far (HR8799 bcde, 51 Eri b, GJ504b, etc), as well as some benchmark brown dwarf companions (HD 206893b, etc). We will present our results and detail how they change our view of the atmospheric properties and formation process of those substellar companions. We will also review the status of the survey and its main results.

How does planetary material arrive in the atmospheres of polluted white dwarfs?

Bonsor, Amy (amy.bonsor[at]gmail.com)

Institute of Astronomy, University of Cambridge

Abstract: Planetary material observed in the atmospheres of white dwarfs uniquely provides the bulk composition of planetary bodies. But, how does this planetary material arrive in the white dwarf atmosphere? Infrared observations of polluted white dwarfs hint at the presence of dusty material close to some, but not all, polluted white dwarfs. In this work, I consider infrared observations of an unbiased sample of white dwarfs collated from the literature and show that the observations are inconsistent with the standard model of an opaque, flat dust disc supplying the accretion for all polluted white dwarfs. I discuss alternate explanations.

SCUBA-2 Observations of Nearby Stars: The complete survey results

Booth, Mark (mark.booth[at]uni-jena.de)

AIU, Jena

Abstract: SCUBA-2 Observations of Nearby Stars (SONS) was one of seven legacy surveys undertaken on the James Clerk Maxwell Telescope between 2012 and 2015. It involved surveying 100 stars known to be debris disc hosts at 850 and 450 μm to search for their excesses in the sub-mm. We detect discs around 49 of the 100 stars in the survey at 850 μm and also detect 450μm emission around 14 of these. With these detections we can determine dust masses for the discs and, by fitting to the full SEDs, we can determine the spectral slopes for the dust in the system and infer a radii from the temperature. 16 of the images show resolved emission, allowing us to determine the actual size of those discs for comparison with that inferred from the SED. I will discuss what trends we see in these properties with regards to age and luminosity, what they mean for the stirring mechanism in the system and what we can infer about the dust properties.

The chemical evolution of discs and planets driven by radial drift

Booth, Richard (rab200[at]ast.cam.ac.uk)

Institute of Astronomy, Cambridge

Abstract: How and when giant planets form is a key challenge which planet formation theories struggle to resolve, with core accretion appearing to require longer than the typical life time of protoplanetary discs. A variant of core accretion, in which the planet's core grows by accreting cm sized pebbles may overcome the time scale problem. These two scenarios make differing predictions for the late accretion of solids, because pebble accretion must stop before the planet accretes its envelope, while the accretion of planetesimals is thought to continue. This provides a way to constrain how they might have formed is through their chemical compositions. Jupiter, being carbon rich (C/H ∼4x solar), provides a useful benchmark case because a high C/H ratio produced by the late accretion of planetesimals, which are oxygen rich, would produce a low C/O ratio. Here I will show that a high C/H ratio can also be achieved via the radial transport of volatiles in icy dust grains. This evolution is supported by the composition of the gas accreted on to T Tauri stars, which show variations in the Si:C and Si:N ratio that agree with model predictions. This suggests that Jupiter might have acquired its high C/H ratio through the accretion of metal rich gas, resulting in a high C/O ratio. Juno's imminent measurement of Jupiter's oxygen abundance will place constraints on how Jupiter acquired its metals, and thus the importance of pebble versus planetesimal accretion in forming its core.

Magnetic fields in circumstellar disks: The potential of Zeeman observations

Brauer, Robert (rbrauer[at]astrophysik.uni-kiel.de)

Institute of Theoretical Physics and Astrophysics, University of Kiel

Abstract: Recent high angular resolution polarimetric continuum observations of circumstellar disks provide new insights into their magnetic field. However, direct constraints are limited to the plane of sky component of the magnetic field. Observations of Zeeman split spectral lines are a potential approach to enhance these insights by providing complementary information.

We investigate which constraints about magnetic fields in circumstellar disks can be derived from Zeeman observations of the 113 GHz CN lines. Furthermore, we analyze the requirements to perform these observations. We simulate the Zeeman splitting with the RT code POLARIS (Reissl et al. 2016) extended by our Zeeman splitting RT extension ZRAD, which is based on the line RT code Mol3D (Ober et al. 2015).

We find that Zeeman observations of the 113 GHz CN lines provide significant insights into the magnetic field in circumstellar disks. However, with the capabilities of recent and upcoming instrument/observatories, even spatially unresolved observations would be challenging. Nevertheless, observations are feasible for the most massive disks with a strong magnetic field and a high abundance of CN/H. The most restrictive quantity is the magnetic field strength, which should be at least in the order of $\sim$1 mG. In addition, the inclination of the disk should be around 60° to preserve the ability to derive the line-of-sight (LOS) magnetic field strength and to obtain a sufficiently high circularly polarized flux.

Metallicity effect on planet formation by pebble accretion

Brügger, Natacha (natacha.bruegger[at]space.unibe.ch)

Physikalisches Institut Universität Bern

Abstract: Recent works propose that planets form by accreting small pebbles. I study how this model works and its accuracy compared to observations. I also work on the metallicity effect on the formation of planet by accretion of these pebbles. In order to do that I vary the density of pebbles and compute full disc evolution.

Dust-drag induced fluid instability: Experimental investigations

Capelo, Holly (holly.capelo[at]ds.mpg.de)

Max Planck Institute for Dynamics and Self-organization

Abstract: We present experimental evidence for fluid instability in a low-pressure dust-gas mixture. Our facility operates in a parameter regime meant to test the assumptions underlying the streaming instability in protoplanetary discs. We will discuss the findings of the experiments and connect the results to the case of planetesimal formation.

Migration of low-mass planets through resonant pulling

Coleman, Gavin (gavin.coleman[at]space.unibe.ch)

Universitat Bern

Abstract: It is understood that more massive planets which migrate in a protoplanetary disc, at a faster rate than less massive planets, can capture planets interior to their orbits into resonant chains, forming a single migrating resonant convoy. In this case, the most massive planet is typically the outermost planet of the resonant chain. Here I will present results where low-mass planets captured into external mean motion resonance with a more massive interior planet, can have its migration rate dynamically enhanced, allowing the less massive planets to migrate further in the disc, than they can individually. I will then discuss the implications of these results with respect to observed exoplanetary systems, and also the possible observational signatures that could point to this mode of formation.

Direct imaging of exoplanets in binary stars

Daemgen, Sebastian (daemgens[at]phys.ethz.ch)

ETH Zürich

Abstract: Historically, binary systems were often excluded from planet searches because they were considered hostile environments to planet formation and they presented technical complications for many detection methods. However, a growing body of detections shows that binary systems host a significant fraction of the overall planet population. In fact, 1/2 of all directly imaged planets are bound in binary or triple stars. On one hand this demonstrates that we have to consider the dynamical gravitational environment of multiple stars in exoplanet science as it likely plays a major role in shaping the planet population that we see. On the other hand, binary stars represent promising grounds for direct imaging searches for planets.

I will give a brief overview of the status of exoplanets in binary stars and highlight the implications for exoplanet science as a whole. I will further present results from our ongoing "Search for Planets Orbiting Two Stars" (SPOTS) and the "Visual Binary Exoplanet Survey" (ViBES). These are the first and largest extreme adaptive optics planet surveys targeting exclusively binary stars.

Planetesimal formation follows the snow line

Drazkowska, Joanna (joannad[at]physik.uzh.ch)

University of Zurich

Abstract: These is a major gap in our understanding of planet formation between its early and late stages. The scientists who consider growth of planetary embryos typically assume that the embryos and planetesimals formed very rapidly and with a smooth radial distribution. On the other hand, the researchers performing dust coagulation models rarely find any growth over centimeter sizes. It is commonly accepted that the jump change in circumstellar disk properties around the snow line, with the water ice greatly enhancing abundance of solids, is important for planet formation. At the same time, recent laboratory experiments confirmed that dust aggregates containing water ice are significantly more sticky than dry ones. I will show how these features enable efficient planetesimal formation at the snow line and present numerical models exploring how this process works in an evolving protoplanetary disk.

Polarimetric observations of debris disks

Engler, Natalia (englern[at]phys.ethz.ch)

Institute for Astronomy, ETH

Abstract: We present our newest results from the high-contrast imaging polarimetry of debris disks with SPHERE-ZIMPOL. Polarimetry is a very sensitive differential measuring method for accurate measurements of the polarized and therefore scattered light from circumstellar dust. The measured polarization signal allows to reconstruct the morphology of debris disks and contains additional diagnostic information on the scattering dust, different from the intensity signal. Using the example of debris disk surrounding HIP 79977, we will demonstrate the capabilities of SPHERE-ZIMPOL for debris disk imaging with an unprecedented angular resolution which sheds new light on the architecture of this system.

First imaging of the AR Pup post-AGB binary disk

Ertel, Steve (sertel[at]email.arizona.edu)

Steward Observatory, University of Arizona

Abstract: Circumbinary disks are thought to play an important role in the post-main sequence evolution binary stars with orbital time scales of months to years. These systems may even be responsible for the formation of the majority of bipolar planetary nebulae. The disks are thought to form through angular momentum transfer from the companion to the material ejected by the giant star.

Interestingly, despite their different origin, these disks seem to be very similar to protoplanetary disks: They have similar mass and extent and show clear evidence of spatial evolution and dust processing in form of crystallization, grain growth, and dust settling. Even a large inner cavity has been detected in one disk, similar to transition disks. This evolution is particularly surprising given the very short life times of these disks (only few 10^4 – 10^5 years). While it is questionable if such disks actually form planets, these properties make them an interesting, extreme laboratory to test protoplanetary disk evolution and planet formation models: Any such model should also be able to explain the evolution of these disks!

Using VLT/SPHERE, we have imaged the disk around the post-AGB binary AR Pup for the first time. This is only the second such disk ever imaged directly. We will present a brief review of our knowledge about such disks and discuss our results on AR Pup. We will also give an outlook on our ongoing investigation of this new benchmark object and future prospects in imaging more such disks.

Dust vs. gas outer radii of disks: What's the difference?

Facchini, Stefano (facchini[at]mpe.mpg.de)

Max Planck Institut für Extraterrestrische Physik

Abstract: The high sensitivity and angular resolution of ALMA are providing new insights on the typical properties of protoplanetary disks. ALMA observations of close bright disks confirm earlier indications that there is a clear difference between the dust and gas radial extents, whereas ALMA surveys of star forming regions indicate that this difference might not be statistically significant. The origin of this difference is still debated, with both radial drift of the dust and optical depth effects being suggested. In this work, the feedback of realistic dust particle distributions onto the gas chemistry and molecular emissivity is investigated, with a particular focus on CO. The difference of dust and gas radial sizes is largely due to differences in the optical depth of CO lines and millimeter continuum, without the need to invoke radial drift. The gas outer radius probed by ^{12}CO emission can easily differ by a factor of 2 between the models for turbulence ranging between typical values. Grain growth and settling concur in thermally decoupling the gas and dust components, due to the low collision rate with large grains. Thus, the gas can be much colder than the dust at intermediate heights, reducing the CO excitation and emission. The low thermal coupling is expected to arise also in the dust cavity of large transition disks, or in the dust gaps recently observed at high angular resolution. A proper treatment of the gas thermal structure is fundamental to infer the properties of the proto-planets invoked in these systems.

The evolution of protoplanetary disks from their taxonomy in scattered light

Garufi, Antonio (antonio.garufi[at]fastwebnet.it)

Universidad Autonoma de Madrid

Abstract: Disk evolution can be constrained from the comparison of disks with different properties. A first attempt of disk taxonomy is now possible thanks to the increasing number of high-resolution images of Herbig Ae/Be and T Tau stars becoming available. We revise the standard evolution of Group I and Group II disks around Herbig stars and study how the evolutionary tracks of TTSs differ from those of more massive stars by means of a taxonomic analysis of more than 30 well-known objects. The comparison of different properties, from both the literature and constrained by scattered-light images, is revealing intriguing constraints on the formation of planets and on the global evolution of the disk geometry.

Self-induced dust traps: Overcoming planet formation barriers

Gonzalez, Jean-François (Jean-Francois.Gonzalez[at]ens-lyon.fr)

Centre de Recherche Astrophysique de Lyon

Abstract: Planet formation is thought to occur in discs around young stars by the aggregation of small dust grains into much larger objects. The growth from grains to pebbles and from planetesimals to planets is now fairly well understood. The intermediate stage has however been found to be hindered by the radial-drift and fragmentation barriers.

We identify a powerful mechanism in which dust overcomes both barriers. Its key ingredients are (i) backreaction from the dust on to the gas, (ii) grain growth and fragmentation and (iii) large-scale gradients. The pile-up of growing and fragmenting grains modifies the gas structure on large scales and triggers the formation of pressure maxima, in which particles are trapped.
We show that these self-induced dust traps are robust: they develop for a wide range of disc structures, fragmentation thresholds and initial dust-to-gas ratios. They are favored locations for the formation of pebble-sized solids and their subsequent growth into planetesimals, thus opening new paths towards the formation of planets.

Comet 67P: The most primitive body in our Solar System?

Güttler, Carsten (guettlerc[at]mps.mpg.de)

Max Planck Institute for Solar System Research, Göttingen, Germany

Abstract: Comet 67P/Churyumov-Gerasimenko was accompanied by the Rosetta spacecraft for more than two years on its orbit around the sun. With a broad suite of complementary instruments and the Philae lander on the comet's surface, a wide range of aspects were studied: from the surface morphology with its physical properties and composition to the gas and dust particle in the near coma.
The visible surface of a comet is in constant change as it is active from solar insulation, sublimation of volatiles and the lift-off of dust particles. However, the overall nucleus appears very primitive, showing a very low core temperature, high porosity, and low strength. On a larger scale, we observe the prominent bi-lobed shape and a layer structure wrapping around the individual lobes.
Putting together the puzzle of many individual Rosetta measurements, we conclude that comet 67P is among the most primitive bodies in our solar system. The challenge is now to discriminate which properties are indeed primordial or can otherwise be explained by evolutionary processes and, ultimately, establish a comprehensive picture of the comet's formation and evolution.

Exoplanets orbiting giant stars

Jones, Matias (mjones[at]eso.org)

ESO

Abstract: Evolved stars (subgiants and giants) are suited targets for precision radial velocity (RV) studies by two main reasons: 1) they are cooler and rotate slower than their former main-sequence progenitor, which allow us to achieve RV precision at the m/s level for intermediate-mass stars , and 2) we can use them to study the dynamical evolution of planetary orbits due to the interaction with the expanding stellar envelope.
Since 2009, we have been conducting a radial velocity survey called EXPRESS (EXoPlanets aRound Evolved StarS) aimed at studying the population of planets orbiting giant stars. So far, we have computed precision radial velocities for a sample of 166 bright giant stars, resulting in the detection of more than 20 giant planets and brown dwarf candidates and 24 spectroscopic binaries.
In this talk I will describe our project and present the main results after 8 years of observations. Finally, I will discuss our findings in the context of planetary formation.

Debris disks

Kennedy, Grant (gkennedy[at]ast.cam.ac.uk)

University of Warwick

Abstract: Debris disks are analogues of our Asteroid and Edgeworth-Kuiper belts that orbit other main-sequence stars. Through the study of the dust grains and pebbles that are observed, and the development of theories that explain their origins and structure, we learn about the layout, dynamics, compositions, and histories of mature planetary systems. In this talk I will highlight recent debris disk observations and theory, and aim to place these results in the more general context of planetary systems as a whole.

