PLATO 2.0 Science Workshop

Day 1 - Monday 29 July 2013

11:00	*Registration open*	

Session 1: The PLATO 2.0 Mission

13:00	Welcome	
13:05	PLATO as M3 candidate mission	Arvind Parmar ESA
13:20	PLATO 2.0: Science objectives and consortium overview	Heike Rauer Institut fuer Planetenforschung, DLR, DE
13:50	PLATO Mission overview	Philippe Gondoin ESA
14:10	The PLATO payload	Roberto Ragazzoni INAF-Osservatorio Astronomico di Padova, IT
14:25	The PLATO Science Ground Segment	Raymond Burston MPS, DE
14:40	PLATO Science preparation	Don Pollacco Warwick University, UK
14:55	Ground based follow-up - The context: Past and future projects	Stephane Udry University of Geneva, CH
15:15	*Coffee Break*	

Session 2: Past and future facilities

15:40	CoRoT greatest hits: recopilatory of the best lessons in 4CCDs	Roi Alonso Instituto de Astrofísica de Canarias, ES
16:05	Lessons for PLATO from CoRoT (and Kepler) on follow-up observations.	François Bouchy Institut Astrophysique de Paris, FR
16:25	Passing the baton from Kepler to TESS, a wealth of exoplanetary and Astrophysics science results achieved and anticipated	Jon Jenkins SETI Institute, US
17:00	The CHEOPS mission	Willy Benz University of Bern, CH
17:20	The Gaia catalogue: a treasure trove for PLATO 2.0 target selection and characterization	Alessandro Sozzetti INAF-Osservatorio Astrofisico di Torino, IT
17:40	Atmospheric characterization of PLATO exoplanets with the E-ELT	Matteo Brogi Leiden University, NL
18:00	Astrophysical false positives in transit surveys: from Kepler to PLATO 2.0	Alexandre Santerne Centro de Astrofisica da Universidade do Porto, PT
18:15	Precise spectroscopic stellar parameters for the PLATO targets	Annelies Mortier Centro de Astrofísica da Universidade do Porto, PT
18:30	Discussion	
19:00	*Welcome drink and Poster session*	
19:45	*Bus departure to Noordwijk hotels*	

Day 2: Tuesday 30 July 2013

Session 3: Planetary transits analysis

08:45	The challenge of the detection of transiting terrestrial extrasolar planets	Juan Cabrera German Aerospace Center, DE
09:00	The need of precise planetary parameters and extras: How to get them with PLATO	Szilard Csizmadia Institut fuer Planetenforschung, DLR, DE
09:15	Position angles and coplanarity of multiple systems from transit timing	Aviv Ofir Institute for Astrophysics, Göttingen, DE
09:30	Statistical validation of PLATO2.0 planet candidates	Rodrigo Díaz Laboratoire d'Astrophysique de Marseille, FR

Session 4: Asteroseismology and stellar science

09:45	Asteroseismology across the HR diagram	Marc Antoine Dupret University of Liège, BE
10:15	Oscillations of solar-like stars and red giants, the observer perspective	Saskia Hekker University of Amsterdam, NL
10:35	*Coffee Break*	
11:05	Asteroseismology of exoplanet host stars: results from Kepler and prospects for PLATO	William Chaplin University of Birmingham, UK
11:25	Asteroseismology and methods for stellar parameter estimation	Michael Bazot Centro de Astrofisica da Universidade do Porto, PT
11:40	Reaching the 1% accuracy level on stellar mass and radius determinations from asteroseismology	Valerie Van Grootel University of Liège, BE
11:55	Update on inversion methodologies	Daniel R. Reese University of Liège, BE
12:10	Stellar rotation and magnetic activity seen through Astroseismology	Rafael A. Garcia SAp, CEA/Saclay, FR
12:25	Determination of the stellar properties of the PLATO targets from non-seismic constraints	Thierry Morel University of Liège, BE
12:40	Detailed analysis of Kepler-10: Synergy between asteroseismology and exoplanet research	Hans Kjeldsen Aarhus University, DK
12:55	*Lunch*	

Session 5: Star-Planet interactions

14:25	Stellar activity	Isabella Pagano INAF-Osservatorio Astrofisico di Catania, IT
14:45	Star-planet tidal and magnetic interactions	Nuccio Lanza INAF – Osservatorio Astrofisico di Catania, IT
15:05	Star-planet interaction	Helmut Lammer Austrian Academy of Sciences, AT
15:25	Enshrouded close-in exoplanets	Carole Haswell The Open University, UK
15:40	Dealing with stellar activity in high-precision photometric and spectroscopic transit observations	Mahmoudreza Oshagh Center for Astrophysics of Uni of Porto. PT
15:55	Magnetic fields of planet-host stars	Rim Fares University of St Andrews, UK
16:10	*Coffee Break*	

Session 6: Planetary science

16:40	How could PLATO serve Planetary Physics and what can we learn from Solar System planets for terrestrial exoplanets?	Tilman Spohn DLR, DE
17:10	Gaseous and icy giant planets	Ravit Helled Tel-Aviv University, IL
17:40	Comparison of transit spectra and direct imaging spectra	Jean Schneider Paris Observatory, Meudon, FR
17:55	What can we learn about exoplanetary atmospheres in the optical?	Kevin Heng University of Bern, CH
18:10	Circumbinary planet detection with PLATO	Hans Deeg Instituto de Astrofísica de Canarias, ES
18:25	Exoplanets around evolved stars	Roberto Silvotti INAF-Osservatorio Astrofisico di Torino, IT
19:00	*Bus departure to Noordwijk hotels*	
20:00	*Dinner*	

Day 3, Wednesday 31 July 2013

Session 7: Planet formation

08:30	Planet formation and dynamics	Willy Kley Universität Tübingen, DE
08:55	Evolution of multi-planet systems	Richard Nelson Queen Mary University of London, UK
09:20	Dynamical evolution of planetary systems - PLATO's contribution	Cilia Damiani Laboratoire d'Astrophysique de Marseille, FR
09:35	What do we know about collisions in planetary systems?	Rudolf Dvorak University of Vienna, AT
09:50	Planet formation and system chronology	Günther Wuchterl Thüringer Landessternwarte Tautenburg, DE
10:05	Planet synthesis modelling	Christoph Mordasini MPIA, DE
10:30	*Coffee Break*	

Session 8: Complementary and legacy science

11:00	Stellar populations and galactic science	Andrea Miglio University of Birmingham, UK
11:25	Complementary and legacy Science	Konstanze Zwintz KU Leuven, BE
11:50	PLATO science on classical variable stars	Robert Szabo Konkoly Observatory, HU
12:05	Discussion	
12:45	*End of meeting*	

Posters

#1	Characterizing stellar and exoplanetary environments via Ly-alpha transit observations of exoplanets	K.G. Kislyakova et al. Austrian Academy of Sciences, AT
#2	Extreme orbital forcing simulations with the PlaSim general circulation model and its implications on habitability	Manuel Linsenmeier & Salvatore Pascale University of Hamburg, DE
#3	EXOTRANS a detection pipeline ready to face the challenge to hunt and characterize exoplanetary systems in upcoming space missions.	Sascha Grziwa U. Koeln, DE
#4	The PLATO Simulator: Modelling Space-Based Imaging	Pablo Marcos-Arenal et al, KU Leuven, BE
#5	The HoSTS Project: Homogeneous Analysis of Transiting Systems	Yilen Gomez Maqueo Chew et al. Warwick University, DE
#6	The BT-Settl model atmospheres for Stars, Brown Dwarfs, and Gas Giant Planets	France Allard Centre de Recherche Astrophysique de Lyon, FR
#7	TNG spectrophotometric measurements of HAT-P-1	Marco Montalto et al. Centro de Astrofisica da Universidade do Porto, PT
#8	A Survey for planets of main-sequence stars of intermediate mass	Eike W. Guenther Thueringer Landessternwarte Tautenburg, DE
#9	Population considerations for binary stars using transit searches	Ulrich Kolb et al. The Open University, UK
#10	Hybrid methods in planetesimal dynamics	Pau Amaro Seoane Max Plack for Gravitational Physics, DE
#11	Stellar Characterization for Transiting Exoplanet Surveys: Lessons from Kepler, Prospects for TESS and Plato	Eric Gaidos University of Hawaii at Manoa, US

