PLATO ESP 2020
Programme and abstract book

Times in CET = UT+1 (Berlin time)

(I) Invited talk: 25 min talk + 5 min discussion
(C) Contributed talk: 17 min talk + 3 min discussion
(M): Mini-presentation: 2 min – 2 slides presentation, no discussion

Last updated: 20 November 2020

Programme:

30th November (Monday)

13:55-14:00: Welcome message (Don Pollacco)
14:00-14:20: The PLATO Mission (Heike Rauer)

14:20-14:50: A. Correia: Probing close-in planets internal structure with PLATO (I)
14:50-15:10: S. Millholland: Testing Obliquity-Driven Sculpting of Exoplanetary Systems with PLATO (C)
15:10-15:30: V.K. Hodzic: Misalignement of Pi Men c (C)
15:30-15:50: D. Veras: Constraining orbital shrinking from chaotic tidal evolution with PLATO's asteroseismic ages (C)

15:50 – 16:10: BREAK

16:10-16:20 Mini-presentations:

16:10-16:12	J. Zhang:	Living with a Giant Sibling: the Spin-Orbit Misaligned Inner Planets Perturbed by a Newly Discovered Giant Planet in Kepler-129 System (M)
16:12-16:14:	C. Pezzotti:	Atmospheric evaporation in the Kepler-444 system (M)
16:14-16:16:	A. Leleu:	Recovering small dynamically active planets from transit surveys (tbc, M)
16:16-16:18:	N. Hinkel:	Planetary interios via Hypatia catalog (tbc, M)

16:18-16:20: A. Valio: Evaporation of Kepler-411b

16:20-16:50: T. Guillot: Interiors and Evolution of Giants Planets: Lessons from Juno (I)
16:50-17:10: D. Thorngren: Slow Cooling and Fast Reinflation for Hot Jupiters (C)
17:10-17:30: L. Noack: Parametrisations of interior properties for planets composed of Earth-like materials (C)
17:30-17:50: Ph. Baumeister: Shaping atmospheres of terrestrial planets with interior-atmosphere feedback processes (C)

17:50-18:10: All Roundtable: discussion of the talks of the day

1st December (Tuesday)

14:00-14:30: D. Fabrycky: Architecture of multiplanetary systems: our view after Kepler and before PLATO (I)
14:30-15:00: R. Nelson: Formation and evolution of multi-planet systems: What can PLATO tell us? (I)
15:00-15:20: Y. Alibert: The Next Generation Planet Population Synthesis model (C)
15:20-15:40: L. Mishra: Characterizing architecture of planetary system at the system level: comparison of Bern Model with Kepler observations, system level metrics, and role of PLATO (C)

15:40-16:00: BREAK

16:00-16:20: Mini-presentations

16:00-16:02	D. Stamatellos:	The architecture of disc-instability planets around M dwarfs (M)
16:02-16:04	A. Mortier;	A near resonant planetary system around an old star (M)
16:04-16:06	E. Szuszkiewicz:	Wave planet interactions (tbc, M)
16:06-16:08	R. Ligi:	On the Fulton-gap (M)
16:08-16:10	N. Nettelmann:	Constraining the interiors of gaseous exoplanets (M)
16:10-16:12	S. Berge:	PyPlanet (M)
16:12-16:14	M. Ammler-von Eiff:	Accurate stellar chemical abundances for studies of planetary interiors (M)
16:14-16:16	B. Akinsamni:	Second fluid Love-number from transit light curves (M)
16:16-16:18	E. Ford:	Potential and limitations of EPRV Follow-up (M)
16:18-16:20	S. Seager (tbc)	

16:20-16:40: A. Petit: On the spacing of tightly packed systems (C)
16:40-17:00: S. Poon: On the origin of the eccentricity dichotomy displayed by compact super-Earths: dynamical heating by cold giants (C)
17:00-17:20: V. Adibekyan: Observational evidence of the compositional link between rocky planets and their hosts (C)
17:20-17:40: L. Weiss: Planet Interiors and Architectures: Lessons from Kepler and TESS (C)
17:40-18:00: All Roundtable: discussion of the talks of the day

2nd December (Wednesday)

14:00-14:30:	C. Dorn	Diversity of Super-Earth (I)
14:30-15:00:	J. Owen	The close-in exoplanet population in time (I)
15:00-15:20:	O. Mousis	Irradiated ocean planets bridge super-Earth and sub-Neptune populations (C)
15:20-15:40:	F. Otegi	Internal characterization of super-Earths and sub-Neptunes (C)
15:40-16:00:	BREAK	
16:00-16:10:	Mini-presentations	
16:00-16:02	R. Alves:	Shannon entropy and N-Body integrations (M)
16:02-16:04	L. Kaye:	Measuring the masses of two of the three planets transiting TOI-270 from timing variations (tbc, (M))
16:04-16:06	E. Pereira:	Search for circumbinary planets around evolved eclipsing binaries (M)
16:06-16:08	S. Barros:	Improving transit characterization with gaussian process modelling of stellar variability (M)
16:08-16:10	-	
16:10-16:30:	N. Marounina	Are Water Worlds Hot and Steamy or Cold and Icy? (C)
16:30-16:50:	J. Haldemann:	AQUA: A Collection of H2O Equations of State for Planetary Models (C)
16:50-17:10:	L. Rogers	Constraining Water World Populations from Exoplanet demographics with PLATO (C)
17:10-17:30:	L. Acuña:	Characterisation of the hydrospheres of TRAPPIST-1 planets (C)
17:30-17:50:	M. Schlecker:	A compositional link between warm super-Earths and cold Jupiters (C)
17:50-18:10:	All	Roundtable: discussion of the talks of the day

3rd December (Thursday)

14:00-14:20: R. Mardling: Outcomes of convergent migration: why are so many systems not in resonance (C)
14:20-14:40: M. Ali-Dib: Halting Super-Earths envelope accretion and predictions for PLATO (C)
14:40-15:00: J. Venturini: The origin of the radius valley: hints from formation and evolution (C)
15:00-15:20 R. Luque: Testing radius valley emergence models in M dwarfs (C)
15:20-15:40: J. Lillo-Box: Characterization of three special multi-planetary systems: LHS1140, K2-32 and K2-233 ©

