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# On the origin of inertia-gravity waves emitted by quasi-balanced flow

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A recent laboratory experiment of Williams, Haine, and Read (2005; JFM) has observed co-existence of inertia-gravity waves (IGWs) and large-scale quasi-balanced flow in a rotating two-layer annular fluid. The IGW amplitudes in the experiments show a linear variation with Rossby number in the range 0.05–0.14, at constant Burger number (or rotational Froude number). We seek a dynamical explanation for the source of these IGWs by exploring the asymptotic renormalization theory of Wirosoetisno, Shepherd, and Temam (2002; JAS), for the limit of small Rossby number (Ro). The first-order renormalized equation derived by those authors contains only resonant triplet interactions, and thus cannot generate IGWs from potential vorticity modes. In fact, if the initial IGW energy is zero, as it is in the laboratory experiment (at least to leading order in Ro), the equation reduces to quasi-geostrophic dynamics. The renormalized solution contains also a first-order "slaved" term consisting only of IGWs, however. This term is zero initially, but increases in a few fast wave periods to be O(Ro). These IGWs are slaved to the vortical flow, but not balanced, so they oscillate rapidly in time. We compute the analogue of this slaved term in the particular configuration of the laboratory experiment using results of a two-layer, quasi-geostrophic (QUAGMIRE) numerical model. Comparison with the IGW activity observed by Williams, Haine, and Read gives a decisive answer to the question of whether this mechanism is responsible for the IGWs seen in the experiment.