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Gain of balance and critical level absorption for inertio gravity waves

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The absorption of an inertio gravity wave (IGW) at critical levels is analyzed in the rotating linear case, and for a constant vertically sheared flow. We give for the first time an exact solution valid over the entire domain, and check its validity by deriving from it the classical values of the transmission and reflection coefficients of the wave $|T| = exp\left(-\pi\sqrt{J(1+\nu^2)-0.25}\right)$ and $|R| = 0$, respectively. Here J is the Richardson number and ν the ratio between the horizontal transverse and along shear wavenumbers.

For large J, a WKB analysis permits to interpret this classical result in term of tunneling. In this interpretation, the wave as it arrives to the lowest inertial critical level becomes evanescent (there is a turning point very near the critical level), and the transmitted signal is just the amplitude of this evanescent disturbance at the upper inertial level where it becomes an IGW again. As this evanescent solution is near a quasi-geostrophic solution between the inertial levels we see that it is a gain of balance there that explain the exponential smallness of the transmitted wave.

The exact and approximate solutions also permit to describe how the "valve" effect, which amplify the disturbances with phase line tilted in the direction of the isentropes, is only significant when the flow is inertially unstable (when $J < 1$). In this case, a small incident asymmetric transverse wave can result in a very large disturbance between the inertial levels, a result that establish a correspondence between the absoptive properties of the shear layer and the criteria for flow stability.