Quick Research Review

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Objectives

- Continuous train of IGW excited in stratified WD atmosphere by binary companion, grows due to stratification, reaches nonlinear amplitudes $\xi_z k_z \gtrsim 1$ before the peak of the envelope.
- Seek long-term behavior of nonlinear dissipation, whether steady-state or periodic.

Numerical Simulations, No Shear

Setup

- 2D, Fourier × Chebyshev, damping zones, ran at both 128×512 and 256×1024 over $3H \times 12H$ grid, where H is scale height.
- Target waves $k_x = \frac{2\pi}{3H}, k_z = \frac{2\pi}{H}, \omega \approx 0.32N$, N B-V frequency.
- Wave is excited by volumetric forcing $e^{-z^2/2\sigma^2} \cos(k_x x - \omega t)$ with $\sigma = \frac{3H}{32} \lesssim \frac{1}{k_z}$.
- Regularized by numerical viscosity $\nu \gtrsim \frac{\omega}{k_{\max} k_z}$.

- High resolution ($\nu = 4\frac{\omega}{k_{\max} k_z}$): `nl3.mp4`. Note that mean flow starts to build up at the outgoing damping zone, and once it hits criticality it starts to move down while continuing to steepen. Eventually, it stops moving and produces reflection below, while leaving behind a sinusoidal mean flow above.
- Low resolution ($\nu = 3\frac{\omega}{k_{\max} k_z}$): `nl3_lowres.mp4`. Qualitatively similar, but the mean flow forms later.
- Tried masking nonlinear terms near damping zones, `nl3_lowres_test.mp4`. Still mean flow interaction!

- Damping layer is causing mean flow to begin building up like Daniel said; is removing nonlinear terms near damping layer a good idea?
- Further growth/propagation is critical layer absorption? Eventual reflection might build up when shear flow is too steep $\mathrm{Ri} \gtrsim 1/2$ or WKB breaks down $\frac{\partial k_z}{\partial z} \sim \frac{k_z}{\lambda_z}$.
  The sign of the flow is wrong though, $\sim -\frac{1}{c_{gz}}\langle u_x u_z \rangle_x$!

Numerical Simulations, Shear Flow

Setup

- 2D, Fourier × Fourier, damping zones, running at 64×256. No height stratification, domain is $H \times H$ (though H is now physically meaningless).
- Target waves $k_x = \frac{2\pi}{H}, k_z = \frac{20\pi}{H}, \omega \approx 0.1N$, N B-V frequency. Volumetric forcing.
- Regularized by ∇^6 hyperviscosity.

- Initialize w/ shear flow and let evolve. Try both narrow and wide profiles (`vstrat*.mp4`).
- Conclusion: attenuated transmission when thin, barely-critical layer, smooth WKB-like wavelength shortening when broad, critical flow, but steep $\frac{\partial U_0}{\partial z}$ gives reflection!
- Recall Booker & Bretherton result

$$T \sim \exp\left[-\pi\sqrt{\frac{N^2}{(U_0')^2} - \frac{1}{4}}\right] \qquad R \sim \exp\left[-2\pi\sqrt{\frac{N^2}{(U_0')^2} - \frac{1}{4}}\right]. \tag{1}$$

WKB criterion $\Rightarrow \frac{k_z^2}{N} U_0' \frac{\lambda^2}{2} \ll 1$.

- Winters d'Asaro had a local $\mathrm{Ri} \sim 0.5$.