15:40-16:00 BREAK

16:00-16:10: Mini-presentations
- 16:00-16:02 Y. Judkovsky: An analytic approach for light curve modelling (M)
- 16:02-16:04 R. R. Pothuneni: Investigative Study of Close Binary Systems with Circumbinary Planets (M)
- 16:04-16:06 L. de Almeida: DRUM TONES (M)
- 16:06-16:08 A. Ofir: A simplified photodynamical model for planetary mass determination in Low-Eccentricity Multi-Transiting Systems (M)
- 16:08-16:10 Arnaud Michel Planetary mass-radius relations across the galaxy

16:10-16:30: M. He: The Intrinsic Architectures of Planetary Systems: Correlations in Periods, Sizes, and Stellar *Types from Kepler (C)*
16:30-16:50: M. Standing: Impact of the measured parameters of exoplanets on the inferred internal structure (C)
16:50-17:10: B. Bitsch: Chemical composition of giant exoplanets due to pebble, planetesimal and gas accretion (C)
17:10-17:30: K. Schlaufmann:The Impact of PLATO-based Planet Occurrence and Mass-radius Analyses on the Terrestrial-mass Planet Formation Timescale (C)
17:30-17:50: L.M. Serrano: The architecture of planetary systems hosting ultra-short period planets (C)
17:50-18:20: Concluding remarks (Magali Deleuil, 10 minutes) and general discussion (by all)

ABSTRACTS

in order of the presentations

D. Pollacco (University of Warwick, UK)
E-mail: d.pollacco@warwick.ac.uk

Title: Welcome message

Monday, 13:55-14:00

H. Rauer (Deutsches Zentrum für Luft- und Raumfahrt, Germany)
E-mail: heike.rauer@dlr.de
Title: The PLATO Mission

Monday, 14:00-14:20

A. Correia (University of Coimbra, Portugal)
E-mail: acor@uc.pt

Title: Probing close-in planets internal structure with PLATO (I)

Monday, 14:20-14:50

Abstract:
Planets orbiting very close to their host stars have been found, some of them on the verge of tidal disruption. The ellipsoidal shape of these planets can significantly differ from a sphere, which modifies the transit light curves. Here we show that the differences in the light curve can be detected by PLATO on a few cases. These measurements will provide an estimation of the fluid Love number, which is invaluable information on the internal structure of close-in planets.

S. Millholland (Princeton University, USA)
E-mail: sarah.millholland@princeton.edu
Title: Testing Obliquity-Driven Sculpting of Exoplanetary Systems with PLATO (C)

Monday, 14:50-15:10

Abstract:
The tilt of a planet's spin axis off its orbital axis ("obliquity") is a basic physical characteristic that dictates the planet's climate, impacts its dynamical evolution, and sheds light on its formation history. Moreover, non-zero obliquities can strongly enhance the tidal dissipation rate of close-in planets, which shapes both their interior structures and orbital architectures. Here I will review recent theories that suggest that close-in, compact, multiple-planet systems frequently experience high-obliquity dynamical evolution due to secular spin-orbit resonances. I will highlight the wide-ranging consequences of this obliquity-driven sculpting by linking it to several features of the observed planet population, including a pile-up of planets wide of mean-motion resonances, signatures of tidally-induced radius inflation among sub-Neptune-mass planets, and the existence of the ultra-short-period planets. Obliquity-driven sculpting can be tested directly by detecting photometric signatures of short-period planetary obliquities and oblateness. Such photometric signatures include transit light curve deviations due to triaxial deformations, transit depth variations due to spin-axis precession with non-zero obliquities, and full-phase light curve perturbations due to planetary tidal deformations and obliquities. Despite attempts, no robust detections of these signatures have been made thus far. The exquisite photometric precision offered by the PLATO mission will enable us to place robust constraints on planetary oblateness, obliquities, and tidal parameters, thus offering fundamental tests of obliquity-driven sculpting of planetary orbits and interiors.

V.K. Hodzic (University of Birmingham, UK)
E-mail: vxh710@bham.ac.uk
Title: Misalignement of Pi Men c (C)

Monday, 15:10-15:30

Abstract:
Planet-planet scattering events can leave an observable trace of a planet's migration history in the form of orbital misalignment with respect to the stellar spin axis, which is measurable from spectroscopic timeseries taken during transit. I will present high-resolution spectroscopic transits observed with ESPRESSO of the close-in super-Earth pi Men c, one of the smallest planets for which this has been done. I retrieve the planet-occulted light during transit and find that the orbit of pi Men c is misaligned with the stellar spin axis. This result, together with the recently discovered inclined orbit of the outer planet in the system, suggests dynamical interaction may have played a role in this system, and hints that super-Earths may form at large distances. I also detect clear signatures of solar-like oscillations within the ESPRESSO radial velocity timeseries, where the data reach a radial velocity precision of ~20 cm/s. I successfully retrieve the frequency of maximum oscillation using Gaussian processes, but the oscillations make it challenging to detect the Rossiter-McLaughlin effect using traditional velocimetric methods. Future missions such as PLATO will uncover many similar systems which may be amenable to similar techniques.

D. Veras (University of Warwick, UK)
E-mail: d.veras@warwick.ac.uk
Title: Constraining orbital shrinking from chaotic tidal evolution with PLATO's asteroseismic ages (C)

Monday, 15:30-15:50

Abstract:
One mechanism for shrinking and circularizing highly eccentric giant planet orbits is internal f-mode chaotic tidal excitation. PLATO will have a unique ability to probe planetary architectures by identifying this high-eccentricity migration scenario through a combination of (i) photometric transit detections, (ii) tight asteroseismic age constraints on young main-sequence host stars, and (iii) the ability to detect planets around young white dwarfs. The age of the host star provides a natural timescale constraint on the dynamical efficacy of the process. I will describe how this process works through recent detections of multiple giant planets orbiting white dwarfs with well-constrained ages, highlighting the benefits that PLATO's capabilities will provide.