From planetesimals to planets in a turbulent disk

Kobayashi, Hiroshi (hkobayas[at]nagoya-u.jp)

Nagoya University

Abstract: In a protoplanetary disk without turbulence, the relative velocities between planetesimals are small and then larger planetesimals grow much faster than smaller ones, which is called runaway growth. If planetesimals grow via collisions naturally in a turbulent disk, the stirring by the density fluctuation caused by turbulence effectively increases the relative velocities between planetesimals, which suppress the onset of runaway growth. We carry out simulations for the mass and velocity evolution of planetesimals in a turbulent disk. When planetesimals are small, the average relative velocity between planetesimals is much greater than their surface escape velocity, so that orderly growth occurs instead of runaway growth. As planetesimals grow via collisions, their relative velocity approaches their surface escape velocity. Once the velocities are comparable, the runaway growth of planetesimals occurs.

The planetesimal radius at the onset of runaway growth (runaway radius) tends to be large in strong turbulence. The runaway growth results in a small number of planetary embryos, while most remnant planetesimals keep having the runaway radius. Planetary embryos grow until collisional fragmentation depletes planetesimals. Large planetesimals are collisionally strong because of self-gravity. Therefore, the large runaway radius allows embryos to be massive.

Growing embryos with 10 Earth masses, suitable to become the cores of Jupiter and Saturn, requires the runaway planetesimal radius of 100 km, similar to the proposed fossil feature in the size distribution of main belt asteroids. We find that this can happen if the turbulent accretion stress is about 0.001 times the gas pressure.

Hydrodynamics and thermodynamics of embedded planets' first atmospheres

Kuiper, Rolf (rolf.kuiper[at]uni-tuebingen.de)

Institut für Astronomie und Astrophysik, Universität Tübingen

Abstract: In the core accretion paradigm of planet formation, gas giants form a massive atmosphere in a run-away gas accretion phase once their progenitors exceed a threshold mass: the critical core mass. On the one hand, the majority of observed exo-planets, being smaller and rock/ice-dominated, never crossed this line. On the other hand, these exo-planets have accreted substantial amounts of gas from the circumstellar disk during their embedded formation epoch.

We investigate the hydrodynamical and thermodynamical properties of proto-planetary atmospheres by direct numerical modeling of their formation epoch. Our studies cover one-dimensional (1D) spherically symmetric, two-dimensional (2D) axially symmetric, and three-dimensional (3D) hydrodynamical simulations with and without radiation transport. We check the feasibility of different numerical grid geometries (Cartesian vs. spherical), perform convergence studies, and scan the physical parameter space with respect to planet mass and optical depth of the surrounding.
In terms of hydrodynamic evolution, no clear boundary demarcates bound atmospheric gas from disk material in a 3D scenario in contrast to 1D and 2D computations. The atmospheres denote open systems where gas enters and leaves the Bondi sphere in both directions.
In terms of thermodynamics, we compare the gravitational contraction of the forming atmospheres with its radiative cooling and advection of thermal energy, as well as the interplay of these processes. The coaction of radiative cooling of atmospheric gas and advection of atmospheric-disk gas prevents the proto-planets to undergo run-away gas accretion. Hence, this scenario provides a natural explanation for the preponderance of super-Earth like planets.

Collisions and compositional evolution during rocky planet accretion

Leinhardt, Zoë (Zoe.Leinhardt[at]bristol.ac.uk)

University of Bristol

Abstract: The Earth appears non-chondritic in its abundances of refractory lithophile elements, posing a significant problem for our understanding of its formation and evolution. It has been suggested that this non-chondritic composition may be explained by collisional erosion of differentiated planetesimals of originally chondritic composition. In this work, we present N-body simulations of terrestrial planet formation that track the growth of planetary embryos from planetesimals. We simulate evolution through the runaway and oligarchic growth phases under the Grand Tack model and in the absence of giant planets. These simulations include a collision model that allows multiple collision outcomes, such as accretion, erosion, and bouncing events, and enables tracking of the evolving core mass fraction of accreting planetesimals. We show that the embryos grown during this intermediate stage of planet formation exhibit a range of core mass fractions, and that with significant dynamical excitation, enough mantle can be stripped from growing embryos to account for the Earth's non-chondritic Fe/Mg ratio. We also find that the crust is preferentially lost relative to the mantle during impacts, and have developed a scaling law based on these simulations that approximates the mass of crust in the largest remnant. Using this scaling law we have estimated the effect of crustal stripping on incompatible element abun-

dances during the accretion of planetary embryos. We find that on average approximately one third of the initial crust is stripped from embryos as they accrete, which leads to a reduction of ∼20% in the budgets of the heat producing elements if the stripped crust does not reaccrete. Erosion of crusts can lead to non-chondritic ratios of incompatible elements, but the magnitude of this effect depends sensitively on the details of the planetesimal melting process. Such values are in keeping with compositional estimates of the bulk Earth.

Collisions and drag in debris discs with eccentric parent belts

Löhne, Torsten (torsten.loehne[at]uni-jena.de)

AIU Jena

Abstract: High-resolution images of circumstellar debris discs reveal off-centred rings that indicate past or ongoing perturbation, possibly caused by secular gravitational interaction with unseen stellar or substellar companions. The purely dynamical aspects of this departure from radial symmetry are well understood. However, the observed dust is subject to additional forces and effects, most notably collisions and drag. To complement the studies of dynamics, we therefore aim to understand how the addition of collisional evolution and drag forces creates new asymmetries and strengthens or overrides existing ones. We augmented our existing numerical code Analysis of Collisional Evolution by an azimuthal dimension, the longitude of periapse. A set of fiducial discs with global eccentricities ranging from 0 to 0.4 was evolved over gigayear timescales. Size distribution and spatial variation of dust were analysed and interpreted. We discuss the basic impact of belt eccentricity on spectral energy distributions (SEDs) and images. We find features imposed on characteristic timescales. First, radiation pressure defines size cut-offs that differ between periapse and apoapse, resulting in an asymmetric halo. The differences in size distribution make the observable asymmetry of the halo depend on wavelength. Second, collisional equilibrium prefers smaller grains on the apastron side of the parent belt, reducing the effect of pericentre glow and the overall asymmetry. Third, Poynting--Robertson drag fills the region interior to an eccentric belt such that the apastron side is more tenuous. Interpretation and prediction of the appearance in scattered light is problematic when spatial and size distribution are coupled.

Double-ring debris disks at 10s of au: Probing how far out planets can form

Marino, Sebastian (sebastian.marino.estay[at]gmail.com)

Institute of Astronomy, University of Cambridge

Abstract: The census of exoplanets only shows a few with tens of AU separations. On the other hand, observations of debris disks have shown that planetesimals can form at large separations, but it is not yet clear how far planets can form. Debris disks provide a unique tool as they can reveal the presence of planets at tens of AU. Here we present new cycle 4 ALMA observations of HD92945 and HD107146 that display broad disks with double rings or gap structures at tens of AU that suggest the presence of perturbing planets at large separation. However, 2 possible scenarios could explain this data that differ in where the planets formed: (1) a planet formed in situ opens a gap in a broad disk by direct scattering and resonance overlap; (2) an eccentric planet formed closer in, but was scattered out to larger radius then opens a gap through secular interactions with an outer disk. The two scenarios predict significant differences in the disks' high-resolution structure that we can study with these new ALMA observations.

The planetary accretion shock and the luminosity of gas giants

Marleau, Gabriel-Dominique (gabriel.marleau[at]space.unibe.ch)

Universität Bern

Abstract: In the core-accretion formation scenario of gas giants, most of the gas accreting onto a planet is processed through an accretion shock. This shock is key in setting a planet's post-formation luminosity, with differences of several orders of magnitude at a given mass. In turn, processes at and ahead of the shock determine the radiative loss efficiency, i.e. the fraction of the accreting gas's kinetic energy which is radiated away from the system. We use one-dimensional radiation-hydrodynamical simulations to compute this efficiency and to obtain post-shock entropies. With an perfect-gas equation of state (EOS), we find efficiencies as low as roughly 40 percent, implying that a large fraction of the total accretion energy is brought into the planet. We also present simulations with an improved EOS which includes the dissociation and ionisation of hydrogen into account. We compare these results to semi-analytical estimates and finally discuss possible observational implications.

The spiralling signatures of planet formation

Meru, Farzana (farzana.meru[at]ast.cam.ac.uk)

Institute of Astronomy, University of Cambridge

Abstract: The young star Elias 2-27 has recently been observed with ALMA to posses a massive circumstellar disc with two prominent large-scale spiral arms out to 250au. These are the first observations of extended spirals in the disc midplane. We perform three-dimensional Smoothed Particle Hydrodynamics simulations, radiative transfer modelling, synthetic ALMA imaging and an unsharped masking technique to explore three possibilities for the origin of the observed structures – an undetected companion either internal or external to the spirals, and a self-gravitating disc. We find that a gravitationally unstable disc and a disc with an external companion can produce morphology that is consistent with the observations. In addition, for the latter, we find that the companion could be a relatively massive planetary mass companion ($< 10 - 13$MJup) and located at large radial distances (between $\sim 300 - 700$ au). Such a companion could not have formed by core accretion so quickly at such large distances. We therefore suggest that Elias 2-27 may be one of the first detections of a disc undergoing gravitational instabilities, or a disc that has recently undergone fragmentation to produce a massive companion.

Gas mass tracers in protoplanetary disks: CO is still the best

Molyarova, Tamara (molyarova[at]inasan.ru)

Institute of Astronomy of the Russian Academy of Sciences, Moscow, Russia

Abstract: Protoplanetary disk mass is a key parameter controlling the process of planetary system formation. CO molecular emission is often used as a tracer of gas mass in the disk. In this work we consider the ability of CO to trace the gas mass in a wide range of disk structural parameters and also search for chemical species that could possibly be used as mass tracers alternative to CO. Specifically, we apply detailed astrochemical modeling to a large set of protoplanetary disk models, to select molecules with abundances correlated with the disk mass and relatively insensitive to other disk properties. We find that CO is indeed the best molecular tracer, despite it is not the main carbon carrier, although reasonable assumptions about CO abundance in the disk should be used. Effective chemical depletion results in CO fraction in the disk a few times lower than would be expected in the case when only freeze-out and photo-dissociation are considered, confirming that gas masses determined from CO observations can be up to an order of magnitude underestimated. We study chemical partition of carbon and demonstrate that in average only 20% C-atoms resides in gas-phase CO, albeit with variations from 2 to 50%. When disk structural parameters are known, H_2O, HCN, and H_2CO can potentially serve as mass tracers.

A rocky composition for close-in low-mass exoplanets from the location of the valley of evaporation

Mordasini, Christoph (christoph.mordasini[at]space.unibe.ch)

Physikalisches Institut, Universität Bern

Abstract: The recent discovery by Fulton et al. (2017) that the radius distribution of close-in low-mass Kepler planets is bimodal with a deep minimum at about 1.7 Earth radii could be one of the most important observational constraints for planet formation discovered recently, as such planets are the most frequent type of planets we know of. The observed minimum probably separates smaller solid planets from larger sub-Neptunian planets with H/He.

In this talk I will show with end-to-end models of planet formation, thermodynamic evolution, and atmospheric escape that the minimum can be explained by the mass and distance-dependent evaporation of the primordial H/He envelope, which leads to an evaporation valley that is devoid of planets.

Even more importantly, it is found that the location of the evaporation valley and the minimum depends strongly on the bulk composition of the cores of these close-in low-mass planets. It is found that the observed location of the valley is consistent with a predominately rocky (silicate +iron) composition of the planets, but excludes an ice-rich composition as expected for a formation outside of the iceline.

Combined with the excess of period ratios just outside of low-order mean-motion resonances, this suggests that low-mass Kepler planets formed inside of the water iceline, but still undergoing orbital migration. This is a fundamental constraint for their formation mechanism, which is currently still strongly debated.

Chemical evolution of protoplanetary disks and its consequence on water and organics contents in planetesimals and comets

Nagahara, Hiroko (nagahara[at]elsi.jp)

Earth-life Science Institute, Tokyo Inst. Tech.

Abstract: Chemical evolution of protoplanetary disks was investigated with a numerical model combining dust transportation by advection and diffusion, which results in mixing of dusts moving inward and those outward, and chemical composition of dusts that are controlled by temperature. The model describes the fluid dynamics with the Lagrangean expression, which enables us to track movement of individual grains, that is, we know the temperature of individual grains with time. We have two free parameters, disk initial size (10 to 100 au) and mass (0.05 tp 0.5 solar mass). The parameters defines the temperature and density profile of the disk as well as its evolution.

We found that (1) protoplanetary disk is chemically heterogeneous at the early stage and becomes homogeneous with time, (2) the time scale of chemical homogenization is dependent on the disk initial condition, (3) the relative abundance of ice and organics against silicates and metal varies largely with time and space, (4) the chemical variation of chondrites are reproduced with initially compact (<a few tens au and <0.2 solar mass) disk, but are not with initially extended disk. (5) comets with roughly half ice and organics and half silicates, metal and FeS are reproduces also with initially compact disk.
The present work demonstrates that the very early stage of star formation controls chemical evolution of protoplanetary disks, which results in chemical composition of planetesimals and comets. It further affects the water and organics contents of planets.

Linking planet formation to planet internal structure

Nettelmann, Nadine (nadine.nettelmann[at]uni-rostock.de)

Institute of Physics, U Rostock

Abstract: Mature giant planets (GPs) are an important class of objects for studying planet formation as they contain as significant amount of protoplanetary nebula gas and condensed material.
Recent years have seen two important progresses regarding the link between the structure and the formation of GPs: (i) new planet formation models include the effect of planetesimal capture by the protoplanetary atmosphere on the final composition distribution (core mass, heavy element enrichment Z) [1,2]; (ii) the numerous exoplanets with measured mass, radius, even atmospheric properties allow to derive correlations between planetary and stellar properties [3].
These advances partially support our expectations (high-Z planets form preferentially around high-Z stars) but sometimes also conflict with our conventional views (super-high-Z planets, diluted cores [2,4], inhomogeneous interiors [2]).
In this talk I will adopt both ways of thinking and discuss the possible relevance for the data analysis of the current Juno mission at Jupiter.

[1] Venturini, Alibert, Benz (2016), A&A 596:90
[2] Helled, Stevenson (2017), ApJL 840:4
[3] Thorngren, Fortney, Murray-Clay, Lopez (2016), ApJ 831:64
[4] Fortney & Nettelmann (2010), SSRv 152:423

Photoevaporation of protoplanetary discs in sub structured environments

Nicholson, Rhana (r.b.nicholson[at]2011.ljmu.ac.uk)

Astrophysics Research Institute, LJMU

Abstract: The environment in which stars are born affects the formation and evolution of their protoplanetary discs. From close encounters with neighbouring stars stripping their protoplantary discs to massive stars emitting far ultra violet (FUV) and extreme ultra violet (EUV) radiation that evaporates the disc, environment plays a strong role. Stars form in sub structured, fractal clusters, however previous studies examining the effects of photoevaporation of discs in clusters primarily focused on spherical clusters. We investigate how the effects of photoevaporation of protoplanetary discs varies in clusters with a plummer sphere mass distribution as compared to clusters with an observationally comparable set of initial conditions. We explore a range of initial conditions and cluster masses. We shall present the results at this conference.

