Axisymmetric Internal Wave Tunneling

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The various mechanisms through which inertia-gravity waves can propagate through geophysical fluids trigger a constantly renewed interest due to their assumed significant role in energy transport and dissipation processes, notably in the oceans. In this context, numerous studies have been devoted to such waves in stratified fluids, i.e. fluids that exhibit a density gradient. Idealized linear stratifications, with constant density gradients, or piece-wise stratifications, linear by parts, are particularly interesting to understand and model the propagation of internal gravity wave through a column of stratified fluid. In the oceans, stratifications are fundamentally non-linear and often display density interfaces with, sometimes, layers of constant density that should inhibit internal waves propagation. In-situ measurements as well as experimental and numerical observations, however, show that internal waves can propagate through such barrier-layers in particular situations, through a process called wave tunneling [3,4], analoguous to the well-known tunneling effect at play in quantum mechanics.

This study extends the results of Sutherland and Yewchuk [4] on 2D Cartesian internal wave tunneling to the case of 3D axisymmetric wave fields. Using an experimental apparatus that has been proven capable of generating axisymmetric internal wave fields [1] and that has been used previously to study internal wave transmission through density gradient interfaces [2], along with numerical simulations, we show quantitatively that such waves can efficiently tunnel through constant density layers and still conserve their structure. We propose a simple three-layer model allowing for the computation of transmission coefficients for the velocity fields, and we test it on a case study. We notably show that there exists a smooth transition between the fully propagating and the tunneling regimes.

References

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