Functional Materials and Bio-inspired Molecular Devices Investigated with Ultrafast Optical Spectroscopies

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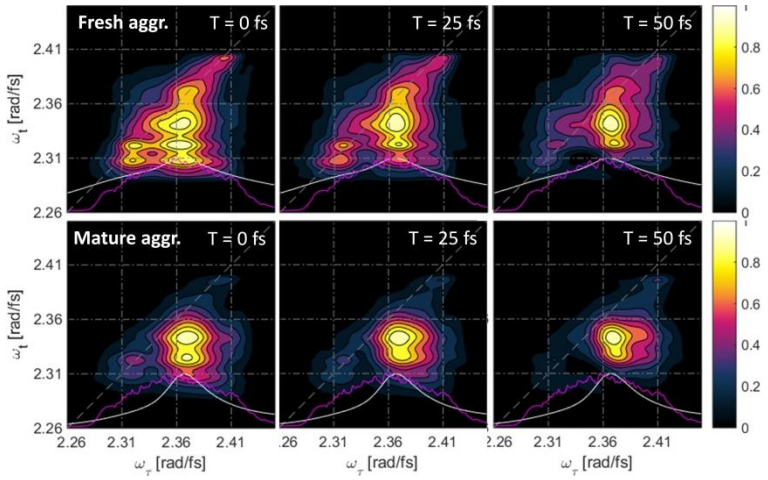
Femtosecond (ultrafast) spectroscopies have provided a level of knowledge of the most fundamental molecular processes which was inconceivable just one decade ago, since they can resolve the fastest nuclear motions, track down the different electronic and vibrational relaxation processes and unveil coherences and couplings.

Functional processes crucial to design and optimize novel materials, as solvation dynamics, presence and nature of short and long range inter- and intra-molecular couplings, identifying all the relaxation channels from a given exited state, charge and energy transfer mechanisms, interplay between electronic and structural dynamics, role of local electrostatics, etc., can nowadays be directly investigated with a minimal need of modelling and assumptions.

I will give a non-exhaustive overview of the most popular and recent electronic ultrafast spectroscopies and I will show their capability with few examples from my recent research activity, which is devoted to investigate light-induced dynamics of molecular materials characterized by unusual electronic and structural properties, potentially interesting for applications.



Electronic 2D spectroscopy at different population times (T) on a molecular J-aggregate of cyanine dyes. These 2D spectra reveal the exciton coupling map and its earliest changes of fresh and mature aggregates (top and bottom panels, respectively). The former is supposed to be more inhomogeneous, smaller and flexible than the latter and the couplings seem to be enhanced by this condition.

[1] A. Cannizzo: “Ultrafast UV spectroscopy: from a local to a global view of dynamical processes in macromolecules”; perspective article on Physical Chemistry Chemical Physics 14 (2012) 11205

[2] Y. Rodriguez, F. Frei, A. Cannizzo, T. Feurer: “Pulse-shaping assisted multidimensional coherent electronic spectroscopy”, Journal of Chemical Physics 142 (2015) 212451

[3] A. A. Maznev, *et al.* “Generation of coherent phonons by coherent extreme ultraviolet radiation in a transient grating experiment”, Applied Physics Letters 113 (2018) 221905 (10.1063/1.5048023).