Entanglement and (in)distinguishability

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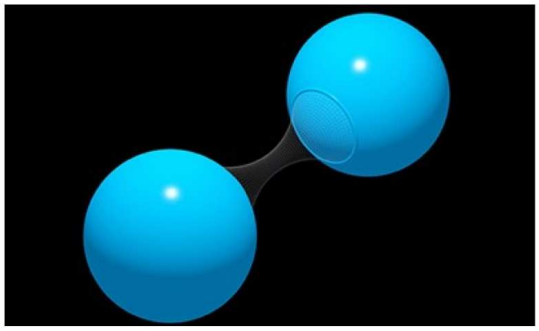

Abstract

For distinguishable particles, the theory of entanglement has reached an agreed upon standard formulation with useful insights into locality and quantum correlations in general, both from a fundamental and a practical point of view. Instead, in the case of identical particles, despite them being at the roots of quantum many-body systems, a number of subtle issues and controversial aspects has led to different constructions. By inspecting the existing definitions of separable states, that is of states without entanglement, I classify them into four different classes corresponding to four different approaches to identical particle entanglement: one that looks at modes rather than at particles, called mode-entanglement, and three hinging on particles. I check them against three physically natural criteria that should be satisfied. Namely, i) that entanglement should correspond to non-local correlations between individually addressable subsystems, as for distinguishable particles, and consequently entangled states cannot be generated only by means of local operators; ii) that, by freezing suitable degrees of freedom, identical particles can be turned into effectively distinguishable ones; therefore that, under such effective conditions, their entangled states should correspond to the standard ones; and finally iii) that in absence of other quantum resources, only entanglement can outperform classical information protocols.