Ultracold Neutral Plasma Resonant Response to Few-Cycle Radio-Frequency Pulses

Jacob L Roberts
Colorado State University, Fort Collins, CO

ABSTRACT

Ultracold neutral plasmas exhibit a resonant response to applied radio-frequency (RF) radiation. This response has been interpreted as the excitation of a plasma collective mode. Understanding the response of ultracold plasmas to external electric fields such as these is an important diagnostic in determining the plasma expansion rate, density, and electron temperature and provides important insight into energy transport mechanisms in these plasmas. In reported experiments performed elsewhere, the RF was applied continuously to the plasma during the whole experiment. In contrast, we have applied RF pulses in short bursts to the plasma to examine the resulting resonant response. We find that pulses as short as two cycles at \( \sim 10 \text{ MHz} \) produce a significant and nearly immediate increase in the electron escape rate from the plasma. The measured timescale of the plasma response to few-cycle bursts is inconsistent with the expected timescale based on the standard interpretation of resonant excitation via a local plasma oscillation. Our observations are consistent instead with a different interpretation of the response; one based on the motion of the entire electron cloud with respect to the ion component. In this colloquium, I will report on our observations of this effect, including the improvement in signal-to-noise that is obtained by using few-cycle RF pulses, the observations in support of our interpretation of the plasma response, and the implications for density measurements of ultracold plasmas and the nature of energy flow in these plasmas. I will also provide an overview of the research and scientific interest in the field of ultracold neutral plasma physics.

BIO

Prof. Jacob Roberts earned his B.S. degree in physics from the University of Notre Dame in 1994. After that he pursued his graduate thesis work in atomic parity violation measurements and then Bose-Einstein Condensate physics at the University of Colorado at Boulder, where he earned his Ph. D. in 2001. After working with ultracold neutral plasmas at the National Institute of Standards and Technology in Gaithersburg, MD as a post-doctoral research associate for two years, Prof. Jacob Roberts joined the faculty of CSU in the Department of Physics in 2003.