Topographic & buoyancy effects in turbulent boundary layers

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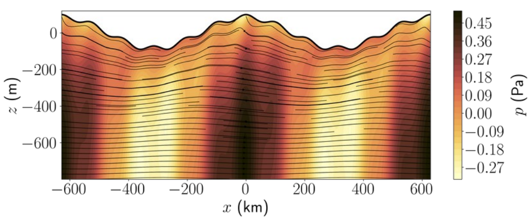
Geophysical data constrain the fluid core-mantle coupling of the Earth and the Moon. But it disagrees with our latest dynamical models (Dehant et al. 2012). It is attributed to our models' limits: we know little on the boundary stress due to turbulent rotating flows in presence of buoyancy and *topographic effects* (pressure coupling). Beyond the planetary cores (where magnetic effects are also key) such models are relevant for oceanic or atmospheric flows, where these generic ingredients combination modifies the stress on the ground floor.

In the frame of the ERC project THEIA , this PhD will tackle this problem by combining theoretical, numerical & experimental approaches. Indeed, strong turbulence remains out-of-reach for theoretical or numerical approaches. But it is hard to consider magnetic fields, or to image the boundary layer in experiments. These approaches are thus complementary.

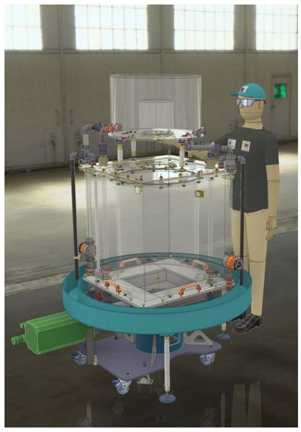
With the help of the in-house CNRS engineer Max Solazzo, we have thus designed a flexible experimental setup, where a salty water density profile is created within a rotating tank. Different kind of experiments and measurements are planned in order to characterize the role of each ingredients combinations, and to describe the mixing. This setup will be built before December 2022, and will provide a solid basis for a larger scale experiment.

To complement the experiments, we have at hand various codes (local numerical methods) to do weakly turbulent simulations, e.g. of the experiment, with all the relevant ingredients. XSHELLS will also be used to study the turbulence onset, and the *boundary stress*, in the spherical global geometry. Finally, theoretical studies will underlie all these works. The Ekman layer instability onset has e.g. only been calculated for steady layers (e.g. Desjardins et al. 2004), and it has to be extended to oscillating layers (Buffett, 2021). One can also wonder how *non-linear boundary layer* effects modify the bulk flow, and thus the drag, in presence of *topography* (Cébron et al., 2021), which requires the use of ellipsoidal skew coordinates. Finally, turbulence hampers theoretical progress but upper bounds have recently been obtained for turbulent topographic dissipation (Kerswell, 2016). This rigorous approach remains to be extended to *buoyancy effects* (stable stratification), which is also of interest in ocean modelling (turbulent mixing is an important yet poorly-known input in ocean models).

The PhD student will naturally collaborate with other members of the team. Applicants will have a master (or equivalent degree) preferably in physics or mechanics and have a basic knowledge of fluid dynamics. The PhD is funded for 3 years and will start during the fall 2022. The PhD student will be hosted at ISTerre in Grenoble.



Theoretical laminar flow (before turbulent flows). Copyright: Remy Monville.



Experimental setup : view of the CAD design. Copyright: Max Solazzo.