Measuring Impossible Parameters with Indefinite Causal Order

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Quantum theory promises sensors with dramatically improved precision relative to their classical counterparts, but noise quickly ruins these advantages. Indefinite causal order—quantum superposition of ordering of events — can increase communication capacity in the presence of noise. Here we experimentally demonstrate that using indefinite causal order to probe noisy channels and a to-be-measured channel can withstand arbitrarily more noise than any quantum system with definite causal order, even if the probe is fully mixed and one of the noisy channels erases all information.