GENERATION AND STABILITY OF GRAVITO-INERTIAL WAVES

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In the ocean, stratification and rotation allow for the existence of gravito-inertial waves. Instabilities of these waves, such as parametric subharmonic instability (PSI), may play a key role in the mixing process of the deep ocean. In an experimental setup, we generate gravito-inertial waves which undergo instabilities that match the spatial and temporal resonance conditions of PSI, stipulated by the theory. In order to take into account the effect of rotation on the growth of the PSI, we introduce the Coriolis force in a preexisting model, which predicts the growth rate of the PSI instability in the case of an infinite plane wave. In this case, we show that rotation stabilizes the primary waves. However, experimentally, we see that increasing the rotation does in fact destabilize the primary wave (see figure 1, left panel). This phenomenon is explained by adding a finite size effect to the theoretical growth rate for infinite plane waves similar to what is done in [1] for purely internal waves (no rotation). We find that this effect is in agreement with the enhanced parametric subharmonic instability observed at the "critical latitude" in the ocean [2].

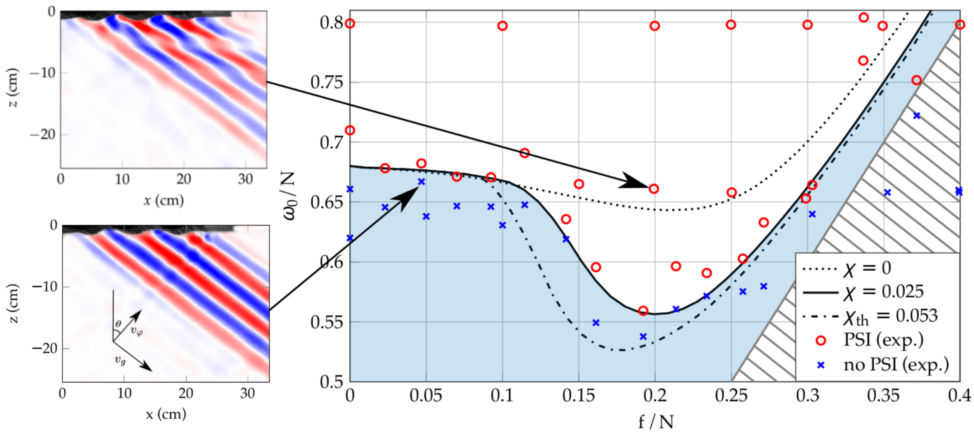

Figure 1. Left panels: vertical density gradient field, associated to two waves generated for the same characteristics of the wave generator and same stratification (buoyancy frequency $N \approx 1$ rad.s^{-1}) but two different Coriolis parameters ($f = 2\Omega$, where Ω is the angular rotation velocity): $f/N = 0.05$ and $f/N = 0.2$. Only the wave at the highest rotation speed undergoes an instability (top left panel). Right panel: evolution of the PSI threshold with rotation. Circles (crosses) mark experimental observation where PSI was (not) observed. The arrows show the corresponding experiments in the left panel. Different theoretical predictions are shown for various values of χ, which corresponds to the relative strength of the finite size effect. The best agreement was found for $\chi = 0.025$.

Estimation of the theoretical growth rate of the instability allows us to find the threshold of the instability in terms of primary wave frequency. As shown in figure 1, the theoretical predictions ($\chi = 0.025$) are in very good agreement with experimental observations. These results confirm our approach in the modeling of the finite size of the primary wave beam.

Finally, at constant primary wave frequency, we analyze the evolution of the secondary wave characteristics with rotation. We find that rotation has a complex role: it shifts the frequency of the secondary waves but may also foster the appearance of multiple triads. For the largest values of rotation rate, unexpected sub-inertial waves appear, whose existence we try to interpret.

References

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