
Feedback loop between nonlinear internal wave standing modes and induced mixing

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Résumé

Nonlinear internal waves constitute a major pathway for energy transfer and mixing in stratified fluids, which is very important for geophysical flows. We present an experimental investigation of standing nonlinear internal wave modes in a uniformly stratified fluid confined within a rectangular tank, with a particular focus on the development of triadic resonant instability (TRI) and its impact on mixing processes. Large-amplitude waves are generated by forcing resonant box modes, which subsequently produce secondary waves through TRI, governed by both nonlinear resonance conditions and geometrical mode selection. Combined PIV and PLIF measurements provide access to the long-term evolution of the velocity field together with changes in the background stratification. Our observations show that well-developed triadic interactions do not necessarily induce mixing. Although robust nonlinear dynamics develops under weak forcing, the density stratification stays nearly unchanged. Increasing the forcing amplitude, however, leads to mixing, characterized by the growth of a central mixed layer and a clear increase in background potential energy. As the background density field evolves, the primary forced mode spatial structure is modified, promoting transitions between distinct families of resonant triads with different mixing efficiencies. At local scales, mixing events appear intermittent and spatially localized, mainly in regions characterized by strong shear and unstable density gradients. Overall, these results highlight a two-way feedback between nonlinear internal wave dynamics and the progressive modification of stratification.

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