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Using high-dimensional entanglement for closing the detection loophole in Bell experiments

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I present two approaches for closing the detection loophole in Bell experiments. Both exploit that high-dimensional entanglement allows for loophole-free experiments with low detection efficiency.

The "penalized N-product Bell inequalities" [1] is a method for, starting from any qudit-qudit correlation violating a Bell inequality with a certain critical detection efficiency, identifying correlations and Bell inequalities for which the critical detection efficiency decays exponentially with N, where N is the number of qudits encoded in each entangled particle.

The "graph-based Bell inequalities" [2] are a family of Bell inequalities for which the critical detection efficiency for maximally entangled states is a function of some invariants of a class of graphs. By exploring this class, we identify correlations with low detection efficiency and relatively low local dimension.

[1] N. Miklin, A. Chaturvedi, M. Bourennane, M. Pawłowski and A. Cabello,
Phys. Rev. Lett. 129, 230403 (2022).
[2] Z.-P. Xu, J. Steinberg, J. Singh, A. J. López-Tarrida, J. R. Portillo and A. Cabello,
Quantum 7, 922 (2023).

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