Two Suns in the sky: The effects of stellar binarity on planet formation

Parker, Richard (R.Parker[at]sheffield.ac.uk)

University of Sheffield, UK

Abstract: Planet formation is often considered to be an isolated process that occurs around single stars, when in reality a significant fraction (perhaps more than half) of stars form in binary systems. Furthermore, observations have shown that planet formation is as common in binary systems as around single stars. However, I will show that binary properties can change through dynamical interactions in star-forming regions and that this can have catastrophic effects on planets that have already formed, or that are forming around the stars. I conclude by discussing how observational incompleteness in surveys of binaries in star-forming regions is hampering efforts to quantify these effects.

The evolution and dispersal of planet-forming disks

Pascucci, Ilaria (pascucci[at]lpl.arizona.edu)

Lunar and Planetary Laboratory, The University of Arizona

Abstract: Disks of gas and dust around Myr-old stars are the birth sites of planets. Hence, their evolution and dispersal directly impact what type of planetary systems can form. I will review empirical constraints on disk evolution and dispersal with emphasis on those that come from disks caught in the act of clearing out planet-forming material. I will also discuss theoretical models that offer a physical interpretation and summarize their successes and shortcomings. I will conclude by highlighting which investigations are most promising to further constrain our physical understanding of disk evolution and dispersal.

Effect of different snow lines on the dust evolution in protoplanetary disks

Pinilla, Paola (pinilla[at]email.arizona.edu)

Department of Astronomy/Steward Observatory, The University of Arizona

Abstract: Recent high angular resolution observations of protoplanetary disks at different wavelengths have reveled several kind of structures, including multiple bright and dark rings. One potential origin for these rings is different grain growth near snow lines that can affect dust dynamics. In this talk, I will present the effect that snow lines have on the dust evolution, following the growth, fragmentation and dynamics of multiple dust size particles. In particular, I will present the effect that main volatiles, such as H_2O, CO (or CO_2), and NH_3 can have on the dust distributions over million-year timescales. The models are combined with radiative transfer calculations in order to compare with observations. Structures like rings and gaps can be formed between snow-lines, and I will present future observational perspectives to disentangle this scenario with other gap-origin mechanisms, such as embedded giant planets or radial variations of the disk viscosity.

CARMENES

Quirrenbach, Andreas (A.Quirrenbach[at]lsw.uni-heidelberg.de)

Landessternwarte Heidelberg

Abstract: CARMENES is a next-generation radial-velocity instrument that has been constructed for the 3.5m telescope at the Calar Alto Observatory by a consortium of eleven Spanish and German institutions. It consists of two separate echelle spectrographs covering the wavelength range from 0.55 to 1.7 microns at a spectral resolution of R = 82,000, fed by fibers from the Cassegrain focus of the telescope. CARMENES saw "First Light" on Nov 9, 2015. We report on results from the commissioning and the first year of operation, and describe the large M dwarf survey that is the core science program of CARMENES.

Terrestrial planet formation: The Solar System in context

Raymond, Sean (rayray.sean[at]gmail.com)

Laboratoire d'Astrophysique de Bordeaux

Abstract: The distribution of exoplanets shows a much broader diversity the Solar System and includes planets that are alien to us. The known extra-solar systems can be divided into: i) Solar System-like systems with Jupiter-like planets on wide-separation, near-circular orbits; ii) systems with “angry” gas giant planets on eccentric or very short-period orbits; and iii) systems containing only low-mass planets, often referred to as “hot super-Earths”. I will describe the dynamics at play in each of these settings, and explore the implications for the formation (and in some cases destruction) of rocky worlds.

The evolution of photo-evaporating viscous discs in binaries

Rosotti, Giovanni (rosotti[at]ast.cam.ac.uk)

Institute of Astronomy, University of Cambridge

Abstract: In this talk I will consider the evolution of photo-evaporating proto-planetary discs surrounding the components of a binary system, assuming that the photo-evaporation is driven by X-rays from the respective star. This topic has received little attention despite the fact that a large fraction of stars are in binaries. In addition, binaries can be used as a laboratory of disc evolution, providing a benchmark for theoretical models. I will show how

disc evolution is sensitive to the binary separation. Discs in wide binaries clear inside out like in single stars. In close binaries (< 20-30 AU for average X-ray luminosities) disc dispersal proceeds from outside in due to the tidal torque of the companion. Fewer transition discs created by photoevaporation are thus expected in binaries. In addition the reduced viscous time at the outer disc edge reduces the disc lifetime, consistently with results from observations. Since this effect is more severe for the secondary, the disc around the primary is longer lived. For wide binaries instead the difference in photo-evaporation rate makes the secondaries longer lived (although this results is somewhat dependent on the assumed scaling of viscosity with stellar mass). I will show how these results are broadly compatible with the growing sample of resolved observations of discs in binaries. I also predict that binaries have higher accretion rates than single stars for the same disc mass. Thus binaries probably contribute to the observed scatter in the relationship between disc mass and accretion rate in young stars.

A low-mass planet in the habitable zone of the nearby M-dwarf K2-18

Sarkis, Paula (sarkis[at]mpia.de)

Max Planck Institute for Astronomy

Abstract: K2-18 is a nearby M2.5 dwarf, located at 34 pc and hosting a transiting super-Earth which was discovered first by the K2 mission and later confirmed with Spitzer Space Telescope observations. With a radius of 2.279 R_{earth} an orbital period of about 33 days, the planet lies in the habitable zone of its host star and receives stellar irradiation similar to Earth. Here we perform radial velocity follow-up observations with the CARMENES visual channel with the goal to determine the mass and density of the planet. We estimate a planetary mass of 8.45 M_{earth} yiedling a bulk density of 3.92 g/cm^3. This indicates a low-mass planet with a composition consistent with a solid core and a volatile-rich envelope. At a period of about 9 days for which a second planet was announced recently using data from the HARPS spectrograph, we see a much weaker signal with CARMENES and favour the interpretation that this signal could be affected by stellar activity. K2-18 b joins the growing group of low-mass planets detected in the habitable zone of M dwarfs. The brightness of the host star in the near-infrared makes the system an excellent target for detailed atmospheric studies with the James Webb Space Telescope.

Diversity of exoplanets

Schlichting, Hilke (hilke[at]ucla.edu)

UCLA/MIT

Abstract: Super-Earths display a large diversity in their gas-mass fractions and bulk densities. This diversity is especially surprising for observed exoplanets residing in tightly-packed multiple-planet systems. We will discuss new work that self-consistently treats the gas accretion and sub-sequent evolution as the gas disk dissipates. We will show that exoplanet observations are challenging to explain by gas accretion, subsequent evolution and sculpting by photo-evaporation alone. We suggest that the large observed range in exoplanet bulk densities may be due to one or two giant impacts that occurred late in the dynamical evolution of super-Earth systems once the gas disk dissipated. Such late giant impacts are likely to be common because super-Earths that contain several percent of their total mass in hydrogen and helium must have formed in the presence of the gas disk and their dynamical interaction with the disk is expected to have resulted in migration and efficient eccentricity damping. This leads to densely-packed planetary systems. As the gas disk dissipates, mutual gravitational excitations between the planets cause their eccentricity to grow culminating in one or two giant impacts before reaching long-term orbital stability. We will present new results on the atmospheric mass loss in giant collisions between super-Earths and will use these results to test if the observed diversity of super-Earths bulk compositions can be explained by atmospheric mass loss due to giant impacts or if it has to be attributed to different formation paths of these systems.

The 'missing link' in planet formation theory and why the size distribution of asteroids and Kuiper belt objects is so similar

Schreiber, Andreas (aschreiber[at]mpia.de)

Max Planck Institute for Astronomy

Abstract: The most promising way around the direct growth hindering m-sized barrier is in-situ planetesimal formation via gravitational collapse of massive particle clouds. In this talk, I present the circumstances under which planetesimals, which we believe are the same as cometesimals, and its remnants we today call asteroids, are thought to form and how we were able to close the missing link between mm and km sized objects.

For the presented work, I performed hydro-simulations of the so called streaming instability within the environment that a collapse is expected to happen in. This instability is known mainly for its ability to concentrate dust, but I will introduce its turbulent diffusive behavior as the limiting factor for this in-situ collapse to occur. We further find this diffusive process to be pre-determining the planetesimal birth size of around 100 km indepen-

dent of semi-major axis! With this we were the first to find an explanation why observed asteroid and classical Kuiper-belt size distribution, as well as Jupiter Trojans sizes and Pluto impact crater statistics, have a kink exactly at this size precise size. Moreover, we could derive from first principles a collapse criterion, similar to the Jeans criterion for stars but for planetesimals, giving us a prediction on the initial planetesimal size and find this in agreement with our simulations.

What drives accretion in protoplanetary disks?

Simon, Jake (jbsimon.astro[at]gmail.com)

University of Colorado

Abstract: It is still uncertain what exactly is responsible for driving angular momentum transport in protoplanetary disks, thus setting the environment in which planets are born. This transport may find its origin in turbulence driven by the magnetorotational instability (MRI), magnetically driven winds that remove angular momentum vertically, or some combination of both. Recent disagreement between predicted signatures of turbulence from numerical simulations and observational constraints made by ALMA have brought into question the turbulent origin of angular momentum transport. Here, I present preliminary results explaining the lack of observed signatures of turbulence in the disk around HD163296 and motivate future studies, both observational and theoretical to address the origin of accretion in protoplanetary disks.

Probing exoplanet atmospheres

Snellen, Ignas (snellen[at]strw.leidenuniv.nl)

Leiden Observatory

Abstract: In this talk I review different methods of probing exoplanet atmospheres using ground- and space-based observatories, using techniques relying on direct imaging and transits/eclipses. I will also gives some examples of recent results.

Growing pebbles by charged aggregation

Steinpilz, Tobias (tobias.steinpilz[at]uni-due.de)

Universität Duisburg-Essen, Fakultät für Physik

Abstract: At the bouncing barrier about mm-size particles collide frequently without sticking. This might be a problem for further evolution due to reduced growth. However, we find that even identical grains heavily charge up in collisions. Keeping overall neutrality this allows the formation of larger aggregates bound together by electrostatic forces. We find in microgravity experiments that indeed cm-size aggregates can form. Furthermore, an attractive force enhances the cross section. This might bridge the gap between bouncing barrier and gravitational instability scenarios.

Circumplanetary disk simulations and observational efforts

Szulagyi, Judit (judits[at]ethz.ch)

ETH Zurich, Institute of Astronomy

Abstract: Recently, younger and younger planets were detected, often still embedded in gaseous circumstellar disks. In this evolutionary phase, giant planets are still accreting from their own disk, the circumplanetary disk. This disk is the key for the late giant planet formation, for satellite formation and for observations of forming giant planets. I will present the newest radiative, global hydrodynamic simulations coupled with wavelength-dependent radiative transfer- and chemistry tools to understand better the basic characteristics of circumplanetary disks (mass, temperature, entropy, luminosity, H-alpha flux etc.). Based on these properties, I will give predictions on how to detect the circumplanetary disk and how they influence the planets' properties derived from previous observations. I will close with showing our recent ALMA data on the subject.

Posters

Fragmentation of protostars dust shells at the Hayashi stage

Abdulmyanov, Tagir (abdulmyanov.tagir[at]yandex.ru)

Kazan State Power Engineering University

Abstract: The aim of this study is to determine the density variations of a protostars dust shells at the Hayashi stage. The simplified model of the density wave perturbations are obtained on the base hydrodynamic equations. According to this model, the fragmentation of dust shells may occur at the stage of slow compression of protostar. Using the solution of the wave equation, the 3-D profiles of the density of the dust shell are defined.

Luminosity variations of protostars at the Hayashi stage

Abdulmyanov, Tagir (abdulmyanov.tagir[at]yandex.ru)

Kazan State Power Engineering University

Abstract: In the present paper, the luminosity variations of protostars at the Hayashi stage are considered. According to the density wave model, the luminosity of protostars will have significant variations throughout the Hayashi stage. The initial moments of the formation of protoplanetary rings of the Solar system and the luminosity of the protostar for these moments are obtained.

Coagulation of charged dust in protoplanetary disks

Akimkin, Vitaly (akimkin[at]inasan.ru)

Institute of astronomy of the Russian academy of sciences, Moscow, Russia

Abstract: Electrostatic interaction affects collisional cross-section of charged dust grains. Photoelectric and collisional charging are two primary mechanisms driving grains to positive and negative potentials, respectively. By solving the Smoluchowski equation for protoplanetary disk conditions, we show, that effective coagulation occurs in a layer at intermediate heights, where these two charging mechanisms compete and both negative and positive grains are present. In an illuminated disk atmosphere, the photoelectric charging leads to the retention of small positively charged grains. In dark regions, where the collisional charging dominates and grains are mostly negatively charged, the electrostatic barrier ef-

fectively slows grain growth. Turbulence-induced relative grain velocities help to overcome electrostatic barrier outside the dead zone only if compact dust is assumed, while the growth of fractal aggregates is significantly hampered by the electrostatic repulsion.

Laboratory experiments on charge separation in collisions of identical grains

Boden, Lucia (lucia.boden[at]stud.uni-due.de)

University of Duisburg-Essen

Abstract: Within a protoplanetary disk electrical charging of grains is possible in collisions by triboelectric effects. It was only recently discovered that also identical grains can gain large net charges in collisions. This can lead to ionic particle aggregates and might aid early phases of planet formation e.g. at the bouncing barrier. We started to measure the charge distribution in a sample of colliding grains depending on a number of parameters (particle size, collision number and time, ambient pressure and humidity). First results will be reported.

Dust asymmetries and spirals around HD 142527 and MWC 758

Boehler, Yann (y.boehler[at]rice.edu)

Rice University

Abstract: We obtained ALMA observations of the two protoplanetary disks HD 142527 and MWC 758 at a high angular resolution of ~0.15-0.2", of the dust continuum at 0.87 millimeter and of the ^{13}CO and C^{18}O J=3-2 emission line. HD 142527 is famous for its large horseshoe structure with the dust emission at the north of the disk about 20 times larger than in the south. MWC 758 has two dust clumps at different azimuths, with a contrast in dust intensity of about a factor 2 and 5. Both disks present a cavity, probably carved by planet(s), and spirals detected in both IR scattered ligth and in the ^{13}CO peak emission.
We will discuss the complex morphology of these two disks, in particular of the spirals, and will present our modeling of the dust clumps. We will then see if they are conform with the dust trapping scenario and if they may be an appropriate environment to form new planets.

