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Towards optical quantum control of nuclear spins in a Helium-3 gas

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The nuclear spin of Helium-3 atoms in a room-temperature gas is a very well isolated quantum system featuring record-long coherence times of up to several days. It is used in a variety of applications ranging from magnetometry and gyroscopes to magnetic resonance imaging and precision tests of fundamental physics. While the exceptional isolation of Helium-3 nuclear spins ensures long coherence times, it renders measurement and control difficult. We report first experiments towards optical quantum control of Helium-3 nuclear spins. We make use of metastability-exchange collisions to mediate an effective interaction between the nuclear spins and light, which allows us to read out the coherent nuclear spin dynamics with an optical Faraday measurement [1]. Reaching quantum-noise limited detection and increasing the coupling strength will allow us to prepare non-classical nuclear spin states via QND measurements, as we have investigated in a detailed theoretical study [1,2].

References
[1] A. Serafin, M. Fadel, P. Treutlein, and A. Sinatra, Phys. Rev. Lett. 127, 013601 (2021).
[2] A. Serafin, Y. Castin, M. Fadel, P. Treutlein, and A. Sinatra, Comptes Rendus Physique 22, 1 (2021).

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