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EINLADUNG zum Habilitandenseminar der Fakultät für Physik

Sprecherin: Dr. Stephan SPONAR
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Vortragstitel: Foundations of Quantum Mechanics studied in Neutron Optics

Kurzfassung

Neutron interferometry [1], where an interference e_ects of matter waves passing through a perfect silicon-crystal interferometer is observed, and neutron polarimetry (also referred to as spin-interferometry) have established a powerful tool for investigation of fundamental quantum mechanical concepts with massive particles. The former technique enabled several text-book experiments, such as demonstrations of 4_ spinor symmetry of spin-1/2 particles, spin superposition, gravitationally induced phase and topological phase e_ect, as well as studies of intra-partite entanglement. The latter is used for topological phase measurements, spin-rotation coupling or tests of alternative theories of quantum mechanics.
In this talk I will give an overview of our recent work on weak measurements [2], a new type of quantum variable introduced by Yakir Aharonov in 1988. Our neutron optical approach is realized by utilizing neutron interferometry, where the neutrons spin is coupled weakly to its spatial degree of freedom [3]. This scheme is applied to study a new counter-intuitive phenomenon, the so-called quantum Cheshire Cat. The peculiarity of this phenomenon lies in the fact that if a quantum system is subject to a certain pre- and post- selection, it can behave as if a particle and its property are spatially separated, which is demonstrated in an experimental test [4]. Weak values are also useful to characterize quantum systems. Quantum state tomography, the usual approach to reconstruct the quantum state prior to a measurement, involves a lot of computational post-processing. So in 2011 a novel more direct method was established using weak measurements. Our procedure is based on that, but at the same time uses strong measurements, which makes it possible to determine the quantum state with higher precision and accuracy [5].
Heisenberg's uncertainty principle [6] is without any doubt one of the corner stones of modern quantum physics. However, unlike proposed by Heisenberg, the present perception, as a product of widths of probability distributions, i.e., standard deviations, sets limits on the preparation of a quantum system. In other words, it de_nes how sharp the values of two non-commuting observables can be determined if they are measured separately. In 2003, Masanao Ozawa thus proposed a measurement error-disturbance uncertainty relation, where information of the error when measuring one observable and the thereby induced disturbance on another jointly measured observable are well de_ned. This approach, based on rigorous and general theoretical treatments of quantum measurements, is usually refereed to as operator-based. I will give an overview of our neutron polarimetric approache for investigation of measurement error-disturbance uncertainty relation via successive measurements of incompatible neutron spin observables [7, 8]. In parallel, so called operational de_nitions of error and disturbance were developed by Paul Busch and his co-workers. In this theoretical framework error and disturbance are evaluated from the di_erence between output probability distributions. Despite the ongoing controversy of these two competing approaches, in the case of projectively measured qubit observables, such as neutron spin components, both approaches lead to the same outcomes [9]. In our most recent experiments information-theoretic, or entropic, uncertainty relations are

studied. Here, error and disturbance are de_ned via correlations between the input states and measurement outcomes. For certain non-commuting spin observables, the relation is saturated only for general quantum measurements, i.e., positive-operator valued measures (POVMs) [10].

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Zeit: Donnerstag, 26. März 2020, 16 Uhr
(im Anschluss an die Fakultätsratssitzung)

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