T. Guillot (Observatoire de la Cote d'Azur, France)
E-mail: tristan.guillot@oca.eu

Title: Interiors and Evolution of Giants Planets: Lessons from Juno (I)

Monday, 16:20-16:50

Abstract:
The interiors of giant planets are not as simple as once envisioned. Juno's observations of Jupiter's deep atmosphere show that it is not well mixed, and most probably convectively stable on average, with intermittent convective outbursts. This raises questions on our ability to accurately model the interiors and evolution of giant planets in general. Plato's ability to determine precisely radii and ages could be key to make progress in this field, particularly when coupled to a precise characterization of the planetary atmosphere.

D. Thorngren (University of Montreal, Canada)
E-mail: daniel.thorngren@umontreal.ca
Title: Slow Cooling and Fast Reinflation for Hot Jupiters (C)

Monday, 16:50-17:10

Abstract:
The growing population of known transiting hot Jupiters is an invaluable dataset for the study of giant planet interiors and hot Jupiter thermal evolution. Here we use ISOClassify to derive ages for the transiting planet parent stars to study how the radii of their planets evolve with time. Two significant and novel effects are apparent. First, hot Jupiters appear to take several billion years to cool/contract to an equilibrium radius, a timescale orders of magnitude longer than previously expected for standard models of giant planet contraction long used for hot Jupiters, directly imaged planets, and in the solar system. Second, by comparing planets around stars evolving at different rates, we see that hot Jupiters reinflate as their parent stars brighten on the main sequence. These two results imply that the anomalously large radii of hot Jupiters is due to both a delayed cooling effect and the direct injection of stellar energy into the planets' interiors. We interpret these findings in the context of mechanisms suggested to explain hot Jupiter radius anomalies.

L. Noack (Freie Universität Berlin, Germany)
E-mail: Lena.Noack@fu-berlin.de

Title: Parametrisations of interior properties for planets composed of Earth-like materials (C)

Monday, 17:10-17:30

Abstract:
Observations of Earth-sized exoplanets are mostly limited to information on their masses and radii. Simple mass-radius relationships have been developed for scaled-up versions of Earth or other planetary bodies such as Mercury and Ganymede, as well as for one-material spheres made of pure water(-ice), silicates, or iron. However, they do not allow a thorough investigation of composition influences and thermal state on a planet's interior structure and properties.

In this work, we investigate the structure of a rocky planet shortly after formation and at later stages of thermal evolution assuming the planet is differentiated into a metal core and a rocky mantle (consisting of Earth-like minerals, but with a variable iron content).
We derived possible initial temperature profiles after the accretion and magma ocean solidification. We then developed parameterisations for the thermodynamic properties inside the core depending on planet mass, composition, and thermal state. We provide the community with robust scaling laws for the interior structure, temperature profiles, and core- and mantle-averaged thermodynamic properties for planets composed of Earth's main minerals but with variable compositions of iron and silicates.

The scaling laws make it possible to investigate variations in thermodynamic properties for different interior thermal states in a multitude of applications such as deriving mass-radius scaling laws or estimating magnetic field evolution and core crystallisation for rocky exoplanets.

Ph. Baumeister (Technische Universität Berlin, Germany)
E-mail: philipp.baumeister@tu-berlin.de

Title: Shaping atmospheres of terrestrial planets with interior-atmosphere feedback processes (C)

Monday, 17:30-17:50

Abstract:
During the lifetime of a terrestrial planet, the evolution of its atmosphere is mainly driven by volcanic outgassing of volatiles from the planet's interior. Outgassing rates are shaped by feedback processes in both the interior and the atmosphere, which are influenced by several factors, such as the initial mantle volatile content affecting convection in the mantle as well as the possibility to produce partial melts, and atmospheric pressure limiting the outgassing of volatiles from surface melts. We use a 1D parameterized convection model to simulate the evolution of H2O and CO2 outgassing into the atmospheres of terrestrial exoplanets, including feedback processes between interior and atmosphere, and utilize a chemical equilibrium model to describe the composition of the atmosphere over time. We are conducting an extensive parameter study to investigate a wide range of initial conditions, including, among others, the initial water content of the mantle, its redox state, the initial surface pressure of a primordial atmosphere, and the ratio between planetary core and mantle size. For planets with cores smaller than Earth's, the atmosphere tends to be dominated by CO2, whereas H2O is the main atmosphere component for planets with larger cores. Furthermore, the total mass of the atmosphere remains largely constant throughout the evolution of the planet, regardless of the initial surface pressure.

D. Fabrycky (University of Chicago, USA)
E-mail: fabrycky@uchicago.edu
Title: Architecture of multiplanetary systems: our view after Kepler and before PLATO (I)

Tuesday, 14:00-14:30

Abstract:
Architecture of multiplanetary systems: our view after Kepler and before PLATO.

R. Nelson (Queen Mary University of London, UK)
E-mail: fabrycky@uchicago.edu

Title: Formation and evolution of multi-planet systems: What can PLATO tell us? (I)

Tuesday, 14:30-15:00

Abstract:
One of the great successes of the Kepler mission has been to provide a census of multi-planet systems, in particular the compact systems of super-Earths and mini-Neptunes. We now have at least a partial view of the distributions of planetary radii, multiplicities and orbital eccentricities of these systems. Understanding how they formed and dynamically evolved is a key unanswered question in exoplanetary science, and one that has been the focus of numerous recent theoretical studies. In this talk I will briefly review recent work that has focused on both the migration-and-growth and the in situ formation scenarios. I will also present results from recent efforts to explain the so-called multiplicity and eccentricity dichotomies displayed by the Kepler systems. I will end by offering a perspective on how PLATO can transform our understanding of these enigmatic systems.

