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Collective Modes in a Trapped Gas from Second-Order Hydrodynamics WILLIAM LEWIS, PAUL ROMATSCHKE, University of Colorado Boulder — Navier-Stokes equations are often used to analyze collective oscillations and expansion dynamics of strongly interacting quantum gases. However, their use, for example, in precision determination of transport properties such as the ratio shear viscosity to entropy density (η/s) in strongly interacting Fermi gases problematic. Second-order hydrodynamics addresses this by promoting the viscous stress tensor to a hydrodynamic variable relaxing to the Navier-Stokes form on a timescale τ_π. We derive frequencies, damping rates, and spatial structure of collective oscillations up to the decapole mode of a harmonically trapped gas in this framework. We find damping of higher-order modes (i.e. beyond quadrupolar) exhibits greater sensitivity to shear viscosity. Thus measurement of the hexapolar mode, for example, may lead to a stronger experimental constraint on η/s. Additionally, we find "non-hydrodynamic" modes not contained in a Navier-Stokes description. We calculate excitation amplitudes of non-hydrodynamic modes demonstrating they should be observable. Non-hydrodynamic modes may have implications for the hydrodynamization timescale, the existence of quasi-particles, and universal transport behavior in strongly interacting quantum fluids.

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