**QFT — assignment 2: the Photoelectric Effect**

1. **the photoelectric effect [Sakurai 2.4]**

(i) Write the decay amplitude for the reaction $H_0\gamma \to e^- p$ where $H_0$ is the ground state of hydrogen. Assume that the outgoing electron is in a plane wave and that the proton is very heavy so that its recoil can be neglected.

(ii) Show that the differential cross section is

$$\frac{d\sigma}{d\Omega} = 32\left(\frac{e^2}{4\pi\hbar c}\right)\left(\frac{\hbar}{mc}\right)\left(\frac{c}{\omega}\right)\frac{1}{(k_f a_0)^5}\frac{\sin^2\theta\cos^2\phi}{[1-(v/c)\cos\theta]^4}. \tag{1}$$

Assume that $a_0 k_f \gg 1$ where $a_0$ is the Bohr radius and choose a coordinate system where the incident photon momentum is along $\hat{z}$ and the polarisation is along $\hat{x}$.

2. **hyperon decay [Sakurai 2.5]**

The phenomenological interaction responsible for radiative hyperon decay, $\Sigma^0 \to \Lambda\gamma$, is taken to be

$$H_{int} = \frac{\kappa\hbar e}{(m_\Lambda + m_\Sigma)c}\tau_{\Lambda\Sigma}\vec{\sigma}\cdot(\nabla\times\vec{A})|_{\vec{x}=0}, \tag{2}$$

where $\tau_{\Lambda\Sigma}$ is an operator that converts a $\Sigma^0$ into a $\Lambda$, leaving the spin unchanged (both are spin 1/2 particles), and $\kappa$ is a dimensionless coupling constant.

(i) Show that the angular distribution of the decay is isotropic, even if the $\Sigma$ is polarised.

(ii) Determine the mean lifetime of the $\Sigma$ in seconds. Take $\kappa = 1$, $m_\Sigma = 1.192$ GeV, and $m_\Lambda = 1.115$ GeV.