## U02a Fermion Flavor Mixing in the Oscillating Background

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We investigate the effects of flavor mixing on the non-perturbative production of fermions after inflation, *preheating*, considering the system whose action is given by

$$\begin{aligned}\mathcal{S} &= \int d^4x\sqrt{-g}\Big[\frac{1}{2}\partial_\mu\phi\partial^\mu\phi - V(\phi) + i\overline{\psi}_\alpha(\bar{\gamma}^\mu D_\mu - m_\alpha)\psi_\alpha - h_\alpha\phi\overline{\psi}_\alpha\psi_\alpha \\ &\quad + i\overline{\psi}_\beta(\bar{\gamma}^\mu D_\mu - m_\beta)\psi_\beta - h_\beta\phi\overline{\psi}_\beta\psi_\beta - \delta(\overline{\psi}_\alpha\psi_\beta + \overline{\psi}_\beta\psi_\alpha)\Big].\end{aligned}$$

$\bar{\gamma}^\mu$ is the curved-space Dirac matrices, and $D_\mu \equiv \partial_\mu + (1/4)\gamma_{\alpha\beta}\omega_\mu^{\alpha\beta}$ is the spin-1/2 covariant derivative, where $\omega_\mu^{\alpha\beta}$ is the spin connection. We adopt the massive chaotic inflationary scenario and as is predicted by it the background metric is assumed to be flat FRW.

When the eigenvalue of the mass matrix in the flavor basis vanishes, resonant fermion production occurs through the Yukawa coupling. The time dependence of the unitary transformation from flavor eigenstates to mass eigenstates prevents us for regarding the system as merely composed of independent, decoupled two states and when $\delta/\Delta m$ and $\delta/\Delta h$ is small the flavor mixing takes place resonantly like that in *the MSW effect*. The off-diagonal components of the mass matrix in the flavor basis have the effect of shifting the value of $\phi$ when the production occurs. Through either of the two effects it is possible to generate heavy fermions which can be produced only gravitationally in the one field analysis.