Analyzing quantum foundations and applications with single photon experiments

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Quantum optics experiments employing a single photon source, as well as a single photon detector, allow us to probe the foundations of quantum theory. In the last few years I have designed a line of experiments based on weak measurements [1] for this purpose. Two of them have already been performed:

1. Measuring incompatible observables by exploiting sequential weak values [2] – We measured for the first time the polarization of single photons in two incompatible bases. By performing a sequence of two weak measurements over a large ensemble of single photons, we were thus able to infer the information regarding two non-commutative operators, practically measured on the same state.
2. Determining the quantum expectation value by measuring a single photon [3] – Here we did not use an ensemble of photons, but rather employed the quantum Zeno effect for inferring the polarization expectation value using a genuine single photon. This was the first demonstration of protective measurement [4], similar in spirit to our proposal in [5]. The protection mechanism allows to defy the statistical character of the expectation value, which up to now was always evaluated using a large ensemble of similarly prepared particles.

I will discuss some consequences of these experiments, both theoretical (e.g. the meaning of the wavefunction) and practical (e.g. state and process tomography).

If time allows me, I will outline some of our upcoming experiments, such as those concerned with the study of entanglement and nonlocality [6,7].

References

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