Y. Alibert (University of Bern and NCCR PlanetS)
E-mail: alibert@space.unibe.ch
Title: The Next Generation Planet Population Synthesis model (C)

Tuesday, 15:00-15:20

Abstract:
We will present the Next Generation Planet Population Synthesis model (NGPPS), also know as the Generation III Bern model. This model solves as directly as possible the underlying equations for the structure and evolution of the gas disc, the dynamical state of the planetesimals, the internal structure of the planets yielding their gas accretion rate and internal structure, the accretion rate of planetesimals, disc-driven orbital migration, and the gravitational interaction of concurrently forming planets via a full N-body calculation. The model also follows the long-term evolution of the planets on Gigayear timescales after formation including the effects of cooling and contraction, atmospheric escape, bloating, and stellar tides. After a presentation of the model, we will present some of the key first results of the model focussing in particular on the diversity of expected planetary system architectures in the Galaxy.

L. Mishra (University of Bern & Geneva, Switzerland)
E-mail: lokesh.mishra@space.unibe.ch

Title: Characterizing architecture of planetary system at the system level: comparison of Bern Model with Kepler observations, system level metrics, and role of PLATO (C)

Tuesday, 15:20-15:40

Abstract:
In this contribution, I discuss the peas in a pod trend observed in the architecture of planetary systems. Kepler observations have indicated towards the existence of several trends in the architecture of Kepler systems, akin to peas in a pod. Neighbouring planets tend to have similar sizes, mass and are evenly spaced. Adjacent planets show size/mass ordering (outer planet is larger). Large planets tend to have wider orbital spacing, while smaller planets tend to be tightly packed (Weiss et al. 2018, 2020, Millholland et. al. 2017).

First, we are intersted in understanding whether theoretically simulated planetary systems reproduce these observations? Using synthetic planetary systems from the Bern Model and a new code "KOBE", which extensively accounts for the geometrical limitations of the transit method and detection biases of Kepler, theory is compared with observations(Mishra et. al. in prep., Emsenhuber et. al. 2020a,b). The comparison shows theoretical systems show the peas in a pod architecture trend, in good agreement with observations. I discuss:
a) role of detection biases on these trends, and
b) theoretical scenarios which could explain these trends.

Second, we want to focus our investigations on system architecture at the system level. So far, the approach to analyse these trends, in current studies, is limited to a population level study, using correlation coefficients (exceptions are the works of Alibert 2019 and Gilbert & Fabrycky 2020). These methods, however, are not suitable to analyse the architecture of any one system. To this end, I develop new metrics which allow the architecture of a single system to be characterized. This novel method allows:
a) investigation and quantifiable analysis of the architecture of a single system,
b) comparison of the architecture of different systems,
c) unification of architecture trends,
d) extension of the peas in a pod trend, and
e) link system architecture to initial conditions, among others.

I present the above implications of the new metrics by applying them to the synthetic populations of planetary systems from the Bern Model and observed exoplanets. Some of the results of this work are:
a) extension of peas in a pod: in addition to similarity and ordering, systems also exhibit anti-ordering,
b) unification of peas in a pod: the size trends emerge from the mass trends, and the spacing trend, potentially, emerges from the mass and packing trends, and
c) correlation of system architecture with stellar metalicity: stars with low metallicity tend to have systems which exhibit similarity, while stars with high metalicity can have systems which are ordered/anti-ordered.

Third, I discuss how the findings of PLATO will take us forward with our understanding of system architectures. These include understanding the system architecture as function of stellar types, influence of extended parameter space (longer periods and shorter radii), connecting system architecture with stellar age, among others.

A. Petit (Lund Observatory, Sweden)
E-mail: antoine.petit@astro.lu.se
Title: On the spacing of tightly packed systems (C)

Tuesday, 16:20-16:40

Abstract:
Previous transit missions have revealed the existence of numerous multi-planetary systems packed close to their stability limit. They also present a surprising intra-system uniformity in radius and orbital spacing. This feature likely emerges from the formation and dynamical history of the system. Understanding it in detail is thus key to constrain our planet formation scenarios. While the stability limit has been known empirically for decades, no theoretical explanation was proposed yet. I present a mechanism driving the instability of tightly packed system. Based on the chaotic diffusion along the network of three-planet resonances, it reproduces quantitatively the timescale of instability obtained numerically over several order of magnitudes in time and planet-to-star mass ratios. PLATO being the next large long-baseline transit survey, it will likely discover hundreds or more of such tightly packed systems. I discuss the observational implications of this model, in particular the expected differences between Super-Earths and terrestrial planet systems.

S. Poon (Queen Mary University of London, UK)
E-mail: s.t.s.poon@qmul.ac.uk

Title: On the origin of the eccentricity dichotomy displayed by compact super-Earths: dynamical heating by cold giants (C)

Tuesday, 16:40-17:00

Abstract:
Recent analyses of Kepler exoplanet data have reported a dichotomy in the eccentricity distribution displayed by systems where a single planet transits compared with that displayed by multi-planet systems. In this talk, I will present an N-body simulation study that examines the hypothesis that the dichotomy has arisen because inner systems of super-Earths are frequently accompanied by outer systems of giant planets that can become dynamically unstable and perturb the inner systems. Different from previous studies, the outer giants that we consider have masses between those of Neptune and Saturn, and are centred on orbital radii between 2 to 10 au, placing them below the present RV detection threshold. Our results show that the observed eccentricity dichotomy can be reproduced by a subset of the N-body simulations when they are synthetically observed, and that the multiplicity distribution of the Kepler systems can also be approximately reproduced. Our study suggests that an understanding of the observed orbital and physical properties of the compact systems of super-Earths discovered by Kepler, and which will be discovered by PLATO in the future, require holistic modelling that couples the dynamics of both inner and outer systems of planets during and after the epoch of formation.

