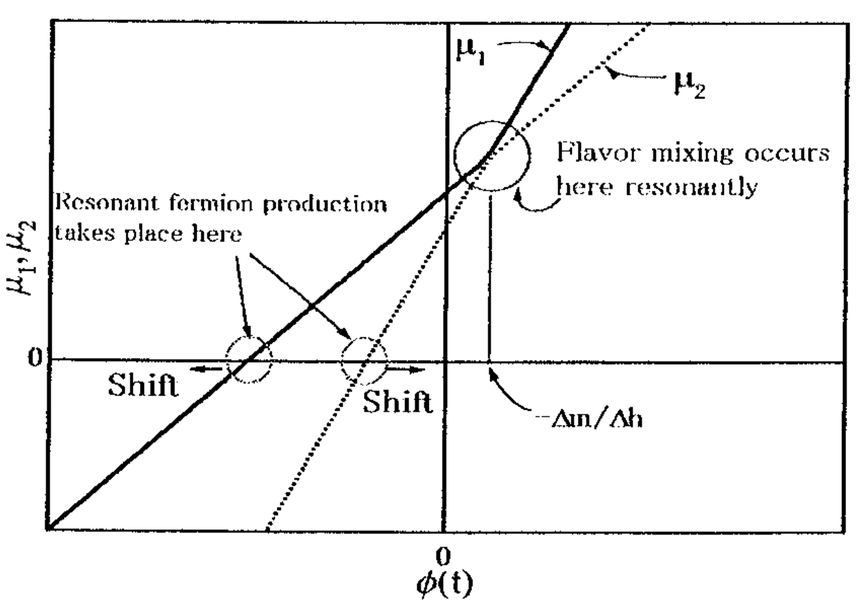
Fermion Flavor Mixing in the Oscillating Background

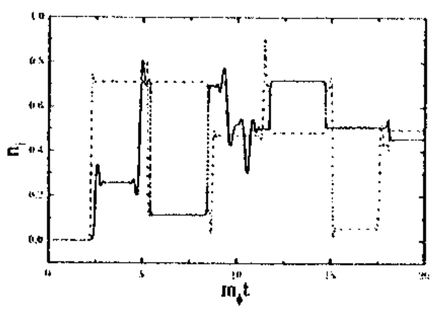
KANAI Tsuneto* and TSUJIKAWA Shinji
Research Center for the Early Universe, University of Tokyo

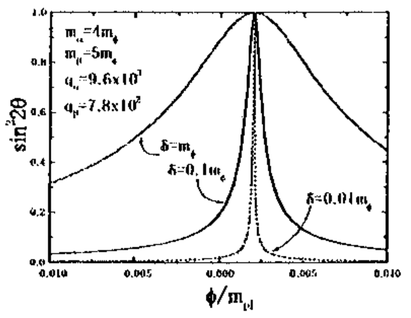
We investigate the effects of flavor mixing on the non-perturbative production of fermions after inflation, *fermionic preheating*, considering the system whose action is given by

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

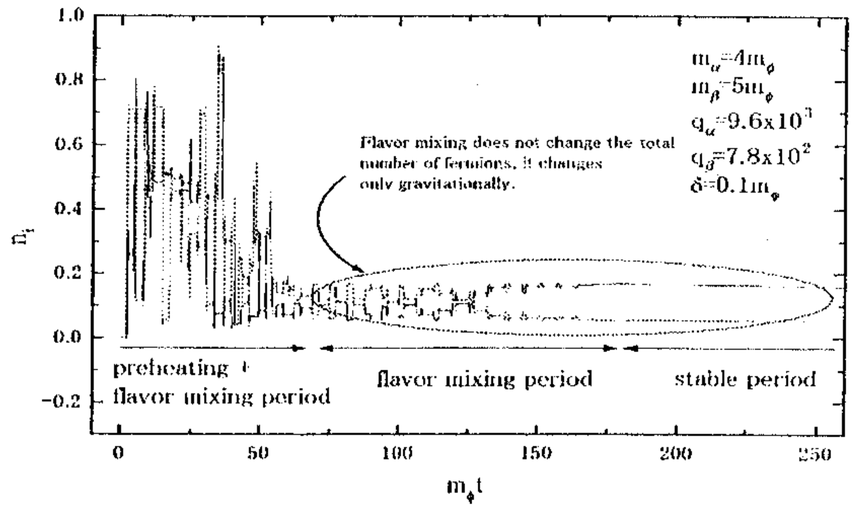
$\bar{\gamma}^\mu$ is the curved-space Dirac matrices, and $D_\mu \equiv \partial_\mu + (1/4)\gamma_{\alpha\beta}\omega_\mu^{\alpha\beta}$ is the spin-1/2 covariant derivative, where $\omega_\mu^{\alpha\beta}$ is the spin connection. We adopt the massive chaotic inflationary scenario and as is predicted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



