Talk Abstracts

Monday 9th

Constraining the population of planets in debris disc systems with gaps and astrometric accelerations using JWST

Raphaël Bendahan-West

Disc Structures 1: 14:00-14:12

Combining the insights from ALMA observations of debris discs and the enhanced sensitivity of JWST presents an opportunity to advance our understanding of planetary systems. In the last 5 years, ALMA has revealed substructures within debris discs, hinting at planetary presence, yet the direct detection of these putative planets remains elusive. Now with JWST's capabilities, we have an unprecedented opportunity to detect the population of planets at 10s of au currently inferred by ALMA.

While only three debris discs have shown gaps so far, we are becoming more aware that these gaps might be common. As seen in the Solar System, the presence of gaps hints towards the presence of planets. These gaps could either be carved by planets in situ or by inner planets exercising secular resonances.

In this talk, I will present JWST Cycle 1 MIRI 11um observations focused on the three known debris discs with gaps: HD107146, HD92945, HD206893. I will show how these observations combined with astrometric accelerations allow us to constrain the population of planets in the inner regions of these systems, at the disc inner edge and in the gap location, ultimately evaluating the degenerate scenarios proposed as the origin of these gaps.

Talk Abstracts

The Inner Regions of Protoplanetary Discs

Isabelle Codron

Disc Structures 1: 14:12-14:24

In the last 10 years, protoplanetary disc observations have revealed a wide variety of substructures including gaps, asymmetries and misalignments/warps that are often interpreted as signposts of planet formation. These enormous advancements thanks to instruments like SPHERE and ALMA have, however, been very biased towards the outer regions of protoplanetary discs. In contrast, we still know little about the inner region of discs even though constraining their structure and evolution is fundamental to understanding how and when the ubiquitous close-in planets form. This knowledge gap is quickly being filled thanks to optical interferometry instruments such as MIRC-X at CHARA, and PIONIER and GRAVITY at the VLTI, which allow us to resolve these small scales. In this talk, I will present new MIRC-X and PIONIER observations of HD143006, a disc known to have shadows and asymmetries in its outer disk. My observations resolve and constrain the orientation of this system's inner disk, revealing a best-fit misalignment of the inner/outer disc of 45° and thus confirming the origin of the shadows seen in scattered light images. I will also present the first detailed characterisation of the inner regions of 5 further Herbig discs from GRAVITY data, as well as preliminary results on the origin of the asymmetries seen in their non-zero closure phases.

Talk Abstracts

How do planets carve smooth gaps in inviscid discs?

Amelia Cordwell

Disc Structures 1: 14:24-14:36

Gaps and rings are near ubiquitous in observations of protoplanetary discs and a promising cause for them may be the gravitational interaction of planets with the disc. However, in inviscid discs theory predicts no evolution of surface density due to planet-driven shocks in the co-orbital region near the planet, despite this always occurring in inviscid simulations. As protoplanetary discs are now known to have very low levels of viscosity, this means we are unable to understand the initial stages of gap evolution that are visible in young discs like HL Tauri. I will show how an often-overlooked term in the angular momentum balance caused by the time-dependence of specific angular momentum of gas parcels - the ldot term - drives this discrepancy and present a new model connecting the angular momentum deposition of a planet driven wave to surface density evolution both near and far from the planet. This simple model is capable of predicting the initial stages of gap evolution with very good concordance to simulations. I will also discuss the implications that this has for observations through dust dynamics and gap opening timescales. Our study brings to focus the importance of explicitly including the ldot term when modeling the planet-driven evolution of protoplanetary discs.

Sandwich Planet Formation in action

Maria de Juan Ovelar

Disc Structures 1: 14:36-14:48

Sandwiched Planet Formation is a mechanism of planet formation proposed to limit the solid mass available in regions of protoplanetary discs (PPDs) between two planets (rings) via subsequent dust trapping. The mass of any planet that then might form in these regions would be restricted, allowing for configurations of planetary systems where relatively small planets are caught between two larger ones, as often seen in observations of planetary systems. Looking in detail at the distribution of dust in these particular dust traps we find that there are significant features such as an unusually large dust to gas ratio (d/g>1 in some cases), or the different morphologies of the distribution corresponding to different dust sizes, that might shed light onto the physical processes of planetesimal formation that might be taking place. In this talk we will explore this issue using multi-wavelength synthetic imaging observations of PPDs featuring ring-like substructures caused by two planets. When combined, these are able to break up the distribution of gas and dust in its different components, revealing essential details about the conditions under which sandwiched planet formation occurs.

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UKI Discs

Talk Abstracts

How Planet-Induced Disc Morphology Encourages Planetesimal Growth

Amena Faruqi

Disc Structures 1: 14:48-15:00

Observations have shown that protoplanetary discs can display varied morphology, including features such as gaps and rings. One possible explanation for these features is a planet embedded in the disc, perturbing the dust and gas. If such a planet is migrating, the resulting perturbations produce gaps and rings that can differ in location, density, and size based on the planet's location. Given that these discs are believed to be the birthplace of planets, it is crucial to take into consideration how such perturbations to the density distribution of the disc may affect the planet formation process, particularly in the early stages when dust grains grow to pebble-sized bodies via pairwise collisions. It can be hypothesised that the enhanced density of dust in rings may lead to an accelerated growth rate, increasing the likelihood for additional planets to form. However, numerical models of protoplanetary discs often exclude the evolution of the size distribution of dust grains, due to the computationally expensive nature of the required calculations, so this is yet to be tested. In this talk, I will present my results, which use a version of FARGO3D capable of modelling collisional growth of dust grains, to investigate how the dust size distribution evolves in rings formed by a stationary or migrating planet and what this may tell us about sequential planet formation.

Talk Abstracts

Directly imaging massive planets sculpting the inner edges of debris discs with JWST-MIRI

Andrew James

Disc Structures 2: 15:30-15:42

Directly imaged debris discs can be a signpost in the darkness for finding exoplanets; those with sharp inner edges can be evidence for exoplanets, and can be responsible for sculpting these inner edges. All three targets in our JWST Cycle 1 proposal, HD202628, HD21997, and GJ14, have well-resolved ALMA imaging and all show evidence of having sharp inner edges. With the goal of utilising the deep mid-infrared sensitivity of the JWST-MIRI instrument, we used pre-launch performance estimates to customise our observations to be sensitive to sub-Jovian mass companions.
In this talk, I will present these MIRI coronagraphic observations at 11.4 microns with emphasis on the new detection parameter space we cover and the sensitives we reach utilising the streamlined python package SpaceKLIP. Although our results have shown no evidence for planets down to $\sim$ 1MJup in all cases, combined with other factors such as proper motion anomalies - which we are exploring in our JWST Cycle 2 proposal - we can place important constraints on the presence of any bodies that might be responsible for these sharp inner edges.

