Non-Equilibrium Oscillatory Dynamics of Electrons on the Surface of Liquid Helium

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The two-dimensional electron system (2DES) formed by electrons above the surface of liquid helium facilitates the exploration of 2D non-equilibrium phenomena in an almost perfectly clean environment. Research highlights have included, Wigner crystallization, the ripplonic Lamb shift, coupling of Rydberg states to Landau levels, quantum information processing, zero-resistance states, and a plethora of important results on many-electron phenomena and non-equilibrium physics.

Under certain conditions, the surface electrons exhibit *spontaneous* oscillations. We have measured the resultant signals induced in 5 Corbino electrodes at $\sim$0.3 K, with a perpendicular magnetic field and microwave radiation applied to attain the zero-resistance state. Analysis of these signals using multi-scale, time-resolved, methods yields results consistent with magnetoplasmons modulated by slow surface gravity waves, with the latter requiring consideration of the 3rd dimension. Calculation of phase differences and phase coherences between signals from differently-positioned pairs of electrodes enables reconstruction of the electron dynamics on the helium surface.

We will show that treating the time-resolved dynamics with logarithmic frequency resolution, opens up new possibilities for understanding these paradigmatic far-from-equilibrium phenomena, bringing together the quantum and classical processes involved.