北京大学量子材料科学中心

International Center for Quantum Materials, PKU

Weekly Seminar

Probing non-equilibrium states at atomic scale by time-resolved scanning probe microscopy

Jinbo Peng 彭金波

Tsung-Dao Lee Institute (TDLI), Shanghai Jiao Tong University

Time: 3:00 pm, Nov. 15, 2023 (Wednesday)

时间：2023年11月15日 （周三）下午3:00

Venue: Room w563, Physics building, Peking University

地点：北京大学物理楼，西563会议室

Abstract

Non-equilibrium states of molecules or solids play crucial roles across a broad range of fields such as the photovoltaics, chemical reactions and phase transition, etc. The detection and control of local non-equilibrium states are extremely crucial for understanding and tuning many basic processes involving electron and energy transfer, but they remain a great challenge to date. Optical methods with the ultrafast laser have proven to be very powerful in detecting various non-equilibrium states, but they suffer from a poor spatial resolution which is about half the wavelength due to the optical diffraction limit. Scanning probe microscopies such as the scanning tunneling microscope (STM) and atomic force microscope (AFM) have the advantage of ultrahigh spatial resolution down to atomic level [1, 2]. However, they are usually only accessible to the equilibrium ground states due to their poor temporal resolution (~0.1 ms). Here I will show how we broke this constraint by developing a novel electronic pump-probe AFM technique, which allows us to probe the lifetimes of molecular excited states (triplet states) at atomic scale for the very first time [3]. The advantage in ultrahigh spatial resolution of our technique was demonstrated by atomically observing the triplet quenching induced by single oxygen molecules. In the end, I will briefly show how the temporal resolution was further improved by combining the STM with ultrashort optical or terahertz pulses, realizing the atomic spatial resolution and femtosecond temporal resolution simultaneously [4, 5]. Such a technique will make it possible to track various ultrafast dynamics at atomic scale such as molecular vibrations and rotations, phonons, carrier dynamics, spin dynamics, phase transitions, etc.

[1] Peng et al., Nature communications 9, 122(2018).
[2] Peng et al., Nature 557, 701 (2018).
[3] Peng et al., Science 373, 452 (2021).
[4] Terada et al., Nature Photonics 4, 869 (2010).
[5] Cocker et al., Nature Photonics 7, 620 (2013).

About the speaker

彭金波，上海交通大学李政道研究所副教授，李政道学者。2012年本科毕业于华中师范大学，2017年博士毕业于北京大学物理学院量子材料中心(导师:江颖教授)。2017-2022年分别在德国雷根斯堡大学和日本筑波大学进行博士后研究。主要从事凝聚态物理和表面物理方向的实验研究，长期专注于研发国际尖端的具有超高空间和时间分辨率的扫描隧道显微镜(STM)和原子力显微镜(AFM)技术，实现对单分子及固体的超高时空分辨的成像和动力学研究。以第一/通讯作者(含共同)在Science, Nature, Nature Physics, Nature Communications等上发表多项高影响力的工作。入选国家和上海高层次青年人才计划（海外），工作入选“2018年中国科学十大进展”，受邀参加诺贝尔奖获得者大会，被评选为日本JSPS特别研究员、德国洪堡学者等。