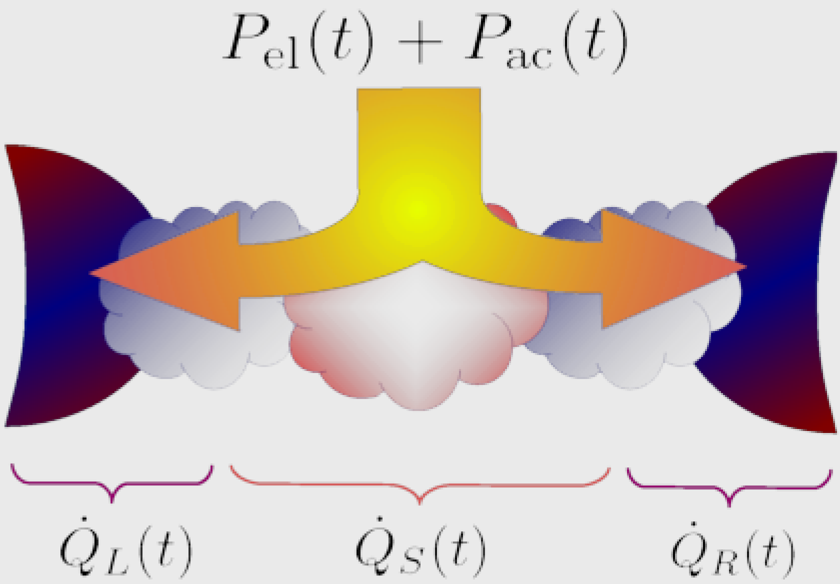
Periodic Energy Transport and Entropy in Quantum Electronics

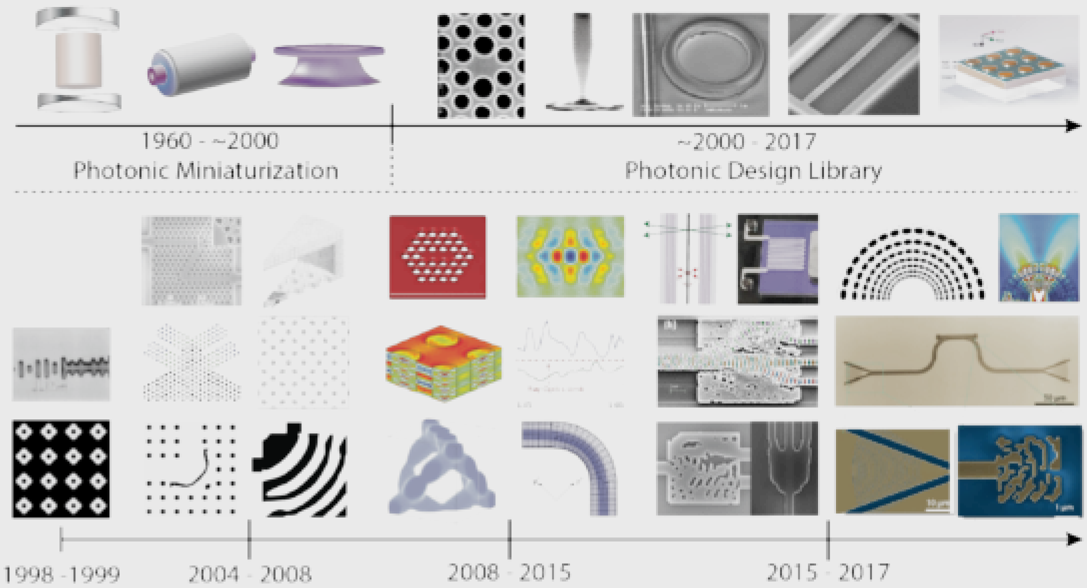


Title: Periodic Energy Transport and Entropy in Quantum Electronics.
When: Monday, July 2, (2018), 12:00.
Place: Department of Theoretical Condensed Matter Physics, Faculty of Sciences, Module 5, Seminar Room (5th Floor).
Speaker: David Sánchez, Institute for Cross-Disciplinary Physics and Complex Systems IFISC (UIB-CSIC), Palma de Mallorca, Spain.

Most of the recent literature on quantum thermodynamics focuses on static fields and the resulting stationary transport effects. However, there is a growing interest in analyzing thermodynamic properties of quantum conductors in the presence of time-dependent potentials. In this case, dynamics is the main objective of the theory as fluxes and responses depend explicitly on time. It is also of paramount importance for potential applications to discriminate which portion of the energy invested to operate quantum devices is amenable to be used and which one is wasted by dissipation. This distinction is at the heart of thermodynamics and is conventionally addressed in quasistatic processes where the system under study is very weakly coupled to the reservoirs. In quantum electronics, nevertheless, the generic situation is to have the driven structure strongly coupled to the rest of the circuit, which plays the role of a reservoir.

