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Toward the Observation of Entangled Pairs in BEC analogue Expanding Universes

by Iván Agulló, Adrià Delhom, and Álvaro Parra-López

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www.ucm.es/iparcos/

UNIVERSIDAD COMPLUTENSE MADRID

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Abstract

Pair creation is a fundamental prediction of quantum field theory in curved spacetimes. While classical aspects of this phenomenon have been observed, the experimental confirmation of its quantum origin remains elusive. In this article, we quantify the entanglement produced by pair creation in a two dimensional Bose-Einstein Condensate (BEC) analogues of expanding universes and examine the impact of various experimental factors, including decoherence from thermal noise and losses. Our analysis evaluates the feasibility of detecting entanglement in these systems and identifies optimal experimental configurations for achieving this goal. Focusing on the experimental setup detailed in cite{Viermann:2022wgw}, we demonstrate that entanglement can be observed in these BEC analogues at a significance level of ~2σ with current capabilities, and at $\geq$3.3σ with minor improvements. Achieving this would provide unequivocal evidence of the quantum nature of pair creation and validate one of the most iconic predictions of quantum field theory in curved spacetimes.

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