Device independent witnesses for genuine multipartite entanglement

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As experiments bring to light entangled states involving more and more particles, like up to six photons or fourteen ions [1,2], the need to certify that these states constitute a useful resource for practical purposes increases. In particular, one would like to show that entanglement shared between less particles cannot be used as a replacement for these states.

In a multipartite scenario involving n parties, a state is said to be genuinely n-partite entangled if it is not biseparable, i.e. if it cannot be produced by mixing states that are separable with respect to some partition. Several works have suggested ways of detecting such entanglement in experiments [3]. Typically these involve measurement of a witness of genuinely multipartite entanglement, or analysis of the state reconstructed from a full tomography.

Such approaches, however, require a detailed description of the observed systems and of the measurements performed in order to conclude the presence of multipartite entanglement. Indeed, one can easily violate an entanglement witness with a separable state if different measurement settings than the ones prescribed by the witness are used.

Here we consider the set of biseparable quantum correlations, which consists of all measurement statistics that can be observed by measuring an arbitrary biseparable quantum state [4]. In other words the production of non-biseparable quantum correlations constitutes a task which can only be achieved with the aid of genuinely multipartite entangled states. Since these correlations are defined independently of a specific Hilbert space dimension and of the precise nature of the measurements performed, we call inequalities satisfied by biseparable quantum correlations Device Independent Entanglement Witnesses (DIEWs).

DIEWs for two parties amount to Bell inequalites, i.e. witnesses of nonlocality. However for more parties, Bell inequalities are not necessarily witnesses of multipartite entanglement. Still we present a family of DIEWs that can be used in scenarios involving any number of parties. In addition to providing tests to detect multipartite entanglement which do not rely on the above assumptions, these inequalities shed some light on the relation between multipartite entanglement and multipartite nonlocality.

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