V. Adibekyan (Instituto de Astrofísica e Ciências do Espaço (IA), Portugal)
E-mail: vadibekyan@astro.up.pt

Title: Observational evidence of the compositional link between rocky planets and their hosts (C)

Tuesday, 17:00-17:20

Abstract:
Because of their common origin, it is expected (or assumed) that the composition of planet building blocks should (to a first order) correlate with stellar atmospheric composition, especially for refractory elements. In fact, information on the relative abundance of refractory and major rock-forming elements such as Fe, Mg, Si are commonly used to improve interior estimates for terrestrial planets (e.g. Dorn et al. 2015; Unterborn et al. 2016) and has even been used to estimate planet composition in different galactic populations (Santos et al. 2017). However, there is no direct observational evidence for the aforementioned expectation/assumption and was even recently questioned by Plotnykov & Valencia (2020).
By using the largest possible sample of precisely characterized low-mass planets and their host stars, we show that the composition of the planet building blocks indeed correlates with the properties of the rocky planets. This result can bring important implications for the future modelling of exoplanet composition with missions like PLATO.

L. Weiss (University of Hawaii, USA)
E-mail: weisslm@hawaii.edu
Title: Planet Interiors and Architectures: Lessons from Kepler and TESS (C)

Tuesday, 17:20-17:40

Abstract:
The physical and orbital properties of exoplanets allow us to place the Solar system—and its formation history—in a galactic context. In particular, multi-planet systems are natural laboratories in which planets form around the same star and within the same protoplanetary disk, offering a controlled environment for studying planet formation. Although the NASA Kepler and TESS Missions have discovered hundreds of multi-planet systems containing small, potentially rocky planets, our ability to test planet formation theories is limited by an incomplete census and characterization of planets in these systems. My talk will illustrate lessons learned from studying systems with multiple small transiting planets identified by the Kepler and TESS missions, drawing on information from Gaia, transit timing variations, and radial velocity follow-up. I will highlight strategies consistent with the PLATO Mission goal of understanding small planet interiors and the architectures of the systems in which they reside.

C. Dorn (University of Zürich, Switzerland)
E-mail: cdorn@physik.uzh.ch
Title: Diversity of Super-Earth (I)

Wednesday, 14:00-14:30

Abstract:
The increasing number of newly discovered extrasolar planets reveal a remarkable diversity in planet sizes and mean densities. Among the most frequently occurring planets are super-Earths and mini-Neptunes, whose interiors are largely unknown. Detailed interior characterization is challenging since data are few and have significant uncertainties. Given data of mass and radius alone, many interiors can be modelled and it is key to make additional constraints available. With the focus on Super-Earths, I will discuss a range of additional constraints that help to improve interior estimates, including stellar abundances, stellar XUV irradiation and age. For the data of mass and radius, I will discuss what data precision is needed in order to better constrain specific interior properties.

J. Owen (Imperial College London, UK)
E-mail: james.owen@imperial.ac.uk
Title: The close-in exoplanet population in time (I)

Wednesday, 14:30-15:00

Abstract:
Evolutionary models for close-in super-earths/sub-neptunes indicate the that the population has evolved significantly over its billion-year history. This evolution is primarily driven by thermal contraction and escape from a planet's primordial H/He envelope. Using the currently observed, and "evolved" exoplanet population I will discuss what evolutionary models predict in terms of the exoplanet population through time and what information can be extracted from observations of young planets.

O. Mousis (Laboratoire d'Astrophysique de Marseille, France)
E-mail: olivier.mousis@lam.fr

Title: Irradiated ocean planets bridge super-Earth and sub-Neptune populations (C)

Wednesday, 15:00-15:20

Abstract:
Small planets ($\sim$1--3.9 $\Rearth$) constitute more than half of the inventory of the 4000-plus exoplanets discovered so far. Smaller planets are sufficiently dense to be rocky, but those with radii larger than $\sim$1.6 $\Rearth$ are thought to display in many cases hydrogen/helium gaseous envelopes up to $\sim$30\% of the planetary mass. These low-mass planets are highly irradiated and the question of their origin, evolution, and possible links remains open. Here we show that close-in ocean planets affected by greenhouse effect display hydrospheres in supercritical state, which generate inflated atmospheres without invoking the presence of large hydrogen/helium gaseous envelopes. We present a new set of mass-radius relationships for ocean planets with different compositions and different equilibrium temperatures, which are found to be well adapted to low-density sub-Neptune planets. Our model suggests that super-Earths and water-rich sub-Neptunes could belong to the same family of planets, i.e. hydrogen/helium-free planets, with differences between their interiors simply resulting from the variation in the water content.

F. Otegi (University of Geneva & University of Zürich, Switzerland)
E-mail: jonfr17@gmail.com
Title: Internal characterization of super-Earths and sub-Neptunes (C)

Wednesday, 15:20-15:40

Abstract:
In this work we aim to study several aspects that affect the internal characterization of super-Earths and sub-Neptunes: observational uncertainties, location on the M-R diagram, impact of additional constraints such as bulk abundances or irradiation, and model assumptions.
We used a full probabilistic Bayesian inference analysis that accounts for observational and model uncertainties. We employed a nested sampling scheme to efficiently produce the posterior probability distributions for all the planetary structural parameter of interest. We included a structural model based on self-consistent thermodynamics of core, mantle, high-pressure ice, liquid water, and H-He envelope.
Regarding the effect of mass and radius uncertainties on the determination of the internal structure, we find three different regimes: below the Earth-like composition line and above the pure-water composition line smaller observational uncertainties lead to better determination of the core and atmosphere mass, respectively; and between these regimes internal structure characterization only weakly depends on the observational uncertainties. We also find that using the stellar Fe/Si and Mg/Si abundances as a proxy for the bulk planetary abundances does not always provide additional constraints on the internal structure.
Finally we show that small variations in the temperature or entropy profiles lead to radius variations that are comparable to the observational uncertainty. This suggests that uncertainties linked to model assumptions can eventually become more relevant to determine the internal structure than observational uncertainties.

