Abstracts

Session 1

PSM management
David Brown

The PSM is managed by a combination of three work packages : the PSM Coordinator; the PSM Office, and the PSM Coordination Team.

I will present a summary of recent (and ongoing) management activities from the perspective of the PSM Office, including how they relate to the work of WP12, and will also provide an overview of open action items at Office level. I will also look ahead to upcoming events over the next 18 months, and show how Stellar Science work packages can contribute to making these successful.

Session 2

Challenges for fitting observations of PLATO stars on the main sequence
Daniel Reese

In order to handle the large number of stars to be observed by PLATO, it is necessary to put together an efficient asteroseismic pipeline which combines a number of methods. The deduced stellar properties need to be accurate in order to allow a precise characterisation of exoplanetary systems, in accordance with the PLATO requirements. In this talk, I will describe various forward methods, including their strengths and weaknesses as well as various sources of error, and point out some of the open questions that still need to be addressed. I will then discuss how these methods can be used in conjunction with other methods, namely inversion techniques and glitch analysis, thus leading to improved constraints and/or less model-dependence.

Challenges for fitting observations of PLATO subgiant stars
Sebastien Deheuvels

The seismic modeling of subgiants is a powerful tool to investigate the physical processes that operate in the core of low-mass stars. During this phase of the evolution, non-radial modes start to have a mixed character and thus convey precious information about the structure of the core. This can also be used to infer properties of the core during the main sequence because the chemical profile of subgiants (to which mixed modes are sensitive) still retains the imprint of its evolution. Despite the great scientific interest of mixed modes, their presence in the oscillation spectra of subgiants makes the seismic modeling of these objects very challenging. The rapid contraction of the core during the subgiant phase causes the frequencies of mixed modes to vary on short timescales compared to the evolution timescale. This is an issue for traditional grid-based modeling because it requires particularly fine-mesh grids, which limits the parameter space that can be explored. Iterative minimization techniques, which require the calculation of stellar models on the run, are also made impractical by the discrepancy between the timescale of the variations of mixed mode frequencies and the nuclear timescale. We here describe attempts that have been made to alleviate this problem and the results that have been obtained for CoRoT and Kepler subgiants. We also present the future works that are planned to organize the seismic modeling of subgiants in the preparation of the PLATO mission.

Session 3

Age determination in detached eclipsing binary systems

Scilla Degl'Innocenti

The talk will review the state-of-the-art of age determination in detached eclipsing double-lined binary systems, for which stellar mass and radius can be determined with precisions of a few percentage points or better. Simultaneously with the improvement of the precision of observational data, several groups developed different techniques to derive the system ages by fitting the observations to a grid of pre-computed stellar models. The results and the precision of these estimates will be discussed taking also into account both the errors in the observational constraints and the systematic bias caused by the uncertainties still present in stellar model calculations (convective core overshooting and element diffusion efficiency, mixing-length value etc..) and in the assumed initial helium content.

Isochrone fitting : model uncertainties and limitations

Pier Moroni

Stellar models are indispensable tools to infer fundamental information on stellar populations. In spite of their remarkable improvement in last years, the current generation of stellar tracks and isochrones is still affected by not negligible uncertainties. I will discuss the major sources of uncertainty and their impact on isochrone fitting and age estimates of stellar clusters.

Inferring stellar ages from Gaia data

René Andrae

I briefly review the basic Gaia data products for spectroscopy, photometry and astrometry, from which model-based stellar ages can be inferred in certain regions of the parameter space. Then I describe the DPAC pipeline module that is currently implemented to estimate stellar ages, luminosities, masses and radii. From there, I present an enhanced modelling approach, which combines all available spectroscopic, photometric and astrometric information from Gaia into a single inference problem, invoking stellar evolutionary models to explore the parameter space. Some preliminary results based on simulated data are shown.

Activity-related age indicators

Sydney Barnes

This talk will briefly review the principal activity-related age indicators currently in use for cool field stars, encompassing late-F, G, K, and M stars on the main sequence. It will begin with chromospheric emission, the one with the longest track record. It will also address gyrochronology, the method of deriving ages from rotation periods, which has been developed over the past decade or so. Both successes and challenges will be addressed, including the role of open clusters as calibrators.

