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A femtotesla pulsed gradiometer using multipass cells at finite fields WONJAE LEE, Princeton University, MARK LIMES, ELIZABETH FOLEY, THOMAS KORNACK, Twinleaf LLC, MICHAEL ROMALIS, Princeton University — We describe a ^{87}Rb scalar gradiometer using two multipass cells which increase the path length of the probe beam by one order of magnitude. This gives a much higher optical depth on resonance, which is crucial for quantum-nondemolition (QND) measurements. As a result, we can directly record a large optical rotation. When the optical rotation exceeds $\pi/4$ radians, the optical rotation signal wraps around, showing multiple zero-crossings in a single Larmor period. This exotic signal gains a higher signal intensity, which indicates that a single photon can interact with higher number of alkali atoms. The magnetic field sensitivity then can reach beyond the naive Cramer-Rao lower bound, the minimum bound for the estimated frequency variance of a sine wave in the presence of photon shot noise. The lower probe power consumption is also critical for development of a miniaturized magnetometer. We have implemented a novel method of zero-crossing detection of the wrapped signals. We report a magnetic sensitivity of 7 fT/$\sqrt{\text{Hz}}$ in the geomagnetic field range, which agrees well with the quantum spin noise limit.

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