Axion-like particles and fifth force with neutron interferometry

<u>Aniello Quaranta</u>
Università Degli Studi Di Salerno, Salerno, Italy

Phenomena, ranging from neutrino mixing to the dark matter and energy, to the muon g-2 anomaly, together with the strong CP problem (i.e. the absence of CP symmetry violation in strong interaction, for which an elegant solution was put forward by Peccei and Quinn through the introduction of pseudo–scalar particles known as axions) show the necessity of physics beyond the standard model of particles. Axions and axion–like particles (ALPs) with masses from the ultralight to the heavy axions, could represent a possible dark matter component. Not only are they capable of solving the strong CP problem in a natural way, but they also have small coupling constants to ordinary matter, and arise in the spectrum of string theories, thus representing a natural candidate for the missing matter in the universe. Many experiments have searched for ALPs, however, up to now no evidence for ALPs has been found. ALPs interact with the electromagnetic field, and moreover, they are expected to play the role of a mediating boson in a new fermion–fermion interaction ("fifth force"). Therefore, different experiments were designed to probe such interactions, which may be induced by ALPs and generic (pseudo)-scalar fields beyond the standard model. Another extremely thriving field of physics is the neutron interferometry. It has allowed to verify many theoretical effects, such as the Sagnac effect, the geometric phase and the wave–particle duality in quantum mechanics.

Here, we report on a new approach to detect ALPs (and more generally bosons capable of mediating a new force among standard model particles), which suggests the use of a neutron interferometer in which two sub–beams are subject to external magnetic fields of equal strength but different direction, as a device to reveal fermion-fermion interaction mediated by axions. Indeed, we show that a detectable neutron phase difference, depending only by the axion–induced interaction between neutrons, can be achieved by setting the magnetic fields in the arms of the interferometer, one in the direction of propagation of the relative sub-beam and the other one orthogonally to the propagation. We fix the experimental parameters in order that the phase difference depends only on the axion–mediated interaction and the contributions given by the other interactions are removed. Then we show how a neutron interferometer is sensible to the presence of ALPs in a significant portion of parameter space.