THESIS DEFENSE: Action Microspectroscopy for Nanophotonics

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February 27, 2026

10:00

ICFO Auditorium

Stimulating an object and watching what the object does in response is the basis of scientific discovery. As much is true for much of experimental nanophotonics, where a material is stimulated with light and we observe how the material responds with nanometric precision.
In this thesis I describe the development of a new approach to experimental nanophotonics: Action Microspectroscopy.
The exploration of how light and matter interact holds the key to understanding, then harnessing, the properties of matter. For instance, light harvesting materials require a deep understanding of their interaction with energy in order to engineer an optimal combination of light absorption and the ensuing conversion to charge.
The syntheses of new optoelectronic materials with exotic properties need precision techniques to observe such properties in action and the unexpected consequences such

properties may have. As the leading edge of technology delves deeper into the nanoscale, approaches to explore matter on the same scale must be devised to keep pace.

Action Microspectroscopy is a Fourier transform excitation spectroscopy platform designed to energetically, spatially and temporally diagnose the excited state in atomic systems. Its development came in stages, each benchmarked by a chapter in this thesis. Firstly, I demonstrated that the spectral response of many single molecules in a widefield image could be simultaneously acquired, meaning that spatial and spectral detail could be combined to diffractionlimited precision.

The second step was to focus on the outcome of the excited state in a two dimensional semiconductor, WSe2. By studying the material's response in fluorescence and photocurrent, it was possible to determine which exciton (excited state electrons bound to positive holes) states were more likely to lead to charge conversion and which were more likely to re-release their energy as a photon.

Finally, by combining spatial detail with temporal resolution in photocurrent detection, I show that the measurement of the exciton-specific transfer of energy in materials can be achieved. I obtain spatially resolved pump-probe measurements of exciton states in WSe2, with a view to spatially resolved 2 dimensional electron spectroscopy.

Friday February 27, 10:00 h. ICFO Auditorium

Thesis Director: Prof Dr. Niek Van Hulst and Dr. Luca Bolzonello

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