
**ABSTRACT BOOKLET**

(authors in alphabetical order)

**Péter Ábrahám: Mid-infrared variability of young stellar objects: implications for inner disk structure**

Circumstellar disks around pre-main sequence stars are not only more structured than thought before, but also subject to rapid structural and compositional changes. I will review multi-epoch mid-infrared observations, which demonstrate that the thermal emission of the inner disks changes on annual/decadal timescales. I will also present a 10 μm interferometric monitoring of the T Tauri star DG Tau, which reveals different levels of variability in the innermost 5 au and in the rest of the inner disk. We consider two possible explanations for the observed flux changes: changing irradiation by the central source and changing scale height of the inner disk. Both scenarios may have strong impact on the initial conditions of terrestrial planet formation.

**Edwin Bergin: Tracing the Ingredients of Habitable Worlds**

In this talk I will trace the ingredients of habitable worlds, specifically compounds bearing key elements H, O, C, and N from their implantation into icy rocks in the early stages of planet formation to the fate of these carriers during the final stages of planetary assembly. First I will emphasize new breakthroughs in our understanding brought about by ALMA. Thus, I will present new data illustrating the presence of rings of hydrocarbon emission within disks surrounding two nearby young stars. We suggest that these rings are likely a common chemical feature that hint at radial gradients in the gas phase C/O content that will likely be imprinted within the atmospheres of forming gas giants. I will also present a new detection of optically thin tracer that provides the first glimpse of the physical conditions of the midplane gas from 5 – 17 AU in the nearest protoplanetary disk. If time allows we will present results from a study combining experts in astrochemistry, geophysics, and planetary science where we use the C/N ratio as a monitor of the delivery of key ingredients of life to nascent terrestrial worlds. Thus I will outline our knowledge about carbon and nitrogen in the Earth and discuss the potential reservoirs available to supply needed C and N to a young-forming planet. We will use this information to outline key relevant processes including kinetic chemistry during the early stages, thermal metamorphism in growing planetesimals, along with core formation and atmospheric loss during planetary assembly. The stochastic nature of these processes hints that the surface/atmospheric abundances of biosphere-essential materials will likely be variable.

**Til Birnstiel: The Long Way From Dust to Planetesimals**

Solids in planet forming disks are inherited from the interstellar medium: dust particles at most a micrometer in size. Circumstellar disks are the environments where these particles need to grow at least 40 orders of magnitude in mass. Our understanding of this growth process is far from complete, with different physics seemingly posing obstacles at various stages along the way. Still, the ubiquity of planets in our galaxy suggests that planet formation is a robust mechanism.
This talk focuses on the early stages of planet formation, the growth of small dust grains towards the gravitationally bound "planetesimals", the building blocks of planets. I will introduce the key physics involved in the growth processes and discuss how they are expected to shape the global behavior of the solid content of disks. I will discuss how these effects are substantially affecting the further evolution of both the disk and the planets that form in them and will conclude by reviewing some of the recent observational advances in the field that foreshadow an exciting future of the field of planet formation and its chemistry.

**Til Birnstiel/Hubert Klarh: The Heidelberg planetesimal factory**

**Bertram Bitsch: Giant planet formation via pebble accretion**

Planetary cores of a few Earth masses can attract a gaseous envelope during the gas phase of the disc and evolve into giant planets. However, during the growth phase of the planetary core, the protoplanet migrates through the protoplanetary disc and loses a large fraction of its semi-major axis. Inward migration all the way to the central star can be avoided, if the planetary core forms far enough away. However, at large orbital distances, the core formation time-scale via planetesimal accretion is much longer than the lifetime of the protoplanetary disc. This time-scale problem can be avoided when pebbles are accreted instead of planetesimals (Ormel & Klahr, 2010; Lambrechts & Johansen 2012). Pebbles can be accreted efficiently, because they feel a headwind from the gas robbing them of angular momentum, which allows accretion of pebbles from the entire Hill sphere, accelerating the growth of planetary cores significantly. This allows the formation of planetary cores at large orbital distances (Lambrechts & Johansen 2014). But as the planet grows, it changes the structure of the surrounding gas disc. In particular the gas outside of the planet's orbit is accelerated towards super Keplerian speeds, stopping the flow of pebbles onto the planet. The planet can now undergo gas accretion, where it eventually enters runaway gas accretion to form a giant planet (Lambrechts et al. 2014). During this growth phase the planet migrates through the evolving protoplanetary disc (Bitsch et al. 2105b). I will show here that simulations of giant planet growth via pebble accretion are consistent with the orbital distance - mass distribution and metallicity of observed giant planets.

