Theoretical Quantum Physics

Group Seminar

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Entanglement between identical particles is a useful and consistent resource

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Abstract

The existence of fundamentally identical particles represents a foundational distinction between classical and quantum mechanics. Due to their exchange symmetry, identical particles can appear to be entangled - another uniquely quantum phenomenon with far-reaching practical implications. However, a long-standing debate has questioned whether identical particle entanglement is physical or merely a mathematical artefact. In this work, we provide such entanglement with a consistent theoretical description as a quantum resource in processes frequently encountered in optical and cold-atom systems. Moreover, we demonstrate that identical particle entanglement is even a useful resource, being precisely the property resulting in directly usable entanglement from such systems when distributed to separated parties, with particle conservation laws in play. The utility of our results is demonstrated by a quantitative analysis of a recent experiment on Bose-Einstein condensates. This work is hoped to bring clarity to the debate with a unifying conceptual and practical understanding of entanglement between identical particles.

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