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Online adaptive estimation of decoherence timescales for a single qubit

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The estimation of decoherence timescales is important not only as a key performance indicator for quantum technology, but also to measure physical quantities through the change they induce in the relaxation of quantum sensors. Typically, decoherence times are estimated by fitting a signal acquired while sweeping the time delay between qubit preparation and detection on a pre-determined range. Here we describe an adaptive Bayesian approach, based on a simple analytical update rule, to estimate T_1, T_2^* and T_2 with the fewest number of measurements, demonstrating a speed-up of factor 3-10, depending on the specific experiment, compared to the standard protocols. We also demonstrate that, when sensing time τ is the resource to be minimised, a further speed-up of a factor $\sim$2 can be obtained by maximising the ratio between Fisher information and time τ, compared to the Fisher information.

We demonstrate the online adaptive protocols on a single electronic spin qubit associated with a nitrogen-vacancy (NV) centre in diamond, implementing Bayesian inference on a hard-realtime microcontroller in less than 100 μs, a time negligible compared to the duration of each measurement. Our protocol can be readily applied to different types of quantum systems.

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