Talk Abstracts

Multi-Wavelength Analysis of HD 32297's Edge-on Debris Disk

Patricia Luppe

Disc Structures 2: 15:42-15:54

We present the multi-wavelength analysis of HD 32297's edge-on debris disk, a well-known gas-bearing debris disk orbiting a young A star. This system exhibits one of the largest infrared excesses observed among main-sequence stars. Our data include the first ALMA Band 10 (814 GHz) observation of a debris disk, showcasing the capability to explore a new regime of dust sizes at high resolution from ground-based observations.
We employ a multi-wavelength joint-modelling approach, incorporating high-resolution data from Bands 7, 8, and 10, with unprecedented resolution of up to 50 milliarcseconds (corresponding to 6.5 astronomical units). This methodology enables a comprehensive analysis of the disk's vertical structure and variations across different wavelengths.
The disk's exceptionally edge-on and well-resolved nature offers a unique test bed for dynamics.

Shadows and spiral arcs in the Protoplanetary Disc HD 139614

Katie Milsom

Disc Structures 2: 15:54-16:06

We present an analysis of multi-epoch scattered light images of HD 139614 taken using GPI and SPHERE. The scattered light observations of HD 139614 show various azimuthally asymmetric features such as a broad shadow across ~2/3 of the outer disc, an inner bright ring at ~100-160 mas, and three arc-like features. We find that two of the arc-like features around the disc may be spiral in nature, which could be the result of infalling material or buoyancy waves from a perturbing companion. We also find that the azimuthal brightness distribution of the inner ring shows temporal variability on the timescale of months. On this timescale it is unlikely that the variation is due Keplerian rotation of dust structures at the bright ring radius, but it is more likely due to changes in shadowing cause by a warp in the inner disc which may be induced by a companion. We present initial models of the temporal variation of warps induced by a companion by combining 1-d warp propagation theory with a fast ray-tracing code, enabling us to rapidly scan parameter space for observational signatures that may match our images.

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Talk Abstracts

Disc walls and fake vortices: crescent-shaped asymmetries in ALMA observations of protoplanetary discs

Álvaro Ribas

Disc Structures 2: 16:06-16:18

Crescent-shaped asymmetries are common in millimetre observations of protoplanetary discs and are usually interpreted as true overdensities due to vortices or companions. However, many of them appear on a single side of the major axis and are roughly symmetric about the minor axis, suggesting a geometric origin. In this talk, I will present our work interpreting such asymmetries as emission from the exposed cavity walls of inclined discs, which we use to characterise their vertical extent. We focus on the discs around CIDA 9 and RY Tau, first modelling their observations in visibility space with a simple geometric prescription for the walls, and then exploring more detailed radiative transfer models. Accounting for the wall emission yields significantly better residuals than purely axisymmetric models, and we can place some constraints on their scale heights at the cavity radius. Additionally, we identify crescent-shaped asymmetries in eleven discs, finding compelling evidence that they are due to their exposed walls based on their orientations. Modelling this effect in larger samples of discs will help to build a statistical view of their vertical structure.

Talk Abstracts

Tuesday 10th

Constraining the inner disk structure around intermediate mass YSOs from CO overtone emission

Cade Bürgy

Disc Composition & Chemistry 1: 09:30-09:42

A large fraction of exoplanets orbit within ~1 au from their parent star suggesting either the formation at larger radii and planet migration towards shorter orbits or the in-situ formation at the current orbit. In both scenarios, our knowledge about planet formation and planet-disk interaction is limited by the predictions of inner disk models.
For the first time, we combine simultaneous optical interferometry using GRAVITY (UTs) and high-resolution CRIRES+ spectra to probe the CO ro-vibrational overtone emission tracing the inner disk and thus observationally constrain the conditions in Earth-like orbits around four Herbig Ae/Be stars. Fitting a geometrical model to the visibility amplitudes has revealed that the emitting CO is significantly more compact than the continuum emitting region indicating it originates from within the dust sublimation front. Additionally, we observe the typical s-shaped differential phase signal across the first bandhead as well as a small closure phase signal indicating that rotating, centro-symmetric material is present down to a resolution of ~2 mas. Through spectral modelling, we have found good agreement with a narrow ring of warm (~2000K) and dense (~1e21 cm^(-2)) CO in a close-in Keplerian orbit (~0.3au), which agrees to the emitting size found through visibility modelling. To reproduce the observed spectra, we require intrinsic line widths that significantly exceed thermal broadening indicating an excess in turbulent motion in some of the targets.

Unraveling the origin of excess carbon in planet-forming environments around low-mass stars

Javiera Díaz

Disc Composition & Chemistry 1: 09:42-09:54

The material available in planet-forming disks will determine the composition of planets. Therefore, it is crucial to understand what physical and chemical processes are occurring therein by constraining the abundance and distribution of organic volatiles in the planet-forming regions of disks. Previous observations of disks around low-mass stars hinted at a rich chemistry of small organic volatiles in the inner regions. In addition, chemical models for M-dwarfs predicted that small organic molecules are more abundant in disks around low-mass stars than around higher-mass stars, in agreement with the observations at that time. However, recent JWST observations of a low-mass star's disk revealed a planet-forming region particularly rich in hydrocarbons, in contrast with predictions from models. To try to understand and interpret these observations, we employ chemical kinetics models and compute the abundances of key volatiles in the inner disk. I will present results from models in which we adopt different initial elemental abundances, to quantify how hydrocarbons, H_2O, and CO_2 abundances and distributions respond to C/O ratio variations in the disk and constrain the local elemental ratios that best explain the trends in these observations. The C/O variations and scenarios explored are motivated by physical processes in the disk that can drastically alter the elemental ratios in the gas, such as icy pebble trapping (oxygen depletion), and carbon-grain destruction (carbon enrichment). Hence, we show how these observations, as interpreted by the models, can also give insight into the physical structure and evolution of the inner disk.

ARKS - Presenting spectrospatial distribution of CO gas in 18 nearby debris discs

Sorcha Mac Manamon

Disc Composition & Chemistry 1: 09:54-10:06

Belts of exocomets, also known as debris discs, are extrasolar Kuiper belt analogs. They are ubiquitous around nearby stars, particularly young main sequence stars at a few 10s of Myr (~75% occurrence rate). Emission from collisionally-produced dust has long been observed in these belts, but until recently these belts were thought to be gas free. One of ALMA's greatest discoveries, enabled by its unprecedented sensitivity, has been the presence of gas in now over 20 exocometary belts. This is likely a product of exocometary release, giving us access to the volatile composition of exocomets for the first time.

In this talk, I will present the first gas results from the ALMA survey to Resolve exoKuiper belt Substructures (ARKS) ALMA Large Program, aimed at characterising 18 exoKuiper belts at unprecedented sensitivity and resolution. I will present the 12CO and 13CO spectrospatial distribution for all detected systems, and the deepest upper limits constraining the CO release and photo-destruction mechanism, as well as a comparison with substructure as observed in dust continuum. The spectrospatial resolution (down to 26 m/s) achieved by ARKS will also enable the first kinematics study of gas-rich debris discs, enabling a search for substructures produced by the interaction between CO gas and adolescent planets.

