

Physics 499 Winter 2016

Homework Assignment 3

Kinematics and Simulation of $\pi - N$ scattering

Due February 16th

In this assignment, you will write two programs: One to calculate the center of mass momentum for a general two-particle interaction and, another to simulate the outcome of a scattering experiment.

Problem 1.

Suppose you are interested in a two-body scattering problem where particle 1 collides with particle 2 at rest. After the collision, particle 3 and particle 4 emerge:

$$1 + 2 \rightarrow 3 + 4 \tag{1}$$

- **Your program should input** the masses of the 4 particles: m_1 , m_2 , m_3 , and m_4 . It should also input the laboratory kinetic energy of particle 1. Particle 2 is at rest in the lab frame.
- **Your program should output** the center of mass energy of the system (i.e. the total invariant energy of the system), and the momentum of particle 3 (also 4) in the center of mass frame.

Problem 2.

The experiment will be π^+ particles scattering off of a neutron. The differential cross section is given by:

$$\frac{d\sigma}{d\Omega} = |f_0 + f_1 \cos(\theta)|^2 \tag{2}$$

where f_0 and f_1 are the "s" and "p" amplitudes for orbital angular momentum $l = 0$ and $l = 1$. The angle θ is the angle of the scattered pion in the *center of momentum (or mass)* frame.

Take for the values of f_0 and f_1 to be the following:

$$\begin{aligned} f_0 &= 1.1 + 0.1i \text{ fm} \\ f_1 &= -1.5 + 0.2i \text{ fm} \end{aligned}$$

You should assume a Gaussian scatter of each data point, with a σ of x times the value of the differential cross section. Your program should let the user input the value of x . **Your root program should output a plot of the simulated data for angles between 10° and 160° in increments of 10 degrees.** The horizontal axis should be the scattering angle in units of degrees, and the vertical axis should be the differential cross section in units of millibarns.