

Propagation and Interactions of Nonlinear Internal Gravity Wave Beams

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Recent numerical simulations and field observations reveal that thunderstorms often give rise to gravity-wave disturbances that propagate in the atmosphere along specific directions. Similar beam-like wave structures are generated in the ocean by tidal flow over bottom topography. These wave beams are akin to the arms of the classical St Andrews-Cross wave pattern (see, for example, the front cover of the paperback version of the text *Waves in Fluids* by M.J. Lighthill) due to a localized source oscillating at a frequency below the buoyancy frequency in a uniformly stratified, inviscid Boussinesq fluid. An asymptotic theory for the propagation of modulated two-dimensional and axisymmetric nonlinear wave beams will be presented, that takes into account viscous effects as well as refraction effects due to the presence of a mean flow and nonuniform buoyancy frequency. The theory explains why a linear approach has been useful in interpreting certain observations of isolated beams in the atmosphere. On the other hand, nonlinear effects play an important part in the reflection of wave beams from a sloping wall and in collisions of obliquely propagating beams. Nonlinear interactions are confined solely in the vicinity of the sloping wall where the incident and reflected beams meet, and this interaction region gives rise to additional reflected beams with higher-harmonic frequencies. Similarly, nonlinear interactions in the overlap region of two colliding beams induce secondary beams with frequencies equal to the sum and difference of those of the colliding beams. The theoretical predictions are consistent with numerical simulations and experiments.

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