**Mickael Bonnefoy: Characterization of planetary systems during the SHINE/SPHERE direct imaging survey**

The SPHERE high-contrast imager has entered operation in May 2014 at the VLT. The SHINE survey conducted on the instrument aims to characterize the giant planet population beyond 5 AU around 400–500 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 the orbital, physical, and chemical properties of the companions, and in turn set constraints on the formation mode(s) 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, Beta Pic b, 51 Eri b, etc), as well as some benchmark brown dwarf companions. I will present our results and detail how they change our view of the architecture and formation history of those systems.

**Gianni Cataldi: Searching for biosignatures in exoplanetary impact ejecta**

With the number of confirmed rocky exoplanets in the habitable zone increasing steadily, their characterisation and the search for exoplanetary biospheres is becoming an increasingly urgent issue in astrobiology. To date, most efforts have concentrated on the study of biosignatures in exoplanetary atmospheres. Instead, we aim to investigate the possibility of characterising an exoplanet (habitability, geology, presence of life etc.) by studying material ejected from the surface during an impact event. For a given impact event, we estimate the escaping mass and assess its subsequent collisional evolution in a circumstellar orbit ("debris disk"). We calculate the fractional luminosity of the dust as a function of time after the impact event and study its detectability with current and future instrumentation. We consider the possibility to constrain the dust composition, giving information on the geology of the exoplanet or the presence of a biosphere. Despite considerable difficulties (small dust masses, noise such as exozodiacal dust etc.), studying dusty material ejected from an exoplanetary surface might become an interesting complement to atmospheric studies in the future.

**Giovanni Dipierro: Two mechanism for gap opening in dusty discs: Application to HL Tau**

Recent spectacular spatially resolved observations of gaps and ring-like structures in nearby dusty protoplanetary discs have revived interest in studying gap-opening mechanisms. In this talk I'll describe the two distinct physical mechanisms for dust gap opening by embedded planets in protoplanetary discs: I) A mechanism where low mass planets, that do not disturb the gas, open gaps in dust by tidal torques assisted by drag in the inner disc, but resisted by drag in the outer disc; and II) The usual, drag assisted, mechanism where higher mass planets create pressure maxima in the gas disc which the drag torque then acts to evacuate further in the dust.
Starting from our numerical evidences, we derive a grain size-dependent criterion for dust gap opening in viscous protoplanetary discs by revisiting the theory of dust drift to include disc-planet tidal interactions and viscous forces. We finally apply our findings to the case of the HL Tau protoplanetary discs. We perform global, three dimensional dusty smoothed particle hydrodynamics calculations of multiple planets embedded in dust/gas discs which successfully reproduce most of the structures seen in the ALMA image. We find a best match to the observations using three embedded planets with masses of 0.08, 0.1 and 0.5 $M_J$ in the three main gaps observed by ALMA, though there remain uncertainties in the exact planet masses from the disc model.

**Christian Eistrup: The importance of chemical evolution for setting the volatile composition in planet-forming regions**

Disk midplanes are the birthplaces of planets, and the conditions in the midplanes influence the chemical composition of the material from which planets end up forming. The chemical composition of gases and ices in the midplane are usually determined by the positions of icelines in planet formation and population synthesis models, and chemical reactions are usually not considered. But could chemical reactions cause chemical evolution that changes the abundances of important volatile species? I will present results from chemical kinetic simulations for volatile material in a disk midplane, and discuss the effects of chemical evolution under different physical and chemical assumptions. The implications for planet and comet compositions will be addressed.