Here, I will discuss in detail the energy transfer through a mesoscopic conductor attached to fermionic reservoirs. The energies of the sample evolve with time due to the coupling with nearby ac gate terminals. Deep inside the reservoirs, electrons relax their excess energy and the baths can thus be considered in local thermal equilibrium. We will also consider the entropy production in the whole system and will identify the different terms arising in the redistributed energy and heat. Importantly, when the energies shift slowly with time the response is adiabatic and an exact Joule law can be demonstrated for the time domain. Our analysis is completely general and does not rely on the particular approach followed to evaluate the relevant dynamical quantities.

Recent Developments and Applications of Inverse Design in Nanophotonics



Title: Recent Developments and Applications of Inverse Design in Nanophotonics.

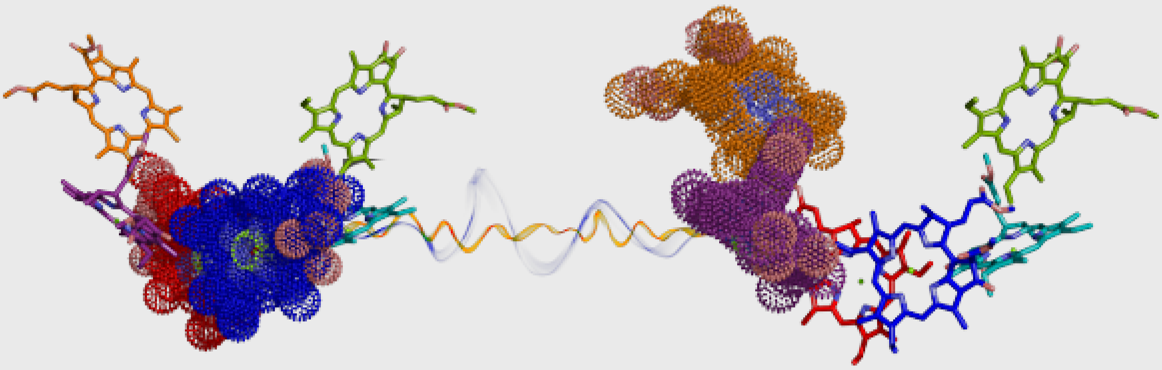
When: Thursday, June 21, (2018), 12:00.

Place: Department of Theoretical Condensed Matter Physics, Faculty of Sciences, Module 5, Seminar Room (5th Floor).

Speaker: Alejandro W. Rodríguez, Department of Electrical Engineering, Princeton University, USA.

Large-scale optimization (or inverse design) in photonics has begun to shape the landscape of on-going experiments and research problems in areas ranging from light harvesting to optical communication. In this talk, I will survey recent developments and applications of inverse design techniques in nanophotonics, including computer-aided discovery of photonic structures designed to greatly enhance nonlinear optical processes such as frequency generation, or that exhibit high-order exceptional points. Exceptional points, which are complicated spectral degeneracies in non-Hermitian systems, can lead to modifications in the local density of states or spontaneous emission rate of emitters embedded in optical resonators (a generalization of the familiar Purcell enhancement figure of merit) and can also lower the power requirements of certain nonlinear processes. Time permitting, I will also show that inverse design techniques can be exploited to enhance heat transfer between nanostructured surfaces separated by sub-micron vacuum gaps, which depends strongly on the shapes and materials of the bodies. We find that in a variety of conditions, the discovered structures lead to enhanced radiation rates which follow the expected scaling with material susceptibility derived recently from bounds based on energy conservation (a generalization of the familiar blackbody limits to situations involving sub-wavelength structures).

The Quantum Design of Photosynthesis for Bio-Inspired Solar-Energy Conversion



Title: The Quantum Design of Photosynthesis for Bio-Inspired Solar-Energy Conversion.
When: Wednesday, June 13, (2018), 12:00.
Place: Department of Theoretical Condensed Matter Physics, Faculty of Sciences, Module 5, Seminar Room (5th Floor).
Speaker: Elisabet Romero, The Institute of Chemical Research of Catalonia (ICIQ), Tarragona, Spain.

Photosynthesis holds the key to the efficient use of solar energy using abundant and renewable materials. At the heart of Photosynthesis, the pigment-protein complex photosystem II reaction center (PSII RC), performs charge separation with near unity quantum efficiency despite its highly disordered energy landscape, and thus converts sunlight to electrochemical energy.

To achieve this amazing feat, the PSII RC exploits The Quantum Design Principles of Photosynthetic Charge Separation1-2, complementary and interrelated solutions to ensure rapid forward and irreversible transfer of energy and electrons within a disordered and fluctuating environment. Thus, these principles provide a guide for the rational design and construction of systems able to transfer energy and electrons with high efficiency and in the right direction. In this talk, I will present these principles with a focus on the role of vibronic coherence and discuss my view on how to implement coherence in bio-inspired systems with the potential to perform efficient energy and electron transfer.

References

Romero, E., Augulis, R., Novoderezhkin, V. I., Ferretti, M., Thieme, J., Zigmantas, D. & van Grondelle, R. Quantum coherence in photosynthesis for efficient solar-energy conversion. Nat. Phys. 10, 676-682 (2014).

Romero, E., Novoderezhkin, V. I. & van Grondelle, R. Quantum design of photosynthesis for bio-inspired solar-energy conversion. Nature 543, 355-365 (2017).