# 3rd Project MEFT Workshop

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# Book of Abstracts

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# Asteroseismology: Studying angular momentum transport in red giant stars

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Computational and analytical models predict several mechanisms of transport of angular momentum (AM) capable of describing the physical phenomena in stars interiors through their evolution. However, recent measurements of core rotation rates of red giants revealed that the mechanisms occurring inside stars, responsible by transfer of AM, are still largely unknown.

This project consists in choosing a set of bench mark models from the evolution of a 1.6 $M_{\odot}$ star, and implement AM transfer mechanisms, using the open source Modules for Experiments in Stellar Astrophysics, MESA.

The main goal is to give more insight into the impact of this processes in the stars internal structure, mainly in their asteroseismic parameters, which has not been extensively explored until now. To do so, we are working on imposing constraints and even exclude some of this mechanisms. The project focus on Tayler-Spruit Dynamo (Spruit 2002) and Fuller Mechanism (Fuller et al. 2019), that provide more efficient AM transport than most other mechanisms. One subsequent step involves calibrating the stellar models using high precision asteroseimical diagnosis to make comparisons with future observations.

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# PALS –Setup optimisation and application to macromolecular materials characterisation

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One of the fundamental structural aspects in soft condensed matter is the free volume, which include atomic defects, vacancies, pores and voids, which exists in the interior of matter, due to irregular packing, density fluctuations and topological constrains. The free volume is considered as the volume fraction enabling molecular reorganisation and is of fundamental importance in influencing a material's physical, chemical and mechanical properties.

Positron annihilation lifetime spectroscopy (PALS) is a non-destructive spectroscopy technique that enables a complete study of the free volume structure in materials, especially regarding the existence, dimension and concentration of these free volumes. PALS is based on the measurement of the elapsed time between the implantation of positrons into the material and the emission of the radiation resultant from the positron-electron annihilations. The lifetime of positrons is different for the ones which annihilate in the bulk of the material and the ones which annihilate in its free volumes. Therefore, the lifetime of the positron can then be used to determine the free volume size and concentration of the sample.

Then, this work aims at the experimental optimisation of a PALS spectrometer, with a subsequent application of this tuned experimental setup to the characterisation of macromolecular materials, namely radiation processed polymer-based and hybrid materials for biomedical applications and for the consolidation of stone-based materials.

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## Self-Organization of Learning Rules

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Evolutionary Game Theory defines a mathematical framework to study the evolving dynamics of communities in biology or social sciences, typically in regimes where the evolution is deterministic. In this framework, the cooperative strategy updating is commonly based on relative payoff comparison and social learning by natural selection. However, in the real world it might be different, as individuals may not follow a social learning behaviour. In this study we propose a stochastic evolutionary game dynamics asymmetric model, for finite populations, in which individuals may adopt three different behaviours to update strategy: social learning, conformism or counterfactual thinking. We analyze these behaviours impact on the gradient of selection and on the fixation probability in a N-person group community.

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## Smart fingertip tactile sensors for agrorobotics applications

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In the agricultural business, as well as in distribution networks and packaging industry, food items suffer changes that need to be controlled. In particular, in fruit/vegetable handling there is crescent effort to introduce automated technologies for manipulation and optical inspection. In this project, a tactile sensor will be implemented that allows for a quick evaluation of the quality of the fruit/vegetable when being handled by a robotic hand. Particularly, the student will dedicate himself to develop e-skin technologies and sensors embedded in elastomers and artificial skin in a way that combines the tactile ability with a more sensitive perception of texture. Various detection strategies will be probed, with the implementation in a multiparametric integrated sensor in a robotic hand as the final goal.

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## Stability of circular orbits in the 3 body problem

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The 3 body problem has been studied for the last few centuries. While there are some known particular solutions, like the Euler and Lagrange solutions, and some specific cases, like the restricted 3 body problem, that have been more thoroughly studied, our knowledge about this topic is far from complete.

The N body problem can be reduced to a system of equations whose only parameters are the masses of the bodies involved. These equations show that in a limit where masses are small, the orbits tend to become Keplerian. This work will focus on identifying stability conditions for the parameters that allow the existence of stable periodic orbits in a general 3 body problem configured as a planetary system, i.e., 2 bodies (planets) orbiting the 3rd one (a star). Preliminary results already suggest the existence of a limited interval for the masses for which the systems are stable.

Results obtained from this study will serve as a foundation for a cornerstone of this work, the search for stable orbits in the N body problem, in order to shed some light on the structure of our Solar System, on the formation of planetary systems and planets by accretion, and on empirical and unexplained observations such as the Titius-Bode law.