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ON THE PROBLEM OF THE STORAGE OF ULTRACOLD NEUTRONS AT APERIODIC PULSED NEUTRON SOURCES. SIMULATION OF NONSTATIONARY STORAGE OF ULTRACOLD NEUTRONS IN NEUTRON GUIDES WITH AN EXIT END REFLECTOR

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In our previous article [1] a method of nonstationary UCN storage when using an aperiodic pulse reactor with well separated neutron pulses as a neutron source was proposed. The method consists of using high quality neutron guide and a fast shutter at the entrance window of the UCN storage chamber. In subsequent publications, Monte Carlo simulations were performed for nonstationary UCN transport in nonperfect horizontal [2] and vertical [3] neutron guides and of nonstationary UCN storage in the experimental chambers. In this article we want to present the results of the Monte Carlo simulation for nonstationary UCN transport when the end part of the guide is equipped with a reflector and may be used for UCN storage. In this case high UCN densities may be achieved in comparatively small volumes (1-2l), which may be useful for experiments with UCN.

The considered geometries are shown in fig.1: a - straight vertical neutron guide was used for normalization, b - $\pi/2$ -bent vertical and c - curved S-shaped horizontal neutron guides. The cross sections of the neutron guides in all calculations were $6 \times 6 cm^2$. For nonperfect neutron guides the calculations were performed taking into account of UCN losses due to capture and diffuse scattering as in [2, 3]. It was supposed that the pulse width and source width are equal to zero, and that the angular distribution of the incoming neutrons obeyed the cosine law. The neutron spectrum was described as the low energy tail of the Maxwell spectrum. The boundary energy of the neutron guides was taken as $200neV$ (stainless steel).

Figures 2-6 show the UCN linear density distributions at the end section (with a 2m length) of the neutron guide at different consecutive time moments after the UCN source pulse. In all calculations for the vertical neutron guide, the normalization was performed to the energy interval of neutrons, outgoing from the source, which transform to UCN, with an energy less than $200neV$, when they reach the exit window of the ideal straight neutron guide (fig.1a). For the curved horizontal neutron guide, the normalization was made to one UCN leaving the source in the Maxwell spectrum interval between 55 and $200neV$.

The nonperfect neutron guides were supposed to have a capture loss coefficient $\eta = 5 \cdot 10^{-4}$, and surface roughness parameters $\sigma = 30$Å, $T = 250$Å[2, 3].

It is seen from these figures that a significant part of UCN reaching the end section of the neutron guide may be trapped in it with the use of a fast shutter located near the exit cross section. Accounting for UCN losses during transport along the neutron guide ([2, 3]) this part can reach 30-50% for an end section used for trapping equal to 0.5-1m. According to the estimation of [1] with a pulsed thermal neutron fluence of $10^{14} n/cm^2$ and using one of the best UCN moderator (for example very cold deuterium), up to 10^8 UCN can reach the exit of the neutron guide, giving a stored UCN density of $\sim (3-5) \cdot 10^4 cm^{-3}$.

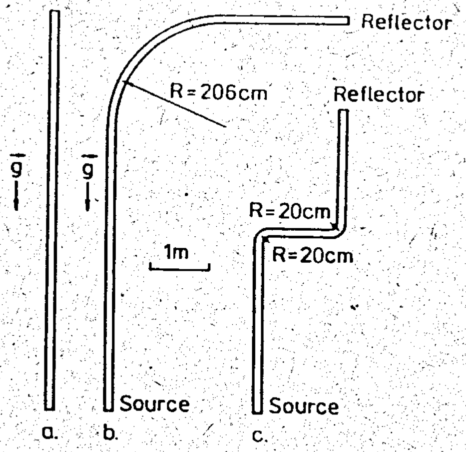

Fig.1 Neutron guide configurations used in the Monte Carlo simulations: a–vertical straight, b–vertical $\pi/2$-bent, c–horizontal S-shaped.

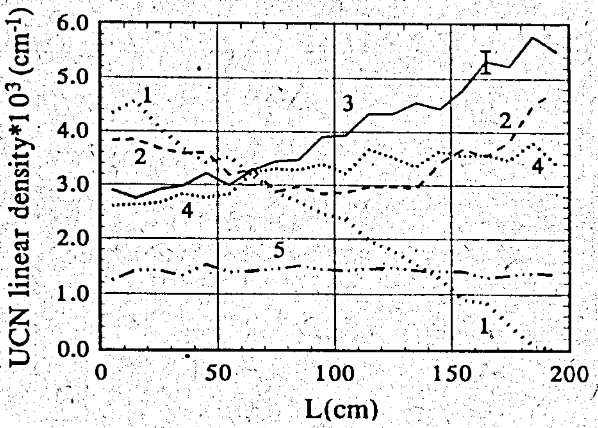

Fig.2 UCN linear density distributions at the end of a 2m long section of neutron guide for configuration fig.1b, at different time moments t after the source pulse for an ideal neutron guide with a diffuse reflector at the end: 1 - $t = 1.2s$, 2 - $t = 1.4s$, 3 - $t = 1.6s$, 4 - $t = 2.1s$, 5 - $t = 2.9s$.

