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Rayleigh-Taylor Instability in Nonlinear Optics SHU JIA, JASON W. FLEISCHER, Princeton University — We demonstrate, theoretically and experimentally, an all-optical Rayleigh-Taylor instability. By applying a polar (Madelung) transformation to the nonlinear Schrödinger equation for paraxial beams, we identify fluid density with light intensity and fluid velocity with the gradient of the optical phase. Pressure is obtained by using a self-defocusing nonlinearity in a photorefractive crystal, while acceleration is created by imposing a refractive index gradient. In this way, we are able to control the effective gravity, pressure, and input density ratio. The perturbed interface at the output is then studied as functions of these parameters. Observations of the characteristic spatial period show excellent agreement with analytical calculations from perturbation theory. In this case, wave diffraction, rather than viscosity or surface tension, sets the scale for long-wave growth. Further, we show that compressibility effects are important and demonstrate that care must be taken regarding shock-wave formation. The results hold for any Schrödinger fluid, e.g. superfluids and quantum plasma, and lay the foundation for a variety of fluid-inspired instabilities in nonlinear optics.

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