# PLATO Mission Conference 2017

## Tuesday 5th September

08:30-10:30 The PLATO Mission

08:30
Don Pollacco (University of Warwick)
**Welcome**

08:35
Ana Heras (ESA)
**PLATO, the M3 mission in ESA's Cosmic Vision programme**

08:50
Heike Rauer (DLR)
**PLATO Science and Mission Consortium**

09:20
Bengt Johlander (ESA)
**The PLATO satellite – ESA perspective**

09:35
Mario Schweitzer (OHB)
**The PLATO satellite – payload consortium perspective**

09:50
Stéphane Udry (University of Geneva)
**PLATO ground-based follow-up observations**

10:10
Giampaolo Piotto (University of Padova)
**The PLATO Input Catalogue**

11:00-12:30 Exoplanets 1

11:00
Suzanne Aigrain (University of Oxford)
**Transit Detection in presence of stellar noise** *(invited)*

11:25

Jon Jenkins (NASA Ames Research Center)

**Synergies between the Kepler, K2 and TESS Missions with the PLATO Mission** *(invited)*

Two transit survey missions will have been flown by NASA prior to the launch of ESA's PLATO Mission in 2026, laying the groundwork for exoplanet discovery via the transit method. The Kepler Mission, which launched in 2009, collected data on its 100+ square degree field of view for four years before failure of a reaction wheel ended its primary mission. The results from Kepler include 2300+ confirmed or validated exoplanets, 2200+ planetary candidates, 2100+ eclipsing binaries. Kepler also revolutionized the field of asteroseismology by measuring the pressure mode oscillations of over 15000 solar-like stars spanning the lifecycle of such stars from hydrogen-burning dwarfs to helium-burning red giants. The re-purposed Kepler Mission, dubbed K2, continues to observe fields of view in and near the ecliptic plane for ~80 days each, significantly broadening the scope of the astrophysical investigations as well as discovering an additional 156 exoplanets to date. The TESS mission will launch in 2017 to conduct an all-sky survey for small exoplanets orbiting stars 10X closer and 100X brighter than Kepler exoplanet host stars, allowing for far greater follow-up and characterization of their masses as well as their sizes for at least 50 small planets. Future assets such as James Webb Space Telescope, and ground-based assets such as ESO's Very Large Telescope (VLT) array, the Extremely Large Telescope (ELT), and the Thirty Meter Telescope (TMT) will be able to characterize the atmospheric composition and properties of these small planets. TESS will observe each 24° X 96° field of view for ~30 days and thereby cover first the southern and then the northern hemisphere over 13 pointings during each year of the primary mission. The pole-most camera will observe the James Webb continuous viewing zone for one year in each hemisphere, permitting much longer period planets to be detected in this region. The PLATO mission will seek to detect habitable Earth-like planets with an instrument composed of 26 small telescopes in several 2232 deg2 FOVs with a range of observation durations over a mission lifetime of up to eight years. This paper summarizes the findings of the Kepler/K2 missions, previews the likely results from the TESS mission, and explores the lessons learned and to be learned from these prior missions that can be incorporated into the observation and data reduction strategy for the PLATO Mission so as to maximize the science return.

11:50

David Armstrong (University of Warwick)

**Automatic planet candidate vetting in the PLATO era**

Surveys for transiting planets produce candidate signals at a far faster rate than true planets. Planets in the sample must be selected for further follow-up observations, while avoiding spending limited telescope time on false positive signals such as contaminating eclipsing binaries and instrumental artefacts. This process typically involves human inspection, a time intensive task with hard to quantify biases. Recent methods have turned to the field of machine learning in an attempt to automate the process, demonstrating the plausibility of several methods on surveys such as Kepler, K2 and NGTS. I will highlight developments in 'autovetting' for space and ground based surveys, showing that not only can the best candidates be found quickly and with minimal human intervention, but that there is the potential to simultaneously derive true posterior probabilities for the nature of a candidate signal, in the theme of published algorithms such as PASTIS and BLENDER. For PLATO such methods will be crucial, to deal with the large number of targets and hence candidates that will be produced. Efficiently selecting the best candidates will minimise time wasted following up false positive signals, while allowing rigorous determination of planet occurrence rates through limiting human participation in the planet search pipeline.

12:05

Christopher Watson (Queen's University Belfast)

**Unearthing Earth analogues hidden in noise: Clues from the HARPS-N solar telescope?**

Stellar surface inhomogeneities (manifestations of which include spots, plage, convective blueshift suppression, and granulation) induce radial velocity (RV) perturbations that can mask or even mimic the Doppler wobble effect induced by an orbiting planet. Understanding and correcting for this stellar noise is crucial for pushing exoplanet RV detection limits towards Earth analogue exoplanet confirmation using the next generation of stabilised spectrographs. In this talk I will present some highlights from the HARPS-N solar telescope consortium. This telescope feeds full-disk sunlight into the HARPS-N spectrograph, and thus enables observing the Sun as a star with high RV precision. In particular, I will show that the manifestations of solar activity can be tracked in individual absorption lines even on approach to the minimum of the solar cycle. Such signatures are also clearly visible in HARPS spectra of alpha Cen b. The ability to trace such signals in stellar spectra may provide an important route to directly tracking the impact of stellar noise, and thus developing optimal correction techniques to yield the true stellar RVs in the future.

12:20

Shay Zucker (Tel Aviv University)

**Shallow Transits - Deep Learning**

Deep learning is currently the trendiest progress in the field of Artificial Intelligence. Deep learning techniques have proven success in varied fields, such as image processing, speech recognition and even drug discovery. Specifically, it can provide new hope in needle-in-a-haystack problems, such as detection of very faint signals in the presence of noise. Detection of transiting terrestrial planets in the presence of stellar-activity red noise is one such problem. The non-linear nature of deep learning renders it completely different from traditional techniques. The talk will give a very short tutorial of what deep learning is, and how it can be applied to detect and analyze transiting terrestrial planets. Some very preliminary results of a pilot study will be presented.

## 13:35-15:30 Core Stellar Science 1

13:35

Margarida Salvador Cunha (IA/University of Porto)

**Current performance of seismic diagnostics and stellar parameter determination** *(invited)*

I will discuss different procedures to infer stellar fundamental parameters, namely, the stellar mass, radius, and age, from the analysis of combinations of seismic and non-seismic data. The performance of these procedures will be illustrated through the presentation of results obtained for simulated and space-based data. In that context, I will also briefly discuss additional seismic diagnostics that are of interest in the context of the characterization of exoplanetary systems

14:05
Othman Benomar (NYUAD, UAE)
**Seismic measurements for main sequence stars and subgiants** *(invited)*

Due to asteroseismology, important steps forward have been made on our understanding of the physics of Sun-like stars. This was only possible by analysing the exquisite data from space instruments such as CoRoT and Kepler. Meanwhile, new methods have been developed to measure precisely properties of the stellar pulsations (such as frequency and rotational splitting).

Here, I will review some of the methods that are currently used to determine the characteristics of the pulsation of main-sequence and sub-giant stars. I will also discuss the assumptions made on the current fit models.

14:25
Martin Bo Nielsen (New York University Abu Dhabi)
**Limits on radial differential rotation in Sun-like stars from parametric fits to oscillation power spectra**

Rotational shear in Sun-like stars is thought to be an important ingredient in models of stellar dynamos. So far, research has focused on the more easily measured latitudinal differential rotation, but little progress has been made on constraining the radial part of the differential rotation in Sun-like stars. Using asteroseismic measurements of rotation we apply a new technique to constrain the radial shear in five Sun-like stars observed by Kepler. We apply a parametric model of the radial rotation rate which allows for two different rotation rates, one in the radiative interior and one in the convective envelope. This model is used in a fit to the full oscillation spectrum of each of the five stars. Since rotation can also be measured from starspot signals in these stars, we apply a prior on the convective envelope rotation rate based on the rotation rate measured from surface features. Using this approach we find that the interior rotation rate does not differ from the envelope by more than approximately +/-30%.

14:40
Tim White (Aarhus University)
**Observing the brightest stars**

The brightest stars to be observed by PLATO will provide the most outstanding opportunities to combine complimentary observations to precisely characterize stars and their planets. Although saturation of PLATO's cameras will pose a challenge for these stars, our experiences with the CoRoT, Kepler and K2 missions have shown we will still be able to obtain photometry precise enough to detect stellar variability and transiting exoplanets. I will discuss recent efforts using Kepler and K2 observations of naked-eye stars to illustrate the potential of PLATO. In particular, I will discuss the cases of HD 185351, a red giant where the combination of asteroseismology, spectroscopy, and interferometry has been used to constrain mixing from the convective core during the main sequence, and K2 observations of the brightest members of the Pleiades star cluster.

14:55
Patrick Gaulme (New Mexico State University & Max Planck Institute for Solar System Research)
**Calibrating Asteroseismology with Multiple-Star Systems**

It is widely agreed that asteroseismology has become the most reliable way to infer global and internal properties of solar-like stars. It allows for measuring stellar masses and radii in a simple way, by comparing the oscillation properties of a given star to the Sun's. Since masses and radii lead to ages and distances, solar-like oscillators represent key tracers of stellar populations. However, a fundamental question that has not been addressed is the reliability of asteroseismic inference on solar-like oscillators, despite evidence that significant biases exist. The only way to calibrate asteroseismology is to compare asteroseismic masses and radii with independent estimates. Eclipsing binaries have become very popular as benchmarks for stellar physics, as they provide accurate ways to measure masses, radii, and distances. It is possible to determine the mass and radius of each component of a double-lined spectroscopic binary from measurements of eclipse photometry and radial velocities. It is also possible to measure the mass of stars belonging to eccentric binary systems [e.g., Welsh+11, ApJS 197, 4], and hierarchical triple systems [e.g., Borkovits+16, MNRAS 455, 4136]. Gaulme+16 (ApJ, 832, 121) led a preliminary study based on ten "Kepler" red giants that belong to eclipsing binaries and showed that asteroseismology overestimates masses of about 15% and radii of about 5%. For PLATO, it is fundamental to extensively calibrate solar-like asteroseismology, given its importance to determine properties of planetary systems and stellar populations. Eclipsing binaries, triple systems, and eccentric binaries are excellent way to do this, but not many systems are actually adequate to run such tests. In this presentation, I will expose a plan to reach that goal by the launch of the PLATO mission. This involves identifying of a set of at least 50 solar-like oscillators (from main-sequence to red-giant) in multiple-stars systems, from the CoRoT, Kepler, and K2 data, and forthcoming GAIA eclipsing-binary catalogue and TESS asteroseismic observations, as well as significant ground-based observational support, consisting of colour photometry and high-resolution spectroscopy.

15:10
Maurizio Salaris (ARI - Liverpool John Moores University)
**The structure and evolution of M dwarfs** *(invited)*

M dwarf stars are particularly promising to detect earth-sized planets in the habitable zone, and the characterization of M-dwarf stars is crucial to determine the parameters of their planetary systems.

This review will discuss the relevant physics of M dwarf stars, their modelling, recent work and open problems.

## 16:00-18:00 Complementary Science 1

16:00
Andrew Tkachenko (KU Leuven)
**Introduction to the PLATO Complementary Science Program**

16:30
Mark Gieles (University of Surrey)
**PLATO's capacity and opportunity for cluster studies** *(invited)*

17:00

Pierre Maxted (Keele University)

**Eclipsing binary stars with Kepler K2 - a foretaste of Plato complementary science**

Exoplanet discovery has driven the development of space-based photometry and efficient, stabilized high-resolution spectrographs that can be used to measure masses and radii to much better than 1% for stars in binaries showing well-defined eclipses. With Gaia parallaxes it will also be possible to obtain precise model-independent effective temperatures for many stars in eclipsing binary systems. In this talk I will show some results from a detailed study of eclipsing binary systems using Kepler K2 data and discuss the potential for testing and calibrating the next generation of stellar evolution models using the powerful combination of asteroseismology and eclipsing binary stars.

