ESPCI PARIS — PSL UNIVERSITÉ PARIS — Institut Langevin ONDES ET IMAGES

Single-molecule fluorescence lifetime imaging nanoscopy for biophysics and thermoplasmonics

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Super-resolution imaging techniques enable to image objects with a resolution at the nanometer length scale (~10 nm), well below the classical limit imposed by the diffraction of light (typically ~200 nm). Among these techniques, **single-molecule localization microscopy (SMLM) [1]** approaches are based on the capacity of detecting single-molecules and the ability of *switching on* and *off* fluorescent emitters.

At Institut Langevin, ESPCI Paris PSL, we have further developed such concept and conceived a novel microscopy system capable of simultaneously detecting single fluorescent molecules as well as their fluorescence lifetime, and thus obtaining super-resolved fluorescence lifetime images (smFLIM) [2,3]. So far, we have applied our system to study light-matter interactions in plasmonic and dielectric nanostructures and obtained super-resolved cartographies of the local density of electromagnetic states (LDOS) of silver nanowires, gold nanocones [4] and GaP nanodimers [5] (Fig. 1a, b). However, this new approach opens up new and exciting applications not only in the fields of materials science and nanophotonics, but also for biological imaging and biophysics [6].

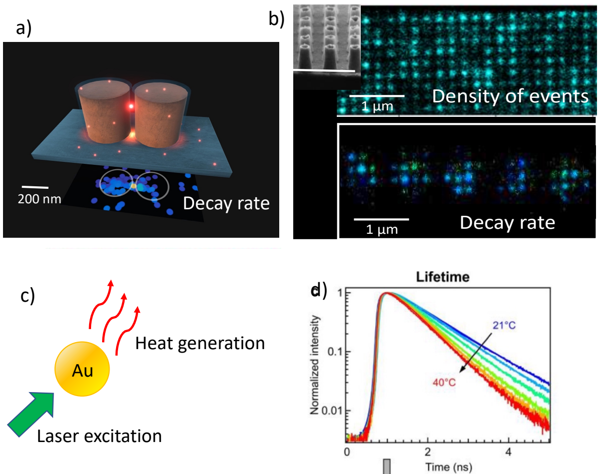

Figure 1. a) Super-resolved decay rate map of single molecules labeling a nanoantenna composed of two GaP disks [5]. b) Super-resolved map of the density of events and decay rate of single molecules in the near-field of an array of truncated gold nanocones (shown in the SEM image) [4]. c) Heating generation from a plasmonic nanoparticle. d) Fluorescence lifetime modification induced by temperature modification [8].

We are looking for a motivated student to work with us to explore a new application of smFLIM, that is the study of temperature increase in nanostructured samples based on single-molecule fluorescence modification.
The ability of remotely control the temperature of a plasmonic nanoparticle with light has seen important applications in several fields, going from nanomedicine and biology to photothermal chemistry and solar light harvesting [7]. The quantity which is usually measured is a global enhancement of the temperature over all the nanoparticles. However, new insights could be gained with a local mapping of the temperature, with nanometric resolution. smFLIM has the potential to address this challenge, by using stochastically photoactivatable molecules that have a fluorescence response which is temperature dependent [8]. The sensitivity of single-molecules' fluorescence to this parameter will be explored in the internship and its application to the map of plasmon induced temperature enhancement will be investigated.

We are accepting applications from students with different background and motivation, ranging from optics and nanophotonics to physical-chemistry and biophysics, and from fundamental research to applied sciences interests.

Possibility to go on with a PhD ? Yes.
Funding secured: no, grant to be requested.

References (references from the group are in blue):

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2. D. Bouchet, et al., Optica **6**, 135 (2019)
3. G. Blanquer, et al., ACS Photonics **7**, 393-400 (2020).
4. M. Córdova-Castro et al. arxiv:2506.15095, to be published (2025).
5. M. Córdova-Castro et al., Light: Science & Applications, **13**, 7 (2024).
6. A. F. Koenderink, et al., Nanophotonics, 11, 169 (2022)
7. G. Baffou, et al. *Nat. Mater.* 19, 946 (2020).
8. Q. Jiang at al., *ACS Photonics* 6, 1763 (2019).