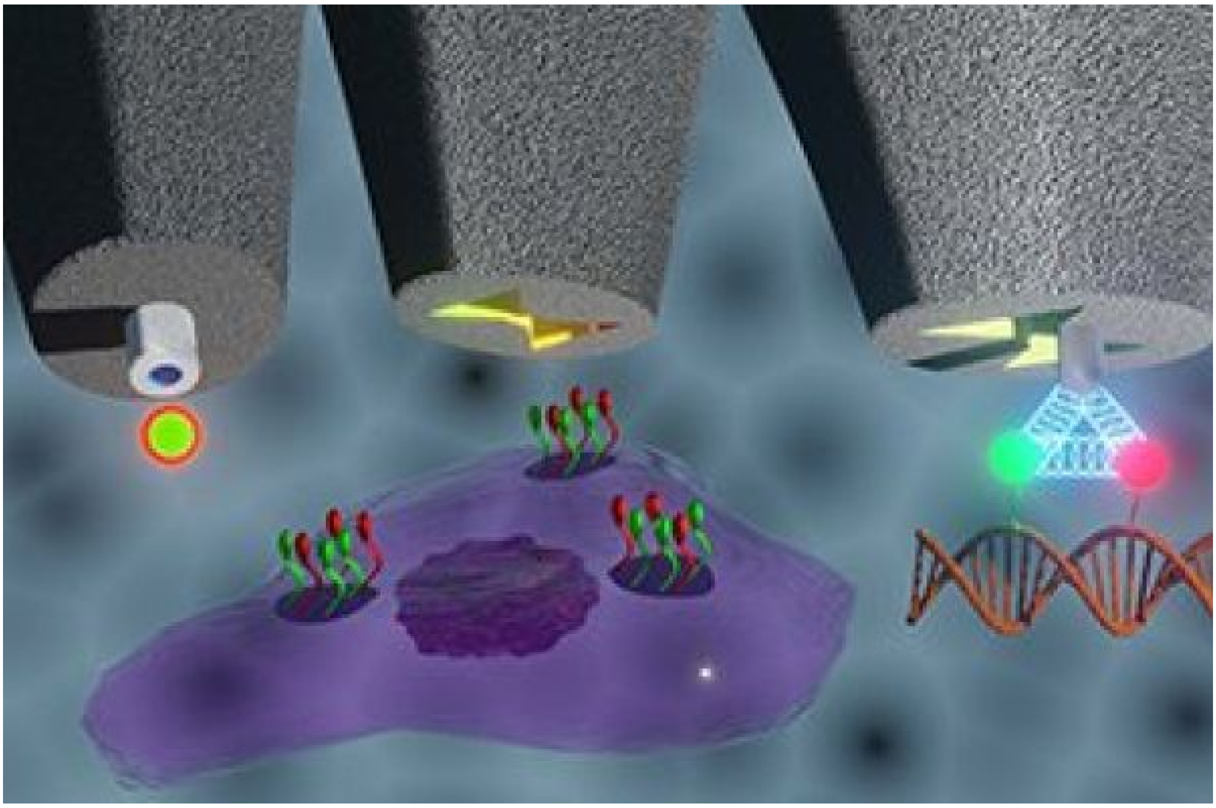

PhD THESIS DEFENSE: Nanoscale Control of Near-Field Interactions Between Single Emitters and Photonic Antennas-on Probe

MARIA SANZ-PAZ

July 27, 2020

15:00

ICFO Auditorium and Online (Teams)

PhD Thesis Defense, July 27, 2020, 15:00. ICFO Auditorium - MsTeams

MARIA SANZ-PAZ

Single Molecule Biophotonics

ICFO-The Institute of Photonic Sciences

Photonic antennas are metallic (or dielectric) nanoscale structures that convert propagating light into highly confined fields, and vice versa, in analogy to common radio antennas but on nanometric scales that lead to interaction with light. As such, they can enhance and confine electric fields at the nanoscale. These properties can be exploited in applications that require high signal-to-background ratios and sub-diffraction illumination volumes, such as for super-resolution microscopy or in bio-sensing at high physiological concentrations. Furthermore, when in close proximity to single emitters, photonic antennas can affect their emission properties. This latter property allows for improving fluorophore characteristics, such as reduced photobleaching or increased quantum yield. Although there are already numerous studies on these effects and their possible applications, some of the properties of photonic antennas are still not fully understood or exploited. Moreover, the degree by which optical antennas influence fluorescence properties depends crucially on the near-field interaction between the emitter and the antenna. This requires ultimate control of their relative position and orientation which has been challenging to achieve in most experimental configurations.

This Thesis aims to study interactions between antennas and emitters in contexts that have not been deeply studied yet, and to use them for applications where they allow us to observe molecular mechanisms that are not accessible with conventional diffraction-limited optical methods. The research has revolved around fabrication and the application of photonic antennas engineered at the apex of tapered optical fibres and manipulated using a near-field scanning optical microscope. Such an approach guarantees full control of the antenna position with respect to the sample with nanometric precision. We developed and characterized new antenna designs with different optical properties tuned for the specific application of interest. For example, most antenna designs are aimed to enhance the electric field, ignoring the magnetic contribution of the total field. In this Thesis, we use dielectric antennas to enhance the emission from magnetic dipoles. This opens new fields of application of nanoantennas, such as increased sensitivity in chiral spectroscopy. Furthermore, extending the study of photonic antennas and their interaction with multiple emitters commands for new antenna designs that are broadband and thus have the ability of influencing fluorophores with different spectral properties. Most commonly used antennas are resonant in a narrow region of the visible spectrum, so that their applications are restricted to single-colour imaging and/or biosensing. Here, we design antennas to be broadband in the visible spectrum. This is interesting from both fundamental and applied points of view. On the one hand, we used broadband antennas in the context of Forster Resonance Energy Transfer (FRET) to manipulate the interaction between a single donor and a single acceptor emitter on the nanoscale. On the other hand, the fluorescent enhancement for multiple wavelengths opens up the possibility of performing multicolour super-resolution imaging or detecting the interactions between differently labelled species on a living cell. In this Thesis, we combine these broadband antennas with high temporal resolution methods such as Fluorescence Correlation Spectroscopy (FCS) or Fluorescence Cross-Correlation Spectroscopy (FCCS) to investigate the diffusion and interaction of multiple species on the membrane of living cells with both sub millisecond temporal and nanometric spatial resolution. The dissertation finishes with a brief discussion of the main results achieved in this research and proposes new avenues for future research in the field.

Monday, July 27, 2020, 15:00. ICFO Auditorium - MsTeams

Thesis Advisor: Prof Dr Maria Garcia Parajo

Hosted by: Maria Garcia Parajo

Maria Sanz-Paz's Thesi Cover