Problem Set 3

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Problem 1

a)

Fermions have intrinsic parity +1, and anti-fermions have intrinsic parity −1. The total parity is therefore:

$$\pi = \pi_u \pi_{\bar{d}} (-1)^l = (-1)^{l+1} \tag{1}$$

b)

$$\pi = \pi_f \pi_f (-1)^{l=1} = -1 \tag{2}$$

c)

Verify that the spherical harmonic $Y_1^1 = \sqrt{\frac{3}{8\pi}} \sin\theta e^{i\phi}$ is an eigenfunction of parity with eigenvalue $P = -1$

The parity operator just flips the spatial coordinates. $\hat{P}(\theta, \phi) = (\pi - \theta, \pi + \phi)$

$$\hat{P} Y_1^1 = \sqrt{\frac{3}{8\pi}} \sin(\pi - \theta) e^{i(\phi + \pi)} \tag{3}$$

Using the fact that $\sin\theta = \sin(\pi - \theta)$ and $e^{i\pi} = -1$ we get:

$$\hat{P} Y_1^1 = -\sqrt{\frac{3}{8\pi}} \sin\theta e^{i\phi} = -Y_1^1 \tag{4}$$

Problem 2

a)

- The energy of the particle beam. At very high energies it might seem like the barrier does not exist.
- The type of particle in the beam. If the particles interact very little (like neutrinos), their cross-section will be quite small.
- The efficiency of the detector.
- Density of particle stream and target.