N. Marounina (University of Chicago, USA)
E-mail: nmarounina@uchicago.edu
Title: Are Water Worlds Hot and Steamy or Cold and Icy? (C)

Wednesday, 16:10-16:30

Abstract:
Water worlds are water-rich (>1% water by mass) exoplanets the did not manage to accrete or retain hydrogen-helium nebular gas. To date, studies of the interior structure of water world exoplanets have either assumed that the planets are cold and icy (with most of their water condensed in high pressure ices, like scaled-up versions of Jupiter's moon Ganymede) or that the planets are hot and steamy (with most of their water in extended envelopes of vapor and supercritical steam). We combine models of planet interior structure, phase equilibria, and atmospheric radiative transfer to simulate the post-accretion evolution of water world exoplanets. We apply these models to delineate the regions of planet parameter space (i.e., orbital separation, planet mass, and volatile mass fraction) within which planets are likely to remain hot and steamy or cool sufficiently to form high pressure ice mantles and/or liquid water oceans. Our model predictions have important implications for both the habitability of water worlds (whether or not they can host liquid water oceans) and their observable characteristics (e.g., apparent transit radius, mean planet density, and atmospheric spectra).

J. Haldemann (University of Bern, Switzerland)
E-mail: jonas.haldemann@space.unibe.ch
Title: AQUA: A Collection of H2O Equations of State for Planetary Models (C)

Wednesday, 16:30-16:50

Abstract:
Due to its abundance in the universe and its chemical properties, water is a key component in planetary models. It plays a major role during the formation and evolution of planets and at the same time it is thought to be a key ingredient in the emergence of life on Earth. Given its complex phase diagram, it is very challenging to model the properties of water over the large pressure and temperature ranges where water could occur on other planets. But a detailed description is crucial to properly characterize planets, given the increased accuracy of instruments like ESPRESSO or CHEOPS or the upcoming PLATO mission. In Haldemann et al. (2020) we presented AQUA a collection of equations of state of water, spanning a very wide range from 0.1 Pa to 400 TPa and 150 K to 10^5 K, which can be used to model the interior of planets. In this talk we show how the equation of state is constructed and quantify its impact when characterizing exoplanets. We also compare against other equations of state commonly used in the field, like ANEOS or QEOS.

Reference: Haldemann et al. (2020), Astronomy & Astrophysics (in press), https://arxiv.org/abs/2009.10098

L. Rogers (University of Chicago, USA)
E-mail: larogers@uchicago.edu

Title: Constraining Water World Populations from Exoplanet demographics with PLATO (C)

Wednesday, 16:50-17:10

Abstract:
Exoplanets are revolutionizing planetary science by enabling statistical studies of a large number of planets. Identifying sub-populations and trends in the planet mass-radius distribution is a promising avenue to break some of the degeneracies plaguing exoplanet bulk composition inferences. In this talk, I will present a thorough investigation of the population-level degeneracies that persist when interpreting a statistical sample of planet mass, radius, and orbital period measurements. Extending the hierarchical Bayesian approach to exoplanet demography from Neil & Rogers (2020), we use mixture models to describe the exoplanet mass-radius-period distribution, allowing for the possibility of multiple compositional sub-populations of planets (including planets with gaseous envelopes, evaporated rocky cores, evaporated icy cores, intrinsically rocky planets, and intrinsically icy planets). We present current Kepler-based constraints on the overall contribution of each compositional sub-population to the total planet distribution, and offer projections for PLATO’s capabilities to distinguish between water worlds and planets with primordial envelopes.

L. Acuña (LAM, Aix-Marseille University, France)
E-mail: lorena.acuna@lam.fr
Title: Characterisation of the hydrospheres of TRAPPIST-1 planets (C)

Wednesday, 17:10-17:30

Abstract:
Ongoing space missions (CHEOPS, TESS) are unveiling a wide variety of densities for low-mass exoplanets. This includes sub-Neptunes, whose low densities can be explained with the presence of a volatile-rich layer. Water is one of the most abundant volatiles, after H and He, that can be in the form of different phases depending on the planetary surface conditions. Therefore, it is required to develop models that incorporate accurate descriptions of the properties of water at its different phases. We present an interior structure model that includes steam, supercritical and condensed phases within a Bayesian retrieval scheme. This approach allows us to constrain the planetary composition of multiplanetary systems that present both warm and temperate planets, such as TRAPPIST-1. We find that the two inner planets are hot enough to present water in supercritical phase with steam atmospheres, being extended enough to be probed with space missions such as PLATO and JWST. In addition, we are able to account for the densities of all planets in the system with a single Fe/Si mole ratio. These new water estimates enable us to distinguish a transition of close-in, water-poor planets to outer, water-rich planets. All planets except planet d follow a trend between water content and semi-major axis. We propose alternatives to explain this deviation from the trend.

M. Schlecker (MPIA, Germany)
E-mail: schlecker@mpia.de
Title: A compositional link between warm super-Earths and cold Jupiters (C)

Wednesday, 17:30-17:50

Abstract:
Recent demographic studies have suggested a positive correlation between the occurrence rates of inner super-Earths and outer giant planets, challenging some established planet formation theories. We set out to test this trend by simulating a large number of multi-planet systems in a core accretion context and confirm the correlation, albeit weaker than proposed.

A peculiar trend emerges when we associate the disk properties of our model with the bulk composition of inner low-mass planets: in disks of moderate solid content (~100 Mearth), super-Earths form from icy material beyond the water ice line and migrate to observable distances. No giant planets are formed. On the other hand, in massive disks (~>200 Mearth), dry super-Earths form on close orbits and are frequently accompanied by an outer gas giant.

This results in the testable hypothesis that high-density inner super-Earths are proxies for cold Jupiters in the same system. I will discuss how observational confirmation of this prediction has the power to constrain central open questions in contemporary planet formation theory, ranging from efficiency of pebble accretion to planet migration.

