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Laser spectral analysis using ^{87}Sr atoms with a quantum projection limited noise floor MICHAEL BISHOF, XIBO ZHANG, MICHAEL J. MARTIN, JUN YE, JILA, National Institute of Standards and Technology and University of Colorado, Department of Physics, University of Colorado, Boulder, CO 80309, USA — Ultra-stable lasers are essential tools in a variety of precision measurement experiments and their stability often dictates the performance of the experiments they serve. For example, a Sr clock recently demonstrated record clock stability by using a laser with 10^{-16} fractional stability[1]. Despite the importance of laser performance, evaluating noise spectra of state-of-the-art lasers remains challenging. Often, multiple lasers of similar performance are built for the sole purpose of evaluating laser noise [2]. We demonstrate a technique to measure the noise spectrum of a single ultra-stable laser using optical lattice-trapped ^{87}Sr atoms as a quantum projection noise-limited reference. Using a simple theoretical framework, we deduce the laser spectrum from measured fluctuations in atomic excitation. Measurements using a variety of probe sequences are consistent with resonant features observed in an optical beat with a less stable laser. Furthermore, we use features from this beat to actively reduce resonant noise in our ultra-stable laser. Finally, we show how knowledge of our laser's spectrum informs the optimal conditions for clock operation.

[1] T. L. Nicholson et al., PRL 109, 23081 (2012).
[2] T. Kessler et al., Nature Photon. 6, 687-692 (2012).

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