17:15

Andrea Miglio (University of Birmingham)

**Galactic Archaeology** *(invited)*

Deciphering the assembly history of the Milky Way is a formidable task, which becomes possible only if one can produce high-resolution chrono-chemo-kinematical maps of the Galaxy. Data from large-scale astrometric and spectroscopic surveys will soon provide us with a well-defined view of the current chemo-kinematical structure of the Milky Way, but will only enable a blurred view on the temporal sequence that led to the present-day Galaxy. As demonstrated by the (ongoing) exploitation of data from the pioneering photometric missions CoRoT, Kepler, and K2, asteroseismology provides the way forward: solar-like oscillating giants are excellent evolutionary clocks thanks to the availability of seismic constraints on their mass and to the tight age-initial-mass relation they adhere to. In this paper we identify five key outstanding questions relating to the formation and evolution of the Milky Way that will need precise and accurate ages for large samples of stars to be addressed, and we identify the requirements in terms of number of targets and the precision on the stellar properties that are needed to tackle such questions. By quantifying the asteroseismic yields expected from PLATO for red-giant stars, we demonstrate that these requirements are within the capabilities of the current instrument design, provided that observations are sufficiently long to identify the evolutionary state and allow robust and precise determination of acoustic-mode frequencies. This will allow us to harvest data of sufficient quality to reach a 10% precision in age. This is a fundamental pre-requisite to then reach the more ambitious goal of a similar level of accuracy, which will only be possible if we have to hand a careful appraisal of systematic uncertainties on age deriving from our limited understanding of stellar physics, a goal which conveniently falls within the main aims of PLATO's core science.

17:45

Susana Barros (Instituto de Astrofísica e Ciências do Espaço)

**Modeling stellar activity with Gaussian Processes**

With the increase of the precision of observations, stellar intrinsic variability is becoming the dominant limitation in the study and characterization of exoplanets. Stellar activity affects both the radial velocity measurements and the transit observations. To account for stellar activity one needs to use sophisticated correlated noise models such as Gaussian processes.

I will present some applications of Gaussian processes to model stellar variability in high precision photometric light curves. I will start with example of modelling activity with Gaussian processes to study phase curves. Then I will focus on exploring the effect of stellar granulation in transit observations and show that Gaussian processes can help un-bias the derived transit parameters.

# Wednesday 6th September

08:30-10:00 Planet-Star Interactions

08:30
Antoine Strugarek (CEA-DAp)
**Magnetic interactions between stars and close-in planets** *(invited)*

Close-in planets generally orbit in a sub-alfvénic stellar wind, where the perturbations they excite in the corona are able to travel upwind down to the stellar surface, and potentially induce observable phenomena. The effective connection between the planet and its host takes the form of two Alfvén wings. Depending on the topology of the planetary and stellar magnetic fields, on the rotation profile of the corona, and on the orbital parameters, it is possible that none, one, or the two of the Alfvén wings connect together the star and the planet.

I will explore the formation and sustainment of Alfvén wings in global three-dimensional simulations under the magneto-hydrodynamic formalism with the PLUTO code. I model globally the stellar wind of a typical cool star in which a close-in orbiting planet is introduced as a boundary condition. By varying the magnetic topologies of the planetary and stellar magnetic fields, I explore the variety of Alfvén wings that can develop and quantify the Poynting flux flowing through those wings. With an extensive set of simulations, I deduce scaling laws of the amount of magnetic energy such magnetic interactions can channel to the lower stellar corona, as well as the amount of angular momentum that can be exchanged between the two bodies due to magnetic torques. As a result, I parametrize the accessible energy available to modify the apparent magnetic activity of the star. I will also quantify the phase and latitude offsets that can be expected between the planetary subpoint on the stellar surface and the actual location where energy is deposited. I will conclude by showing some preliminary attempts to apply these results to the cases of more complex, non-axisymmetric topologies using of the observed magnetic fields of Kepler-78.

09:00
Theresa Lueftinger (University of Vienna)
**Evolution of stellar magnetic fields**

PLATO, with its main aims to detect habitable zone planets and characterise their host stars will provide unique space-quality data that will allow to assess stellar activity phenomena and their impact on the atmospheres and the magnetospheres of surrounding planets in great detail.

Stellar magnetism is the crucial driver of activity, ionization, photodissociation, chemistry and winds in stellar environments. Thus, it has an enormous impact on the atmospheres and the magnetospheres of surrounding planets. Modelling of stellar magnetic fields and their winds is extremely challenging, both from the observational and the theoretical points of view, and only big advances in observational instrumentation and a deeper theoretical understanding of magnetohydrodynamic processes in stars enable us to model stellar magnetic fields and their winds – and the resulting influence on surrounding exoplanets – in more and more detail.

The changing faces of stellar magnetism with spectral type and stellar evolution, and the triggered activity phenomena most likely cause a variety of conditions in favour - or against - the emergence of life on the surface of exoplanets – a centerpiece of present-day exoplanet research and key to the upcoming exoplanet mission PLATO.

We have initiated a research network (NFN): 'Pathways to Habitability - From Disks to Active Stars, Planets to Life', to address questions on the formation and habitability of environments in young, active stellar/planetary systems. In this presentation, we will discuss the work we are carrying out within this project and focus on how stellar (rotational) evolutionary aspects in relation to activity, magnetic fields and winds influence the erosion of planetary atmospheres in the habitable zone.

We will present recent results of our theoretical and observational studies based on Zeeman Doppler Imaging (ZDI), field extrapolation methods and wind simulations and will apply these results to non-thermal loss mechanisms in planetary atmospheres.

09:15
Luca Fossati (Space Research Institute, Austrian Academy of Sciences)
**Planetary atmospheric escape**

Atmospheric escape is a key component of planetary evolution, effectively shaping the observed exoplanet population. I will review the major observational and theoretical results gathered so far on the topic of exoplanet atmospheric escape, focusing particularly on (sub-)Neptune- and terrestrial-mass planets, which are most relevant for the PLATO mission. I will finally review the telescopes and instrumentation that are expected to be available at the time of PLATO science operations for follow-up observations aiming at the study of the, possibly escaping, upper atmosphere of planets discovered by PLATO.

09:30
Cilia Damiani (Max Planck Institute for Solar System Research)
**Modelling star-planet tidal interactions to constrain migration scenarios**

It is debated whether close-in giant planets can form in-situ and if not, which mechanisms are responsible for their migration. One of the observable tests for migration theories is the value of the obliquity. But after the main migration mechanism has ended, the combined effects of tidal dissipation and the magnetic braking of the star lead to the evolution of both the obliquity and the semi-major axis. I will present an improved model for the tidal evolution of the obliquity that only depends on global stellar parameters and includes the effect of magnetic braking in the framework of the double zone model.

Using known exoplanetary systems, this model is used to constrain the initial obliquity of a population of hot-Jupiters. However, mainly due to the poor constraint on the stellar ages, we cannot obtain constrains strong enough to firmly distinguish different migration theories. Major advances are thus expected with the results of the PLATO 2.0 mission, selected as the next M-class mission of ESA's Cosmic Vision plan, that will allow the complete characterization of host stars using asteroseismology, and an unprecedented precision on stellar ages.

09:45

Christiane Helling (University of St Andrews)

**Modelling Exo-Clouds: the element abundance challenge**

It is very unlikely that extrasolar planets do not have clouds. Even if we have no direct evidence for clouds on e.g. CoRot 7b or 55 Cnc e yet, basic physical and chemical considerations suggest the formation of clouds in such chemically active atmospheric gases. The clouds will, however, differ from what we might expect. For example, the giant gas planet HD189733b has an extensive cloud cover with a strong chemical inward-gradient, but the hot rocky super-Earth CoRot7b will have its clouds predominantly on the night side. In both cases, clouds effect the atmosphere's thermal structure by their opacity and by element depletion

Understanding cloud formation in exoplanets, Exo-Clouds, is one of the essential tasks in cool atmosphere modelling to harvest PLATO observations in full. Modelling cloud formation requires, beside a set of sensible equations, material data like element abundances. We will present recent studies of cloud and gas properties in metal-rich atmospheres like 55 Cnc e. We will focus on rocky planets to which we apply our kinetic cloud formation model.

## 10:30-12:30 Exoplanets 2

10:30

Antonio García Muñoz (Technische Universität Berlin)

**Exoplanet phase curves and their interpretation** *(invited)*

The brightness variations that occur during the out-of-transit phases of an exoplanet orbit provide unique insight into various aspects of an exoplanet, including its atmosphere. This insight is highly complementary to what is obtained during the transit. The increasing availability in recent years of phase curve data of unprecedented quality at optical and infrared wavelengths has prompted a rapid progress of this remote sensing technique. Looking towards the future, it is foreseen that the technique will mature even further as new space missions with enhanced capacities (collecting areas, time baselines, spectral coverage, etc.) become operational. In this talk, I will review the current status in the investigation of exoplanet phase curves, outline future expectations, and summarize what is needed both observationally and theoretically to fully exploit the potential of this technique.

10:50

Tiago Campante (University of Porto)

**Synergy between asteroseismology and exoplanet observations**

Over the past decade, space-based asteroseismology has played an important role in the characterization of exoplanet-host stars and their planetary systems. In this talk, I will review current key synergies between asteroseismology and exoplanetary science such as the precise determination of radii and ages of host stars, the measurement of spin-orbit alignment and its impact on hot-Jupiter formation theories, as well as orbital eccentricity determination via asterodensity profiling. I will conclude with an outlook on future synergies (e.g., the precise characterization of super-Earths/Neptunes orbiting solar-type stars and the prospect of conducting a populational study of giant planets around evolved stars) and further provide an overview of the asteroseismic yield of exoplanet-host stars expected for the Transiting Exoplanet Survey Satellite (TESS).

11:10
Vincent Van Eylen (Leiden Observatory)
**Combining asteroseismology and exoplanet science**

The Kepler and K2 missions have provided a wealth of information about stars, through asteroseismology, and about exoplanets, through their transits. In this talk, I show that 'one and one is three', when asteroseismology and exoplanets are combined. I present several topics where asteroseismology has been crucial to advance our understanding of exoplanet formation and architecture, and place the Kepler and K2 results in the context of the PLATO mission.

Highlights include 1) the inference of detailed planetary parameters through stellar parameters, 2) understanding orbital eccentricities of small planets, without radial velocities, through combining transit durations with mean stellar densities, and 3) determining stellar obliquities through rotational splittings of oscillating planet host stars. Finally, I will also show how 4) determining properties of subgiant and giant stars can help solve outstanding problems in planet formation and evolution.

Combining these four themes, I show the unique contributions asteroseismology has made to our understanding of exoplanet systems, in particular for their formation, evolution and system architecture. Starting from Kepler and K2 breakthroughs, I make predictions about the rich science that PLATO will enable by combining asteroseismology with exoplanets.

11:25
Hans Deeg (Instituto de Astrofísica de Canarias)
**Research on Circumbinary Planets with PLATO**

Current research issues on Circumbinary Planets (CBP) and the impact that we expect from PLATO will be described. CBPs are planets orbiting both components of a binary star; they may be detected by several techniques based on precise photometric time series. The first CBP detections arose from the precise timing of binary eclipses, finding several planets with decade-long orbital periods. Later, successful transit-detections were made in data of the Kepler mission. CBPs detected by transits are now the majority of known CBPs, with common features being masses in the Neptune-range and periods of a few months that are (with one exception) close to the innermost limit for a stable orbit around the central binary. A few CBPs have also been detected by direct imaging. Circumbinary planets are an interesting test-bed for planet formation models, as they need to account for the additional perturbation and stability issues arising from the binaries' orbit. The current sample of such planets is however still very small and the true parameter space for their existence is still poorly known, of note being a likely absence of CBPs around very short-periodic binaries. An open issue is also the true distribution of inclinations between the binary and planet orbital plane, as determining this distribution suffers from strong detection biases. Current CBPs are also mostly on faint stars which impedes good characterisation. The potential of PLATO to contribute to these issues is outlined, which is the subject of its Work Package 112510.

11:40

Roberto Silvotti (INAF-Osservatorio Astrofisico di Torino)

**Planets transiting hot subdwarfs and white dwarfs: from Kepler/K2 to TESS to PLATO.**

During the red giant expansion close planets are attracted near or inside the star's envelope by the tidal forces while distant planets are pushed away because of the stellar mass loss. For this reason we expect to find a period gap in the final distribution of the planetary orbital periods.

Some of the planets inside the period gap, those who escaped engulfment, are potentially detectable through their transits.

Although Kepler/K2 has not detected any planet transiting hot subdwarf stars or white dwarfs, probably due to the small statistics, however it has found an intriguing white dwarf (WD1145+017) with irregular transits likely due to a disintegrating asteroid or minor planet. Thanks to much larger statistics, in ~1 year from now TESS will probably start finding the first planets transiting hot subdwarfs and white dwarfs or at least several systems similar to WD1145+017.

Together with other 3 colleagues studying this field, I am member of the TESS TSWG (Target Selection Working Group) and we are proposing to include a number of hot subdwarfs and WDs in the TESS CTL (Candidate Target List), to be observed at 2 min cadence. Taking advantage from the TESS discoveries, PLATO has the opportunity to further increase the statistics of these evolved planetary systems and shed light on this poorly studied field, which concerns the final configuration of ~95% of the stars, all those with a MS mass <8-10 solar masses.

