Dirac Leptogenesis in a U(1)' flavor model

Jinrui Huang

In collaboration with Mu-Chun Chen, Will Shepherd

UC Irvine

Pheno 2011 May 9th **arXiv:1105.xxxx**

Introduction

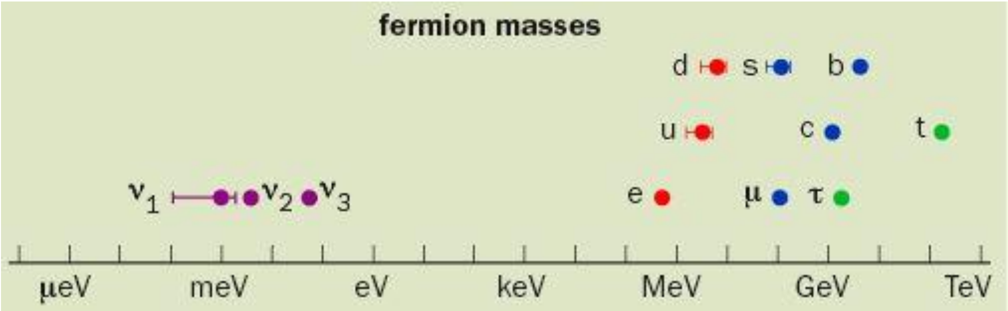
C. L. Bennett et al., Astrophys. J. Suppl. 148, 1(2003)

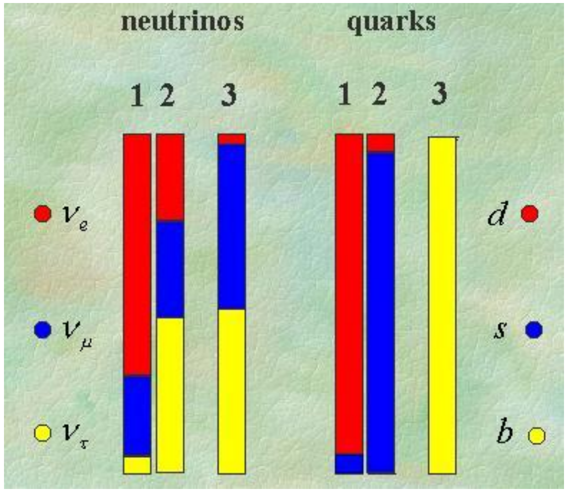
We observed,

❖ **Baryon number Asymmetry:**

$$\eta = (6.1 \pm 0.3) \times 10^{-10}$$

❖ **Fermion mass hierarchy and mixings:**





However, there is NO good explanation in SM.

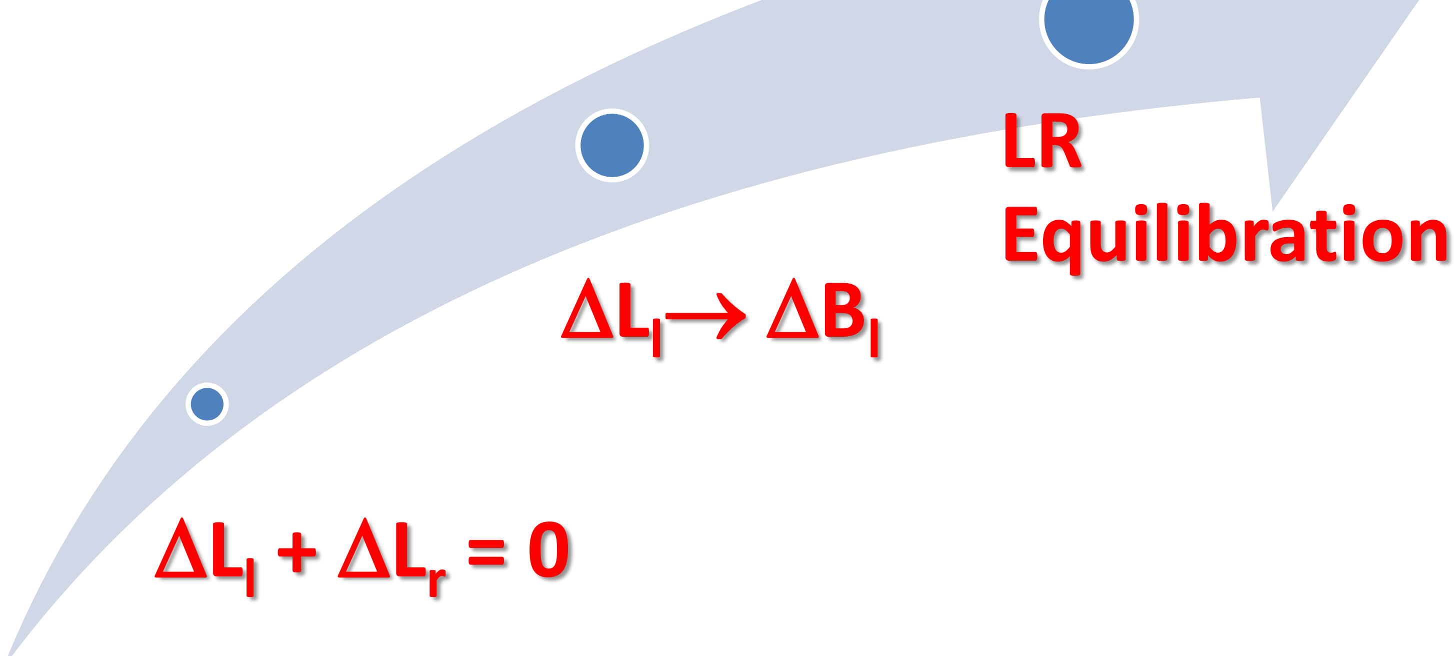
Therefore, we study the dirac leptogenesis in a family U(1)' model to explain those phenomena.

