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Doppler Gyroscopes: Frequency vs Phase Estimation

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The burgeoning field of quantum metrology seeks to find "quantum advantages"over existing classical measurement schemes. Owing to its importance in gyroscopes and gravitational wave detection as well as its fundamental nature in all branches of interferometry, phase estimation beyond the standard quantum limit has been the prototypical example. Pragmatically, due to loss, quantum phase estimation techniques have, so far, only offered a few percent improvement over the standard quantum limit in the few-photon regime or a few dB improvement in the high power regime. However, what if phase estimation for a class of experiments is suboptimal? Depending on the measurement apparatus, phase estimation may have different fundamental limits than frequency estimation. I will discuss a new type of gyroscope that relies on an ultra-steep, frequency-dependent gain measurement rather than performing phase estimation in a passive gyroscope. Withthis technique we can achieve orders of magnitude improvement below the phase-estimation standard quantum limit of a single-loop Sagnac interferometer of the same size. I will discuss important insights into a long-debated open question about the role of Doppler shifts in the Sagnac effect.

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