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Title: Quantum Sensing at the Edge: Precision Limits Near Dynamical Singularities

Abstract:

Singularities such as **exceptional** and **hybrid exceptional-diabolic (HED)** points naturally arise in the study of **open quantum systems**, where the interplay of loss and gain gives rise to rich and unconventional dynamical behaviour. In this talk, I will discuss how general singularities can be harnessed to achieve **enhanced sensitivity** in quantum sensing. Drawing on methods from **quantum estimation theory** and **perturbative analysis of singular matrices**, we examine how the sensitivity of a quantum system is governed by the structure of its response near these points. In particular, we show that operating at HED points can yield a **twofold improvement in estimation precision** compared to standard exceptional points. The analysis also identifies **heterodyne detection** as an optimal measurement strategy that achieves the fundamental quantum limit of precision. Overall, the results highlight how the unique features of open-system dynamics can be leveraged to develop **ultrasensitive metrological protocols** and advance **next-generation quantum technologies**.

References:

1. Javid Naikoo, Ravindra W. Chhajlany, Janek Kołodynski, *Phys. Rev. Lett.* **131**, 220801 (2023)
2. Javid Naikoo, Ravindra W. Chhajlany, Adam Miranowicz, *New J. Phys.* **27**, 064505 (2025)