Dirac Leptogenesis

K. Dick, M.Linder, M. Ratz, D. Wright, PRL 84, 4039 (2000)

H. Murayama, A. Pierce, PRL 89, 271601 (2002)

- NO Lepton Number Violation!
- It is difficult to naturally generate the small Dirac Neutrino masses.

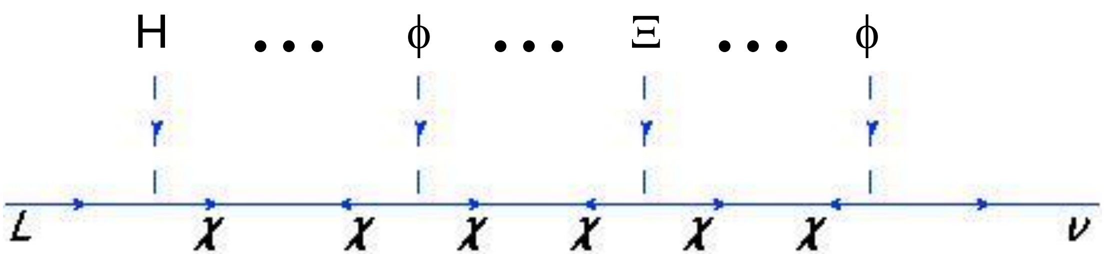


U(1)' as a Family Symmetry

D. D. Froggatt, H. B. Nielsen, Nucl. Phys. B147, 277 (1979)

$$L_{Yukawa} = Y_u Q u H_1 + Y_d Q d \overline{H}_2 + Y_e L e \overline{H}_2 + Y_\nu L \nu H_1 \Xi$$

Froggatt Nielsen Mechanism



$$Y_{ij} \sim (y_{ij} \frac{\phi}{\Lambda})^{|q_i + q_j + q_H|}$$

$$\frac{<\Xi>}{\Lambda} \sim O(1)$$

$$\lambda = \frac{<\phi>}{\Lambda} \cong 0.22$$

(Cabibbo Angle)

○ **Effective Yukawa matrices depend on the U(1)' charge assignment.**

○ **Ξ ξ χ χ play important roles in Dirac letogenesis.**

U(1)' Charge

SU(5) X U(1)'

All of the anomalies are cancelled.

Normalize q_Φ = -1

Field	$U(1)'$ charge	Field	$U(1)'$ charge
L_1, d_1	$q_{f_1} = 2/15$	Q_1, u_1, e_1	$q_{t_1} = 68/45$
L_2, d_2	$q_{f_2} = -13/15$	Q_2, u_2, e_2	$q_{t_2} = 23/45$
L_3, d_3	$q_{f_3} = -13/15$	Q_3, u_3, e_3	$q_{t_3} = -67/45$
ν_1	$q_{N_1} = 2/9$	H_1	$q_{H_1} = 134/45$
ν_2	$q_{N_2} = 11/9$	H_2	$q_{H_2} = -196/45$
ν_3	$q_{N_3} = 11/9$	Ξ	$q_\Xi = 44/3$

Effective Yukawa matrices

$$Y_u \sim \begin{pmatrix} \lambda^6 & \lambda^5 & \lambda^3 \\ \lambda^5 & \lambda^4 & \lambda^2 \\ \lambda^3 & \lambda^2 & \lambda^0 \end{pmatrix}$$

$$Y_d \sim \begin{pmatrix} \lambda^6 & \lambda^5 & \lambda^5 \\ \lambda^5 & \lambda^4 & \lambda^4 \\ \lambda^3 & \lambda^2 & \lambda^2 \end{pmatrix}$$

