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To cite this article: V G Syromyatnikov and V M Pusenkov 2017 *J. Phys.: Conf. Ser.* **862** 012028

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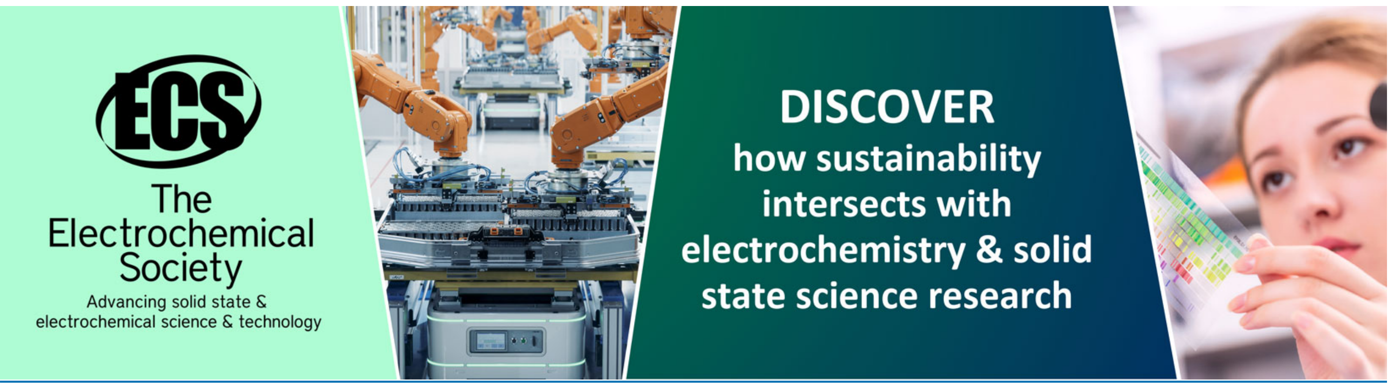

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New compact neutron supermirror transmission polarizer

V G Syromyatnikov [1,2], V M Pusenkov [1]

[1] Petersburg Nuclear Physics Institute, National Research Center "Kurchatov Institute", Gatchina, St. Petersburg, 188300, Russia

[2] Department of Physics, St. Petersburg State University, Ulianovskaya 1, Petrodvorets, St.Petersburg, 198504, Russia

E-mail: syromyatnikov_vg@pnpi.nrcki.ru

Abstract. A new compact neutron supermirror transmission polarizer is suggested. The polarizer consists of a set of plates transparent to neutrons placed in the magnet gap. There are no air gaps between the plates. Polarizing supermirror coating without absorbing underlayer is deposited on the polished surfaces of the plates. Magnetic and nonmagnetic layers of the supermirror coating as well as the material of the plates have nearly equal neutron-optical potentials for spin-down neutrons. There is a considerable difference between neutron-optical potentials of layers in the supermirror structure for spin-up neutrons. As a result, spin-up neutrons reflect from the supermirror coating and deviate from their initial trajectories whereas spin-down neutrons do not practically reflect from the coating and, consequently, do not deviate from their initial trajectories. Thus, spin-down neutrons dominate near the axis of distribution of intensity on the angle for the beam transmitted through this polarizer, i.e., the beam is substantially polarized. Application is discussed of this polarizer in a research facility for small angle scattering of monochromatic neutrons with wavelengths $\lambda = 4.5 \div 20$ Å. The polarizing cross section of the beam of this facility is 30x30 mm^2. Calculated parameters are presented of a polarizer on silicon plates with supermirror CoFe/TiZr (*m* = 2) coating. The suggested polarizer is compared with solid state bender, S-bender and widely known transmission neutron polarizer V-cavity in the same spectral range. Two polarizers are used to cover the wavelength range $\lambda = 4.5 \div 20$ Å: the first one whose length is 50 мм covers the range $\lambda = 4.5 \div 10$ Å and the second one whose length is 21.2 мм covers the range $\lambda = 10 \div 20$ Å. The length of each of these polarizers is more than 30 times smaller than that of V-cavity! On the other hand, basic parameters of the proposed polarizer, polarization of the beam falling on the sample P and transmission coefficient T^- of the main spin component, exceed those of V-cavity. T^- = 0.8 – 0.9 for both polarizers and for each wavelength range. Polarization P is very high. P is better than -0.99 for wavelength range $\lambda = 12.5 \div 20$ Å at the beam divergence of 24 mrad.

1. Introduction

Beam former is used in Small-Angle Neutron Scattering (SANS) facilities for monochromatization and collimation of neutron beams. In order SANS facilities be suitable for investigation of magnetic properties of materials, the beam former should also be able to polarize the beam.

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Such a beam former-polarizer is known which is based on spatial spin resonance of neutron beam [1, 2]. It is used in some SANS facilities (see e.g., [3, 4]). However, this beam former has significant drawbacks: bulkiness and complexity in operation (because it contains four elements: polarizer, magnetic resonator, spin-flipper, and analyzer). Monochromatic beam produced by this polarizer has a significant non-monochromatic background caused by imperfect polarization by polarizer and analyzer. Besides, it is difficult to switch from polarized to unpolarized neutrons in SANS facilities with such a beam former.

A beam former is also used in SANS facilities for polarization of neutron beams which contains bender - multichannel polarizing supermirror neutron guide described in [5]. Neutron beam deviates from its initial trajectory when passing through the polarizing bender. Due to this circumstance, much time is needed for rebuilding of the SANS facility when switching from polarized to unpolarized neutrons. The beam former presented in Fig. 1 has become the most widely spread one in SANS facilities in recent 15 years. A neutron beam having a broad spectral distribution falls on a sample after successive passing through the velocity selector (1), the transmission polarizer (2), and the collimation system (3).

