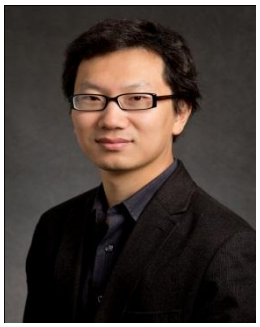
北京大学量子材料科学中心
International Center for Quantum Materials, PKU

Seminar

How to Walk on Water?
– Ioffe-Regel Localization of Acoustic Excitations in Liquids

Professor Yang Zhang[1,2,3,4]

Department of Nuclear, Plasma, and Radiological Engineering, Department of Materials Science and Engineering, Department of Electrical and Computer Engineering, Beckman Institute for Advanced Science and Technology, University of Illinois at Urbana-Champaign



Time: 2:00pm, May 25, 2018 (Friday)

时间：2018年05月25日 （周五）下午2:00

Venue: Room W663, Physics Building, Peking University

地点：北京大学物理楼 西663

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.

About the Speaker

Yang Zhang is an associate professor in Department of Nuclear, Plasma, and Radiological Engineering, Department of Materials Science and Engineering, and Department of Electrical and Computer Engineering at University of Illinois at Urbana-Champaign. He is also a core faculty member and lead of Computational Molecular Science at the Beckman Institute of Advanced Science and Technology. Zhang received his B.S. in Electrical Science and Technology from University of Science and Technology of China in 2004 and his Ph.D. in Nuclear Science and Engineering from Massachusetts Institute of Technology in 2010. He was a Clifford G. Shull Fellow at Oak Ridge National Laboratory from 2010 to 2012. The research of his group focuses on the **extreme/interfacial/non-equilibrium physics and chemistry of liquids**. His group synergistically combines and pushes the boundaries of *statistical and quantum mechanical theories-based simulations* and *neutron and X-ray experiments*. The goal is to understand **long timescale phenomena and rare events** in matter. On the application side, leveraging their expertise on liquids and soft materials, his group builds **soft robots and wearable human-enhancing devices**. He has been recognized with several awards including, most recently, the American Nuclear Society Landis Young Member Engineering Achievement Award. He is an associate editor of *Science and Technology of Advanced Materials.* [http://zhang.engineering.illinois.edu/]