**Stéphane Guilloteau: Small disks observed with ALMA**

**Stéphane Guilloteau /Anne Dutrey: Planet formation in young multiple systems**

**Christiane Helling: Diverse clouds in chemically diverse planetary atmospheres**

The ensemble of Extrasolar planets is extremely diverse. Recent discoveries discuss carbon-rich planets and add silicate-rich lava planets to the ensemble of planets with an oxygen-dominated atmosphere chemistry. I will discuss our progress in developing an unified cloud model applicable to atmospheres that change their chemical composition from oxygen to carbon rich, for example during disk evolution or due to atmospheric element depletion/enrichment processes. Clouds are also sources of charge and discharge processes which will influence the local atmosphere chemically and electrically. Different charge/discharge processes act under different local conditions leading to the built-up of a partially ionised gas inside the atmosphere opening new windows of exploration. Solar system observations can be used as first guide and I will show our recent work on lighting statistics with view on extrasolar planets.

**Michiel Hogerheijde: DCO+, DCN, N2D+, and H2CO in the disk of HD163296**

Deuterated species trace cold material in planet-forming disks, and deuteration degrees can be linked to the radial origin of major volatile reservoirs. Especially DCO+ has also been suggested as a tracer of the CO snow line. With ALMA, we have detected the emission of DCO+, DCN, and N2D+ in the planet forming disk around HD163296. We find that DCO+ is not uniquely associated with the CO snow line, but rather extends across much of the disk. In contrast, DCN is concentrated in the inner disk while N2D+ forms a ring in the outer disk. These latter two species reflect two deuteration pathways, operating at different temperatures. DCO+ is seen to form through both pathways. Our data also revealed H2CO emission to extend far across the disk, with an additional reservoir in the outer disk that is likely explained by photodesorption from ices, hinting at a reduction of dust content in the outer disk. Together, these observations illustrate how different molecules trace distinct aspects of the disk.

**Akimasa Kataoka: Dust coagulation with porosity evolution**

We have revealed the overall porosity evolution from micron-sized dust grains to km-sized planetesimals; dust grains form extremely porous dust aggregates where the filling factor is $\sim 10^{-4}$, and then they are compressed by their collisions, the disk gas, and their self-gravity. The mass and porosity of the final product is consistent with the comets, which are believed to be the remnants of planetesimals. Then, we have further performed coagulation simulations including the porosity evolution. We have found that planetesimals can form inside of ~10 AU avoiding the radial drift barrier. In addition, we have calculated the opacity evolution of porous dust aggregates and found that the radial drift barrier at outer radius is still a severe problem.

**Ákos Kereszturi: Heat sources in early planetesimals**

The formation conditions and early evolution of small planetesimals are highly influenced by the possible heat sources, changing their mineral composition. Both the observed signatures of these heat sources (by laboratory analyis of meteorites) and the theoretical possibilites for their origin and consequences are investigated at CSFK. This presentation will overview the ongoing activities here, focusing on early alterations of chondrites, chemical modelling of hydration driven heating, and isotopic studies aimed at discovering the stellar origin of the main radioactive heat source, the aluminium-26 nucleus.

**Csaba Kiss: Collision history of the Kuiper belt and binary Kuiper belt objects**

Theories of satellite formation in the Kuiper belt usually involve collisions as a natural source of friction. While in some cases catastrophic impacts may have played a role (e.g. the Haumea collisional family), in most cases the formation of binaries should have occurred through low velocity encounters. Although collisions in the Kuiper belt are very rare today, the observed properties of binary systems may help us to unravel the conditions at the early stages of debris disk evolution when multiple system are thought to have formed. In this presentation I review the main theories and show how the present knowledge and future observations can constrain the formation and evolution scenarios of binary and multiple systems in the trans-Neptunian region.

**Ágnes Kóspál: Episodic accretion as time-dependent initial condition for planet-formation**

Perhaps the most fundamental question of star and planet formation is the link between the properties of the circumstellar disk around a forming protostar and the properties of the planets formed in the disk. Based on the considerable knowledge accumulated separately on circumstellar disks and exoplanets in the last decades, the disk–planet connection will inevitably be in the forefront of star formation research in the coming years. In my talk, I will emphasize that there is a less studied but possibly equally important aspect of disk complexity that lies in the time domain: time-variable (episodic) accretion and the effect of accretion outbursts on the disk. Using the advanced instrumentation and numerical simulations, we can address the following questions: How does the mass accretion proceed in realistic, structured, non-axisymmetric disks? What physical mechanisms explain the accretion-driven eruptions? What is the (physical, chemical, mineralogical) effect of the eruptions on the disk?