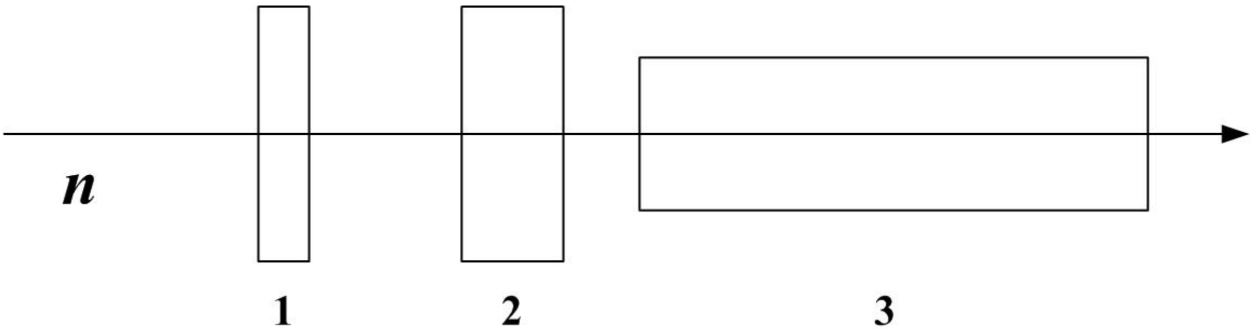

Figure 1. Sketch of beam former for SANS facility. 1 - velocity selector, 2 - transmission polarizer, 3 - collimation system.

This beam former allows dealing with both polarized and unpolarized neutrons so that the trajectory of the beam does not change upon switching between these two regimes. This circumstance is in the origin of the wide spreading of the beam former of this type.

Variants of use are described in [6] of the V-cavity, S-benders, and elliptic neutron guides as transmission polarizers.

The transmission polarizer is frequently done in the form of V-cavity. The V-cavity of one of the first types is described in [7] which is used in the range of wavelengths $\lambda = 4.5 \div 20$ Å. Basic characteristics of this polarizer are the following: the coefficient of transmission of neutrons with the main spin component of the beam decreases gradually from 0.7 for 6 Å to 0.2 for 18 Å; the polarizing efficiency is not worth than 0.93 for wavelengths in the range 4 Å < λ < 10 Å and it decreases gradually to 0.8 upon wavelength increasing to $\lambda = 18$ Å. The beam axis does not change when passing through the polarizer. The polarizer V-cavity consists of a straight neutron guide and two equal long polarizing supermirrors on silicon substrates placed inside this neutron guide. Walls of the neutron guide are covered by natural Ni (m = 1). Each mirror contains a set of rectangular polished silicon plates which are lined up and which edges are pressed to each other. A polarizing supermirror *CoFe/Si* coating (m = 2) covers the plates. These long polarizing supermirrors are crossed with each other. The axis of the beam (of the neutron guide) forms with each of them a small angle θ = 8.33 mrad. The angle between supermirrors is equal to 2θ. Angle θ is defined as $\theta = \alpha_c \cdot \lambda_{\min}$, where α_c is a critical angle of the supermirror and $\lambda_{\min}$ = 4.8 Å is the shortest wavelength of the neutron spectrum. The V-cavity is placed in a saturating magnetic field. The set of plates is cased. Neutrons having (+) spin component (i.e., neutrons with spin component oriented parallel to the guiding magnetic field) are reflected from one of the plates of the V-cavity by an angle smaller than the critical one. Then, they are reflected from walls of the neutron guide with m = 1 by an angle greater than the critical one. As a result, the divergence increases of the neutron beam with (+) spin component that leads to their absorption either after falling on the wall by an angle greater than the critical one, or after reflection from the silicon mirror, or in the collimation system. Thus, the number of neutrons with (+) spin component is much smaller in the beam passed through the V-cavity than that with (-) spin component (i.e., the passed neutron beam has a negative polarization). The extensive length of V-cavity L = 1800 mm is defined as $L = d/2\theta$, where d = 30 mm is the neutron beam width used in the facility and θ = 8.33 mrad. Both the straight neutron guide whose walls are covered by natural nickel (m = 1) and the magnetic system for the V-cavity have the same length L. Taken together, they form a heavy, bulky and lengthy unit which is difficult to handle. For example, it is necessary to remove the entire bulky polarizer with magnetic system in order to transfer to nonmagnetic system investigation. Besides, it is difficult to make the polarizer because it is difficult to line up silicon plates on such a large length of 1800 mm and to fix them. Moreover, such a polarizer is placed inside expensive and lengthy (~ 1800 mm) magnetic system.

Supermirror neutron polarizers are known on substrates which are transparent for neutrons [8-13] including transmission polarizers. A supermirror transmission solid state bender on silicon substrates is discussed in [12]. The bender consists of a stack of thin silicon wafers, which thickness is 0.16 mm, coated with polarizing FeCo/Si supermirrors (m = 2.3). Being inserted in an unpolarized neutron beam, this device works as a spin splitter by transmitting the spin down component without any change in its flight path and reflecting the spin up component. The bender cross section is 20*100 mm, where the captured beam width is 20 mm and its height is 100 mm. The bender length is 54 mm. The bender was tested using a monochromatic beam having the wavelength of 4.72 Å together with the solid state collimator. Rocking curves were measured for the neutron intensity transmitted through both the bender and the collimator. Triangular transmission with a maximum of 54% of the spin down component and a mean flip ratio above 100 were reached over an angular range with a FWHM of 0.37 degree. A spin down neutrons can be extracted with the angle width of 1 degree with the mean flip ratio of the order of 120 (P = 0.983). The transmission coefficient of such a beam through the bender was found to be of the order of 0.67.