R. Mardling (Monash University, Australia)
E-mail: rosemary.mardling@monash.edu
Title: Outcomes of convergent migration: why are so many systems not in resonance (C)

Thursday, 14:00-14:20

Abstract:
The period ratio distribution of adjacent pairs of planets is fairly uniform, with some enhancement near first-order commensurabilities, especially 3:2. I will present a new formalism which allows one to determine the outcome of convergent migration given planet-to-star mass ratios, together with migration and eccentricity-damping timescales. What does it actually mean to be ``in resonance''? What if one or both resonance angles circulate? Under what disk conditions is true resonance capture possible? What does the present state of a system tell us about formation conditions?

M. Ali-Dib (iREx, University of Montreal, Canada)
E-mail: mmalidib@gmail.com
Title: Halting Super-Earths envelope accretion and predictions for PLATO (C)

Thursday, 14:20-14:40

Abstract:
Super-Earths are by far the most dominant type of exoplanet, yet their formation is still not well understood. In particular, planet formation models predict that many of them should have accreted enough gas to become gas giants. Here we examine the role of the protoplanetary disk in the cooling and contraction of the protoplanetary envelope. In particular, we investigate the effects of 1) the thermal state of the disk as set by the relative size of heating by accretion or irradiation, and whether its energy is transported by radiation or convection, and 2) advection of entropy into the outer en- velope by disk flows that penetrate the Hill sphere, as found in 3D global simulations. We find that, at 5 and 1 AU, this flow at the level reported in the non-isothermal simulations where it penetrates only to ~ 0.3 times the Hill radius has little effect on the cooling rate since most of the envelope mass is concentrated close to the core, and far from the flow. On the other hand, at 0.1 AU, the envelope quickly becomes fully- radiative, nearly isothermal, and thus cannot cool down, stalling gas accretion. This effect is significantly more pronounced in convective disks, leading to envelope mass orders of magnitude lower. Entropy advection at 0.1 AU in either radiative or convective disks could therefore explain why super-Earths failed to undergo runaway accretion. These results highlight the importance of the conditions and energy transport in the protoplanetary disk for the accretion of planetary envelopes.

We finally make predictions for the Sub-Neptunes and Jupiter mass planets occurrence rate for Plato.

Papers:
Ali-Dib, M., Cumming, A., & Lin, D.N.C. (2020a) MNRAS 494, Issue 2, pp.2440-2448
Ali-Dib, M., Cumming, A., & Lin, D.N.C. (2020b) MNRAS, Submitted

J. Venturini (ISSI Bern, Switzerland)
E-mail: julia.venturini@issibern.ch
Title: The origin of the radius valley: hints from formation and evolution (C)

Thursday, 14:40-15:00

Abstract:
The existence of a Radius Valley in the Kepler size distribution stands as one of the most important observational constraints to understand the origin and composition of exoplanets with radii between that of Earth and Neptune. In this presentation, we provide insights into the existence of the Radius Valley from, first, a pure formation point of view, and second, a combined formation-evolution model. We run global planet formation simulations including the evolution of dust by coagulation, drift and fragmentation; and the evolution of the gaseous disc by viscous accretion and photoevaporation. A planet grows from a moon-mass embryo by either silicate or icy pebble accretion, depending on its position with respect to the water ice line. We include gas accretion, type-I/II migration and photoevaporation driven mass-loss after formation. We perform an extensive parameter study evaluating a wide range in disc properties and embryo's initial location. We find that due to the change in dust properties at the water ice line, rocky cores form typically with ~3 ME and have a maximum mass of ~5 ME, while icy cores peak at ~10 ME, with masses lower than 5 ME being scarce. When neglecting the gaseous envelope, the formed rocky and icy cores account naturally for the two peaks of the Kepler size distribution. The presence of massive envelopes yields planets more massive than ~10 ME with radii above 4 RE. While the first peak of the Kepler size distribution is undoubtedly populated by bare rocky cores, the second peak can host half-rock/half-water planets with thin or non-existent H-He atmospheres. Some additional mechanism inhibiting gas accretion or promoting envelope-mass loss should operate at short orbital periods to explain the presence of ~10-40 ME planets falling in the second peak of the size distribution.

R. Luque (Instituto de Astrofisica de Canarias, Spain)
E-mail: rluque@iac.es
Title: Testing radius valley emergence models in M dwarfs (C)

Thursday, 15:00-15:20

Abstract:
The dearth of small planets in the radius distribution known as the radius gap is one of the most surprising results of the Kepler mission. Originally studied for FGK stars, the TESS mission is now extending the sample towards low-mass stars. Moreover, most of the TESS planet candidates in this regime are amenable to characterization with precise radial velocities, which allow us to compute the bulk densities and estimate their composition and interiors. In this talk, I will review the current efforts to measure the bulk densities of small planets orbiting low-mass stars, with a special focus on particular systems found inside the radius valley, for which their compositions are difficult to infer, but very valuable to test what mechanisms are efficient in sculpting the radius valley in low-mass stars.

J. Lillo-Box (Center for Astrobiology, Spain)
E-mail: jlillo@cab.inta-csic.es
Title: Characterization of three special multi-planetary systems: LHS1140, K2-32 and K2-233 (C)

Thursday, 15:20-15:40

Abstract:
The diverse architectures of planetary systems found so far continue to amaze our community. As new high-precision radial velocity instruments allow more in depth characterization of the mass of its rocky components, the study of the planetary interiors becomes more and more reliable. Also, these long-term monitoring campaings, together with space-based missions, allow us to better understand their architectures and feed formation and evolution models. In this talk, I will present our recent results on three outstanding planetary systems and their impact for the PLATO mission. K2-32, a solar system in miniature showing the same architecture than our own but in a more compact configuration. K2-233, a young system where we confirmed the first rocky worlds around a star younger than 1 Gyr-old. And finally, LHS 1140, a system we have intensively observed with ESPRESSO to characterize the interior structure of its habitable zone rocky planet and found hints for additional interesting and exciting components. This three systems will be put in context of the PLATO mission and how it will further help us understanding such complex architectures.

