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A WIDE-SPECTRUM NEUTRON POLARIZER  
FOR A PULSED NEUTRON SOURCE

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## 1. Introduction

To develop a wide-spectrum neutron polarizer for the pulsed neutron source is an important task [1,2]. This task is especially vital in the case of unconventional use of neutrons, when the neutron beam divergence within the source to user flight path is assigned as depending on neutron wavelength [3].

The polarizer [2] is performed as a set of  $N$  Soller stacks of magnetized mirrors placed on a drum along the cross-section circle. The polarizer is positioned at the distance  $L_1$  from the neutron source and rotates uniformly, in synchronism with the pulse repetition frequency, around the axis which is parallel to the neutron beam.

Neutrons emitted from the source reach the polarizer in the time proportional to their wavelength and are then polarized by the respective stack of mirrors characterized by the angle  $\varphi$  of its turn about the axis.

## 2. Calculations and discussion

To characterize the polarizer quality, we will introduce parameter  $\alpha = E^2 T$  [4], where  $E$  is the neutron polarizer efficiency and  $T$  is the neutron transmission. Parameters  $E$  and  $T$  are determined by transmission  $t^+$  and  $t^-$  of the "+" and "-" components of the neutron flux in the magnetic field in accordance with relationships  $E = (1-r)/(1+r)$  and  $T = t^+ t^-$ , where  $r = t^-/t^+$ .

The polarizer is optimized if  $\alpha = \max$ , which is provided by conditions  $t^+ \rightarrow 1$  and  $r \rightarrow 0$ . For these conditions to be satisfied, the angle  $\theta_n$  of inclination of mirrors in the stack to the beam axis must be proportional to angle  $\varphi$ .

Utilization of an even number  $n$  of collisions of a neutron with a pair of mirrors at passing the polarizer makes it possible to use a neutron source of relatively small linear dimensions. To

provide for maximal transmission, the condition  $\theta = nd/l$ , where  $d$  is the distance between mirrors and  $l$  is the mirror length, is satisfied.

The wavelength interval  $\Delta\lambda$  and the relative transmission band of a pair of mirrors  $\beta = \delta\lambda/\lambda$  being specified, we get  $\Delta\lambda = 2\sum \delta\lambda_j = 2\beta\sum \lambda_j$  for minimal number  $N$  of stacks. Setting  $\lambda_j = b\lambda_{j-1}$ , we get  $\Delta\lambda = 2\beta\lambda_1(b^N - 1)/(b - 1)$ . Fig. 2 shows the dependence  $E^2T(\lambda)$  for  $N=1, 2, 4$  and  $8$  (curve 1, 2, 3 and 4, respectively). Here the coefficient of the neutron reflection from the mirror was calculated by the formula  $R^\pm = ((1 - V^\pm)/(1 + V^\pm))^2$  for  $\theta > \theta^\pm$ , where  $V^\pm = (1 - (\theta^\pm/\theta)^2)^{1/2}$ , and  $\theta^\pm$  is the critical grazing angle for the "+" and "-" spin components, respectively, and  $\theta$  is the neutron grazing angle ( $R^\pm = 1$  for  $\theta \leq \theta^\pm$ ). The values of other parameters are following:  $L_1 = 2m$ ,  $L_2 = 2m$ , the polarizer radius  $R = 50cm$ , the mirror length  $l = 30cm$ , the polarizer rotation frequency  $f = 5Hz$ ,  $b = 4.5, 2.1$  and  $1.44$  for  $N = 2, 4$  and  $8$ , respectively, the beam dimensions  $H_0 = 0.1mm$ ,  $S_0 = 0.1mm$ ,  $H_5 = 2H_0 = 0.4mm$  and  $S_5 = 2S_0 = 2mm$ .

One can see (Fig. 2, curve 1) that the relative transmission band is  $\beta = 0.35$  (at  $E^2T = 0.5$ ) and is equal to the value of  $(\theta^+ - \theta^-)/(\theta^+ + \theta^-)$ . It follows from Fig. 2 that at  $N = 8$ , the  $\Delta\lambda$  interval, where  $E^2T \geq 0.95$ , is  $1 \pm 20\Delta$ . An increase in the beam cross-section dimensions leads to a decrease in  $E^2T$ .

