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Ultrafast Dynamics of Strongly Coupled Plasmas

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Structural and dynamical properties of complex systems, including molecules, liquids, solids, and plasmas, can be understood via the properties of the multidimensional potential energy function U. In general, local minima in U, and fluctuations between them, determine the properties of the systems. Recently, *rapid switching* of the potential energy function, and observations of the subsequent nonequilibrium evolution, has emerged as an interesting and important extension to the equilibrium case. Equally ubiquitous, this case occurs whenever matter absorbs radiation into the electronic component, thereby modifying the effective ion-ion interaction in the potential energy function U. A well known example is the nonthermal melting of solid surfaces in which laser excitation weakens the ionic bonds and leads to melting *without direct energy flow* into the ions via radiation or collisions. Our understanding of such nonequilibrium dynamics would benefit from dilute experiments, with their longer timescales, and the ability to rapidly switch from extremely strong to extremely weak interactions, or vice vers. Such experiments are, in fact, possible with a strongly coupled plasma, and experiments [Chen et al., *PRL* **93**, 265003 (2004)] have begun to be carried out. Such plasmas are created from a neutral gas, in which $U = 0$, which is rapidly photoionized to a plasma with strong Coulomb interactions. Beyond confirmations of earlier predictions [Murillo, *PRL* **87**, 115003 (2001)], the experiments reveal a complicated relaxation processes in which oscillations in the kinetic energy appear. Here, I will discuss the physics of such systems in general with a focus on recent theoretical results that quantify the ultrafast dynamics [Murillo, *PRL*, **96**, 165001 (2006)] of plasmas experiencing an impulsive change in U. In particular, I will show that kinetic energy oscillations seen in the experiments are associated with formations of pair correlations in a strongly coupled plasma.