

Simultaneous readout of noncommuting collective spin observables beyond the standard quantum limit

Philipp Kunkel¹, Maximilian Prüfer¹, Stefan Lannig¹, Rodrigo Rosa-Medina¹,
Alexis Bonnin¹, Martin Gärttner¹, Helmut Strobel¹, Markus K. Oberthaler¹

¹Kirchhoff-Institut für Physik, Universität Heidelberg, Im Neuenheimer Feld 227, 69120 Heidelberg, Germany.

We augment the information extractable from a single absorption image of a spinor Bose-Einstein condensate by coupling to initially empty auxiliary hyperfine states. Performing unitary transformations in both, the original and auxiliary hyperfine manifold, enables the simultaneous measurement of multiple spin-1 observables. In this talk, I show how we apply this scheme to an elongated atomic cloud of ⁸⁷Rb to simultaneously read out three orthogonal spin directions and with that access the spatial spin structure (fig. 1). In the context of spin mixing our readout scheme enables the direct visualization of the corresponding many-body dynamics in the spin nematic phase space without state reconstruction. By detecting spin nematic squeezing we demonstrate that this readout even allows the extraction of quantum correlations without state tomography.

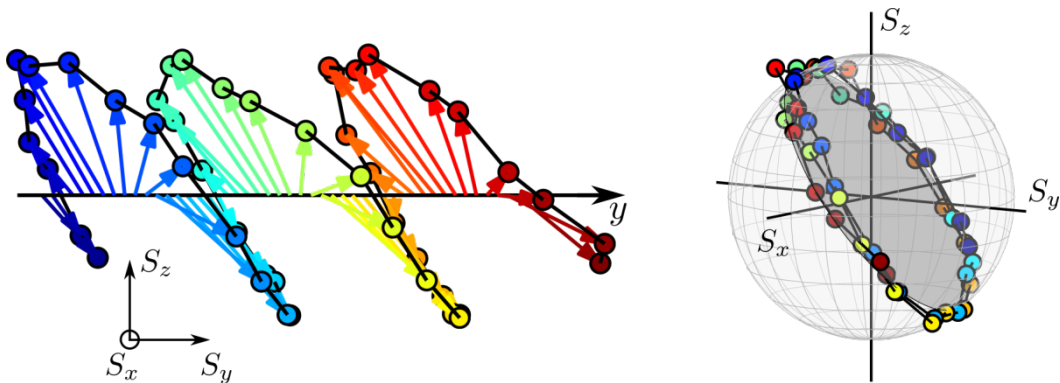


Figure 1. Reconstructed spin vector in space from a single experimental realization and its distribution on a spin sphere.