One-body entanglement as a resource

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Abstract. We show that one-body entanglement, which is a measure of the deviation of a fermionic state from a Slater Determinant (SD) and is determined by the mixedness of the single particle density matrix, can be considered as a quantum resource. The associated theory has SDs and their convex hull as free states, and fermion linear optics operations, which include one-body unitary transformations and measurements of the occupancy of single particle modes, as basic free operations. It is shown that this resource is consistent with a model of fermionic quantum computation which requires correlations beyond antisymmetrization.

Keywords: Quantum entanglement, Fermion systems, Resource theories.

Quantum entanglement and identical particles are two fundamental concepts in quantum mechanics. Entanglement, in particular, has been subject of intense research during the last decades because of its role as a resource in quantum information processing tasks [1] in which only local operations and classical communication (LOCC) are allowed [2]. While entanglement has been extensively studied for systems of distinguishable constituents, less attention has been paid to the case of indistinguishable fermions, partly because the notion of particle indistinguishability is in conflict with that of locality. While different approaches have been considered in studying entanglement in systems of indistinguishable particles, the notion of mode entanglement [3] has prevailed as that which is a useful resource because it enables a direct connection with the LOCC paradigm.

In this work we propose to identify entanglement in a fermion state with correlations beyond symmetrization, which can be quantified by the mixedness of the eigenvalues of the single-particle density matrix (SPDM) of the system, which we call *One-body entanglement* [4]. In particular, we show that this mixedness is non increasing under Fermion Linear Optics (FLO) operations [5], implying that the one-body entanglement can be regarded as a resource described by a quantum resource theory [6] in which the *free states* live in the convex hull of the set of SDs and the free operations belong to the FLO set.

Possible extensions of the set of free operations are discussed, along with the connection of this resource with a concrete model of quantum computation [7].

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