A supermirror solid state S-bender is presented in [13]. This polarizer does not deflect the axis of the beam passing through it as well. An 80 mm long polarizing S-bender with a large cross-section of 30*100 mm has been simulated, built and tested. The results of the experiment show for the wavelength of 4.4 Å a homogenous polarization of the order of P = 0.987 across the bender cross-section and a high transmission 68 % of the spin up component of the neutron beam. The angle divergence of the beam at the end of this polarizer was 1.85 degrees. The S-bender length is 80 mm. The bender design has the advantage of delivering the polarized beam in the direction of the incoming beam.

The aim of the present work is to work out a neutron transmission supermirror polarizer of a new type for a SANS facility which provides a high polarizing efficiency and the transmitting coefficient of the main spin component of the beam. The new polarizer must be substantially more compact, cheaper, and easy to handle and use.

2. Design and principle of operation of the suggested polarizer

The polarizer design (side view) is shown in Fig. 2. A set of neutron transparent plates P is sandwiched between two broken polished metal surfaces 1 and 2 (the punch and the matrix) so that each plate of thickness d forms a broken asymmetric neutron guide channel with supermirror walls. This channel is shown in Fig. 3. As is shown in the figure, the channel height (plate thickness) is d, the front part of the channel (plate) has length L_1 and it makes with the beam axis angle θ_1, and the corresponding parameters the output part of the channel are L_2 and θ_2, respectively. The width of the channel along the axis perpendicular to the plane of the figure is equal to L_3 (not shown in the figure) is determined by the width of the incident beam.

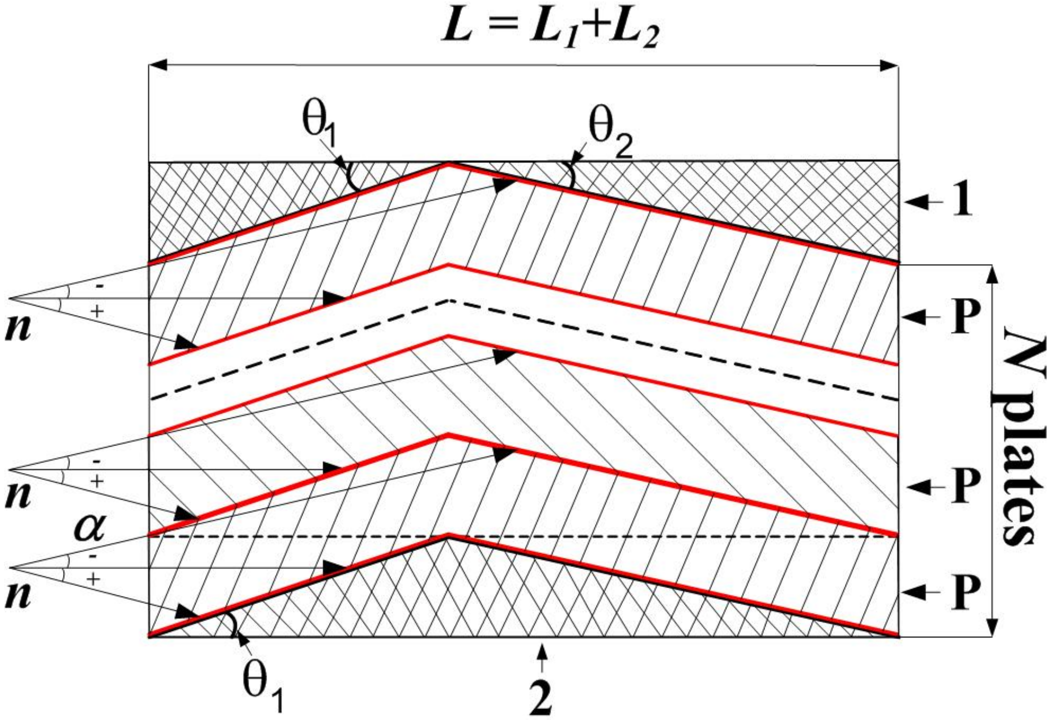

Figure 2. General view of the proposed compact neutron transmission supermirror polarizer.

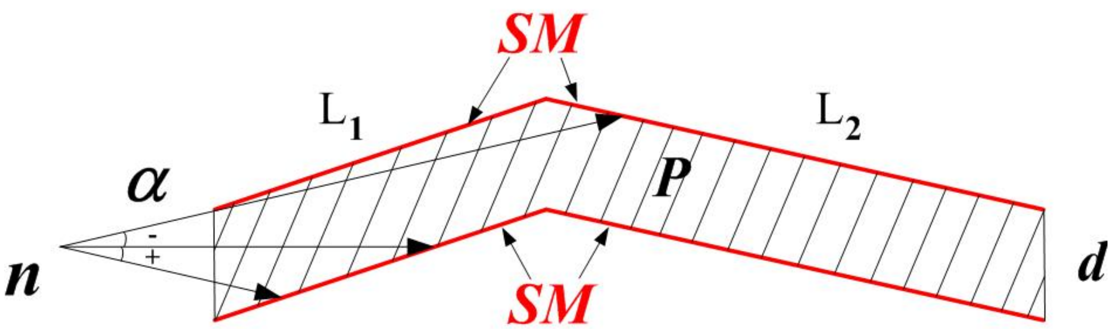

Figure 3. General view of one channel of the proposed compact transmission neutron supermirror polarizer.

