Entanglement and quantum statistics

Entanglement is the strongest form of genuine quantum correlations, and represents the impossibility to describe portions, i.e. marginals, of a composite system with full precision when the whole systems is known with the highest precision [1]. The vast majority of the work in entanglement theory has been developed in the setting of distinguishable particles. Nevertheless, physical systems are fundamentally made of identical particles that cannot be individually addressed [2]: an observer cannot distinguish which particle is manipulated. For these reasons, the peculiarities of identical particles must be properly considered for a good definition of fundamental, genuinely quantum correlations.

A consistent notion of entanglement for indistinguishable particles consistes in the identification from non-classical correlations between subsets (subalgebras) of observables [3, 4, 5, 6, 7]. This approach makes evident that there are no observables addressing an individual particle leaving unchanged all the others. The above observable subsets either commute or anticommute with each other, according to the quantum statistics. Each subset is therefore individually addressable without disturbing the other, and so defines a local subsystem. This approach recovers the standard definition of entanglement for distinguishable particles, while for systems of identical particles it accounts for correlations between occupations of orthogonal modes in the Fock space, e.g., fields localised in ordinary space or in momentum space.

The aim of the project is to extend the above theory of entanglement to generalised quantum statistics that are relevant in several physical scenarios. For instance, tests of deviations from the Bose and the Fermi statistics has been proposed by means of deformed commutation relations, i.e. which interpolates between bosonic fields and fermionic fields [8]. Another example is fractional statistics (anyonic particles), i.e. that acquire a complex phase under particle permutation, which emerge in many-body physics [9]. Nevertheless, the entanglement notion considered in literature is that of ordinary particles constituting the original models and not of genuinely anyonic degrees of freedom.

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