Pebble ice mantle sublimation at the ice lines: The case of CO_2

Bosman, Arthur (bosman[at]strw.leidenuniv.nl)

Leiden Observatory

Abstract: Formation of planetesimals and planets in proto-planetary disks in not well understood. The formation of planetesimals through the steaming instability, and the formation of (giant) planets through pebble accretion are promising mechanisms to solve some of the open questions in planet formation. Both mechanisms depend on the existence of pebbles which are expected migrate towards the star.
When these pebbles drift inward they take with them their icy mantles, changing the radial distribution of chemicals. At certain radii in the disk the pebble will cross an iceline where part of its ice mantle will evaporate. This will preferentially release a single species to the gas-phase. This can, in theory, significantly change the gas-phase abundances of certain species near their respective icelines.
In previous work, we have shown that an abundance enhancement near the CO_2 iceline might visible with JWST-MIRI. The CO_2 abundance in the inner disk has been shown to be low ($<10^{-7}$ w.r.t. H_2), while the ISM and outer disk CO_2 ice abundance is expected to be high, >10% of the water ice abundance. This two order of magnitude difference between ice and gas abundance makes CO_2 a better target for observing this effect than, for example, H_2O and CO.
To quantify the effect of radial drift on gas-phase abundances near the icelines, we have developed a viscous disk model including grain growth, radial drift and gas-phase chemistry. I will discuss the modelling results as well as the implications for observations with JWST-MIRI.

Study of effects of the viscosity in the planetary migration in a binary star system

Braga Camargo, Bárbara Celi (bcbc.fisica[at]gmail.com)

UNESP- BRAZIL

Abstract: In planetary formation using a hydrodynamics approach, it is necessary to provide a set parameters for the gas disk where the planet will be formed. One parameter that can significantly affect the evolution of a protoplanet is the viscosity of the gas. In this work, we test the mass accretion and the migration of a protoplanet immersed in a gas disk with different values of viscosity. In this system the gas is around the primary star but there is a strong perturbation from a very close secondary star, at about 20 astronomical units. It was noted that there is greater accretion of mass as the viscosity value of the gas increases, as expected and the perturbation of the secondary also contributes to the accre-

tion of mass. There is also a migration towards the primary star, whose values also increase in the addition of the viscosity values and disturbance of the secondary star.

New determination of the ice-line position: Radial drift and subsequent water depletion of planetesimals

Burn, Remo (remo.burn[at]space.unibe.ch)

University of Bern

Abstract: The determination of the composition of planets by observations and numerical studies is crucial in order to understand the processes of their formation and predict their possible habitability. The compositions of gas and solids accreted by planets depend on the physico-chemical properties of the disc (surface density, stellar luminosity) at a given location and on the migration of grains, planetesimals, planets and gas which are all time-dependent.

The ice-line, described as the distance from the central star, where ice grains can form, is still used in models to exclude the existence of accreted water on planets within this limit. However, meter-sized icy bodies could migrate towards the star and release water and other volatile species by further accretion in planets in the inner system, allowing thus to change deeply their chemical composition compared to precedent numerical studies. This is particularly true if the majority of the mass accreted by planets is composed of small objects.

From these considerations, we study the water depletion of icy bodies during their migration in the disc [1] by using a cometary nucleus model [2]. We show the location that can be reached by these solids for different sizes, before being fully depleted, and the resulting new ice-line position for different types of disks (surface density, irradiation, photoevaporation).

References:

[1] Y. Alibert, C. Mordasini, W. Benz, and C. Winisdoerffer, Astronomy & Astrophysics, 434, 343 (2005)

[2] U. Marboeuf, B. Schmitt, J.-M. Petit, O. Mousis und N. Fray, Astronomy & Astrophysics, 542, A82 (2012)

Restricting the orbit of the hypothetical Planet Nine

Cáceres Reátegui, Jessica (jessica[at]on.br)

Observatório Nacional

Abstract: The gradual discovery of distant Kuiper Belt Objects (KBOs) and possible members to the inner Oort cloud strongly supports the hypothesis about the existence of a distant planet in the solar system known as planet nine. Trujillo and Sheppard (2014) noted that all known objects with semimajor axis greater than 150 au and not disturbed by Neptune present a clustering in the argument of perihelion that can not be explained in terms of any observational biases. Batygin and Brown (2016) found that distant KBOs are also confined in longitude of the ascending node and demonstrated that their confinement could be caused by a planet with a perihelion distance between 150-350 au, semimajor axis between 380-980 au, mass between 5-20 Earth masses and inclination of 30 deg. On the other hand, Gomes et al. (2017) showed that the current inclination of the planetary system relative to the solar equator (∼6 deg.) may be explained by the presence of the ninth planet if eccentricities greater than those suggested by Batygin and Brown are considered. In our work we attempt to restrict the range of parameters of the planet nine that provide a greater probability of reproducing the confinement in the angles of distant KBOs. We will present the results obtained from a suite of numerical simulations and a statistical analysis by comparing the outputs of each simulation with the observed confinement. We will also analyse the influence of the planet nine in possibly molding the dynamically Cold Kuiper Belt by Kolmogorov-Smirnov tests.

The nature of the near-IR excess in V892 Tau: Circumstellar disk or dusty component inside the circumbinary cavity?

Cahuasquí, Juan Andrés (cahuasqui[at]ph1.uni-koeln.de)

I. Physikalisches Institut, Universität zu Köln

Abstract: We present a MIDI interferometric study of the system V892 Tau located in the Taurus-Auriga star forming region at 140 pc. V892 Tau is composed of a primary Herbig AeBe star and a 4" distant low-mass component NE from the more massive object. We focus on the HAeBe star which is found to be itself a close binary with a ∼50 mas (∼7 AU) separation and a 13-year period. The central pair is surrounded by a large circumbinary disk truncated at a radius of about 18 AU. In order to resolve the nature of the IR flux lacking in the SED of the system, the 9-year baseline observations with MIDI/VLTI, distributed into two epochs in 2004, one in 2009 and 2 two in 2013, were analyzed with a temperature gradient model aiming at simultaneously reproducing the mid-infrared visibilities, differential phases and SED for three different scenarios: 1) binary pair + circumbinary disk; 2) binary pair + circumbinary disk + circumstellar disk surrounding one component; and 3) binary pair + circumbinary disk + warm component. Our model coupled to the fit optimizer MAGIX reveals that the observational measurements are best reproduced by the configuration that includes the warm component in the neighborhood of the central pair and whose location is well determined by the sensitivity of the differential phases. We discuss the possible nature and morphology of this additional component and its observational role in our interferometric data.

Image processing for exoplanet detection

Cantalloube, Faustine (cantalloube[at]mpia.de)

MPIA

Abstract: Exoplanet imaging requires intensive efforts from instrumentalist to reach the high resolution and high contrast needed to image exoplanetary systems. One essential piece of this process is the image processing that is applied in order to disentangle the planetary signal from the surrounding noise and to extract the candidates spectra.

After introducing the framework of image processing, I will present the state of the art methods that are used today while emphasizing the difficulties to obtain reliable spectra and relevant detection limits. In order to interpret correctly the results from follow-up and from large surveys, it is essential to make sure these output are defined in line with the instrument feature and the object parameters.

Dynamics of planets around binary stars

Capuzzo Dolcetta, Roberto (roberto.capuzzodolcetta[at]uniroma1.it)

Dep of Physics, Sapienza, Univ. of Roma, Italy

Abstract: I will report of our results of the orbital evolution of planets around binary stars in a star cluster environment.

Constraining protoplanetary disk geometry with VLT/SPHERE polarimetric imaging

de Boer, Jos (deboer[at]strw.leidenuniv.nl)

Leiden Observatory

Abstract: The scattering surfaces of protoplanetary disks often contain a wealth of structure, such as gaps, rings and spiral arms when we observe them at high angular resolution. High-contrast imaging with VLT/SPHERE has allowed us to determine the height of the scattering surfaces in disks with multiple rings and to place constraints on the effects of planet-disk interactions. Additionally, the height information allows us to apply a height-corrected deprojection (or rotation) of the disk image, which mimics the phase-on appearance of an inclined flaring disk. We will present these methods for SPHERE images of RX J1615 and HD 34282.

Simulation of the dynamics of the debris disk with gas

Demidova, Tatiana (proxima1[at]list.ru)

Pulkovo Observatory

Abstract: The calculations show that the stable resonance large-scale structures, which is caused by the motion of a planet, can form in planetesimal disks of single and binary stars. But the presence of the small portion of the gas can affect strongly the process of the formation of such structures, especially spreading speed of them. We consider long-time dynamics of the planetesimals in a debris disk of a binary or single star in the presence of the gas in the disk. The quantitative influence of the disk gas on the formation and stability of the resonance large-scale structure is investigated. The systems with the parameters of HL Tau and Kepler-16 used as the main models.

Two-fluid model of a protoplanetary disk of a young star with a low-mass companion

Demidova, Tatiana (proxima1[at]list.ru)

Pulkovo Observatory

Abstract: The young stars are surrounded by the extended gas-dust disks on the early stage of the evolution. The matter of the disk is a construction material for planetary systems. The dust is one percent from the total disk mass. But it plays a very important role in the thermal balance and chemical evolution of the disk. The spectral energy distribution in infrared and millimeter range is completely determined by the dust component of the disk. The motion of the low-mass companion nearby the star produces the periodic perturbation of the disk matter. It leads to the formation of the large-scale inhomogeneities. The structure of them in the gas and dust components may be different. Here we present the results of gas-dynamic calculations of such systems by the SPH method. The disk matter consist of the two types of the particles with the gas and dust properties, the dynamics of which are calculated in common. The temperature gradients in the disk are taken into account both in the vertical direction and in the disk plane.

Temperature limit in planet formation at 1000 K

Demirci, Tunahan (tunahan.demirci[at]stud.uni-due.de)

University of Duisburg-Essen

Abstract: Dust drifting inwards in protoplanetary disks is subject to increasing temperatures. In laboratory experiments we tempered basaltic dust between 873 K and 1273 K and find that the dust grains change size and composition.

These modifications influence the outcome of self-consistent low speed aggregation experiments at a transition temperature of 1000 K. Cooler dust grows to a maximum a few times larger in mass than warmer dust.

If the probability of planetesimal formation is tied to the maximum aggregate size e.g. by streaming instability then planetesimal formation is favored below 1000 K. This number is in agreement to extrasolar planet statistics as terrestrial planets are essentially limited to positions equivalent to less than 1000 K.

Dust aggregation on the mm-scale at elevated temperatures might therefore be a key factor for terrestrial planet formation.

Water delivery to the TRAPPIST-1 planets by asteroids

Dencs, Zoltán (dencs.zoltan[at]csfk.mta.hu)

Konkoly Observatory

Abstract: Three of the seven rocky planets in TRAPPIST-1 system orbit in the habitable zone of the host star, as a result water is most likely in liquid state, what needs for the formation of life. According to theories, water is absent on the surface of planets formed inside the snowline. If there were no water transport in the system. A potential explanation is that a giant companion perturbs the water containing asteroids' orbit, as in the case of late heavy bombardment in Solar System. To simulate the water delivery we ran N-body simulations. The simulated system incorporates the seven known planets, and additional hypothetical perturber (giant planet or flyby star), and a debris disk. The simulation contains half a million asteroids, and nine gravitationally interacting bodies. We used our own developed GPU based N-body integrator. The initial water distribution in the system set by the unperturbed orbital distance of asteroids. To register the water delivery by planetary accretion the mass of the water are continuously monitored.

First results of the Next Generation Transit Survey, NGTS

Eigmüller, Philipp (philipp.eigmueller[at]dlr.de)

Deutsches Zentrum für Luft- und Raumfahrt, Institut für Planetenforschung

Abstract: The Next Generation Transit Survey (NGTS) is a new wide-field, ground-based exoplanet survey designed to detect Neptunes and super-Earths transiting bright stars. The survey is carried out with a purpose-built facility at Cerro Paranal, Chile. An array of twelve independant telescopes fitted with back-illuminated deep-depletion CCD cameras are used to intensively survey fields at intermediate Galactic latitudes.
We will present the survey, its current status, and show first scientific results.

A catalogue of solar-type stars with both debris disks and planets

Eiroa, Carlos (carlos.eiroa[at]uam.es)

Universidad Autónoma de Madrid

Abstract: This poster presents a catalogue of all (to our knowledge) known solar-type stars hosting simultaneously debris disks and planets.

Formation of giant planets at tens-of-AU distances

Elbakyan, Vardan (vgelbakyan[at]sfedu.ru)

Southern Federal University

Abstract: Planets form in the disks of gas and dust around young stars. One of possible scenarios for giant planet formation is gravitational fragmentation of protostellar disks. Here we show that massive gaseous fragments that have formed in the outer regions of a protostellar disk may become perturbed by other fragments and quickly migrate toward the central star (during $\sim$ few 10^4 years). However, some fragments halt their migration at a distance of a few tens of AU, while losing a substantial fraction of their outer envelope via tidal torques and keeping only a dense and hot nucleus. At the same time, the central temperature of these truncated fragments may exceed the hydrogen dissociation temperature ($\sim$2000 K) and the central region of the fragment can collapse into a gas giant planet, which provides a potential explanation for the existence of giant planets at distances of tens of AU.

Co-authors:
Eduard Vorobyov

Inner mean-motion resonances with eccentric planets as a source of exocomets and exozodis

Faramaz, Virginie (vfaramaz[at]astro.puc.cl)

IA-PUC

Abstract: High levels of dust have been detected in the immediate vicinity of many stars, both young and old. A promising scenario to explain the presence of this short-lived dust is that these analogues to the zodiacal cloud (or exozodis) are refilled in situ through cometary activity and sublimation. As the reservoir of comets is not expected to be replenished, the presence of these exozodis in old systems has yet to be adequately explained. It was recently suggested that mean-motion resonances with exterior planets on moderately eccentric (ep $\gtrsim 0.1$) orbits could scatter planetesimals on to cometary orbits with delays of the order of several 100 Myr. Theoretically, this mechanism is also expected to sustain continuous production of active comets once it has started, potentially over Gyr time-scales. We aim here to investigate the ability of this mechanism to generate scattering on to cometary orbits compatible with the production of an exozodi on long time-scales. We combine analytical predictions and complementary numerical N-body simulations to study its characteristics. We show, using order of magnitude estimates, that via this mechanism, low-mass discs comparable to the Kuiper belt could sustain comet scattering at rates compatible with the presence of the exozodis which are detected around Solar-type stars, and on Gyr time-scales. We also find that the levels of dust detected around Vega could be sustained via our proposed mechanism if an eccentric Jupiter-like planet were present exterior to the system's cold debris disc.

Photodynamical modelling: An update on Kepler-9

Freudenthal, Jantje (jfreude[at]astro.physik.uni-goettingen.de)

Institut für Astrophysik Göttingen

Abstract: A photodynamical model describes all transit lightcurves of a planetary system simultaneously under consideration of the system's dynamics. Calculating the lightcurves from the output of a numerical integration over the time span of observations leads to a better understanding and characterization of the system. Such a model is most suitable for systems that show variations in the transit time (TTVs). These variations as well as variations in transit depth and duration are directly modelled and explained by the gravitational interaction of all system's objects. Our model is coupled with a Markov chain Monte Carlo algorithm, that helps to explore the parameter space. We present the application of our model to the Kepler-9 system including new ground-based observations of transit lightcurves from the years 2014 - 2017 obtained by the KOINet, a multi-site network of telescopes around the globe organized to follow-up KOIs with large TTVs.

