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Foundations of Quantum Mechanics studied in Matter-Wave Optics.
Quantum Cheshire-Cat and Uncertainty Relations

The validity of quantum-mechanical predictions has been confirmed with a high degree of accuracy in a wide range of experiments. Although the statistics of the outcomes of a measuring apparatus have been studied intensively, little has been explored and is known regarding the accessibility of quantum dynamics and the evolutions of a quantum system during measurements. For this sort of fundamental studies of quantum mechanics, interferometric and polarimetric approaches, in particular by the use of neutron's matter-waves, provide almost ideal experimental circumstances. The former device explicitly exhibits quantum interference between spatially separated beams in a macroscopic scale. In contrast, interference effects between two spin eigenstates are exposed in the latter apparatus. Exploiting both strategies, alternative theories of quantum mechanics, Kochen-Specker theorem and so on are studied. Recently, as a study of quantum dynamics, neutron interferometer experiments are carried out: a new counter-intuitive phenomenon, called quantum Cheshire-cat, is observed and full determination of weak-values of neutron's ½-spin is accomplished. In addition, extending the first experimental test of the new error-disturbance uncertainty relation by using a modified neutron polarimeter setup, we performed the experiment investigating the validity of the relation also for mixed ensemble as well as a new noise-disturbance uncertainty relation in an entropic form. In my talk, I am going to give an overview of matter-wave optical approach to investigations of fundamental aspect of quantum mechanics.

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