Monitoring Electron Dynamics of Molecules by Spectroscopy with Quantum-Correlated Light

Z D Zhang[1]

[1] *Department of Physics, City University of Hong Kong, Kowloon, Hong Kong*
Contact Email: zzhan26@cityu.edu.hk

Quantum-correlated photons, *e.g.*, entanglement and squeezing, open up a new avenue for molecular spectroscopy, by using parameters of the quantum-light correlations as new control knobs. With recent advancements of quantum optical technologies, imaging and controlling the electron and phonon motions in a variety of molecules are achievable, towards unprecedented time-energy scales and precision that are not attainable by classical light. Two essential problems emerge thereby: 1. quantum-light interactions with molecules containing much richer degrees of freedom than atoms; 2. Quantum fluctuations. The underlying physics still remains elusive for molecular spectroscopy and metrology.

In this talk, I will present an overview of our recent works on nonlinear optical spectroscopy for molecular dynamics, using quantum-correlated photons [1-3]. The entangled twin photons and squeezed light will be of the most interest, with a focus on the time-resolved scheme. The pump-probe and Raman spectra with quantum-correlated light are studied, where the microscopic models are developed for a real-time monitoring of electron dynamics [2,3]. Our results reveal an incredible time-frequency resolution beyond the classical Fourier's limitations, which therefore presents a quantum supremacy in the ultrafast spectroscopy.

References

[1] Z D Zhang, X Y Nie, D Y Lei and S Mukamel, Phys. Rev. Lett. **130**, 103001 (2023)

[2] Z D Zhang, T Peng, X Y Nie, G S Agarwal and M O Scully, Light Sci. Appl. **11**, 274 (2022)

[3] J J Fan, Z-Y Ou and Z D Zhang, Light Sci. Appl. **13**, 163 (2024)