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Shear-driven transport and mixing in the interiors of massive stars

Vincent Prat and **Stéphane Mathis**

Laboratoire AIM Paris-Saclay, CEA/DRF - CNRS - Université Paris Diderot, IRFU/SAp
Centre de Saclay, F-91191 Gif-sur-Yvette, France

Abstract. Turbulent transport and mixing generated by hydrodynamic instabilities triggered by rotation gradients are key mechanisms in the evolution of massive stars. We present here a summary of the progresses on shear-induced mixing obtained with numerical simulations, along with a new prescription for horizontal turbulence.

Keywords. Hydrodynamics, instabilities, turbulence, diffusion, stars: interiors, stars: rotation

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Since Zahn (1992) proposed the formalism for shear mixing in stellar radiative zones, several prescriptions based on phenomenological arguments have been proposed. Spectroscopic and asteroseismic data show that transport in stars is much stronger than what is predicted by these models (e.g. Aerts 2015). Numerical simulations appear as a crucial tool to reliably estimate the transport due to magneto-hydrodynamical processes.

Stellar radiative zones are characterised by a very high thermal diffusivity. To reduce the prohibitive computational cost that this induces, Prat & Lignières (2013) used the small-Péclet-number approximation (Lignières 1999) and showed that it is consistent with the model of Zahn (1992). Later, Prat & Lignières (2014) and Prat *et al.* (2016) investigated the effect of chemical stratification and viscosity on vertical shear mixing. They showed that these two ingredients are able to inhibit the transport and proposed new prescriptions, which generally predict even less transport than older models.

In Mathis *et al.* (2017b), we also proposed a new description of horizontal mixing which accounts for the strong anisotropy resulting from the interplay between stable stratification in the radial direction and the Coriolis acceleration in the horizontal directions. Our new prescription allows us to recover a weak differential rotation in the radiative core of the Sun (Mathis *et al.* 2017a). The validity of this new model needs to be confirmed by numerical simulations, and the implications for massive stars have to be investigated.

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