A divergent neutron beam ***n*** comes to the entrance of each channel (Figs. 2 and 3). Entrance angle α of neutrons is counted off from horizontal line. The sign of α is defined as it is shown in Figs. 2 and 3. A polarizing supermirror coating <SM> covers all polished surfaces of width ***d***. For neutrons with (-) spin component of the beam, the neutron-optical potentials are close to each other of the supermirror coating layers and the material of the plate so that the critical angle α_c^- is close to zero for the boundary "material-supermirror". Slight exceeding is allowed of the plate potential over potentials of layers of the supermirror. For neutrons with (+) spin component of the beam, the neutron-optical potentials of its layers differ significantly from each other so that the corresponding critical angle α_c^+ is great for the same boundary. Polarizer plates are in the field of the magnetic system of the polarizer.

This field lies in supermirror plane and perpendicular to the plane of the figure (Fig. 3). The applied field saturates the magnetic layers of supermirrors deposited on the plates. The number of broken asymmetric channels (plates) and their width L_3 are defined by the required beam cross section used in the facility which is equal to $h \times L_3$, where h is the beam height. *N* such channels are used which are pressed to each other without air spaces, where *N* is defined as $h = N \cdot d$.

Channel parameters are given by the following relationships:

$\theta_1 = \lambda \cdot \alpha_c^+$, where λ is the smallest wavelength of neutrons in the beam formed by velocity selector; α_c^+ is the critical angle of the supermirror for (+) spin component of the beam; γ is required divergence of the beam coming to the sample through the polarizer and the collimation system; $\theta_2 = \theta_1 - \gamma$; d is plates thickness made from a material which absorbs neutrons weakly (e.g., silicon, quartz, sapphire etc.); $L_1 = d / \theta_1$; $L_2 = d / \theta_2$; L_1 *u* L_2 are plates lengths.

The device operates as follows.

The neutron flux coming from the neutron guide and having wide angular and spectral distributions enters the entrance of the velocity selector, where a monochromatic beam is formed with wavelength λ and with a width $\Delta\lambda / \lambda$ defined by the selector. Then, the resulting beam comes to the entrance of the proposed polarizer. Trajectories of neutrons with (-) spin component do not practically change when coming through the polarizer because these neutrons do not reflect from boundaries “material-supermirror” (as soon as α_c^- ~0). In contrast, neutrons with (+) spin component do reflect from boundaries “material-supermirror” (as soon as α_c^+ > 0) and their trajectories change considerably.

Consequently, the number of neutrons with (-) spin component is much greater than that of neutrons with (+) spin component at the exit of the polarizer near the axis of the angle distribution of intensity. Then, the transmitted beam has negative polarization.

Neutron fluxes with (+) and (-) spin components coming from the polarizer go through the collimation system and come to the sample. Divergences of these fluxes are determined by divergence of the collimation system. The reduction is more pronounced of intensity of (+) spin component than that of (-) spin component because the divergence of flux of (+) spin component is enhanced much greatly upon coming through the polarizer. The polarization of the beam falling on the sample depends on divergence of the collimator. Then, the choice of this divergence depends on the physical problem to be solved using the facility.

3. The new compact neutron supermirror transmission polarizer on silicon

As an example of the suggested transmission polarizer, we consider the polarizer in which silicon is chosen as a material that absorbs neutrons weakly. This polarizer is planned to use in beam former for SANS-2 facility at reactor PIK. The structure *CoFe/TiZr* ($m = 2$) [14] without absorbed sublayer *TiZrGd* is used as the polarizing supermirror covering on silicon. For neutrons with (-) spin component, potentials are equal to zero of layers *TiZr* and fully magnetized layers *CoFe*, whereas the silicon has small positive potential. Thus, a small jump of potential is on the boundary between silicon and supermirror for neutrons with (-) spin component reflection from which is insignificant for such neutrons. Price is very small of polished silicon plates of width 0.3 mm and the supermirror coating *CoFe/TiZr* ($m = 2$). The beam cross section for SANS-2 is $30 \times 30\ mm^2$, i.e. $h = L_3 = 30\ mm$. At *d=0.3* mm, the number of plates (channels) *N* in polarizer is equal to 100.

Neutron flux leaving the neutron guide with nickel coating ($m = 1$) comes to the entrance of the velocity selector. Monochromatic beam with wavelength λ and $\Delta\lambda / \lambda = 0.1$ made by the velocity selector comes to polarizer.

Let us compare the suggested former with *V*-cavity for $\lambda = 4.5 \div 20$ Å. Two one-type compact polarizers of the suggested construction (for $\lambda = 4.5 \div 10$ Å and $\lambda = 10 \div 20$ Å) are needed to cover this range of wavelengths.

The geometrical parameters of polarizers:

1. The first polarizer: $\lambda = 4.5 \div 10$ Å, $d = 0.3\,mm$ - thickness of silicon plates, supermirror coating - *CoFe/TiZr* ($m = 1.81$) without sublayer *TiZrGd*, $\theta_1 = 15\,mrad$, $\theta_2 = 10\,mrad$, $L_1 = 20\,mm$, $L_2 = 30\,mm$, $\alpha_c = 3.1\,mrad/$Å (for reflection from silicon), $\gamma = 5\,mrad$.

Length of the first polarizer $L = L_1 + L_2 = 20 + 30 = 50\,mm$ that is 36 times smaller than the length of V-cavity!

