PRELIMINARY RESULTS OF NEUTRON LIFETIME MEASUREMENTS WITH GRAVITATION UCN TRAP

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The first preliminary results of neutron lifetime measurements with a gravitational UCN trap are presented.

A scheme of our method is shown in fig. 1. The setup consists of a criogenic trap with a gravitational valve for UCN storage, used at the same time as the gravity spectrometer. UCN confinement in the storage regime is achieved by a sphere rotating around a horizontal axis from a position with the hole facing downwards to a position with the hole facing upwards. In this case low energy neutrons become enclosed in the trap due to the gravitation field.

The possibility of spectral measurements (due to the step-by-step rotation of the sphere from the top position) allows the channel of UCN leakage, due to neutron interaction with the trap walls, to be controlled. A low loss rate, due to the neutron interaction with the wall, is achieved by keeping the trap at a temperature of 10 — 15 K and by choosing a poorly absorbing material for the trap walls. Oxygen frozen on the surface of the trap was used as a covering material.

The UCN storage time in a trap (τ_{st}) is determined by the free neutron lifetime (τ_n) and the lifetime of the losses due to the interaction with the trap walls (τ_{los})

$$\tau_{st}^{-1} = \tau_n^{-1} + \tau_{los}^{-1} . \qquad (1)$$

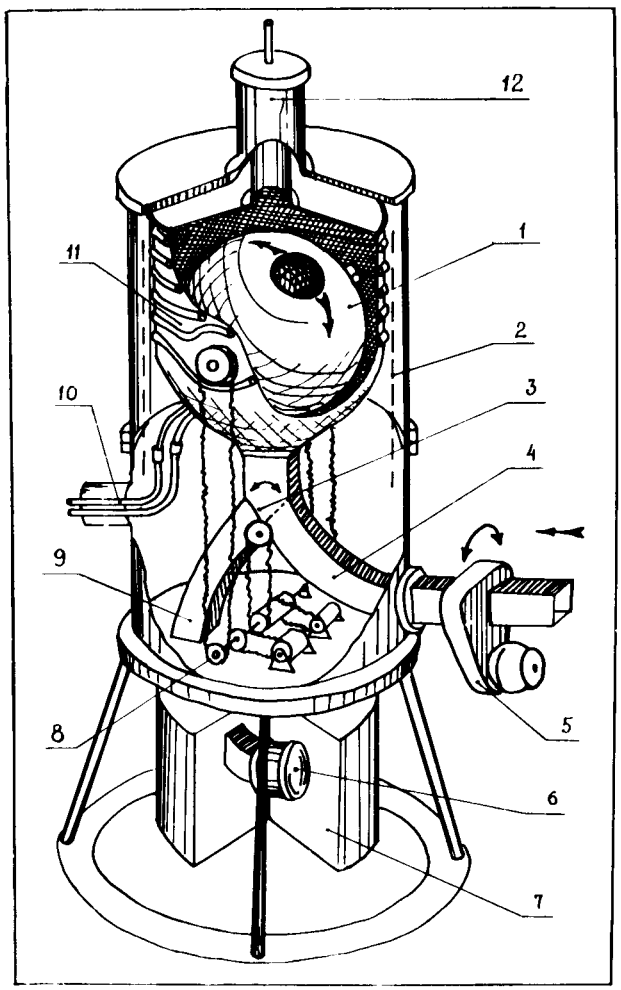

Fig. 1. Setup for measurement of neutron lifetime with gravitational trap: *1* — UCN storage trap; *2* — nitrogen screen; *3* — distribution valve; *4*, *9* — neutron guide; *5* — — injection valve; *6* — UCN detector; *7* — detector shield; *8* — system for rotation; *10* — cryopipes; *11* — cryostat; *12* — system for frozen cover

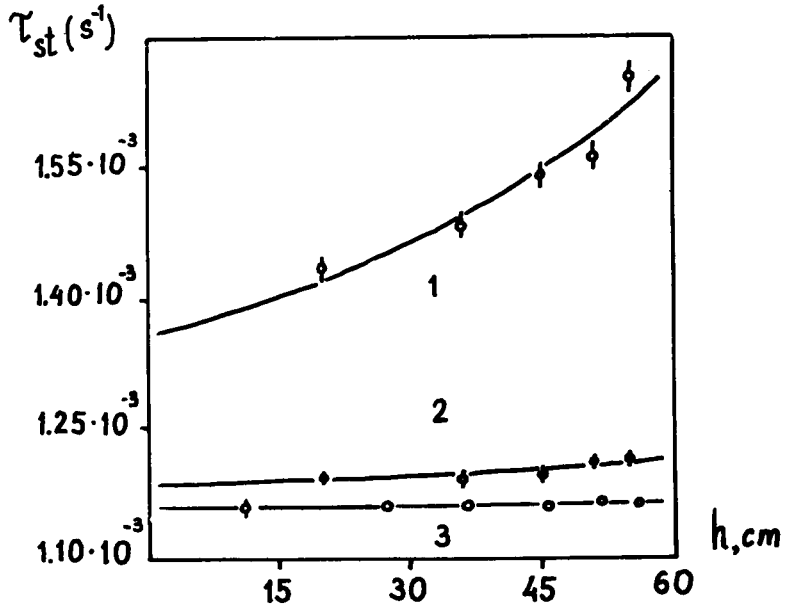

Fig. 2. Energy dependence of UCN storage time;
1 — berylium trap at room temperature; *2* — berylium trap at low temperature; *3* — oxygen trap

The energy dependence of UCN storage time for a spherical trap has the following form:

$$\tau_{st}^{-1} = \tau_n^{-1} + \frac{1}{4}\frac{3\cdot5\cdot7}{2\cdot4}\frac{\eta g}{V_c}\cdot\frac{[(4x-3)\,arcsin\,x^{1/2} - (2x-3)\,x^{1/2}\sqrt{1-x}]}{x^{5/2}(3.5-2\,x/x_{max})}, \qquad (2)$$

where $x = h/H_c$, $x_{max} = H/H_c$, h is the distance from the lower point of the sphere to the edge of the hole or the energy of the neutrons in units of height, H is the sphere diameter, H_c is the critical energy of the sphere material in units of height, V_c is the critical velocity, g is the gravity acceleration, η is the ratio of the imaginary and real parts of the scattering amplitude. In the limit of small energies $\tau_{los}^{-1} = \eta g/V_c$.

The storage time dependence on neutron energy was measured for the berylium trap (heating) at room temperature, for the same berylium trap (heating) at 10 — 15 K and for the trap with on--frozen oxygen. The results are shown in fig. 2. The solid curves correspond to the least square fits of the function (2) with free parameters τ_n and η.

Fits with two free parameters give the following results for the cold berylium trap: $\tau_n = (872 \pm \pm 13)$ s; $\eta = (2.3 \pm 0.7)\cdot10^{-5}$; $\tau_{los} = (4.4 \pm 1.6)$ h; for the oxygen trap: $\tau_n = (869 \pm 9)$ s, $\eta = (1.7 \pm 2.4)\cdot10^{-6}$; $\tau_{los} > 22$ h. The combined result for neutron lifetime is (870 ± 8) s.

The results obtained have to be considered as a preliminary results of the first measurements. Additional experiments are necessary with a higher precision in the measurements of storage time energy dependence, as well as better control of all experimental parameters. A test of the hypothesis that weak UCN heating is due to vibrations — is also necessary.