Session 4

Introduction : benchmarks in WP120

Joergen Chistensen-Dalsgaard

In the broadest sense benchmark stars are stars with well-determined properties, to be used to test analysis techniques for characterizing less well-observed stars. This spans a broad range of levels of detail and accuracy. At one end of the spectrum the Sun, with suitably degraded data, is an excellent benchmark to test detailed asteroseismic analysis techniques. At the other extreme on the asteroseismic scale, stars with even fairly limited asteroseismic characterization can serve as benchmarks for techniques based, e.g., on 'classical' observables such as effective temperature and gravity. Other examples are stars in well-observed binary systems or open clusters. The extensive work on Gaia benchmark stars is clearly very valuable in the context of WP120, particularly if they have been, or will be, characterized by asteroseismology, a process that will continue during the PLATO mission and hence further improve the data-analysis techniques.

Interferometry and asteroseismology : a symbiosis for stellar characterization

Lionel Bigot

The core stellar science of the PLATO mission aims at characterizing stars by seismology. The required precision in terms of mass, radius, and age needs to combine oscillation frequencies together with other sources of data, like Gaia but also ground base observations. In this respect, the bright targets of the core program will allow the determination of angular diameters by interferometry. In this talk I will review recent works made by this complementary technique, compare interferometric and seismic diameters and discuss the limitations.

Benchmark stars : prospects from eclipsing binaries

Pierre Maxted

In this talk I will review the state-of-the-art in measuring the masses, radii and other properties of solar-like stars in detached eclipsing binary stars (DEBs). I will also present some recent results for DEBs discovered using data from Kepler K2. Based on these results, I will make the case that we can and should identify and characterise solar-type stars in DEBs that will be observed by PLATO, i.e., to predict the solar-like p-mode oscillation spectra of these stars prior to PLATO launch.

The programme : "Accurate masses for double-lined spectroscopic binary components

Yveline Lebreton

For almost four years now, the Gaia satellite has been collecting high precision astrometric data for a very large number of stars, including all the spectroscopic binaries known to date.

Since the masses of the components of a double-lined spectroscopic binary (SB2) can be obtained by cross-matching the astrometric orbit of the photocentre with the spectroscopic orbit of the components, we have been observing since 2010 a sample of about 70 SB2 with the aim of determining their orbital elements in order to get an accuracy of 1 percent on their mass.

We will present the results obtained sofar for 24 systems for which we have now very precise orbits. The full programme will be achieved in the four years to come at the time when Gaia observations will be available. In parallel, we have obtained new interferometric measurements with the PIONER instrument at VLTI/ESO and collected some others in the literature and will present the results obtained on the masses of eight SB2s.

Benchmark targets for studying rotation and activity of Sun-like stars and its evolution

José Do Nascimento

In this talk, I will present relevant aspects related to rotation period measurements and activity of old Sun-like stars and its consequences to stellar evolution studies. We will also discuss how solar twins can be used as benchmark targets and how important is to observe solar analogs from field and clusters to constraint calibrations of the rotation-activity and rotation-age (gyrochronology) of PLATO studios. We will discuss recent GAIA DR2 contributions the field.

Lessons learned from the TESS target selection
Keivan Stassun

We summarize lessons learned from the target selection effort for the NASA Transiting Exoplanet Survey Satellite (TESS) mission. Key elements of this effort include combining many all-sky catalogs of stellar properties for $\sim 10^9$ stars in order to identify approximately 10^6 promising targets, and to then define a prioritization scheme for selecting the $\sim 10^5$ final postage-stamp targets. We also briefly discuss plans for extracting light curves from the lower cadence full-frame images that will also be produced by the TESS mission, enabling light curves to be produced for 10^7 to 10^8 stars across the entire sky. We conclude with some key considerations that may be of particular importance for target selection in the PLATO mission.