PLATO 2.0: Science Objectives and Consortium Overview

Heike Rauer (DLR) and the PLATO Consortium

PLATO 2.0 is a proposed ESA M3 mission which will revolutionize our understanding of extra-solar planets through its discovery and bulk characterization of planets around hundreds of thousands of stars. With launch foreseen in 2022, PLATO 2.0 will follow the very successful space missions CoRoT and Kepler, as well as ESA's first small mission CHEOPS and NASA's mission TESS. PLATO 2.0 will carry out high-precision, long-term photometric and astroseismic monitoring of up to a million of stars covering over 50% of the sky, and provide orders of magnitudes more small planets around bright stars than the previous missions. Its exquisite sensitivity will ensure that it detects hundreds of small planets at intermediate distances, up to the habitable zone around solar-like stars. PLATO 2.0 will characterize planets for their radius, mass, and age. It will provide the first large-scale catalogue of well-characterized small planets at intermediate orbital periods, relevant for a meaningful comparison to planet formation theories and providing targets for future atmosphere spectroscopy. This data base of bulk characterized small planets will provide a solid basis to put the Solar System into a wider context and allow for comparative exo-planetology. Furthermore, its precise lightcurves will furthermore allow us to search for e.g. exomoons, exo-rings, and binary planets.

In addition, the precise stellar parameters obtained by astroseismic studies will open new doors to better understand stellar interiors and allow us to constrain poorly-understood physical processes, like convection, improve our understanding of stellar evolution, and determine precise age of stars and planetary systems.

The talk will provide an overview of PLATO 2.0's science goals and the mission consortium.

CoRoT Greatest Hits: Recopilatory of the Best Lessons in 4 CCDs

Roi Alonso and Claire Moutou, Laboratoire d'Astrophysique de Marseille, France
CoRoT Exoplanet Team

The CoRoT mission (Dic 2006 - Nov 2012) used a 27-cm telescope on a low-Earth orbit to produce high-precision photometric time series of more than 163,000 stars. It pioneered the search for exoplanets from space, and during its 2136 days on orbit it detected up to today about 500 planet candidates. A few of them (5%) were confirmed as planets with the numerous ground-based efforts conducted by the community. We will summarize the (subjective) best scientific findings and operational lessons learned from this mission, focussing on those of interest for PLATO 2.0.

Passing the Baton from Kepler to TESS, a Wealth of Exoplanetary and Astrophysics Science Results Achieved and Anticipated

Jon Jenkins, SETI, US

Kepler vaulted into the heavens on March 7, 2009, initiating NASA's search for Earth-size planets orbiting Sun-like stars in the habitable zone, where liquid water could exist on a rocky planetary surface. In the 4 years since Kepler began science operations, a flood of photometric data on upwards of 190,000 stars of unprecedented precision and continuity has provoked a watershed of 134+ confirmed or validated planets, 3200+ planetary candidates (most sub-Neptune in size and many comparable to or smaller than Earth), and a resounding revolution in asteroseismology and astrophysics. The most recent discoveries include Kepler-62 with 5 planets total of which 2 are in the habitable zone with radii of 1.4 and 1.7 Re. The focus of the mission is shifting towards how to rapidly vet the 18,000+ threshold crossing events produced with each transiting planet search, and towards those studies that will allow us to understand what the data are saying about the prevalence of planets in the solar neighborhood and throughout the galaxy. This talk will provide an overview of the science results from the Kepler Mission and the work ahead to derive the frequency of Earth-size planets in the habitable zone of solar-like stars from the treasure trove of Kepler data.

NASA's quest for exoplanets continues with the Transiting Exoplanet Survey Satellite (TESS) mission, slated for launch in May 2017 by NASA's Explorer Program. TESS will conduct an all-sky transit survey to identify the 1000 best small exoplanets in the solar neighborhood for follow up observations and characterization. TESS's targets will include all F, G, K dwarfs from +4 to +12 magnitude and all M dwarfs known within ~200 light-years. 500,000 target stars will be observed over two years with ~500 square degrees observed continuously for a year in each hemisphere in the James Webb Space Telescopes continuously viewable zones. Since the typical TESS target star is 5 magnitudes brighter than Kepler's and 10 times closer, TESS discoveries will afford significant opportunities to measure the masses of the exoplanets and to characterize their atmospheres with JWST, ELTs and other exoplanet explorers.

The success of the Kepler Mission and the selection of TESS should raise the tides for future exoplanet discovery and characterization missions focused on terrestrial exoplanets.

The CHEOPS Mission

Willy Benz, University of Bern, Switzerland

The CHaracterizing ExOPlanets Satellite (CHEOPS) has been selected in 2012 as the first S-class mission of the European Space Agency (ESA) science programme. It will also be the first mission dedicated to search for transits by means of ultrahigh precision photometry on bright stars already known to host planets.

The main science goals of the CHEOPS mission will be to study the structure of exoplanets with radii typically ranging from 1-6 Earth radii orbiting bright stars. With an accurate knowledge of masses and radii, CHEOPS will set new constraints on the structure and hence on the formation and evolution of planets in this mass range. In particular, CHEOPS will:

- Determine the mass-radius relation in a planetary mass range for which only a handful of data exist and to a precision never before achieved.
- Identify planets with significant atmospheres as a function of their mass, distance to the star, and stellar parameters. The presence (or absence) of large gaseous envelopes bears directly on fundamental issues such as runaway gas accretion in the core accretion scenario or the loss of primordial H-He atmospheres.
- Place constraints on possible planet migration paths followed during formation and evolution for planets where the clear presence of a massive gaseous envelope cannot be discerned.
- Probe the atmosphere of known Hot Jupiter in order to study the physical mechanisms and efficiency of the energy transport from the dayside to the night side of the planet.
- Provide unique targets for future ground- (e.g. E-ELT) and space-based (e.g. JWST, EChO) facilities with spectroscopic capabilities. With well-determined radii and masses, the CHEOPS planets will constitute the best target sample within the solar neighbourhood for such future studies.
- Offer up to 20% of open time to the community to be allocated through competitive scientific review.

This talk will briefly review the main characteristics of the mission and present the current status of its development.

The Gaia Catalogue: a Treasure Trove for PLATO 2.0 Target Selection and Characterization

Alessandro Sozzetti, INAF - Osservatorio Astrofisico di Torino, Italy

I will briefly review the status of Gaia, now within a few months from launch. I will then outline the profound impact of the final Gaia catalogue data products on the science of PLATO 2.0, particularly in terms of a) delivery of a virtually contamination-free list of millions of bright, nearby main-sequence F-G-K-type dwarfs, and b) accurate re-calibration of all transiting planet hosts revealed by PLATO 2.0 based on Gaia's extremely precise direct distance estimates.

Atmospheric Characterization of PLATO Exoplanets with the E-ELT

Matteo Brogi and Ignas Snellen, Leiden University, The Netherlands

The discovery of exoplanets orbiting bright stars is the main science goal of PLATO. These planets are ideal targets for atmospheric characterization, which is currently limited to a small sample because of the very stringent signal-to-noise requirements.

