Can Quantum Physics Remember Its Path?

New experiment challenges hidden-variable models with memory of optical history

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THE DATA

$2+2p_y$

Mixed-context Bell bound

This upper limit on quantum correlation violations in path-memory models was derived from a closed-wave-plate trajectory experiment.

The experimental result shows that when Bob’s analyzer setting is implemented via a calibrated closed loop C_γ, the measured correlation remains indistinguishable from the Bell inequality limit within precision. This constrains any hidden-variable theory that posits path memory as a physical mechanism, supporting the quantum principle of operational equivalence.

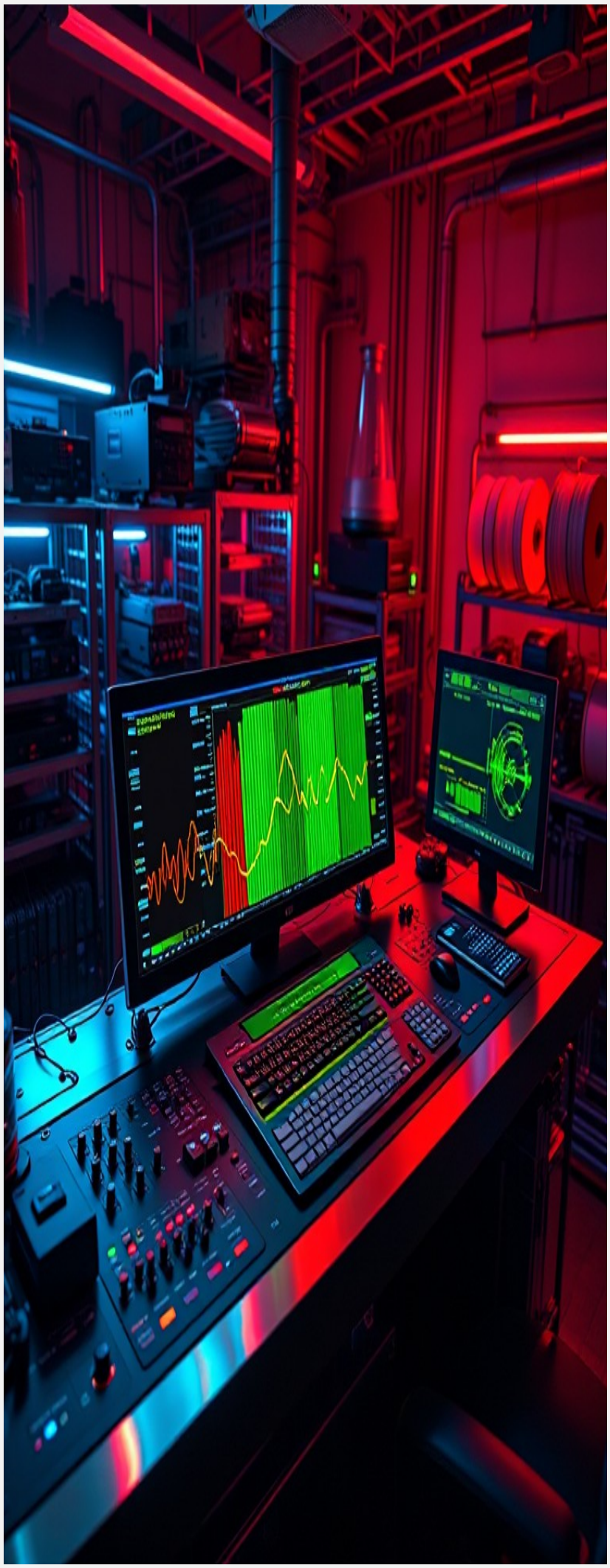


Source: arXiv · Published November 17, 2026
https://arxiv.org/abs/2611.23418

01

Quantum Equivalence Is Not Optional

The experiment confirms that quantum mechanics enforces operational equivalence: identical final measurement operators produce identical statistics regardless of the physical path taken to implement them. This is not a feature of convenience but a fundamental constraint on any viable hidden-variable model. Any theory that assigns physical significance to the trajectory—such as transporting a hidden frame—must account for this indistinguishability, which strongly limits its predictive power.



02

Memory Is Not a Quantum Resource

The failure to observe a measurable holonomy $ \delta_\gamma$ in the looped implementation implies that quantum systems do not retain a physical memory of their past paths. This undermines models that rely on gauge-like hidden variables with persistent memory. For AI and quantum computing, this reinforces that quantum state evolution is fundamentally non-classical—memory effects are not encoded in trajectories but in entanglement and superposition alone.

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