$$i \frac{d}{dt} \begin{pmatrix} \nu_e \\ \nu_\mu \end{pmatrix} = H_f \begin{pmatrix} \nu_e \\ \nu_\mu \end{pmatrix}$$

$$= H_f U(\theta_m) \begin{pmatrix} \nu_{1m} \\ \nu_{2m} \end{pmatrix}$$

$$i\frac{d}{dt}\begin{pmatrix} v_{1m} \\ v_{2m} \end{pmatrix} = i\frac{dU^{+}(\theta_m)}{dt}U(\theta_m)\begin{pmatrix} v_{1m} \\ v_{2m} \end{pmatrix} + \begin{pmatrix} -\Delta_m & 0 \\ 0 & +\Delta_m \end{pmatrix}\begin{pmatrix} v_{1m} \\ v_{2m} \end{pmatrix}$$

$$\frac{dU^{+}}{dt} = \frac{d}{dt}\begin{pmatrix} \cos\theta_m & -\sin\theta_m \\ \sin\theta_m & \cos\theta_m \end{pmatrix} = \begin{pmatrix} -\sin\theta_m\,\dot{\theta}_m & -\cos\theta_m\,\dot{\theta}_m \\ \cos\theta_m\,\dot{\theta}_m & -\sin\theta_m\,\dot{\theta}_m \end{pmatrix}$$

$$\frac{dU^{+}}{dt}\cdot U = \dot{\theta}_m\begin{pmatrix} -\sin\theta_m & -\cos\theta_m \\ \cos\theta_m & -\sin\theta_m \end{pmatrix}\begin{pmatrix} \cos\theta_m & \sin\theta_m \\ -\sin\theta_m & \cos\theta_m \end{pmatrix} = \dot{\theta}_m\begin{pmatrix} 0 & -1 \\ 1 & 0 \end{pmatrix}$$

$$i\frac{d}{dt}\begin{pmatrix} v_{1m} \\ v_{2m} \end{pmatrix} = \begin{pmatrix} -\Delta_m & -i\dot{\theta}_m \\ i\dot{\theta}_m & \Delta_m \end{pmatrix}\begin{pmatrix} v_{1m} \\ v_{2m} \end{pmatrix}$$

$$\gamma = \frac{|\Delta m|}{|d\theta_m/dt|} = \frac{\Delta m_m^2}{2E}$$

$$\frac{d\theta_m}{dt}$$

$$\Delta m_m^2 \sin 2\theta_m = \Delta m^2 \sin 2\theta$$

$$\Delta_m = \sqrt{\left(\Delta \cos 2\theta - \frac{V_c}{2}\right)^2 + (\Delta \sin 2\theta)^2}$$

$$\sin^2 2\theta_m = \frac{(\Delta \sin 2\theta)^2}{\left(\Delta \cos 2\theta - \frac{V_c}{2}\right)^2 + (\Delta \sin 2\theta)^2}$$

$\gamma_{res} << 1$

$$\frac{\exp\left(-\frac{\pi}{2}\gamma\right) - \exp\left(-\frac{\pi}{2}\frac{\gamma}{\sin^2\theta}\right)}{1 - \exp\left(-\frac{\pi}{2}\frac{\gamma}{\sin^2\theta}\right)}$$

$x \equiv \frac{\pi}{2}\gamma$

$$\frac{\exp(-x) - \exp\left(-\frac{x}{\sin^2\theta}\right)}{1 - \exp\left(-\frac{x}{\sin^2\theta}\right)} \approx \frac{\cancel{-x} - \cancel{1} + \frac{x}{\sin^2\theta}}{\cancel{-}\cancel{1} + \frac{x}{\sin^2\theta}}$$

x small $= \dfrac{-1 + \frac{1}{\sin^2\theta}}{\frac{1}{\sin^2\theta}}$

$\cot^2\theta$

$$\langle \nu_e | \nu(t) \rangle = \sqrt{P_f}\, e^{i\chi_1} \cos\theta \exp\left(\int_1 \cdots\right)$$

$$+ \sqrt{1-P_f}\, e^{i\chi_2} \sin\theta \exp\left(\int_2 \right)$$

$$\left|\langle \quad \rangle\right|^2 \longrightarrow P_f \cos^2\theta + (1-P_f)\sin^2\theta$$

$$+$$