The planned E-ELT promises enormous advancements in high-contrast direct imaging, radial velocities, and low- to mid- resolution spectroscopy. Moreover, an important role for exoplanet studies will be played by high-resolution spectroscopy (R ~ 100,000), which only recently reached maturity thanks to NIR observations with VLT/CRIRES. The ability to resolve individual molecular lines, Doppler-shifted because of the planet orbital motion, allows a reliable identification of molecules, constraining the structure of the planet atmosphere, and revealing the planet radial velocity, which for non-transiting planets means a direct estimate of planet mass and orbital inclination. These in turn rely on a precise measurement of the stellar mass, another goal of PLATO.

With a 40m-class telescope, it will be possible to study at high-resolution the entire known sample of giant planets, determining relative molecular abundances and C/O ratios. For the brightest systems, phase-curves and global atmospheric patterns (winds, superrotation...) will be revealed by changes in strength and radial velocity of the spectral features. Finally, if very common, terrestrial planets orbiting nearby M-dwarfs could be characterized as well, by detecting potential biomarkers such as O_2. This means that, by observing at very high-resolution with the E-ELT, we could already start characterizing terrestrial planets in the next decade.

Astrophysical False Positives in Transit Surveys: From Kepler to PLATO 2.0

Alexandre Santerne
Centro de Astrofísica da Universidade do Porto, Portugal

Rodrigo F. Diaz, José-Manuel Almenara, Magali Deleuil, François Bouchy
Laboratoire d'Astrophysique de Marseille, France

Nuno Santos
Centro de Astrofísica da Universidade do Porto, Portugal

Claire Moutou, Guillaume Hébrard
Laboratoire d'Astrophysique de Marseille, France

Astrophysical false positives are a classical nuisance of exoplanet-transit surveys. They might bias statistical analysis based on the transit candidates that are then used to constrain theories of planet formation, migration and evolution. Therefore, it is crucial to unveil the nature of these impostors using complementary data, such as centroid curve or follow-up observations. In this talk, I will first review the state of the art of identifying astrophysical false positive in Kepler data as well as the various estimations of the false-positive rate. Then, I will compare the expected false-positive probability of the PLATO mission, with the ones of Kepler and CoRoT. Finally, I will discuss which follow-up observations will be more efficient to reject the various scenarios of false positive of the PLATO mission.

Precise Spectroscopic Stellar Parameters for the PLATO Targets

Annelies Mortier, Sergio Sousa, Nuno Santos, Vardan Adibekyan, Elisa Delgado Mena, Maria Tsantaki, Vasco Neves

Centro de Astrofísica da Universidade do Porto, Portugal

The characterization of transiting planets is the fundamental goal of the PLATO mission. In order to determine precise and accurate planetary parameters, it is crucial to characterize the host stars as precise and accurate as possible. This will lead to important clues for the formation and evolution of planets.

We present an overview of our work regarding the spectroscopic characterization of planet hosts, both dwarfs as giants, with spectral types varying from F to M. We show the importance of having a precise and homogeneous derivation of the stellar parameters.

The Challenge of the Detection of Transiting Terrestrial Extrasolar Planets

Juan Cabrera, Institute of Planetology, DLR, Germany

Terrestrial rocky planets are of high interest and there are many relevant questions awaiting answers, from basic ones, like which is the yield of planet occurrence, for which we can only provide some limits today, to more detailed ones like how does planetary formation depend on stellar environment, how large can rocky cores grow before starting runaway gas accretion, or how large can be gas envelope to rocky-core ratio in low mass planets, considering the availability of material and the atmospheric escape and erosion from the stellar environment. To address these questions, we need to increase the sample of known Earth-sized transiting planets.

Terrestrial rocky planets represent a formidable challenge for current technology. The photometric transit signal of an Earth-sized planet around a solar-like star is only 80 parts per million and such precision is only achievable for space-based missions. The careful analysis of space-based data has taught us that one of the main limitations of transit detection is the impact of stellar activity. Unfortunately enough, in some cases the photometric amplitude and the typical timescale of this activity is comparable to the photometric signature of transiting planets. We want to identify the necessary improvements that are required in the filtering methods, in the transit detection algorithms, and in the observational strategy to optimize the yield of terrestrial transiting planets of PLATO.

The Need of Precise Planetary Parameters and Extras: How To Get Them with PLATO

Szilard Csizmadia, German Aerospace Center

Transiting exoplanets are key objects to measure the radii of exoplanets. The radius will give the most valuable extra information to our knowledge on exoplanets from transits, because it allows us to study the internal structure, atmosphere, surface inhomogeneties etc. of the planet. However, this require high precision (1-5% for internal structure studies) or extreme high accuracy (0.1% for atmospheric studies). The planet parameter determination is affected by several factors, like our knowledge on limb darkening, stellar activity, and the interaction between stellar activity and limb darkening. Furthermore, the stellar activity also has impact on the stellar radius measurements what introduces systematic errors. The list and the rate of these disturbing effects are summarized in this talk. Stellar spots also affects the measured TTVs. We also present ideas how to increase the accuracy in the transit parameter determination.

Position Angles and Coplanarity of Multiple Systems from Transit Timing

Aviv Ofir, Institute for Astrophysics, U. Göttingen, Germany

A simple geometrical argument allow us to show that an apparent transit timing variation (TTV) is predicted in long light curves, and that this TTV depend also on the on-sky position angle of the planetary orbit, relative to the ecliptic plane. This is a new observable derivable from transit light curves.

We calculate that the on-sky position angle would be readily observable using the future PLATO mission data, and possibility observable in already-known radial-velocity systems (if they exhibit transits). We also find that on-sky coplanarity of multiple objects in the same system can be probed more easily than the on-sky position angle of each of the objects separately.

We give some initial science question that the presented new observable may be related to and help addressing. We find that there is a good match between projected capabilities of the future PLATO space missions and the new observable.

Statistical Validation of PLATO2.0 Planet Candidates

Rodrigo Díaz, José Manuel Almenara
Laboratoire d'Astrophysique de Marseille (LAM), France

Alexandre Santerne
Centro de Astrofísica Universidade do Porto, Portugal

Claire Moutou, Anthony Lethuillie, Magali Deleuil
Laboratoire d'Astrophysique de Marseille (LAM), France

PLATO2.0 should uncover thousands of small transiting planet candidates around bright stars. The resources required to confirm a significant fraction of these candidates via radial velocity will surely be prohibitively large, specially considering that the expected amplitude of the radial velocity variations will be extremely small. In order to ensure the planetary nature of these candidates, alternative methods will be needed.

The technique of planet validation is coming of age with the candidate harvest of the Kepler mission. Thousands of candidates with expected radial-velocity amplitudes outside the reach of current instrumentations have led to a development of this technique. The basic idea behind planet validation is to compare the probability of the planetary hypothesis against that of all reasonably conceivable alternative false-positive hypotheses. The candidate is considered as validated if the posterior probability (i.e. after the available data have been taken into account) of the planetary hypothesis is sufficiently larger than that of all false positive scenarios. This technique, however, does not provide any information on the mass of the transiting object.

I will present the Planet Analysis and Small Transit Investigation Software (PASTIS), a fully-bayesian tool developed at LAM to validate transiting candidates rigorously. The methods and models used in PASTIS will be presented, in particular the differences with and advantages over the BLENDER technique will be outlined. I will then focus on the results of a series of tests performed using synthetic light curves to evaluate the capabilities and limitations of our method. Unlike for the faint Kepler candidates, the results show that most PLATO2.0 candidates could be promptly validated using their discovery light curves alone.

