June 21, 2017

To the editors,

We are delighted to submit this Letter titled 'Synthetic clock states via continuous dynamical decoupling' to *Physical Review Letters*. We enclose the manuscript, including an extended Supplemental Materials addendum. We expect that the abstract (139 words), text (2796 words) and four figures will occupy about four pages, or 8 columns, in total. Our Letter is simultaneously submitted with the independent and complementary work by R. Anderson *et al*. (2017).

We experimentally realized a trio of synthetic 'clock' states by driving the $F = 1$ ground state manifold of ^{87}Rb with a strong RF magnetic field, in a process called continuous dynamical decoupling (CDD). The resulting quantum states are remarkably insensitive to environmental magnetic noise (a common and deleterious parasite in laboratory environments), our CDD technique suppressed its impact by as much as 4 orders of magnitude. Furthermore, this approach adds no loss or heating mechanisms and thus provides a decoherence-free subspace for a next generation of ultra-sensitive experiments.

An important property of the dynamically decoupled states is that ac magnetic fields, and far-from-resonance Raman couplings, both have transition matrix elements between all pairs of states. This is a critical element for moving forward on proposed implementations of topological matter via Raman laser coupling.

Additionally, we used a concatenated version of CDD to suppress residual noise arising from fluctuations of our driving field strength. We succeeded in increasing the robustness of the doubly-dressed states against fluctuations of our driving field this way, thus verifying the concatenating effect of CDD.

This work cross-cuts across different traditional domains of physics, and is applicable to two- and three-level quantum systems without any regard of the particular details. As such we expect that this work will be well received outside the fairly narrow confines of ultra-cold atom physics.

Sincerely,

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