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Quantum information with top quarks at the LHC

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Due to its genuine relativistic behavior, exotic character of interactions and symmetries, and fundamental nature, high-energy colliders are attractive systems for the experimental study of fundamental aspects of quantum mechanics. We propose the detection of entanglement between the spins of top-antitop-quark pairs at the LHC, representing the first proposal of entanglement detection in a pair of quarks, and also the entanglement observation at the highest energy scale so far. We show that entanglement can be observed by direct measurement of the angular separation between the leptons arising from the decay of the top-antitop pair. The detection can be achieved with high statistical significance, using the current data recorded during Run 2 at the LHC. In addition, we develop a simple protocol for the quantum tomography of the top-antitop pair. This experimental reconstruction of the quantum state provides a new experimental tool to test theoretical predictions of New Physics beyond the Standard Model. Our work explicitly implements canonical experimental techniques in quantum information in a two-qubit high-energy system, paving the way to use high-energy colliders to also study quantum information theory.

In-person participation

Yes

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