2^{nd} Physics of Nuclei and Particles Exercises

Physics Course, 2º Semester

1. The Doppler broadening of a Breit-Wigner resonance cross section is the process where the resonance peak get larger as the temperature of the target increases. The zero-temperature radiative capture cross-section illustrated in Fig.1 is the intrinsic cross-section to which the Breit-Wigner formula is immediately applicable. The excited state has spin 12, and there are two significant decay channels; the dominant one is γ-emission and the other is neutron emission. Estimate the relative probability of neutron radiative capture at resonance, and estimate the elastic neutron scattering cross-section at resonance.

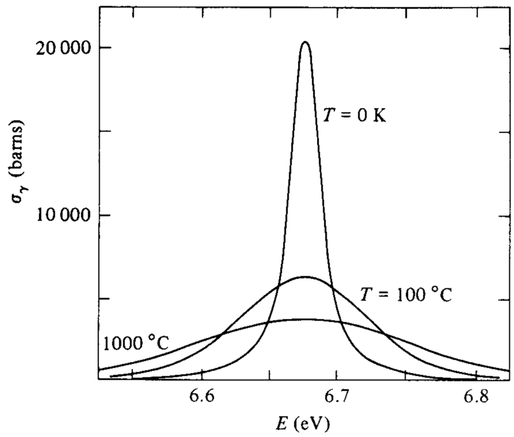

Figure 1) The Doppler broadening of the Breit–Wigner cross-section σ_γ for neutron radiative capture by ^{238}U. The resonance is at 6.67 eV and its natural width is 0.026 eV.

2. A nucleus (*j=0*) has a neutron resonance at 65 eV and no other resonances nearby. For this resonance, Γ_n = 4.2 eV, Γ_γ = 1.3 eV and Γ_α = 2.7 eV, and all other partial widths are negligible. Find the cross-section for (n, γ) and (n, α) reactions at 70 eV.

3. Neutrons incident on a heavy nucleus with spin *j*=0 show a resonance at an incident energy E_R = 250 eV in the total cross-section with a peak magnitude of 1,300 barns, the observed width of the peak being Γ = 20eV. Find the elastic partial width of the resonance.

4. a) A neutron with kinetic energy T_0 (non-relativistic) collides elastically with a stationary nucleus of mass M. In the centre-of-mass system the scattering is isotropic. Show that on average the neutron energy after the collision is

$$T_1 = \frac{M^2 + m_n^2}{(M + m_n)^2} T_0$$

b) Consider the nuclei of a graphite moderator to be pure ^{12}C, with a number density of 0.9×10^{29} nuclei/m^3. For neutron energies less than 2 MeV the scattering is elastic, with a cross-section approximately constant ~4.5 b.
Estimate (a) the number of collisions required to reduce the energy of a 2 MeV fission neutron to a thermal energy of 0.1 eV, and (b) the time it takes.