11:55

Vincent Bourrier (Geneva Observatory)

**Observing Dusty planets with PLATO**

The exoplanet population is a treasure trove of exciting discoveries, not least among them the existence of ultra-short period (USP) exoplanets. These small rocky planets are so close to their stars that the melting of their surface or intense volcanism can lead to the formation of heavyweight envelopes, rich in dust and highly sensitive to stellar activity. The larger USP planets are expected to be surrounded by a gravitationally-bound envelope, whose evolution in dust content over time would lead to variations in their optical radius. USP planets with lower mass than Mercury can see this envelope escape and form extended dust tails, such as the ones detected with Kepler and K2. Analysis of their asymmetrical transit light curve yield information on the structure and composition of the tails, and hence of the planet. High-precision photometry and a good knowledge of the host star activity will be required to study dust-induced radius variations and the dust tails from disintegrating planets. PLATO will thus allow us to perform a thorough characterization of USP planets and to build statistics on their population, making a major scientific impact in our understanding of these extreme exoplanet systems, their origin and their evolution.

12:10

Edward Gillen (University of Cambridge)

**Young transiting planets in the K2 clusters**

Young open clusters are fruitful targets for exoplanet searches because they represent coeval populations of shared elemental composition, which can be dated to a precision unattainable for field stars. Young transiting planets in these clusters are particularly valuable as they offer a window onto the formation and early evolution of planetary systems. However, very few such systems are known, making them of great interest for exoplanet searches such as Kepler/K2, TESS and PLATO.

K2 has recently targeted five nearby young open clusters, spanning 1-800 Myrs. I will present our program to characterise young planets in the K2 clusters using our innovative Gaussian process regression techniques. I will focus on the Praesepe open cluster and will present: the characterisation of a small planet transiting a young M-dwarf; the first transiting brown dwarf detected in a young cluster; and two young M-dwarf eclipsing binaries. I will then compare the known young K2 planets to the older Kepler sample, probing the evolution of planet size and orbital eccentricity. Finally, I will discuss how PLATO can contribute to detecting young planets in open clusters.

12:25

Juan Cabrera (DLR)

**Mimics amongst K2 validated planets**

While selecting super-Earths suitable for further characterisation from the ground from a list of confirmed and validated exoplanets detected by K2, we found some suspicious cases that led to us reassess the nature of the detected transiting signal.

We performed a photometric analysis of the K2 light curves and centroid motions of the photometric barycenters. Our study shows that the validated planets K2-78b, K2-82b, and K2-92b are not planets, but background eclipsing binaries. The eclipsing binaries are inside the Kepler photometric aperture, but outside the ground-based high -resolution images that were used for validation.

We advise extreme care in the validation of candidate planets that are discovered by space missions. It is important that all the assumptions in the validation process are carefully checked. An independent confirmation is mandatory in order to avoid wasting valuable resources on further characterisation of non-existent targets.

## 13:40-14:40 Exoplanets 2 (continued)

13:40

René Heller (Max Planck Institute for Solar System Research)

**Extrasolar moons**

Moons in our solar system serve as tracers of planet formation and evolution. The densities and water contents of the Galilean moons, for example, put observational constraints on the properties of the circum-Jovian accretion disk, in which they formed 4.5 billion years ago; the Uranian satellites store information about the proposed bombardment process that caused the tilt of Uranus' spin axis; and most important for us, the Moon was formed through a giant impact of a Mars-sized object into the proto-Earth, which set the initial conditions for our contemporary astrophysical environment and, hence, for the terrestrial climate and life as we observe it today. We describe the high-accuracy space-based stellar photometry that has recently led to the discovery of the Neptune-sized exomoon candidate around the Jupiter-sized transiting exoplanet Kepler-1625b. This example, irrespective of whether it can be confirmed by follow-up observations with Hubble (scheduled for October 2017) or not, demonstrates that large exomoons are detectable in the wings of the phase-folded planetary transit light curves, an effect known as the orbital sampling effect. If the claim can be validated, it suggests that exomoon detections with PLATO could (i.) offer new constraints on planet formation and migration; (ii.) trigger an innovation push for moon formation theories; (iii.) provide unprecedented tools to measure planetary obliquities; (iv.) offer new means to constrain planetary masses; (v.) deliver novel insights into the wider context of the solar system planets and moons.

13:55
Valerio Nascimbeni (Università di Padova)
**Review of TTV techniques and application to PLATO**

Transit Time Variation (TTV) is a powerful dynamical technique to measure planetary masses within a multiple planetary system, without need of (or in synergy with) radial velocity measurements. It has also been exploited to infer the presence of additional, previously unknown bodies in the same system, even non-transiting ones. I will review the basic physical principles and the computational challenges behind TTVs, and the most intriguing results achieved so far. I will show how TTVs will help the science case of PLATO, alone and/or in synergy with data from Kepler/K2, TESS and CHEOPS.

14:10
Rosemary Mardling (Monash University and University of Geneva)
**The information-rich properties of resonant chains**

Resonant chains are a beautiful example of Nature's ability to create highly complex structures in a thermodynamically favourable environment. The best-known example of such a celestial molecule held together by gravity is Jupiter's Laplace resonance for which the orbital periods of Io, Europa and Ganymede are such that $1/P_I-3/P_E+2/P_G< 10^{-9}$ deg/day, indicating that the system is highly relaxed, and in particular that the whole system is exquisitely coupled. Nature has revealed several resonant exoplanet chains including the TRAPPIST-1, Kepler-223 and Kepler-444 systems in which 7, 4 and 5 planets orbit an ultra-cool dwarf, a Sun-like star and a K-dwarf respectively. Each is governed by a superposition of pair-wise near-commensurabilities of the orbital frequencies, as well as several Laplace-like relationships which link the whole chain together. As a consequence, measurements of TTVs and Laplace-angle variations give us direct access to the planet masses, without the usual degeneracies involving the eccentricities which plague mass determinations in near-resonant systems. Moreover, it is not necessary to resolve short-period fluctuations in the TTVs, but rather, their long-period large amplitude variations alone encode the planet masses, as well as conditions in the protoplanetary disk when the chain was formed. This talk will outline the physics of resonant chains, and how planet masses can be determined even when the transit data is noisy.

14:25

Aviv Ofir (Weizmann Institute of Science, Israel)

**A spectral approach to transit timing variations**

The high planetary multiplicity revealed by Kepler implies that Transit Time Variations (TTVs) are intrinsically common. The usual procedure for detecting these TTVs is biased to long-period, deep transit planets whereas most transiting planets have short periods and shallow transits. Here we introduce the Spectral Approach to TTVs technique that allows expanding the TTVs catalog towards lower TTV amplitude, shorter orbital period, and shallower transit depth. In the Spectral Approach to TTVs we assume that a sinusoidal TTV exists in the data and then calculate the improvement to chi^2 this model allows over that of linear ephemeris. This enables detection of TTVs even in cases where the transits are too shallow so individual transits cannot be timed, and it is more sensitive due to the reduced number of free parameters in its model. We used it to, among other things: (a) detect 131 new periodic TTVs in Kepler data (an increase of ~2/3 over a previous TTV catalog); (b) Identify cases of multi-periodic TTVs, for which absolute mass determination may be possible. Our extended sample of systems with measured TTVs shows no deficit of short period or low amplitude transits, in contrast to previous surveys in which the detection schemes was significantly biased against such systems. The Spectral Approach allows to quickly identify TTVing planets even in shorter-baseline datasets, and is thus ideally suited for future missions such as TESS and PLATO. We further extend our analysis by using perturbation theory assuming small amplitude TTVs at the detection stage. This procedure allows us to linearize much of the search, greatly improving the detection speed (few seconds per star).

## 14:40 – 15:40 Core Stellar Science 2

14:40

Patrick Eggenberger (Geneva Observatory, University of Geneva)

**Transport of angular momentum within stars**

Thanks to space missions, solar-like oscillations have been characterized for a large number of stars. This has opened the way to the determination of the internal rotation of these stars. In this presentation, we discuss how these measurements can help us progress in our understanding of the transport of angular momentum in stellar interiors.

15:10

Allan Sacha Brun (AIM & Département d'Astrophysique)

**3-D MHD numerical simulation with the ASH code**

We present a series of 3-D MHD numerical simulation with the ASH code of solar-like stars aimed at characterising their differential rotation and magnetic state over a large range of rotation rate and luminosity. We discuss their dynamical properties and derive scaling laws that will be useful during the PLATO mission to identify the various state of rotation (solar-like, anti-solar or Jupiter like) and the resulting dynamo state of the host star.

15:25

Remo Collet (Aarhus University)

**Stellar abundance and parameter determinations with the aid of three-dimensional model atmospheres**

Classical determinations of stellar parameter and compositions of late-type stars often rely on the use of stationary, one-dimensional (1D), hydrostatic model stellar atmospheres for the quantitative interpretation of interferometric and spectroscopic observations. Recent years, however, have seen a rapid development in the field of three-dimensional (3D) hydrodynamic modelling of stellar atmospheres and stellar spectra.

In this contribution, I will present results from realistic, time-dependent, hydrodynamic 3D simulations of stellar atmospheres of solar- and late-type stars, covering a wide range of stellar parameters and compositions, from main sequence to red giant branch and with metallicities from [Fe/H]=+0.5 down to [Fe/H]=-4. These 3D model atmospheres have been generated using a custom version of the radiation-magnetohydrodynamics Stagger-Code which implements state-of-the-art input micro-physics (equation of state and opacity data) and a realistic treatment of non-grey radiative transfer.

I will describe the main properties of the simulations and discuss the application of 3D model atmospheres to spectroscopy and interferometry of late-type stars. I will illustrate the main effects of 3D modelling of stellar atmospheres and stellar spectra on the predicted strengths and shapes of spectral lines, and on the determination of fundamental stellar parameters, highlight systematic differences with respect to calculations based on classical, 1D, hydrostatic models.

Finally, I will also discuss the application of 3D models to the analysis and interpretation of data from space-borne and ground-based stellar surveys for the determination of accurate stellar parameters, elemental abundances, and radial velocities.

16:10-18:00 Core Stellar Science 2 (continued)

16:10

Laurène Jouve (IRAP Toulouse)

**Latest developments in the physics of solar/stellar dynamos** *(invited)*

In this talk, we will review some aspects of the stellar magnetism and in particular what numerical simulations tell us about the physical processes underlying the observations.

In cool stars, a convective dynamo is thought to be responsible for the presence and evolution of magnetic fields. The question of the impact of the internal stellar structure on the magnetic field topology will be addressed. We will focus in particular on the role of differential rotation and of a tachocline. Another important aspect of stellar dynamos is the possible presence of magnetic cycles and how its period depend on the stellar parameters. Numerical simulations addressing this issue will be presented. Finally, one step of the dynamo process is the emergence of magnetic flux from the interior where it is created and organised to the exterior where it emerges as starspots. We will also show results of global 3D MHD numerical simulations of such a process.

16:30

Friedrich Kupka (University of Göttingen)

**Modelling of convection**

Stellar age determination is one of the main scientific deliverables of the PLATO mission and cannot be accomplished satisfactorily without stellar modelling. The latter in turn requires the modelling of convection. In this presentation I will summarize the advantages and shortcomings of current modelling strategies and also argue why a larger variety of models should be part of PLATO mission preparation related convection modelling instead of the mere optimization of the traditional mixing length parameter.

16:45

Stefanie Raetz (Institute for Astronomy and Astrophysics Tübingen (IAAT))

**Exploring the Rotation-Activity Relation of late-type main sequence stars with PLATO**

Stellar activity is directly linked to magnetic fields that are believed to be generated and maintained by a dynamo which is driven by differential rotation and convection. Therefore, rotation and stellar activity are intimately connected.

The rotation-activity relation of late-type stars based on the measurements of the X-ray luminosity is empirically divided in two regimes: a "saturated" plateau of constant activity for fast rotators and a "correlated" regime for slow rotators. However, for M dwarfs the long rotation periods (implying long spin down times) and faint X-ray emission make the rotation-activity relation notoriously poorly defined.

Combining periods from the K2 mission with archival X-ray data we have started towards providing a statistical sample of bright and nearby M dwarfs with both known rotation period and X-ray detection. Our studies are based the Superblink proper motion catalogue by Lepine and Gaidos (2011).

We present here the results of this ongoing study and we describe the potential of upcoming missions, PLATO and eROSITA, for a decisive step in nailing down the rotation-activity relation of M dwarfs.

