Humpty Dumpty

For example, consider the Humpty Dumpty proposal in [175] [176] [177]. In this proposal the authors' state [177]

> *More generally put, we support the view that the loss of coherence in measurements on quantum systems can always be traced to correlations between the (relevant) degrees of freedom of the measuring apparatus and the system being observed. The correlations are built up in the course of the measurement, and their tempora1 evolution is correctly described by quantum mechanics. In particular, one need not resort to invoking the notions of "state reduction" or the "collapse of the wave function" as dei ex machina, whose dynamical properties are allegedly outside the framework of quantum mechanics.*

The authors analyze spin coherence in which a particle in an eigenstate of spin x is separated into two paths via a Stern-Gerlach apparatus oriented in the z direction and then recombined. Afterwards, a measurement is made in the x direction. They add a which-way detector using micro-masers in the upper path of the device which is disturbed if the spin takes the upper path. The authors show that the statistics of the output of the Stern-Gerlach apparatus can be found if they trace out the effects of the micro-masers. In the case that the masers are initialized with a coherent state, they predict that there is no effect on the coherence in the final measurement. When the maser is initialized to a number state, there is a complete loss of coherence.

The results of the Humpty Dumpty analysis are certainly correct. In the case that the initial state of the maser is a coherent state, there is no effect on coherence, so consider the case that initial state of the micro-maser is a number state. The analysis in [177] in terms of the effect of the final spin measurement can be seen to be the same whether or not a projective measurement is made on the micro-maser by projecting into a number state. Hence the experiment proposed in [177] is not capable of distinguishing entanglement from measurement.

One can ask what predictions would be found if a similar setup as proposed in [177] were used in the Chapter 3 UMDT. In the Chapter 3 UMDT one must compare Schrödinger predicted entanglement versus the product state demanded under measurement. One is not allowed to trace-out the which-way micro-maser in the computation of entanglement if one were to use the same setup as [177] in each of the two detectors. If the micro-maser interaction with a particle constitutes a bona fide measurement device in terms of projecting the particle, then the Chapter 3 UMDT would show entanglement to break down. On the other hand, if the micro-maser interaction is unitary, the entanglement would survive and be seen in an actual experiment. This would be an interesting experiment to conduct, but we believe that at microwave and optical frequencies, experiments have already established that there exist interactions that are unitary and hence entanglement would be predicted to be seen in such an experiment. Therefore, the micro-masers considered in [177] are not guaranteed to be bona fide measurement devices, and the analysis found in [177] simply confirms that there exist atom-field interactions in cavity QED that are unitary.

One might be tempted to conclude that because there exist micro-maser unitary interactions, that all particle evolution must be unitary. Such conclusions are certainly reasonable in an inductive framework, but when a deductive framework is called for, such an approach can be expected to lead one to ruin, as will be more thoroughly discussed in Chapter 6.