DPP10-2010-000096

Abstract for an Invited Paper
for the DPP10 Meeting of
the American Physical Society

Experimental Measurement of Viscoelasticity of Strongly-Coupled Dusty Plasma[1]

YAN FENG, The University of Iowa

Until recently, the basic physics concept of strongly-coupled plasmas was studied mainly theoretically. This research area is now more active because experiments are possible, due to the development of laboratory plasmas that are strongly-coupled and allow convenient diagnostics. A dusty plasma consists of highly-charged microspheres immersed in a typical electron-ion plasma. The microspheres self-organize, arranging themselves with equal spacing, forming a spatial structure like a crystalline lattice. In these experiments, video microscopy is a diagnostic that allows measurement of the positions and velocities of all microspheres, as functions of time. This has opened up a wide range of experiments of fundamental physical interest that are impossible with any other experimental system. This talk is a report of the first experimental measurement, in any physical system, of viscoelasticity of a liquid as characterized by the wavenumber-dependent viscosity. A two-dimensional crystalline lattice is formed by levitating charged polymer microspheres in an argon RF plasma. This lattice is then melted, using random energy added by rastered laser beams that push the microspheres. The microspheres are analogous to molecules in a normal liquid, but the dusty-plasma experiment has the advantage that unlike molecules, the microspheres are large enough to be tracked individually using image analysis methods. A recently-developed method of computing the wavenumber-dependent viscosity, based on particle positions and velocities, is then used. It is shown that viscosity diminishes as length scales become smaller. This serves as a measure of viscoelasticity: energy dissipation (viscosity) diminishes while energy storage (elasticity) increases as scale lengths become smaller in a liquid. This experiment result for the wavenumber-dependent viscosity is consistent with a molecular dynamics simulation.

[1]Work supported by NSF and NASA.