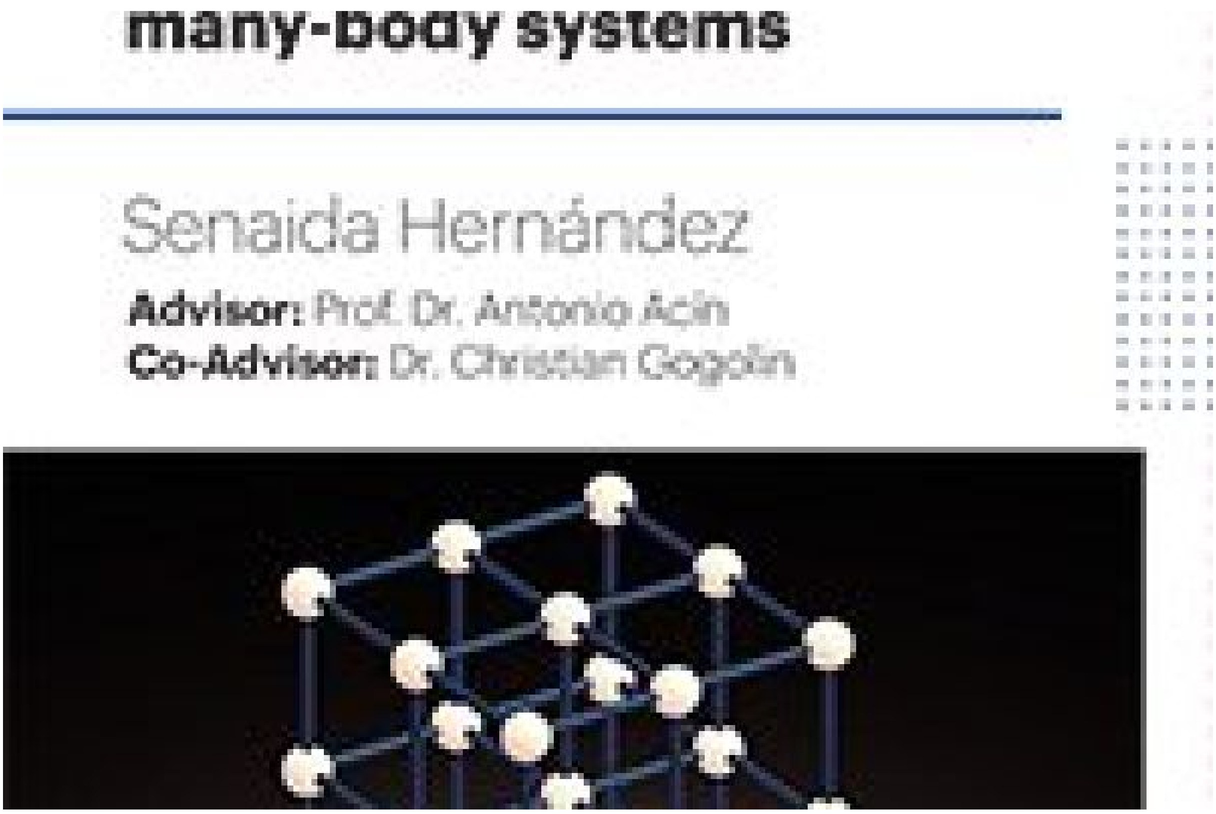

PhD Thesis Defense SENAIDA HERNANDEZ SANTANA 'Local Temperature and correlations in Quantum Many-Body Systems'

SENAIDA HERNANDEZ SANTANA

April 12, 2019

Friday, April 12, 12:00. ICFO Auditorium

SENAIDA HERNANDEZ SANTANA

Quantum Information Theory

ICFO-The Institute of Photonic Sciences

Quantum Mechanics was established as the theory of the microscopic world, which allowed to understand processes in atoms and molecules. Its emergence led to a new scientific paradigm that quickly spread to different research fields. Two relevant examples are

Quantum Thermodynamics and Quantum Many-Body Theory, where the former aims to characterize thermodynamic processes in quantum systems and the latter intends to understand the properties of quantum many-body systems. In this thesis, we tackle some of the questions in the overlap between these disciplines, focusing on the concepts of temperature and correlations. Specifically, it contains results on the following topics: locality of temperature, correlations in long-range interacting systems and thermometry at low temperature. The problem of locality of temperature is considered for a system at thermal equilibrium and consists in studying whether it is possible to assign a temperature to any of the subsystems of the global system such that both local and global temperatures are equal. We tackle this problem in two different settings, for generic one-dimensional spin chains and for a bosonic system with a phase transition at non-zero temperature. In the first case, we consider generic one-dimensional translation-invariant spin systems with short-range interactions and prove that it is always possible to assign a local temperature equal to the global one for any temperature, including at criticality. For the second case, we consider a three-dimensional discretized version of the Bose-Einstein model at the grand canonical ensemble for some temperature and particle density, and characterize its non-zero-temperature phase transition. Then, we show that temperature is locally well-defined at any temperature and at any particle density, including at the phase transition. Additionally, we observe a qualitative relation between correlations and locality of temperature in the system. Moving to correlations, we consider fermionic two-site long-range interacting systems at thermal equilibrium. We show that correlations between anti-commutative operators at non-zero temperature are upper bounded by a function that decays polynomially with the distance and with an exponent that is equal to the interaction exponent, which characterizes the interactions in the Hamiltonian. Moreover, we show that our bound is asymptotically tight and that the results extend to density-density correlations as well as other types of correlations for quadratic and fermionic Hamiltonians with long-range interactions. Regarding the results on thermometry, we consider a bosonic model and prove that strong coupling between the probe and the system can boost the thermal sensitivity for low temperature. Furthermore, we provide a feasible measurement scheme capable of producing optimal estimates at the considered regime.

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Thesis Advisor: Prof Dr Antonio Acin