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Effects of viscosity on internal wave focusing by an oscillating torus.

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An experimental study of the focused internal waves generated by a horizontally oscillating torus in a linearly stratified fluid is presented for a large range of Stokes numbers from 100 to 6000. For low Stokes number the waves are unimodal, i.e. in each propagation direction they diffuse to form a single wave beam, after their emission at the critical locations where the wave rays are tangential to the torus boundary. In that regime, the waves amplify in amplitude in a single focal zone. With increasing Stokes number the waves become bimodal, forming dual wave beams in each propagation direction and focusing in four zones of amplitude amplification.

Comparison of the experimental results at small oscillation amplitude with an original linear theory gives excellent agreement over the entire Stokes number range. As the oscillation amplitude increases the wave amplitude saturates in the focal zone. This saturation only appears at large oscillation amplitude for low Stokes number and is present already at moderate oscillation amplitude for high Stokes number.

Fourier analysis reveals triadic interactions of the fundamental wave with two subharmonic waves owing to focusing. This triadic resonance is visible only at large oscillation amplitude when viscous effects are high, i.e. for low Stokes number, but with increasing Stokes number it manifests itself at smaller oscillation amplitude. For high Stokes numbers, above 1800, and large oscillation amplitudes, greater than or equal to the minor radius of the torus, wave turbulence is observed.

The Stokes drift, calculated theoretically, appears as the key to understand the generation of vertical mean flow in the focal zone. At low and moderate Stokes numbers the mean flow is almost exactly opposed by the Stokes drift, while for higher Stokes numbers perturbations of this flow start to appear with time, possibly due to the generation of subharmonics.