PLATO will observe on the order of ~3500 targets from the Superblink catalogue by Lepine and Gaidos (2011) and will provide light curves with a noise level better than 800 ppm (within the P1 and P4 star samples) with rotation periods up to hundreds of days. eROSITA, the German instrument on the Russian SRG satellite to be launched in 2018, will perform an X-ray All Sky Survey 20 times more sensitive than the ROSAT All Sky Survey, and, hence, will detect faint X-ray sources.

Here, we focus on two aspects. First, the transition between the saturated and correlated regime. The rotation-activity relation constructed with photometric activity indicators from K2 lightcurves show this transition to be much sharper than expected. Secondly, the search for a quantitative change of the rotation-activity relation at the fully convective boundary (SpT M3/M4) which can be expected from dynamo models.

17:00

Nadiia Kostogryz (Kiepenheuer-Institut für Sonnenphysik)

**Stellar limb darkening and polarization: Prospects for PLATO mission.**

Space telescopes such as Kepler, TESS and PLATO (will) provide high-precision photometry for detection and characterization of exoplanets via transits. To properly interpret exoplanetary transit light curves, accurate calculations of center-to-limb variations of intensity of the host star are needed. This requires solving the radiation transfer equation including scattering and polarization, since neglecting polarization leads up to 8% uncertainties in limb darkening and, therefore, influences planetary parameter estimates. We have solved the polarized radiation transfer equation in the presence of continuum scattering, considering plane-parallel and spherical models of stellar atmospheres and calculated center-to-limb variation of intensity and polarization for different spectral type stars. Using these models, we have computed flux variations within passbands of the PLATO mission during transits of various size planets and examined which accuracy of model computation is needed to match the measurement accuracy.

17:15

Emeline Bolmont (CEA, Saclay)

**Effect of the history of stars on the tidal evolution of close-in planets**

Since 1995, numerous close-in planets have been discovered around low-mass stars (M to A-type stars). These systems are susceptible to be tidally evolving, in particular the dissipation of the kinetic energy of tidal flows in the host star may modify its rotational evolution and also shapes the orbital architecture of the surrounding planetary system. In this context, observations show that the tidal dissipation in stars strongly depends on their mass, age and rotation.

This sheds a light on the importance of knowing the host star of a planetary system. In this context, the PLATO mission will allow to get the stellar parameters with unprecedented precision, and also very importantly the age of the star and thus of the planetary system itself. To understand the orbital architecture of the observed planetary systems in a statistical point of view, it is thus necessary to understand the evolution of the tidal dissipation in host stars.

In recent theoretical studies, we have demonstrated that the amplitude of the stellar dissipation within the convective region can vary over several orders of magnitude as the star evolves, and that it strongly depends on the stellar mass, age and rotation in agreement with the observations. Within this framework, we used the stellar evolution code STAREVOL to compute grids of the simultaneous evolution of the star's structure, rotation and tidal dissipation in its external convective envelope. We make these grids publicly available. Together with an orbital evolution code, this allows us to provide a more complete and realistic picture of the dynamics of close-in planets orbiting low-mass stars. In particular, we show how the metallicity of the star impacts the tidal evolution of massive close-in planets in a time-dependent manner. Our model also reproduces some observed statistical trends in the population of hot Jupiters with metallicity and rotation of their host stars. In the continuity of these first results, we are now developing new integrated models that couple an orbital evolution model and the stellar evolution code STAREVOL to bring theoretical modelling to the level needed to interpret future PLATO observations on the orbital architecture of exoplanetary systems and their hosts stars. The forthcoming roadmap for this effort along the preparation of PLATO will be discussed.

17:30

Nuno Santos (IA/U. Porto)

**Constraining planet structure from stellar chemistry**

The study of the chemical composition of stars that have orbiting planets provides important clues about the frequency, architecture, and composition of exoplanet systems. In particular, recent studies have pointed out that the knowledge about the chemical composition of the star, and specifically the abundances of C, O, Si, Mg, and Fe, may provide important clues about the chemical composition of the rocky orbiting planets. In this talk I will first review the status of this research. I will then use a simple stoichiometric model to predict the chemical composition of planets orbiting stars of different populations in our Galaxy. In particular, I will derive the expected distributions of their mantle-to-core mass ratios and water mass fractions. The results of this study can be used to set important constraints for the modelling of the rocky planet composition once precise masses and radii are known, as expected with PLATO.

17:45

Manuel Guedel (University of Vienna)

**Toward habitable planets: Evolutionary studies of planets around solar-type stars**

One of the major goals of PLATO is to identify Earth-like habitable planets around Sun-like stars. Planetary habitability requires conditions that are to a large extent determined by the stellar and planetary environment. A stable atmosphere and conditions allowing for the long-term presence of liquid water are among the most important prerequisites for habitability.

Atmospheres are processed by a wide range of stellar radiative output; ultraviolet, extreme ultraviolet, and X-ray radiation are produced by various stellar magnetic features and drive chemistry, ionization and heating in upper planetary atmospheres, leading to thermal evaporation. To understand the pathways of a planet toward habitability, a full understanding of the co-evolution of the planetary atmosphere and stellar radiative output is required. The latter in turn depends on the stellar rotation rate and its long-term evolution, all determined by the initial rotation rate after the protoplanetary disk phase.

We present results from a large project devoted to the study of the long-term evolution of star-planet systems with a focus on the radiative interactions driving atmospheric evolution. We discuss the stellar spin-down behaviour and the resulting - non-unique - stellar radiative history in the pre-main sequence and the main-sequence phase; we present a novel reconstruction of the entire ultraviolet-to-X-ray spectral energy distribution as a function of the rotation rate for solar-type stars; and we show results underlining the importance of the stellar rotational evolution for the thermal loss of primordial and secondary atmospheres of planets. We also discuss applications to selected exoplanets and discuss the mechanisms with respect to the possible early evolution of solar-system planets.

## Thursday 7th September

08:30-10:00 Complementary Science 2

08:30
Jérôme Ballot (IRAP Toulouse)
**How to deal with rapid rotation?**

Rotation, through the centrifugal distortion and the Coriolis force, has an important impact on stellar oscillations. Excepted for slowly rotating stars, these effects cannot be considered as perturbations.

Substantial progress has recently been achieved both in theory and observations. The space missions CoRoT and Kepler have provided seismic data with unprecedented quality allowing the community to accurately determine the frequencies of hundreds of oscillation modes in these stars. Moreover, in the last years, new theoretical approaches as well as new 2D codes have been developed to model the internal structure of rotating stars and to compute their oscillation spectra. I'll thus present the recent progresses we did.

I'll also introduce our international ISSI team aiming at building a joint effort between modellers and observers, based on existing seismic data for fast rotators, in order to address major difficulties in understanding and studying stars with rapid rotation.

08:45
Vincent Prat (CEA Saclay)
**Seismology of rapidly differentially rotating stars with gravity waves**

Differential rotation plays a key role in stellar evolution. First, it triggers instabilities, turbulence and large-scale flows that induce transport of chemicals and angular momentum in stars. This deeply modifies their structural, rotational, chemical and magnetic evolution. Second, it impacts drastically the propagation and the frequency spectrum of gravity waves in the cases of strong gradients of angular velocity and fast rotation, for which perturbative methods fail. This is of great importance for stars that will be probed by the PLATO mission since gravity waves allow for probing stellar interiors and their rotation thanks to seismic diagnoses based on their asymptotic properties. Moreover, these waves are able to transport angular momentum and are one of the mechanisms proposed to explain the weak differential rotation revealed in a broad diversity of stars by the CoRoT and Kepler space missions.

Generalising our previous work done in the case of uniform rotation, we derived a new asymptotic theory for gravity waves propagating in a differentially rotating star, taking the full effects of rotation (both Coriolis and centrifugal accelerations) into account for general differential rotation profiles that vary both with radius and latitude. Using the theory of rays to model the propagation of gravito-inertial waves, we probe their properties for different kinds of differential rotation profiles. Consequences on observables such as their frequency spectrum and visibility are then discussed in the framework of the preparation of the PLATO mission and of the development of the needed new generation of 2D rotating stellar models.

09:00
Samaya Nissanke (Radboud University)
**PLATO and the extragalactic universe** (invited)

09:30
Bartlomiej Debski (Astronomical Observatory of the Jagiellonian University)
**A new classification scheme for intrinsic variability of close binary stars**

In this work we present a new classification scheme for the intrinsic variability of the close binary stars' light curves. We show how to use long-timebase photometry to quickly find binaries with the signatures of a starspot migration and clues to the determination of which component of the binary star is the more massive one. The study concentrates on contact binaries and can be extrapolated to the detached, near-contact binaries. Our findings can be easily applied during the production of the Plato Binary Star Catalogue or case study of objects with intrinsically variable light curves.

09:45
Juan Carlos Suárez (Universidad de Granada)
**On the frequency pattern estimates from an entropy based method.**

I will present a simple yet powerful method based on Shannon's entropy to detect frequency patterns in the oscillation spectra. This method relies only on the observed frequency spectra. We will present how large separation of the Sun, solar-like stars and even delta Scuti stars are accurately detected with this method. Due to its simplicity, it can easily be implemented in PLATO pipelines.

## 10:00 – 13:00 Exoplanets 3

10:30
Christoph Mordasini (University of Bern)
**Evolution of planetary systems** (invited)

Planet formation is a complex process that spans growth over many orders of magnitude from dust grains to giant planets. It also includes many different physical processes, feed-back mechanisms, and non-linearities. Besides first principles, observational constrains are therefore needed to develop the theory of planet formation and evolution. In my talk, I will first review the most important lessons learned mainly from transit and follow-up radial velocity observations. I will address the planetary radius distribution, the mass-radius and mass-mean density relations, and the evaporation valley. They all carry crucial information about the accretion of gas and solids during formation, orbital migration, as well as mass loss during evolution. I will then address recent topics that are of special interest for PLATO, like for example the evolution of the planetary population as a function of time.

11:00

Doris Breuer (DLR, Institute of Planetary Research)

**Comparative planetary interiors and the effects on habitability** *(invited)*

The planetary interiors of rocky exoplanets play a substantial role in influencing the habitability of these planets. First of all they provide volatiles for the atmosphere, which influences the surface temperature and is therefore crucial for the possible existence of liquid water on the surface. The efficiency of volatile outgassing (and volatile recycling) on the other hand depends on various factors such as the heat transport mechanism, e.g. plate tectonics with its surface recycling or stagnant lid convection, the interior structure (relative size of the core) as well as the planetary composition and mass. Second, the interior with its dynamics is responsible for a magnetic field that protects the atmosphere against erosion by the solar wind. In this talk, I will review our current knowledge on these interactions between interior and atmosphere and the problems we are facing to better understand the influence of the interior on the habitability of a planet

11:30

Tristan Guillot (Observatoire de la Cote d'Azur)

**From Juno to Plato: the link between solar giant planets and giant exoplanets**

Juno is in orbit around Jupiter since July 2016 and is progressively changing the way we see the planet. The gravity field measured during just the first two orbits is an order of magnitude more accurate than previous measurements (Bolton et al. 2017, Folkner et al. 2017), allowing discrimination between contradictory measurements prior to Juno and to further constrain interior differential rotation and structure. Interior models consistent with the data favour solutions in which Jupiter’s core is diluted in the envelope (Wahl et al. 2017), in line with recent models of the formation of the planet. The increased accuracy seen in Juno’s gravity measurements in the next orbits also gives hope that the mystery of whether Jupiter’s observed zonal flows penetrate deep into the interior or not (Kaspi et al. 2017) may be solved.

This has consequences for giant exoplanets as well: Some of the important questions that arise are whether giant planets are partially mixed or not, whether they retain a central core and how to link their interior and atmospheric composition. Plato's high precision photometry will inform us directly on the composition of a large variety of gaseous planets, from "mini-Neptunes" to "super-Jupiters" and brown dwarfs. Identifying in parallel their atmospheric compositions will be key to a much better knowledge of the composition and interior structure of these planets. In addition, the understanding of atmospheric dynamics obtained thanks to Juno can be directly applied to the planets to be characterized by Plato.

11:45

Dimitri Veras (University of Warwick)

**How PLATO's asteroseismic stellar age constraints could track planetary evolution**

The space mission PLATO will usher in a new era of exoplanetary science by expanding our current inventory of transiting systems and constraining host star ages, which are currently highly uncertain. This capability might allow PLATO to detect changes in planetary system architecture with time, particularly because planetary scattering due to Lagrange instability may be triggered long after the system was formed. Here, we utilize previously published instability time-scale prescriptions to determine PLATO's capability to detect a trend of decreasing planet frequency with age for systems with equal-mass planets. For two-planet systems, our results demonstrate that PLATO may detect a trend for planet masses which are at least as massive as super-Earths. For systems with three or more planets, we link their initial compactness to potentially detectable frequency trends in order to aid future investigations when these populations will be better characterized.