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Talk Abstracts

Volatile composition of the planet-hosting disk HD 169142

Luke Keyte

Disc Composition & Chemistry 1: 10:06-10:18

Determining the abundances of key volatiles in protoplanetary disks is essential for establishing connections between the compositions disks and planets. The disk around the Herbig Ae star HD 169142 is a compelling target for such a studies due to its molecule-rich nature and the presence of a confirmed protoplanet. In this talk, I discuss the chemical composition of the HD 169142 disk at small spatial scales, aiming to draw links between the composition of the disk and the planet-accreted gas. Using thermochemical models alongside ALMA observations, I compare the radically different morphologies of a range of molecular species. Observed SiS emission near the HD 169142 b protoplanet is particularly intriguing, vastly exceeding chemical model predictions. This supports the previous hypothesis that it is tracing shocked gas or a localised outflow. I contextualise these findings in terms of the potential atmospheric composition of the embedded planet.

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Talk Abstracts

The detectability of amorphous and crystalline water ice in debris discs: insights from scattered light observations

Minjae Kim

Disc Composition & Chemistry 1: 10:18-10:30

Ice is ubiquitous in the Universe, but the presence of ice in the debris disc component of exoplanetary systems is not yet strongly established observationally. In this study, we explore the characterisation of amorphous and crystalline water ice features in debris discs, considering the diverse nature of debris discs around stellar spectral types A, F, G, K, and M. In particular, we quantify and discuss the impact of parameters such as volume fraction of ice and grain size, and ice depletion mechanisms such as sublimation, on the observational appearance of debris discs including spectral energy distributions, flux ratios, and scattering phase functions. The results show that ice features in debris discs are sensitive to a variety of factors, including the spectral type of the host star, the radial disc location and inclination, and the ice fraction. An increased ice fraction enhances flux density contrasts at ~2.7 and ~3.3 mu, indicating ice composition and distribution, particularly in less inclined discs. The 3.1 and 3.4 mu crystalline ice features discriminate crystallinity and serve as a temperature probe, which is more evident around luminous stars. Furthermore, we provide flux ratios between ice and PAH, which can potentially mimic ice, at ice feature wavelengths, providing valuable limits for understanding the existence, properties, and spatial distribution of ice in debris discs. Lastly, the ratio between phase functions at 3.3 and 2.8 mu correlates with ice fraction, differing for amorphous and crystalline ice-dust mixtures.

Chemcomp: Calculating disc and planetary compositions

Bertram Bitsch

Disc Composition & Chemistry 2: 11:00-11:12 (online)

The chemcomp code (Schneider & Bitsch 2021a) is a 1D semi-analytical planet formation code. This code includes pebble drift and evaporation to compute the disc's composition as well as planetary growth and migration to calculate the orbital evolution and composition of growing planets. We utilized this code in the past to calculate the atmospheric abundances of growing giant planets (Schneider & Bitsch 2021a,b, Bitsch et al. 2022) and the disc's chemical evolution (Mah et al. 2023). I will give a short introduction to the capabilities and shortcomings of the code and present some before mentioned key results. We have now made the code publicly available for the whole community to use (Schneider & Bitsch 2024).

Talk Abstracts

A general framework for the chemical characterization of circumstellar gaseous discs around white dwarfs with Cloudy

Felipe Lagos-Vilches

Disc Composition & Chemistry 2: 11:12-11:24

Double-peak emission lines from gaseous debris discs around white dwarfs offer a unique opportunity to model the chemical abundances of the disrupted planet(esimal)s from which they are formed. We here present a python-based framework to characterize the radial extent of those gaseous discs along with their element abundances by modeling the observed emission-line intensity ratios with the photo-ionization code Cloudy. To explore the wide parameter space of chemical compositions
and/or radial extent of the disc, we implemented a multiprocessing wrapper around cloudy to conduct a large number of simultaneous simulations, which are ranked in a semi-automatic fashion according to their capability to reproduce the observed intensity ratios. To test our algorithm we use as a benchmark the gaseous disc around the white dwarf WD J0914+1914 which shows emission lines of sulphur, oxygen and hydrogen. We found that intensity ratios are well reproduced by abundance ratios
(by number) of log10 (S/H) = log10 (O/H) $\simeq -0.5$, total hydrogen number density n(H) $\simeq$ 10^10cm^−3 and total gas density $\simeq$ 10−12 g/cm3, with the best model predicting the presence of additional emission lines which were later confirmed through a thorough inspection of the data. Future characterizations will also include the use of Doppler maps to better constraint line ratios in white dwarfs with eccentric gaseous discs, such as SDSS 1228+1040.

Talk Abstracts

Constraining the rotational temperature of methanol in the planet-forming disc HD 100546

Lucy Evans

Disc Composition & Chemistry 2: 11:24-11:36

There is growing evidence that planet formation is already underway during the protoplanetary disk stage, which makes the chemical study of such objects imperative when considering the planet-forming environment. This talk presents ALMA observations which aim to study the chemistry of two Herbig disks: HD100546 and IRS48. This research has resulted in a chemical inventory of these two objects and allows for the first detailed characterisation of the complex organic reservoir. The main topic of the talk will be one such investigation, focusing on multiple detected lines of methanol and its chemical predecessor, formaldehyde, towards HD100546, which likely hosts two giant planets. Methyl formate is also detected, revealing another level of chemical complexity. Previous research has suggested that methanol has an inherited origin in HD100546 as it could not form efficiently in situ. As the simplest complex organic molecule (COM), methanol is a fundamental molecule within the context of astrochemical origins, as it represents a bridge between simple molecules and more complex compounds that are vital to life. Multiple lines of methanol and formaldehyde are detected towards both the hot inner and cold outer disk, suggesting that the outer dust grains are icy. Through rotational diagram analysis of our line-rich dataset, we constrain and compare for the first time the temperature and column density of these two organic molecules in both spatial components. This enables a thorough, spatially dependent investigation into the organic chemical history of this protoplanetary disk, including the inherited methanol hypothesis and thermal vs non-thermal desorption.

Talk Abstracts

The snow line instability in protoplanetary discs

Alfie Robinson

Disc Composition & Chemistry 2: 11:36-11:48

The spatial distribution of chemical species in discs is heavily influenced by the snow lines of different molecules. Models of chemical freeze-out have been used to attempt to connect the formation and evolution of nascent planets within their discs to the compositions of exoplanets and their atmospheres. Typically, snow lines are viewed as stable structures whose radii in the disc are set by the temperature profile, only evolving if this underlying profile changes. Recent work, however, suggests that these structures can be unstable to temperature perturbations for certain opacity criteria - criteria which are typically met for large swathes of the mid-to-outer disc. This instability suggests that snow lines can move through tens of au in kyr timescales, following a limit cycle between two stable equilibria. This dynamical evolution may have a profound effect on our understanding of the disc chemical distribution. In this current work, we have continued the investigation into snow line instability, studying the problem in both the radial and vertical dimensions and including multi-species dust dynamics and growth alongside ice-vapour chemistry and 2D radiative transfer. We identify two snow line positions by heating the disc up from cold temperatures or cooling from high temperatures. We let the snow lines dynamically evolve from these two states to understand how they evolve in a time-dependent and self-consistent manner. From this, we can study the effect that snow lines have on the dust population and the temperature structure, and begin to make a map of chemical abundance throughout the disc.

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Talk Abstracts

Determining the H2/CO Ratios of Gas Rich Exocometary Belts: Primordial or Secondary Origins?