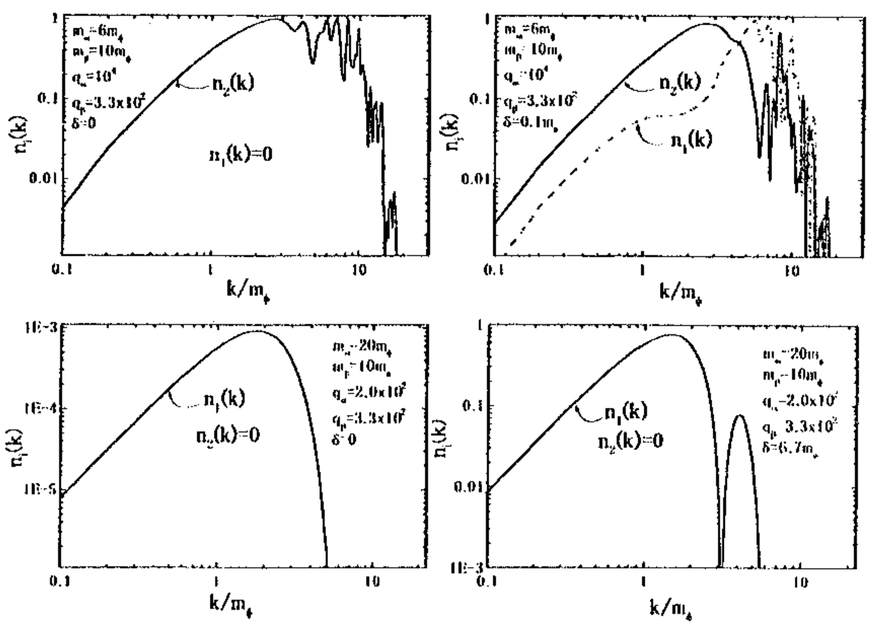




The time dependence of the unitary transformation from flavor eigenstates to mass eigenstates prevents us for regarding the system as merely composed of independent, decoupled two states and when $\delta/\Delta m$ and $\delta/\Delta h$ is small the flavor mixing takes place nonadiabatically like that in *the MSW effect*. When the eigenvalue of the mass matrix vanishes, resonant fermion production occurs through the Yukawa coupling. We propose the previous diagram to understand the situation, and the mixing angle as a function of ϕ is also displayed. The off-diagonal components of the mass matrix in the flavor basis shift the value of ϕ when the production takes place. By the shifting effect or the nonadiabatic *MSW resonance* it is possible to generate the heavy and weakly coupled fermions which can be generated only gravitationally in the one field analysis.



Here we present some integration results. In the above diagram we can understand the situation in which the two kinds of the resonances occur and gradually vanish as the amplitude of the inflaton field decays, and the below four graphs indicate that by taking account of the influence of the flavor mixing superheavy, smaller m/h fermion which may be interesting for the dark matter problem and for the problem of ultra-high energy cosmic rays can be created.



*kanai@resceu.s.u-tokyo.ac.jp