<u>12:00</u>
Francesco Marzari (University of Padova)
**Planets and debris disks**

The presence of a debris disk around a star is a clear indication that planetesimals formed from the primordial circumstellar disk. It is then conceivable that planets emerged from that planetesimal population establishing a strong bond between debris disks and planets. However, the subsequent dynamical evolution of the planet system may disperse the planetesimal population via gravitational interactions preventing the formation of long lasting debris disks. This is likely to occur when the planets are massive and undergo a phase of planet-planets scattering (Marzari, 2014). On the other hand, small planets, like super-Earths of Neptune-size planets, might peacefully coexist with planetesimal belts and possibly sculpt them with their gravitational perturbations. It would then be interesting to select targets for PLATO showing infrared excess in order to derive some significant statistics concerning the coexistence of planets and planetesimal belts. In particular, it will be interesting to link the presence of one or more debris disks with the value of the planet(s) mass. We intend to present some recent exploration of the interaction between planets and planetesimal belts.

<u>12:15</u>
Richard Nelson (Queen Mary University of London)
**Low mass planet migration in magnetised protoplanetary discs**

In this talk I will describe the results of recent work that examines the migration of low mass planets in magnetised discs where the non-ideal processes Ohmic resistivity, ambipolar diffusion and the Hall effect operate. In such disc models a horizontal magnetic field can develop that creates a laminar disc with a radial flow near the mid plane due to magnetic torquing. This flow can strongly influence the behaviour of planets by allowing both inwards and outwards migration, depending on the direction and speed of the gas flow in the disc. I will place the new work in the context of existing work on planet formation and describe the unified picture that emerges.

<u>12:30</u>
Alexander Mustill (Lund University)
**The dynamical evolution of transiting planetary systems including a realistic collision prescription**

Planet--planet collisions are a common outcome of instability in systems of transiting planets close to the star, as well as occurring during in-situ formation of such planets from embryos. Previous N-body studies of instability amongst transiting planets have assumed that collisions result in perfect merging between the two planets. Here, we explore the effects of implementing a more realistic collision prescription on the outcomes of instability and in-situ formation at orbital radii of a few tenths of an au. There is a strong effect on the outcome of the growth of planetary embryos, so long as the debris thrown off in collisions is rapidly removed from the system (by collisional processing to dust, and then removal by radiation forces). If this is the case, then systems form fewer detectable planets than systems evolved under the assumption of perfect merging in collisions. This provides some contribution to the ``Kepler Dichotomy'': the observed over-abundance of single-planet systems.

The effects of changing the collision prescription on unstable mature systems of super-Earths are less pronounced. In unstable systems of super-Earths, perfect mergers only account for a minority (~40%) of collision outcomes, a fraction which falls further (to 20-30%) if the system is destabilised by massive planets undergoing scattering or Kozai perturbations further from the star (scenarios described in Mustill et al., 2017, MNRAS, 468, 3000). However, most collisions resulting in mass loss are grazing impacts in which only a few per cent. of mass is lost. As a result, there is little impact on the final masses and multiplicities of the systems after instability when compared to systems evolved under the assumption that collisions always result in perfect merging. We do however find an effect on planetary spacing (in mutual Hill radii), with the realistic collision prescription resulting in slightly more widely-separated systems than when assuming that all collisions result in perfect mergers.

12:45
Bastien Brugger (LAM, Aix-Marseille University)
**Breaking the mass radius internal composition degeneracy for rocky planets**

Models of planetary interiors are necessary to probe the composition of planets using only their mass and radius. However, such models are limited by a degeneracy existing on the composition of studied bodies. We present a model that handles various compositions of solid terrestrial planets, from Mercury-like to ocean planets. We show that the aforementioned degeneracy can be broken by incorporating the planet’s bulk Fe/Si and Mg/Si ratios, assuming they are similar to the host star’s. Applying our model to several exoplanets shows that the uncertainties on their fundamental parameters remain too important to constrain their compositional parameters, like the core and water mass fractions, with a precision better than ~10%. This value will however be greatly reduced with the results from the PLATO mission, which will provide fundamental parameters of small exoplanets with a precision never reached yet. We will continue to develop our interior model into a tool adapted to the investigation of exoplanets in the low-mass regime, to improve our understanding of the transition from terrestrial to gaseous planets.

## 14:00-15:30 Ground-based support for Space Missions

14:00
David Ciardi (Caltech/IPAC-NExScI)
**Lessons Learned from the Kepler and K2 Follow-Up Programs: Leading to TESS ... now PLATO**

From 2009 to 2015, the Kepler Follow-Up Observation Program aimed to confirm the planetary candidates discovered by Kepler. As a small team with more than 3000 nights at the telescope in those 7 years, the Kepler FOP obtained high-resolution imaging, stellar spectroscopy, and radial velocity observations. In addition the world-wide community contributed to the follow-up effort bringing the observational completeness of the planetary candidates to nearly 100%. With the transition from Kepler to K2, the community learned to work in a new paradigm where all of the mission data (from which candidates were discovered) were public and the yet the telescope follow-up resources remained competitive. After an initial set of papers, the community began to work more collaboratively in an effort to be more effective in the use of limited ground resources. With the imminent launch of TESS, the TESS Follow-Up Observation Program is engaging the community to work together in an effort to utilize the follow-up resources more efficiently and effectively. And now with the adoption of PLATO, lessons from Kepler and K2 and soon-to-be-learned from TESS are applicable to the plethora of planetary candidates that will be discovered by PLATO and characterized by detailed follow-up observations. I will present an overview of these programs, the lessons we have learned from years at the telescope and trying to coordinate the community and how these lessons are being applied to TESS and may be applied to PLATO.

14:30
Alexandre Santerne (Laboratoire d'Astrophysique de Marseille)
**The HARPS-K2 ESO Large Program**

The ESO-K2 Large Program uses the HARPS spectrograph with the aim at precisely characterising up to 20 new low-mass transiting planets from the K2 mission. Our objective is to measure masses of the selected planets to a precision better than 20% to determine their internal structure (e.g. rocky or gaseous). We are focusing on relatively bright F - K dwarfs hosts, with transiting planets in the radii between the Earth and Neptune. The program runs for 70 nights spread over 2 years, and began in October 2016. In this talk, I will present the objectives and the first results of this program and I will draw important perspectives for the characterisation of small planets with PLATO.

14:50
Szilard Csizmadia (DLR, Institut für Planetenforschung)
**High-precision mass and radius determination of K2 planets**

Ground-based radial velocity measurements of transiting exoplanets yield reliable masses. In combination with the measured transit radii, these observations yield the planet densities, as well as confirming the planetary nature of the systems. Densities are vital to understand planetary composition and formation, and the nature of the transition between gaseous and rocky planets.

Our KESPRINT consortium has characterised a significant fraction of the detected K2 planets with an RV mass measurement. The success of KESPRINT stems from the close collaboration between the detection and follow-up teams and from organized allocation of follow-up resources; an approach which can be applied to future survey missions such as TESS and PLATO. We pay attention to the difficulties of characterization of exoplanets caused by the available telescope time distributed among many independent teams.

In this talk the contribution of K2 to the field will be reviewed, with particular focus on those planets for which the mass has been measured by the KESPRINT team using RV. Recent highlights include an inhabitant of the so-called 'sub-Jovian desert', one of the oldest planetary systems yet discovered, and also an ultrashort planet around an M-dwarf.

15:10

Enric Pallé (Instituto de Astrofisica de Canarias)

**HiRES/ELT follow-up of PLATO candidates for atmosphere characterisation**

HIRES is the proposed high-dispersion (R 100,000+) spectrograph for the European Extremely Large Telescope, currently under Phase A study. Here I will discuss the unique capabilities of HIRES for the follow-up and characterization of exoplanet atmospheres, with particular emphasis on the detection of the atmospheric composition of rocky planet atmospheres. I will also discuss the role of HIRES as a key follow-up facility for the PLATO mission.

15:55-18:00 Ground-based support for Space Missions (continued)

15:55

David Latham (Harvard-Smithsonian Center for Astrophysics)

**TESS Follow-up Observing Program**

I will review the plans for the TESS Follow-up Observing Program Working Group (TFOP WG) and will describe the various opportunities for experts from the community to get involved. The TFOP WG is organized into Sub Groups for Seeing-Limited Photometry, Recon Spectroscopy, High-resolution Imaging, Precise Radial Velocity Work, and Space-based Photometry. I will summarize the TFOP WG Charter and Publication Policy, which are designed to encourage coordination, cooperation, and collaboration, while protecting the intellectual property of members.

16:20

François Bouchy (Geneva Observatory)

**Existing and new RV facilities for the follow-up of transit candidates for TESS and PLATO**

16:40

Andreas Quirrenbach / Pedro Amado (Landessternwarte Heidelberg / INTA-CSIC)

**CARMENES: Instrument, Survey, and Perspectives**

CARMENES is a new radial-velocity instrument that has been constructed for the 3.5m telescope at the Calar Alto Observatory by a consortium of eleven Spanish and German institutions. It consists of two separate echelle spectrographs covering the wavelength range from 0.55 to 1.7 μm at a spectral resolution of R = 82,000, fed by fibers from the Cassegrain focus of the telescope. CARMENES saw "First Light" on Nov 9, 2015. We report on the instrument characterization and performance verification. We present selected results from the first year of operation, discuss further plans for the large M dwarf survey that is the core science program of CARMENES, and describe the potential of CARMENES for complementing PLATO.

17:00
Nathan Hara (Observatoire de Paris)
**Compressed Sensing tools for RV data analysis**

To detect exoplanets via radial velocity measurements, it is key to have efficient algorithms to detect possible periodic variations. The well-known problem of aliasing makes the task difficult, the contributions of several signals might add up and artificially enhance spurious periods. We present a tool based on Compressed Sensing theory that allows to avoid the problems of aliasing in most cases and simplifies the analysis of radial velocity data sets. We apply the method to real and simulated data sets (55 Cnc, GJ 876, Radial Velocity Fitting Challenge) and show that it can retrieve small signals in complex situations.

17:15
Nicholas Walton (IoA, University of Cambridge)
**Gaia synergies with PLATO**
This presentation will describe the powerful linkages between the Gaia and PLATO missions coupled with the future potential of the WHT's WEAVE multi-object spectrograph for the study of exoplanet populations.

ESA's Gaia mission commenced nominal operations phase in July 2014. Over the course of its (at least) five year mission, Gaia will discover, via their astrometric signatures, more than 20,000 massive Jupiter sized long period planets at distances out to several hundred parsecs around all star types. In addition Gaia will discover a significant number of short period hot Jupiters around M stars. Gaia's first data release was in Sept 2016, with the second data release (Gaia DR2) being April 2018. This will contain ~1 Billion sources with full five parameter astrometry, with expected systematic parallax errors below 100 microarcsecs. Gaia DR2 will also contain integrated colours for most sources, and mean radial velocities for brighter sources.

The ESA PLATO mission, planned to launch in 2026, will photometrically observe a million host stars, and will detect, via the transit technique, planets down to Earth masses. PLATO will observe two fields of over 2,000 square degrees for 1 to 3 years each. At least one of these will be in the northern hemisphere. where WEAVE (a new multi object high resolution spectrograph currently under construction for the 4.2m William Herschel Telescope, surveys commencing late 2018) will have the potential to provide detailed chemical characterisation of the host stars of the Gaia and PLATO exoplanet systems. This will enable insights into, for instance, metallicity of the host star correlations against both massive exoplanets (perhaps confirming current relationships), and lower mass exoplanets (e.g. low metallicity stars hosting long period planets, host stars depleted or enhanced in refractory elements tracing alternative rocky/giant planet formation pathways).

17:30
Peter Wheatley (University of Warwick)
**NGTS support to PLATO**

I will outline how the Next Generation Transit Survey (NGTS) could support the PLATO mission by characterising the variability of target stars, monitoring their stellar activity, and identifying false positive transit signals from background eclipsing binaries. NGTS is a ground-based transit survey based at the ESO Paranal Observatory employing an array of twelve small telescopes optimised for high precision measurements of bright stars. The facility has been operational since 2016 and routinely produces sub-mmag photometry on bright stars. The twelve telescopes are independently pointable, enabling efficient support for PLATO.

