4.2 NEUTRON RESONANCES, LEVEL SPACING

The quantity M' in equation (4-1) depends upon certain matrix elements H as described in section 2.4. These matrix elements in turn depend upon the possible states of the intermediate or compound nucleus in such a way that when the sum of the incident particle's kinetic energy and binding energy is equal (or nearly equal) to the energy of some excited state of the compound nucleus then the factor M' becomes large resulting in a peak in the absorption cross section for this particular kinetic energy of the incident particle. When the particle's kinetic energy is such that the total energy available to the compound nucleus is different from any energy corresponding to an excited state of the compound nucleus then the factor M' is relatively constant for variation in incident particle energy.

Putting these observations symbolically the general nuclear process can be written:

$$A + P \rightarrow C \rightarrow B + R \tag{4-5}$$

A = initial (target) nucleus
P = incident particle
C = compound nucleus
B = residual (recoil) nucleus
R = emitted particle

with the energy relations:

$$\text{(Conservation of Energy)}\quad W_A + W_P + E_P = W_B + W_R + E_R$$

$$\text{(Definition of } E_{Pr}\text{)}\quad W_A + W_P + E_{Pr} = W_{Cr} \tag{4-6}$$

W_A = internal energy of initial nucleus
W_P = internal (binding) energy of incident particle
E_P = kinetic energy of incident particle
W_B = internal energy of residual nucleus
W_R = internal (binding) energy of emitted particle
E_R = kinetic energy of emitted particle
E_{Pr} = kinetic energy of incident particle when that kinetic energy is just equal to that necessary to bring the compound nucleus to an excited state characterized by internal energy W_{Cr}
W_{Cr} = internal energy of compound nucleus C at resonance r.

Perhaps the best way to appreciate the significance of equations (4-5) and (4-6) is to consider the (n,γ) process. A is the target nucleus, P the neutron, B the residual nucleus (isotopic to A but with one unit increase in mass number), and R the emitted gamma photon. Assume A is in the [illegible] corresponding internal energy W. The energy level system of the initial state,