Gregor Weihs, Thomas Kauten, Benjamin Gschösser, Thomas Kaufmann, Patrick Mai, and Zoltán Vörös

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Gregor Weihs, Thomas Kauten, Benjamin Gschösser, Thomas Kaufmann, Patrick Mai, and Zoltán Vörös
University of Innsbruck, AT

Precision Tests of Quantum Interference

Interference is where quantum mechanics deviates from classical statistical physics. The superposition of wavefunctions combined with Born's rule results in interference terms that are due to all the possible pairings of all the states in the superposition. In order to embed quantum mechanics into a framework of generalized probabilistic theories Sorkin [1] defined higher-order interference terms, deviating from the pairing of states. This can be best understood in the situation of a triple-slit experiment, where one can easily show that for standard quantum mechanics the three-path interference term vanishes identically. The triple slit experiment can also be used to test for the generalization of quantum mechanics in terms of the underlying numbers, i.e. whether hypercomplex quantum mechanics is allowed or not [2]. In a series of ever more precise tests using multipath interferometers [3] we have been able to bound the deviation from ordinary quantum interference to a level of less than 10?4. The systematic uncertainty in this measurement is due to detector nonlinearity, which we can eliminate using true single photon sources. Tests for hypercomplex numbers, on the other hand, are plagued by the finite interference visibility achievable in free-space interferometers. With integrated waveguide interferometers we are trying to approach unit visibility.

[1] R. D. Sorkin, Quantum Mechanics as Quantum Measure Theory, Modern Physics Letters A 9, 3119—3127 (1994).
[2] A. Peres, Proposed Test for Complex versus Quaternion Quantum Theory, Phys. Rev. Lett. 42, 683—686 (1979).
[3] I. Söllner, B. Gschösser, P. Mai, B. Pressl, Z. Vörös & G. Weihs, Testing Born's Rule in Quantum Mechanics for Three Mutually Exclusive Events, Found. Phys. 42, 742—751 (2012).

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