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Single Ion Quantum Lock-In Amplifier SHLOMI KOTLER, NITZAN AKERMAN, YINNON GLICKMAN, ANNA KESELMAN, ROEE OZERI, Weizmann Institute of Science — Invented by Dicke, the lock-in measurement is a phase-sensitive detection scheme that can extract a signal with a known carrier frequency from an extremely noisy environment. Here we report on the implementation of a quantum analog to the classical lock- in amplifier. All the lock-in operations: modulation, detection and mixing, are performed via the application of non-commuting quantum operators on the electronic spin state of a single trapped Sr+ ion. We increase its sensitivity to external fields while extending phase coherence by three orders of magnitude, to more than one second. With this technique we measure magnetic fields with sensitivity of 25 $pT/\sqrt{Hz}$, and light shifts with an uncertainty below 140 mHz after 1320 seconds of averaging. These sensitivities are limited by quantum projection noise and, to our knowledge, are more than two orders of magnitude better than with other single-spin probe technologies. As a first application we perform light shift spectroscopy of a narrow optical quadruple transition. We remark that the quantum lock-in technique is generic and can potentially enhance the sensitivity of any quantum sensor. (http://arxiv.org/abs/1101.4885)

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