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Experimental Simultaneous Extraction of Non-Commuting Obervables for Accessing Quantum Correlations in a Spinor Bose-Einstein Condensate

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While entanglement between single pairs of discrete entities like photons, atoms, or ions is routinely implemented and investigated in experiments, the extension to continuous systems is still a challenge on the side of preparation as well as detection. We explore this continuous limit with our experiments employing a quasi-1-dimensional Bose-Einstein condensate of ^{87}Rb which features rich and well understood spin-1 dynamics due to the interatomic interactions. We combine the spatial resolution provided by an in-situ imaging system with a flexible readout scheme for simultaneously extracting multiple non-commuting observables to access different components of the continuous spin field describing our atomic cloud. Therefore, we apply this technique not only to access cross-correlations between different observables to identify the structure of excitations in non-equilibrium systems but we also directly certify entanglement between spatial subsystems. In this talk I will introduce the implementation of this readout scheme and provide an overview of thereby experimentally accessible observables and correlations revealing entanglement.

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