NEUTRON MIRROR SUPERPOLARISER: PRINCIPLE AND CALCULATION

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Polarised neutrons are used in different methods with polarisation analysis /1—3/. Polarising mirrors and supermirrors are widely used as neutron beam polarisers and analysers /4—8/. In order to utilise the high quality surface of glass in fabricating polarising mirrors an antireflecting underlayer /4/ is necessary on which a ferromagnetic film is evaporated. The composition of the ferromagnetic is chosen so as to make the nuclear (ϱ_N) and magnetic (ϱ_M) coherent scattering length densities equal. In the latter case no «spin-down» neutron reflexion from the ferromagnetic film occurs and polarising properties of the mirror are entirely determined by the antireflecting underlayer.

The beam polarisation by a mirror is equal to

$$P = \frac{R_+ - R_-}{R_+ + R_-} ,$$

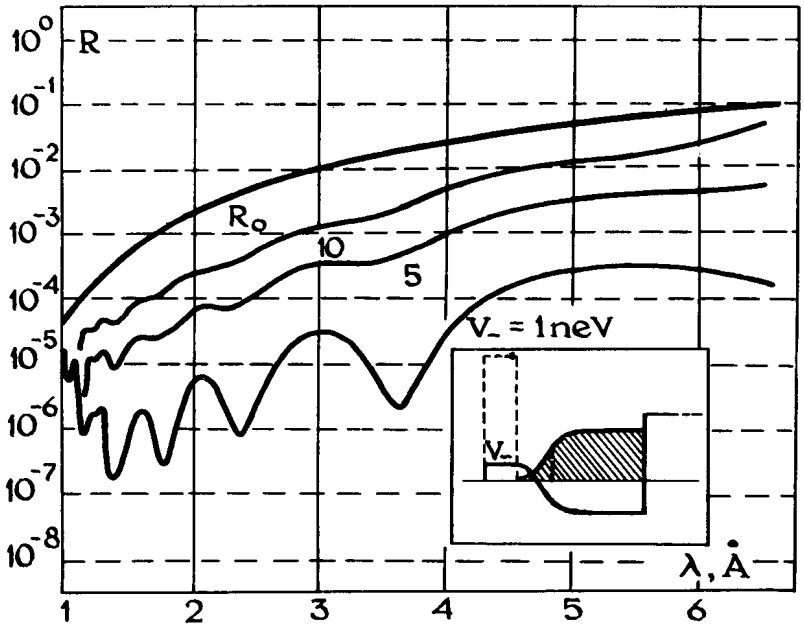

Fig. Calculated spin-down neutron reflectivities (R_) for the grazing angle 10 min from a homogeneous film. 1200 Å thick with the potential V_ of given values, on an antireflecting underlayer with the transition layer 4000 Å thick on basis of TiGd30 alloy. For comparison the reflectivity from a usual coating is shown (R_0). Note: R_+= for spin-up neutrons with λ>1.6 Å. The principle of the superpolariser is illustrated in the set-in figure. The dashed line shows the potential of the ferromagnetic film for spin-up neutrons. The imaginary part of the underlayer potential is cross-hatched (the real part is considered to be negative)

where R_+ and R_- are reflectivities of «spin-up» and «spin-down» neutrons, accordingly. When $R_+ >> R_-$, this polarisation $P=1-2R_-/R_+$. An increase in the polarisation rate R_+/R_- means an increase in the signal/background ratio and in the resolving power.

A smoothing of the real and imaginary parts of the optical potential can be shown, by calculation, to significantly diminish the reflexion from the underlayer /9/. Given a high efficiency antireflecting underlayer, the main factor determining the polarisability of a mirror is the decompensation of ϱ_N and ϱ_M. A preliminary fitting of experimental data on reflexion from a ferromagnetic film (considered to be homogeneous) on a usual underlayer yields the potential for «spin-down» neutrons $V_- < 10$ neV. The interference maxima of the reflectivity can be decreased by reducing the reflexion from the second boundary of the ferromagnetic film through varying the real part of the transitory absorbing layer potential not from 0 but from the value V_. Reflectivities calculated for this specific case (fig.) are of the same order of magnitude with those in the case of a semi-infinite medium with the potential $V=V_-$ where only one boundary «works».

The calculations thus show that there is a possibility to make neutron mirrors significantly exceeding in polarising efficiency those used nowadays. The main technical problem to be resolved in making a high efficiency antireflecting layer is the «dilution» of an absorbing material with a non-absorbing one so as to produce a smooth transition from one to the other.

The other problem calling for a separate study is the influence of various imperfections of the ferromagnetic film on the polarising efficiency of the mirror.

For further details see /9/.

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