Kevin Smith

Disc Composition & Chemistry 2: 11:48-12:00

Exocometary belts also known as debris disks were initially thought to be gas free, however the sensitivities offered by instruments like ALMA and Hubble have allowed CO gas detections in over 20 belts. Many younger exocometary belts have been measured to have CO gas masses comparable with Herbig Ae protoplanetary disks. This has lead to a debate as to the origin of the gas in these belts. The gas could be primordial (H2-rich and persisting from the protoplanetary phase of evolution) or secondary (H2-poor and outgassed in-situ by exocomets). Our study aims to break this dichotomy using VLT CRIRES+ near-IR high-resolution (R~100000) spectra to probe H2 absorption along the line of sight to the star in the edge-on CO-rich disks around HD131488 and HD110058. Detectable H2 emission requires hotter temperatures than is expected in exocometary belts and thus we search for ground state absorption from the H2 2.223 micron rovibrational line. Our results combined with existing HST-STIS CO absorption data yield the first direct measurement of CO/H2 abundance ratios in debris disk gas. We achieve high enough SNRs to differentiate between primordial and exocometary gas composition in CO-rich debris disks,enabling a significant step forward in our understanding of gas disk evolution.

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Talk Abstracts

The rise and fall of the giant planet occurrence rate

Heather Johnston

Star-disc Connection: 14:30-14:42 (online)

We carry out pebble-driven planet formation simulations to investigate the rise and fall of the giant planet occurrence rate. We introduce pre-main sequence stellar evolution and stellar mass dependent accretion rates to conduct planet population synthesis. Our results show that the accretion rate is a key mechanism that governs the occurrence rate distribution. We find that giant planets around more massive stars tend to be (i) more massive, (ii) form at a faster rate, and (iii) undergo runaway gas accretion at different locations than around low-mass stars. Hence, we can infer that giant planet composition may vary with stellar mass.

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Talk Abstracts

What Time Can Tell Us About Space: Mapping Accretion in Intermediate-Mass YSO

Ruhee Kahar

Star-disc Connection: 14:42-14:54

Although substantial effort has been put into understanding formation of low-mass stars and their planetary systems, the knowledge of their intermediate mass counterparts is still lacking as their accretion mechanisms are unknown because their magnetic fields are too weak to sustain magnetospheric accretion.

I will present my study of time variability of accretion-related lines in young intermediate-mass stars, using the STAR-MELT code, combined with long- and short-cadence spectroscopic and photometric data. This code measures the variability in velocity and relative intensity for different lines and we aim to trace the structure of accretion columns and distinguish between different accretion mechanisms as they evolve over time. The analysis data is newly received from CARMENES as well as being supplemented by archival data, to assist in distinguishing rotational modulation from accretion rate variations. Our first results are that we observe rapid changes in the emission lines consistent with some degree of rotational modulation. By the end of this project, our plan is to have analysed the time-resolved spectroscopy so that the data can be used to explore the 3-D structure of accretion columns and unveil the planet-disc connection and the inner structure of protoplanetary discs.

I will also present an overview of some of the first results of the young stellar cluster NGC 2264 from the North-PHASE Legacy Survey. We have been investigating the stellar variability of the young stars distributed within the cluster with an aim to find new YSO, characterise accretion and study inner disk evolution within the cluster.

Talk Abstracts

Discs around neutron stars

Bettina Posselt

Star-disc Connection: 14:54-15:06

The first extrasolar planets were discovered around an isolated pulsar in 1992. Wolszczan 1994 confirmed three small planets orbiting PSR B1257+12 in nearly circular orbits. This system could be explained by planet formation in a disc around the neutron star. Familiar discs around neutron stars are accretion discs with an associated binary donor companion. However, discs are also discussed to be formed from supernova fallback material at the time of birth of the compact object. Such discs can be expected to have different properties in comparison to protoplanetary discs. In neutron star research, supernova fallback discs and their debris remnants are discussed in order to understand neutron star population evolution, or sudden changes in observed fluxes, spectra, or spin properties of a pulsar. After an overview about neutron star discs, I will present new results from our JWST observations of a magnetar for which a passive disc was reported based on Spitzer data.

Reference: Wolszczan 1994, Science, Volume 264, Issue 5158

Study of the degree of dust settling and turbulence in highly-inclined protoplanetary discs

Juanita Antilen

Disc Properties 1: 15:35-15:47

In initial stages of planet formation, primordial dust particles are well coupled to the gas, move along with it, and grow through collisions. When these particles increase their size, they start to decouple from the gas, drift towards the star, and settle to the midplane. Dust settling creates favorable conditions for planet formation in protoplanetary discs, which occurs in the highest density regions, and it is greatly affected by the gas dynamics, the initial grain size distribution and the gas to dust ratio. We constrain the strength of dust settling and level of vertical turbulence for three highly inclined protoplanetary discs: DoAr 25, MY Lup and RY Lup. For this aim, we perform radiative transfer modeling of ALMA and VLT/SPHERE data, which trace the vertical distribution of mm- and um-sized dust grains. This work provides new insights about the physical conditions in the earliest stages of planet formation.

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Talk Abstracts

Investigating YSO Dippers with XShooter

Aaron Empey

Disc Properties 1: 15:47-15:59

The Dipper subclass of YSOs are characterised by frequent dips in their light curves. Predicted to account for around 30% of Classical T-Tauri Stars (CTTSs) their behaviour ranges not only in the timescale but also in the level of periodicity exhibited and the strength of the dips. A range of targets exhibit irregular patterns with dips accounting for up to 50% of the photospheric flux, and although their origin is still a matter of debate, the driving mechanism is likely related to short term changes in the level of dust extinction . Characterisation of the dust grains and their evolution provides interesting insights into the physical properties of the complex inner disk region of protoplanetary disks. We present the first multi-epoch survey of 16 irregular Dippers from the Upper Scorpius star forming region, observed with XShooter. Analysis of the variability of the continua, photospheric lines, and Gaia photometry confirm the observed dips are not due to changes in accretion nor the presence of stellar spots, and are due to the dust from the inner disk region. Comparison with opacity dust models suggest well processed dust grains, with maximum sizes on the order of tens of microns in some cases. Given the properties of the observed dips in this sample, various lifting mechanisms of the grains are explored.

Talk Abstracts

Results from the Planet-Earth Building-Blocks Legacy e-MERLIN Survey (PEBBLeS) - how do the rocks start forming in discs?

Jane Greaves

Disc Properties 2: 16:00-16:12

PEBBLeS has acquired over 800 hours of 4.5 cm data from e-MERLIN, seeking to image protoplanetary dust discs at the longest wavelength yet attempted. Where the dust spectrum is continuous into the mid-cm-regime, pebbles of cm-size have formed, overcoming drift and fragmentation barriers. The resolution of e-MERLIN can distinguish if rocks are growing fastest where terrestrial or giant planets would form, by solar system analogy. Our 10 fields are a flux-limited survey for the northern sky, and a pre-cursor to SKA Cradle of Life science. I will present the survey results for the first time along with initial trends on which kinds of systems seem to form planetary cores most easily.

