Nicola PANCOTTI

Group of Prof. Ignacio Cirac,
Max-Planck-Institute for Quantum Optics (MPQ), Garching

1. Short CV

1990: born in Senigallia (AN), Italy
2009-2013: studied Physics at La Sapienza University, Rome, Italy
2013: master of physics with honours at La Sapienza University, Rome, Italy
Since February 2015: Student in the group of Prof. Ignacio Cirac, Max-Planck-Institute for Quantum Optics, Garching
Since January 2016: ExQM PhD student in the same group.

Awards & Prizes

2010 Excellent Fellowship from Physics Department at La Sapienza University, Rome
2013 Erasmus Fellowship (London)

External collaborations:
Leonardo Banchi, Sougato Bose – University College of London,
Peter Wittek – ICFO Barcelona,
Jacob Biamonte – University of Malta

2. PhD Project: "Many Body Physics with Tensor Networks"

At the moment, we are studying thermalization and localization. In particular, we focus on many body localization (MBL) and we try to extrapolate information using Tensor Network (TN) techniques. We are looking at the phase transition point which separates the ergodic phase from the localized phase; however the analysis gets complicated by the presence of Griffith's phases nearby the transition.
The best results in this direction are produced via exact diagonalization and hence are limited to small sizes. We would like to improve these results to much larger systems. Furthermore, with TN, we can infer sensitive information about the two phases; for instance, we are able to give a good characterization of the (quasi) integrals of motion in the localized phase which are known to completely characterize the system.
Just to give some details, the algorithm performs an optimization which minimizes the commutator between an unknown operator and the Hamiltonian of the system; a prototypical Hamiltonian we use is the 1D Heisenberg model with random magnetic field.
TN are very powerful, they provide us with many possibilities to study MBL. Another direction of research we undertake, is the so called 'Matrix Product Oprator (MPO) compression'. This method allows one to analyze how information and entanglement spread all over the system. Briefly, we represent the unitary time evolution operator of the closed system as an MPO of fixed bond dimension D, we compress the MPO to smaller bond dimension D'<D and we compute the error. We expect and indeed we see the error in the localized phase to be much smaller compared to the one in the ergodic phase. This is because if a system is localized, information should not spread; whereas entanglement spreads only

logarithmically. At the moment we are trying to test this last statement with TN obtaining very promising results.

I am also interested in applying machine learning techniques to quantum mechanics [1]. At the moment I am part of a collaboration which aims to improve some results that appeared recently in the literature. Some scientists were able to find the ground state of Ising and Heisenberg Hamiltonians by making use of a Restricted Boltzmann Machine, a physics-inspired machine learning algorithm.
In this work we try to improve their approach introducing more sophisticated machine learning algorithms.
Our aim is to study more complex physical frameworks with better precision.

Publications and preprints:

[1] L. Banchi, N. Pancotti, S. Bose "Quantum gate learning in qubit networks: Toffoli gate without time-dependent control", *NPJ Quantum Information* **2** (2016), 16019 EP

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