Neural-network-assisted quantum magnetometers

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As important branches in quantum technologies, quantum sensing and quantum metrology have experienced significant progress, placing themselves at the forefront of the new generation of technologies harnessing quantum effects. In this presentation, different quantum magnetometers assisted by neural networks are introduced. Our results show that neural networks are valuable in distinct quantum systems for quantum sensing leading to adaptive protocols for quantum detection with broad working regime and high accuracy.

Firstly, the benefits to integrate neural networks are illustrated to decipher the information contained in the sensor responses at the data processing stage of general quantum sensing tasks. We experimentally demonstrate that the combination of $^{171}Yb^{+}$ atomic sensors with adequately trained neural networks enables to investigate target fields in distinct challenging scenarios [1]. In particular, we characterize radio frequency fields in the presence of large shot noise, including the limit case of continuous data acquisition via single-shot measurements. Furthermore, by incorporating neural networks, we significantly extend the working regime of atomic magnetometers into scenarios in which the RF driving induces responses beyond their standard harmonic behaviour [2].

Secondly, the way for the practical use of quantum many-body systems as black-box sensors exploiting quantum resources to improve precision estimation is demonstrated. Entangled quantum many-body systems can be used as sensors that enable the estimation of parameters with a precision larger than that achievable with ensembles of individual quantum detectors [3]. Neural networks faithfully reproduce the dynamics of quantum many-body sensors, thus allowing for an efficient Bayesian analysis. We exemplify with an XXZ model driven by magnetic fields and demonstrate that our method is capable to yield an estimation of field parameters beyond the standard quantum limit scaling.

References:

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[3] Y. Ban, J. Casanova, R. Puebla, Neural networks for Bayesian quantum many-body magnetometry, arXiv: 2212.12058 (2022).