

# Modelling the impact of turbulent convection on solar-like oscillations: a combined Lagrangian PDF/SPH approach

(Abstract for a talk)

Asteroseismology has enabled us to make significant progress in our understanding of stellar physics, through ground-based or space-borne missions such as CoRoT and Kepler, as well as the upcoming PLATO mission. While the frequencies of the observed solar-like p-modes give invaluable information about the structure of the star, their finite lifetime also allow to resolve the shape of their line profile in the Fourier domain, which carries the signature of the processes responsible for the driving and damping of the modes. This gives us access to crucial information about the turbulent convection just beneath the surface of the star, which constitutes one of the main obstacles towards realistic stellar evolutionary models.

However, in order to exploit the wealth of asteroseismic data at our disposal to better constrain the properties of stellar convection, it is necessary to theoretically model the relation between these properties and the asteroseismic observables (namely the amplitude of the modes, their linewidth, and the shift between the theoretically predicted frequencies and their observed counterparts, i.e surface effects). In doing so, traditional approaches are either based on parametric empirical formulations, or else on 3D simulations. These approaches show unavoidable limitations, among which the impossibility to realistically describe the full turbulent cascade, and especially the turbulent dissipation of kinetic energy.

In this talk, I will present a new alternative theoretical framework designed to circumvent these limitations. The turbulent medium is described by a set of fluid particles whose positions and properties are tracked over time, in a Lagrangian frame. Because of the turbulent nature of stellar convection, the particle properties evolve according to a system of stochastic differential equations (SDE). I couple this method with a procedure, borrowed from Smoothed Particle Hydrodynamics (SPH), to extract the relevant mean flow quantities directly from the set of fluid particles. This leads to a linear stochastic wave equation, from which coupled SDEs for the amplitude and phase of the normal modes of the system can be extracted. In the limit where mode interaction can be neglected, this simultaneously gives a theoretical estimate for the amplitude, linewidth and surface effect of each mode, directly as a function of the statistical properties of the underlying turbulent fluctuations. I will show that this formalism allows to constrain turbulent convection models through the direct comparison of these estimates with observed mode properties.