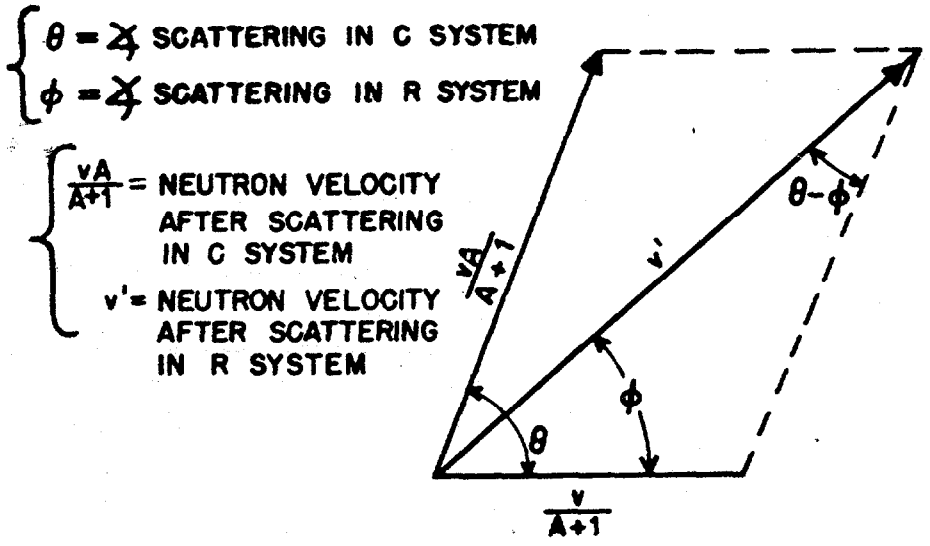

Figure 29. Neutron Scattering in laboratory (R) system.

It should be noted that although equation (6-2) is the ratio of the kinetic energies observed in the laboratory system, nevertheless, the angle θ is the angle of scattering as observed in the center of gravity system. This could be expressed in terms of the laboratory scattering angle ϕ by means of equation (6-1). However, since we are going to want to average over all angles, we will keep the C system scattering angle, as averaging in the C system is relatively simple. In fact, for isotropic scattering, the average of the cosines of θ is zero:

$$(\cos\theta)_{av} = \left[\int_0^{\pi} \cos\theta \, 2\pi \sin\theta \, d\theta\right] / \left[\int_0^{\pi} 2\pi \sin\theta \, d\theta\right] = 0 \qquad (6\text{-}3)$$

On the other hand, the average of the cosine of the laboratory scattering angle is not equal to zero but is a positive number, showing that the colliding particles have a tendency to preserve their direction of motion. From equation (6-1), it follows that:

$$\cos\phi = 1/\sqrt{1+\tan^2\phi} = \frac{A\cos\theta + 1}{\sqrt{A^2 + 1 + 2A\cos\theta}}$$

Averaging the $\cos\phi$ as before:

$$(\cos\phi)_{av} = \frac{\int_0^{\pi} \cos\phi \cdot 2\pi \sin\theta \, d\theta}{\int_0^{\pi} 2\pi \sin\theta \, d\theta} = \int_0^{\pi} \frac{(A\cos\theta + 1)\sin\theta \, d\theta}{2(A^2 + 1 + 2A\cos\theta)^{\frac{1}{2}}} = \frac{2}{3A} \qquad (6\text{-}4)$$

As was expected, the average of the cosine is greatest for neutron collisions with lighter nuclei; that is, the tendency to keep going in the original direction is greatest when the target nucleus has the least mass.

a-93-56