Talk Abstracts

Exploring the Gas-Dust-Planetesimals Interplay in WD Debris Discs with SPH

Rafael Martinez-Brunner

Disc Properties 2: 16:12-16:24

Over 99% of all known exoplanets have host stars that will become white dwarfs. Planetary material which approaches a white dwarf breaks up and accumulates into a disc at the outer edge of the WD's Roche sphere. 60+ WD debris discs are known so far. Mounting and increasingly detailed observations of these discs show peculiar features: non-axisymmetric geometrical structure, sudden flux variations, accompanying disintegrating planetesimals, and Gas and dust accretion. However, a theoretical understanding of these features is critically lacking. Significant attempts have been made, but almost none include a key factor: the gas-dust interactions. In that context, this project is the first detailed study of gas-dust interactions in white dwarf planetary debris discs with Smoothed-Particle Hydrodynamics (SPH). For the simulations, we use PHANTOM SPH, an open-access, well-tested, and easily modifiable code. Incorporating the combined evolution of gas and dust in these extreme environments is critical to understanding disc shape and their properties.

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Talk Abstracts

A multi-wavelength study of the VLA 1623 protostellar system using JWST, ALMA and JVLA

Isaac Radley

Disc Properties 2: 16:24-16:36

The planet formation process requires significant grain growth from micron to centimetre sizes, yet observations of planet-forming disks at the longest (cm) wavelengths have been limited. Further characterisation of planet-forming disks at these wavelengths requires both high sensitivity and high spatial resolution observations.

In this talk, I will present a multi-wavelength analysis of the VLA 1623 protostellar system spanning 5 orders of magnitude (micron to cm) combining observations from JWST, ALMA and JVLA. Our extremely high resolution (~10 au) enables us to probe changes in both the dust distribution and dominant emission mechanisms across this large wavelength range for the first time. We find that the emission is dominated by dust up to 1.4 cm, and many tens of Earth masses of large (~cm-sized) grains are present even at these earliest stages of planet formation. Additionally, our results suggest the presence of winds and/or jets at longer wavelengths. In one source, we find the first hints of a spatially resolved jet perpendicular to the protoplanetary disk.

Our results form a first look into a wider survey of the Ophiuchus star-forming region which will constrain the mm and cm emission of YSOs from class 0 to class III. Our findings will lay the foundations for the next generation of centimetre observations using upcoming facilities such as the SKA and ngVLA.

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Talk Abstracts

Time-resolved spectroscopy and multi-band photometry of a white dwarf with a transiting debris disc

Akshay Robert

Disc Properties 2: 16:36-16:48

In 2022, WD 1054–226 was reported as the fourth polluted white dwarf with a transiting debris disc, and remarkably, the debris orbits in the habitable zone of the host star at a period of 25.02h, where a planetary surface can support liquid water. The light curves show myriad unusual features, with the most pronounced dimming components every 23 min – the 65th harmonic of the fundamental period – and numerous orbital drifters. I will present time-resolved spectroscopic data of WD 1054–226, consistent with the presence of multiple refractory heavy elements. We have also obtained infrared light curves of the target, which enable investigations into the colour dependence, and therefore the size distribution, of the transiting material. Finally, new, updated optical light curves both demonstrate the stability of the 65th harmonic over a timescale of four years and probe the long-term presence of the drifting components. Overall, the data indicate that while some properties of the debris at WD1054–226 are typical of white dwarf circumstellar discs, the transiting components offer a unique and powerful window in constraining the eccentricity, size, and inclination of the orbiting structures.

Talk Abstracts

Wednesday 11th

Constraints on the physical origin of large cavities in transition disks from multi-wavelength dust continuum emission

Anibal Sierra

Disc Properties 3: 09:30-09:42

The physical origin of the large cavities observed in transition disks is to date still unclear. Different physical mechanisms produce disk cavities of different depth (e.g., a companion, dead zones, enhanced grain growth), and the expected spatial distribution of gas and solids in each mechanism is not the same. In this work, we analyze the multi-wavelength interferometric visibilities of dust continuum observations obtained with ALMA and VLA for six transition disks: CQTau, UXTau A, LkCa15, RXJ1615, SR24S, and DMTau, and calculate high angular resolution brightness radial profiles, where diverse emission morphology is revealed at different wavelengths. The multi-wavelength data is used to compute constraints on the radial profile of the dust surface density, maximum grain size, and dust temperature in each disk, and they are compared with the observational signatures expected from various physical mechanisms responsible for disk cavities.
The observational signatures suggest that the cavities observed in the high-mass disks (CQTau, UXTau A, LkCa15, and RXJ1615) could potentially originate from a dust trap created by a companion. Conversely, in low-mass disks (SR24S, DMTau), the origin of the cavity remains unclear, although it is compatible with a pressure bump and grain growth within the cavity.

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Talk Abstracts

Horseshoes and spiral waves: capturing the 3D flow near a low-mass planet analytically

Joshua Brown

New and Improved Models/Methods 1: 09:42-09:54

The key difficulty faced by 2D models for planet-disc interaction is in appropriately accounting for the impact of the disc's vertical structure on the dynamics. 3D effects are often mimicked via softening of the planet's potential, however planetary torques often depend strongly on the choice of softening length. We show that for a linear flow perturbing a vertically isothermal disc, there is a particular vertical average of the 3D equations of motion which exactly reproduces 2D fluid equations for arbitrary adiabatic index. There is a strong connection here with the Lubow-Pringle 2D mode of the disc. Correspondingly, we find a simple, general prescription for the consistent treatment of planetary potentials embedded within '2D' discs. The flow induced by a low-mass planet involves large-scale excited spiral density waves which transport angular momentum radially away from the planet, and 'horseshoe streamlines' within the co-orbital region which allow fluid elements on similar orbital radii to the planet to periodically exchange angular momentum with the planet. We derive simple linear equations governing the flow which capture both effects accurately simultaneously. We find remarkably strong agreement with the flow computed in 3D numerical simulations, calculating concurrent estimates for the horseshoe region width and one-sided Lindblad torque. We predict the vertical structure of the co-orbital flow and horseshoe width for a range of adiabatic indices, and present an accurate co-orbital flow solution which allows for inexpensive future study of corotation torques.

Talk Abstracts

The properties of embedded disc-instability protoplanets

Ethan Carter

New and Improved Models/Methods 1: 09:54-10:06

The formation of self-gravitating clumps as a result of fragmentation in a gravitationally unstable disc offers an alternate formation mechanism for gas giant planets and brown dwarfs on wide orbits. Clumps formed as a result of gravitational fragmentation have the potential to evolve further into protoplanets on a dynamical timescale. Recent observations of systems such as AB Aur appear to provide potential candidates for protoplanets formed as a result of disc instability. We model the formation and evolution of self-gravitating clumps in gravitationally unstable discs and determine the properties of young protoplanets still embedded in the disc. We compare our more realistic treatment using a radiative transfer approximation to previous studies testing the effect of different barotropic equations of state on the properties of protoplanets embedded in discs.

