Neutron interferometry for studies of experimental quantum mechanics

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Neutron interferometers provide ideal situations of experimental observations of interference between coherently split, well-separated beams of matter waves, in this case neutron de Broglie waves. Interferometers made of perfect silicon crystal was invented for x-rays in 1964 and first performance with neutrons was confirmed by Rauch, Treimer and Bonse at the Atominstitut, Vienna in 1974. The Atominstitut was distinguished as an European-Physical-Society (EPS) Historic Site on 22 May 2019. Over the past almost half century, neutron interferometer experiments are bringing impact on fundamental quantum and neutron physics [1-3].

Since the time-independent Schrödinger equation, i.e., formally equivalent to the Helmholtz wave equation, accounts for the observations, some similarities of classical optics are easy to understand and anticipated. However, thermal neutrons are involved there, which have kinetic energy ~20meV, a wave length about 2Å, and move with a velocity ~2000m/s. In addition, neutrons provide experimental access to all of the four fundamental forces and a wide range of hypothetical interactions, which makes neutrons special.

I give a short review of accomplishments of neutron interferometer experiments studying fundamental phenomenon in quantum mechanics. Special emphasis is put on the historical success of the inventor of neutron interferometer, Helmut Rauch.

[1] H. Rauch and S. A. Werner, *Neutron Interferometry (2nd ed.)*, Oxford Univ. Press, Oxford (2015).
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[3] S. Sponar, R.I.P. Sedmik, M. Pitschmann, H. Abele and Y. Hasegawa, Nature Review Physics, **3**, 309–327 (2021).