Since the PLATO target stars will be bright, concentrating radial velocity efforts on validated planets should permit their full characterization. Their masses, radii, and orbital parameters can be obtained if the characteristics of the stellar hosts are known. Furthermore, the brightness of the host stars will allow for detailed studies on these objects, thus leading to a more complete and profound understanding of extrasolar planets.

Asteroseismology Across the HR Diagram

Marc-Antoine Dupret, University of Liège, Belgium

In this presentation, I present the power of asteroseismology as a tool for a very precise and accurate characterization of stars. I first consider the case of planet hosting stars. For solar-like main sequence stars, I show with well-chosen examples and simulations that we can aim for precisions of the order of 1-2% for the seismic measurements of stellar radii, 2-4% for the stellar masses and 10-20% for the ages. I also discuss the case of red giants which are known with CoRoT and Kepler to present very rich oscillation spectra and are, for some of them, hosting planets. In a second part of my presentation, I present the ability of asteroseismology to probe stellar interiors. In addition to the previous mentioned stars, I also discuss the cases of massive stars and extreme horizontal branch stars. Finally, I show how asteroseismology of red giants and white dwarfs gives precise constraints which can be used for the probing of the structure and evolution of the Milky Way.

Asteroseismology of Exoplanet Host Stars: Results from Kepler and Prospects for PLATO

Bill Chaplin, University of Birmingham, UK

I shall review results from Kepler on the application of asteroseismology to the study of exoplanet systems, and discuss the exciting prospects for applying similar analyses to significantly larger numbers of systems discovered by PLATO.

Asteroseismology and Methods for Stellar Parameter Estimation

Michael Bazot, Centro de Astrofisica da Universidade do Porto, Portugal

A large number of stellar physics studies focus on the problem of estimating characteristics of stars, being given a theoretical model for stellar structure and evolution and some observations on an object. In this talk I will first briefly review the methods used to achieve such a goal. Second, I will emphasize the interest of using asteroseismic data in order to constrain more robustly stellar parameters such as the mass, the age or the initial chemical composition; and derived quantities such as the radius. Through examples, I will illustrate the gain of precision obtained with this technique. Particular care will be given to the case of planet-hosting stars.

Reaching the 1% Accuracy Level on Stellar Mass and Radius Determinations from Asteroseismology

Valerie Van Grootel
University of Liège, Belgium

Stephane Charpinet
IRAP Toulouse, France

Gilles Fontaine, Pierre Brassard
Université de Montréal, Canada

Betsy Green
Steward Observatory, University of Arizona, US

Asteroseismic modeling of subdwarf B (sdB) stars provides measurements of their fundamental parameters with a very good precision; in particular, the masses and radii determined from asteroseismology are found to typically reach a precision of ~ 1%. However, the models of sdB stars are still imperfect, containing various uncertainties associated with their inner structure and the underlying microphysics (composition and transition zones profiles, nuclear reaction rates, etc.). Therefore, the question of the accuracy of the stellar parameters derived by asteroseismology from the sdB models is legitimate.

I will present in this talk the seismic modeling of the pulsating sdB star in the eclipsing binary PG 1336-018, for which the mass and the radius are independently and precisely known from the modeling of the reflection/irradiation effect and the eclipses observed in the light curve. This allows us to quantitatively evaluate the reliability of the seismic method and test the impact of various uncertainties in our stellar models on the derived parameters. I will show that the sdB star parameters inferred from asteroseismology are precise, accurate, and robust against model uncertainties.

Update on Inversion Methodologies

Daniel R. Reese, Université de Liège, Belgium

The goal of the PLATO mission is to characterise exoplanetary systems as a whole. A key component of this process is gaining a better understanding of the host stars, both through asteroseismology and through ground-based follow up. In this context, seismic inversions play a vital role. Indeed, they enable us to deduce stellar parameters as well as rotational and structural profiles in a less model-dependant way. In this talk, I will present a review of inversion methodologies including some of the latest developments. I will explain how these methods work, show what information can be deduced and describe some of the latest results.

Stellar Rotation and Magnetic Activity seen through Astroseismology

Rafael A. García, Sevice d'Astrophysique CEA-Saclay, France

Continuous photometric coverage of stars provided by asteroseismic space missions are a great opportunity to study their surface and internal rotation, as well as their stellar magnetic variability. As starspots cross the visible disk of stars, they produce modulations in the light curves that can be used to track the surface rotation and the existence of solar magnetic activity cycles when observations are long enough (typically more than a year). Moreover, when p modes can be measured, we can infer the internal structure of the stars, their internal differential rotation, and we can study the perturbations induced by the magnetic cycle in the properties of the modes. The combination of all this information is providing new light on the physical mechanisms driving the surface and internal dynamics of stars. In this talk I propose to review some of the open questions we have and how asteroseismic measurements --with the support of ground based observations-- are important, and why PLATO is the only instrumentation capable of address this kind of science in the next few decades.

Determination of the Stellar Properties of the PLATO Targets from Non-Seismic Constraints

Thierry Morel, AGO, University of Liège, Belgium

We will describe the procedures that may be implemented to derive the parameters of the planet host stars from non-seismic constraints. We will also discuss how these results can be combined with those from asteroseismology in order to increase the accuracy.

Detailed Analysis of Kepler-10: Synergy between Asteroseismology and Exoplanet Research

Hans Kjeldsen, Theoretical Astrophysics Centre, Aarhus University , Denmark

From an observational point of view there is a lot of synergy between asteroseismology and exoplanet research, and some of the best studied exoplanetary systems are those where asteroseismology is used to characterize the host stars and measure the properties of the host stars such as mass, radius and age. In some cases the star-planet spin-orbit alignment or degree of miss-alignment can also be measured. Thanks to the excellent data we get from the Kepler and CoRoT space missions as well as from high-quality spectrographs at VLT (UVES), NOT (FIES) and the ESO 3.6m (HARPS) we have in the recent years been able to perform asteroseismology on thousands of stars. This has led to a revolution in our understanding of detailed properties of stars including properties of convection, rotation and core fusion processes. The field of exoplanet research is also being revolutionized mainly thanks to the unique data from the Kepler mission.

In the talk I will discuss the detailed results of analysis of the Kepler-10-system. The frequencies of the oscillation modes in the host star – Kepler-10 – has been used to measure the stellar radius of Kepler-10 to better than one per cent and the age to better than 10 per cent in accuracy. Since the exoplanet parameters from the Kepler data (transit measurements) depends on the stellar parameters we can only determine accurate parameters for exoplanets if we know the stellar parameters. The exoplanet Kepler-10b is known to be a rocky planet mainly due to the accurate asteroseismic stellar parameters combined with high-precision radial velocity measurements.

Stellar Activity

Isabella Pagano, INAF - Catania Astrophysical Observatory, Italy

"Stellar activity" is a collective name used to group the variability phenomena observed in the outer atmospheres of late type-stars mainly due to the presence of highly structured magnetic fields emerging from the convective envelope.

Stellar activity phenomena - spots, faculae, flares and microflares - produce footprints in the optical light curves that are recorded by space telescopes searching for planetary transits with exquisite precision, good enough cadence, and extraordinary time coverage.

I will show how the extraction of stellar activity signatures from PLATO 2.0 light curves provides fundamental information for the mission main science goal, i.e. the detection and characterization of the physics of exoplanetary systems. In fact, i) the level of activity as well as the active regions rotational modulation are linked to rotation, hence provide hints to the exoplanetary age; ii) stellar activity lays down the stellar environment with a definite effect on the habitability; eventually, iii) stellar activity is a source of noise for both the characterization of transits and the measurements of stellar RV signals induced by planets. Moreover, PLATO 2.0 will provide data on stellar activity - e.g., rotation rate, amplitude and sign of differential rotation, short and long-term cycles of activity, statistics of white light flares and microflares - of unprecedent value for the variety of stellar populations present in the mission target sample.