A flared model of gaseous white dwarf accretion discs

Yixuan Chen

New and Improved Models/Methods 1: 10:06-10:18

The gaseous and dusty discs around white dwarfs (WDs) are created by the destruction of the last remnants of planetary material, so they are important for understanding the final stages of planetary systems and the composition of exoplanets. More than twenty such discs have been detected by now, but they are often modelled as flat, optically thin, debris discs purely made up of dust. In the presence of gas, the flat disc model might be a poor representation of the disc structure and underestimate its temperature, hence failing to explain their infrared excess.
To improve our understanding of gaseous WD discs, I will discuss a flared disc model which comprises an optically thin superheated surface layer and an optically thick interior in radiative equilibrium. The flaring shape is due to the gas pressure in the irradiated disc, which allows the disc to absorb more WD radiation, developing a higher disc temperature and stronger infrared emission. The new model has been input into an MCMC framework to explore its parameter space and test the ability of the model to retrieve the observations. The results show the SEDs generated from the flared disc model are in better agreement with the observational data for those discs with the largest infrared excess, providing further insights into the characteristics of gaseous WD discs. The new model can also be a useful tool for investigating WD accretion and the final part of the evolution of planets in WD systems.

Talk Abstracts

Exploring the kinematics of protoplanetary discs: a theoretical perspective

Cristiano Longarini

New and Improved Models/Methods 1: 10:18-10:30

Today, thanks to ALMA telescope, it is possible to look into planet formation in real time, observing protostellar discs. The electromagnetic emission of both gas and dust components can be detected, showing that the morphology of these environments is extremely complex. One of the revolutions of ALMA is its ability to detect CO isotopologues emission from protoplanetary discs, at high spatial and spectral resolution. This offers a unique opportunity to map the kinematics of these systems with an incredible precision, investigating the physical conditions in which planets form. Hence, in order to correctly interpret the data, precise theoretical models are needed.

In this talk, I am presenting the state of the art models for the azimuthal velocity of protoplanetary discs, their rotation curve. Despite a Keplerian appearance , these curves contain rich information about disc and the central star. I will show that it is possible to measure the disc gravitational potential, by modelling the self gravitating contribution, giving a direct estimate of the disc mass. In addition, I will discuss the crucial role of the thermal structure, emphasising the importance of precise modelling, to correctly interpret the data. I will show our results applied to the MAPS and exoALMA sample, and discuss about future perspective regarding rotation curves.

Exocomet Hunting with Convolutional Neural Networks

Azib Norazman

New and Improved Models/Methods 1: 10:30-10:42

Exocomets are analogues of comets in our Solar System, and there has been strong evidence of their existence through detections with spectroscopic methods. While detecting them in photometry is challenging, recent high-precision photometric surveys such as Kepler and TESS have yielded some detections. Challenges remain in properly distinguishing exocomets from false-positive signals, such as binary/planet transits and stellar variability, and obtaining high quality data to properly quantify the shape of transits. Previous studies to search for exocomets in photometry included visual searches, and an automated approach that fits models to potential transits. The automated method has limitations, assuming that exocomet transits look like the models, and relying on model fitting convergence.

Convolutional Neural Networks (CNN) are a promising machine learning method to detect rare events in lightcurves, with recent work applying this technique towards detecting stellar flares and dipper stars. Here, we present a CNN-based method to search for exocomet transits in photometry. The aims are to assess whether machine learning techniques are a more thorough or efficient approach in hunting for the rare exocomet events. With the small sample of exocomet detections in photometry, we developed a synthetic training set based on the asymmetric profile of exocomet transit shapes injected into real photometric lightcurves, and run our CNN model on the real sample of lightcurves. We are applying this method to the Kepler and TESS prime missions, and will present initial results at the time of the conference.

Talk Abstracts

Realistic modelling of radiative cooling for gravitationally unstable discs

Alison Young

New and Improved Models/Methods 1: 10:42-10:54

There is plenty of evidence now that planet formation begins very soon after the formation of the disc itself. At early stages, protostellar discs tend to be more massive and are therefore likely to be susceptible to the gravitational instability, which can play a key role in their evolution and in planet formation. As such, there is renewed interest from the planet formation community in exploring the role of the gravitational instability in building planets. Simulations of gravitationally unstable discs indicate that spiral structures may assist the formation of dust clumps which can then gravitationally collapse to form planetesimals. So far, modelling has largely been restricted to simplistic approximations of cooling, and prescribed temperature profiles, while the alternative of employing ray-tracing radiative transfer adds considerable computational expense. We present an improved method for approximating radiative cooling in hydrodynamical models of discs, designed for simulating self-gravitating discs more accurately and with a reasonably small increase in walltime compared to the beta-cooling approximation. Because the evolution of self-gravitating discs is very sensitive to the cooling rate, we observe differences in the outcomes of models implementing different methods. A disc with initial conditions that led to marginal stability with an older method now fragments with a more realistic cooling model. I will introduce our new radiative cooling approximation and present results of comparisons with different cooling methods. Finally, I will discuss the implications for future models of gravitational instability in discs and what we can learn from them.

Talk Abstracts

The Role of Drag and Gravity on Dust Concentration in a Gravitationally Unstable Disc

Sahl Rowther

New and Improved Models/Methods 2: 11:25-11:37

We carry out three dimensional smoothed particle hydrodynamics simulations to study the role of gravitational and drag forces on the concentration of large dust grains (St > 1) in the spiral arms of gravitationally unstable protoplanetary discs, and the resulting implications for planet formation. We find that both drag and gravity play an important role in the evolution of large dust grains. If we include both, grains that would otherwise be partially decoupled will become well coupled and trace the spirals. For the dust grains most influenced by drag (with Stokes numbers near unity), the dust disc quickly becomes gravitationally unstable and rapidly forms clumps with masses between 0.15 - 6 Earth masses. A large fraction of clumps are below the threshold where runaway gas accretion can occur. However, if dust self-gravity is neglected, the dust does not form clumps, despite still becoming trapped in the gas spirals. When large dust grains are unable to feel either gas gravity or drag, the dust is unable to trace the gas spirals. Hence, full physics is needed to properly simulate dust in gravitationally unstable discs.

Dust trapping of large grains in spiral arms of discs stable to gas fragmentation could explain planet formation in very young discs by a population of planetesimals formed due to the combined roles of drag and gravity in the earliest stages of a disc's evolution. Furthermore, it highlights that gravitationally unstable discs are not just important for forming gas giants quickly, it can also rapidly form Earth mass bodies.

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Talk Abstracts

Pebble drift in HD 163926 - constraining the mass of dust and ice reaching the terrestrial planet formation region

Joe Williams

New and Improved Models/Methods 2: 11:37-11:49

The transport of dust and volatiles through protoplanetary discs during the planet formation phase is thought to be key in shaping the architecture of the emerging planetary systems, and plays a central role in interpreting chemical diversity in the inner and outer disk regions as revealed by JWST and ALMA. Currently, pebble-based volatile transport mechanisms from the outer to the inner disc remain poorly constrained, leaving open questions about the available chemical budget for exoplanet core and atmosphere compositions.

We present a novel method combining (1) molecular tracers of pebble drift in the outer disk (namely enhanced gas-phase CO inside 70au), (2) radial drift modelling, and (3) MCMC sampling to constrain fundamental disk properties of HD 163296 by reproducing the inferred cumulative mass flux through the CO snow line. This includes initial disc gas mass, current dust mass, and characteristic radius, as well as the fragmentation velocity of the pebble population. We find that dust grains need to be 'fragile' to reproduce current disc dust mass observations.