M. He (The Pennsylvania State University, USA)
E-mail: myh7@psu.edu

Title: RV-search for circumbinary planets (C)

Thursday, 16:10-16:30

Abstract:
Kepler's multi-transiting planet systems provide valuable insights into the correlations within planetary systems and their architectures if the detection biases are properly accounted for. With a forward model for the primary Kepler mission (SysSim), we can robustly assess underlying trends in the distribution of planets in terms of their sizes, orbital spacings, and occurrence with spectral type. I will present an advanced statistical model to show that a population of systems at the angular momentum deficit (AMD) stability limit can reproduce many features of the observed population. This AMD model naturally predicts that systems with intrinsically more planets have lower eccentricities and mutual inclinations than those with fewer planets. I will show that there is evidence for these trends with multiplicity in the Kepler distributions of circular-normalized transit durations and transit duration ratios. I will also revisit the observed "peas in a pod" trends and show that the preferences for the ordering of planets in increasing size and for their uniform spacings cannot be explained by detection biases, and are even more extreme than our simple clustering in periods and planet sizes. Finally, I will discuss how our simulated planet catalogs can be used to make predictions for additional non-transiting companions conditioned on systems with transiting planets, such as those observed from the TESS mission, to aid RV follow-up observations.

M. Standing (University of Birmingham, UK)
E-mail: mxs1263@bham.ac.uk
Title: RV-search for circumbinary planets (C)

Thursday, 16:30-16:50

Abstract:
Circumbinary planets, those which orbit both stars of a binary system, challenge our understanding of planet formation and orbital evolution. Planet formation around binary stars was thought to be difficult, and therefore these circumbinary planets were confined to the realm of science-fiction. Yet during its lifetime, Kepler discovered several of these objects. Since the discovery of Kepler-16b in 2011, 13 circumbinary planets have been discovered in 11 systems by transit missions. Despite the radial velocity method being the most established technique for planet detection, no circumbinary planets have been detected by radial velocity measurements to date. Understanding how these planets form and how common they are can provide us with a unique insight into planet formation in these extreme systems. PLATO will likely detect transiting circumbinary planet candidates, however, radial velocities would be required to confirm them.

I will present the current status of the BEBOP (Binaries Escorted By Orbiting Planets) RV project, after two years of survey using the HARPS instrument at ESO. Although our sample is limited, we have identified 16 candidate signals consistent with circumbinary companions at this stage. They represent a higher number than we anticipated when we initiated the survey. I will outline our methods and review the various candidates that we have. This includes one of our most interesting candidates, a second outer circumbinary planet in EBLM J0608-59 (TOI-1338), where TESS has recently identified a 95 day circumbinary planet. If this candidate is confirmed, it would make EBLM J0608-59 the second multi-planetary circumbinary system ever discovered.

B. Bitsch (MPIA, Germany)
E-mail: bitsch@mpia.de

Title: Chemical composition of giant exoplanets due to pebble, planetesimal and gas accretion (C)

Thursday, 16:50-17:10

Abstract:
We investigate whether the combination of pebble- and planetesimal accretion will help to explain the enrichment of heavy elements in giant exoplanets. To achieve this goal, we perform semi analytical 1D models of protoplanetary disks including the treatment of viscous evolution and heating, pebble drift and simple chemistry to grow planets from embryos to Jupiters by accretion of pebbles, planetesimals and gas while they migrate through the disc. The treatment of pebble- and planetesimal accretion simultaneously unveils that measured compositions mainly depend on the amount of heavy elements polluted in to the gas by the evaporation of pebbles that is subsequently accreted by the planets.

K. Schlaufmann (Johns Hopkins University, USA)
E-mail: kschlaufman@jhu.edu

Title: The Impact of PLATO-based Planet Occurrence and Mass-radius Analyses on the Terrestrial-mass Planet Formation Timescale (C)

Thursday, 17:10-17:30

Abstract:
Space-based transit missions like Kepler have conclusively shown that small, long-period planets are more common than large, short-period planets. These small, long-period planets are therefore the most common outcome of planet formation currently known in the Galaxy. Nevertheless, they are underrepresented in mass--radius and mass--density relations because of the biases of the transit technique and the difficulty of Doppler-based mass inferences for low-mass, long-period planets. Occurrence-weighted mass--radius relations that appropriately account for the increase in planet occurrence with period have shown that the typical planets with masses M_p in the range 1 M_Earth <~ M_p <~ 20 M_Earth have a few percent of their masses in H/He atmospheres. The common presence of H/He atmospheres around low-mass planets is the expected outcome of planet formation that finished before protoplanetary disk dissipation. In contrast, the Earth's core finished forming more than 40 million years after the dawn of the solar system. PLATO can contribute to a deeper understanding of the most common outcome of planet formation by focusing on the occurrence of and TTV-based mass inferences for planets with radii R_p in the range 1 R_Earth <~ R_p <~ 3 R_Earth orbiting solar-type stars with orbital periods P >~ 50 days. If at P >~ 50 days low-mass planets with R_p ~ 2 R_Earth are more common than low-mass planets with R_p ~ 1 R_Earth, then low-mass planet formation occurred slowly in the solar system for some reason that will need to be explained by more sophisticated models of planet formation.

L.M. Serrano (University of Torino, Italy)
E-mail: luisamaria.serrano@unito.it
Title: The architecture of planetary systems hosting ultra-short period planets (C)

Thursday, 17:30-17:50

Abstract:
Ultra-short period (USP) small planets have orbital periods shorter than about one day and form a class of objects that usually falls below the photo-evaporation gap. They were initially thought to be stripped cores of hot-Jupiters that lost their atmospheres due to photo-evaporation. However, the lack of correlation between high metallicity and occurrence of USP planets suggests a different formation scenario: USP planets might either have formed in situ or might be naked cores of Neptune-like planets, that formed at large orbital distances from their host star and then migrated inwards. In this talk, I will summarize the properties of USP small planets, focusing on the architecture of the planetary systems they belong to. I will also report on the discovery of a new USP planet transiting a late K-type dwarf, that hosts 2 additional non-transiting planets, close to the 1:4 mean motion resonance. I will put the system in context and describe the formation process that better suits its architecture.