The Ultracold Neutron Physics Program at the ILL

Ypač šaltų neutronų fizikos programa ILL

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The Institut Laue Langevin (ILL) is an international research centre at the leading edge of neutron science and technology. As the world's flagship centre for neutron science, the ILL provides scientists with a very high flux of neutrons feeding some 40 state-of-the-art instruments, which are constantly being developed and upgraded.

The instruments of the nuclear and particle physics group (NPP) and their fields of research are briefly presented.

ILL's two ultracold neutron installations are described in more detail. The ongoing research program using ultracold neutrons as measuring the lifetime of the free neutron, the search for an electric dipole moment and gravity resonance spectroscopy are highlighted.

The best experiments in the world cannot agree on how long free neutrons live before decaying into other particles [1]. Precision measurements of the neutron lifetime provide stringent tests of the standard electroweak model as well as crucial inputs for tests of Big-Bang nucleosynthesis. Neutron lifetime can be related to CKM Matrix unitarity. Neutron lifetime also dominates the uncertainty in theoretical calculation of primordial ^{4}He.

Two main types of experiments are underway: bottle-like traps count the number of neutrons that survive after various intervals of storage time, while beam experiments look for one of the particles into which neutrons decay.

Resolving this question is vital to answering a number of fundamental questions about the universe.

For particles to have electric dipole moments, the forces concerned in their structure must be asymmetric with regard to space-parity (P) and time reversal (T). P violation is a well-known intrinsic feature of the weak interaction which is responsible for the beta-decay of the free neutron. T violation turns out to be necessary to explain the survival of matter at the expense of antimatter after the Big Bang. By searching for an EDM of the free neutron hypothetical new channels of T-violation can be investigated.

The experiment is based on a precision measurement of the Larmor precession frequency of polarised ultracold neutrons stored in a cell in a magnetic field. An EDM would reveal itself by a response of the Larmor precession frequency of the neutron to an electric field applied over the storage volume. An upper limit on the absolute value of the neutron EDM of $|d_n| < 3.0\text{x}10^{-26}$ e·cm (90% CL) has been found [2].

Neutrons appear to be ideal test particles to search for non-Newtonian gravity at micrometer separations, as with their vanishing electrostatic sensitivity they avoid many of the problems appearing with other test masses. Over the past decade, the *q*BOUNCE collaboration has developed a technique named Gravity Resonance Spectroscopy (GRS) that allows to probe the bound states of ultracold neutrons in the Earth's gravitational field [3].

Keywords: ultracold neutrons, neutron lifetime, neutron electric dipole moment, gravitationally bound quantum sates.

Literature

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