CHAPTER VI

THE SLOWING DOWN OF NEUTRONS

6.1 THE CHANGE OF DIRECTION AND ENERGY UPON COLLISION

When a neutron is elastically scattered by a nucleus, the nucleus being initially at rest, generally there is a transfer of kinetic energy from the neutron to the nucleus. If the struck nucleus is hydrogen, then the neutron will lose of the order of half its energy in the collision. Successive collisions will, on the average, continue this process, so that a 1 Mev neutron becomes thermal (0.025 ev) in about 24 collisions.

In this chapter, we shall consider in detail the nature of this slowing down process. It will be found that classical collision theory is applicable and leads to results in agreement with experiment. As in the classical problems of colliding bodies, it is convenient to set up two frames of reference:

The laboratory system (R system) - In this system, the frame of reference is determined by considering the target body at rest before the collision.

The center of gravity system (C system) - In this the frame of reference is determined by considering the center of gravity of target and projectile at rest.

In the latter, it is apparent that we are looking at the assemblage of colliding bodies as a whole and considering its center of gravity as stationary. It is important to note that all *experimental measurements* made of nuclear collisions use the *laboratory system* of reference. On the other hand, practically all *laboratory system* of reference. On the other hand, practically all *theoretical calculations* are made in the *center of gravity system*. We shall see that the C system affords a view of things that is basically simpler than that of the R system.

Consider in the R system the collision of a neutron (mass = 1)of velocity v with a nucleus of mass A, initially at rest. Since the total mass of the system of colliding particles is A + 1 and the initial neutron momentum is $1 \cdot v$, it follows that the velocity of the center of gravity (as seen in the R system) is $v/(A + 1)$. The velocities of the nucleus A and the neutron relative to the center of gravity are $v/(A + 1)$ and $vA/(A + 1)$, respectively. These velocities are in opposite directions, so that the total momentum of the system with respect to the center of gravity is zero. After the collision, the magnitudes of the velocities are uncahnged, but the directions of motion are along a different line. (see Figure 28). The magnitudes must remain unchanged, since the total momentum with respect to the center of gravity must remain zero. The change in direction will depend upon the exact nature of the collision. If θ is the angle between the initial direction and scattered direction (in the C system), then $\theta = 0$ means the collision was "glancing" while $\theta = \pi$ means it was "head-on".

It is apparent that an observer in the C system would see the two colliding bodies initially heading for each other along a single straight line, with the heavier body moving more slowly. After the collision, the C system observer would see the two bodies moving away in diametrically opposite directions, with unchanged velocities. The C system observer would say that the collision process was *isotropic* if all angles (θ) between "before" and "after" directions of motion were equally probable. As the C system has no preferred direction of motion (center of gravity at rest), we adopt the same terminology and call the *scattering isotorpic when all values of θ are equally probable.*

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