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Dear Editors,

We hereby submit our manuscript, "*Revealing the emergence of the classicality in nitrogen-vacancy centers*," by Thomas Unden, Daniel Louzon, Michael Zwolak, Wojciech H. Zurek and Fedor Jelezko, for your consideration as a letter in Physical Review Letters.

We report the first laboratory observation of the natural emergence of classical objectivity from the underlying quantum substrate. We experimentally examine a single electron spin – the central spin/system – interacting with a nuclear spin environment in diamond at room temperature (i.e., NV center surrounded by a ensemble of ^{13}C). To enable the observation of classical objectivity, the challenge is to obtain knowledge of what the environment knows about the system. This is true in any setting, but especially hard in natural settings where the environment components are not engineered but rather are spatially and energetically (e.g., the coupling strengths) uncontrolled, as well as have stray interactions.

We solve these problems by developing a novel control scheme based on dynamical decoupling that allows us to identify and selectively address individual spins in the environment. This makes it possible to prepare an initial state where the system is in a quantum – "weird" – superposition and out of equilibrium with the environment, exactly the setting in our everyday world should a, e.g., microscopic object be in a superposition that then decoheres by the photon environment. We then allow the system and environment to evolve under their intrinsic Hamiltonian and, later, we observe the state of the system and the environment. We see the appearance of redundant information about the pointer states of the system within the components of the environment. This redundant information allows observers to independently find out about the state of the system indirectly, i.e., without perturbing it. We have thus observed the process of the pointer states becoming the effectively classical states of the system.

We believe our work is of both fundamental and technical interest (the novel control scheme, for instance, allows one to prepare artificial states, such as GHZ states between the system and the environment, which are important to metrology. We also show how this is done and implement it in NV centers).

Thank you in advance for your consideration. We are looking forward to hearing from you.

Sincerely yours,

Thomas Unden, on behalf of all coauthors

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