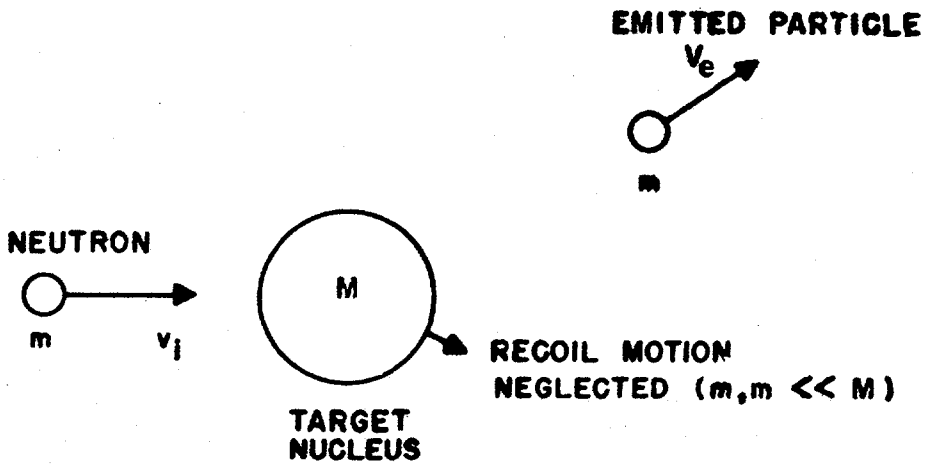

Figure 6. Absorption process.

Inelastic Scattering

Consider a neutron of mass m incident on a nucleus of mass M. If the target nucleus is not considered to be very heavy compared to the neutron then all variables should be referred to the center of gravity system. In this case the neutron mass must be replaced by its "reduced mass" $\mu = mM/(m + M)$. (For $M/m >> 1$ this reduces to m so that center of gravity and laboratory systems are approximately the same.) Suppose the first excitation level of the target nucleus is at an energy W above the ground state. Then if the neutron has a kinetic energy $\mu v_i^2/2 < W$ (center of gravity system) no inelastic scattering can take place. But if $\mu v_i^2/2 > W$ and the nucleus is excited to this level, the kinetic energy of the outgoing neutron after the collision will be

$$(\mu v_e^2/2) = (\mu v_i^2/2) - W$$

so that the cross section becomes

$$\sigma = M' \frac{(\mu v_e)^2}{v_e} \frac{1}{v_i} = M' \mu^2 (v_e/v_i) = M' \mu^2 \sqrt{1 - \frac{2W}{\mu v_i^2}}$$

Writing W as $\mu v_o^2/2$ with v_o the threshold velocity for excitation of the nucleus to the energy W makes it easier to see how the cross section might be expected to behave near the threshold.

$$\sigma = M' \mu^2 \sqrt{1 - (v_o/v_i)^2}$$

$$= M' \mu^2 \sqrt{(v_i + v_o)/v_i} \sqrt{(v_i - v_o)/v_i}$$

For $(v_i - v_o)/v_i << 1$ (near the threshold) the cross section is approximately $M' \mu^2 \sqrt{(2/v_i)(v_i - v_o)}$ showing that near the threshold the cross section increases from zero as the square root of the excess velocity, provided M' can be considered constant. Since

a-93-19