Interferometry and exoplanets.
Roxanne Ligi

PLATO will provide us with an extraordinary number of newly discovered exoplanets that transit their star. To characterise those exoplanets, we need to determine the global parameters of their host stars. Interferometry is a powerful technique that is commonly used to measure the angular diameter of stars ; in the case of transiting exoplanets, the stellar radius is essential to estimate the planetary one. I will show that current and future developments in interferometry will allow to characterise PLATO targets, like the SPICA project which goal is to measure the angular diameter of 1000 stars. I will also present recent results based on interferometric observations which led to accurate exoplanets interior estimates, and which offer an interesting prospect for an optimal use of PLATO data.

Benchmarks for asteroseismology : what we learnt from oscillating red giants in eclipsing binaries with Kepler
Patrick Gaulme

Eclipsing binaries have become very popular benchmarks for stellar physics, as they provide accurate ways to measure masses, radii, and distances. It is especially important for testing the accuracy of asteroseismic measurements. Among the 3000 eclipsing binaries detected by Kepler, only about 15 both display solar-like oscillations and are double-lined spectroscopic binaries. All are red giants. Here I review what was done with that sample, and how can we go further for PLATO by building upon this experience.

Session 5

Multi-dimensional stellar structure models applied to the problem of convective boundary mixing (overshooting)

Isabelle Baraffe

I will present the recent development of multi-dimensional stellar structure models based on a new fully compressible hydrodynamics time implicit code, MUSIC, devoted to stellar and planetary interiors. I will discuss the main challenges in the computation of multi-dimensional stellar structures and some of the advantages of our approach with MUSIC for the study of stellar fluid dynamics problems. MUSIC is interfaced with stellar evolution codes, which provide initial 1D stellar structures for any type of star and allows exploration of a wide range of stellar phases and masses. I will present our first applications, in particular the study of envelope overshooting in pre-Main Sequence stars. I will show the success of our approach with MUSIC within the context of lithium depletion in the Sun and in solar-like stars. I will discuss the application of our numerical framework to the problem of core overshooting and its potential within the context of PLATO. A major motivation for these multi-dimensional studies is to derive new prescriptions to be implemented in stellar evolution codes and thus to improve stellar evolution models.

Impact of atomic diffusion on the structure and surface abundances of G and F type stars : stellar parameter determinations and effects of rotation

Morgan Deal

Atomic diffusion, including the effect of radiative accelerations on individual elements, leads to variations of the chemical composition inside the stars as well as the surface abundances evolution. Indeed the accumulation in specific layers of the elements, which are the main contributors of the local opacity, modifies the internal stellar structure and surface abundances. Here we show that the variations of the chemical composition induced by atomic diffusion in G and F type stars can have significant impact on their structure, stellar parameters and seismic properties. We will also discuss the effect of the coupling between rotation and atomic diffusion for such stars. These processes need to be taken into account in stellar evolution models as the observations are more and more precise, especially in the context of the future space missions TESS and PLATO. We will illustrate theses issues with some case studies.

Other aspects of input physics : nuclear rates, screening, opacities, EOS

Aldo Serenelli

The uncertainties in the input physics to stellar models determine to a large extent our capability to obtain accurate and precise stellar parameters from observational data. In this talk, I will try to discuss the current status of this problem for several 'microscopic' ingredients, including nuclear reaction rates, opacities, the equation of state, as well as the uncertainty associated with the initial composition, both metals and helium.

Coupling 3D atmospheres to 1D stellar models

Victor Silva Aguirre

In recent years, sets of 3D hydrodynamical simulations of stellar atmospheres covering large portions of the HR diagram at different metallicities have become available. However, the timescales involved in the physics of convection make them impractical for following nuclear evolution. In this talk I present our results on the usage of average 3D structures in our one-dimensional evolutionary calculations to circumvent this problem, and our ongoing efforts to construct on-the-fly patched models and set the new standard for models of stellar structure and evolution in the PLATO 2.0 era.