Our results extend to predictions of the mass of dust and ice reaching the water snow line, providing constraints on the quantities of solids and water available for planet formation in the inner disk. We also speculate on the nature (earth-like, super-earth etc.) of planets forming within the terrestrial planet-forming region of HD 163296 by comparing our predictions against planet formation simulations; we conclude that HD 163296 is likely to form terrestrial or super-earth planets in the inner disc.

Talk Abstracts

On the role of resonance absorption in flows receptive to the magnetorotational instability

Mattias Brynjell-Rahkola

Disc Processes 1: 11:49-12:01

The role of the magnetorotational instability (MRI) in protoplanetary discs has long been debated. In the innermost regions of the disc (i.e. up to around 1 AU), Ohmic diffusion dominates the energy dissipation, and gas ionization levels are likely to be high enough to yield an O(1) or larger magnetic Reynolds number. Under these conditions, the MRI is widely believed to be active and contribute to the radial transport of angular momentum. Further out on the other hand, this instability is expected to become suppressed, which leads to the formation of so called dead zones. Near the boundary of such regions, the flow is neutrally stable to the MRI and capable of dissipating large amounts of energy in narrow resonance layers, where the Doppler-shifted disturbance wave frequency and the Alfvén frequency are equal in magnitude. This absorption process stems from mixing of wave phases, and is largely independent of the viscosity and the resistivity of the flow. In this talk, we revisit the non-axisymmetric MRI of a predominantly toroidal magnetic field in a disc with Ohmic diffusion. We analyse the Alfvén resonances and discuss their role in determining the onset of instability and the operation of a dynamo in which the MRI sustains the magnetic field against dissipation.

Talk Abstracts

The effect of disc photoevaporation on the evolution of migrating giant planets

Emmanuel Greenfield

Disc Processes 1: 12:01-12:13

Giant planets do not just shape the circumstellar disc with gaps as found in observations like HL Tau or TW Hydra but also affect the final assembly of planetary systems. Additionally, multi-planet migration is often overlooked in formation models. This is relevant as most systems harbour multiple planets and we expect to discover thousands of such diverse systems with the upcoming Gaia releases. Effects like photoevaporation will also alter the disc structure and are not yet well studied for multi-planetary systems. All of this together is important for characterising the different formation pathways.

The main hypothesis is that deeper resonances increase eccentricity, but planet-disk interactions damp eccentricity, causing a feedback loop resulting in oscillations. As photoevaporation removes material inside the gap, disc interactions weaken so eccentricity stabilises at larger values, deepening the resonance. Less material contributing to innermost Lindblad torques should also slow down migration.

Initial Fargo3D simulations of two Jupiter mass planets in 2:1 resonance confirm this idea. For sufficiently strong photoevaporative winds (depletion rate of around 5x10^{-9} solar masses/year) eccentricity stops oscillating and stabilises quickly. After 10^5 years it reaches a value roughly double than the model without photoevaporation (which itself is decaying). The libration angle oscillates with a smaller amplitude, making the resonance deeper.

These results lead to a deeper exploration of the influence of disc mass, planet mass, resonance type and viscosity. We explore this phenomenon over the entire disc lifetime and characterise how photoevaporation changes migration rates and resonance trapping timescales.

Hydrodynamic instability and warping in vertically bouncing accretion disks

Loren E Held

Disc Processes 1: 12:13-12:25

Many protoplanetary disks (e.g. HK Tau, GW Ori) have been found to be misaligned and/or tidally truncated by a binary companion. This can result in the disk becoming distorted (eccentric or warped). Eccentric and warped accretion disks exhibit vertical breathing motions in the plane perpendicular to the disk which are absent in circular and co-planar disks. In extreme cases, this vertical motion is manifested as a vertical bouncing of the gas leading to shocks and heating of the gas, as observed in recent global numerical simulations. In this paper we investigate disk bouncing by means of 3D hydrodynamic local (shearing box) models, which can capture many of the salient features of warped disks. To determine the numerical and physical dissipation mechanisms at work during a bounce we start by looking at unforced bouncing motion, determining the effect of resolution, boundary conditions, vertical box size, and initial bounce amplitude on the dissipation and energetics of the bounce. We then drive the bounce by introducing a time-dependent gravitational potential. A key — and unexpected — result is that a purely bouncing disk is unstable to parametric instability, which results in an initially flat disk developing warp, which we confirm through a local stability analysis. The warp is associated with strong radial shocks after non-linear saturation. Finally, if time, we will discuss a separate but related project on disk breaking.

Disc evolution in intermediate mass stars: survey extension

Daniela Iglesias

Disc Processes 1: 12:25-12:37

The stellar mass range between 1.5 and 3.5 Msun presents a particularly interesting circumstellar disc evolution; most notably, it is dominated by the EUV/FUV photoevaporation regime on the pre-main sequence, it contains the majority of gaseous debris discs, and it also show trends with giant planet frequency. In our previous spectroscopic VLT/X-Shooter survey (UV to nIR), combined with WISE data (nIR to mIR), we identified 135 pre-main sequence intermediate mass stars (IMSs) in an unbiased sample of the Southern sky. Our sample, encompassing protoplanetary, debris and a significant number of discs between these two stages, shows IR excess evolution that differs from that seen for low-mass stars, exemplified by samples drawn from nearby star forming regions. We find that, in IMSs, the inner disc regions are vacated in their entirety and not through a gradual inside-out dissipation. Most recently, we have extended the survey adding 246 new young IMSs candidates with near-IR excess with the aim to improve our statistics and search for new hybrid discs candidates caught in the evolution between protoplanetary and debris disc. These new candidates have been selected using new Gaia DR3 data, have been observed with UVES spectrograph, and their excesses have been studied with WISE data in combination with Kurucz stellar atmosphere models. In this talk, I will present the results of this new survey.

Talk Abstracts

Dust dynamics in the inner regions of protoplanetary disks

Thomas Jannaud

Disc Processes 1: 12:37-12:49

The study of protoplanetary disks is of particular interest, as it may explain how the gas and dust they are made of aggregate to eventually form planets. There has recently been tremendous progress in this field, spearheaded by many observations in the radio and infrared bands (ALMA, SPHERE, GRAVITY...).
However, the wealth of physics happening in those disks left many important questions unanswered, especially in their inner regions (0.03 to 5 au) where core accretion occurs. To fully understand accretion and ejection in this zone, one needs to take into account the presence of both gas and dust, as well as the influence of non-ideal MagnetoHydroDynamic (MHD) effects. The latter help shape the transition between the inner turbulent region, deemed active, and the outer laminar region, deemed dead. This transition, thought to be around 1 au, controls the pile-up of dust as well as the ejection of magnetic winds and jets. Our aim is to study the interdependence of these two processes to better understand planet formation in the inner disk.
We use the GPU code IDEFIX to run 3D global MHD simulations of the protoplanetary disks inner regions. In those, dust is added as a pressure-less fluid, subject to gas drag. We will present the first results from these simulations, highlighting the entrainment of dust, the creation of vortices and the launching of magnetically-driven winds.
If time allows, we will also present some results on the large-scale collimation of protoplanetary disk winds and jets.

