DEPARTMENT OF PHYSICS
THE UNIVERSITY OF HONG KONG

HK Institute of
Quantum Science & Technology
香港量子研究院

Physics
Colloquium

Physics Colloquium

Cold-atom quantum sensing via Bayesian quantum estimation

October 22, 2025 (Wednesday)

10:30 a.m.

MWT2, G/F, Meng Wah Complex, Main Campus, HKU

Prof. Chaohong LEE
Shenzhen University

Abstract:
Quantum sensors based on frequentist interferometry face a trade-off between sensitivity and dynamic range. Bayesian quantum estimation, combining Bayesian statistics with quantum metrology, can surpass the limit of conventional frequentist measurements. For cold-atom CPT clocks, our adaptive Bayesian protocol achieves Heisenberg-limited sensitivity in integration time and improves fractional frequency stability by 5.1(4) dB over conventional PID locking while enhancing robustness against technical noise. In CPT magnetometry, we optimize measurement sequences to improve precision scaling from $T^{-0.5}$ to $T^{-0.85}$. Using Bayesian quantum estimation to optimize the interferometry sequence, we yield a 145.6 nT dynamic range (14.6 dB higher than frequentist counterpart of 5.0 nT) with a sensitivity of 6.8 ± 0.1 $pT/Hz^{1/2}$ (3.3 dB improvement over the frequentist counterpart of 14.7 ± 0.4 $pT/Hz^{1/2}$). In addition to atomic clocks and magnetometers, this framework may bridge high sensitivity and broad dynamic range for other interferometry-based quantum sensors.

Biography:
Chaohong Lee is a Chair Professor at Shenzhen University. He received his Ph.D. in 2003 from the Wuhan Institute of Physics and Mathematics, Chinese Academy of Sciences. From 2003 to 2009, he conducted postdoctoral research at the Max Planck Institute for the Physics of Complex Systems and the Australian National University. In 2009, he joined Sun Yat-Sen University as a Full Professor before moving to Shenzhen University in 2022 as a Distinguished Professor; he was appointed Chair Professor in 2024. His research focuses on quantum atomic gases, quantum precision measurements, and quantum topological states, with over 120 publications in prestigious international journals such as Rev. Mod. Phys., Phys. Rev. Lett., Science Advances, Nature Communications, PRX Quantum, Appl. Phys. Rev., and Phys. Rev. A/B/E/Applied/Research etc.

Anyone interested is welcome to attend.

Enquiries:
Tel: 3917 2360 Fax: 2559 9152 Email: physdept@hku.hk