Star-Planet Tidal and Magnetic Interactions

Antonino Francesco Lanza, INAF- Osservatorio Astrofisico di Catania, Italy

Stars interact with their close-in planets through tides, irradiation and magnetic fields. I shall briefly review these kinds of interactions in the light of some recent observations and theoretical developments.

The great potential of PLATO for this kind of studies will also be discussed considering selected results from MOST, CoRoT, Kepler, as well as some ground-based transit search experiments.

Star-Planet Interaction

Helmut Lammer, Space Research Institute, Austrian Academy of Sciences, Graz, Austria

The origin and evolution of planetary atmospheres is briefly discussed. A focus will be given to the origin and host star triggered escape of hydrogen-dominated protoatmospheres and further evolution of secondary atmospheres during a planet's history. It will be shown that the formation age of a terrestrial planet, its mass and size, as well as the lifetime in the EUV-saturated early phase of its host star and the star's plasma outflow play a significant role in the atmospheric evolution of all planet-types. It is also shown that more massive planets such as super-Earths in orbits within the habitable zone of their host stars might have problems to lose nebular- or catastrophically outgassed initial protoatmospheres. In such a case these planets could end up as mini-Neptunes, or as water worlds with CO2 and hydrogen- or abiotic oxygen-rich upper atmospheres. If an atmosphere of a terrestrial planet evolves to an N2-rich atmosphere too early in its evolutionary lifetime, the atmosphere may be lost by thermal and non-thermal atmospheric escape processes. Various examples will be shown which indicate that the evolution to Earth-analogue habitats is a very complex endeavor. Finally it will be shown that the possible characterization of stellar and planetary plasma environments of planets discovered by PLATO in transiting orbits of bright stars together with space observatories such as the WSO-UV, can be used for validating the discussed atmospheric evolution studies. Such observations would enhance our understanding on the impact on the activity of the young Sun on the early atmospheres of Venus, Earth, Mars and other Solar System bodies as well as exoplanets.

Enshrouded Close-In Exoplanets

Carole Haswell, The Open University, UK

Our near-UV HST observations of the extreme hot Jupiter WASP-12b revealed extended exospheric gas overfilling the planet's Roche lobe and causing reproducible enhanced transit depths at 65 distinct wavelengths. There is complete absorption, i.e. zero emergent flux, in the cores of the very strong MgII h&k lines at all orbital phases.

I will present several lines of evidence to show this is due to diffuse gas lost from WASP-12b, which enshrouds the entire planetary system. Our results suggest a new interpretation of the known correlation between hot Jupiter atmosphere type and host star activity as indicated by the cores of the very strong CaII H&K lines. I will place this in the context of the evaporating rocky exoplanet KIC 1255b. Finally I will discuss the general implications of these findings for the Galaxy's population of planets and for studies of star-planet interactions.

Dealing with Stellar Activity in High-Precision Photometric and Spectroscopic Transit Observations

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Stellar-activity features such as spots can complicate the determination of planetary parameters through spectroscopic and photometric observations. The overlap of a transiting planet and a stellar spot, for instance, can produce anomalies in the transit light-curves that may lead to an inaccurate estimation of the transit duration, depth, and timing. These inaccuracies can for instance affect the precise derivation of the planet radius. We present the results of a quantitative study on the effects of stellar spots on high-precision transit light-curves. We show that spot anomalies can lead to an estimate of a planet radius that is 4% smaller than the real value. Likewise, the transit duration may be estimated about 4%, longer or shorter. Depending on the size and distribution of spots, anomalies can also produce transit-timing variations (TTVs) with significant amplitudes. For instance, TTVs with signal amplitudes of 200 seconds can be produced when the spot is completely dark and has the size of the largest Sun spot. We also found that studying high-precision radial velocity observation during transit, RM effect, can be affected by several phenomena.

Magnetic Fields of Planet-Host Stars

Rim Fares, University of St Andrews, UK

Claire Moutou, LAM, France

Jean-FrancoisDonati, IRAP, France

Claude Catala, Observatoire de Paris, France

Evgenya Shkolnik, Lowell Observatory, US

Moira Jardine, University of St Andrews, UK

Andrew Cameron, University of St Andrews, UK

Magali Deleuil, LAM, France

The stellar magnetic fields play an important role at all stages of stellar evolution.

In Hot Jupiter systems, the study of the stellar magnetic field is crucial to understand the environment in which the planet evolves along its orbit. It is also an important key to understand star-planet interactions (magnetic and tidal) and their effects on both the star and the planet.

I will present my work on the reconstruction of the magnetic fields of a sample of hot-Jupiter host stars using Zeeman-Doppler Imaging. The stars show similar magnetic properties to other cool stars without Hot Jupiter. But, for the first time, a magnetic cycle on a star other than the Sun was observed. Compared to the solar cycle, this cycle is very short. The origin of such a short cycle is not understood yet: the planet might influence the stellar magnetic field.

How Could Plato Serve Planetary Physics and What can we Learn From Solar System Planets for Terrestrial Exoplanets?

Tilman Spohn, DLR Institute of Planetary Research, Berlin, Germany

The PLATO mission and associated terrestrial observation campaigns are expected to yield an unprecedented set of planetary data: mass, radius and age of several thousands extra solar planets, including hundreds of small planets up to 1 AU. The age estimate is under the assumption that the planets form rapidly after the formation of the central star which is universally accepted to be true for solar system planets and in line with present models of planetary system formation. The composition of solar system planets in particular the relative concentrations of elements resembles that of the sun albeit with increasing levels of depletions in volatile elements as one goes from giant planets to rocky planets.

Mass and radius give the average density which is the most fundamental piece of data to derive the composition of the planet after due corrections for self-compression are applied. Planetary scientists use a ternary diagram linking planets in the solar system to three basic components termed gas (H, He), ice (H2O, NH3, CH4) and rock (silicates, iron) augmented by the radius to become a Toblerone-diagram. The solar system has only a small subset of the planet compositions that seem in principle to be possible. It would be most interesting to further fill the Toblerone-diagram and see what nature has to offer.

The average density further is a most fundamental parameter for models of the interior structure and possible dynamics of planets although it has to be clearly said that the exercise has non-uniqueness issues. Nevertheless, solar system bodies suggest that planets observable with PLATO will differentiate into layers of increasing volatility as one goes from the iron-rich core to the rocky mantle and crust to the hydrosphere and atmosphere. The level of tectonic activity and the potential for a magnetic field should increase with radius and decrease with age although the dependence of rock rheology on pressure may become an issue for planets significantly more massive than the Earth. The interior and the atmosphere will communicate depending on the tectonic style via outgassing driven by volcanic activity and regassing if plate tectonics is active. Plate tectonics is an integral part of the carbon-silicate-cycle and thought to be an element of habitability. There is an ongoing debate on how reliably plate tectonics can be predicted to occur on rocky planets and although the issue cannot be considered closed it is clear that size and mass are most fundamental parameters.

Gaseous and Icy Giant Planets

Ravit Helled, Tel-Aviv University, Israel

The discovery of giant planets outside the solar-system opens an opportunity to improve our understanding of giant planet internal structure and formation mechanism.

Giant planets are made of mostly light materials, have masses between about ten to a few hundred Earth masses and are typically divided into two sub-classes: "gas giants" which are massive objects and consists of mostly hydrogen and helium, and "icy giants" which are thought to consist mainly of rocks/ices with a thin gaseous hydrogen/helium envelope, and have a total mass of ~ 10-20 Earth masses. While in the solar-system there is a rather sharp transition between the gas and icy giants in terms of mass and composition, the masses and inferred compositions of giant planets and super-Earths/mini-Neptunes orbiting other stars have a large range.

