TRANSPORT AND EMERGENT PROPERTIES IN OPEN QUANTUM SYSTEMS: APPLICATION TO COLD ATOMS

PH.D RESEARCH PROJECT (DEPT. MATH. AND PHYS., UNICATT BRESCIA.)

FAUSTO BORGONOVI AND GIUSEPPE LUCA CELARDO

OPEN QUANTUM SYSTEMS: COLD ATOMS

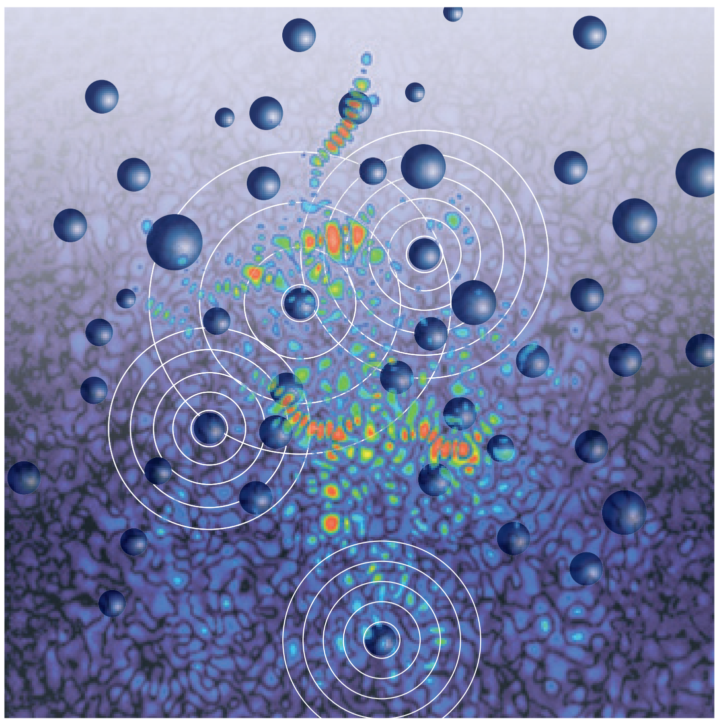

FIGURE 1. Image taken from *Ultracold matter: Disorderly arrest*, R. Kaiser, Nature Physics, News and Views, 04 March 2012

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 Ph.D. research projects we propose aim to investigate the interplay of openness and internal interaction in determining emergent properties in cold atoms 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 photon propagation in cold atoms systems. The interaction of cold atomic vapors with light is a very promising field of research. We plan to study the interplay of disorder and superradiance in these systems in collaboration with experimental groups (http://www.kaiserlux.de/coldatoms/). The main experimental goal is to achieve photon trapping in the cold atoms system by different means, such as Anderson localization and Dicke subradiance [1]. On the theoretical side we plan to analyze both static disorder, which leads to Anderson localization, and time dependent disorder, which induces dephasing.

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:

- R. Kaiser, INLN (CNRS) Nice, France.
- N. Piovella, Dipartimento di Fisica, Universitá degli Studi di Milano, Italy.
- I. Rotter, Max Plank Institute on Complex Systems, Dresden, Germany.
- L. Kaplan, Tulane University, New Orleans, USA.
- V. Zelevinsky, Michigan State University, Lansing, USA.
- F. Izrailev, BUAP, Puebla, Mexico.

Our Group:

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

References

[1] G. L. Celardo, A. Biella, L. Kaplan, and F. Borgonovi Fortschr. Phys., 1-11 (2012); DOI 10.1002; Special Issue on "Quantum Physics with Non-Hermitian Operators: Theory and Experiment".

(F. Borgonovi and G.L. Celardo) Dipartimento di Matematica e Fisica and Interdisciplinary Laboratories for Advanced Materials Physics, Università Cattolica, via Musei 41, 25121 Brescia, Italy; I.N.F.N., Sezione di Pavia, Italy

E-mail address: fausto.borgonovi@unicatt.it, nicedirac@gmail.com;