2. The second polarizer: $\lambda = 10 \div 20$ Å, $d = 0.3\,mm$, supermirror coating - *CoFe/TiZr* ($m = 1.81$) without sublayer *TiZrGd*, $\theta_1 = 31\,mrad$, $\theta_2 = 26\,mrad$, $L_1 = 9.7\,mm$, $L_2 = 11.5\,mm$, $\alpha_c = 3.1\,mrad/$Å (for reflection from silicon), $\gamma = 5\,mrad$.

Length of the second polarizer $L = L_1 + L_2 = 9.7 + 11.5 = 21.2\,mm$ that is 85 times smaller than the length of V-cavity!

The first or the second polarizer will be placed in the beam depending on the neutron wavelength λ to be used in the facility which is defined by the velocity selector.

As it follows from calculations, the both polarizers have non-symmetric form: $L_2 > L_1$. Let us consider a symmetric system. In this case, if a neutron reflects twice from walls of the first part of the polarizer, it would reflect twice by the same angle from walls of the second part of the polarizer so that the outlet angle (with respect to the beam axis) would be equal to the inlet one. In addition, the transmission of spin-up neutrons would increase considerably for angles α near the beam axis. Hence, the polarization would decrease for this angle range. Implementation of the asymmetry in the polarizer allows eliminating this effect.

Dependence is shown in Fig. 4 for (+) spin component of the beam of the parameter λ/θ (θ is the glancing angle) of the modeling reflection coefficient from supermirror polarizing coating *CoFe/TiZr* ($m = 1.81$) evaporated on polished silicon substrates. This dependence has been used in calculations.

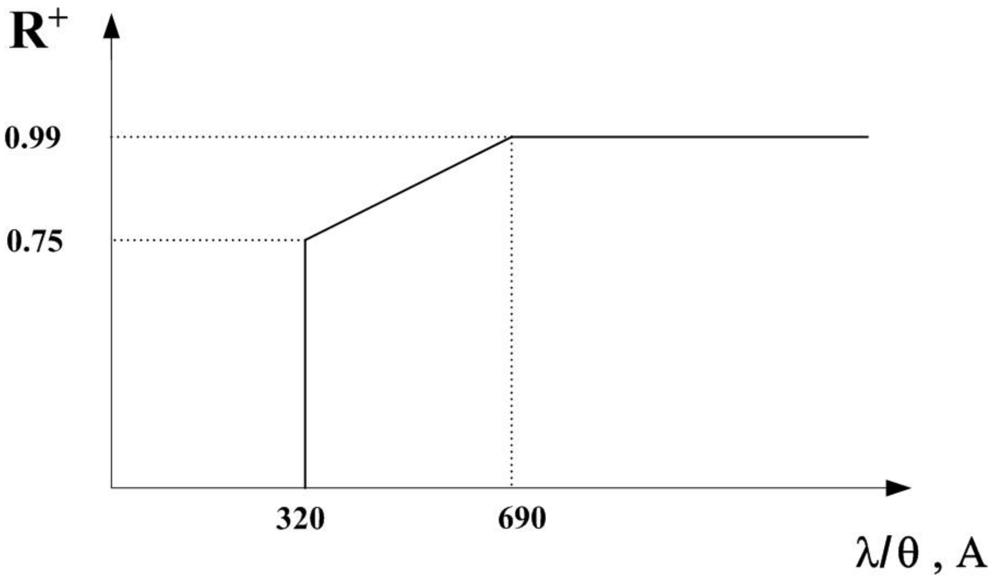

Figure 4. Modeling reflection coefficient of spin-up neutrons from supermirror polarizing coating *CoFe/TiZr* ($m = 1.81$) evaporated on polished silicon substrates for reflection from silicon in dependence of parameter λ / θ.

Parameters of polarizing supermirror CoFe/TiZr have been used in calculations. Upon reflection from such supermirror from vacuum, the cut of the curve reflectivity corresponds to $\lambda / \theta = 310$ Å whereas for the area of the total reflection λ/θ = 600 Å. Upon reflection from such supermirror from silicon, a shift of these cuts arises due to the refraction in silicon. As a result, one obtains 320 и 690 Å (Fig. 4) for the corresponding values because the critical angle in silicon α_c = 0.812 mrad/ Å or $(\lambda/\theta)_c$ = 1232 Å.

Calculations have been carried out for each polarizer of dependence on the incoming angle α of intensities at the polarizer exit of (+) I^+ and (-) I^- spin components of monochromatic beam for some neutron wavelengths. By the reason discussed above, for I^-, the beam divergence does not change upon coming through the polarizer. The beam intensity of this spin component has been just slightly reduced due to neutron absorption in silicon. Then, I^- has been large. Calculation of angle distribution of I^+ at the polarizer exit has been carried out mainly using software based on so-called "short section approximation" method which is described in [15]. This method allows to trace the trajectory of each neutron coming through practically any neutron-optical device. As a result, I^+ and I^- can be calculated with high accuracy at the exit of this device.

Calculation of I^+ is substantially more complicated than that of I^- because, apart from absorption of the beam in the silicon, a reflection (including multiple reflection) should be taken into account from supermirror walls of polarizer channels. Besides, a transmission through these walls without reflection should be taken into account of a small part of neutrons which takes place because the reflection coefficient is smaller than unity at $\lambda / \theta = 320 \div 690$ Å (see Fig. 4).