17:45

Thibaut Roger (Bern University/NCCR PlanetS)

**Star by Star : Estimating the Yield of PLATO with YETI FUR (Yield Estimator for Transiting Instrumentation and Follow-Up in Radial velocities)**

With 4 years of observations and a field of view 24 times bigger than Kepler, PLATO will with no doubt find thousands of exoplanets of all varieties.

More than detection, its sensitivity and target selection will enable the mission to characterise exoplanets with unprecedented precision.

In order to get an idea of what to expect from the mission, we perform simulations of photometric transit and radial velocity follow-up observations for each star of the PLATO Input Catalog (PIC). We opted for a modular approach which allows us to explore and understand the influence of various parameters, including observing strategies, stellar parameters, or several mass-radius relationships for planets. This approach will also enable us to apply our yield estimator to other missions in the future.

We present here estimations of the yield of characterised planets (3% precision on radii and 10% on the mass), not only by the PLATO satellite itself, but also by its follow-up in radial velocity measurements. YETI FUR also calculates the follow-up time that will be necessary to reach the required precision on the mass which will enable exoplanet classification (gaseous, rocky, etc. ).

## Posters

1 - Heike Rauer (DLR)
**PLATO Mission Consortium**

We will provide a broad overview of the structure of the PLATO Mission Consortium, the people involved, and contact details for those wishing to join.

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3 - Ray Burston (Max Planck Institute for Solar System Research)
**PLATO Data Centre**

The PLATO Science Ground Segment (SGS) will provide ground support for the validation, calibration, and analysis of the PLATO observations. The SGS comprises the PLATO Science Operations Centre (SOC), the PLATO Data Centre (PDC), PLATO Science Management (PSM), the PMC Calibration/Operation Team (PCOT), and the Ground-based Observation Programme (GOP) Team. The SOC is under ESA responsibility whereas the PDC, PSM, and PCOT are provided by the PLATO Mission Consortium (PMC). The PDC will define and develop software tools to be run at the SOC for the preparation of the observation runs, monitoring of the observations, validation and optimization of the on-board processing, and production of Level-0 and Level-1 data. The PDC will also provide the PLATO Input Catalogue (PIC) to the SOC for scientific mission planning, based on specifications by PSM. The PDC is also responsible for computing the scientific Level-2/Level-3 Data Products, using the scientific specifications and algorithms that will be provided by PSM. The PDC also provides support tools to assist PMC scientists to inspect and scientifically validate the PLATO products, as well as to rank planetary candidates.

4 - David Brown (University of Warwick)
**PLATO Science Management**

The PLATO Science Ground Segment (SGS) will provide ground support for the validation, calibration, and analysis of the PLATO observations. The SGS comprises the PLATO Science Operations Centre (SOC), the PLATO Data Centre (PDC), PLATO Science Management (PSM), the PMC Calibration/Operation Team (PCOT), and the Ground-based Observation Programme (GOP) Team. The SOC is under ESA responsibility whereas the PDC, PSM, and PCOT are provided by the PLATO Mission Consortium (PMC).

The PSM is split into five major branches. Two of these (Exoplanet Science and Stellar Science) will provide scientific specifications for analysis routines and algorithms to the PDC. These specifications will help to define the approach used to analyse PLATO data, and produce the final scientific products of the mission. These branches are also responsible for scientifically validating these products, checking that they are suitable for meeting the mission's scientific objectives. A third branch (PLATO Target / Field Characterisation) is responsible to specifying the information that is to be provided in the PLATO Input Catalogue, while a fourth branch (Follow-Up) plays a role in organising the ground-based follow-up of PLATO targets and candidates. Finally, there is a branch dedicated to Complementary Science.

5 - Victor Atilio Marchiori (LESIA, Observatoire de Paris)
**Optimized photometric masks for deriving PLATO on-board lightcurves**

This work presents the preliminary results of the development carried out to design optimized photometric masks to derive on-board lightcurves for an ample set of target stars of the ESA's space mission PLAnetary Transits and Oscillations of stars (PLATO). PLATO possess a unique and unprecedented multi-telescope approach. Each telescope (24+2=26 in total) build is such that 90% of its point spread function (psf) energy is concentrated within only four pixels of the detector. While this configuration is key to attain the ultra-high precision photometry requirements of the mission, it has though an inconvenient. The size of the pixels is significantly large with respect the size of the psf, leading to considerably higher photometric sensibility to spacecraft jitter, contaminant neighbouring stars and long-term star position drift. Hence, to reduce the sensibility to jitter and the flux pollution induced by the presence of a contaminant star, rather than using classical aperture binary masks to derive on-board photometry, it is proposed the use of weighted Gaussian masks. It allows us to simultaneously retrieve most of the star flux located at the centre of the star image and – in comparison with the classical (binary) aperture masks – smoothly minimize the flux contribution of neighbouring contaminants as well as the noise induced by the satellite. To prevent the target stars from going out of the mask due to the long-term star position drift, the mask positions will be updated on-board on a regular-basis. Compared to the classical aperture masks, the use of weighted Gaussian mask tends to minimize the discontinuities introduced by each mask update. In this context, this work presents the methodology behind the development of the masks, with a highlight on the preliminary results obtained with a study of impact of contaminant stars on their performance. The photometric parameters evaluated in this analysis are the signal-to-noise ratio (SNR), the flux stability and the contamination rate. The sources of noise introduced in the simulations include at this stage photon noise, readout noise, and background noise.

6 - Valerian Chifu (MPSSR)
**On-board outlier detection algorithms for PLATO**

Due to the large number of observed stars and limitations in the downlink bandwidth of the PLATO spacecraft, for a large fraction of the targets (P5 sample) the flux values will be computed and time-averaged on-board. For these cases it is important to detect the outliers that affect the flux measurements before they are time-averaged.

To develop an algorithm that is capable of detecting the outliers we used the LESIA Plato Image Simulator to simulate light curves of stars with magnitudes between mV = 8 and mV = 16, as will be observed with PLATO. Outliers were included assuming various cosmic particle rates, where C = 10/s/cm2 served as a benchmark value based on experience from the Kepler space mission. The purpose of these simulations was to ensure the algorithm flags measurements with cosmic particle hits effectively but still preserves short-term variability in the light curve that is due to astrophysical effects, such as flares, transit ingress/egress, and star spot crossings during planetary transits.

We developed an algorithm that is based on the calculation of the median and the mean absolute deviation (MAD) in a running window. This algorithm is parameterized by two input parameters, α and b. The former defines the number of MADs from the median that is used as a threshold to identify an outlier; the latter define the number of data points around the measurement under investigation.

7 - Pablo Gutiérrez-Marqués (MPSSR)
**Phaedrus, a rapid prototype of the PLATO processing pipeline**

The PLATO mission will implement a data acquisition capability that exceeds the available downlink transmission budget by more than two orders of magnitude. Furthermore the photometric precision goals defined by the mission require an important amount of processing on ground as well. The result is that the data generated by the mission will undergo several levels of processing (both on board and on ground) before it reaches a scientifically usable state.

At this point in the mission, the selection of the processing algorithms (particularly the ones on board) might have an impact on the implementation of the data processing systems. All the proposed algorithms have been tested independently in the previous phases of the study, but there has not been a joint implementation that demonstrates that all the algorithms can work together correctly.

Phaedrus (taking its name from one of the Plato dialogs) is a rapid prototype for all the processing systems involved in the data handling of PLATO. Starting with the simulated output of the sensors, Phaedrus will simulate the different steps of on-board and on-ground processing to generate scientifically usable products (Level 1).

The focus of Phaedrus is on functional interfaces, ensuring that all the information required for each processing step is available on time and in the right location. The goal is to identify inconsistencies in the specification of the algorithms, where the expected outputs of one step are (slightly) different from the assumed inputs of the next.

8 - Pamela Rowden (The Open University)
**Estimating PLATO's false positive rate using Kepler as a calibrator**

With a large pixel size, there is concern that PLATO's false positive rate due to background eclipsing binaries may be unacceptably high. Using the Kepler main mission as a calibrator, our population synthesis studies show that, for terrestrial planets, the detectable exoplanet population is likely to exceed the detectable blended and unblended eclipsing binary population: thereby indicating that any signal indicating a terrestrial planet detected by PLATO is more likely to be a genuine exoplanet than a false positive.

We utilised observations from the Kepler main mission recorded in the Kepler Eclipsing Binary

Catalogue (Prsa et al, 2011; Slawson et al, 2011; Kirk et al, 2016) and a synthetic field we generated using the BiSEPS (Binary Stellar Evolution Population Synthesis) code to match the on sky area observed by Kepler during the main mission (Farmer, Kolb & Norton, 2013) to calibrate our study.

By matching primary and secondary eclipse depths, the effective temperature and the orbital period of systems in the Kepler Eclipsing Binary Catalogue with corresponding systems in the synthetic Kepler field, the calibration was obtained. We used this calibration to generate a synthetic eclipsing binary population in a PLATO field centred on l = 65°, b = 30°, considering both blended and unblended eclipsing binaries.

At the same time, the synthetic Kepler field was used to generate an intrinsic exoplanet distribution calibrated to the observed distribution of confirmed planets from the NASA Exoplanet Archive (NExSci). By switching from Kepler precision to PLATO precision we can now generate a synthetic exoplanet population as seen by PLATO in the synthetic PLATO field.

The eclipsing binary and exoplanet simulations can then be combined to estimate the ratio of planets to binaries. Both exoplanet and eclipsing binary simulations take account of blended and unblended transits, and the effects of blending can be quantified.

While the rate of false positives due to blended and unblended eclipsing binaries is likely to exceed the rate of genuine planets for larger planets, for the terrestrial planets which are PLATO's main focus, in particular the Earth twins, planets are likely to outnumber eclipsing binaries.

9 - Josep Manel Carrasco (University of Barcelona)
**Gaia simulations for PLATO**

Our team at the University of Barcelona (UB) has been participating to Gaia Mission since its very early phases. Among the different tasks developed for Gaia, UB team has contributed to the Data Simulations, Initial Data Treatment, Data compression, Photometric instrument design and calibration, Catalogue releases, among others. All this expertise should now be applied to PLATO 2.0 mission to allow its optimal results. In particular, our involvement in Gaia data releases can be used to adapt our simulation tools to PLATO 2.0 requirements in order to simulate the different stellar fields proposed and also determine the background contribution of faint stars observed by Gaia but not detectable with PLATO 2.0. Photometric transformations from Gaia passbands to PLATO and also synthetic photometry derived from Gaia low resolution spectra will be put in place. All these tasks will be developed under PSPM WP-131-150 (PLATO-Gaia simulations).

10 - David Ciardi (Caltech/IPAC-NExScI)
**Assessing the Impact of Stellar Companions on the Determination of Planet Properties for Transiting Planets**

The radii of planets discovered with the transit method are derived from knowledge of the true transit depth and the stellar radius. Unknown stellar companions to transit hosts cause a systematic underestimation of the planetary radii by diluting the transit depths and by possibly being the true stellar host. For the Kepler candidate systems, we have quantified the effects of the assuming that stars are single and have no stellar companions - and have extended this analysis to the closer target stars of TESS which is appropriate for PLATO as well. Additionally, for those Kepler stars with detected stellar companions, we have assessed whether the stellar companions are bound or unbound, and we have reassessed the planetary transits depths based upon the flux dilution from the companions and modeled whether or not the planets can orbit the secondary stars. Taking into account the stellar companions, we have revised the planetary radii upward and the corresponding planetary densities downward. High resolution imaging is a powerful technique, especially for TESS and PLATO, for determining true and accurate planetary radii and densities necessary for us to understand the frequency and properties of planetary bodies.

11 - Šarūnas Mikolaitis (Institute of Theoretical Physics and Astronomy, Vilnius University)
**Spectroscopic and Photometric Survey of Northern Sky for the ESA PLATO space mission**

We conduct spectroscopic and photometric observations using instruments of the Molėtai Astronomical Observatory of Institute of Theoretical Physics and Astronomy, Vilnius University: the high-resolution (R=60000) VUES spectrograph on 1.65 m. telescope and the CCD photometer installed on the 35/51 cm wide field Maksutov-type telescope. We aim to provide the full spectroscopic characterization of bright FGK-type dwarfs with V<8 mag in preliminary PLATO NPF and STEP02 fields as well as in TESS Northern Continuous viewing zone. We also aim to deliver the photometric variability information for stars with V<11 mag across various PLATO fields. The first data release will be presented in this contribution.

