New Advances in Stellar Physics: From Microscopic to Macroscopic Processes
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Preface

Stellar modelling is faced with the drastic improvement of observational data, including precise spectroscopy, astrometry, interferometry and asteroseismology. In this context, it is important to recognize that the chemical abundances observed in stellar surfaces are not the original ones, and that they continuously evolve inside stars, with important consequences on the stellar structure.

Stars are made of non-uniform multi-component gases, the various chemical species diffuse with respect to one another during stellar evolution, from the main sequence to the final stages, unless large motions force chemical homogeneity. In simple cases, the atomic species move downwards or upwards according to the relative importance of the gravity and the radiation forces that act upon them.

This physical process has been known for a long time as the main reason for the so-called "chemically peculiar stars", but its importance for all kinds of stars is now recognized, owing to helio- and asteroseismology. Comparisons between solar models and the internal solar structure deduced from helioseismology proved the existence of element settling below the convective zone. Seismic observations of stars, including solar-type stars, main-sequence A stars, extreme horizontal branch stars (sdB) and many others proved that the diffusion of chemical elements has to be taken into account to explain the observations. The consequences are also visible at large scales in the Universe, as in the example of the age determination of globular clusters.

This atomic (or microscopic) diffusion is a slow but efficient process, in strong competition with macroscopic motions and mixing. The latter include rotational instabilities of various kinds, internal waves, mass loss and thermohaline mixing, all of them slowing down the microscopic diffusion without preventing it completely, except in dynamical convection zones. Detailed comparisons of spectroscopic observations with models including the computations of element diffusion show that this competition with macroscopic motions is necessary to account for the abundance determinations. The influence of magnetic fields is also important in this framework.

The interdependence of microscopic and macroscopic processes in stars has been recently revived with the evidence that diffusion-induced heavy elements accumulation in some stellar regions should lead to hydrodynamical instabilities. On the other hand, element settling can stabilize mixing in other regions. This narrow connection between processes treated in the framework of microscopic statistical physics and processes treated in the framework of macroscopic hydrodynamical physics still has to be investigated.

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This meeting is in honour of Sylvie Vauclair, who has devoted a large part of her scientific career to the study of both microscopic and macroscopic processes in stars. She was among the first few astrophysicists during the 70's who were involved in the fruitful scientific adventure of considering diffusion processes in chemically peculiar stars, and she opened further important directions of research. She also has had a prominent role in teaching physics in Paris and Toulouse universities, and in supervising a number of PhD students. She is deeply involved in popularizing astrophysics through numerous media.

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