Neutrons exhibit total reflection characteristics in a manner analogous to x radiation. If a beam of x rays is incident on a polished surface at a glancing angle, the beam is totally reflected. Most substances have indices of refraction for x rays very slightly less than unity. The index of refraction is closely related to the scattering properties of the substances since the interference of scattered x rays and incident x rays is responsible for the resulting wave transmitted in the substances. The change of phase in the transmitted wave can be described most conveniently in terms of wave velocity change or a refractive index. The same phenomena occur for neutrons incident at glancing angles on a polished surface. The index of refraction for neutrons is also very close to unity. This means that a converging lens for neutrons would have to bulge very much along the axis to be effective if it were made of substances where the refractive index is slightly greater than unity. For substances in which the refractive index is less than unity, a converging lens would look like the diverging lens of optics, that is, very thin close to the axis and thick at distances far from the axis. While these lenses are possible in principle, the fact that the refractive index is always very close to unity makes neutron lenses impractical.

PROBLEMS

1. Given $R = 0.282 \times 10^{-12}$ cm (the classical electron radius) and a depth of a rectangular potential well of 10.8 Mev (the singlet state of the deuteron) and of 19.7 Mev (triplet state), answer the following questions concerning the scattering of neutrons by protons.

   1. Are there any bound states in each of these cases?

   2. What is the value of "a"?

   3. What is the average cross section for low velocity neutrons in hydrogen?

2. For NaCl [using the (001) planes only] make a table of the λ reflected (1st and 2nd order) at the following various values of angle $\theta = 1, 2, 3, 4, 5, 10, 20, 30, 40°$. Calculate the neutron energy in ev for each λ. What is the relative intensity of first and second order beams, assuming a Maxwell distribution ($T = 300°K$) for the neutrons?

3. Show that if a continuous distribution of neutrons impinges on a microcrystalline substance where $M < M_o$, that the scattered intensity is of the order of that expected from a noncrystalline substance of the same number of atoms for all energy neutrons. Use the fact that the resolution of a microcrystal reflecting neutrons of wavelength λ according to the Bragg formula is given by $\delta\lambda/\lambda \sim 1/M$.

a-93-5