



MASTER IN PHOTONICS – PHOTONICS BCN EUROPHOTONICS-POESII MASTER COURSE

PROPOSAL FOR A MASTER THESIS

Dates: April - September 2017

Laboratory : Quantum Information Theory
Institution: ICFO-The Institute of Photonic Sciences
City, Country : Castelldefels, Spain

Title of the master thesis: Simulating Three-Dimensional Quantum Systems with Trotter-Suzuki Decomposition

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Summary of the subject (maximum 1 page) :

The Trotter-Suzuki approximation leads to an efficient algorithm for simulating the time-dependent Schrödinger equation [1-2]. The same methodology can approximate the ground-state energy with imaginary time evolution and it can also simulate physical systems described by the Gross-Pitaevskii equation. An implementation has been developed that scales to massively parallel computing clusters that include many-core central processing units and also general-purpose graphics processing units [3-4]. Systems of interest that can be simulated include Bose-Einstein condensates, quantum holography, and spin glasses.

The current implementation of the algorithm is restricted to two-dimensional systems. The proposed project would extend the high-performance kernels to three-dimensional lattices, which would open up an entirely new avenue of applications. Of particular interest are systems whose behavior may not be captured by their simple projection to the two-dimensional plane; as examples, we may mention simulating the real-time dynamics of bent vortex lines in Bose-Einstein condensates, studying the turbulent structures arising after periodic modulations, the transport properties of quantum gases in complex optical potentials, or their response to synthetic gauge fields.

- [1] Trotter, H. (1959) Proceedings of the American Mathematical Society **10**, 545–551.
- [2] Suzuki, M. (1990) Physics Letters A **146(6)**, 319–323.
- [3] Wittek, P. & Cucchietti, F. (2013) Computer Physics Communications **184**, 1165–1171.
- [4] Wittek, P. & Calderaro, L. (2015) Computer Physics Communications, **197**, 339-340.

Keywords : Trotter-Suzuki approximation, high-performance computing, Bose-Einstein condensate, Gross-Pitaevskii equation

Additional information :

* Required skills : C++, numerical methods

* Miscellaneous :