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Measuring an unknown phase with quantum-limited precision using nonlinear beamsplitters YUPING HUANG, Ohio University, MICHAEL MOORE, Michigan State University — High precision phase measurement is currently a central goal of quantum interferometry. In general, the precision is described by the phase estimation uncertainty $\Delta\theta$, which is characterized by two scaling behaviors, shot-noise limited with $\Delta\theta \sim 1/\sqrt{N}$ and Heisenberg limited with $\Delta\theta \sim 1/N$ (N the total particle number). According to Bayesian analysis, Heisenberg limited preciosion for $\theta = 0$ can be achieved in a Mach-Zehnder interferometer with $(|N-1, N+1\rangle + |N+1, N-1\rangle)/\sqrt{2}$ as input state based and a single measurement or $|N, N\rangle$ input based on multiple measurements. As θ deviates from zero, both schemes degrade rapidly to worse than shot-noise-limited precision. In contrast, a Quantum Fourier Transform (QFT) based interferometer can measure an arbitrary θ at Heisenberg limited precision, but requires a quantum computer. To extend the range of precisely measurable θ without a quantum computer, we propose using nonlinear beam-spitters. We find that this can achieve nearly Heisenberg-limited precision over a wide range of θ. This scheme can be implemented in a bimodal Bose-Einstein condensate (BEC) system with tunable scattering length. Numerical calculations show: i) at $\theta = 0$, $\Delta\theta \sim 1/N$; and ii) as θ moves towards $\pm\pi/2$, the precision crosses over smoothly to $\Delta\theta \sim 1/\sqrt{N}$, providing a wide range over which the precision is nearly Heisenberg limited.

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