Growing porous grains in 3D SPH simulations

Garcia, Anthony (anthony.garcia[at]univ-lyon1.fr)

Centre de Recherche Astrophysique de Lyon

Abstract: In protoplanetary discs, micron-sized grains should grow up to reach planetesimal sizes in order to ultimately form planets. However, dynamical studies show that once they reach a critical size, they drift rapidly into the accreting star. This is known as the radial-drift barrier.

In order to overcome this barrier, several methods have been proposed such as particles traps (e.g. vortices or planet gaps) which all involve large-scale dynamics. In this work, we choose to investigate the intrinsic properties of the grains during their growth, in particular their porosity.

We thus consider the growth of grains with variable porosity as a function of their mass in several regimes of compression/expansion (Kataoka et al. 2013, Okuzumi et al. 2012) and implement it in our 3D SPH two-fluid code (Barrière-Fouchet et al. 2005).

We find that growth is accelerated for porous grains that can reach kilometer sizes. On the other hand, drift is slowed down for porous grains that can grow up to larger sizes before drifting towards the star. As a result, grains in the outer regions of the disc reach larger sizes than when porosity is neglected. Those two mechanisms can help grains overcome the radial-drift barrier and form planetesimals.

The HD97048 transition disk as seen by SPHERE and ALMA

Ginski, Christian (ginski[at]strw.leidenuniv.nl)

Leiden Observatory

Abstract: Recently stunning images of the HD97048 transition disk revealed several rings and gaps in polarized scattered light and mm emission. The observations and their implications will be discussed and radiative transfer modeling of both data sets will be presented. With both complementary observations we tackle the question whether nascent planets are the cause of the observed structure.

Predicting rocky exoplanet interiors: The effect of different mineralogical models

Haldemann, Jonas (jonas.haldemann[at]space.unibe.ch)

Theoretical Astrophysics and Planetary Science (TAPS), Uni Bern

Abstract: Not available

Planet-induced vortices: The effects of realistic planet formation timescales

Hammer, Michael (mhammer[at]email.arizona.edu)

University of Arizona

Abstract: Several recent observational studies using ALMA have discovered transition disks with high-contrast crescent-shaped asymmetries in the dust, a feature that may be explained by dust-trapping vortices generated by gap-opening giant planets. However, other studies of vortices through simulations often neglect the time it takes to grow a planet to Jupiter-size, a process that may last more than 1000 orbits. In this work, we use two-fluid (gas and dust) hydrodynamical simulations and synthetic ALMA images to show that more realistic planet formation timescales result in vortices that are much weaker and look very different, if they even form at all. These weaker vortices have (i) shorter lifetimes, (ii) lower over-densities, and (iii) more elongated azimuthal extents – all by a factor of two or more compared to the more concentrated vortices induced by planets that were grown less realistically in less than 100 orbits. Additionally, the wide elongated shapes of these vortices make them much less efficient at trapping dust directly in the center of the vortex, making them easy to distinguish from their more concentrated counterparts. Lastly, we compare our synthetic images to those from recent disk surveys, and identify candidate vortices with both concentrated and elongated shapes.

Polluted white dwarfs: Insights regarding the chemistry of terrestrial planets

Harrison, John (jhdh2[at]cam.ac.uk)

Institute of Astronomy, Cambridge

Abstract: Currently, our best estimates for the bulk composition of terrestrial exoplanets come from observations of planets' masses and radii, but lead to degenerate solutions. The frequency of solar system-like chemistry and geology in the galaxy is poorly understood. The pollution of white dwarfs by rocky exo-planetary material provides a unique opportunity to study the chemistry and geology of exo-planetary systems. Rocky bodies are scattered inwards from a planetary system that has survived the host star's evolution to the white dwarf phase and accreted by the white dwarfs. Spectra of these polluted white dwarfs yield ratios of key rock forming species and key volatile species. We explain and reproduce the chemistry seen in the polluted white dwarf data where more than 5 elements have been detected. We do this with models that consider the accretion of fragments of differentiated bodies which may or may not have depletion of moderately volatile species. These models allow us to constrain where in the planetary system the white dwarf pollutants originated and to probe the rate of collisional processing in exo-planetary systems. These results will further our understanding of not only the bulk chemistry of terrestrial planets and the rarity of the solar system's chemistry, but the role host stars play in dictating the chemistry of a terrestrial planet and the role of dynamics in post main sequence systems.

Spread of the dust temperature distribution in circumstellar disks

Heese, Stefan (sheese[at]astrophysik.uni-kiel.de)

Institute for Theoretical Physics and Astrophysics, University of Kiel

Abstract: The correct calculation of the dust temperature is essential for the analysis of various physical and chemical processes in circumstellar disks.

We investigate the impact of considering the optical properties of a detailed grain radius distribution on the resulting temperature structure and observational appearance of circumstellar disks (Heese et al., accepted).

We compare our results to those obtained under the assumption of averaged optical properties representative for the same distribution of grain radii.

We find that in optically thin disks, using a detailed grain radius distribution has prominent effects on the temperature structure and observational appearance of the disk. Most notably, the temperature spread can be as large as ∼63%. Such a temperature difference between smaller and larger grains can also explain the low temperature of the disk of the

Flying Saucer, derived in Guilloteau et al. (2016). This temperature spread results in a decrease of the net dust surface below a certain temperature too and makes the snowline a function of grain radius, spanning a radial range of ∼30 AU between the coldest and warmest grain species. Furthermore, the thermal emission at short wavelengths is stronger in the case of a detailed grain radius distribution, thus the observational appearance is changed as well.

Almahata Sitta meteorite remains fascinating

Hoffmann, Viktor (vh.hoffmann[at]web.de)

Geosciences, Dep. Geo- and Env. Sciences, Univ. München

Abstract: Since the discovery of Almahata Sitta meteorite (asteroid 2008TC3), the Hayabusa sample return mission (asteroid Itokawa) or the Dawn mission to dwarf planet Ceres and the giant protoplanet Vesta our knowledge concerning the formation and composition of asteroids has significantly increased. During the next years we can expect further exciting input for example from the Hayabusa 2 mission to asteroid (162173) Ryugu, a near Earth asteroidal object of likely carbonaceous chondrite - like composition. In our contribution we will try to summarize our major results concerning the Almahata Sitta meteorite which for the first time ever provides a detailed view of the internal composition of a rubble pile asteroid. Recently, many new individuals of the Almahata Sitta meteorite are available, even a number of new and previously unknown meteorite lithologies could be identified in the new sample set.

Collisions of charged grains in drop tower experiments: Recharging and restitution

Jungmann, Felix (felix.jungmann[at]stud.uni-due.de)

University of Duisburg-Essen

Abstract: Collisions of charged grains can lead to sticking where uncharged grains e.g. of mm-size do no longer stick. This can enhance collisional growth towards planetesimals. We study such collisions in drop tower experiments. Specific aspects considered here are coefficients of restitution and recharging in collisions depending on the absolute charge on a particle.

Near-infrared scattered light observations of the pre-transitional disk PDS 70

Keppler, Miriam (keppler[at]mpia.de)

Max-Planck-Institut fuer Astronomie, Heidelberg

Abstract: We present new polarimetric near-infrared observations of the disk around the pre-transitional T-Tauri star PDS 70 using SPHERE/IRDIS. With our high spatial resolution observations we confirm the presence of a dusty ring beyond a dust depleted cavity with a radius of about 65 au, as seen in previous HiCIAO observations. We detect signal at small projected separations (< 25 au), possibly caused by scattering from the inner disk component. We find evidence for temporal variations in the azimuthal brightness distribution of the outer disk, which may point to dynamical variations in the inner disk that modulate the outer disk illumination. We confront our observational results with a radiative transfer model and discuss the disk characteristics in context of possible gap formation scenarios.

Impact of collisions on the appearance of debris disks

Kim, Minjae (mkim[at]astrophysik.uni-kiel.de)

Christian-Albrechts-Universität zu Kiel

Abstract: Not available

Hydro-dynamic stability of radially and vertically stratified disks

Klahr, Hubert (klahr[at]mpia.de)

MPIA

Abstract: Keplerian disks have proven to be extremely stable to perturbations – when magnetic fields are not in operation. But disks around young stars are complicated entities – they share a lot of properties with planetary atmospheres. One can learn a lot from the stability of rotating stars. Disks around young stars have a radial temperature gradient driven by stellar irradiation, which leads to a thermal wind, e.g. vertical shear. In addition, the temperature gradient leads to a height dependent radial stratification that can be radially buoyant. Without thermal relaxation these disks are linearly stable, but with the right

amount of cooling and heating, for instance by the radiative transport of heat, one can drive a Goldreich-Schubert-Fricke Instability (see for instance Nelson et al. 2013) and a Convective Overstability (Klahr and Hubbard 2014; Lyra 2014). In this talk I discuss some recent results from linear stability analysis and numerical experiments.

Probing the dust composition of the inner disk region with NIR interferometry

Klarmann, Lucia (l.a.klarmann[at]uva.nl)

University of Amsterdam

Abstract: Terrestrial planets and super-earths can form in the inner regions of protoplanetary disks, or migrate there during their formation. The dust in this region is therefore the base material for planet formation, or can change the composition of migrated planets that continue growing via dust accretion. But the refractory properties of the different dust components also define the shape of the inner disk and the position of the inner rim.
Using NIR interferometry, it is possible to obtain values for the position of the inner rim. But these values already depend on assumptions about the inner rim geometry.
We use radiative transfer (RT) modelling, including dust evaporation and condensation, to compare values from synthetic interferometric observations with physical disk properties. The shape and position of the inner rim is obtained from RT disk models with different dust compositions and grain size distributions. We then calculate NIR visibilities and apply standard geometric models to determine the inner rim shape and position from the synthetic observations.
We find that disk parameters derived from modelling visibilities by fitting simple geometric brightness distributions as is usually done in interferometry lead to systematic differences between the geometric parameters derived and the actual values of parameters like inner disk rim location and rim width. Furthermore we find that there are degeneracies between grain size and composition that make the chemical analysis of interferometric observations challenging. We do show how detailed modelling can deal with some of these problems.

Planets in turbulent discs

Kley, Wilhelm (wilhelm.kley[at]uni-tuebingen.de)

University of Tuebingen

Abstract: In weakly ionized discs turbulence can be generated through the vertical shear instability (VSI). Embedded planets feel a stochastic component in the torques acting on them which can impact their migration.
In this work we study the interplay between a growing planet embedded in a protoplanetary disc and the VSI.
We performed a series of three-dimensional hydrodynamical simulations for inviscid locally isothermal discs that are VSI unstable and corresponding viscous discs having the same effective viscosity with embedded planets in the mass range from 5 to 100 Earth masses.

Constraining the structure of the potential planet forming region in circumstellar disks with combined MATISSE/VLTI and ALMA observations

Kobus, Julia (jkobus[at]astrophysik.uni-kiel.de)

Institute of Theoretical Physics and Astrophysics, Christian-Albrechts-Universität zu Kiel

Abstract: We investigate the potential of combining MATISSE/VLTI and ALMA observations for constraining the dust density distribution in the potential planet forming region of circumstellar disks. While MATISSE is sensitive for the thermal emission from warm dust located in the upper disk layers, ALMA traces the emission from cold dust in the entire disk. From the combination of their complementary data sets we expect constraints for the radial and vertical structure of the potential planet forming region. In particular, we aim to answer the following questions: 1. Given the specifications of both instruments and observations, which accuracy can be reached in the estimation of the radial profile, the flaring and the scale height of the dust density distribution? 2. How does grain growth and sedimentation affect the data analysis? 3. Which further complementary observations are most urgently needed to derive unique solutions for the disk structure? Based on an analytical density distribution we apply 3D radiative transfer simulations to calculate first the thermal emission and scattering maps of the disks and in the second step the visibilities and closure phases for the interferometers. Subsequently we take the instrumental characteristics into account, simulate real observations, and analyze them guided by the above questions.

Recycling of dust in protoplanetary disks by thermal creep

Krämer, Anna (anna.kraemer[at]uni-due.de)

Universität Duisburg-Essen

Abstract: The motion of particles of different sizes in protoplanetary disks plays an important role in planet formation. In the outer regions dust particles can agglomerate to larger bodies by collisions which then move inwards. A possibility to prevent the loss of this material through accretion by the star is erosion by thermal creep.

The insolation of the star at the inner part of the protoplanetary disk produces a temperature gradient within the surface of dusty bodies. Due to the low gas pressure, this leads to a gas flow from the cooler inner regions to the warmer surface layer. This induces an overpressure below the surface and dust particles are ejected. These small particles then might be transported to outer parts of the protoplanetary disk to take part in planet formation.

In parabolic flights, we investigated the gas flow quantitatively. In this case, a granular bed with glass beads (d=460-580 µm) was confined within a void of a Peltier element that produced the temperature gradient. This setup was mounted in a vacuum chamber which was filled with different gases (He, N_2, CO_2, air) at pressures between 0.01-100 mbar. The gas flow was visualized by tracer particles and the gas velocity was calculated from the particle trajectories. It varies systematically with the pressure (0.5-10 cm/s) and increases with decreasing molecular mass. The data are discussed in the framework of a capillary model for granular media and allow more detailed predictions for dust recycling close to a star in the future.

The influence of magnetic fields on dust aggregation

Kruss, Maximilian (maximilian.kruss[at]uni-due.de)

Universität Duisburg-Essen

Abstract: Iron is one of the most abundant elements in protoplanetary disks and especially abundant in close-in planets like Mercury. In the presence of an aligning magnetic field in the inner disk region iron particles can attract each other by long range dipole forces. Fragmenting collisions of silicate-iron aggregates might knock off loosely bound silicates selectively and therefore boost the formation of larger iron aggregates as suggested by Hubbard (2014). We will present an experiment to study the influence of magnetic fields on the mechanical strength of silicate-iron aggregates.

The origin of spiral structures in the transitional disk around MWC758

Kudo, Tomoyuki (kudotm[at]subaru.naoj.org)

Subaru telescope, NAOJ

Abstract: An intriguing current research topic in transitional disks is characterizing disk asymmetries, e.g., spiral arms. The mechanism responsible for creating such spiral features is still unclear; one possibility is that such features may be caused by young planets in the process of forming in the disk. To investigate how spiral arms form, we conducted Subaru/HiCIAO+SCExAO near-IR observations (fwhm: ∼0.05 arcsec) of the spiral structures around the Herbig Ae star MWC758, and compared the morphology of these new data against earlier epoch imagery obtained ∼5 years ago. By comparing known arms with earlier epoch imagery, we confirmed the spiral structures has been little change morphology over time; this would be positive proof of structures induced by wide-orbit planet(s) over ∼100 AU. In this presentation, we will show the results of our discussion about the origin of spiral structures around MWC758 based on a morphological time variation.

