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Test of quantum nonlocality with branching ratios of K_SK_S in vector meson decays

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In the quantum-entangled neutral kaons system, the two kaons can be described as wave functions. When one kaon collapses into the K_S state, the other one collapses instantaneously into the K_L state, showing the relation between entanglement and nonlocality. In this work, in order to test the instantaneous effect, we introduce the locality hypothesis assuming that decay information travels at the speed of light. Since there's a time window during which one kaon has no idea the other has decayed, some K_SK_S decays may happen which are forbidden by quantum mechanics. We calculate the branching ratios of K_SK_S in vector meson decays under locality hypothesis and compare them with experimental results. Taking J/ψ as an example, the branching ratio of $J/\psi \to K_SK_S$ is $(5.5 \pm 0.9) \times 10^{-6}$ under locality assumption, which is excluded by the BESIII experimental upper limit in 2017: $Br(J/\psi \to K_SK_S) < 1.4 \times 10^{-8}$. More experimental results are expected to perform this test in the future.

Summary

To summarize, we have calculated the branching ratios of forbidden process $e^+e^- \to V \to K_SK_S$ under locality assumption and compared them with experimental upper limits. The result of J/ψ validates the nonlocality of quantum theory. And the upper limit of $\psi(2S)$ is expected to be more sensitive to perform this test in the near future.

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