12 - Jörg Weingrill (Leibniz-Institut für Astrophysik (AIP))
**Preparatory observations of the PLATO Southern Field using the BMK10k robotic telescope**

The BMK10k is a robotic telescope dedicated to observe the Southern Plato Field (SPF) from Chile starting in first quarter 2018. The length of the observation run is currently planned for three years with a possible extension. The BMK10k is a combination of a 30cm lens telescope with a 100Megapixel CCD camera resulting in a field of view of 7.25°×7.25° and a plate scale of 2.54 arcsecs per pixel in comparison with PLATO having 15 arcsecs per pixel.

The SPF will require ~50 pointings rasterized 7×7 with a 10sec and 120sec exposure in Johnson V or Johnson R (TBD) plus 60sec overhead for readout and positioning. Each sky position will be sampled two to three times per night. The expected photometric precision is 0.01mag for a 16mag star and 1.0mmag for a 12mag star.

The BMK10k project will provide magnitudes and rms values for each star in the SPF along with a classification flag for inactive, rotational active and close binary stars. The survey will also reveal constant stars at the mmag level to be used as calibration targets.

Due to the smaller pixel scale of the the BMK (2.54") in comparison with PLATO (15"), background contaminants will be easily identified.

13 - Sascha Grziwa (RIU-PF at the University of Cologne)

**Wavelet based filter methods for the detection and characterization of transiting planets in light curves of space based telescopes.**

Over the last year's stellar variability in light curves was successfully used to characterize stars. Nevertheless, stellar variability is one of the main constraining factors when detecting transits of small planets in high resolution stellar light curves. The Rheinisches Institut für Umweltforschung (RIU-PF) has developed the software EXOTRANS to detect transits of exoplanets in stellar light curves since the CoRoT space mission (2006-2013). During the following years EXOTRANS was improved with different wavelet based filter methods (VARLET and PHALET) to separate stellar variation, orbital disturbances and instrumental effects from light curves. PHALET was also integrated into our "Advanced BLS" algorithm to remove detected transits in light curves to search for additional transits of planets. We use EXOTRANS to detect transit candidates in light curves of the Kepler successor K2 as one of the three detection teams of the KESPRINT collaboration. Many new candidates were detected in K2 light curves which were successfully confirmed by ground-based follow-up observations of the KESPRINT collaboration.

We present examples of confirmed planets of the KESPRINT collaboration focusing on the detection and selection process of promising candidates for follow-up. The experience from CoRoT, Kepler and K2 will help to improve the detection and characterization of transiting planets in future missions like TESS and PLATO.

14 - Hannu Parviainen (Instituto de Astrofísica de Canarias)

**Ground-based multicolour photometry in planet candidate validation**

PLATO is expected to find a vast number of new planet candidates. However, as with the previous CoRoT and Kepler missions, only a fraction of these candidates will be legitimate planets, and the candidate follow-up and validation will require a significant amount of resources.

Radial velocity follow-up can be carried out only for the most promising candidates around bright, slowly rotating, stars. Thus, before devoting RV resources to candidates, they need to be vetted using cheaper methods, and, in the cases for which an RV confirmation is not feasible, the candidate's true nature needs to be assessed using these alternative methods alone.

Ground-based transit photometry is a standard follow-up tool for planet candidate vetting. However, the colour information is not yet used fully to the extent it could be. Especially, the transit shape has a wavelength-varying component that depends on the relative size of the transiting object, which can be used to estimate the true radius ratio even for strongly blended candidates.

We study the use of multicolour transit photometry in planet candidate validation in a Bayesian parameter estimation setting that uses Gaussian processes to model the correlated noise. In theory, the method can be highly valuable as a part of the candidate validation process (especially since the observations can be carried out using small automated ground-based telescopes), but work needs to be done to define its practical limitations.

15 - Petr Kabath (AI Czech Academy of Sciences)
**Joint Taunteburg-Ondrejov spectroscopic follow-up facility**

Two meter class telescopes will play a crucial role for the ground-based follow-up for TESS and PLATO space missions. Thueringer Ladnessternwarte Tautenburg and Astronomical Institute Ondrejov are operating 2-m twin Zeiss telescopes which are equipped with Echelle spectrographs. TLS spectrograph is capable of 3 m/s accuracy in radial velocities and Ondrejov spectrograph can currently achieve about 40 m/s accuracy in radial velocities but this will be improved. The spectral resolution of both spectrographs is about 45000 and the limiting magnitude is about 12. Currently, we work on a joint project, which monitors K2/KEPLER candidates and aims for characterization of bright stars and their potential planets. We can also identify suitable candidates for further follow-up and thus effectively sort out false positives. Currently we work on the design study of refurbishment of 1.52-m telescope at La Silla which could be fully integrated into PLATO follow-up. Both observatories and their capabilities will be introduced in the poster presentation.

16 - Felix Mackebrandt (Max Planck Institute for Solar System Research)
**The stellar pulsation timing detection method for substellar companions**

The rapid pulsations of subdwarf B stars (sdBs) can be used to detect substellar companions from periodic variations in the expected arrival times of the pulsation maxima. This timing method is particularly sensitive to planets at large distances and complementary to other exoplanet detection methods because they are not efficient for stars with small radii and high gravities. Thus, the timing method opens up a new parameter range in terms of the host stars and helps to understand the formation process of single sdBs. To date planetary candidates in sdB-systems are for example V391 Peg b, HW Vir b, c, HS 0705+67003 b and Kepler-429 b, c, d.

In consideration of the PLATO space mission this allows us to enhance the diversity of potential exoplanet host stars. Therefore, we are currently developing and testing an automated pipeline to validate this method and to apply it to many different sets of observations. This allows us not only to probe evolved stars but also main-sequence A stars (delta Scuti) as exoplanet host stars.

17 - Steve Boudreault (Max-Planck-Institut für Sonnensystemforschung)
**PDC WP 334 600 Science Flux Alerts: detection of transient astronomical events of scientific interest with PLATO**

The ESA mission PLAnetary Transits and Oscillations of stars (PLATO) is aiming at obtaining light curve of a few hundred thousand stars for detection of planetary transits and characterisation of their host-star with asteroseismology analysis. It cannot be excluded that, during PLATO lifetime, non-planet-transiting and non-asteroseismology events will be detected including supernovae, classical novae, gamma-ray-burst, gravitational microlensing, stellar Superflares, and other unexpected and/or unclassified events. The goal of the Science Flux Alert is to detect and give an alert about a possible detection of one of these rare events of scientific interest for additional observations, considering their brevity and non-repeatability, while they are in progress.

18 - Gaetano Scandariato (INAF-OACT)
**Comparing planetary radii from TESS and CHEOPS**

The Transiting Exoplanet Survey Satellite (TESS) will certainly provide a collection of exoplanets around nearby bright stars, and the CHaracterizing ExOPlanet Satellite (CHEOPS) will be useful for follow-up studies. Due to their operations in different pass-bands, the apparent planetary radius measured with the two instruments may differ if the planet has an atmosphere and/or the host star is active. In this respect, we study the fractional difference in the transit depth in the two pass-bands of CHEOPS and TESS as function of the atmospheric properties of exoplanets and stellar activity of the host stars.

19 & 20 - Kate Isaak (ESA/ESTEC)
**CHEOPS: an overview of the mission**
**CHEOPS: the Guest Observers Programme**

CHEOPS (CHaracterising ExOPlanet Satellite) is the first exoplanet mission dedicated to the search for transits of exoplanets by means of ultrahigh precision photometry of bright stars already known to host planets, with launch readiness foreseen by the end of 2018. It is also the first S-class mission in ESA's Cosmic Vision 2015-2025. The mission is a partnership between Switzerland and ESA's science programme, with important contributions from 10 other member states. It will provide the unique capability of determining accurate radii for a subset of those planets in the super- Earth to Neptune mass range, for which the mass has already been estimated from ground- based spectroscopic surveys. CHEOPS will also provide precision radii for new planets discovered by the next generation of ground-based transits surveys (Neptune-size and smaller). The high photometric precision of CHEOPS will be achieved using a photometer covering the 0.35 - 1.1um waveband, designed around a single frame-transfer CCD which is mounted in the focal plane of a 30 cm equivalent aperture diameter, f/5 on-axis Ritchey-Chretien telescope.

20% of the observing time in the 3.5 year nominal mission will be available to Guest Observers from the Community. Proposals will be requested through open calls from ESA that are foreseen to be every year, with the first 6 months before launch.

In poster #1 I present an overview of the mission on behalf of the ESA Project Team and the CHEOPS Mission Consortium; the focus of poster #2 will be observing with CHEOPS, with an emphasis on the ESA-run CHEOPS Guest Observers Programme through which members of the Community will be able to apply for observing time on CHEOPS.

21 - John Lee Grenfell (DLR)
**Observations of exoplanet atmospheres using the PLATO fast cameras**

We assess broadband color filters for the two fast cameras on the PLATO 2.0 space mission with respect to characterization of atmospheric composition, haze and geometric albedo. Literature values are taken for the differences in transit depth between the broadband lower wavelength interval and the upper broadband wavelength interval. We consider (i) Hot Jupiters (having solar bulk compositions with varying metallicities and the same radius and incoming stellar insolation as

HD209458b) placed at 25pc and 100pc away from the Earth and (ii) Low Mass Low Density planets (for different atmospheric compositions and clouds) with the same radius and incoming stellar insolation as GJ1214b) placed 10pc and 25pc away from the Earth. Planets orbiting main sequence central stars with stellar classes F, G, K and M are investigated. We assess the S/N ratio with respect to photon noise. Results suggest that the broadband filter could resolve atmospheric Rayleigh absorption for light, low metallicity planetary atmospheres both with and without sub-micron hazes for planets up to ~25pc away from the Earth. It could determine wavelength-dependent geometric albedos for hot Jupiters up to ~100pc away from the Earth for planets orbiting cooler (K- and M-dwarf) main sequence stars and at least up to 25pc away for planets orbiting G-and F-stars.

22 - David Armstrong (University of Warwick)
**PLATO Optical Phase Curves: Variability in Exoplanet Atmospheres**

The study of exoplanets is moving from a phase of discovery to one of detailed characterisation. Here I will demonstrate one aspect of this: the study of exoplanet phase curves, and in particular their variability over time. Weather is common on all planets in the Solar System; but is this also true in the unusual exoplanets now known? PLATO can answer this question through the study of planetary phase curves, and is indeed the only upcoming instrument with the necessary precision at optical wavelengths. I will look at the first detection of variability in a giant exoplanet, HAT-P-7b. HAT-P-7b has a strong superrotating equatorial jet. I will show how changes in the speed of this jet, driven by either instabilities or directly by a magnetic dynamo, can cause observable shifts in the planetary phase curve and allow us to place limits on the planet’s magnetic field. PLATO has the capability to discover a sample of such planets, directly investigating planetary atmospheres, and potentially even magnetic fields.

23 - Judith Korth (RIU-PF, Cologne)
**Orbital parameter estimation of extrasolar multi-planet systems by Transit Time Variation**

Transit Time Variation (TTV) is the earlier or later occurrence of a planetary transit across the stellar disk relative to the time of a reference transit. TTV is dominantly caused by third body orbit perturbations by attracting forces acting on the transiting planet by at least one another planet inside or outside of the orbit of the known transiting planet. Gravitational interactions perturb the velocity of the transiting planet in its orbit which manifests in a periodical perturbation of the revolution period. Measurements of the transit times and the identification of differences from a mean transit period may prove the existence of further planets. The TTV is therefore a tool to confirm planetary candidates in multi-planet systems. Even non-transiting planets can be detected by the analysis of the TTV of a transiting planet. Their orbital elements can be estimated if the TTV is sufficiently resolved.

The shape of the TTV curve, the sequence of the individual transit time differences as a function of observing time, depends on the orbital elements of the planet(s) in the system and may show very complex structures.

PLATO will observe various stars for which the usual planetary mass determination by ground-based radial velocity observation is not always possible. TTV is an alternative method for orbit determination which uses only the information from the light curve.

24 - Prabal Saxena (NASA Goddard)

**Connecting Physical Mechanisms to Observations of the Rocky Exoplanets Most Amenable to Characterization**

Close-in solid exoplanets such as 55 Cnc e and Corot 7b promise to be the class of solid exoplanets most amenable to characterization by transit photometry and spectroscopy in the near future. However, these planets promise to also possess some of the most extreme surface and atmospheric environments. Such extreme characteristics and potential surface and atmospheric variability may already have been observed on 55 Cnc e. Connecting viable physical mechanisms to such observations and determining a strategy to rule out specific mechanisms is critical to interpreting current and future data. This presentation will discuss some of the different physical mechanisms most often hypothesized to exist on these planets and describe research efforts and observing strategies to distinguish between them.

