



CRC 1227
Designed Quantum States of Matter



GUEST LECTURE

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(Guest of Prof. Klemens Hammerer)

Leibniz Universität Hannover
DQ-mat Colloquium
20 May 2021, 3.00 pm
(via Zoom-Meeting)

"Optimal metrology with variational quantum circuits on trapped ions"

Cold atoms and ions possess unparalleled performance in frequency metrology; epitomized in the atomic clock. More recently, these atomic systems have been used to implement programmable quantum computers and simulators with highest reported operational fidelities across platforms. Their strength in metrology and quantum information processing offers the opportunity to utilize tailored, programmable entanglement generation to approach the 'optimal quantum sensor' compatible with quantum mechanics. Here we report for the first time quantum enhancement in metrology beyond squeezing through low-depth, variational quantum circuits searching for optimal input states and measurement operators in a trapped ion platform. We perform entanglement-enhanced Ramsey interferometry finding optimal parameters for variational quantum circuits using a Bayesian approach to stochastic phase estimation tailored to the sensor platform capabilities and finite dynamic range of the interferometer. We verify the performance of circuits by both directly using theory predictions of optimal parameters, and performing online quantum-classical feedback optimization to 'self-calibrate' the variational parameters. In both cases we find that variational circuits outperform classical, and direct spin squeezing strategies under realistic noise and imperfections. With 26 ions we achieve 2.02(8) dB of metrological gain over classical interferometers, and 5.29(5) dB of 'effective squeezing' on an optical transition. These experiments demonstrate that low-depth entangling circuits provide an excellent approximation to optimal interferometry. Successfully demonstrating operation beyond standard squeezing using on-device optimization opens this approach to application across a wide array of sensor platforms and tasks.

All DQ-mat members and all interested are cordially invited to attend.