# Spin-0 Higgs decays to $\gamma\ \gamma$

- In the $X_0$ rest frame: $\theta$ is the angle of the photon with respect to the z-axis.

- Effective Lagrangian:

$$\mathcal{L}_{\rm eff} = -\frac{\alpha}{8\pi}(\sqrt{2}G_F)^{\frac{1}{2}} I\ F_{\mu\nu}F^{\mu\nu} X_0$$

where $F_{\mu\nu} = \partial_\mu A_\nu - \partial_\nu A_\mu$.

- Decay distribution:(summing over photon polarizations)

$$d\Gamma = \frac{1}{2m_H}\sum |\mathcal{M}|^2 (2\pi)^{-2} d_2(PS).$$

$$d\Gamma/d\cos\theta = \left(\frac{\alpha}{\pi}\right)^2 |I|^2 \frac{G_F m_H^3}{16\sqrt{2}\pi}.$$

# Spin-1 $W$ decays to $e\ \bar{\nu}_e$

- Averaging $|\mathcal{M}|^2$ over $W$-polarizations and summing over the fermion spins,

$$d\Gamma = \frac{1}{2m_W}\frac{1}{3}\sum_{\text{spins}}|\mathcal{M}|^2(2\pi)^{-2}d_2(PS).$$

$$d\Gamma/d\cos\theta = \frac{g^2 m_W}{96\pi}.$$

- Gauge boson polarization vectors:

$$\begin{aligned}\epsilon_0^\mu &= (p/m_W, 0, 0, E/m_W),\\ \epsilon_\pm^\mu &= \frac{1}{\sqrt{2}}(0, 1, \pm i, 0).\end{aligned}$$

where $\epsilon_0^\mu$ is the longitudinal (L) polarization with helicity $h = 0$ and $\epsilon_\pm^\mu$ are transverse (T) polarizations with helicity $h = \pm 1$.

# Spin-1 $W$ decays to $e\,\bar{\nu}_e$

- In the $W$-rest frame

$$\begin{aligned} d\Gamma_{\pm}/d\cos\theta &\sim (1 \pm \cos\theta)^2, \\ d\Gamma_L/d\cos\theta &\sim \sin^2\theta. \end{aligned}$$

where $\theta$ is the angle of the electron with respect to the longitudinal axis.