The curve for scattering in hydrogen (paraffin) shown in Figure 18 exhibits a fairly constant cross section of 21 barns at low neutron energies. However, at very low neutron velocities, there is a sudden increase of σ_s. This is explicable in terms of the variation of μ^2. For neutrons scattered from hydrogen, μ is half the neutron mass *except* where the relative neutron-proton velocity is too small to provide sufficient energy to free the hydrogen (bound to the paraffin) or excite the molecule. In this latter instance, which obtains for very slow neutrons, the hydrogen bound in the large molecule has an effective mass that is very large. Thus

$$\mu = \tfrac{1}{2} \text{ for } E_n > \text{ binding energy of H to paraffin}$$

$$\mu = 1 \text{ for } E_n \ll \text{ binding energy of H to paraffin}$$

So that the Γ_n will stand in the ratio of the squares of μ, or 1:4. This will increase the scattering cross section for very slow neutrons. In Figure 18, it is seen that experiment confirms that this increase is by a factor of 4 so that the neutron scattering cross section (measured in chilled paraffin*) is about 80 barns. This result may be stated as follows. *The scattering cross section for slow neutrons incident on bound protons is four times that for free protons.*

5.3 SCATTERING BY A POTENTIAL

In cases where resonance effects are negligible, the problem of elastic scattering of neutrons can be treated by considering the target nucleus to be replaced by a potential well. The analysis, then carried through by the usual methods of Schroedinger theory, turns out to yield results valid for thermal neutrons scattered by many elements. It is possible to determine accurate information on σ_s even though the shape of the potential is not known with any certainty.

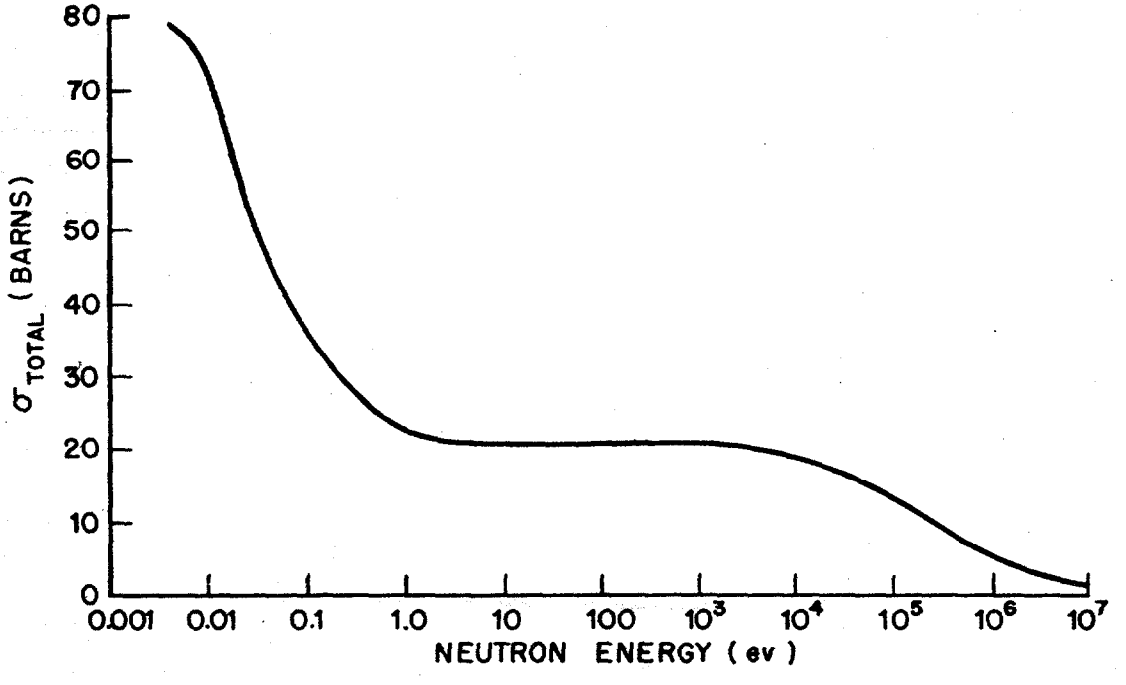

Figure 18. Hydrogen Cross Section [Rev. Modern Phys. 19:260 (1947)].

*Also measured using graphite filter, See Phys. Rev. 70:815 (1946).

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