FACOLTÀ DI SCIENZE MATEMATICHE, FISICHE E NATURALI
DIPARTIMENTO DI MATEMATICA E FISICA "NICCOLÒ TARTAGLIA"

Theoretical study of the dissipative excitonic quantum walk on complex molecular graphs

Introduce:
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Abstract

The scope of this talk is twofold and can be integrated simultaneously in quantum information theory and energy transport.
The aim of this theoretical work is to study the evolution of an exciton (an excited state able to de- localize through matter) used in order to transmit either quantum information or energy at nanoscale. To do so, we consider that the excitonic quantum transport takes place on specific molecular networks whose topology can be associated with graphs. Within this framework, the exciton can be seen as a real quantum walker able to "jump" between the nodes of a complex graph formed by intercon- nected molecular groups. In this context, we pay a special attention to the modulations that different quantum environments can generate on the excitonic propagation (decoherence, relaxation . . .).
In a first part of the talk, we focus on the excitonic quantum transport of information in the presence of a local phonons environment. In this context, we introduce a theoretical approach called PT∗.
The particularity of this method is to overcome the usual Born-Markov approximations and to treat on an equal footing exciton and phonons [1, 2, 3]. Knowing the basics of the method, we then present an application of PT∗ to study the evolution of a quantum information on a particular network : the star graph. To do so, we introduce the theoretical developments we have realized to understand all the exotic features of the decoherence process generated by the phononic environment (non-markovian behaviors. . .).
In a second part of the talk, we introduce a study of the quantum transport of energy on a complex molecular network : an extended star graph [4]. In this context, we consider that the central core of the graph is in contact with an external absorbing system able to trap the energy carried by the exciton. This being so, we focus on the optimisation of the absorption process at the core of the graph ("superradiance transition"). Furthermore, we demonstrate how the topology of the considered network can greatly influence the absorption evolution.

References
[1] Saad Yalouz, Vincent Pouthier, and Cyril Falvo. Exciton-phonon dynamics on complex net- works: Comparison between a perturbative approach and exact calculations. Physical Review E, 96:022304, Aug 2017.
[2] Saad Yalouz, Cyril Falvo, and Vincent Pouthier. The excitonic qubit coupled with a phonon bath on a star graph: anomalous decoherence and coherence revivals. Quantum Information Processing, 16(6):143, 2017.
[3] Saad Yalouz and Vincent Pouthier. Exciton-phonon system on a star graph: A perturbative approach. Physical Review E, 93:052306, May 2016.
[4] Saad Yalouz and Vincent Pouthier. Continuous-time quantum walk on an extended star graph: Trapping and superradiance transition. Physical Review E, 97:022304, Feb 2018.

Seminario

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