**Quentin Kral: Evolution of gas in debris discs, towards understanding observations**

A non-negligible quantity of gas has been discovered in an increasing number of debris disc systems. ALMA high sensitivity and high resolution are changing our perception of the gaseous component of debris discs as CO is discovered in systems where it should be rapidly photodissociated. It implies that there is a replenishment mechanism and that the observed gas is secondary. Atomic gas discs (carbon, oxygen and metals) are also observed in some systems. Can we explain all gas observations at once? Can we understand why CO is observed in some systems whilst only CII or OI is observed in others? Among others, these questions will be addressed in this talk as a new self-consistent gas evolution scenario is proposed to explain gas observations.

**Sebastian Krijt: Vertical transport of dust, ice, and water in planet-forming regions**

Protoplanetary disks are dynamical environments and material (i.e., gas, dust, ice) is continuously being exchanged between the dense midplane (where planet formation takes place) and the disk's upper layers (where UV photons can easily penetrate). Understanding the efficiency of this transport is key when studying the chemical composition of the solids that are coagulating in the midplane, or when interpreting molecular line emission from the disk atmosphere. For example, large dust grains – incapable of leaving the disk midplane – can sequester important volatiles (e.g., water, CO) if such species can efficiently freeze out onto those grains. By modeling dust coagulation/fragmentation, dust dynamics (settling & turbulent diffusion), simple gas-grain chemistry (sublimation, condensation, and photo-desorption), and vapor diffusion simultaneously, we build a coherent picture of how water and dust co-evolve in the region just outside the radial snowline, constraining both the ice-to-rock ratio of the planetary building blocks in the midplane, as well as the water vapor abundance higher up in the disk.

**Sebastian Marino: ALMA observations of HD 181327 and Eta Corvi debris discs**

In this talk I will present recent ALMA observations of two systems with debris discs. We detect for the first time CO gas in a debris disc around a solar-type star, HD 181327 (~20 Myr old). We find that the gas in this system is of secondary origin, i.e. released by exocomets in the disc, and we probe the CO/rock exocometary composition in the disc, finding it matches with Solar System comets. The second system is Eta Corvi, 1.4 Gyr old, which has an outer belt at 150 AU and a hot dust component located within 3 AU. The latter needs to be replenished from material farther out, e.g. in a scenario similar to the Late Heavy Bombardment in the Solar System. With new ALMA observations we constrained the structure of its outer belt to look for features that can hint at what mechanism that is feeding the hot dust.

**Luca Matrà: New ALMA observations of the beta Pictoris disk: exocometary gas and dust from outward migration of beta Pic c**

Recent ALMA observations unveiled the clumpy structure of CO and dust the beta Pictoris disk, a feature that has been attributed to secondary production due to either a giant impact or resonant sweeping with an outward migrating beta Pic c planet. In this talk, I will present new ALMA observations of the disk, at an improved spatial and spectral resolution, which allows us to rule out the giant impact scenario, favouring the presence of two asymmetric clumps in the disk caused by interactions with putative beta Pictoris c. I will then discuss how this dynamical picture may fit the dust disk structure observed across the SED and present an updated view on the architecture of this planetary system.

Our model (Kral et al. 2016) proposes that carbon and oxygen within debris discs are created due to photodissociation of CO, which is itself created from the debris belt (due to grain-grain collisions or photodesorption). The evolution of carbon and oxygen atoms is modelled as viscous spreading, with viscosity parameterised using an α model. The temperature, ionisation fraction and population levels of carbon are followed with a PDR model called Cloudy, which is coupled to the dynamical viscous α model. Only carbon gets ionised due to its lower ionisation potential than oxygen. The carbon gas disc can end up with a high ionisation fraction due to strong FUV radiation field. A high ionisation fraction means that the magnetorotational instability (MRI) could be very active so that α could be very high (Kral & Latter 2016). Our model is tested on the β Pictoris system. This new gas evolution model fits the carbon, oxygen and CO observations in β Pic and provides predictions for the amount of hydrogen in the system and the ratio of water to CO in planetesimals that are part of the debris belt. Overall, this new study provides a self-consistent scenario that might be at play in all debris discs. I will finish by explaining what sets the abundances of the different atoms and molecules and where to look for to observe a particular species (CO, CI, CII, ...). I will also give predictions as for what upcoming missions (SPICA, FIRS) could detect in the future.

