

Condensed Matter & Bio-Physics Seminar

Department of Physics

Thursday, April 26, 2018

“How to Walk on Water?: Ioffe-Regel Localization of Acoustic Excitations in Liquids”

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Abstract: Long wavelength longitudinal phonons can propagate in liquids, but whether transverse phonons exist in liquids has been debated since the 1970s. The classic hydrodynamic theory refutes the existence of the latter because the transverse current fluctuation does not directly couple with density fluctuations and the Brillouin zone is not well-defined. However, such arguments fail to describe the non-linear viscoelastic response of liquids. We performed coherent INS measurements of the phonon dispersion relation of metallic liquids and glasses. Two phonon branches, the longitudinal and the transverse, are clearly identified. These experimental observations are also confirmed in both density and current correlation functions obtained from our MD simulations. Furthermore, we found that the Ioffe-Regel delocalization point of these phonon modes coincides with the onset of super-Arrhenius transport and dynamic heterogeneity, and the breakdown of Stokes-Einstein relation. Therefore, we interpreted phonon delocalization as the microscopic driving force of the strongly-correlated behavior of liquids, i.e., the Arrhenius crossover phenomenon. We have also developed a viscoelastic hydrodynamic theory by introducing a coupling mechanism between the elastic and viscous stress tensors to account for the observed one Rayleigh mode and two Brillouin modes. This work is a major step forward in the understanding of the half-a-century old puzzling problem on the nature of the transverse phonons in liquids.

The seminar will be held at 3:30 pm in 2214 SES.