In this talk I will briefly describe how planetary interiors are modeled, and will present interior models of the four outer planets in the solar system, i.e., Jupiter, Saturn, Uranus and Neptune. New results, uncertainties and open questions, and future investigations will be discussed.

Comparison of Transit Spectra and Direct Imaging Spectra

Jean Schneider, Paris Observatory, France

Plato 2.0 will detect transiting planets on wide orbits around nearby stars. For some of them it will be possible to make a direct image which will be analysed by spectroscopy and polarimetry. On the other hand, as transiting planets, it will be possible to analyse their atmosphere by transit spectroscopy. This offers the unique opportunity to sound different region of the planet atmosphere. I will describe how models and existing observations of Solar System bodies can be used to compare transit and direct imaging spectroscopy, as a template for future Plato planets.

What Can We Learn About Exoplanetary Atmospheres in the Optical?

Kevin Heng, University of Bern, Center for Space and Habitability, Switzerland

The PLATO 2.0 mission aims to advance our understanding of the structure and formation of low-mass exoplanets via ultra-precise radius measurements. I will demonstrate that an equally exciting and complimentary venture will be to study the atmospheres of exoplanets in the visible/optical. Initially, these studies will necessarily focus on gas giants (warm and hot Jupiters), since these are the easiest targets for atmospheric characterization, but the principles learnt are expected to apply also to low-mass exoplanets. Firstly, optical secondary eclipses yield the geometric albedo, which determine the energy budget of incident starlight penetrating the atmosphere and hence its thermal structure (T-P profile). Secondly, optical photometric points of an exoplanetary atmosphere may constrain the Rayleigh slope associated with the dominant, inert component (e.g., molecular hydrogen), which converts relative abundances to absolute ones. These two properties are essential for advancing the spectral and temperature retrieval technique commonly used to extract the chemical abundances of an atmosphere. Thirdly, full-orbit, optical phase curves record the reflectivity of the atmosphere as a function of longitude. If clouds are the dominant source of reflectivity, then optical phase curves effectively measure their relative abundance. Generally, clouds have emerged as an important theme in the study of Earth, Solar System planets, hot Jupiters and directly-imaged exoplanets, and have long been an obstacle plaguing advances in our understanding of brown dwarfs. Obtaining optical data on exoplanetary atmospheres is perfectly complimentary to the infrared spectra expected to be obtained with JWST. Fourthly, precise radius measurements of Earth-like exoplanets in the optical will allow us to characterise it using a single metric that informs us about the absence or presence of an atmosphere.

Circumbinary Planet Detection with PLATO

Hans Deeg, Instituto de Astrofísica de Canarias, Spain

Circumbinary planets are planets orbiting both components of a binary star. They may be detected by a variety of techniques making use of precise photometry. The precise timing of the binary eclipses has delivered most detections. Transits have also been important in their discovery, with 6 such systems currently being known, all from data of the Kepler mission. 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. They are also mostly on faint stars which impedes good characterization. Here we present the case for the detection of such planets with PLATO, which is the subject of its Work Package 112510.

Exoplanets around evolved stars

Roberto SilvottiI, NAF-Osservatorio Astrofisico di Torino, Italy

During the red-giant branch, planets are expected to be pushed inwards or outwards depending whether tidal effects or stellar mass loss are predominant. In this talk we will review the post-RGB planets and compare observations with theoretical predictions. We will analyse the efficiency of the different detection methods for these stars and discuss what contributions to this studies will come from the facilities of the next decade, in particular from GAIA. Finally we will discuss which contribution can be given by PLATO.

Dynamical Evolution of Planetary Systems - PLATO's Contribution

Cilia Damiani, CNRS-LAM, France

The dynamical evolution of planetary systems, after the evaporation of the accretion disk, is the result of the competition between tidal dissipation and the net angular momentum loss of the system. In the case of multiple systems, gravitational interaction between planets must also be taken into account. However, even focusing on single companion systems, the description of the diversity of orbital configurations, and correlations between parameters of the observed system, (e.g. in the case of hot Jupiters) is still limited by our understanding of the transport of angular momentum within the stars, and its effective loss by magnetic braking.

It is clear that a mission like PLATO 2.0, allowing the complete characterization of host stars using asteroseismology, will enable a breakthrough in this kind of study, thanks to the precise and accurate determination of stellar radii and masses and, above all, ages. Moreover, the measure of the rotational profile of the star, possibly down to its core, would help to better understand the mechanisms involved in the evolution of the angular momentum. After introducing the present state of conjectures regarding the observables of the dynamical evolution of extrasolar systems, I will give a few example, in view of PLATO's expected achievements, of results allowing to constrain theories of angular momentum evolution and test models of planetary formation.

What do We Know About Collisions in Planetary Systems?

Rudolf Dvorak, Aron Suli, Thomas Maindl
University of Vienna, Austria

Christoph Schaefer
University of Tuebingen, Germany

It is well known that there is a daily bombardment of smaller bodies on the Earth which may cause even heavy damage (just two months ago); we have detailed studies of the collision which caused the Moon to form. We do not have such studies of early Solar system body collisions depending on their masses, their velocities and their compositions (water, organic material etc.). We started an investigation to first statistically determine the variety of impact parameters for different bodies with respect to the former mentioned parameters which will then be studied in detail with SPH codes to form bigger bodies and finally will be incorporated into the respective n-body simulations.

Planet Formation and System Chronology

Günther Wuchterl, Thüringer Landessternwarte Tautenburg, Germany

Case studies of CoRoT discoveries are discussed to estimate what inference on planet formation can be expected with the accuracy and statistics foreseen for PLATO.

Observed properties of star-planet-systems are confronted with a new and complete theoretical survey of a very wide class of physically possible pathways of evolution for short period planets of F and G stars. The probabilistic approach allows the discussion of planet diversity and its relation to the formation era based on time-dependent theoretical distributions of planetary masses and radii.

Cases include inflated planes, planets with super-cores, very young planets, systems and brown-dwarf-planet transition objects.

Finally we present a synoptic approach to establish a coherent and consistent chronology - an age concept for stars, planets and transition objects including effects of the formation era that are expected to be necessary at PLATO-precision.

Planet Synthesis Modeling - Impact of Grain Opacity and Envelope Evaporation

Christoph Mordasini, MPIA, Germany

Planetary population synthesis is a method that makes it possible to test theoretical models of planet formation and evolution. This is achieved by many different statistical comparisons with observational data found by large surveys using various techniques (transits, radial velocities, in future also direct imaging and microlensing).

I will first give a general overview of the method and its most important results like the planetary initial mass function. I will then focus on subjects that are of special interest for PLATO, namely the planetary radius distribution and the planetary mass-radius relationship. I will show how two important mechanism shape these distributions: First, the magnitude of the grain opacity during the formation phase. The opacity due to grains suspended in the atmosphere of a protoplanet is a key quantity controlling the efficiency at which the planet accretes gas during the nebular phase. This leads to potentially observable imprints in the planetary bulk composition, allowing to constrain observationally grain evolution model.

Second, I will address the role of envelope evaporation. We have recently coupled our formation and evolution model with a model for the loss of the primordial H/He envelope due to stellar X-Ray and EUV irradiation, and conducted population syntheses with it. We find that evaporation leads to distinct features that are particularly well visible in the planetary mass-mean density relation. We find that due to evaporation, a strip arises that is depleted in planets and separates bare rocky planets and planets that have retained some H/He. If close-in planets have migrate inwards from beyond the iceline, then this strip can in contrast get populated with water rich planets.The comparison with observations will therefore put new statistical constraints on planet migration models.

