Rayleigh-Taylor Instability in Nonlinear Schrödinger Flow

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Abstract:

The Rayleigh-Taylor instability (RTI) is a fundamental fluid instability which occurs when a heavy fluid is accelerated into a lighter one. While the RTI in classical fluids is a textbook problem, the instability in quantum fluids has received little attention. Here, we observe the instability directly in the equivalent optical system and show that the wave dynamics is strongly nonlinear and compressible from the start. The interpenetration is effectively supersonic, with density fingering always accompanied by vortex generation. The growth rate for perturbations, obtained analytically, shows that inhibition due to wave diffraction has the same spectral form as viscosity and diffusion, despite the fact that the system is dispersive rather than dissipative. This gives formal support for the observation that turbulence in quantum fluids has the same scaling as that in normal fluids. The results hold for any Schr?dinger flow, e.g. superfluids and quantum plasma, and introduce a new class of fluid-inspired instabilities in nonlinear optics. Joint work with Shu Jia.