Talk Abstracts

From Minutes to Decades: Dynamical Activity in Planetary Debris Disks Around White Dwarfs

Hiba tu Noor

Disc Processes 2: 14:20-14:32

Accretion of debris from tidally disrupted planetary bodies is the consensus model for the presence of photospheric metals in white dwarfs and associated circumstellar debris disks. Infrared emission from these disks is often found to be variable, with long-term variability well-documented and shorter timescales largely unexplored. In this talk, I discuss a work in progress using multi-epoch Spitzer photometry, probing mid-infrared variability in these disks over timescales ranging from minutes to decades. Preliminary findings indicate significant variability across all timescales probed, with potential trends in flux and colour variations, providing new insights into the dynamical processes operating within these evolved planetary systems.

Talk Abstracts

Analysis of triggered fragmentation in self-gravitating discs

Pratishtha Rawat

Disc Processes 2: 14:32-14:44

In the early stages, protoplanetary discs are likely to be gravitationally unstable and can evolve to fragment, which can directly influence the planetary systems that emerge out of such discs. Meru, F. (2015) explored the evolution of self-gravitating discs with initial fragmentation and found that an initial fragment triggers the formation of more fragments in the disc. We reanalysed the results of Meru, F. (2015) to explore the previously understudied impact of detailed thermodynamical modelling of self-gravitating discs with an initial fragment. For fragmentation to occur in a self-gravitating disc, either the sound speed should decrease, the surface mass density should increase, or both. Upon reanalysis of results from Meru (2015), we find that the formation of an initial fragment enhances the mixing of gas, characterised by the inward movement of cooler gas from the outer disc. This movement potentially lowers the sound speed, which, combined with an increase in the surface mass density, triggers the formation of subsequent fragments. Thus, our analysis suggests that both the temperature and the surface mass density might contribute to the destabilisation of the disc, such that it evolves to form subsequent fragments. This brings to light the interplay of physical quantities within the disc that can eventually lead to triggered fragmentation.

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Talk Abstracts

Discs within discs - formation conditions and structures in moon forming discs

Matthäus Schulik

Disc Processes 2: 14:44-14:56

The recent discovery of extended sources around the protoplanets in the PDS 70 system forces us to reconsider the conditions to form circumplanetary discs (CPDs).
Particularly, theoretical work is required to wind back the clock in order to understand how long those CPDs already exist and whether moon-forming material might have already coalesced into large bodies.
In this work we present recent (Schulik+2019, 2020) 3-D radiation hydrodynamic simulations addressing how the mass of the giant planet and cooling from circumstellar disc (CSD) dust influence the collapse of envelope material into a CPD.
We find that opaque material hardly forms a disc, and accretes onto the giant planet from high latitude. Low-opacity material however allows for a CPD to form once the giant planet surpasses the mass of Saturn, for which we present some key properties. Particularly, we show that CPDs feature their own set of spiral arms, and that the CSD spiral arms are tilted, kinematically forcing large gas columns to be accreted through the midplane. Those results expand upon previously found solutions in that they show that CPD spirals are not limited to 2-D simulations (Zhu+2016) and midplane inflow solutions to CPDs can exist, additional to the well-known outflow discs (Tanigawa+2012).
We close with a discussion of the discrepancy between the low-opacity formation conditions of the CPD on one hand, and the delivery of large quantities of dust into the moon-forming region on the other.

The Fomalhaut disc's high interior dust content: PR-drag-caused and universal?

Max Sommer

Disc Processes 2: 14:56-15:08

Recent JWST observations of the Fomalhaut debris disc have revealed a significant abundance of dust interior to the outer planetesimal belt, raising questions about its origin and maintenance. In this study, we adapt and apply an analytical model developed by Rigley & Wyatt 2020 that simulates the dust distribution interior to a belt, as collisional fragments are dragged inward due to Poynting-Robertson (PR) drag. Our model simulates both the spectral energy distribution for the entire disc and radial brightness profiles, which we compare against observations. We find that a substantial water ice component, along with a relatively high collisional strength of dust particles, allows for a reasonable model fit. This indicates that PR transport from an outer belt could alone account for high interior dust contents, potentially complicating efforts to directly image exoplanets within similar belt-bearing systems.

Talk Abstracts

On the origin of the wide orbit circumbinary gas giant planet, Delorme 1 (AB)b

Matthew Teasdale

Disc Processes 2: 15:08-15:20

In recent years, many wide orbit circumbinary giant planets have been discovered. The origin of many of these is still an open question. We investigate the formation of Delorme 1 (AB)b, a 12-14 Jupiter mass planet orbiting its host binary at 84AU, which is actively accreting at 40Myr after formation. Accretion should have ceased long ago due to the dissipation of the protoplanetary disc. Using the SPH code SEREN, we model two possible formation scenarios for this companion. Scenario I calls for the planet to form through gravitational instability and fragmentation. Scenario II is a formation scenario in which the planet forms much closer to the central star through the core accretion method. The planet may then attain the observed separation from its host star either through outward migration or through a scattering event by the binary. We find that in Scenario I, the planet reaches the observed separation through migration or outward scattering by the binary, but its mass is above the observed value. In Scenario II, the planet is able to sustain a mass below the observed value but has difficulty reaching the observed separation. Both scenarios produce a mass accretion rate well above the observed value, which is expected to decrease with time. In conclusion, both models may explain specific features of the observations but not all.

Talk Abstracts

Can the dominant mechanism for angular momentum transport be identified by measuring gas disc sizes?

Simin Tong

Disc Processes 2: 15:20-15:32

Whether viscosity or the magnetised wind is responsible for transporting angular momentum in protoplanetary discs is a long-standing question. Recently, theoretical and observational studies have been conducted to investigate the possibility of distinguishing these two scenarios by gas disc sizes and stellar accretion rates. In this work, we perform 1-D simulations with consideration of viscosity, magnetised and thermal winds, and dead zones to study how "hybrid" discs evolve differently from simple models, which only include either viscosity or magnetised winds. We examine the effects of different strengths of viscosity and winds, initial disc sizes and dead zone sizes on disc evolution and extend the discussion to demographics by generating synthesised populations. We find that the gas disc sizes and stellar accretion rates are good proxies for local angular momentum transport, but the determination of the mechanisms dominating the global angular momentum transport in protoplanetary discs requires other observational diagnostics.

Talk Abstracts

Planet Formation in the Inner Disc

Morgan Williams

Disc Processes 2: 15:32-15:44

To explain the formation or migration of super-Earths and sub-Neptunes requires an understanding of the structure and evolution of the inner disc, in which they are eventually observed. From previous studies, we expect the inner disc to be turbulent due to the effects of the magnetorotational instability (MRI). The boundary between the MRI active inner disc and "dead-zone" further out has been hypothesised as a site for planet formation. To explore this, we have performed time-dependent simulations in 2D (R-z) including: gas-dust dynamics with viscosity due to the MRI, radiative transfer, chemistry, and fragmentation and coagulation of grains. Through including all the aforementioned coupled physics, we can attain greater insight into the potential for planet formation in the inner disc than was possible before.