Nuclear Spin-Squeezing by Continuous Measurement

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The nuclear spin of helium-3 is very well isolated from the environment and has coherence times measured to be hundreds of hours. We propose a method to manipulate at the quantum level the collective nuclear spin of helium gas in a cell at room temperature by means of a continuous quantum non-demolition measurement. A discharge is temporarily switched on in the gas, which populates the metastable state of helium. The nuclear collective spin then slightly hybridizes with the collective spin of metastable atoms thanks to metastability exchange collisions. The metastable atoms interact with light in an optical cavity, and the field leaking out from the cavity is continuously measured. Nuclear spin-squeezing provides a metrological gain for nuclear-spin based sensors such as miniaturized magnetometers and gyrometers whose sensitivity will ultimately reach the limits imposed by quantum mechanics. It also opens up fascinating perspectives on the possibility of creating and maintaining a macroscopic quantum state over very long periods of time.

References

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