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Variational quantum algorithms for quantum optical systems

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Variational quantum algorithms (VQAs) have emerged as a powerful tool to make the best out of the quantum hardware available nowadays. The key idea is to use a classical optimizer to find the set of parameters of a parametrized quantum circuit implemented on the hardware such that it minimizes a given cost function. Beyond digital architectures, VQAs also hold great promise for analog quantum optical simulators, i.e., systems in which ensembles of quantum emitters (e.g., neutral atoms, ions, or excitons) interact with photons. In the first part of this talk, we will adiabatically eliminate the photons, which give rise to effective interactions between the emitters. I will illustrate the power of such interactions in creating wave function Ansätze that capture accurately the ground state of quantum critical spin models (XXZ and Ising) [1]. In the second part, we will focus on the photons. By employing the quantum and classical Fisher information as cost function, I will show how to deterministically generate metrologically-relevant states with large photon numbers exploiting tunable quantum optical non-linearities [2].

References:

- [1] C. Tabares, AMH, L. Tagliacozzo, et al., Phys. Rev. Lett. 131, 073602 (2023).
- [2] AMH, C. Tabares, J. T. Schneider, et al., arXiv:2309.09841 (2023).

Presenter: MUÑOZ DE LAS HERAS (IFF - CSIC MADRID), Alberto

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