Single molecules in photonic quantum technologies

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The generation and manipulation of quantum states of light is required for key applications, such as photonic quantum simulation, linear optical quantum computing, quantum communication, and quantum metrology. In this context, single organic molecules in the family of polycyclic aromatic hydrocarbons (PAH), embedded in suitable host matrices, offer competitive properties and key advantages [1]. Being very small and with well-defined transition dipole moments, they can be used as nanoscopic sensors e.g. of pressure, strain, temperature, electric and magnetic fields, as well as optical fields. Furthermore, PAH molecules can be easily fabricated and exhibit strong zero-phonon lines, which reach their Fourier-limited natural linewidth at liquid helium temperature, thus providing very bright and stable sources of coherent photons in the solid state [2,3,4].
I will present our recent advances on the coupling of single PAH molecules to photonic structures for the enhancement and control of their interaction with quantum light [5,6]. Furthermore, I will discuss two-photon interference (TPI) experiments performed between single-photons emitted by distinct molecules on the same chip [7] (see Fig.1), which stands as a fundamental challenge in the context of solid-state platforms for photonic quantum techs.
In this context, we attain and combine together different milestones: simultaneously addressing on the same sample several molecules operating as on-demand single-photon sources, tuning independently their relative optical frequency [8], measuring in semi-real-time their TPI, and extracting information about joint properties of the photon pairs.
Finally, I will present our recent results on the use of organic molecules as nanoscopic thermal sensors [9], allowing semi-invasive local temperature measurement in a temperature range (3 K to 30 K) where most commercial technologies cannot be used. These results can lead to a deeper understanding of the local phononic environment in complex structures and in an unexplored temperature regime.

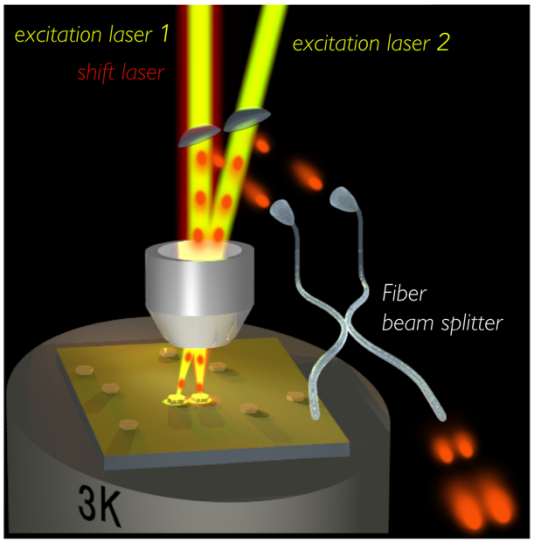

Figure 1: Sketch of the experimental setup employed to measure TPI from distinct molecules, adapted from Ref. [7]

References

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