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Spectroscopy of composite solid-state spin environments for improved metrology with spin ensembles NIR BAR-GILL, LINH PHAM, CHINMAY BELTHANGADY, DAVID LESAGE, Harvard University, PAOLA CAPPELLARO, MIT, JERONIMO MAZE, Pontificia Universidad Catolica de Chile, MIKHAIL LUKIN, AMIR YACOBY, RONALD WALSWORTH, Harvard University — For precision coherent measurements with ensembles of quantum spins the relevant Figure-of-Merit (FOM) is the product of spin density and coherence lifetime, which is generally limited by the dynamics of spin coupling to the environment. Significant effort has been invested in understanding the causes of decoherence in a diverse range of spin systems in order to increase the FOM and improve measurement sensitivity. Here, we apply a coherent spectroscopic technique to characterize the dynamics of a composite solid-state spin environment consisting of Nitrogen-Vacancy (NV) color centers in room temperature diamond coupled to baths of electronic spin (N) and nuclear spin (13C) impurities. For diamond samples with a wide range of NV densities and impurity spin concentrations we employ a dynamical decoupling technique to minimize coupling to the environment, and find similar values for the FOM, which is three orders of magnitude larger than previously achieved in any room-temperature solid-state spin system, and thus should enable greatly improved precision spin metrology. We also identify a suppression of electronic spin bath dynamics in the presence of a nuclear spin bath of sufficient nuclear spin concentration. This suppression could inform efforts to engineer samples with even larger FOM for solid-state spin ensemble metrology and collective quantum information processing.

Nir Bar-Gill
Harvard University

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