Search for neutron to mirror-neutron oscillations

One of four fundamental interactions in universe, the so called weak interaction, responsible among others for a specific class of nuclear decays, the beta decays, is characterized by unusual property. Contrary to the remaining interactions it violates in a maximal way parity, the symmetry with respect to mirror reflection. This leads to the selective choice of handeness: usual matter particles are left-handed, while antimatter - right-handed. The phenomenon is so shocking the already its discoverers, T. Lee and C. Yang (1956), supposed that, in fact, parity is conserved and only a coincidence of some other circumstances makes this fact difficult to realize. They assumed that universe can be split into two parts: the usual one, accessible to our regular observations and the mirror world. The mirror matter is invisible in normal situations because it communicates with the usual one with gravitational force which is very weak on the atomic scale. Nevertheless, both worlds, usual and mirror one share the same spacetime. Continuers of this elegant idea assumed additionally that beside gravity there may exist another unknown and very weak interaction that couples mirror and usual worlds together.

Empirical verification of this fascinating hypothesis that is searches for signatures of mirror matter remain, however, ineffective until now. Nevertheless, the experiments are ongoing since it has been proven that the existence of mirror matter would solve some other deficits in our knowledge about universe equally worrying as parity violation one of them being the problem of so called dark matter. Its existence has solid justification in cosmology while experiments performed in earth labs did not find it until now. Mirror matter provides a promising candidate for dark matter.

It is assumed that mirror matter is very similar to the usual one: each usual particle has its mirror equivalent with identical characteristics like mass, spin etc. If, for instance, an elementary particle possesses a magnetic moment (behaves like elementary compass) its mirror equivalent possesses magnetic moment, too. Large aggregations of magnetic mirror matters produce surrounding mirror magnetic field like earth is surrounded by usual magnetic field. Earth is a massive body that attracts gravitationally. It is expected that in course of its evolution earth could accumulate within its volume plenty of mirror matter, perhaps a mirror celestial body surrounded by mirror magnetic field.

In experimental searches for mirror particles one utilizes so called quantum oscillations known very well from e.g. neutrino physics. Under special conditions (necessary are close values of normal and mirror magnetic fields) an elementary particle periodically changes its identity passing form usual to normal world back and forth. The described here experiment observes very slow neutrons, the so called ultra-cold neutrons (UCN) bouncing from walls in a vacuum vessel with very low and accurately controlled losses in subsequent collisions. Neutrons are moving so that there is no guarantee that after returning from mirror state a neutron appears back in the controlled volume. In consequence, the neutron-to-mirror neutron oscillations (n-n') will lead to additional losses in the neutron storage that would be absent otherwise. We do not know the value of the hypothetical mirror magnetic field in the space occupied by the storage vessel. This is why we plan to scan entire range where other experiments and analyses reported worrying anomalies. The goal of the project is either to unambiguously confirm the existence of a signal from n-n' oscillations or exclude it in the investigated range of mirror magnetic field.

The experiment will be carried out at the Paul Scherrer Institute, Villigen, Switzerland, operating the worldwide strongest UCN source. Physicists from the Jagiellonian University, Cracow, Poland, coauthor this project. They contributed also to the spectacular achievement obtained recently there: establishing the tightest bounds on the electric dipole moment of neutron, the fundamental quantity for particle physics.