Stellar Populations and Galactic Science

Andrea Miglio, School of Physics, University of Birmingham, UK

The detection by CoRoT and Kepler of oscillations in thousands of field stars has opened the door to detailed studies of stellar populations belonging to the Milky Way. The difficulties associated with estimating distances and, to an even greater extent, ages of individual field stars has been a major obstacle to discriminating between different scenarios of formation and evolution of the major components of the Milky Way. GAIA will shortly overcome current limitations associated with estimating distances to stars, however, accurate age determination of individual field stars will still be a major obstacle to our understanding of the Milky Way. In this context, PLATO will extend CoRoT's and Kepler's pioneering studies of solar-like oscillators to a comprehensive survey of Galactic populations, and act as a most effective complement to GAIA.

Complementary and Legacy Science

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Additionally to the main science goals of PLATO, a large variety of time-variable phenomena in various populations of the galaxy can be sampled as complementary science.

Space experiments - such as MOST, CoRoT and Kepler - have illustrated in the past that the fascinating results arising from "additional science" projects were groundbreaking for their science fields. The numerous other targets that automatically will be observed simultaneously to the primary targets of PLATO will give rise to a very rich legacy for stellar and galactic physics. Major breakthroughs are expected in a variety of subjects, e.g. for classical pulsators, red giants, massive stars, young open and globular clusters, early stellar evolution, different types of stellar activity and the structure and evolution of the Milky Way.

PLATO Science on Classical Variable Stars

Robert Szabo, Konkoly Observatory, Budapest, Hungary

High-precision space photometry induced a revolution in exoplanetary science as well as in asteroseismology. I present the latest results on Cepheids and RR Lyrae stars that were obtained by CoRoT and Kepler.

The discovery of new and unexpected dynamical behavior of Blazhko-modulated RR Lyrae stars - such as high-order resonances, period doubling, three-mode states and even chaos - led to a new explanation of the century-old Blazhko enigma. I discuss the astrophysical problems that will be possible to address with PLATO, benefiting from its capabilities, especially from its large field-of-view, long, uninterrupted observations and high-precision photometry. Finally I compare the capabilities of CoRoT, Kepler, TESS and PLATO and will argue that PLATO has significant advantages over its competitor(s).

Characterizing Stellar and Exoplanetary Environments Via Ly-Alpha Transit Observations of Exoplanets

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Transit observations of the Hubble Space Telescope of the hot gas giants HD 209458b and HD 189733b revealed an absorption in the Ly-alpha line during transits suggesting that a huge hot neutral hydrogen corona exists permanently or in the case of HD 189733b sporadically around these exoplanets. There were several attempts to explain the observed phenomena, i.e. the absorption in the wings of the Ly-alpha line, by taking into account such factors as atmospheric Doppler broadening, acceleration of the initially slow planetary hydrogen atoms by the stellar radiation pressure, and the production of energetic neutral atoms (ENAs).

ENAs arise due to charge-exchange between a stellar wind proton and a planetary atom resulting in a hot neutral hydrogen atom moving with the velocity of the former proton and an initially cold planetary ion. Nevertheless all these models have some difficulties in the explanations if they are applied separate. The present study includes all three factors as well as the gravitational and rotational effects (Coriolis, centrifugal, tidal forces). The plasma interaction between stellar wind and the upper atmosphere of a planet is modeled by applying a Direct Simulation Monte Carlo (DSMC) upper atmosphere-exosphere particle model which is coupled with a stellar wind particle interaction code. It allows calculating the appearance, density and form of the hydrogen corona around the planet. We developed also post-processing code which reconstructs the Ly-alpha in-transit spectrum based on the modeled corona. With PLATO more transiting exoplanets around bright stars would be available; our approach allows one to obtain knowledge about the upper atmosphere structure, plasma environment in the vicinity of the exoplanet and indirectly about the strength of the planetary magnetic field.

Extreme Orbital Forcing Simulations with the Plasim General Circulation Model and its Implications on Habitability

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Seasonal forcing is expected to be crucial on planets close to the outer edge of the habitable zone, prohibiting or triggering transitions from ice-covered to ice-free climates through the sea-ice albedo feedback. Assessing its implications, however, requires to go beyond the energy balance models (EBMs) estimations of surface temperature that neglect the effect of spatial and temporal variability. In this study we use PlaSim, an intermediate-complexity GCM coupled to a thermodynamic sea-ice model to investigate the effect of extreme orbital forcing on the surface temperature and habitability of idealized terrestrial planets. The effect of two astronomical parameters, the obliquity of the spin axis and the eccentricity of the orbit, is explored, and the results are supported by sensitivity experiments that include heat capacity, rotation speed, and oceanic transport.

It is shown that eccentric orbits can push the outer limit of the habitable zone far beyond what EBMs predict. While the effect of obliquity is comparatively small on circular orbit, it becomes highly relevant on eccentric orbits. So far, cold climate states have not been investigated in habitability context. Our results reveal that they extend farthest into the HZ for non-oblique planets, whereas they allow for partially habitable regions on highly oblique planets. On circular orbits, planets with a most homogeneous distribution of annual mean insolation are less prone to snowball transitions due to the nonlinearity of the ice-albedo feedback, whereas on eccentric orbits a large obliquity can keep a planet in the warm state.

EXOTRANS a Detection Pipeline Ready to Face the Challenge to Hunt and Characterize Exoplanetary Systems in Upcoming Space Missions

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EXOTRANS a detection pipeline ready to face the challenge to hunt and characterize exoplanetary systems in upcoming space missions.

In 2005 the Rheinische Institut für Umweltforschung (RIU), Department of Planetary Research at the University of Cologne developed EXOTRANS, a pipeline for the detection of extrasolar planets for the CoRoT space mission. This pipeline was in use throughout the complete operation phase of CoRoT. Since the start of the mission the pipeline is evolved continuously. Starting with two filters (trend and harmonic) and the BLS algorithm (box least square) in 2006 the emphasis was on a high grade of automatization, to deal with the huge amount of data produced by space missions like CoRoT, Kepler and even bigger upcoming missions.

Challenges during the mission made it necessary to develop new algorithms.

Our wavelet based filter routine VARLET was developed to separate star variability and discontinuities in light curves. Detected binaries and planetary transits are extracted out of the light curve using PHALET to search for multi-planet systems.

EXOTRANS was successfully applied to the public Kepler data in August 2012. We detected 98% of all candidates found by the Kepler team and even detected additional 143 new candidates not included in the Kepler candidate list (list from January 2013).

Over time our focus has changed from detection only, to detection and characterization of planetary transit candidates. This is important to rule out false positives, to find the best targets for follow-up observation and to build a solid foundation for statistical analysis.

Stellar binaries are simulated to rule out false detections and to classify detected binary systems. Transit timing variations (TTV) are measured and simulated with high precision to confirm planetary candidates and to constrain system parameters.

Transits are compared to simulated light curves to extract the parameters of the planetary system.

We present the status of our approved EXOTRANS pipeline. Examples of CoRoT and Kepler demonstrate the powerful abilities of EXOTRANS for future missions.

The PLATO Simulator: Modelling Space-Based Imaging
Realistic Modelling of High-Precision High-Cadence Space-Based Imaging

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Many aspects concerning the design trade-off a space-based instrument and its performance can best be tackled through realistic simulations of the expected observations. The complex interplay of various noise sources in the course of the observations make such simulations an indispensable part of the assessment and design study of any space-based mission.

We present a formalism to model and simulate photometric time-series of CCD images by including realistic models of the CCD and its electronics, the telescope optics, the stellar field, the jitter movements of the spacecraft, and all important natural noise sources.

