Nuclear spin-squeezing by continuous quantum non demolition measurement

Alice Sinatra

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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 a Helium vapor in a cell at room temperature, by means of a continuous quantum non demolition measurement. A discharge is temporarily switched-on in the vapor 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 are then made to interact with light in an optical cavity, and the field leaking out from the cavity is continuously measured. Nuclear spin-squeezing could provide a metrological gain for all measuring instruments based on the precession of a collective nuclear spin such as magnetometers or gyroscopes. It also opens up fascinating perspectives on the possibility of creating and maintaining a macroscopic quantum state over very long periods of time.

[1] A. Serafin, M. Fadel, P. Treutlein, A. Sinatra, *Nuclear spin squeezing in Helium-3 by continuous quantum non-demolition measurement* https://hal.archives-ouvertes.fr/hal-03058456 (2020).

[2] A. Serafin, Y. Castin, M. Fadel, P. Treutlein, A. Sinatra, *Étude théorique de la compression de spin nucléaire par mesure quantique non destructive en continu / Nuclear spin squeezing by continuous quantum non-demolition measurement: a theoretical study* https://hal.archives-ouvertes.fr/hal-03083577 (2020).