An increase in the rotation frequency excludes the influence of the beam size along the  $Y$  axis (Fig. 3) and correction of the mirror inclination angle in accordance with relationship  $\Delta\theta = Z/L_1$  excludes the influence of the beam size along  $Z$  (Fig. 3).

The performed calculations prove that the polarizer has necessary characteristics at proper choice of its parameters  $N$ ,  $f$ ,  $R$ ,  $\theta$  and can be utilized at the pulsed neutron sources in a wide range of the pulse repetition frequency.

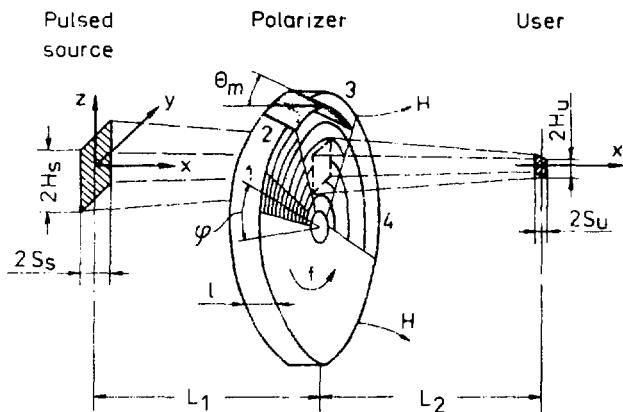


Fig.1. Layout of relative position of the neutron source, the polarizer, and a user.

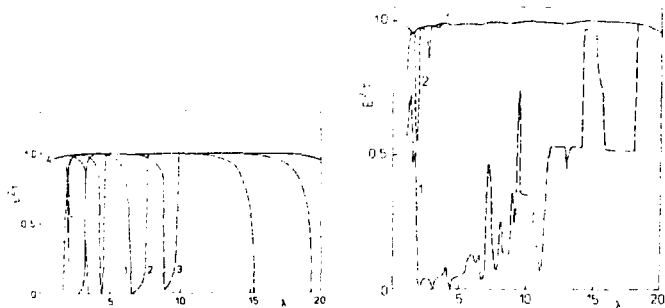


Fig.2. Dependence of the  $E^2T$  on the neutron wavelength, in Angstrom  $\theta^+ = 3.5 \cdot 10^{-3} \lambda(\text{\AA}) [5], \theta^- = \theta^+ / 2$ .

Fig.3. Dependence of the  $E^2T$  on the wavelength (in Angstrom) at  $f = 1.5\text{Hz}$  ( curve 1 ),  $15\text{Hz}$  ( curve 2 ), and  $50\text{Hz}$  ( curve 3 );  $S_p = 1.5\text{cm}$ ,  $S_u = 1\text{cm}$ ,  $H_u = 0.1\text{mm}$ , and  $H_p = 0.2\text{mm}$  and  $5\text{cm}$  without and with correction of the mirror inclination angle, respectively.

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## Широкоспектральный поляризатор нейтронов для импульсного источника нейтронов

Рассмотрен широкоспектральный поляризатор нейтронов для импульсного источника нейтронов. Поляризатор представляет собой совокупность намагниченных зеркал, размещенных на барабане. Равномерное вращение поляризатора синхронизировано с импульсами мощности источника нейтронов. Поляризатор может быть использован на коллимированном пучке нейтронов с площадью поперечного сечения до  $100 \text{ cm}^2$  в интервале длин волн  $2-20 \text{ \AA}$  источника нейтронов с частотой следования импульсов мощности до  $50 \text{ Гц}$ .

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## A Wide-Spectrum Neutron Polarizer for a Pulsed Neutron Source

A wide-spectrum neutron polarizer for a pulsed neutron source is considered. The polarizer is made in a form of a set of magnetized mirrors placed on a drum. Homogeneous rotation of the polarizer is synchronized with the power pulses of the neutron source. The polarizer may be utilized in a collimated neutron beam with cross-section of the order of magnitude of  $100 \text{ cm}^2$  within a wavelength from 2 up to  $20 \text{ \AA}$  on sources with a pulse repetition frequency up to  $50 \text{ Hz}$ .

The investigation has been performed at the Frank Laboratory of Neutron Physics, JINR.

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