This formalism has been implemented in an end-to-end simulation software-tool, dubbed PLATO Simulator, specifically designed for the PLATO space mission assessment and Phase A studies but easily adaptable to similar types of missions.

The main results that were addressed in this work with this simulator concern the noise properties of different photometric algorithms, the selection of the optical design, the allowable jitter amplitude, and the expected noise budget of light-curves as a function of the stellar magnitude for different parameter conditions.

The HoSTS Project: Homogeneous Analysis of Transiting Systems

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With the more than 300 transiting planets known to date, it is only now that statistical studies of planetary systems can be achieved. Previous works have tried to compare the physical properties of the stellar hosts and their planets in search of the tell-tale fingerprints of the planetary systems' formation and evolution processes. However, they have reached mixed conclusions and it is very much a subject of contention in the exoplanet literature. The Homogeneous Study of Transiting Systems (HoSTS) will derive a consistent and homogeneous set of both the stellar and planetary physical properties for a large sample of bright transiting planetary systems with confirmed planetary masses and measured radii. Our resulting catalogs of the fundamental properties of these bright planets and their host stars will enable us to explore empirical correlations (e.g., stellar metallicity and planetary radius) that will lead to a better understanding of planetary formation and evolution. We present our pilot study of the planet hosting star WASP-13 and showcase the importance of our project in order to tease out systematics and truly constrain these relationships.

The BT-Settl model atmospheres for Stars, Brown Dwarfs, and Gas Giant Planets

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Since infrared observations of M dwarf stars (late 80's), brown dwarfs (mid 90's), and extrasolar planets (mid 2000s) are available, one of the most important challenge in modeling their atmospheres as become the understanding of molecular opacities (including the pressure-induced H2 bands), solar elemental abundances, cloud formation, disequilibrium chemistry, and quasi-static collisional broadening. Their atmospheric composition is mostly constituted of molecular hydrogen, helium, molecular nitrogen/ammonia, carbon monoxide/methane, and water vapor. But their SED is also governed by trace elements in the form of SiH, CaH, TiO, VO, CrH, FeH molecular absorption bands, resonance absorption lines of alkali elements, Al, Ti, Fe, Cu, etc., and condensed species (rock, metal, silicate, salt, and ice crystals).

Historically, model atmospheres and synthetic spectra have failed to reproduce the relative strength and shapes on the near-infrared water bands determining the near-infrared SEDs of M and brown dwarfs. As lower mass and cooler dwarfs were discovered, it became clear that their SED was affected by the depletion and greenhouse effects tied to dust cloud formation already below Teff = 2900K or M < 0.11 $M_\star$ (e.g. Tsuji et al. 1996, 2002, 2004, Allard et al. 2001, Ackerman & Marley 2001, Helling et al. 2008a,b, Allard et al. 2012). More recently, the solar elemental abundances --- especially that of oxygen --- have been revised by two independent groups based on radiation hydrodynamical (HRD) simulations (Asplund et al. 2009, Caffau et al. 2011). Such HRD simulations have been applied to the determination of the velocity filed of M dwarfs and brown dwarfs (Freytag et al. 2010). The quasi-static collisional broadening of alkali lines has been developed (Burrows & Volobuyev 2003, Allard et al. 2007a,b). And molecular opacities have also been tremendously improved over the past 20 years (via the GAISA, JANAF-NIS, HITRAN, MARCS, AMES, STDS, and ExoMOL databases). We therefore review the associated progress in modeling the spectroscopic properties of dwarfs across the stellar-substellar transition.

TNG Spectrophotometric Measurements Of HAT-P-1

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I will present the results of a spectrophotometric follow-up of the extrasolar planet host HAT-P-1 conducted at TNG during two observing nights. The purpose of these observations is the detection of the planetary atmosphere absorption features by using the transmission spectroscopy technique. We used the DOLORES spectrograph and accommodated both the target star and a close-by companion star on the same slit to correct for systematic effects. I will provide a critical discussion of the results and a comparison with planetary atmospheric models predictions.

A Survey for Planets of Main-Sequence Stars of Intermediate Mass

Eike W. Guenther, Thueringer Landessternwarte Tautenburg, Germany

In contrast to planets of solar-like stars, very little is known about planets of intermediate mass (1.3-2.1 M_{sun}) stars. The interesting aspect is that the lifetime of the disks of these stars half as long as that of lower-mass stars. Thus, if we detect close-in planets of such stars we know the planets must have formed and migrated inwards within a short time. The theory of planet formation also predicts that intermediate mass should have planets that are in general more massive than the solar-like stars. By measuring the frequency of close-in planets, we can thus constrain the theory of planet formation. If the frequency of the planets orbiting intermediate mass were the same as that of solar-like stars, we expect to find about 20 hot Jupiters, and also 20 close-in planets of 3 to 5 R_{Earth} with PLATO. The capability of PLATO for detecting even relatively small planets orbiting A-type stars is particularly interesting, because this allows us to study how the stellar wind and the intense radiation field of an A-star effects the atmospheres of planets.

Population Considerations for Binary Stars using Transit Searches

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Transit searches deliver a wealth of eclipsing binary star light curves. In blends they dominate the false positive signal, but they are also interesting in their own right as stellar and binary star population diagnostics. We illustrate our population synthesis analysis technique of a transit search survey for the case of the Kepler field. We adapted BiSEPS, a code that includes a fully self-consistent treatment of single and binary star evolution, to generate a sample of synthetic stars that represents the Kepler Input Catalogue (KIC).

By subjecting this synthetic sample to the same target selection criteria that defined the actual Kepler target list we also obtained a synthetic target list. We find that the binary star population is target-selected in a similar fashion to the single star population, and that the binary fraction is unchanged due to the target selection criteria. A preliminary comparison of eclipsing binaries in our synthetic sample and the catalogues of Prsa et al (2011) and Slawson et al (2011) rules out a simple power law initial mass ratio distribution (IMR) and a mass independent binary fraction.

Application of this method to PLATO 2.0 is discussed.

Hybrid Methods in Planetesimal Dynamics

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The formation and evolution of protoplanetary discs remains a challenge from both a theoretical and numerical standpoint. We have developed a new composite algorithm that combines the advantages of high accuracy of direct-summation N-body methods with a statistical description for the planetesimal disc based on Fokker-Planck techniques. We then address the formation of planets, with a focus on the formation of protoplanets out of planetesimals. We find that the evolution of the system is driven by encounters as well as direct collisions and requires a careful modelling of the evolution of the velocity dispersion and the size distribution over a large range of sizes. The simulations show no termination of the protoplanetary accretion due to gap formation, since the distribution of the planetesimals is only subjected to small fluctuations. We also show that these features are weakly correlated with the positions of the protoplanets. The exploration of different impact strengths indicates that fragmentation mainly controls the overall mass loss, which is less pronounced during the early runaway growth. We prove that the fragmentation in combination with the effective removal of collisional fragments by gas drag sets an universal upper limit of the protoplanetary mass as a function of the distance to the host star, which we refer to as the mill condition.

Stellar Characterization for Transiting Exoplanet Surveys: Lessons from Kepler, Prospects for TESS and Plato

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"We only know the planet as well as we know the star." This is certainly correct for transiting planets, as planet radius, occurrence, and equilibrium temperatures depend sensitively on the assumed parameters of the host (and survey) stars. I will review recent ground-based work to estimate the effective temperatures, metallicities, and surface gravities/luminosity classes of stars, focusing on M dwarf stars. I will discuss the importance of accurate stellar parameters for targets of the Transiting Exoplanet Survey Satellite (TESS) mission, including for the recovery of single-transit planets with orbital periods exceeding 27 days using ground-based telescopes. I conclude with speculation about an infrared version of the Kepler mission optimized for M dwarfs.