Results of calculations are shown in Fig. 5 for I^+ and I^- at $\lambda = 5.5$ Å for the first polarizer dependence on α, of intensity I at the entrance of the polarizer and polarization

$P = \dfrac{I^+ - I^-}{I^+ + I^-}$ of the transmitted beam. Neutron absorption in silicon has been taken into account. As expected, P turns out to be negative and the beam divergence of (+) spin component is increased due to the reflection from supermirror walls of the polarizer. The latter circumstance is in the origin of complicated structure of angle distribution of I^+ which has three separated peaks. As it is seen from the figure, the area $\alpha \approx -6 \div 16\ mrad$ has small amount of neutrons of (+) spin component. In contrast, the width of the angle distribution of (-) spin component does not practically change upon coming through the polarizer. As a consequence, the polarization of the transmitted beam in the angle range $\alpha \approx -6 \div 10\ mrad$ is extremely high being close to -1. Results similar to those presented in Fig. 5 have been obtained also for wavelengths $\lambda = 4.5, 6.5, 7.5, 8.5, 9.5$ Å from the working range of the first polarizer.

Results are shown in Fig. 6 of the corresponding calculations for the second polarizer at $\lambda = 12.5$ Å. It is seen that all graphics are similar to those presented in Fig. 5. Results similar to those presented in Fig. 6 have been obtained also for wavelengths $\lambda = 10.5, 11.5, 14.0, 16.0, 18.0, 20.0$ Å from the working range of the second polarizer.

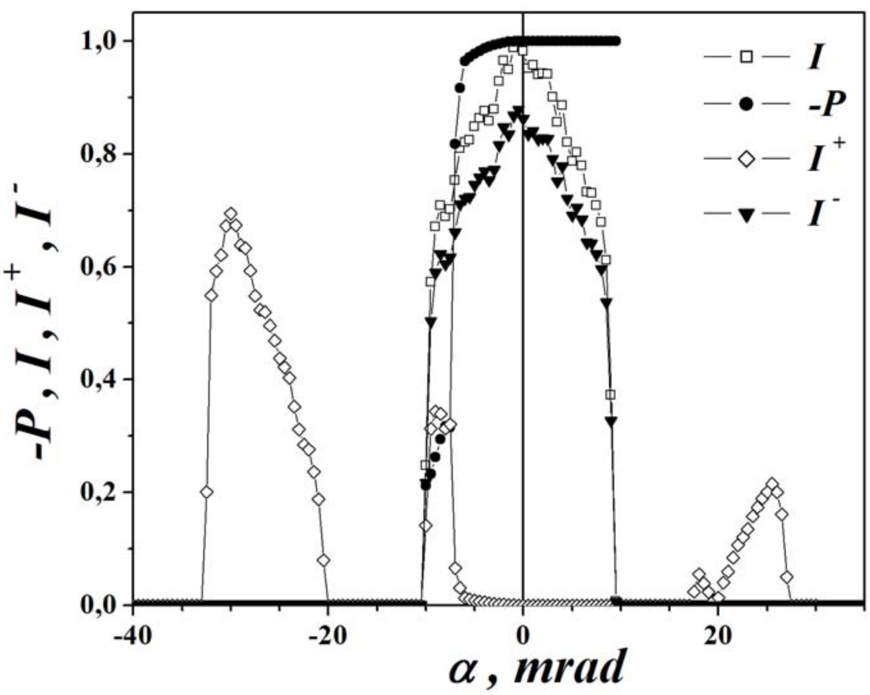

Figure 5. Calculated dependencies on angle α (see Figs. 2 and 3) of normalized intensities I^+ and I^- for, respectively, (+) and (-) spin components of monochromatic neutron beam with $\lambda = 5.5$ Å transmitted through the first polarizer. Dependencies on α are also shown of intensity at the entrance of the polarizer I and polarization P of the transmitted beam.

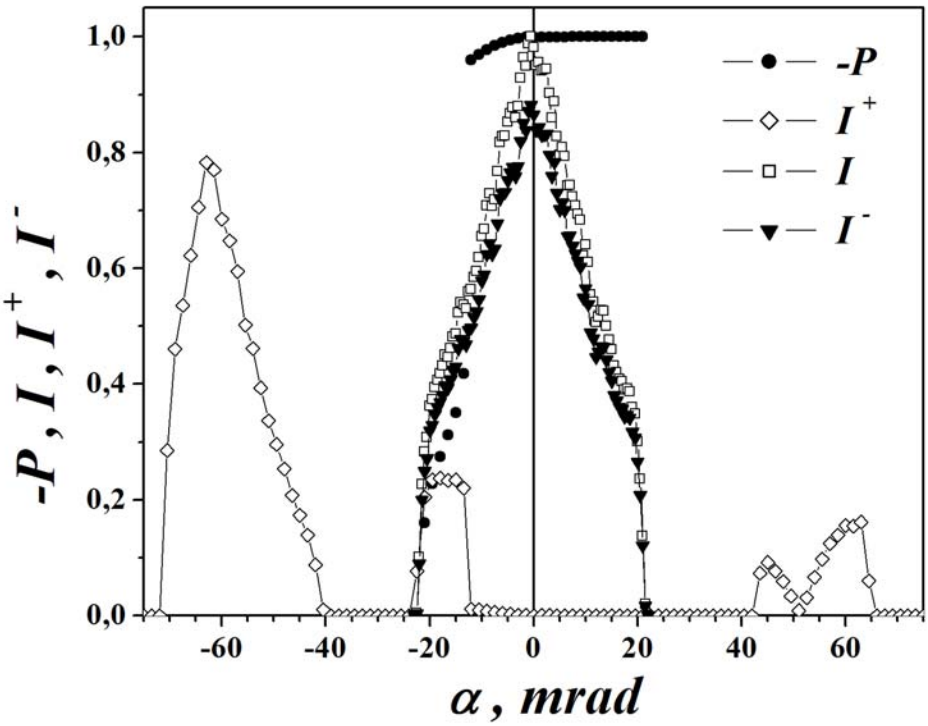

Figure 6. Same as in Fig. 5, but for the second polarizer and for $\lambda = 12.5$ Å.

