Progetto di ricerca correlato all'assegno

The position is funded by the project "Quantum Algorithms for Hydrodynamics Equations" (QAHE), which is an additional WP of the project "Quantum algorithms for the solution of differential equations" (QC4PDE) funded by the National Centre for HPC, Big Data and Quantum Computing, proposal code CN00000013, CUP J33C22001170001

Abstract of the research project:

QAHE aims to determine the resources required by quantum computers to solve hydrodynamics equations in the industrial scenarios relevant for Fincantieri. The goal will be achieved via numerical simulations of the quantum algorithms for nonlinear differential equations. With QAHE, Fincantieri will be able to quantify the potential usefulness of quantum computers for its core business and will become capable of exploring on its own further applications of quantum computers.

Extended description of the research project:

The Navier-Stokes equations model the behavior of a viscous fluid and describe the physics of many phenomena of scientific and engineering interest, among which water flow around a ship hull. Solving such equations constitutes an extremely demanding computational task. Quantum computers promise to be a revolutionary solution to fulfill the need for high-performance computing since they can solve certain computational problems exponentially faster than classical devices. A quantum algorithm to solve the Navier-Stokes equations has been proposed. This algorithm achieves an exponential speedup with respect to classical computers with respect to the dimension of the solution vector. However, the theoretical guarantees are only asymptotic in the limit of infinite dimension, while any application of the algorithm to problems of industrial relevance requires finite-size bounds to the complexity. The goal of QAHE is to determine the actual resources required by the quantum algorithm for the Navier-Stokes equation to solve realistic hydrodynamics problems of industrial relevance for Fincantieri. QAHE will achieve this goal by performing numerical simulations of the quantum algorithm on a classical computer. First, we will study several test cases both with and without turbulence and with different values of the kinematic viscosity, and for each model we will explore how the runtime and the number of qubits required by the quantum algorithm depends on the dimension of the problem and on the evolution time. Then, we will extrapolate our results for the test cases to realistic hydrodynamics problems of industrial relevance. Thanks to QAHE, Fincantieri will gain a broad knowledge on quantum computing and will become capable of exploring on its own the potential applications of quantum computers to its core business, including applications not foreseen in this project.

Piano di Attività

QAHE will be carried out by one postdoc in the Department of Mathematics of UniBo supervised by Prof. De Palma and consists of the following tasks:

Task 1 (M1-M3): Hiring of the postdoc

Task 2 (M4-M12): Determination of the number of qubits required by the quantum algorithm for hydrodynamics equations applied to several models both with and without turbulence and with different values of the kinematic viscosity.

Task 3 (M13-M15): Determination of the time resources required by the quantum algorithm for the hydrodynamics equations.

Task 4 (M16-M18): Determination of the resources required by the quantum algorithm for hydrodynamics equations applied to problems of industrial relevance and evaluation of the benefits for Fincantieri of further exploring the potential of quantum computing.