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**All-optical modeling of superfluid shock waves** JASON W. FLEISCHER, WENJIE WAN, Princeton University — The properties of superfluid-like shock waves and interactions are studied by mapping the condensate problem to a beam propagation problem in nonlinear optics. In both cases, a single, macroscopic wavefunction describes the coherent wave behavior of interest, while the shock itself results from a repulsive/defocusing response to a high-density/intensity perturbation. The waves are dissipationless and dispersive, with an oscillating front whose period decreases towards the leading edge. The initial oscillations resemble a train of dark solitons, while the low-intensity regions at the leading edges result in a sound-like profile. Using a nonlinear photorefractive crystal and the power of optical imaging, we directly observe 1D and 2D shock waves, their nonlinear properties as a function of intensity, and double-shock wave collisions. Analytical calculations and numerical simulations show excellent agreement with the experimental results. Further, it is anticipated that the photonic methods established here will lead to all-optical modeling of even richer superfluid phenomena (e.g. turbulence) in the near future.

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