Superreaction: the Collective Enhancement of a Reaction Rate by Molecular Polaritons in the Presence of Energy Fluctuations

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The last decade has witnessed the emergence of a new field of study around *molecular polaritons* [1]. Polaritons modify the physical and chemical properties of molecular systems significantly through the *strong coupling* of electronic or vibrational molecular excitations to an optical cavity. This coupling leads to the formation of a *hybrid state* of light and matter, resulting in various interesting phenomena. Important applications have been proposed and demonstrated, including the manipulation of chemical landscapes, the modification of chemical reactivity by molecular-vibration polaritons, cavity-enhanced energy transfer and conductivity in organic media. Further applications include polariton lasing and Bose-Einstein condensates, and nonlinear optical properties with applications in optoelectronic devices.

In this talk, I will show that by exploiting the inherent collective character of molecular polaritons in conjunction with the effect of polaron decoupling, a *superreaction* can be realized, involving a *collective enhancement* of charge of excitation-energy transfer reaction rate in a system of donors all coupled to a common acceptor (Fig. 1) [2]. This effect is analogous to the phenomenon of *superradiation*. The underlying mechanism is shown to be the protection of *quantum coherence* between different molecules as the light-matter interaction becomes stronger. It is the demonstration of the *polaron decoupling* effect, i.e., the suppression of environmental influence on the polariton, in a *dynamic* context, as opposed to its static manifestation in optical spectroscopy [3].

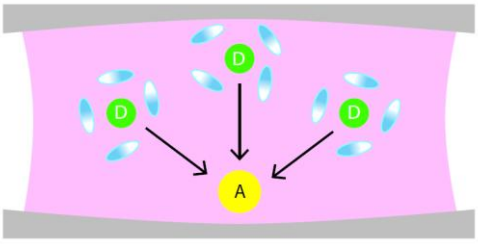

Figure 1: Schematic illustration of a superreaction, involving the collective enhancement of the electron or exciton transfer reaction rate in a system of donors (green) coupled to a common acceptor (yellow), all located inside an optical cavity (light magenta).

[1] T. W. Ebbesen, *Acc. Chem. Res.*, **49**, 2403 (2016).
[2] N. T. Phuc, J. Chem. Phys. **155**, 014308 (2021) (2021 JCP Emerging Investigators Special Collection).
[3] F. C. Spano, *J. Chem. Phys.* **142**, 184707 (2015); N. T. Phuc and A. Ishizaki, *Phys. Rev. Research* **1**, 033019 (2019); S. Takahashi and K. Watanabe, J. Phys. Chem. Lett. **11**, 1349 (2020).