Mixing by breaking of internal waves

J. Deleuze *, S. Joubaud* and P. Odier *

Most geophysical fluids such as the ocean or the atmosphere are stratified and allow the propagation of internal waves in their interior. These waves can propagate over large length scales before eventually breaking and dissipating their energy into heat, but also for a part, into background potential energy. Through this mixing process, internal waves play an essential role in the upwelling of dense bottom waters and in maintaining large scale oceanic circulations. Since they are short-scale phenomena compared to climate model resolution, their experimental study is relevant to parametrize their contribution to scalar transport and include them in ocean dynamics modelling and climate predictions.

Mixing of a scalar like density requires energy transfers from large scales to small scales. Different processes leading to such events have been proposed [1] such as focusing reflection, non-linear interactions between waves or wave turbulence.

In this work, we investigate experimentally non-linear energy transfer and induced mixing in idealized configurations. Quantifying the induced mixing requires observing both velocity and density fields in the fluid in order to infer the diapycnal buoyancy transport. To do so, planar laser-induced fluorescence (PLIF) typically used to study discontinuous stratifications was recently adapted to continuously stratified fluids to observe the whole density field. Simultaneous PIV and PLIF measurements could then be combined to compute density fluxes[2] and quantify mixing.

In a closed domain, a large wave amplitude can be achieved by forcing waves around the resonant frequencies of the domain. Two different geometries are studied. First we use a rectangular tank where the wave is amplified if it corresponds to a vertical and horizontal mode of the domain. Second, a trapezoidal geometry is investigated: it has been shown to be an efficient set-up for the study of amplified internal waves [3,4] due to the focusing of the waves around attractors. In both geometries the resonant wave is then subject to instabilities and breaking by non-linearities. By forcing frequencies going from non-resonances to resonances of the domain, one can study the influence of different parameters of the primary wave on the induced mixing.

---

*ENS de Lyon, CNRS, Laboratoire de Physique

[1] Staquet and Sommeria., *Annual Reviews of Fluid Mechanics* **34**, 559 (2002).
[2] Dossmann et al., *Exp Fluids* **57**, 132 (2016).
[3] Brouzet et al., *EPL,* **113**, 44001 (2016).
[4] Davis et al, *Phys. Rev. Lett,* **124**, 204502 (2020).