Optical studies of entanglements in a single-neutron system

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Abstract

Since the early stage of the development, quantum theory is bizarre: in trying to understand it, we had to forgive everything we know about causality, reality, certainty and so on. This is a completely different world, ruled by its own probability law. Neutron interferometry is one of the most suitable strategies to study quantum mechanics, where quantum interference effect of matter waves can be observed in a macroscopic scale. Starting with 4 -periodicity of spinor wave function, quantum phenomena such as gravitational effect on the wave function, superposition of spinor wave function, topological effect in quantum evolutions, were confirmed experimentally. In parallel, by utilizing an interference effect between two orthogonal spin states of neutrons, it turned out that the polarimetric strategy can be used for similar studies. Recently we accomplished neutron optical experiments concerning noncontextual hidden-variable theories, which are a kind of the hidden variable models of quantum mechanics, like local hidden variable theories, trying to give realistic view of quantum phenomena. Entangled states between degrees of freedom in single neutrons are exploited and following experiments are carried out.

- Violations of Bell-like inequalities for spin-path entanglement in neutron interferometer [1] and for spin-energy entanglement in neutron polarimeter [2].
- Two experiments concerning Kochen-Specker theorem[3, 4]
- Quantum state tomography of spin-path entangled Bell-like states [5]
- Triply entangled GHZ-state [6]

I am going to give an overview of these optical experiments with neutrons and discuss their future perspectives.

Keywords: interferometer, polarimeter, entanglement, Bell's inequality, Kochen Spcker theorem, state tomography, GHZ state

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