Joint CQSE & NCTS Seminar

2022
Feb. 18, Friday

TIME Feb. 18, 2022, 2:30~3:30pm
TITLE Quantum Electrodynamical Chemistry: Molecules Coupled with Vacuum Fluctuations of Electromagnetic Fields
SPEAKER Dr. Liang-Yan Hsu (Associate Research Fellow, Institute of Atomic and Molecular Sciences, Academia Sinica)
PLACE R307, Leung Center for Cosmology and Particle Astrophysics, NTU

Abstract:

In this talk, I will briefly introduce an emerging field "QED chemistry" and my latest development in this research direction. In the past two years, control of chemical processes by a vacuum electromagnetic field has received considerable attention because the entry of quantum electrodynamics into chemistry is a wholly new concept and a huge breakthrough in basic science. Quantum light can affect molecules in a variety of aspects, and I will focus on molecular fluorescence coupled with plasmon polaritons or cavity photons. In the framework of macroscopic quantum electrodynamics, I developed a unified theory of molecular fluorescence, which allows us to describe the dynamics of molecular fluorescence coupled to quantum light from weak to strong light-matter couplings (from Franck-Condon to polariton regimes) in a complicated dielectric environment. Based on this theory, we showed an interesting phenomenon called Franck-Condon-Rabi oscillation, and derived a parameter-free formula which can be used to estimate the exciton-polariton coupling for single molecules in a nanocavity. Our theory is in good agreement with the reported experimental results [Chikkaraddy et al., Nature 535, 127-130 (2016)]. In addition, we investigated the coherent-to-incoherent transition of molecular fluorescence of a chromophore above a silver surface (including bulk and thin-film systems) and explored the distance dependence of fluorescence rate enhancement. Moreover, in the presence of arbitrary inhomogeneous, dispersive, and absorbing media, we established a generalized theory of molecular emission power spectrum which can be expressed as the product of

the lineshape function and electromagnetic environment factor (EEF). Our study clearly shows that molecular emission power spectra cannot be simply interpreted by the lineshape function (quantum dynamics of a molecular emitter), and the effect of the EEFs (photon propagation in a dielectric environment) has to be carefully considered.

Biography Brief:

Education

- B.S., Chemistry, 2005, National Taiwan University, Taiwan
- M.S., Chemistry, 2008, National Taiwan University, Taiwan
- Ph.D.，Chemistry 2015, Princeton University, USA

Experience

- Postdoctoral Fellow, Princeton University, USA (2015-2016)
- Postdoctoral Fellow, Northwestern University, USA (2016-2017)
- Assistant Research Fellow, Institute of Atomic and Molecular Sciences, Academia Sinica, Taiwan (2017-2021)
- Associate Research Fellow, Institute of Atomic and Molecular Sciences, Academia Sinica, Taiwan (2021-Present)

Research Interests

- Nanoelectronics (Molecular Electronics)
- Methodology of Quantum Transport Theory at the Nanoscale (Electron, Exciton, Heat, and Spin Transport)
- Light-Matter Interactions at the Nanoscale (Plasmon-Coupled Exciton Transfer and Spectroscopy)
- Polariton Chemistry (Applications of Macroscopic Quantum Electrodynamics in Chemistry)