PHY982: Nuclear Dynamics

Homework 2 Deadline: 12 Feb 2008

Elastic scattering and optical model

The scattering of a projectile on a target is often approximated into a two body problem with an effective interaction. This interaction $U_{opt}(R)$, usually referred to as the optical potential, contains an imaginary part that takes into account the removal of flux from the elastic channel into other reaction channels.

Consider the elastic scattering of a proton on a target. We will study the elastic scattering of the proton at three different energies $E_{lab} = 5,\ 10$ and 50 MeV. For this purpose you should use the code FRESCO available in '/projects/proj6/phy982/bin'. A manual is available in '/projects/proj6/phy982/man'.

1. Choose a specific target ($A > 40$) and determine the quantum numbers referring to the entrance partition.

2. Copy the file '/projects/proj6/phy982/inputs/example-el.in' into your group directory in '/projects/proj6/phy982/' and modify it according to your specific target. Calculate the elastic scattering corresponding to a pure Coulomb case and introduce the finite size of the target. Make sure that you are including enough partial waves J_{max} in your calculation and that the maximum radius R_{match} ensures the asymptotic behaviour. Compare the angular distributions in the centre of mass for the three energies (file fort.16 contains these cross sections ready for plotting with 'xmgr' which is also in the bin directory).

3. Consulting Perey and Perey, At. Data and Nucl. Data Table 17 (1976) 1, determine adequate nuclear optical potentials and recalculate the elastic scattering taking these into account. Explore, specifically, the effect of the imaginary part. Also, look at the sensitivity to the radius parameter and the diffuseness parameter. Compare these distributions with those calculated in (2) for the various beam energies.

4. Compare the modulus of the S-matrix for each partial wave in the various examples above.

5. For the 10 MeV protons realistic case (both Coulomb and nuclear with absorption) plot the angular distribution for the corresponding inverse kinematics case and compare it with the direct kinematics. Comment the results.

6. Calculate the total elastic cross section, the reaction cross section and the total absorption cross section for the three proton energies including the full effective proton-target interaction.

7. Prepare a report with your results and conclusions. It should not exceed 10 pages.