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Measuring the environment of a Cs qubit with dynamical decoupling sequences

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We report the experimental implementation of dynamical decoupling on a small, non-interacting ensemble of up to 25 optically trapped, neutral Cs atoms.
The qubit consists of the two magnetic-insensitive Cs clock states, which are coupled by microwave radiation. We observe a significant enhancement of the coherence time when employing Carr-Purcell-Meiboom-Gill (CPMG) dynamical decoupling.
A CPMG sequence with ten refocusing pulses increases the coherence time of 16.2(9) ms by more than one order of magnitude to 178(2) ms.
In addition, we make use of the filter function formalism and utilize the CPMG sequence to measure the background noise floor affecting the qubit coherence, finding a power-law noise spectrum $1/\omega^{\alpha}$ with $\alpha = 0.89(2)$.
This finding is in very good agreement with an independent measurement of the noise in the intensity of the trapping laser.
Moreover, the measured coherence evolutions also exhibit signatures of low-frequency noise originating at distinct frequencies.
Our findings point toward noise spectroscopy of engineered atomic baths through single-atom dynamical decoupling in a system of individual Cs impurities immersed in an ultracold ^{87}Rb bath.

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