PY 452: Quantum Physics II   Problem Set 9

Due date: Tuesday, November 24, by 5:00pm

Reading: Please read Griffiths chapter 11, sections 1 & 2.

1. Consider the scattering of a uniform beam of point particles on an immobile spherical obstacle in d dimensions. Show that the ratio of the total backward scattering flux Φ_b to forward scattering flux Φ_f is

$$\frac{\Phi_\mathrm{b}}{\Phi_\mathrm{f}} = \frac{\left(\frac{1}{\sqrt{2}}\right)^{d-1}}{1-\left(\frac{1}{\sqrt{2}}\right)^{d-1}}$$

   Assume that the beam is incident on the scatterer in the $+z$-direction. The forward flux refers to particles that are scattered in a direction with a positive z-component (and vice versa for the backward flux). Notice that there is only backward scattering in one dimension (obvious), predominantly backward scattering in two dimensions, and isotropic scattering in three dimensions. *Hint:* This problem involves almost no calculation with the perspective. Also do the problem for $d = 1$, 2, and 3 first; the case of general d is a bit more ambitious.

2. Griffiths 11.1. This problem asks you to compute the Rutherford cross section. This is classic material that appears in almost all texts of classical mechanics; you may refer to these texts to write the solution. Please also do the following additional part: consider a charged particle of charge $-q$, speed v, and negligible radius that is incident, with impact parameter b, on a uniformly charged spherical particle of radius $R \ll b$ and charge Q. Find the maximum impact parameter so that the incident particle hits the sphere. Comments on the behavior of this impact parameter as $v \to 0$. Note: this additional section involves classical mechanics only.

3. Griffiths 11.4. The problem concerns the low-energy scattering from a delta-shell potential.