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Robust entanglement preparation against noise by controlling spatial indistinguishability

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Initialization of composite quantum systems into highly entangled states is usually a must to enable their use for quantum technologies. However, unavoidable noise in the preparation stage makes the system state mixed, hindering this goal. Here, we address this problem in the context of identical particle systems within the operational framework of spatially localized operations and classical communication (sLOCC). We define the entanglement of formation for an arbitrary state of two identical qubits. We then introduce an entropic measure of spatial indistinguishability as an information resource. Thanks to these tools we find that spatial indistinguishability, even partial, can be a property shielding non-local entanglement from preparation noise, independently of the exact shape of spatial wave functions. These results prove quantum indistinguishability is an inherent control for noise-free entanglement generation.

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