



MASTER IN PHOTONICS – “PHOTONICS BCN” ERASMUS+ “EUROPHOTONICS”

MASTER THESIS PROPOSAL

Dates: April - September 2019

Laboratory : Dept. of Quantum Physics and Astrophysics

Institution: University of Barcelona

City, Country : Barcelona

Title of the master thesis: Static and dynamical properties of few interacting fermions in a one-dimensional harmonic trap

Name of the master thesis supervisor: Bruno Julia Diaz and Artur Polls

Email address : brunojulia@ub.edu / artur@fga.ub.edu

Phone number : 934039179

Mail address : Dpt. FQA (6a planta), Marti I Franques 1, 08028 Barcelona

Keywords : Ultracold atomic systems, quantum correlations, 1D systems, fermions

Summary of the subject (maximum 1 page) :

The recent technical advances in the control and manipulation of ultracold quantum gases allow one to choose the geometry, the number of particles and to tune the interaction between the atoms creating an excellent laboratory to study the mechanisms for the emergence of quantum correlations in many-body systems [1,2].

A very interesting case, experimentally accessible, is the study of one dimensional systems, in which quantum effects are enhanced and where differences between bosons and fermions stemming from the quantum statistics give rise to exotic phenomena.

The aim of the project is the study of the ground state and the excitation spectrum of few interacting fermions in a one dimensional harmonic trap (see recent experiments by S. Jochim group [3]). The interatomic interaction is described by means of a contact interaction whose strength can be modulated. In addition, finite range interactions will be also explored. After the study of the ground state and the spectrum, the system will be probed by exciting the breathing mode. Its associated dynamic structure function will be calculated by using the



UNIVERSITAT POLITÈCNICA
DE CATALUNYA
BARCELONATECH



UNIVERSITAT DE
BARCELONA



matrix elements of the transition or by means of expectation value of certain operators in the ground state. It is relevant to

operator responsible of the energy sum-rules evaluated by the

study the dependence of all these properties on the number of particles and the strength of the interaction.

The project will make intensive use of exact diagonalization techniques in combination with analytical methods to get physical insight into the systems.

[1] I. Bloch, J. Dalibard and W. Zwerger, Rev. Mod. Phys. 80, 885 (2008)

[2] M. Lewenstein, A. Sanpera and V. Ahufinger, "Ultracold Atoms in Optical Lattices", OUP (2012).

[3] F. Serwane et al, Science 332, 336 (2011)

Additional information :

* Required skills : Computational tools, Quantum mechanics

* Miscellaneous :