Early results from SHINE, the SPHERE High-contrast ImagiNg survey for Exoplanets

Langlois, Maud (maud.langlois[at]univ-lyon1.fr)

CNRS

Abstract: With the development of high contrast imaging techniques and instruments, large efforts have been devoted during the past decades to detect and characterize lighter, cooler and closer companions to nearby stars, and ultimately image new planetary systems. Complementary to other planet-hunting techniques, the direct imaging approach has opened a new astrophysical window to study the physical properties and the formation mechanisms of brown dwarfs and planets. With the SPHERE instrument, we have initiated with SHINE, the Sphere High-contrast-ImagiNg survey for Exoplanets, a systematic characterization of 400-600 young, nearby stars close environment aimed at hunting and studying the physical and statistical properties of the giant planet population at wide orbits (>5 AU) between 2015 and 2020. In this talk, we will briefly present the main properties of the SHINE sample, before focussing on the observing startegy, the data reduction and analysis of the survey. The current detection performances achieved with the combination of both near-infrared instruments IRDIS and IFS will be presented in detail.

First scattered light detection of a nearly edge on transitional disk around a T Tauri star

Langlois, Maud (maud.langlois[at]univ-lyon1.fr)

CNRS

Abstract: We report on the discovery of new resolved scattered light emission from a transitional disk around a T Tauri star in the Lupus region. Transition disks are considered to be sites of ongoing disk evolution, and their dust and gas distributions could be signposts of embedded planets. Using high-resolution imaging we study this new disk morphology and photometry. Our aim is to search for companion candidates or companion candidates signatures that would increase our understanding of planet formation. The sharp morphology including spirals features is clearly detectable at wavelengths ranging from 0.9 to 1.6 microns. We show that the observed morphology can be interpreted as an inclined disk with spiral arms. The relative merit of this interpretation is sustained by in depth numerical simulations. We also discuss the likelihood that these features are caused by one 2 Mj planet interacting with the disk.

Planetesimal formation via pebble trapping

Lenz, Christian (lenz[at]mpia.de)

Max-Planck-Institut fuer Astronomie

Abstract: It is believed that planets are formed by so-called "planetesimals", objects being bound by their own gravitational attraction rather than surface and material binding forces. The distribution of planetesimals as "infinitesimal planets" in circumstellar disks is crucial for planet formation. In the early stage of planet formation dust grains grow to pebble size. Standard models use the local dust-to-gas ratio for the streaming instability to form planetesimals from pebbles. Here we present a novel (toy) model where the radial pebble flux delivers the material to pressure bumps which act as pebble traps and where planetesimals can form after gravitational collapse of the accumulated pebbles. The rate of planetesimal formation is then directly proportional to this pebble flux. The pebble flux depends not only on planetesimal formation but mainly on coagulation and fragmentation events of small grains. Hence, our planetesimal model is implemented in a dust and gas evolution code. This allows to test the otherwise free disk parameters by comparing the predicted initial planetesimal distribution with constraints from the Solar System. With our model we obtain planetesimals throughout the entire disk, from roughly 0.7 AU to 300 AU, depending on disk properties. We will also discuss the influence of the most important parameters on the final planetesimal distribution.

A thermomechanical 'Goldilocks' regime for impact splash chondrule formation

Lichtenberg, Tim (tim.lichtenberg[at]phys.ethz.ch)

ETH Zürich

Abstract: Despite continuous efforts, a conclusive and astrophysically consistent chondrule formation scenario remains elusive. Major constraints include chemical, isotopic and textural features of chondrules, in particular retained metal abundances, bulk Fe/Mg ratios, porphyritic textures and the intra-chondrite chemical diversity. In this talk, I will suggest a new coupled evolution-collision scenario where chondrules originate from the collision aftermath of low-mass planetesimals, which are only partially molten from aluminum-26 decay. The model is consistent with the vast majority of thermal and chemical constraints and invokes a diversity of pre-chondrule material compositions. The thermo-mechanical 'Goldilocks' regime favored in our scenario constrains the timing and formation conditions of the earliest planetesimal families and thus the onset of terrestrial planet formation.

Evolution and magnitudes of low mass planets

Linder, Esther (esther.linder[at]space.unibe.ch)

University of Bern

Abstract: Future instruments like NIRCam and MIRI on the JWST or METIS at the E-ELT will be able to image low-mass planets that are too faint for current direct imaging instruments. On the theoretical side, core accretion formation models predict a significant population of distant low-mass planets at orbital distances of 10-1000 AU. So far, evolutionary models predicting the planetary intrinsic luminosity as a function of time have traditionally concentrated on gas-dominated giant planets. We extend these cooling curves to Saturnian, Neptunian, and super-Earth planets. Therefore we simulate the cooling of isolated core-dominated planets with masses of 5 to 300 Earth masses. The planets consist of a core made of iron, silicates, and ices, surrounded by a H/He envelope, similar to the ice giants in the Solar System. The luminosity includes the contribution from the cooling and contraction of the core, the H/He envelope, and radiogenic decay. We use the AMES-Cond grid for the atmosphere. We validate our cooling curves with the Solar System ice giants, and with other evolutionary models. We then present the temporal evolution of planets with masses between 5 and 300 Earth masses, discuss the impact of different post formation entropy, and also calculate magnitudes in JWST filter bands.

Local formation of comets through streaming instability

Lorek, Sebastian (lorek[at]mps.mpg.de)

Max-Planck-Institut für Sonnensystemforschung

Abstract: The streaming instability in the solar nebula followed by the gravitational collapse of particle overdensities successfully forms planetesimals of typically 100 km in diameter. Having the structure of a pebble pile planetesimal, these objects show comet-like properties, such as low density, high porosity, and very low tensile strength. Here, I present results of local coagulation simulations in the comet-forming region beyond 5 au. Sub-micron-sized dust and ice grains grow to porous roughly mm-sized aggregates. The simulations show that porous aggregates enter a bouncing-dominated regime before radial drift removes them from the formation location. Compression through bouncing collisions allows the aggregates to reach the minimum Stokes number necessary for triggering the streaming instability. I study the properties (mass, porosity) of these aggregates and their implications for the gravitational collapse scenario for comet formation. Finally, I link the aggregate sizes found in the simulations to the pebbles observed by the CIVA camera on board the Philae lander of the Rosetta mission on comet 67P/Churyumov-Gerasimenko. Simulation and observation are in broad agreement which renders it possible that comets indeed formed through gravitational collapse of pebble clouds.

The formation of toridal vortices in protoplanetary discs

Loren-Aguilar, Pablo (P.Loren-Aguilar[at]exeter.ac.uk)

University of Exeter

Abstract: In a previous work, we reported the possible existence of a new type of instability in protoplanetary discs (Loren-Aguilar & Bate 2015). We observed, during a set of Smoothed Particle Hydrodynamics (SPH) simulations of dust settling in protoplanetary discs, the formation of global toroidal vortices. The origin of such instability was, though, unidentified. In the present work, we present new sets of simulations that identify drag feedback into the gas, and radial shear as the causes of the instability. In addition to a new set of SPH simulations, we also present shearing-box simulations of dust settling in protoplanetary discs, using the Eulerian code Athena. Both SPH and Athena simulations evidence a good degree of agreement, both in the morphology of the created vortices, and the cause of the instabiltiy.

VLT/SPHERE astrometric monitoring of known young giant exoplanets and brown dwarfs

Maire, Anne-Lise (maire[at]mpia.de)

Max-Planck-Institut fuer Astronomie

Abstract: Astrometric monitoring of directly imaged exoplanets and brown dwarfs allows the study of their orbital parameters and system architectures. Because of the long orbital periods and/or faintness of these objects, accurate astrometry is challenging when based on data acquired on timescales of a few years. The new high-contrast imaging instrument VLT/SPHERE provides exquisite contrasts and astrometric accuracies down to about 1 mas thanks to its dedicated design and the use of optimized observational strategy. We will present the results of astrometric monitorings of several young giant exoplanets and brown dwarfs monitored as part of the SPHERE consortium exoplanet imaging survey.

Nonlinear transverse cascade and sustenance of MRI-turbulence with azimuthal magnetic field

Mamatsashvili, George (g.mamatsashvili[at]hzdr.de)

Helmholtz-Zentrum Dresden-Rossendorf

Abstract: We investigate MHD turbulence driven by the magnetorotational instability (MRI) in Keplerian protoplanetary disk flows threaded by a nonzero net azimuthal magnetic field using the shearing box simulations. Compared to previous studies, we analyze the turbulence dynamics in Fourier (k-)space in order to gain a deeper insight into its sustaining mechanism. As it is well known, in the presence of an azimuthal field, the linear growth of the MRI has a transient character. The transient growth of the azimuthal MRI is strongly anisotropic in Fourier space. This, in turn, leads to anisotropy of nonlinear processes in k-space and, as a result, the main nonlinear process appears to be not an usual direct/inverse, but rather a new type of transverse/angular redistribution of perturbation modes in Fourier space, which we refer to as the nonlinear transverse cascade. It is demonstrated that the turbulence is sustained by a subtle interplay of the linear transient growth of the MRI and nonlinear transverse cascade. The linear transient growth (which serves as the only energy supply to turbulence), the nonlinear transverse cascade and their interplay mainly operate at large length scales, comparable to the box size, which we call the vital area of turbulence in Fourier space. We show that the box geometry does not qualitatively change the dynamical processes, but only "deforms" the distribution of quantities and dynamical terms in Fourier space. This indicates the universal nature of the proposed turbulence sustaining scheme.

Vortex formation in vertical shear instability

Manger, Natascha (manger[at]mpia.de)

Max Planck Institut für Astronomie

Abstract: Many planetesimal formation models rely on particle trapping mechanisms operating somewhere in proto-planetary disks to stall migration onto the central star and enable formation of large planetary precursors. The origin of these traps however is still debated.
We present 3D non-axisymmetric simulations showing Vertical Shear Instability (VSI) to be able to form large and long-lived vortices capable of trapping particles.

Source of life from Meteorites

Marikunte, Guruprasad (mrpguru[at]gmail.com)

Independent Astrobiologist

Abstract: The search for past and present life beyond earth requires a solid understanding of life's origin and evolution on the only planet on which life is know as earth. Asteroids, comets, Meteorites are the source of organic molecules on the early earth. One of the methods scientists use to visualize their imagination of extraterrestrial life is studying life in extreme environmts and extraterrestrial analogues on earth. Craters are an evidence of the activeness of our universe, and are also one of the things that many components of our solar system have in common. Panspermia is one of the major contenders in theories of the origins of life on earth. An important thing to note about the Panspermia hypothesis is that gives no explanation for how life began on earth came to be.

Beware black ice? Properties of HD 105's circumstellar dust constrained by resolved imaging

Marshall, Jonathan (jonty.marshall[at]gmail.com)

University of Southern Queensland

Abstract: HD 105 is a young G0 V star at a distance of 40 pc hosting a moderately bright debris disk ($L_d/L_* \sim 2.6x10^{-4}$). As a member of the Tucana-Horologium association, it has a well established age of 30 Myr. HD 105 might therefore be considered an analogue of the young Sun. The disk was marginally resolved by Herschel/PACS imaging at far infrared wavelengths. Here we present a resolved ALMA image of the disk at 1.3 mm, constraining the disk extent and orientation, along with VLT/SPHERE near-infrared image (from SHARDDS), providing upper limits to the disk scattered light surface brightness. Simultaneous modelling of the available photometry, disk extent, and non-detection in scattered light, reveal that the constituent dust grains must simultaneously have a low albedo and high ice content.

X-ray properties of planet hosting stars - The link between photoevaporation and the semi-major axis distribution of giant planets

Monsch, Kristina (kristina.monsch[at]gmail.com)

Universitätssternwarte der Ludwig-Maximilians-Universität München

Abstract: The location of giant planets in a planetary system can be of high importance for the potential habitability of a planet. If affects its dynamical evolution as well as the delivery of volatiles to terrestrial planets. By shielding them from severe impacts from asteroids and comets, giant planets can even protect them from becoming inhabitable. Therefore, understanding the formation and the dynamical evolution of giant planets is of utmost importance for the study of planetary systems and the possible consequences for the emergence of life.

Recent exoplanet surveys have highlighted the existence of a mind-blowing diversity of planetary systems as well as well-defined trends. One of these is the peak in the semi-major axis distribution of giant planets at 1-2 AU. It has recently been suggested that this distribution may be established during the time of planetary migration in the protoplanetary disc, which is halted by disc dispersal via X-ray driven photoevaporation. We have searched for signatures of this process by matching the exoplanet.eu database with archival Chandra observations to find planet-hosting stars that have been observed in X-rays. We then calculated their X-ray fluxes in a consistent way and analyze the results statistically. We find a prominent feature in the host X-ray luminosity versus semi-major axis plane. This is found to match the results of numerical simulations that investigate the final semi-major axis distribution of giant planets for a given X-ray photoevaporation profile suggesting that X-ray driven photoevaporation may be indeed shaping the final distribution of giant planets.

Search for (sub)stellar companions of exoplanet host stars

Mugrauer, Markus (markus[at]astro.uni-jena.de)

AIU Jena

Abstract: In order to determine the true impact of stellar multiplicity on the formation process of planets and on the evolution of their orbits, as well as to determine the exact multiplicity status of all nearby exoplanet hosts stars, we have already conducted Seeing-limited imaging searches for (sub)stellar companions on wide orbits around exoplanet host stars. Recently, we have complemented these searches with surveys to detect (sub)stellar companions of exoplanet host stars on close orbits. This is a very important astrophysical objective since a large fraction of stars are members of multiple star systems, i.e. planet formation and evolution in stellar systems might be a frequent phenomenon in our galaxy. In this context the closest stellar systems with exoplanets are most intriguing because the gravitational perturbations of the stellar companion on the planet bearing disc at first, and on formed planets afterwards, is expected to be maximal. On this poster I will present a short summary of results obtained in the course of our imaging surveys in the past. In the following I will present results from our ongoing long-term Lucky-Imaging survey of exoplanet host stars, carried out with ASTRALUX at CAHA. In addition, I will introduce our new high contrast imaging surveys, conducted with NACO and SPHERE at ESO-VLT, to detected very close (sub)stellar companions of exoplanet host stars, whose multiplicity was not studied with high contrast AO imaging before.

Co-authors:
C. Ginski, N. Vogt, R. Neuhäuser, C. Adam

Laboratory experiments on adhesive forces between micrometer water ice particles

Münnich, Robert (robert.muennich[at]stud.uni-due.de)

University Duisburg-Essen

Abstract: Water ice is abundant in protoplanetary disks. For phases of collisional growth its sticking properties are important. The experiments reported here quantify these forces by measuring the centrifugal forces necessary to remove grains from a rotating ice wheel. Earlier work indicated that the well accepted linear relation between grain radius and sticking force does not apply. This work reports improvements of the experiment to verify this astonishing result.

The destructive nature of wind erosion for planetesimals in protoplanetary disks

Musiolik, Grzegorz (gregor.musiolik[at]uni-due.de)

Universität Duisburg-Essen, Faculty of Physics

Abstract: While the first steps of planet formation can be attributed to hit and stick collisions of sub-cm dust aggregates, the further evolution is described by the gravitational interaction. The motion of the gas inside of a protoplanetary disk is influenced by a pressure difference and is thus sub-keplerian, by which large, km-sized bodies experience a drag force which might lead to erosive processes of their surface. This effect has a destructive nature and might be crucial to describe growth for large bodies.
We performed first wind tunnel experiments inside a centrifuge in a parabolic flight. We measured the threshold velocities needed to lift ∼100µm JSC 1A dust aggregates in dependence on gravitational attractions of 1g and 0.38g. The threshold velocity decreases from 1.01±0.04 m/s for 1g to 0.82±0.04 m/s for 0.38g. We currently attribute this tendency to a reduced number of contacts inside the dust bed caused by the lower gravitational pressure.

