ULTRAFAST TIME-RESOLVED INVESTIGATIONS OF THERMAL TRANSFER AT THE NANOSCALE

LABORATORY : Institut Lumière Matière

LEVEL : M2

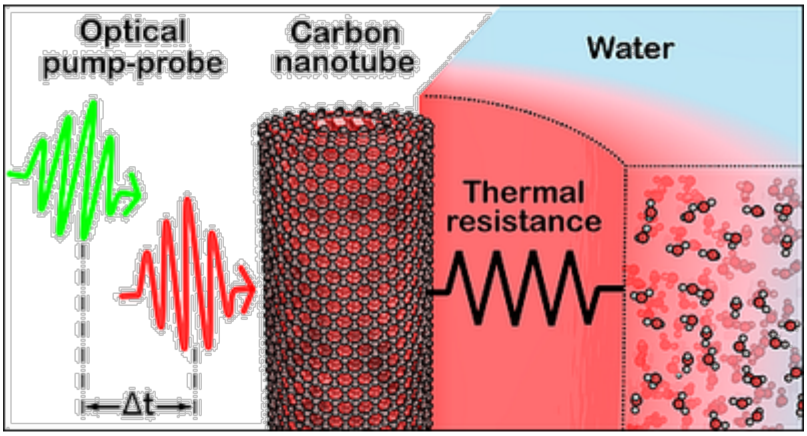
TEAM(S) : FEMTO-NANO

CONTACT(S) : MAIOLI Paolo

CONTACT(S) DETAILS: paolo.maioli[at]univ-lyon1.fr / Tel. 0472448182

KEYWORD(S) : thermal exchanges / ultrafast spectroscopy / nanoscale

SCIENTIFIC CONTEXT :



Ultrafast optical spectroscopy on carbon nanotubes in water [1]

Thermal transport between two materials is limited by the thermal resistance at their interface, known as **Thermal Boundary Resistance (TBR)** or **Kapitza resistance**. TBR arises from mismatched acoustic properties between the materials and the discontinuity of atomic positions at the interface. While some analytical models predict TBR based on phonon scattering, these are limited to ideal interfaces and show low predictive accuracy, particularly at higher temperatures. A deeper understanding of heat transfer across interfaces is essential, especially as heat dissipation constrains the downscaling of nanodevices.

This research investigates TBR both experimentally and theoretically. Experimentally, TBR will be measured by tracking ultrafast cooling dynamics of nano-objects after femtosecond photoexcitation, using **ultrafast optical (pump-probe) spectroscopy**. This non-contact, far-field optical technique allows for fast (cooling occurring on the picosecond to nanosecond scale) and non-perturbative measurement. Systems studied include **Carbon Nanotubes** and **Graphene Nanoplatelets** in liquids and polymers. These materials can be functionalized with molecules to tune interface TBR, and the effects of temperature and pressure will also be explored.

Experimental findings will be **compared to Molecular Dynamics simulations** of interface heat transfer, done in collaboration with Ecole Polytechnique de Turin.

MISSIONS :

The PhD candidate will conduct **optical ultrafast experiments, analyze data, model results, and interact with the theoretical partner**.

OUTLOOKS :

The internship can be **extended into a PhD**. Two ANR PhD fundings under review, plus Ecole Doctorale.

BIBLIOGRAPHY :

[1] A. Casto et al., “Experimental optical retrieval of the Thermal Boundary Resistance of carbon nanotubes in water”, Carbon 229, 119445 (2024)

[2] M. Gandolfi et al., “Ultrafast Thermo-Optical Dynamics of Plasmonic Nanoparticles”, J. Phys. Chem. C 122, 8655–8666 (2018)

[3] R. Rouxel et al., “Ultrafast Thermo-Optical Dynamics of a Single Metal Nano-Object”, J. Phys. Chem. C 124, 15625 (2020)

Homepage of the FemtoNanoOptics group

Personal homepage of the project contact