Probing Light-Matter Interactions in Semiconductor Nanomaterials

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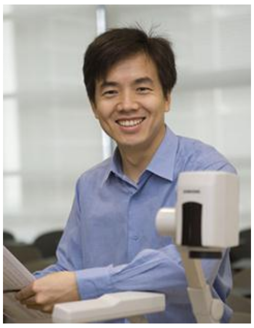

Time: 4:00pm, May 17, 2017 (Wednesday)

时间：2017年5月17日 （周三）下午4:00

Venue: w563, Physics building, Peking University

地点：北京大学物理楼，西563会议室

Abstract

The interaction of light with matter gives rises to a wide range of linear and nonlinear phenomena that we are familiar with, such as absorption, scattering, spontaneous or stimulated emission, and second harmonic generation. In insulators or semiconductors, the electromagnetic field of light polarizes the matter leading to the formation of elemental excitations such as excitons and exciton polaritons, due to long-range dipolar force as well as additional coupling to the optical fields. In this talk, I will first introduce the background of exciton, exciton polaritons and the electron/exciton-longitudinal optical (LO) phonon interactions in semiconductors. I will then present the first laser cooling of semiconductors based on cadmium sulfide nanoribbons, enabled by strong exciton-LO phonon coupling at nanoscale, giving rise to considerable promise in optical refrigeration applications. In zinc telluride nanoribbons, resolved-sideband Raman cooling can be realized with a similar physical picture of cavity optomechanics, whereby the LO phonon sidebands can be tuned to be in resonant with excitonic modes. Cooling or amplification of optical phonons can be realized by changing the detuning of pump laser. Finally, I will introduce our latest work on room temperature exciton-polariton lasing in all-inorganic perovskite $CsPbCl_3$ crystals embedded in optical microcavities. Those crystals have exceptionally large exciton binding energy, strong oscillator strength and can be grown by facile epitaxy-free techniques. Polariton lasing is unambiguously evidenced by a superlinear power dependence, macroscopic ground state occupation, blueshift of ground state emission, and the build-up of long-range spatial coherence. Our work suggests considerable promise of lead halide perovskites towards large-area, low-cost, high performance room temperature polariton devices and coherent light sources extending from the ultraviolet to near infrared range.

References:

1. J. Zhang, *et al*., “Resolved-sideband Raman Cooling of an Optical Phonon in Semiconductor Materials”, Nature Photonics 10, 600-605 (2016)
2. Q. Zhang, *et al*., “High quality whispering-gallery-mode lasing from cesium lead halide perovskite nanoplatelets”, Adv. Funct. Mater. 26, 6238-6245 (2016)
3. S.T. Ha, *et al*.”, “Laser cooling of organic-inorganic lead halide perovskites”, Nature Photonics 10, 115–121 (2016)
4. Q. Zhang, *et al*., “Room-temperature near-infrared high-Q perovskite whispering-gallery planar nanolasers”, Nano Lett. 14, 5995-6001 (2014)
5. J. Zhang, *et al*., “Laser cooling of a semiconductor by 40 Kelvin”, Nature 493, 504-508 (2013) (Cover Highlight, highlighted by Nature Photonics in its April and May issues)

About the Speaker

Qihua Xiong received his B.S. degree in physics from Wuhan University in 1997, and then obtained his M.Sc. Degree from the Shanghai Institute of Applied Physics, Chinese Academy of Sciences, in 2000. He went to the United States in 2000 and received his Ph.D. degree under the supervision of Prof. Peter C. Eklund from The Pennsylvania State University in 2006. After three years postdoctoral experience in Prof. Charles M. Lieber’s group at Harvard University, he joined Nanyang Technological University as an assistant professor in 2009 and promoted to Nanyang Associate Professor in 2014. He was promoted to full Professor in 2016. He is a Fellow of Singapore National Research Foundation awarded in 2009 and the inaugural NRF Investigatorship Award by Singapore National Research Foundation in 2014. He is the recipient of IPS Nanotechnology Physics Award (2015) and Nanyang Award for Research Excellence of NTU (2014). Prof. Xiong’s research focuses on light-matter interactions of emergent quantum matter by optical spectroscopy approaches. He recently ventured into the field of 2D layered materials and laser cooling of solids.