Determining the Quantum Expectation Value by Measuring a Single Photon

(and other recent applications of weak measurements)

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Quantum mechanics exhibits several peculiar properties, differentiating it from classical mechanics. One of the most intriguing is that variables might not have definite values. A complete quantum description provides only probabilities for obtaining various eigenvalues of a quantum variable. The eigenvalues and corresponding probabilities specify the expectation value of a physical observable, but they are known to be statistical properties of large ensembles. In contrast to this paradigm, we demonstrate a unique method allowing to measure the expectation value of a physical variable on a single particle, namely, the polarization of a single protected photon. This is the first realization of quantum protective measurements [1,2], which are based on a combination of weak measurements and the quantum Zeno effect. Before discussing these issues, I will review the notion of weak measurements [3-5] and discuss their realization by presenting our previous experiment [6], where we measured two non-commuting observables, on one and the same photon, using sequential weak measurements. I will conclude by discussing a few applications of these methods, both in metrology and in the study of foundational questions.

References

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