**Michiel Min: Results from SPHERE observations of circumstellar disks**

**Michiel Min: The ice reservoir and snow lines in protoplanetary disks**

Ice is an important component in the planet formation process for two main reasons; 1) it increases the solid surface density and the grain sticking efficiency and strength, and 2) it changes the gas C/O ratio which might be traceable in mature planetary atmospheres. For testing planet formation theories it is therefore important to know where ice is present in the planet forming disk and in what abundances. We present a robust estimate of the water ice content in the disk surrounding the Herbig star HD142527. Also I will discuss the location of the water and CO snowlines in protoplanetary disks as a function of disk parameters and evolutionary status.

**Attila Moór: Self-stirring in young spatially resolved debris disks**

Debris disks are composed of secondary dust grains that are thought to be stem from collisional erosion of larger bodies. To make collisions between planetesimals destructive, it is necessary to dynamically excite (stir) the planetesimals' orbits. According to the most commonly proposed self-stirring mechanism, ensembles of Pluto-sized bodies within the disk itself can stir the population of smaller neighbouring planetesimals so that their collisions lead to fragmentation. The dramatic increase of spatially resolved debris disks in the last few years allows us to confront the predictions of the self-stirring model with the observed disk parameters. Using a sample of resolved debris disks around members of nearby young moving groups and associations we found a significant fraction of these young systems to be incompatible with the classic self-stirring scenario. For these cases we examine alternative explanations.

**Christoph Mordasini: Linking the Formation History of Planets with their Spectrum**

Despite the enormous increase in observational data on extrasolar planets in the past two decades, many aspects of their formation are still not well understood to date. In particular, the formation mechanism of the oldest known class of exoplanets, the hot Jupiters like 51 Peg b, is still not clear. A new approach to disentangle different formation mechanisms might be offered by the spectroscopy of planetary atmospheres. This is because the spectrum represent a window into the composition of a planet. In my talk I will show how it might be possible to find the traces of the planetary formation history in the spectrum of an exoplanet, based on the results of a planet formation and evolution model and assumptions about the refractive and volatile composition of the planetary building blocks. In particular, different migration mechanisms (disk migration versus migration due to the Kozai mechanism or planet-planet scattering) might lead to distinct imprints, which is very important from a planet formation point of view. To this end we simulate a planet's formation using a global planet formation model, tracing the material abundances in the accreted material. We then consider the planet's subsequent evolution, evolving the radius, internal, and atmospheric structure to an age of several Gyrs when exoplanets are typically observed spectroscopically. Using an atmospheric radiative transfer and chemistry model we finally calculate the spectrum of the planets at this age. With this, we can study differences in the spectra resulting from, e.g., different C/O ratios due to different migration histories. It is then discussed whether these imprints can be observed with current and future instruments like JWST, and which steps need to be taken in the theoretical models to better understand the link between formation and spectra. In the final part of my talk I will generalize these results and consider them from a population-wide statistical point of view.

