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Weakly nonlinear internal gravity wavepackets

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Horizontally periodic, vertically localized internal gravity wavepackets induce a horizontal mean flow in a manner analogous to the Stokes drift for surface waves. Unlike the the Stokes drift, however, the wave-induced mean flow of nonhydrostatic internal waves non-negligibly interacts with the waves themselves if they are moderately large amplitude: that is, if their maximum vertical displacement is larger than approximately one percent of the horizontal wavelength. Using Hamiltonian fluid dynamics to write the wave-induced mean flow in terms of the correlation of the vertical displacement and vorticity fields, a nonlinear Schroedinger equation is derived and, through comparison with fully nonlinear numerical simulations, this is shown to accurately portray the initial evolution of internal gravity wavepackets. In particular, parametric subharmonic instability is shown to negligibly affect the wavepacket evolution at early times. Analytic analyses establish stability curves as a function the relative amplitude and frequency of the wavepackets that govern the growth or decay of the amplitude envelope due to modulational stability.