RUSSIAN ACADEMY OF SCIENCES
PETERSBURG NUCLEAR PHYSICS INSTITUTE

Preprint 2570

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Superconducting UCN Polarizer for a New EDM Spectrometer

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Gatchina – 2004

УДК 539.125.5

Сверхпроводящий поляризатор ультрахолодных нейтронов для нового ЭДМ-спектрометра

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Аннотация

Экспериментально показано, что число ультрахолодных нейтронов (УХН) с одной спиновой компонентой, проходящих через алюминиевую фольгу толщиной 100 мкм, расположенную в магнитном поле 5 T, в 3,8 раза больше, чем без магнитного поля. Увеличение пропускания вызвано высокой скоростью УХН, проходящих через фольгу в магнитном поле.

Abstract

A test experiment has shown that the number of UCN of one polarization transmitted through a 100 µm Al foil when placed in a 5 T magnetic field is greater by 3.8 times. The increased transmission is due to a higher velocity of the UCN passing through the foil.

Introduction

There are two possible ways to obtain polarized UCN for the EDM experiment: either one uses magnetized ferromagnetic layers on thin foils [1] or one uses strong magnetic fields of the order of 5 T.

We propose to use a superconducting (SC) solenoid polarizer on the fill lines of the EDM spectrometer. The advantages of such a choice are: 1) the possibility to obtain fully polarized UCN as compared to about 85% polarization using magnetized foils; 2) the possibility to place the vacuum separation foil in the high magnetic field region.

Separation foils are needed in any case between the UCN source volume with the solid deuterium and the EDM volume with the high voltage. A test experiment has recently shown that the number of UCN of one polarization transmitted through a 100 μm Al foil when placed in a 5 T magnetic field is greater by 3.8 times. The increased transmission is due to a higher velocity of the UCN passing through the foil.

The superconducting solenoids will be equipped with ARMCO return yokes in order to suppress the stray fields that might influence the EDM measurements. Due to the fact that the magnetic field of the SC magnets, once switched on, will be very stable over typical measurement times, its influence on the EDM experiment is only static and can be compensated for. In our test experiment on foil transmission at ILL, the possibility to carry out the present RAL-Sussex-ILL EDM experiment together with an even unshielded SC solenoid nearby (about 4 m distance) has been demonstrated.

As it is shown in the calculation, a cylindrical magnetic shield made of ARMCO with a diameter of 700 mm and a thickness of 100 mm can suppress the magnetic field in the EDM spectrometer down to 0.5 Oersted.

The scheme of the experiment

The scheme of the experiment which was recently performed at ILL Grenoble is shown in Fig. 1. UCN from the ILL turbine filled a Be coated gravitational spectrometer volume. After closing the shutter *1*, a well defined UCN spectrum was formed in the spectrometer over 100 s by means of a moveable absorber. The spectrum was very similar to the one that will be obtained in the UCN storage vessel of PSI UCN source, which is under construction now.

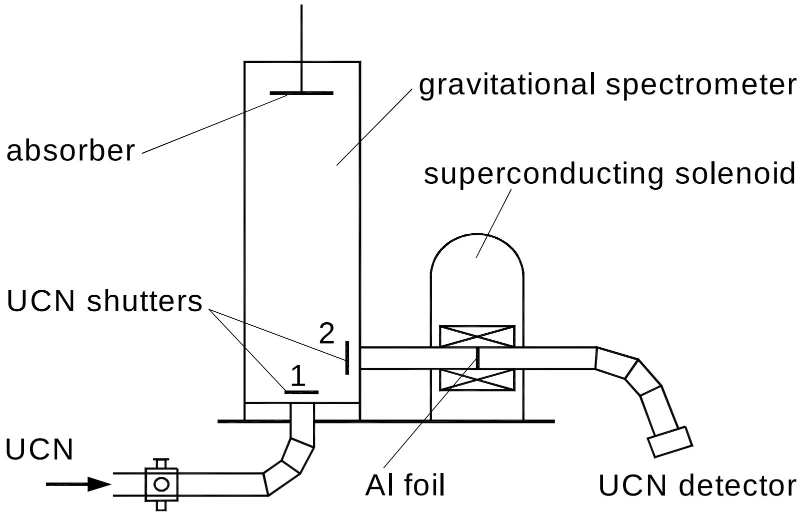

Fig. 1. The scheme of the experimental setup.

When the shutter *2* was opened UCN were counted in the UCN detector. Various cases were studied: with and without Al foil, with and without magnetic field. All four possible cases were studied with the UCN absorber at various positions in order to obtain the energy dependence of the transmission.

Experimental results

Fig. 2. shows differential UCN spectrum, as seen by the UCN detector, with the magnetic field switched on to 5 T and differential UCN spectrum with the magnetic field switched off divided by factor of two because it is an unpolarized beam with two spin components. For a 100 μm thick Al foil the integral number of polarized UCN with the SC magnet switched on is 3.8 times greater than the integral number of UCN with one spin component with the magnet switched off. UCN of one polarization component get accelerated in the magnetic field gradient, and have a longitudinal velocity of more than 7.6 m/s for the 5 T at the foil position. As a result, these neutrons more easily penetrate the Al potential barrier and pass through the foil with considerably smaller losses. Fig. 3 shows the transmission probability as a function of UCN energy outside the solenoid. This probability is determined by the ratio of count rates with and without foil. In case the magnet is switched on, the transmission is only weakly dependent on the spectrum. For the 100 μm Al foil the transmission is larger than 80%, for a 50 μm Zr foil (which can be used for separating the vacuum in the same way as 100 μm Al) it amounts to about 90%.

