TRANSPORT AND EMERGENT PROPERTIES IN OPEN QUANTUM SYSTEMS: APPLICATION TO PHOTOSYNTHETIC COMPLEXES

PHD RESEARCH PROJECT (DEPT. MATH. AND PHYS., CATHOLIC UNIVERSITY, BRESCIA.)

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OPEN QUANTUM SYSTEMS: PHOTOSYNTHETIC COMPLEXES

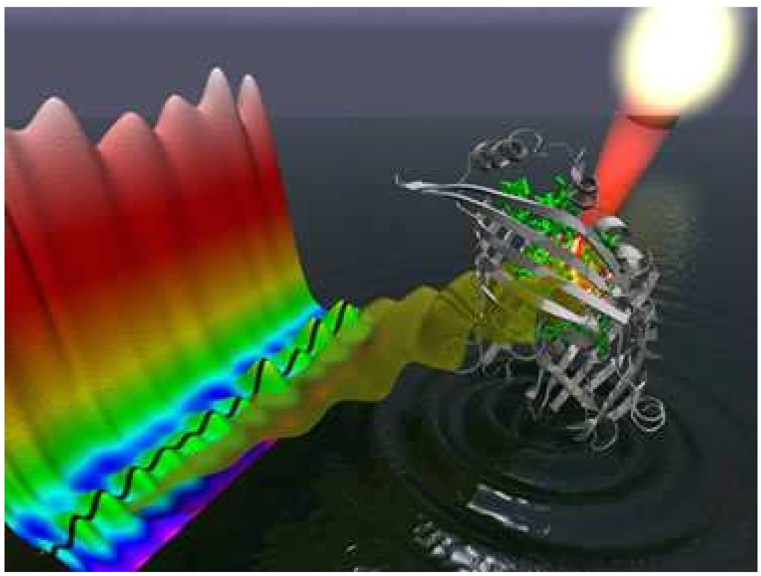

FIGURE 1. Solar light adsorbed by a clorophil molecule (green) in the FMO complex (grey), generates coherent oscillations of excitations. (Image courtesy of Greg Engel, Lawrence Berkeley National Laboratory, Physical Biosciences Division

Open quantum systems (i.e. systems that exchange matter and energy with an external environment) are at the center of many research areas: quantum computing, transport in mesoscopic systems, energy transfer in photosynthetic light-harvesting system and basic theoretical problems, such as the measurement problem in quantum mechanics.

The PhD research projects we propose aim to investigate the interplay of openness and internal interaction in determining emergent properties in light harvesting photosynthetic systems. Emergent properties arise from cooperative effects, therefore they belong to the system as a whole and not to its components. We experience the importance of emergent properties every day, examples of emergent properties is for instance life itself and consciousness.

In particular in this line of research we intend to investigate energy transfer in photosynthetic light harvesting systems.

The amount of energy humans use annually is delivered to Earth by the Sun in one hour! It could be of fundamental importance to use solar energy in an effective way. Most natural photosynthetic systems consist of antenna complexes, which capture photons from the Sun and transport energy to a reaction center. There, it is transformed into chemical energy via charge separation. Antenna complexes are able to transfer excitations to the reaction center with an efficiency exceeding 95%. For a long time, it was thought that energy transfer in photosynthetic light-harvesting complexes occurs through a classical process, similar to a random walk of the exciton to the reaction center. Surprisingly, evidence of coherent quantum energy transfer has been recently found in photosynthetic light-harvesting systems at room temperature [1]. These findings raise two basic questions [2]: How can coherence be maintained in complex biological systems at room temperature? Why is quantum coherence relevant to the efficiency of energy transfer? This research will be persued within the newly born "Quantum Biology Group", in the Department of Mathematics and Physics in Brescia.

This research line will give the opportunity to the Ph.D. student to work within an international network of collaborations, both in Europe and in the USA:

Main International Collaborations:

- G. P. Berman, Los Alamos National Laboratory, New Mexico, USA.
- M. Merkli, University of Newfoundland, Canada.
- V.I. Tsifrinovich, Polytechnic Institute of NYU, New York, USA.

Our Group:

- F. Borgonovi (group leader), email: fausto.borgonovi@unicatt.it.
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- G. Giusteri (Researcher)
- L. Lussardi (Researcher)
- A. Biella (Master Student)
- D. Ferrari (Master Student)

References

[1] G.S. Engel et al., Nature **446**, 782 (2007).

[2] G.L.Celardo, F. Borgonovi, V.I. Tsifrinovich, M. Merkli and G.P. Berman, Journal of Physical Chemistry C (2012) http://dx.doi.org/10.1021/jp302627w.

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