Global stability of internal wave beam.

G. Lerisson*, J-M. Chomaz[1]

[1]LadHyX, CNRS–École polytechnique, 91128 Palaiseau, France

Introduction

Internal gravity waves that exists in a continuously stratified fluid are particularly important in the ocean where they are generated by different mechanisms, as for example interaction of currents or tides with topography, or coupling with waves at the thermocline. By their breaking they are thought to influence the deep ocean mixing and so contribute to the thermohaline circulation. We study through fully non-linear and linear direct numerical simulation the stability of gravity wave. The experiment and theory of [1] shown that quasi-monochromatic gravity wave beam is unstable to triadic instability. We extent their flow configuration by taking into account a mean advection over the wave maker while maintening the wave vector in the same beam width and the same wave frequency in the fluid frame. This family of flows have the same wave lenght and tilt of the isophases but different beam angle. Two limit cases are important: the wave maker fixed with respect to the fluid as in [1] in which the wave is travelling, calling this case a tidal wave, and the wave maker not oscillating with a mean flow exactly opposite to the horizontal phase velocity of the very same wave which corresponds to the classical lee wave problem of the flow over a sinusoidal topography. We show that the global stability properties of these different gravity wave beam depend strongly on the background flow whereas they are made locally of the same gravity wave solution. Remarkably, for intermediate value of the background velocity the wave beam is stable and we have performed a linear stability analysis of the flow using a Krylov technique. Both for small and large value of the background velocity, the flow is unstable leading to the developpment of a response at a frequence that differs from the wave maker forcing, indicating the presence of a Hopf bifurcation. Analysing the spatial fourrier transform of the non-linear saturated unstable mode in the unstable case and of the leading eigenmode in the stable case, we show that for small background flow the small scale branch of the triadic instability is responsible for the destabilization whereas for larger background flow the mode is large scale. We then explore the finite-size effect as in [2] and show that a multipole wavepacket system can exhibit new complexe stability properties based on linear and non-linear coupling.

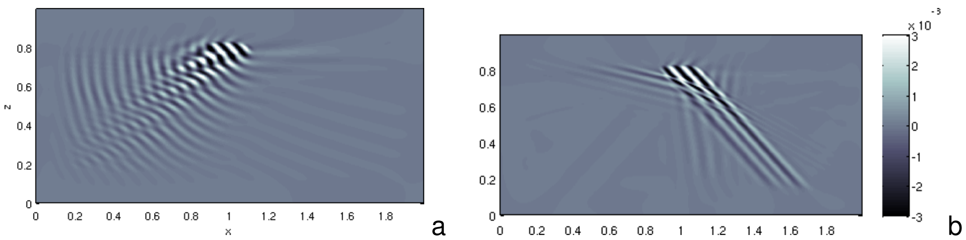

Fig. 1: Density perturbation field of 2D numerical simulation for different values of the mean velocity. In (b) the velocity is null, in (a), it compensates the horizontal phase speed of the wave. We see two differents modes corresponding to two different branches destabilize the beam, a large scale mode in (a) and a small scale mode in (b).

References

[1] Bourget B, Dauxois T, Joubaud S & Odier P *Experimental study of parametric subharmonic instability for internal plane waves*. J. Fluid Mech, 2013.

[2] Bourget B, Scolan H, Dauxois T, Le Bars M, Odier P & Joubaud S *Finite-size effect in parametric subharmonic instability*. J. Fluid Mech, 2014.

*corresponding author: gaetan.lerisson@ladhyx.polytechnique.fr