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NEUTRON SCALES

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Materials with magnetic anisotropy are widely used nowadays. The neutron is a very suitable instrument for studying such materials because it possesses the magnetic moment and has a high penetrability.

In the reported investigation a change in the sign of the difference between the glancing angles of the neutron beam transmitted through a magnetic noncollinear layer and the incident neutron beam on the sample caused by a change of an external magnetic field is observed. The measurements were conducted on the spectrometer of polarised neutrons SPN-1 at the IBR-2 reactor in Dubna. The investigated sample is a Co magnetic film (600 Å) on a glass substrate. The sample dimensions are $100\times50\times5$ mm^3. The external magnetic field is applied at the angle 80^0 to the sample plane. The neutron beam is refracted in the glass after it is transmitted through the magnetic film.

The Co layer plays the role of a spin flipper. At transmission through it the initial state of neutrons "+" with a spin projection in the magnetic field direction changes, with some probability, into the state "-" with a spin projection opposite to the field direction. For the glancing angle θ of the refracted neutron beam in the state "-" the following relation holds:

$$\theta^2=\theta_i^2-[U-12.06\cdot H]\cdot\lambda^2/81.799 ,$$

where θ_i (mrad) is the glancing angle of the incident neutron beam on the sample; U (neV) is the nuclear potential of the nonmagnetic layer; H (kOe) is the external magnetic field strength; λ (Å) is the neutron wavelength. As the external magnetic field increases the medium changes into a less optically dense one (supposed that U>0). When the nuclear potential of the nonmagnetic layer becomes twice as large as its magnetic potential, neutrons propagate in it without refraction (and this is true for any wavelengths and glancing angles). The nuclear potential of the medium is thus "weighed" using an external magnetic field. This constitutes the principle of the neutron scales.

Figure 1 illustrates the neutron wavelength dependence of the glancing angle of the transmitted beam for different magnetic field values. As the external magnetic field increases the glancing angle of the refracted beam increases to a value larger than the glancing angle of the incident beam (3.7 mrad).

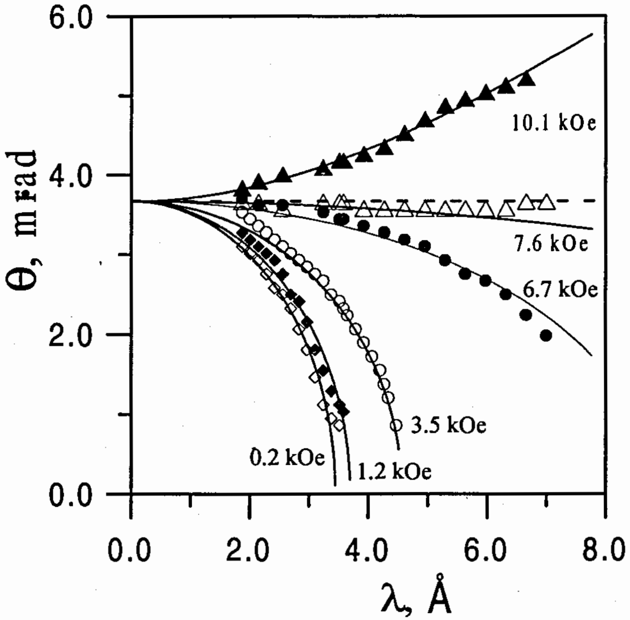

Fig.1. The neutron wavelength dependence of the glancing angle of the transmitted beam for the magnetic field values 0.2 ; 1.2 ; 3.5 ; 6.7 ; 7.6 and 10.1 kOe.

Figure 2 illustrates the difference of squared glancing angles of the transmitted and incident on sample neutron beams as a function of an external magnetic field for different neutron wavelengths. It is seen that all straight lines intersect in one point where the field is H=7.9±0.2 kOe. The nuclear potential U=95.3±2.4 neV corresponds to it. The accuracy of nuclear potential determination depends on the angular resolution of the spectrometer, the accuracy of external magnetic field determination and the statistical error of neutron counts.

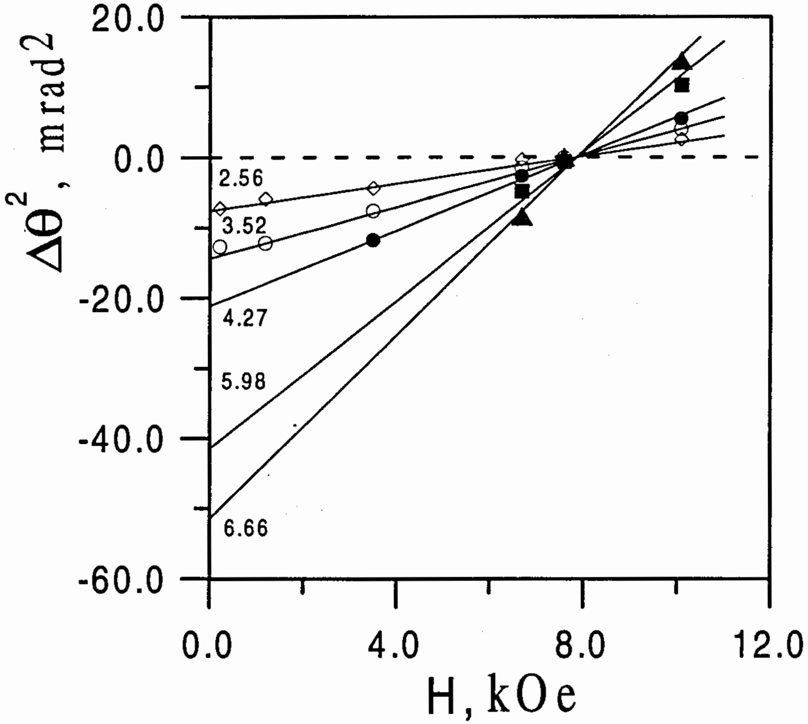

Fig.2 . The difference of squared glancing angles of the transmitted and incident on sample neutron beams as a function of an external magnetic field for the values of neutron wavelength 2.56 ; 3.52 ; 4.27 ; 5.96 and 6.66 Å .

Estimates show that the reported method makes it possible to determine the nuclear potential of the medium with an accuracy of the order $\Delta U/U \approx 10^{-4}$. The method can be used to determine the nuclear potential of any sign as well as the potential of a magnetic medium that plays the role of a neutron spin flipper.

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Нейтронные весы

Исследован эффект изменения знака разности углов скольжения падающего и пропущенного через магнитно-неколлинеарную среду нейтронных пучков в зависимости от величины напряженности внешнего магнитного поля. Эффект использован для определения ядерного потенциала немагнитного слоя.

Работа выполнена в Лаборатории нейтронной физики им. И.М.Франка ОИЯИ.

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Neutron Scales

The effect of a change in the sign of the difference between the glancing angle of the incident neutron beam and the glancing angle of neutrons transmitted through a magnetic noncollinear medium is investigated as a function of the external magnetic field value. The effect is used to determine the nuclear potential of the nonmagnetic layer.

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

Communication of the Joint Institute for Nuclear Research. Dubna, 1998