Multi-order interference and Born's rule

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R. D. Sorkin [1] investigated the possibility that quantum mechanics might be formulated as a generalized measure theory. Born's rule stipulates that quantum mechanical probabilities are absolute squares of complex amplitudes. This results in the well-known phenomenon of interference and constitutes a violation of a sum rule for the additivity of probabilities of mutually exclusive events. One can imagine a yet more general theory by assuming that it violates the next higher sum rule about the additivity of probabilities of three mutually exclusive possibilities. Standard quantum mechanics does obey this second sum rule. It has been shown that a violation of the second sum rule might allow computation that is more powerful than quantum computation.

Previously, we experimentally tested the validity of the second sum rule by measuring the interference patterns produced by three slits and all the possible combinations of these slits being open or closed. We use either attenuated laser light or a heralded single photon source combined with single photon counting to confirm the particle character of the measured light. Within our experimental accuracy and Born's rule is vindicated and the second sum rule appears to be obeyed [2,3].

In order to improve the experimental accuracy we have built a three-path interferometer using a diffractive beam-splitter. This arrangement allows us to use regular shutters in the three beam paths, while being phase-stable enough to measure for long periods of time with much higher throughput than in the triple slit experiment. We will present the latest limit on multi-order interference as well as detector nonlinearity calibration measurements and an estimation of the ultimate limit one may achieve with this method using a range of sources and detectors.

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