Thus the usage of a SC solenoid allows to obtain UCN polarization and to increase the density of polarized UCN by factor of 3.8. In the cases when polarization of UCN is not needed in the experiment the factor of the UCN density increase is about two

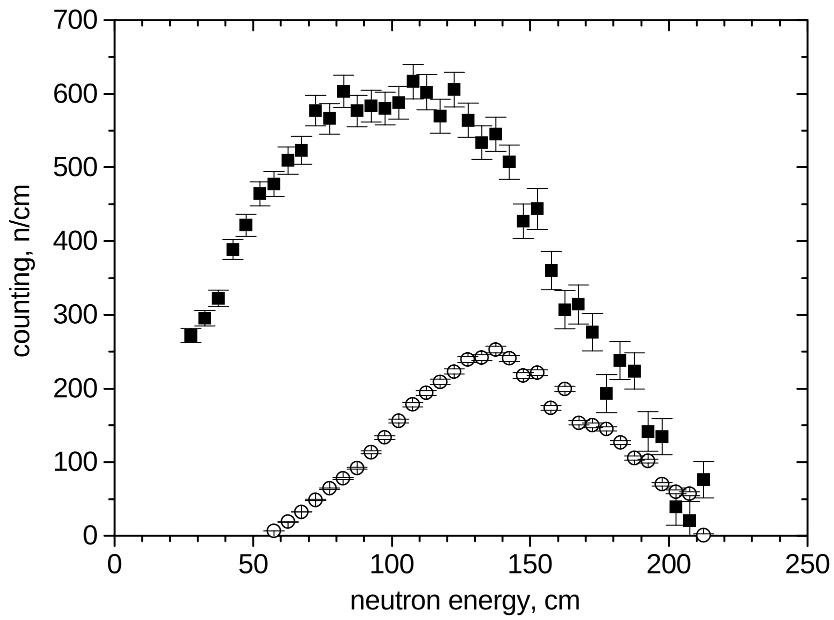

Fig. 2. Differential UCN spectrum for Al foil (100 μm). -■- is the case when the magnetic field is switched on to 5 T. -○- is the case when the magnetic field is switched off (the counting rate is scaled by the factor of two in order to account for the fact that without the field, two polarization components are present while for the solenoid switched on, only one polarization component is transmitted).

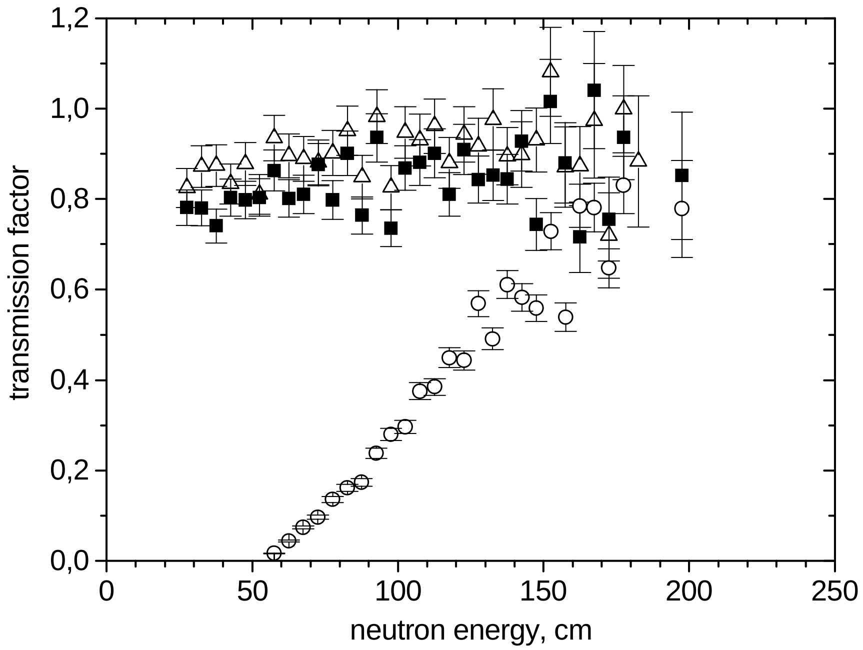

Fig. 3. Absolute transmission of foils with and without magnetic field as a function of UCN energy (height). -■- is the case with Al foil (100 μm) and with the magnetic field switched on. -○- is the case with Al foil (100 μm) and with the magnetic field switched off. -Δ- is the case with Zr foil (50 μm) and with the magnetic field switched off.

times. It is important also for the experiments with unpolarized UCN.

The authors are grateful to Russian Federation of Basic Research for the support under the contracts 02-02-17120 and 04-02-17440, to INTAS for the support under the contract 2001-765, to the Russian Academy of Science for the support under the Program of Fundamental Research.

Reference

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Работа поступила в Издательство ПИЯФ РАН 23.06.2004 г.