Spin entanglement of a thermal atomic pair in an optical tweezer

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One of the great challenges of atomic physics is to accurately prepare, manipulate and measure the quantum-mechanical state of a physical system. One particular property of multi-particles quantum states is entanglement. This property is of high interest for performing non-classical calculations for the use in quantum information or for sensitivity enhanced measurements. Spin entangled states of many body atomic ensembles have been engineered and validated [1,2]. Isolating a single atomic pair thanks to optical tweezers allows to deeply investigate spin-changing collision at the particle level and the entangled state. So far, the spin entanglement of an atomic pair have been successful for groundstate-cooled atoms. Being able to maintain it at a higher temperature would be a step forward to robust measurements into real-world field implementations.

Here, we study hot spin-exchange collision as a route to entanglement. In previous works, we observed the population dynamics of the magnetic sublevels of an atomic pair of ^{85}Rb prepared separately in two microtraps undergoing a collision in an optical tweezer. The spin-changing collision of two thermal atoms initially prepared in a $m = 0$ state leads to strong spin pair correlations between the magnetic states $m = 1$ and $m = -1$ [3]. To probe the entanglement of the pair, a Raman transition pulse couple the two magnetic sublevels, leading to a destructive interference when the pair is entangled. Our measurements and a simulation taking into account the full level structure of the atom while applying the Raman pulse, show that the spin exchange collision successfully create an entangled pair from two thermal atoms. We show that the resulting entanglement can enhance magnetic fields measurements beyond the standard quantum limit [4].

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