Calculated wavelength dependencies are shown in Figs. 7 and 8 of polarization P and transmission coefficient T^- (in which the absorption in silicon is taken into account) of neutrons of (-) spin component for the first and the second polarizers, respectively. As it is seen from the Fig. 7, T^- (curve 4) is large and it decreases from 0.9 to 0.8 upon wavelength decreasing from $\lambda = 4.5$ Å to $\lambda = 9.5$ Å. Curves 1, 2 and 3 for P are shown in Fig. 7 are obtained for angular divergences of the beam at the exit of polarizer of 8 mrad ($\pm$ 4 mrad), 10 mrad ($\pm$ 5 mrad) and 12 mrad ($\pm$ 6 mrad), respectively. As it is seen from these dependencies, the polarization is better than -0.99 in the whole spectral range $\lambda = 4.5 \div 10$ Å and for $\lambda = 5.5 \div 10$ Å for the divergence of 8 mrad and 12 mrad, respectively.

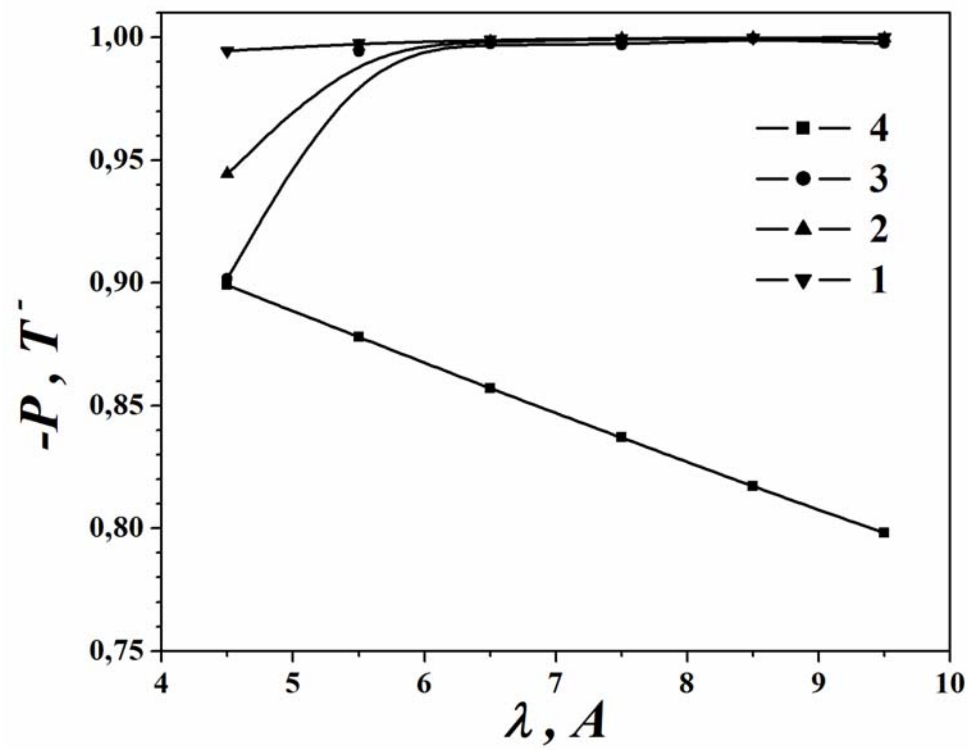

Figure 7. Calculated wavelength dependencies of polarization P (curves 1-3) and transmission coefficient T^- (curve 4) (in which the absorption in silicon is taken into account) of neutrons of (-) spin component (curve 4) for the beam transmitted through the first polarizer. Curves 1, 2 and 3 are obtained for angular divergences of the beam at the exit of polarizer of 8 mrad ($\pm$ 4 mrad), 10 mrad ($\pm$ 5 mrad) and 12 mrad ($\pm$ 6 mrad), respectively.