Session 6

An evolutionary scenario for M dwarf Stars : shortcomings and improvements in stellar modelling

Santi Cassisi

M dwarf stars represent important targets in the framework of the PLATO mission. Due to the peculiar thermal properties of these stars, the physics at work in such objects is quite complex. Therefore, our capability of computing reliable stellar models strongly relies on the availability of accurate and realistic physical ingredients (opacity, EOS, boundary conditions, etc). We review the improvements obtained in the computations of models for these stars, but we will also discuss the shortcomings still affecting these models. Current situation in the computing of models will be discussed as well as the future work that we plan to perform in preparation of the PLATO mission.

Reviving Kufuß model for convection Reviving the Kufuß model for convection A Strategy for algorithmic-self-consistent convection across the PLATO-mission

Guenter Wuchterl

Convection descriptions are relevant for numerous task across the PLATO-mission :

1) energy transfer in stellar evolution, the core of the mission's age concept ;

2) overshooting and mixing, that feed back to ages ;

3) boundary conditions for the seismic analysis ;

4) excitation and damping as feedback to mode-detectability ;

5) atmospheric energy transfer efficiency, line-shapes and effects of activity in the determinations of stellar parameters with atmospheric modeling - the T_{eff}-connection ;

6) limb darkening in transit fitting that determines the relative planetary properties and provides key information on the physics of surface convection ;

7) feedback to the (optimization of) follow up observations for planet characterization via their stellar activity proxies as the line-bisectors in RV-campaigns ;

I will sketch a structure for the scientific theory-management of the consistency of convection for the mission relative to a class of reference theories and give 1 minutes examples for the modified Kuhfuß theory with a conventional mixing length theory limit (Wuchterl and Feuchtinger 1998, Wuchterl and Tscharnuter 2003).

Improving the calibration of the mixing length parameter of convection : implications for the radii of cool stars

Federico Spada

Main sequence, solar-like stars ($M < 1.3 M_{\odot}$) have outer convective envelopes that are sufficiently thick to affect their overall structure and global parameters. In particular, their surface radii are sensitive to the details of inefficient, sub-adiabatic convection, which are poorly described by the Mixing Length Theory (MLT), the standard treatment of convection adopted in stellar evolution codes. The MLT also introduces a free parameter whose calibration and dependence on the current stellar properties and its previous history are left completely unspecified by the theory. I will discuss an improved calibration of the MLT parameter based on three-dimensional radiation hydrodynamics (3D RHD) simulations of convection. In this approach, the MLT parameter is adjusted to match the specific entropy in the deep, adiabatic layers of the convective envelope to the corresponding value obtained from the 3D RHD simulations. This entropy-based calibration takes into account the position of the star in the (log g, log Teff) plane and its chemical composition. Models of the present-day Sun, constructed using the entropy-based calibration, as well as their properties and revised past and future evolution, will also be discussed.

3D simulations of DA white dwarfs for studying overshooting

Friedrich Kupka

Although within the PLATO mission white dwarfs are just part of complementary science, they provide a unique case for studying overshooting underneath stellar convection zones.

By sampling as a group the whole range of convective efficiencies they provide scenarios for overshooting characterized by a variety of physical parameters (Rayleigh and Peclet numbers, superadiabaticity).

Contrary to (mid/late-) main sequence stars this range can be studied with 3D hydrodynamical simulations that are relaxed on the thermal time scale, resolve the convectively driving surface layer alongside a realistic treatment of radiative transfer without assuming the diffusion approximation, and at the same time fully resolve the thermal boundary layer (spatial scales of radiative cooling) in the overshooting zone.

Several cases are presented and the potential for these studies is discussed to provide a reference for methods which either simulate or otherwise estimate overshooting that are applicable to cases for which such detailed 3D simulations are currently impossible. This holds in particular for the core target classes of the PLATO mission.

Session 6

Stagger grid of 3D atmosphere models

Remo Collet

Impact of the stellar surface structure on the solar-like oscillations

R. Samadi, T. Sonoi, L. Manchon, K. Belkacem, H.-G. Ludwig, E. Caffau

Abstract : The so-called "surface effects" are the well known increasing differences between observed solar-like oscillation frequencies and the theoretical ones obtained with standard 1D stellar evolutionary codes. These systematic differences limit the direct use of individual mode frequencies as seismic constraints and thus our ability to exploit the full potential of seismic observations.

