Abstract Submitted
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A femtotesla quantum-noise-limited pulsed gradiometer at Earth's magnetic fields[1] VITO GIOVANNI LUCIVERO, WONJAE LEE, MICHAEL ROMALIS, Princeton University, MARK LIMES, ELIZABETH FOLEY, TOM KORNACK, Twinleaf LLC — A major challenge in optical magnetometry is to realize high field sensitivity in Earth's magnetic field. We present a compact atomic gradiometer with a differential magnetic field sensitivity of 14 $\mathrm{fT}/\sqrt{\mathrm{Hz}}$ at 50 μT using a 0.5 cm^3 multi-pass ^{87}Rb cell. The gradiometer also has very high common mode rejection ratio greater than 10^4 in all three directions. The gradiometer is operated in pulsed mode, with a short pump pulse sequence followed by a free precession interval interrogated by a VCSEL probe laser via paramagnetic Faraday rotation. The noise in the optical rotation measurements is dominated by photon shot noise and atomic spin noise. We derive a generalized Cramèr-Rao lower bound (CRLB) for frequency estimation with a non-white noise spectrum and find that the experimental sensitivity of the gradiometer is in good agreement with predicted quantum noise sources. This result makes the first DC field gradiometer operating in Earth's field to be experimentally quantum-noise-limited and opens the possibility for further quantum enhancement at the geomagnetic field.

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