Detecting non-axisymmetric structures of protoplanetary disks from low-resolution radio interferometric data

Muto, Takayuki (muto[at]cc.kogakuin.ac.jp)

Kogakuin University

Abstract: We suggest a novel method of detecting non-axisymmetric structures of protoplanetary disks from low-resolution radio interferometric data. We make use of visibility, which are directly observed quantities in interferometry. We show that the asymmetric structures on the plane of the sky shows up as asymmetry in the visibility data in the uv-space. We perform a systematic parameter search of a number of disk models and their simulated observations, and investigate how the disk asymmetric structures appear in the visibility data. We find that the asymmetry of the visibility in the uv-space appears even when the array configuration is not very extended. Even in the case where the asymmetry is indistinguishable in the image on the sky plane due to large beam, it is possible to identify such structures in the uv-space. We have developed a method to identify disks harboring possible asymmetric structures, which may be useful, for example, in archival search.

(Sub-)millimeter dust opacities from lab measurements

Mutschke, Harald (harald.mutschke[at]uni-jena.de)

Astrophysical Institute and University Observatory

Abstract: We present laboratory-measured data on the absorptivity/emissivity of small dust particles composed of different materials relevant for cosmic dust. The materials were synthetically produced in the lab and comprise glassy silicates, carbonaceous materials, and crystalline and amorphous water ice. The absorptivity of the samples was measured at different (low) temperatures, using a variety of cryostats and spectrometers for the wavelength range 50 micrometer to 4 millimeter. The data indicate that some of the physical absorption mechanisms active in this wavelength range introduce a significant temperature dependence of the opacity and marked deviations from the commonly assumed power law of the wavelength dependence.

Co-authors:
P. Mohr, F. Lewen (Univ. Köln), T. Dressler (Univ. Köln), D. Häßner, J. Greif

The dust distribution of the 49 Cet debris disc

Pawellek, Nicole (pawellek[at]mpia-hd.mpg.de)

Max-Planck-Institut für Astronomie

Abstract: Dust grains in debris discs are important tracers of the planetesimal formation mechanisms and physical processes operating in these systems. Two main forces influencing the particle orbits are gravity and radiation pressure leading to typical appearances of debris belts including asymmetries. High angular resolution observations at near-infrared wavelengths can provide key constraints on the radial and azimuthal distribution of the small dust grains helping us to better understand where most of the dust particles are released upon collisions. In contrast to near-infrared data, sub-mm observations trace the larger parent bodies. Thus, we are able to get more information on the distribution of the dust grains by using both wavelength ranges for our analysis. Here, we present near-infrared and sub-mm radial profiles of the 49 Ceti debris disc and compare them to our theoretical model taking into account the stellar radiation pressure.

Chemistry and dynamics in protoplanetary discs

Pignatale, Francesco (pignatale[at]ipgp.fr)

IPGP- Institut de Physique du Globe de Paris

Abstract: Not available

The circumstellar disk HD169142: Gas, dust and planets acting in concert? - VLT/SPHERE polarimetric imaging

Pohl, Adriana (pohl[at]mpia.de)

MPIA Heidelberg

Abstract: We will present SPHERE/VLT polarimetric imaging observations of the protoplanetary disk around HD169142, which reveal an inner gap with significantly reduced scattered light flux and a double ring structure at 0.18" (∼21 au) and 0.56" (66 au). A physical disk model is developed considering self-consistent dust evolution models in a disk perturbed by two giant planets, as well as models with a parameterized dust size distribution. We aim to reproduce simultaneously the observations of the disk surface in scattered light with SPHERE and of the disk midplane in dust continuum emission with ALMA. Radiative transfer calculations indicate that the dust evolution model is able to reproduce the ring locations and gap widths in polarized intensity, but fails to reproduce their depths. Models with a constant gas-to-dust ratio and a power law dust size distribution better reproduce the gap depth in scattered light, suggesting that dust filtration at the outer edges of the gaps is less effective than predicted by current models of dust evolution.

Thermal and UV-induced processing of interstellar ice-grain analogues

Potapov, Alexey (alexey.potapov[at]uni-jena.de)

Laboratory Astrophysics Group of the Max Planck Institute for Astronomy

Abstract: New stars and planetary systems are formed from cold and dense cores of dust and gas in molecular clouds that collapse under the influence of gravity. Interstellar dust characterized by refractory grains, which are mainly carbon or silicate based, covered by molecular ice layers is an important ingredient for the formation of planetary systems. Interstellar and cometary ices are dominated by solid water ice. Thermal desorption and pho-

tosputtering processes can change the composition of icy grains. Evaporation and sputtering of water molecules can have a big influence on the evolution of protoplanetary disks. In our laboratory, interstellar ice-grain analogues composed of carbon or silicate particles and solid water ice were produced and subjected to thermal and UV-induced processing. The newly developed experimental setup INSIDE (INterStellar Ice Dust Experiment) was used to simulate the conditions in molecular clouds and planetary disks. First results on the processing of water ice containing carbon or silicate grains will be presented.

Updates on the story of the young transiting planet candidate CVSO-30b

Raetz, Stefanie (straetz[at]stiller-berg.de)

Institut für Astronomie und Astrophysik Tübingen (IAAT), Sand 1, 72076 Tübingen, Germany

Abstract: CVSO-30 is a unique young low-mass system, because, for the first time, a close-in transiting and a wide directly imaged planet candidates are found around a common host star. The inner companion, CVSO-30b, is the first possible young transiting planet orbiting a previously known weak-lined T-Tauri star. An interesting feature of the light curve (LC) of CVSO-30 is that there is an overall change in the transit shape between observing seasons. It was showed that the unusual LC shapes and their variation can be explained by a precessing planet transiting a gravity-darkened star.

We monitored CVSO-30 over a period of three years with the telescopes of the 'Young Exoplanet Transit Initiative' (YETI). In four more seasons we carried out photometric follow-up observations. We can confirm that there is a change in the shape of the transits between different observations and that the fading event even disappears and reappears. If CVSO-30b would be a giant planet on a precessing orbit, which we cannot confirm, yet, the precession period may be shorter than previously thought. An alternative explanation for CVSO-30 may be an occultation of the star by dust from a disintegrating planet. CVSO-30 seem to share some features with other examples of disintegrating planets that have been discovered.

Here I will tell the story of the young transiting planet candidate CVSO-30b and present new photometric observations.

The close-in gaseuos environment of main-sequence stars. Signatures of exocomets

Rebollido, Isabel (isabel.rebollido[at]uam.es)

Universidad Autónoma de Madrid

Abstract: We present the results of an optical spectroscopic survey of more than 100 MS stars, most of them A spectral types, searching for variable absorption features commonly attributed to exocometary activity. We have collected over 2000 high resolution spectra obtained in the last two years during more than 10 observing campaings carried out at La Palma (NOT and Mercator), La Silla (MPG/ESO 2.2 m) and Mexico (TIGRE). Strong evidence of cometary variable events are found in several objects, some of them new detections. We also report on the detection rates of stable, narrow absorption components attributed to circumstellar gas likely related to exocomets. Our observations allow us to construct spectral time series for most of the objects in the sample, allowing us to study the variability arising from metals evaporating when the rocky-icy bodies pass close enough to their host star. We also explore the possible connection between these close-in bodies and the presence of molecular gas attributed to planetesimals/comet-like bodies detected in debris disks systems.

Vortex stretching in self-gravitating protoplanetary discs

Regaly, Zsolt (regaly[at]konkoly.hu)

Konkoly Obsevatory

Abstract: Horseshoe-shaped brightness asymmetries of several transitional discs are thought to be caused by large-scale vortices. Anticyclonic vortices are efficiently collect dust particles, therefore they can play a major role in planet formation. Former studies suggest that the disc self-gravity weakens vortices formed at the edge of the gap opened by a massive planet in discs whose masses are in the range of $0.01 \leq M_{disc}/M_* \leq 0.1$. Here we present an investigation on the long-term evolution of the large-scale vortices formed at the viscosity transition of the discs' dead zone outer edge by means of two-dimensional hydrodynamic simulations taking disc self-gravity into account. We perform a numerical study of low mass, $0.001 \leq M_{disc}/M_* \leq 0.01$, discs, for which case disc self-gravity is though to be unimportant. The large-scale vortices are found to be stretched due to disc self-gravity even for low-mass discs with $M_{disc} \geq 0.005M_*$ where initially $Q \leq 50$ at the vortex distance. As a result of stretching, the vortex aspect ratio increases and a weaker azimuthal density contrast develops. The strength of the vortex stretching is proportional to the disc mass. The vortex stretching can be explained by a combined action of a non-vanishing gravitational torque caused by the vortex, and the Keplerian shear of the disc. Self-gravitating

vortices are subject to significantly faster decay than non-self-gravitating ones. We found that vortices developed at sharp viscosity transitions of self-gravitating discs can be described by GNG model as long as the disc viscosity is low, i.e. $\alpha_{dz} \leq 10^{-5}$.

The potential of the Next Generation Very Large Array (ngVLA) to find the signposts of low-mass planets in young disks

Ricci, Luca (luca.ricci[at]rice.edu)

Rice University

Abstract: The annular gaps and other substructures discovered in several protoplanetary disks by ALMA and optical/NIR telescopes are reminiscent of the interaction between newborn planets and the circumstellar material. The comparison with theoretical models indicates that these structures might indeed result from the gravitational interaction between the circumstellar disk and Saturn-mass planets orbiting at tens of AU from the parent star.
The same observations also revealed that the submm-wave dust continuum emission arising within 10-30 AU from the star is optically thick. The large optical depth prevents us from accurately measuring the dust density and, therefore, image planet-driven density perturbations.
A natural solution to this problem consists in imaging disks at wavelengths of 3mm and longer, where the dust continuum emission from the innermost disk regions is optically thin, but still bright enough to be detected. These wavelengths are covered by the VLA, which, however, lacks the angular resolution and sensitivity to efficiently search for signatures of planets orbiting in the innermost and densest disk regions.
Thanks to its much larger collecting area, resolving power, and image quality the Next Generation VLA (ngVLA) will transform the study of planet formation. I will present the results of a recent study aimed at investigating the potential of the ngVLA of discovering disk sub-structures, such as gaps and azimuthal asymmetries, generated by the interaction with low-mass forming planets at < 10 au from the star.

Implications of turbulence on the formation of gas giant cores via pebble accretion

Rosenthal, Mickey (mmrosent[at]ucsc.edu)

University of California, Santa Cruz

Abstract: Pebble accretion is a promising candidate for rectifying the difficulties with producing the observed population of wide orbital separation gas giants via core accretion. We present an order of magnitude of model of pebble accretion which incorporates the effects of local disk turbulence into not only the particle scale height, but also the small body drift velocities and the radius for binary capture. We find that turbulence does not rule out the rapid growth at high core masses found in previous works: the last doubling time to the critical mass to trigger runaway gas accretion is well within the disk lifetime even for strong turbulence. Instead, the effects of turbulence are most pronounced for low planetary masses; in this regime gas drag enhanced by the turbulent gas velocities can more easily dominate over the planet's gravity. These effects imply that the time limiting step in gas-assisted growth often occurs at low core masses. We further use these considerations to demonstrate how a combination of initial growth by gravitational focusing and subsequent growth by pebble accretion gas can produce gas giants under favorable conditions. We find that this process is quite sensitive to both the strength of turbulence in the disk as well as the size distribution of small bodies available for accretion, which may explain the paucity of wide orbital separation gas giants.

Towards a new theoretical description of solid particles aggregation

Rossi, Eduardo (Eduardo.Rossi[at]unige.ch)

University of Geneva

Abstract: Particle aggregation is considered as a key process in several disciplines: planetary formation, food industry and atmospheric sciences. So far the theoretical description of dust aggregation is commonly related to the solution of the Smoluchowski Coagulation Equations (SCE), a set of Ordinary Differential Equations (ODEs) which basically describe the change in time of an initial grain-size distribution due to the interaction of "single" particles. The complete solution of SCE is conditioned by our general knowledge of the physics of interaction between classes of particles (kernels) and our capability to solve a set of equations which is theoretically infinite. One of the possible approaches to the solution of SCE is to reduce the continuous particle distribution to a finite number of classes. This perspective is particularly close to our initial field data in volcanology, the so called Total Grain Size Distribution (TGSD). Nevertheless the common one-dimensional approach seems to not be appropriate for the complexity of solid particles aggregates. We propose a

new approach to aggregation problems based on non-addictive properties for the multidimensional Population Balance Equations. This study starts from the in-situ observation of volcanic ash aggregates observed during several explosions at Sakurajima volcano, Japan. The underling idea is that the same approach can be of interest also for the planetary formation of polydisperse solid particles.

Spectral characterization of 51 Eridani b: SPHERE, BACON, and future tools

Samland, Matthias (samland[at]mpia.de)

Max Planck Institut für Astronomie

Abstract: Spectra of the young (∼20 Myr), nearby (∼30 pc) and relatively cool (∼750 K) directly imaged planet 51 Eridani b have been obtained with SPHERE (Samland et al. 2017). This new data set combined with previous data, now covers all significant features from the Y-band to the L-band (∼0.8 to ∼4.0 micron). We further use new extensive model grids based on Molliere et al. 2015, 2017 including clouds and non-solar metallicity, the latter having often been neglected in exoplanetary studies. Especially, the prospect of moving planetary metallicity into the regime of being an actual "observable", although extremely challenging, is interesting in the context of formation and evolution scenarios. Our results for 51 Eridani b are suggestive of non-solar atmospheric metallicity several times solar, which may be hard to explain in some formation paradigms. In order to achieve reliable results, we developed the BACON package (Bayesian Atmospheric CharacterizatiON). It features MCMC exploration of the posterior probability parameter distribution of arbitrary atmospheric model grids with photometric and spectroscopic data. It takes into account the correct treatment of correlated noise. We are in the process of incorporating a free retrieval code into the package and expand our analyses to transit spectra. BACON will be made public as open-source project to facilitate a common standard for spectral analysis.

Rapid formation of giant planets at the pressure maxima of protoplanetary disks

Sándor, Zsolt (zs.sandor[at]astro.elte.hu)

Department of Astronomy, Eötvös Loránd University, Budapest, Hungary

Abstract: In the classical core-accretion planet-formation scenario, rapid inward migration of protoplanets and long accretion timescales of kilometer size planetesimals may not favor the formation of giant planets before the dissipation of protoplanetary disks. On the other hand, the existence of pressure maxima in the disk could act as migration traps and locations for solid material accumulation, favoring the formation of massive cores.
We numerically study the radial drift of pebbles and planetesimals, and planet migration at pressure maxima in a time evolving 1D disk and their effect on the formation of massive cores as triggering the gaseous runaway accretion phase. The equations governing the growth of the solid core by planetesimal and gas accretion are also solved simultaneously.
Our simulations show that the pressure maxima generated at the edges of the low-viscosity region of the disk act as planet migration traps, and that the pebble and planetesimal surface densities are substantially increased due to the radial drift towards pressure maxima locations implying a significant shortening of the giant planet formation timescales. Pressure maxima generated at the edges of a low-viscosity region of a protoplanetary disk seem to be preferential locations for the formation and trap of massive cores.

