Comment on Homework # 4 and # 5

Homework #4: 1. Draw $V_\ell^{eff}(\ell = 0,1,2,3)$ for a Woods-Saxon potential, $V_0 = 425$ MeV, $R_0 = 1.5$ fm and $a_0 = 0.5$ fm. Obtain the binding energies and partial cross sections with $\ell = 0,1,2,3$.

A. Binding energies

Pilsoo had an excellent job for the binding energies for the a square well potential with $\rho = (2ma^2V_0/\hbar^2)^{1/2} = 4.8$ in the Homework 3-3 and obtained them as

ℓ	# of nodes	Binding energies (MeV)
0	0	168.4
0	1	14.0
1	0	110.6
2	0	29.7

We now calculate binding energies of the $p-n$ system in a Woods-Saxon potential, $V_0 = 425$ MeV, $R_0 = 1.5$ fm and $a_0 = 0.5$ fm by using the computer program NEPTUNE. Remember that $\rho = (2mR_0^2V_0/\hbar^2)^{1/2} = 4.8$ gives $V_0 \approx 425$ MeV. We obtain

ℓ	# of nodes	Binding energies (MeV)
0	0	221.1
0	1	36.1
1	0	113.1
2	0	19.5

Pilsoo had a different $a = R_0 = 2.3$ fm instead of 1.5 fm. For this geometry, V_0 gives 180 MeV for $\rho = 4.8$. A Woods-Saxon potential, $V_0 = 180$ MeV, $R_0 = 2.3$ fm and $a_0 = 0.5$ fm yields binding energies as

ℓ	# of nodes	Binding energies (MeV)
0	0	105.0
0	1	9.4
1	0	53.2
2	0	4.5

People find a difficulty in giving a guessed initial value. There is a method for finding the binding energies without guessing the initial values. Please consult a paper by G. H. Choi, M. C. Kyum, and B. T. Kim, New Physics, **34**, 376 (1994).

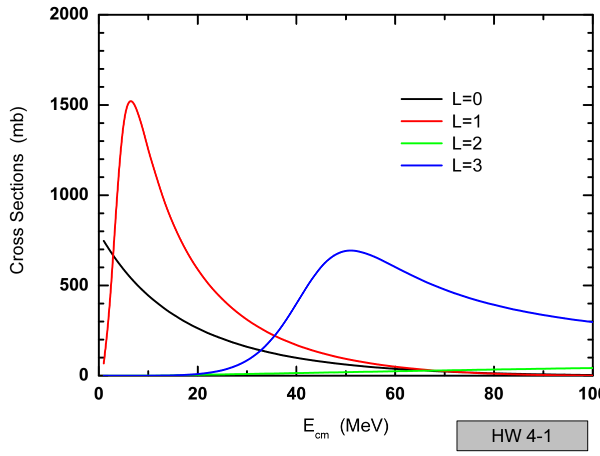

Fig. 1: The partial cross sections for $\ell = 0,1,2,\&3$

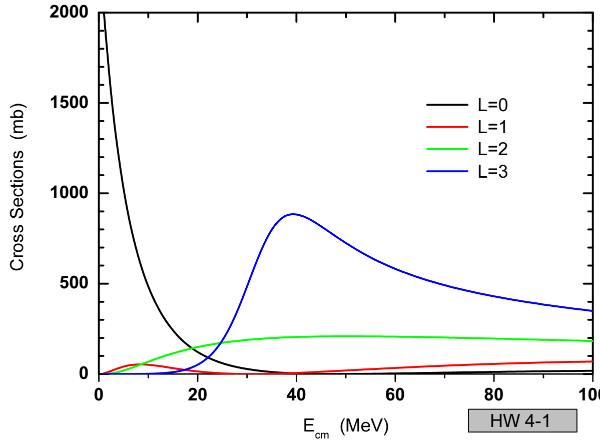

Fig. 2: The partial cross sections for $\ell = 0,1,2,\&3$

B. Partial cross sections

The partial elastic cross sections are not calculated in the program VENUS. Thus one has to modified the program to calculate the partial cross sections

$$\sigma_\ell = \frac{4\pi}{k^2}(2\ell+1)\sin^2\delta_\ell$$

where δ_ℓ is the phase shift due to the nuclear potential.

The modified version of VENUS gives the partial cross sections as Fig.1 in a Woods-Saxon potential, $V_0 = 425$ MeV, $R_0 = 1.5$ fm and $a_0 = 0.5$ fm in terms of E_{cm}.

Fig.2 shows the partial cross sections in a Woods-Saxon potential, $V_0 = 180$ MeV, $R_0 = 2.3$ fm and $a_0 = 0.5$ fm.

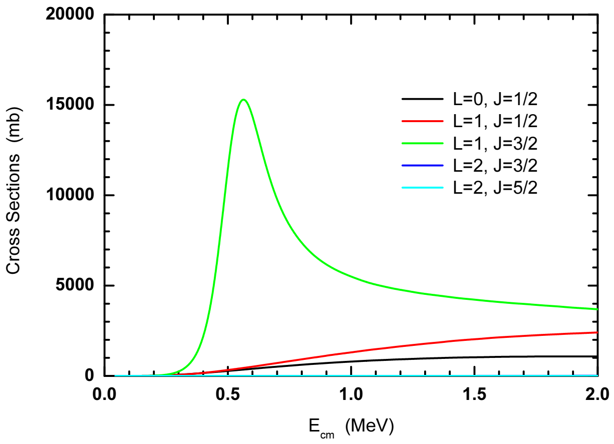

Fig. 3: The partial cross sections for $\ell = 0, 1, \&2$

Homework #5: 3. Obtain the partial cross sections with $\ell = 1$ for a Woods-Saxon potential, $V_0 = 29.84$ MeV, $V_{SO} = -8.24$ MeV, $R_0 = R_{SO} = 2.95$ fm (not reduced) and $a_0 = a_{SO} = 0.52$ fm in the ^{7}Be + p system at energies between 0.1 MeV and 2.0 MeV. (Sorry that the sign of the spin-orbit force is given in the opposite way in the problem!!)

For a charged particle, there is another problem to obtain the partial elastic cross section, since the Coulomb scattering amplitude is not generally decomposed into the partial wave amplitude. However, to investigate resonances for the nuclear potential, you may generate the partial elastic cross sections due to the nuclear potential and may still confirm the nuclear resonance phenomena. Of course, it is not the true partial elastic cross sections which is the square of the sum of the partial Coulomb and nuclear scattering amplitudes.

Fig.3 shows the partial cross sections in the given potential obtained by using the modified VENUS.