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Seminar

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Variational-State Quantum Metrology and Phase-Space Representations for Qubit and Qudit Systems

Wednesday, October 16, 2019

at 14:00 h

ESI, Boltzman Lecture Hall

Abstract: First, I will present our recent results on using variational quantum circuits for quantum metrology (arXiv:1908.08904): Quantum metrology aims to increase the precision of a measured quantity that is estimated in the presence of statistical errors using entangled quantum states. We present a novel approach for finding (near) optimal states for metrology in the presence of noise, using variational techniques as a tool for efficiently searching the classically intractable high-dimensional space of quantum states. We comprehensively explore systems consisting of up to 9 qubits and find new highly entangled states that are not symmetric under permutations and non-trivially outperform previously known states up to a constant factor 2. We consider a range of environmental noise models; while passive quantum states cannot achieve a fundamentally superior scaling (as established by prior asymptotic results) we do observe a significant absolute quantum advantage. We finally outline a possible experimental setup for variational quantum metrology which can be implemented in near-term hardware.

In the second part of my talk, I will briefly summarise key results contained in our recent works [arXiv:1711.07994, J. Phys. A 52 (2019) 055302, Ann.Phys. 408 (2019) 1-50, arXiv:1811.05872]. Planar phase spaces for infinite-dimensional quantum states have been widely used in quantum information theory and well-known cases include Wigner, Husimi Q and Glauber P functions. Phase spaces are often a better theoretical tool (as compared to density matrices) to describe, visualise, and analyse complex, high-dimensional quantum states. To this end, we present our work on continuous phase spaces as a general approach to spherical phase spaces while highlighting connections to the planar case from quantum optics. Our results significantly simplify the description of general classes of both spherical and planar phase spaces as phase-space functions can now be

systematically interpreted and calculated as quantum-mechanical expectation values with the help of so-called parity operators. For the case of finite-dimensional quantum states, we develop new phase-space techniques to exactly and approximately calculate the time evolution by introducing spin-weighted spherical harmonics as an important new tool. Our results on the time evolution are also applicable to experimental bosonic systems in (e.g.) metrology that consist of indistinguishable qubits.

R. Zeier

October 9, 2019