YSOs hit by SNR shocks

Sasaki, Manami (manami.sasaki[at]fau.de)

Remeis-Sternwarte, FAU Erlangen-Nürnberg

Abstract: Since massive stars evolve very fast and die in supernova (SN) explosions only after a few 10^6 years, remnants of core-collapse SNe are often found in regions with active star formation. We study shock-cloud interaction in Galactic core-collapse SNRs. If the SN shock wave interacts with a YSO, we expect that the physical and chemical properties of the YSO are modified. Based on optical and NIR photometry we have identified YSO candidates inside these SNRs and perform spectroscopy of these objects to verify their age and to study their accretion activity.

Atmospheric fitting & tests of speckle influence onto direct imaging candidates

Schmidt, Tobias (tobias.schmidt[at]obspm.fr)

LESIA, Paris Observatory, Paris, France

Abstract: The SHINE survey conducted on the SPHERE high-contrast imager at VLT aims to characterise the giant planet population beyond 5 AU around 400-500 nearby stars. Now, that about half of the observations of SHINE are performed, more and more spectro-photometric information for known and new companion candidates is collected, that can be subsequently used to extract information on planetary and sub-stellar atmospheres and how they might have formed.

While other proposed SHINE presentations focus on giving an overview on the survey and its wealth of characterized objects, here the focus is on details of special or newly characterized objects, methods used to achieve reliable spectro-photometry in the presence of strong speckles for close companions, as well as on the very youngest candidates from SHINE and additional open surveys, providing even more information how young high-mass planet candidates and brown dwarfs form.

Streaming instabilities in laboratory experiments

Schneider, Niclas (niclas.schneider[at]stud.uni-due.de)

University of Duisburg-Essen

Abstract: The streaming instability is one way to concentrate particles in protoplanetary disks. The concentration is strongly related to the coupling of particles to the gas and streaming generates clumping. We started to set up an experiment where a cloud of dust grains initially moves in a thin gas on circular orbits. Their motion can be manipulated by photophoresis supposed to lead to clump formation and concentrations in analogy to streaming. We will report on the status of the project.

Planetary accretion with HST

Schneider, Christian (astro[at]pcschneider.eu)

Hamburger Sternwarte

Abstract: Accreting planets are thought to be bright Halpha sources and LkCa 15 is the first system where such accretion signatures have been claimed. I will present initial results from our HST campaign following-up these initial results. Specifically, we use spectro-astrometry to separate the stellar and the planetary signals. Our preliminary results indicate that our tailored observing strategy allows us reach very high contrast ratios that would allow us the detection of the claimed planetary signals.

Formation of planetesimals near the snowline

Schoonenberg, Djoeke (djoekeschoonenberg[at]gmail.com)

Anton Pannekoek Institute

Abstract: Streaming instability is a promising mechanism to form planetesimals, but it requires an enhanced solids-to-gas ratio. A special location in protoplanetary disks where streaming conditions might be reached is the snowline, where inward-drifting icy pebbles evaporate. Water vapour from the inner disk is transported outwards due to turbulent diffusion and recondenses onto the drifting pebbles, leading to an enhanced solids-to-gas ratio in an annulus outside the snowline. In this talk I will discuss the results presented in Schoonenberg & Ormel (2017). We have constructed a dynamical model of the snowline including radial drift (taking into account the back-reaction of solids onto the gas), gas accretion, turbulent diffusion, evaporation and condensation.
We study the implications of two different pebble interior structures: 1) icy pebbles in the outer disk contain a single silicate core covered by an icy mantle and 2) icy pebbles in the outer disk contain many micron-sized silicate grains that are 'glued' together by ice.
I will present the viability of reaching streaming instability conditions at the snowline location for these two pebble 'designs'. Concerning design 2), I will also address the 'traffic jam' effect of small silicate grains -released when icy pebbles evaporate- that could lead to rocky planetesimal formation interior to the snowline.

High-velocity collisions between small and large dust agglomerates as growth barrier

Schräpler, Rainer (r.schraepler[at]tu-bs.de)

Institut für Geophysik und extraterrestrische Physik

Abstract: In a protoplanetary disk, dust aggregates in the µm to mm size range possess mean collision velocities of 10 to 60 $m \cdot s^{-1}$ with respect to dm- to m-size bodies. We performed laboratory collision experiments to explore this parameter regime and found a size- and velocity-dependent threshold between erosion and growth. By extending an existing analytical model for solid µm-sized impactors to dust agglomerates with sizes up to 50 µm, we show that erosion considerably limits particle growth in protoplanetary disks. For silicate dust, the maximum achievable aggregate size is ∼1 cm at 1 AU and ∼5 cm at 10 AU, for water ice, the size limit is ∼20 cm at 10 AU.

High resolution radiation-hydrodynamics studies of accreting Saturn-mass planets in protoplanetary discs

Schulik, Matthäus (schulik[at]astro.lu.se)

Lund Observatory

Abstract: Recent work in the field of core accretion in order to form gas giants suggests gas accretion to be a 3D problem, contrary to findings in earlier research. Non-hydrostatic, global flows tend to replenish the planetary envelope entropy and therefore a scenario of gas accretion taking the disc environment into account must be modeled.

We study occuring gas flows and the cooling behaviour of massive protoplanetary envelopes, as well as the change in accretion physics as function of disc parameters. Our tool of work is FargoCA, a 3D radiation hydrodynamics code that allows for nonuniform grid structures. Findings include substructures carved by the planet into the gas inside its own Hill-sphere in interaction with the spiral arms. Radiative flux produced near the planet diffuses outward over the Hill-sphere's boundaries. The radiation reaches far out into the disc atmosphere, driving outflows and changing the entropy structure in the disc midplane. We conclude with discussing implications of our findings for the formation of giant planets.

Asymmetries in debris disks – The influence of planets

Sende, Jan (jan.sende[at]uni-jena.de)

AIU Jena

Abstract: Many of the resolved debris disks show asymmetries in their belts. A common explanation are secular gravitional perturbations by planets in the system.
We implemented these perturbations into our collisional debris disk code ACE. We will discuss our preliminary results for the dependency of the debris disk structure on the planets orbital parameters.
One Example would be the shearing of a intially elliptic disk because of differential precesion.

Solving the planetesimals accretion problem for gas giant planet with stochastic migration

Senecal, Luc (luc.senecal[at]space.unibe.ch)

University of Bern

Abstract: Growth of planetary embryo by planetesimals accretion was believed to be the main scenario to form a gas giant planet core until simulations figure that such process wasn't fast enough to permit the creation of a giant planet. We use a possible mechanism that could enable planetesimals accretion to form the 10 earth mass core needed to obtain a gas giant planet. We have performed Nbody calculations of one stochastic migrating planetary embryo inside a planetesimals disk and track the accretion of material. We show that for certain type of stochastic migration it is possible to drasticly increase the amount of mass accreted by the embryo relatively to a standard smooth migration. Stochastic migration due to interaction with the gas nebula may able planetary embryo to grow to the 10 earth mass needed to form a gas giant planet before the dispersal of the gas disk.

Expelled grains from an unseen parent body around AU Mic

Sezestre, Elie (elie.sezestre[at]univ-grenoble-alpes.fr)

IPAG

Abstract: Recent observations of the edge-on debris disk of AU Mic have revealed asymmetric, fast outward-moving arch-like structures above the disk midplane. Although asymmetries are frequent in debris disks, no model can readily explain the characteristics of these features.

We present a model aiming to reproduce the dynamics of these structures. We test the hypothesis of dust emitted by a point source and then expelled from the system by the strong stellar wind of this young M-type star.

We perform numerical simulations of test particle trajectories to explore the available parameter space, in particular the radial location of the dust producing parent body and the size of the dust grains. We consider both the case of a static and an orbiting parent body.

We find that, for all considered scenarii, there is always a set of parameters able to fit the observed features. The common characteristics of these solutions is that they all require a high value of pressure force, meaning that the star is very active. As for the location of the hypothetical parent body, we constrain it to lie around 8 au in the orbiting case.

We show that the scenario of sequential dust releases by an unseen, punctual parent body is able to explain the radial behaviour of the observed structures. We are also able to predict the future evolution of the structures. We expect new structures to appear on the northwest side of the disk in the coming years.

The effect of collisional charging on the planetary dust aggregation

Singh, Chamkor (chamkor.singh[at]ds.mpg.de)

Max Planck Institute for Dynamics and Self-Organization

Abstract: The consequences of electric charge exchange between colliding particles inside evolving protoplanetary dust cloud are widely unexplored. It has been long speculated that this phenomenon may play a significant role in the dust aggregation process which subsequently results in planetesimal formation during the early stages of the birth of a planet. The local charge exchange between colliding particles can collectively alter the dynamics of number of processes such as charge separation over large length scales, buildup of significant potential differences and electric discharge. We investigate this phenomenon by performing direct numerical simulations of the granular hydrodynamic equations coupled with the Maxwell's electrostatic equations which are applicable at small Knudsen number limit. For large Knudsen number we perform molecular dynamic simulations including the electrostatic interactions between the particles.

The influence of ice lines on dust growth in protoplanetary disks

Stammler, Sebastian (stammler[at]usm.lmu.de)

Universitäts-Sternwarte der Ludwig-Maximilians-Universität München

Abstract: Ice lines are special locations in protoplanetary disks at which phase transitions between the solid and the gaseous phase of volatile species occur. Inside of ice lines the temperatures are high enough for volatiles to get evaporated, whereas outside they freeze out as ice and can be accreted by larger bodies. Ice lines are therefore of special interest in planetary sciences since they influence the composition of dust and planetesimals in protoplanetary disks.

Of special interest is hereby the water ice line. Dust particles covered by water ice are thought to be more sticky and can withstand higher collision velocities before they fragment. Dust outside the water ice line can therefore grow to larger sizes compared to dust inside the water ice line where all the water is evaporated.

In addition to that, ice lines of other volatile species can also affect the efficiency of dust growth. Particles that drift inwards through ice lines lose their respective volatile species through evaporation. Backwards diffusing vapor can consequently re-condense on the small monomers outside the ice line. An increasing monomer size leads to a decreasing fragmentation velocity and therefore to smaller particles, which are less affected by radial drift.

This leads to a pile-up of material in regions just outside of ice lines, which can be seen as ring-like axisymmetric features in millimeter observations of protoplanetary disks.

Statistics of collisional parameters computed from numerical simulations

Süli, Áron (a.suli[at]astro.elte.hu)

Eötvös University, Department of Astronomy

Abstract: There are two ways to speed up N-body simulations of planet formation: (i) confine motion to 2D, or (ii) to artificially enhance the physical radii of the bodies (this factor is denoted by A_{ref}). Here, we have computed the basic collisional parameters for A_{ref}=1,2,3,5,10. Since N-body systems are stochastic we have performed 10 simulations for each A_{ref} to obtain reliable results. These 50 simulatios contained 10000 fully interacting bodies which were confined to 2D. We show that one simulation of a specific system provides reliable statistics of the impact parameters therefore in 3D we have simulated only one run for each A_{ref}. Our main goal was to find out the probability distribution functions (pdf) of the basic collisional parameters (impact parameter, velocity, specific impact energy). Using a simple method we have improved the determination of the impact angle and we have shown that 99% of the impacts have an angle less than 75 degree and the distribu-

tion of the impact parameter is uniform. We show that in most cases the impact velocity is greater than the mutual escape velocity and for A_{ref}=1 the pdf of the impact velocity can be remarkably well fitted by a power-law function. We present a scaling law of the impact velocity as a function of A_{ref}, via which future simulations can accurately compute the real impact velocity when $A_{ref} > 1$ and making use of more sophisticated collision scenarios.

Photophoresis in a nutshell

Teiser, Jens (jens.teiser[at]uni-due.de)

Universität Duisburg-Essen

Abstract: The transport of chondrules in protoplanetary disks is still not well understood. Photophoresis has been proposed as an efficient transport mechanism, as the temperature and pressure of protoplanetary disks offer the perfect environment for this mechanism. Photophoresis is based on a temperature gradient within a particle and the interaction between the particle and the surrounding gas. This leads to a net force on the particle, directed along the temperature gradient. In protpoplanetary disks direct stellar radiation and/or thermal radiation from temperature fluctuations can induce such temperature gradients into chondrules or their precursors.
Experiments on photophoresis were limited to timescales of a few seconds, as microgravity is needed and experiments were only performed at the Drop Tower Bremen. The temperature gradient within the millimeter sized particle needs longer timescales to reach a static state (about 1 minute). I will present an experimental setup for a sounding rocket experiment, dedicated to study the photophoretic force on chondrules and its evolution over a timescale of a few minutes. With this experimental setup the temperature gradient in the chondrules will reach a static state, so the results can be applied directly to protoplanetary disks.

Influence of snow lines on the formation of dust traps in protoplanetary disks

Vericel, Arnaud (arnaud.vericel[at]etu.univ-lyon1.fr)

Centre de Recherche Astrophysique de Lyon

Abstract: Statistics show that every star in our Galaxy has at least one orbiting planet, which implies that planet formation is a common process in protoplanetary disks. Theoretically, formation of planetesimals is still hard to achieve. On the one hand, we understand that dust can grow from grains to pebbles and from planetesimals to planets. On the other hand, the intermediate regime is still tricky to simulate due to the fragmentation and radial drift barriers. Taking into account the back-reaction from dust onto the gas has been proven to be very efficient to create pressure maxima (Gonzalez et al. 2017). This back-reaction creates a self-induced dust trap that allows grains to stop their drift and lower their relative velocities, which in turn is a powerful mechanism to ease grain growth. The dust fragmentation threshold is also affected by the presence of snow lines which separate the disk into regions with different sticking properties.

In this work, we investigate the effect of those snow lines on the formation and evolution of self-induced dust traps in global 3D SPH simulations.

Searching 22µm excess stars from WISE

Wu, Chao-Jian (chjwu[at]bao.ac.cn)

NAOC

Abstract: In this poster, we present more than 70 candidates showing an excess of infrared at 22µm from WISE and Hipparcos and 10 FGK 22µm excess candidates from WISE and LAMOST DR2.

The effect of photoevaporation on gas and dust evolution in externally irradiated protoplanetary disks

Yamakawa, Akihisa (yamakawa.a[at]geo.titech.ac.jp)

Tokyo Institute of Technology

Abstract: Gas in protoplanetary disks is thought to disperse through viscous accretion and photoevaporation processes, which affects the dust evolution as well. It is observationally suggested that many star and planetary systems are formed in young star clusters in which intense radiation field from nearby massive star(s) is significant.
In this work we calculate surface density evolution of gas and dust in protoplanetary disks considering photoevaporation by external irradiation from a nearby massive star in addition to viscous accretion toward the central star, using a wide range of parameters, such as size of dust grains and external irradiation.
We compare our numerical results and observations of protoplanetary disks in the Trapezium Cluster in the Orion Nebula by HST and ALMA, and then make constraint on physical parameters of the gas and dust in the disks.