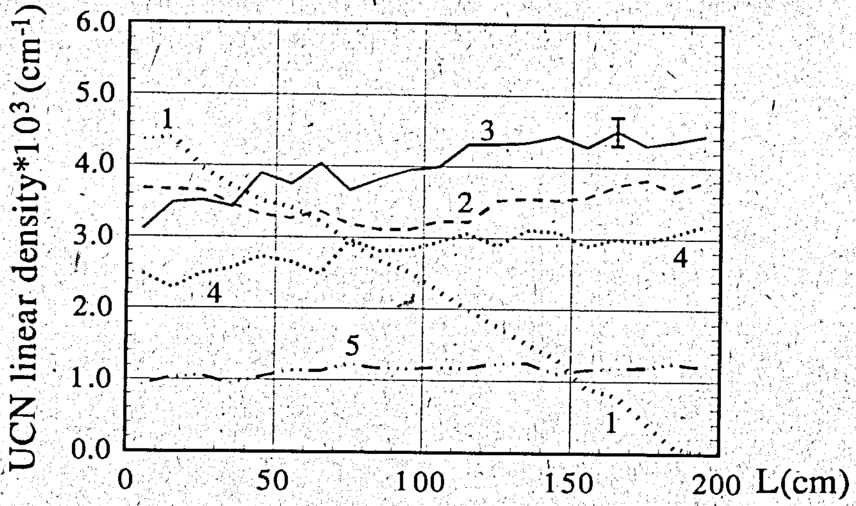

Fig.3 The same as in fig.2 but for a mirror-like reflector.

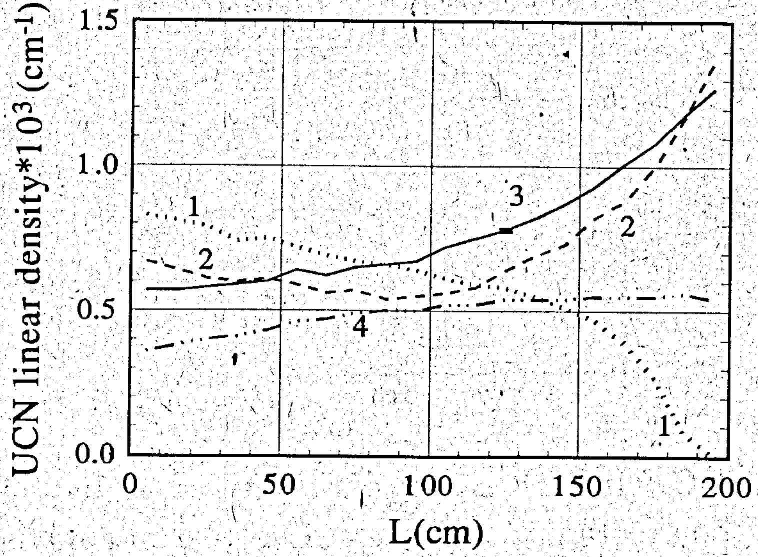

Fig.4 The same as in fig.2 but for a nonperfect neutron guide: 1 - $t = 1.2s$, 2 - $t = 1.4s$, 3 - $t = 1.6s$, 4 - $t = 2.8s$.

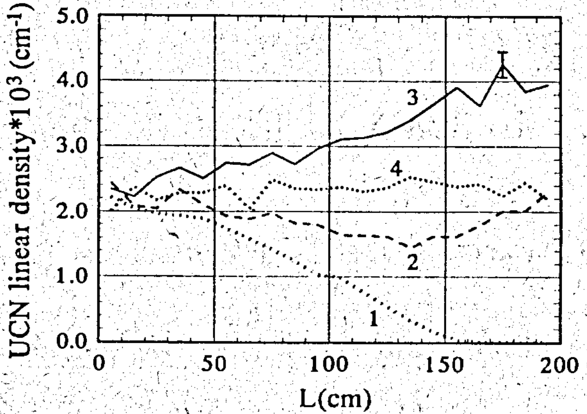

Fig.5 UCN linear density distributions at the end of a 2m long section of neutron guide for horizontal configuration fig.1c at different time moments t after source pulse for an ideal neutron guide with diffuse reflector at the end: 1 - $t = 1.0s$, 2 - $t = 1.2s$, 3 - $t = 1.6s$, 4 - $t = 2.4s$.

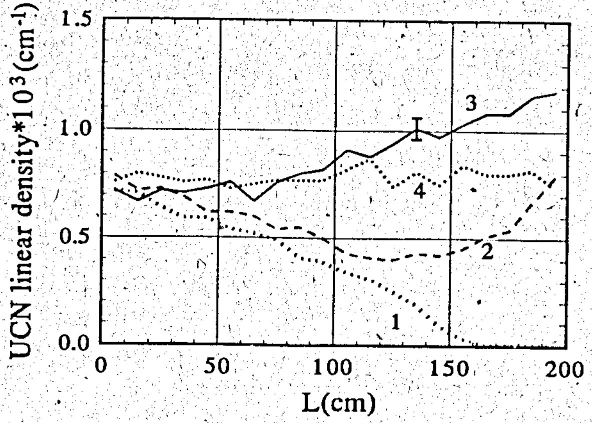

Fig.6 The same as in fig.5 but for a nonperfect horizontal neutron guide: 1 - $t = 1.0s$, 2 - $t = 1.2s$, 3 - $t = 1.9s$, 4 - $t = 2.7s$.

References

[1] Yu.N. Pokotilovski, Nucl. Instr. Meth. A356 (1995) 412

[2] G.F. Gareeva, Al.Yu. Muzychka, Yu.N. Pokotilovski, JINR Preprint E3-95-106, Dubna (1995) and Nucl. Instr. Meth., in press.

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