Entanglement in the Measurement Problem

In the field of Quantum Information, an important application is the computation of entanglement measures. Understanding the entanglement prediction under Schrödinger's equation is quintessential to achieve a full understanding of the measurement problem.

In the UMDT, a Bell experiment has been applied as Step 3 in the construction to discriminate Schrödinger's unitary evolution from the quantum states required under measurement. The CHSH sum was quantified by the entanglement between System $1'$ and System $2'$ in terms of the concurrence. After Step 1 it can be seen from Equation (3.32) that $\mathbb{C}(\rho_{\text{fin},1}) = 2\sqrt{a(1-a)}$. And since it is known that local unitarily evolution does not change entanglement for any entanglement monotone [104] and the concurrence is an entanglement monotone, it follows $\mathbb{C}(\rho_{\text{fin},2}) = 2\sqrt{a(1-a)}$. In the case whereby the devices are bonafide measurement devices, then System $1'$ and System $2'$ are represented in a product state or a measurement state, in which case $\mathbb{C}(\rho_{\text{fin},2}) = 0$.

One might consider what relationship the CHSH inequality has to the issue of nonlocality in the measurement setup that has been proposed. The reader should note that the CHSH inequality so far has been used herein as a tool to demonstrate that the case of measurement is distinguishable from the case of unitary evolution. That is, the argument presented requires only that there be a difference in the CHSH sum between the cases of measurement and unitary evolution, and the issue of whether or not there exists a local hidden variable model for a particular photon superposition state has not been utilized. Nevertheless, one can consider the issue of nonlocality as it relates to the operations that have been proposed. Note that for the case of measurement, whereby the devices result in a tensor product state, the CHSH inequality obtains the value $\sqrt{2}$, which is the upper bound for the strengthed CHSH inequality $S \leq \sqrt{2}$ for separable states. If one considers the tensor product measurement result as resulting from a hidden local variable such that a photon is emitted from the B Port of the beam splitter with probability a and the C port with probability 1-a, then this can be seen to represent a local hidden variable model for the case of measurement. On the other hand, for the unitarily predicted cases whereby the degree of superposition a is such that the CHSH inequality is less than 2, one cannot conclude from the current demonstration whether or not there is a local hidden variable that can describe the results of follow-up measurements. There is, however, a different set of measurements proposed in a generalized Bell inequality in [105] that could be used to demonstrate nonlocality after Step 2 when the state is not maximally entangled. This or other considerations might also be useful in developing procedures that provide maximal distinguishability between measurement and unitary evolution, particularly if the degree of superposition of the photon is less than maximally entangled.