25 - Megan Worters (Centre for Exoplanet Science, University of St Andrews)

**Comparison Catalogue for Gas-Phase Equilibrium Constants**

Observations, like those from PLATO or JWST, require atmosphere models as the theoretical back-bone of data interpretation. One of the core tasks in modelling an atmosphere is the prediction of the chemical composition of the atmospheric gas for given local thermodynamic conditions (Tgas, pgas). The accuracy with which the chemical composition can be calculated affects the accuracy of the opacity calculation, and hence the accuracy of a synthetic spectrum derived from a model atmosphere. If the atmospheres of brown dwarfs and planets are considered, the gas-phase abundances are furthermore a key input for cloud formation modelling.

In order to support the atmosphere modelling communities, we present a comparison study of the material input data for gas-phase equilibrium calculation for 6 different data sets of gas-phase equilibrium constants, Kp. We present a ‘Comparison Catalogue’ for 1155 molecules and molecular ions. Our ‘Comparison Catalogue’ will be made available online.

We note that the chemical equilibrium assumption holds in collisional dominated atmospheres, like for cool stars, brown dwarfs and planets, but fails for chromospheric or exospheric gases.

26 - Diana Rodica Constantin (Astronomical Institute of the Romanian Academy)

**Modelling of the RGs KIC 003758458 and KIC 009882316 by means of asteroseismology with Kepler**

We have analysed oscillations of the RGs KIC 003758458 and KIC 009882316 observed by Kepler. The data consists of the first seven quarters (except Q6 for KIC 003758458) of science operations of Kepler. A Lomb-Scargale algorithm is used to generate the power spectrum. We have estimated directly from the power spectrum the mean large frequency separation and the frequency of the maximum oscillation power. We use the scaling relations to estimate the preliminary asteroseismic mass, which will be confirmed with grid of stellar models calculation. Stellar models are calculated with CESAM2k evolution code. We calculate the oscillation frequencies of p mode of degree l=0, 1, 2 and 3 and the frequency differences of a large number of models along the evolutionary tracks using LNAWENR linear, non-radial, non-adiabatic oscillation code. For the effective temperature we have chosen the KIC value. The best fitting stellar models for the two RGs are provided.

27 - Dumitru Pricopi (Astronomical Institute of the Romanian Academy)
**Looking inside the rotating red giant star KIC 614777 by means of asteroseismology with Kepler**

We have analysed oscillations of the red giants star KIC 6144777 observed by NASA Kepler satellite. The data consists of the first eleven quarters of science operations of Kepler which cover about 27 months. The high signal-to-noise ratio (S/N) and continuous data sets allow us to accurately extract the oscillation parameters from the power spectrum. We have found that the mean large frequency separation, Δν, and the frequency of the maximum oscillation power, νmax, are around 10.9 and 128 μHz, respectively. We use the scaling relations of   and   to estimate the preliminary asteroseismic mass, which will be compared with results of detailed stellar modeling. Stellar models are calculated with CESAM2k stellar evolution code. We have calculated the oscillation frequencies of p mode of degree l up to 3 and the frequencies of a large number of models along the evolutionary tracks using LNAWENR linear, non-radial, non-adiabatic oscillation code. We have chosen the KIC values to constrain the effective temperature, metallicity and surface gravity of the best fitting model of KIC 6144777. We have measured the observed rotational splittings in the nonradial dipole mixed modes and we have found the maximum value of the rotational splitting in the g-m mixed modes as 0.237 μHz. The link between observed rotational splittings and the rotating core is investigated. By fitting a model of internal rotation profile to observed splittings we have estimated the size of rigid rotating core as about 0.004 of stellar radius. Also, we have found differential rotation in the convective envelope as a signature of angular momentum transport from core to envelope. The mean observational period spacing for the l=1 mixed modes of about 61 s suggests that this red giant branch star is in the shell hydrogen-burning phase.

28 - Steven Christophe (LESIA, Observatoire de Paris)
**A model-independent method for analysing oscillation spectra of rapidly-rotating gamma Doradus and SPB stars**

Mixing processes at the interface between convective and radiative regions and angular momentum transport mechanisms remain major uncertainties in the physical description of stars. Gamma Doradus and Slowly pulsating B-type (SPB) stars pulsate in high radial order gravity modes that probe the structure of the radiative deep layers near their convective core, hence giving a chance to obtain observational constraints on these processes. Nonetheless, these pulsators are typically moderate to fast rotators for which it is challenging to disentangle the oscillation spectrum.

On the basis of the traditional approximation of rotation (TAR), we have developed a stellar-model-independent method to decipher the oscillation spectrum of rapidly-rotating gamma Doradus and SPB stars. Using this method, we are able to simultaneously estimate the near-core rotation frequency, the buoyancy radius, and the geometry of gravity modes. Extensive tests on synthetic spectra were carried out to characterise the method and evaluate its performance as a tool to interpret observed oscillation spectra. In this poster, we will present the main steps of the method and the possibilities it has to offer, which we illustrate by two applications on Kepler targets. We will also discuss the limitations in its current implementation.

29 - Takafumi Sonoi (Observatoire de Paris)
**Inclusion of turbulent pressure perturbation in computation of adiabatic oscillation frequencies**

The space-borne missions CoRoT and Kepler have provided a wealth of highly accurate data. However, poor modeling of the upper-most region of solar-like stars spoils the accuracy of theoretical oscillation frequencies, and prevents us from making the best of these observations. This problem is called "surface effect" and a key ingredient to solve it is turbulent pressure for the computation of both the equilibrium models and the oscillations. While 3D hydrodynamic simulations help us include properly the turbulent pressure in the equilibrium models, the way this surface effect is included in the computation of stellar oscillations is still subject to uncertanties. We aim at determining how to properly include the effect of turbulent pressure in computation of adiabatic oscillations. This work analyses adiabatic oscillation frequencies of a patched model of the Sun with an inner part constructed by a 1D stellar evolution code (CESTAM) and an outer part by the 3D hydrodynamical code (CO5BOLD). For computing adiabatic oscillations of equilibrium models including turbulent pressure, two approximations have been proposed previously. One is the reduced gamma (RGM) approximation, which sets the Lagrangian perturbation of turbulent pressure to zero, and the other one is the gas-gamma model (GGM) approximation, which assumes that the relative Lagrangian perturbation of turbulent pressure equals that of thermal pressure. In spite of such crude assumption, a previous work showed that GGM gives certainly better agreement with the solar observed frequencies than RGM. In this work, we compute frequencies with a time-dependent convection (TDC) formalism in the adiabatic limit as well as with GGM and RGM. We figure out that the TDC provides better agreement with the observation than GGM and RGM. In the TDC formalism, a term corresponding to GGM gives substantial contribution to the frequency shift due to the perturbation of turbulent pressure, which implies GGM is more suitable to compute adiabatic oscillation frequencies of equilibrium models including turbulent pressure than RGM.

30 - Javier Pascual Granado (Institute of Astrophysics of Andalusia - CSIC)
**Coarse Graining Spectral Analysis (CGSA - an application to classification of stellar variability**

Many systems in nature present scale invariance in their spatio-temporal dynamics. In particular fractal structure has been observed in solar granulation patterns and light curves of some pulsating stars. The main interest in the study of fractal properties in such physical phenomena lies in the close relationships they have with different underlying dynamic, e.g. chaos, turbulence, stochastic reaction-diffusion processes.

Unlike the most common fractal analysis techniques such as the Rescaled Range Analysis and Multifractal Spectra Analysis, other techniques that can provide a deeper insight into the dynamics of the system, as the Coarse Graining Spectral Analysis (CGSA), are less known in asteroseismology. CGSA is a Fourier based algorithm exploiting the peculiar phase distribution in self-similar time series in order to discriminate in a general time series the stochastic fractal power spectra from the harmonic one.

This technique is a potentially enriching tool for PLATO data analysis. Here we present an interesting application of CGSA to develop classification criteria for delta Scuti, gamma Doradus and solar-like pulsating stars. In addition, fractal and multifractal fingerprints in light curves might be used to infer the mechanism of mode excitation and/or magnetic activity in the outer convective region.

31 - Gaetano Scandariato (INAF-OACT)
**Tomography of Spotted transit Chords (TOSC)**

TOSC (Tomography Of Spotted transit Chords) is a tomographic inverse-approach tool which reconstructs the flux distribution along the transit belt. It provides robust results for light curves with photometric accuracies better than 1 mmag, returning the spot-photosphere temperature contrast with an accuracy better than 100K. The analysis of real data with TOSC returns results consistent with previous studies.

32 - Laurent Gizon (Max Planck Institute for Solar System Research)
**Detection of activity cycles in Kepler stars**

We observe activity cycles in the photometric variability of 3203 Kepler stars, with cycle periods below 6 years and rotation periods below 40 days. Each cycle detection has a false alarm probability less than 5% (calculated by randomly shuffling the measured 90-day variability measurements). We show that the shape of the variability deviates from a pure sine curve, consistent with observations of the solar cycle. Reference: Reinhold, Cameron, Gizon, A&A 603, A52 (2016).

33 - Kristine Lam (University of Warwick)
**Time variability in the evaporation of WASP-12b**

Close-in exoplanets are susceptible to increased stellar irradiation. This energy heats up the planetary atmosphere, causing the material to evaporate and escape into the planet orbit and form a comet-like tail. Under suitable conditions, stellar light is absorbed passing through the tail and can be manifested by hiding the emission feature in the Ca II H & K profiles. WASP-12 hosts an evaporating close-in planet and an enhanced absorption is seen in the Ca II H & K. We present a detailed study of WASP-12 spectra observed around the planet orbit to understand the orbital variation of the system and how the system evolves.

34 - Samuel Gill (Keele University)
**Measuring the masses and radii of EBLMs found by the WASP survey**

We have an ongoing project to measure the mass and radii of M dwarfs eclipsing FGK stars (EBLMs) found by the WASP survey. Measurements of eclipsing M-dwarfs have shown an enlarged radius compared to evolutionary models, which has been attributed to magnetic inhibition of convection. This is also seen in interferometric observations making it unclear whether spin-orbital synchronisation is to blame. We have high-quality transit light curves and spectroscopic orbits for numerous EBLMs allowing us to measure the mass and radius to a precision of a few percent. This, along with GAIA parallaxes, provides an excellent opportunity to calibrate the mass-radius-composition relation for the bottom end of the main sequence. We also discuss model ambiguities and third-light contributions which introduce additional uncertainties on the mass, radius and age of both components.

35 - Samuel Gill (Keele University)
**Determining accurate atmospheric parameters of FGK stars**

Atmospheric properties of FGK stars can be determined by spectral fitting or from the analysis of equivalent width measurements. This is particularly challenging for echelle spectra with low signal-to-noise which are plagued with unusual noise profiles and systematic trends. To address this, we have developed an automated spectral fitting routine using wavelet convolutions to determine the atmospheric parameters of FGK stars from low-quality spectra. We prove our method to be self-consistent and accurate with respect to other spectral analysis techniques. Determining accurate atmospheric parameters of FGK stars are needed obtain the mass of transiting exoplanet host stars and sets the scales of the systems. The method has already been used to determine the atmospheric properties of EBLM J0555-57, and will be used to measure similar binary and exoplanet systems.

36 - Farzana Meru (Institute of Astronomy, Cambridge)
**The spiralling signatures of planet formation**

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

37 - Sergei Nayakshin (University of Leicester)

**Population synthesis models for Gravitational Instability planets, a community effort**

The frequency of directly imaged planetary mass objects orbiting their FGK stars at separations grater than tens of AU is only a few percent. Unfortunately, due to uncertainties in theoretical modelling of clump formation and evolution, two conflicting interpretations of the data are possible: (A) either disc fragmentation on planet mass clumps is similarly rare or (B) this process gives birth up to 10 clumps per star but their survival chances to the present day are extremely low. The latter scenario is of direct interest to the PLATO mission because most of the "missing" wide separation clumps migrate into the inner 0.01 -- 10 AU disc, where their legacy could be observable. Clumps that survive tides from their host stars become bona fide giant planets such as hot or warm Jupiters; those that are disrupted leave behind solid core planets from sub Earth to about Neptune mass. The population of planets that migrated from tens of AU has been predicted to have widely different host metallicity correlations from those made by the Core Accretion theory. One of the key predictions -- absence of clear metallicity preference for planets above 5 Jupiter masses has been recently confirmed.

It is absolutely essential to try to understand how often gravitational instability gives birth to planets, and whether they can contribute to the inner planets usually thought to form via Core Accretion. I shall report a wide ranging, community effort, involving theorists across half a dozen institutions, to bridge the gap between the existing population synthesis models and attempt to make detailed predictions for upcoming exoplanet observations missions and PLATO in particular.