**Dagmara Oszkiewicz: Testing the formation paradigm of differentiated planetesimals in the Solar System**

Planetesimals were the first large solid bodies that formed in the Solar System. Laboratory studies of iron, stony-iron and achondritic meteorites indicate that differentiated (into iron core, silicate mantle and crust) planetesimals were once common in the Solar System. In particular studies of iron meteorites suggest as many as 100 different differentiated planetesimals. The observational evidence among asteroids is however missing. This mismatch between the meteoritic evidence and the insufficient number of achondritic and iron asteroids led to formulation of a new paradigm: planetesimals formed not in the main asteroid belt as previously thought, but closer to the Sun, in the terrestrial planet region; they were then collisionally disrupted and scattered into the asteroid belt, where they continued to dynamically evolve for billions of years. This hypothetical theory has not been thoroughly tested yet. In this study we observationally test the implications of this hypothesis to the current distribution of asteroids in the main asteroid belt. More specifically, if the hypothesis is true, we expect to see scattered distribution of V-type asteroids thought the main asteroid belt. The V-type asteroids originating from multiple parent bodies should also be more plentiful in the inner main asteroid belt then in the mid and outer main belt. Most V-type asteroids in the inner main belt are associated with the planetesimal (4) Vesta complicating the task of separating out asteroids originating from other planetesimals and determining the underlying distribution. Determining their rotational and dynamical properties (including the Yarkovsky drift and numerical simulations) allows us to recognize non-Vestoids and resolve the underlying distribution. We will further constrain the formation location of the differentiated planetesimals. Establishing this early stages of Solar System evolution is crucial to comprehending the next evolutionary phases.

**Adriana Pohl: Millimeter-wave polarization of transition disks due to dust scattering**

We study a new mechanism of millimeter-wave polarization of protoplanetary disks, the dust self-scattering. It considers that thermal emission of the disk itself is scattered off large dust grains. Millimeter polarization is most efficient for a certain interval of intermediate (few hundred micron) grain sizes. Therefore, polarization observations can be used as an independent method from the spectral index to probe grain growth in disks and give constraints on the grain size distribution. In this context we study the dust filtration scenario proposed for transition disks by predicting the polarization at ALMA bands due to scattered thermal emission, based on planet-disk interaction simulations and self-consistent dust growth models. With radiative transfer calculations we investigate the polarization structure and how it is linked to the disk inclination, dust size evolution, planet position and observing wavelength. We find that the polarization pattern of a disk hosting a planetary gap after 1 Myr of dust evolution shows a distinctive three ring structure, where the two inner rings are located just beyond the gap edges. For inclined disks the polarization degree is high enough to be detected with ALMA.

**Zsolt Regály: Vortex-aided planet formation**

Core-accretion theory can explain the formation of both terrestrial and giant planets. According to this scenario, the dust particles coagulate and form planetesimals, which is followed by gravity-assisted collisions to form terrestrial planets and cores of giant planets. However, this theory still has some open questions, which need to be answered to better understand the formation of extrasolar planetary systems. Our four year research project "Novel approach to planet formation" (financed by the Hungarian Scientific Research Fund) addresses the unsolved problems of core-accretion by a novel concept, the planet formation in anticyclonic vortices developed at the outer edge of discs's accretionally inactive zone. The vortex-aided planet formation scenario amis to solve the problems related to the formation of planetesimals, too fast planetary migration, and too slow formation of the cores of giant planets. We will investigate several aspects of our concept such as vortex formation, planet-disk interaction, planetary accretion, etc. by means of 2D and 3D global hydrodynamic and N-body simulations. In my talk a short summary of the planned research and some preliminary results will be presented.

**Maxime Ruaud: Chemistry of cold dense cores and initial conditions for disks chemistry**

Protoplanetary disks are made of interstellar matter, which composition (of the gas and the dust) evolves continuously from the most diffuse parts of the interstellar medium up to the formation of disks. The time scales of star formation are short enough so that the chemistry never reaches steady state, in particular when considering the interactions between the gas and the dust. In other words, the chemical composition in disks may depend on the chemical composition of the material it is made of.
Over the years, complex numerical models have been developed to simulate the chemistry at work in the interstellar medium, taking into account all identified processes and in particular the interaction of the gas and the interstellar dust as well as the formation of molecules at the surface of these grains. These models are typically tested against observations in cold cores since these astrophysical objects are assumed to be physically simple. The same models are then applied to protoplanetary disks where the strong gradients of density, temperature and UV illumination (both vertically and horizontally) represent challenges for these models.
In this talk, I will present results obtained with a state-of-the-art gas-grain chemical model under cold dense cores conditions. I will discuss the interplay between the gas phase and the solid-state chemistry on the formation of simple ice mantles but also on the formation of complex organic molecules. I will show why sophisticated gas-grain chemical models are mandatory to study the chemistry at work in disks. I will also discuss the importance of the history from diffuse clouds to cold dense cores on the molecular composition of the latter.