I will present the current approaches to model "surfaces effects". In particular, the impact of surface metal abundance will be addressed. I will also show some comparisons between the stellar surface layers obtained from the 3D hydrodynamical code Co5BOLD and those derived from 1D stellar models based on various local formulations of convection. Finally, I will discuss about possible ways to improve our description of surface layers with standard 1D stellar evolutionary codes.

Determination of fundamental stellar parameters from the granulation-related background signal

Hans-G. Ludwig

Abstract : The photometric background signal in the frequency range in which granulation resides carries information on the surface conditions of a star. Combined with additional information from spectroscopy (effective temperature, chemical composition) this can be exploited to determine the surface gravity, radius, and mass of the star. I will discuss theoretical and empirical ways for a calibration of the underlying relations. While unclear at the time of writing, at the meeting I hope to be able to give an indication

of the additional information which the approach adds to the information that can be obtained from the oscillatory modes.

Session 7

Kepler light curves as templates for simulating PLATO light curves
Suzanne Aigrain, H. Parviainen, D. Foreman-Mackey

It is important for the PLATO community to have access to realistic stellar variability signals to test the various algorithms that will be used to characterise the stars and detect transiting planets. The Kepler mission archive is a treasure trove of such signals, but they have slightly different noise properties and time sampling from what we expect for PLATO. If we can find a way to remove the observational noise from Kepler light curves and interpolate them to the sampling of PLATO, while keeping our assumptions about the variability content of the light curve minimal, we can effectively turn any Kepler light curve into a stellar variability template for PLATO. In my talk I will show how we can use the "celerite" Gaussian Process regression framework to do just that, and present results for about 1200 bright Kepler targets with effective temperatures from 8000K to 2000K. For each of these stars, we have produced a set of three simulated, noise-free, light curves with 2.5 min sampling lasting 3 years. The simulated light curves and supporting materials (including the code used to generate them) will be available online shortly, and will be used in the hare and hounds exercise that Nuccio Lanza will introduce after my talk.

Stellar angular momentum evolution : latest observations and models
Jérome Bouvier

I will review the latest models developed to account for the angular momentum evolution of solar-type stars, focusing in particular on models considering the impact of close-in planets on the evolution of stellar spin. I will also provide a summary of the latest rotational distributions derived for young open clusters and star forming regions from the Kepler K2 mission, which highlight the need both for improved models and for a denser age sampling of rotational distributions. Plato could be the ultimate tool to reach the latter goal.

The rotation-activity relation of M dwarfs : From K2 to PLATO
Stefanie Raetz

Studies of the rotation-activity relation of late-type stars are essential to enhance our understanding of stellar dynamos and angular momentum evolution. We currently study the rotation-activity relation with the Kepler Two-Wheel (K2) mission for M dwarfs where it is especially poorly understood. The rotation-activity relation based on photometric activity indicators revealed, that, at a critical rotation period of 10d, the activity level changes abruptly. This phenomenon represents an open problem within the framework of dynamo theory. Stellar rotation rates are best derived from the periodic brightness variations that are caused by cool spots on a stellar surface. Photometric observations with space telescopes provide rotation periods even with low amplitudes as well as a wealth of activity diagnostics. In my talk I will describe the activity indicators and the methods for their determination. Despite the outstanding capabilities of K2 for such activity studies there are several limitations. The short observational baseline of 80d does not allow to detect very long rotation periods and, hence, impedes the characterization of activity levels for very slow rotators. The low cadence of the K2 light curves allows us to detect only long duration flares, which represents a strong bias for flare statistics. The PLATO mission with its large field of view can observe thousands of cool dwarfs with a duration of 2 years. Its unprecedented precision, the short cadence as well as the long observational baseline, allows us to study the magnetic activity indicators in up to now unrivaled detail. PLATO will provide high precision light curves for bright nearby M dwarfs with rotation periods up to hundreds of days. I will show the application of the activity analysis methods to simulated PLATO light curves and how the higher cadence and the longer duration will improve the determination of rotation periods and the detection of stellar flares.