High Stokes number wave focusing by a circular ridge: Internal, inertial and inertia–gravity waves

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Abstract

Wave focusing can be considered as a possible scenario for energy concentration in localized zones representing hot spots for incipient overturning in the oceans (Buijsman et al., 2014; Peliz et al., 2009).

In laboratory experiments, internal wave focusing can be produced by horizontal or vertical oscillations of a torus. Ermanyuk et al. (2016) showed that for low Stokes number the wave amplitude increases toward the focal region forming one zone of amplitude amplification. Increasing the oscillation amplitude leads to overturning in this zone. Similarly, experiments in a rotating fluid showed generation of turbulence in the focal zone of inertial waves (Duran-Matute et al., 2013).

The present experiments are performed at the Coriolis platform, 13.5 m in diameter, with a linearly stratified and/or rotating fluid to compare the effects of focusing for internal, inertia–gravity and inertial waves. The waves are generated by a torus ($a = 15$ cm minor radius and $b = 75$ cm major radius) oscillating horizontally with amplitude A. The Stokes number St varies between 3800 and 6800. The angle of propagation θ with the vertical direction is the same for all types of waves. The wave field is measured using PIV.

For large St the structure of the wave beams is bimodal and the focal region is formed of four zones of amplitude amplification. Spectral analysis shows the generation of evanescent higher harmonics close to the torus and in the focal zone. In the presence of rotation, wave energy extends in the vertical direction owing to the generation of columnar vortices. Specifically, horizontal vortices are located in the focal zone for internal waves while for inertial waves they fill the entire domain between the torus and the bottom. The vertical vorticity field of internal waves exhibits a dipolar structure in the focal zone, which transforms in the rotating case, namely for inertia–gravity waves, into a "Yin–Yang-like" structure.

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sciencesconf.org:ejh2016:99926