**Dmitry Semenov: The role of surface chemistry and non-LTE in methanol line excitation in TW Hya**

The first detection of gas-phase methanol in TW Hya with ALMA was reported by Walsh et al. (2016). The methanol emission has a ring-like morphology, with a peak at ~30–50 au and an inferred column density of ~3–6 x $10^{12}$ $cm^{-2}$. To interpret these data, we used a thermochemical model of TW Hya disk coupled with a gas-grain chemical model including laboratory-motivated diffusivities of surface molecules. Based on this model, we performed 3D radiative transfer calculations with LIME and ALMA simulations with CASA. We found that our model reproduces the observations surprisingly well. The modeled $CH_3OH$ emission appears as a ring with a radius of ~60 au. Synthetic and observed line flux densities differ by only a factor of few, with main uncertainty originating from the surface chemistry and collisional rate data. The synthetic $CH_3OH$ spectra calculated at the assumption of LTE can differ by up to a factor of 3.5 from the non-LTE spectra. The computed methanol abundances are sensitive to the initial abundances and hence retain chemical 'memory' of the pre-disk evolutionary stage, which should be taken into account.

**Aurora Sicilia-Aguilar: Studying disks through episodic accretion and variability: exploring the time dimension**

Episodic accretion and changes in the accretion rate are one of the classical mechanisms leading to photometric and spectroscopic variability in young stars. While there is still much discussion about the role of variable accretion in the evolution of the star, about the number of stars with accretion variability, and about the mechanisms behind the changes in the accretion rate, the phenomenon is enthralling.
Accretion variability offers us the possibility of directly "experimenting" with young stars: Variable accretion allows us to witness how the system react when the flow of matter increases onto the star. Increased accretion affects the stellar luminosity and contributes to dust grain processing. The accretion channels also become easier to trace and observe, and the changes can be followed on real time (and on human timescales).
Nevertheless, most objects do not seem to have large changes in their accretion rates, and part of the frequent changes in emission line profiles and other accretion tracers may be caused by stellar rotation. Rotation-induced variability offers us access to explore the very small scales of the circumstellar environment, beyond the resolution of modern interferometry. Combined with time-resolved data, stellar rotation allows us to perform "accretion column tomography", reconstructing a 3-dimensional picture of the stellar environment and accretion columns around the star. Accretion-related metallic lines, which span a large range of critical temperatures and densities, are particularly useful to trace the gas properties very close to the star.
I will discuss how time-resolved spectroscopy can help us to unveil details of accreting, variable and non-variable stars, to explore the causes of variable accretion, and to help us understanding the early evolution of stars – and their disks.

**Judit Szulágyi: How the circumplanetary disk affects the observability of the young, accreting planets?**

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. Even though there is no direct observation of this disk yet, the trace of hot gas around the planet has already been detected by H-alpha emission and extended thermal emission via direct imaging technique. To interpret these observations and to prepare for future ones, simulations of circumplanetary disks has to be carried out to unveil their basic characteristics (mass, temperature, entropy, luminosity, accretion rate). In my talk, I will present the newest radiative hydrodynamic simulations of circumplanetary disks, discuss how we can detect them, and how they influence the planets' properties derived from observations.

**Richard Teague: Surface Density Perturbations in TW Hya Traced by Molecular Emission**

I will present ALMA Cycle 2 observations of TW Hya, of CO (2–1), CN (2–1) and CS (5–4). The CS emission shows a dip-like feature at 80 au, coincident with the dips in emission seen in scattered light (Debes et al. 2013, van Boekel et al. submitted). A similar position and morphology of the features suggests a common origin for both features. We explore the impact surface density perturbations make on molecular emission and demonstrate that a fully depleted cavity would produce a similar morphology in the radial intensity profile. However, with CO and CN emission unaffected, this poses strong constraints on the depth of the gap. This indicates the power of molecular line emission in tracing surface density perturbations and makes it a powerful complement to the high-resolution continuum images of disk midplanes.

