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Critical Quantum Metrology with a Finite-Component Quantum Phase Transition

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Physical systems close to a quantum phase transition exhibit a divergent susceptibility, suggesting that an arbitrarily high precision may be achieved by exploiting quantum critical systems as probes to estimate a physical parameter. However, such an improvement in sensitivity is counterbalanced by the closing of the energy gap, which implies a critical slowing down and an inevitable growth of the protocol duration. In this contribution, we present different metrological protocols that exploit the superradiant phase transition of the quantum Rabi model, a finite-component system composed of a single two-level atom interacting with a single bosonic mode. We show that, in spite of the critical slowing down, critical quantum optical probes can achieve a quantum-enhanced time scaling of the sensitivity in frequency-estimation protocols.

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