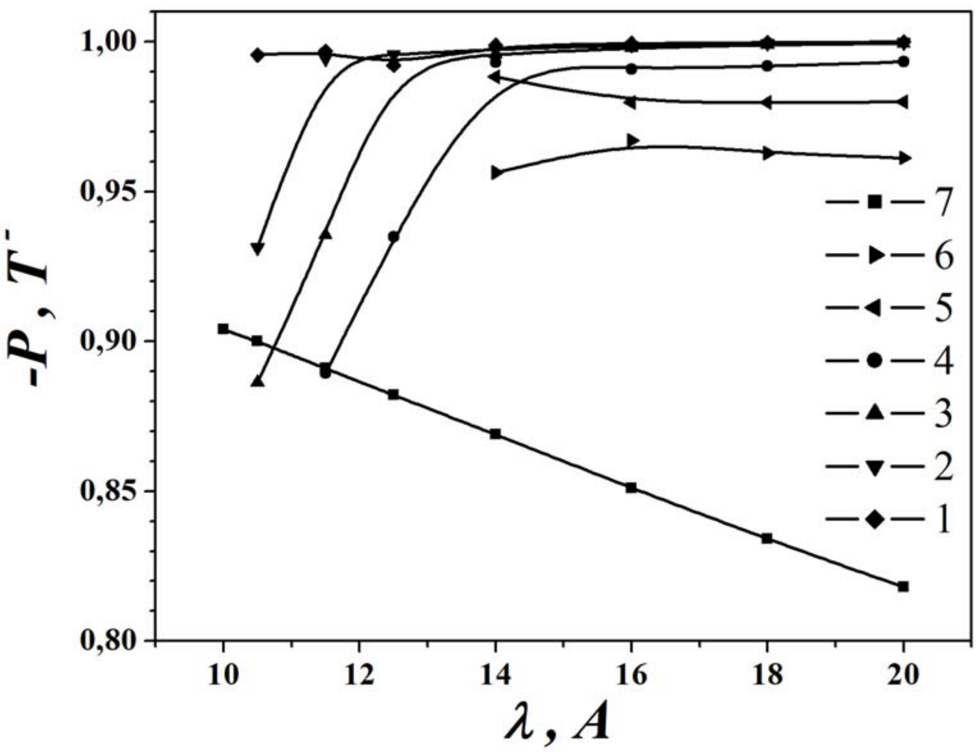

Figure 8. Calculated wavelength dependencies of polarization P (curves 1-6) and transmission coefficient T^- (in which the absorption in silicon is taken into account) of neutrons of (-) spin component (curve 7) for the beam transmitted through the second polarizer. Curves 1, 2, 3, 4, 5, and 6 are obtained for angle divergences of the beam at the exit of polarizer of 12 mrad ($\pm$ 6 mrad), 18 mrad ($\pm$ 9 mrad), 24 mrad ($\pm$ 12 mrad), 30 mrad ($\pm$ 15 mrad), 33 mrad ($\pm$ 16.5 mrad), and 36 mrad ($\pm$ 18 mrad), respectively.

As it is seen from Fig. 8, the transmission coefficient T^- (curve 7) is also high in the second polarizer. It decreases from 0.905 to 0.82 upon wavelength increasing from $\lambda = 10.5$ Å to $\lambda = 20$ Å. Six curves for P are shown in Fig. 8 found for α =12 mrad ($\pm$ 6 mrad), 18 mrad ($\pm$ 9 mrad), 24 mrad ($\pm$ 12 mrad), 30 mrad ($\pm$ 15 mrad), 33 mrad ($\pm$ 16.5 mrad), and 36 mrad ($\pm$ 18 mrad). As it is seen from these dependencies, the polarization is better than -0.99 in the whole spectral range $\lambda = 10.5 \div 20$ Å, at $\lambda = 11.5 \div 20$ Å, at $\lambda = 12.5 \div 20$ Å, and at $\lambda = 14 \div 20$ Å for the divergence of 12 mrad, 18 mrad, 24 mrad, 30 mrad, respectively. The absolute value of polarization of the transmitted beam decreases (remaining, however, quite high) upon further increasing of the angle divergence. For example, $P = -0.98 \div -0.99$ and $P = -0.95 \div -0.97$ for the range $\lambda = 14 \div 20$ Å and angle divergences of 33 mrad and 36 mrad, respectively. For solution of many physical problems in which the small polarization decreasing at $\lambda = 14 \div 20$ Å is inessential, it is possible to substantially increase the intensity of the beam incident on sample by tuning the collimator before the sample on the divergence of 33 - 36 mrad.

4. Discussion and Conclusions

As it follows from the above consideration, basic parameters (P and T^-) of the suggested compact transmission neutron supermirror polarizer (kink polarizer) are high. T^- = 0.8 – 0.9 for both polarizers and for each wavelength range. Polarization P is very high. P is better than -0.99 for both polarizers for wavelength range $\lambda = 4.5 \div 10$ Å at the beam divergence of 8 mrad and for wavelength range $\lambda = 12.5 \div 20$ Å at the beam divergence of 24 mrad. That means that the basic parameters (P and T^-) of the suggested kink polarizer exceed those of widely used transmission neutron supermirror polarizer V-cavity whereas its length (including its magnetic system) is more than 30 times smaller! Besides, its fabrication and operation in experiment are substantially simpler.

Let us compare the suggested polarizer (kink polarizer) with the above mentioned solid state bender [12]. For the accurate comparison, polarizing coating with m = 2.3 should be used instead of that with m = 2 and silicon plates of the width 0.16 mm instead of 0.3 mm. We obtain after a calculation using the above formulas that the length of the first and the second polarizer is 20.7 mm and 8.8 mm, respectively. Then, the first polarizer is 2.6 and 3.9 times as small as the bender [12] and the solid state S-bender [13], correspondingly! For the wavelength of 4.5 Å, the transmission coefficient T^- increases from 0.9 to 0.96. The beam divergence with the polarization P > 0.99 remains 8 mrad.

Thus, the beam polarization at the exit of the suggested polarizer is not worse than that in the above considered solid state benders [12, 13]. At the same time, the divergence of the beam with large polarization is more than two times smaller that leads to the luminosity reduction. On the other hand, the length of the suggested polarizer is 2.6 times as small as that of the considered polarizer that increases the transmission.

The polarization is comparable in all the considered facilities, the transmission is higher for the kink polarizer but its angle divergence is several times smaller than that in the solid state benders. At the same time, the length of the suggested polarizer is 2.6 and 3.9 times smaller than those of considered benders.

When using such benders [12, 13] for neutrons with wavelengths greater than 10 Å the transmission coefficient for them becomes even smaller compared to kink polarizer. In order to reduce these losses can be reduced length benders, but them be bent with a large beam cross-section becomes difficult. There is no such problem in the kink polarizer.

It should be noted also that the main parameters of the suggested kink polarizer meet the requirements for the transmission polarizer in SANS-2 facility at reactor PIK (National Research center “Kurchatov Institute”, Russia).

5. Acknowledgements
The work was supported by the Federal target program of Ministry of Education and Science of Russian Federation (project No. RFMEFI61614X0004).

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