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Observation of Collective Modes of Ultracold Plasmas[1] XIANLI ZHANG, ROBERT FLETCHER, STEVEN ROLSTON, University of Maryland — Applying a radio-frequency electric field to an expanding ultracold neutral plasma leads to the observation of as many as six peaks in the emission of electrons from the plasma. These are identified as collective modes of the plasma and are in qualitative agreement with a model of Tonks-Dattner resonances, electron sound waves propagating in a finite-sized, inhomogeneous plasma. The existing theories that describe Tonks-Dattner resonances assume a fixed outer boundary condition, which is absent from our plasmas that expand freely into vacuum. In calculating the mode frequencies, we assume an outer boundary related to the size of the plasma. These modes are not predicted within cold plasma theory and require in inclusion of the electron pressure term, which is proportional to the electron temperature , in the fluid equations. Such modes may provide an accurate method to determine the time-dependent electron temperature, applicable over a large range in time and density of the expanding plasmas.

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