Uncertainty Relations and Entanglement in Fermion Systems

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The entanglement-related features of systems of identical fermions are relevant to the study of diverse physical systems and also have implications for the development of quantum information technology. However, the concept of entanglement in fermion systems differs from the corresponding concept in systems consisting of distinguishable subsystems. In particular, the development of criteria for entanglement detection for mixed quantum states is much more difficult in the case of fermion systems and remains a largely unexplored problem. The aim of the present contribution is to investigate the violation of uncertainty relations as a signature of entanglement for both pure and mixed states of two identical fermions. In the case of fermions with a four dimensional single particle Hilbert space we obtain several different types of uncertainty-related entanglement criteria based on local uncertainty relations, on the sum of variances of projectors and on various entropic measures. Within the latter approach we consider either entropic uncertainty relations involving a single observable or relations based upon the sum of entropies associated with more than one observable. We extend the projector based entanglement criterion to the case of two-fermion and three-fermion systems with a six dimensional single particle Hilbert space.