**Allona Vazan: Composition and the mass-radius relation of exoplanets**

For many of the detected exoplanets measurements of both mass and radius are available. The relation between the mass and radius provides information about the composition of the planet. However, the radius-mass relation and its time dependency are affected substantially by the thermal evolution of the planet. Often planets are modeled under the assumption that they are adiabatic, convective and homogeneously mixed, but this assumption is made mainly for simplicity, and may not be the case. We simulated planetary evolution and focused on various influences of composition on the heat and material transports. We show that planetary evolution depends on initial composition and its distribution, discuss whether the internal structure changes with time, and how it affects evolution and the observed parameters. This study emphasises the importance of coupling planet formation, evolution, and internal structure self consistently.

**Catherine Walsh: Ice chemistry during the epoch of planet formation**

Forming planets sweep up their constituent ingredients (dust, gas, and ice) within the dense midplanes of protoplanetary disks around young stars. For gas- and ice-giants, the molecular composition of the resulting planetary atmosphere will depend on the relative contributions of carbon-, oxygen-, and nitrogen-bearing volatiles, and whether those volatiles are predominantly in the gas phase or locked up in icy planetesimals. Recent high-angular resolution observations of molecules in protoplanetary disks around nearby young stars have shown that disk midplane composition is governed by chemical and/or physical processes other than condensation (or freezeout) and sublimation (or desorption). An example of this is the depletion of gas-phase CO within its anticipated snowline (~ 30 AU) in the disk around TW Hya (Nomura, et al. 2016; Schwarz et al. 2016). I will present results from recent simulations and observations of protoplanetary disks on the volatile composition (gas and ice) during the epoch of planet formation (e.g., Walsh et al. 2015,2016; Drozdovskaya et al. 2016). I will discuss the effects of chemical evolution on the resulting elemental ratios (e.g. C/O) in the planet-building material during the disk formation process and in situ (i.e., within the protoplanetary disk once formed), and whether it is possible for the composition of planet-building material in nearby disks to be elucidated from existing or future observations. I will also address the origin of planet-building volatiles within disk midplanes and the evidence for and against (mainly in the cometary record) a significant degree of inheritance of icy material from the natal molecular cloud.

**Benjamin P. Weiss: Lifetime of the solar nebula constrained by meteorite paleomagnetism**

A key stage in planet formation is the evolution of a gaseous and magnetized solar nebula. However, the lifetime of the nebula is poorly constrained. Here we present analyses of the remanent magnetization in three groups of meteorites demonstrating that they formed in no detectable magnetic field. We find that the magnetic field at three locations in the midplane of the solar nebula had declined to $< 0.6\ \mu T$ at $4563.5 \pm 0.1$ million years (My) ago, just ~4 My after solar system formation. This indicates that the solar nebula field, and likely the nebular gas, had dispersed by this time. This sets the timescale for formation of the gas giants and disk-driven planet migration and supports formation of younger chondrules by planetesimal collisions.

**Mark Wyatt: How to design a planetary system for different scattering outcomes**

The structure of exoplanetary systems, that is both the dynamical architectures of their planetary systems and the distribution of debris within them, is strongly influenced by interactions between the various components. This talk will consider the dynamics of scattering of planetesimals or planetary embryos by a planet on a circumstellar orbit. Scattering is one type of interaction, the others being secular and resonant perturbations, which dominates the evolution in many situations. Six regions can be identified on the planet mass versus semimajor axis parameter space, classified according to the dominant outcome for the scattered objects: ejected, accreted, remaining, escaping, Oort Cloud, depleted Oort Cloud. These outcomes are used to consider planetary system architectures which maximise the observability of specific signatures, given that signatures should be detected first around systems with optimal architectures (if such systems exist in nature). For example, this analysis shows how there is a sweet spot for detecting giant impact debris, identifies three principles that maximise cometary influx from an exo-Kuiper belt, and can be used to consider the possibility of detecting scattered disk-like populations. Application to recent ALMA imaging of eta Corvi is used to illustrate how debris disk observations can be used to constrain an unseen planetary system.