Theoretical Mechanics, Spring 2022

Problem Set VIII

Deadline: 6PM of Monday, March 21, 2022

1. **(15%) Elastic scattering.** In the elastic scattering of neutrons by protons ($m_n \simeq m_p$) at relatively low energies, the energy distribution of the recoiling protons in the LAB frame is constant up to a maximum energy, which is the energy of the incident neutrons. Find the angular distribution of the scattering in the CM frame.

2. **Differential scattering cross section (30%).**

   (a) (15%) Consider a fixed force center scattering particles of mass m according to the force law

   $$F(r) = \frac{k}{r^3}. \tag{1}$$

   If the initial velocity of the particles is u_0, show that the differential scattering cross section is

   $$\sigma(\theta) = \frac{k\pi^2(\pi - \theta)}{mu_0^2\theta^2(2\pi - \theta)^2 \sin\theta}. \tag{2}$$

   (b) (15%) Similar to the example discussed in class, show that the differential scattering cross section in terms of the scattering angle θ in the CM frame is

   $$\sigma(\theta) = \sigma(\psi) \cdot \frac{1 + \chi\cos\theta}{(1 + 2\chi\cos\theta + \chi^2)^{3/2}}, \tag{3}$$

   where $\chi \equiv m_1/m_2$.