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Quantum Computers and Quantum Simulators for strongly-correlated condensed-matter problems: Applications and benchmarking

Thématiques : Quantum Computing, Many-Body Physics, Variational Methods, Numerical methods

Organisateurs :
Thomas Ayral, Atos Quantum Laboratory, Les Clayes-sous-Bois, France
Benoît Vermersch, Univ. Grenoble Alpes, CNRS, LPMMC, Grenoble, France

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Résumé

Quantum computing has entered the era of Noisy, Intermediate-Scale Quantum (NISQ [1]) computers. In particular, quantum computers have recently reached "quantum advantage" in performing hard, albeit somewhat useless, computational tasks [2, 3] in much shorter times than classical computers. However, the next milestone – that of finding applications for which NISQ computers will outperform classical algorithms – is yet to be reached.

Condensed-matter physics offers a plethora of hard problems that make them an ideal target for such a practical quantum advantage. In particular, some many-body problems arising from the study of the electronic structure of materials are still challenging for classical computers and thus appear as good prospective candidates. In the recent years, many quantum algorithms have been proposed and optimized for NISQ processors in order to solve many-body problems. Alternatively, programmable quantum simulators, where problems of condensed matter are encoded in highly tunable systems of atoms, ions, superconducting qubits, etc, in a `analog' setting have been developed. Recently, a significant experimental progress has been achieved in both quantum computers and simulators platforms, enabling the creation and the probing of the entanglement structure of strongly correlated quantum matter [4-8].

Recently, variational algorithms, both for quantum computers [9] and programmable quantum simulators [10], have been proposed and optimized in order to solve many-body problems. In addition to being likely powerful applications of quantum devices, these problems can also be regarded as benchmark problems to assess and quantify the power of a given quantum computing architecture [11].

The goal of this minicolloquium is to gather experts in quantum algorithms for creating, probing, verifying strongly correlated condensed-matter systems in quantum computers and programmable quantum simulators and on the evaluation of the various experimental platforms for solving such problems.

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