$$Y_e = Y_d^T$$

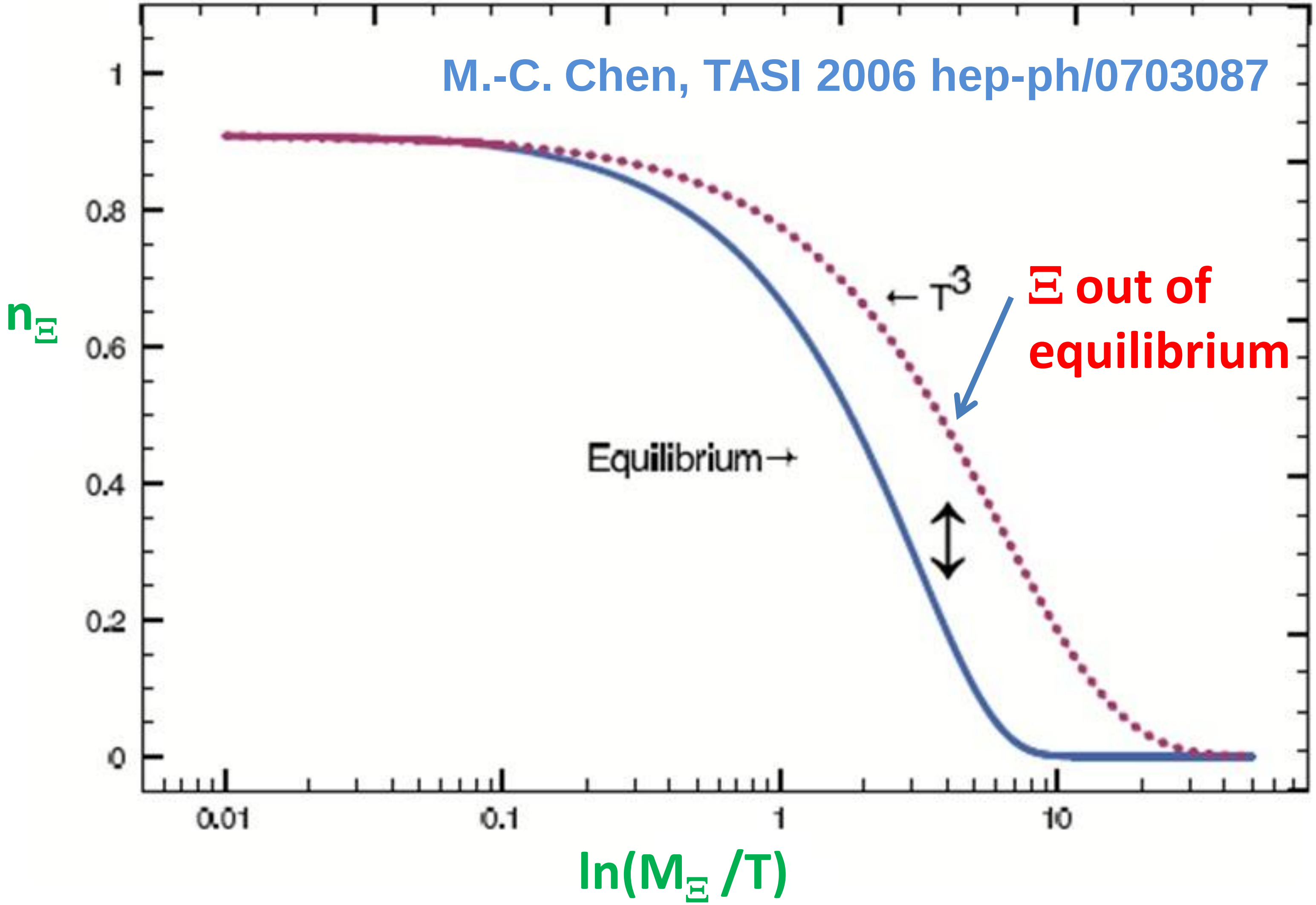
Mass hierarchy and fermion mixings are obtained.

$$Y_\nu \sim \begin{pmatrix} \lambda^{18} & \lambda^{19} & \lambda^{19} \\ \lambda^{17} & \lambda^{18} & \lambda^{18} \\ \lambda^{17} & \lambda^{18} & \lambda^{18} \end{pmatrix}$$

All of the Majorana Mass terms are forbidden by the U(1)’ gauge symmetry

Dirac Neutrinos

Freeze out

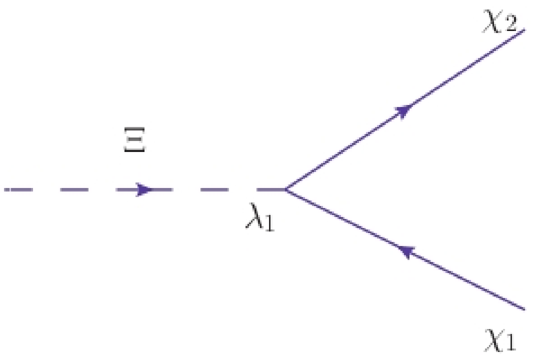


M.-C. Chen, TASI 2006 hep-ph/0703087
1
0.8
0.6
0.4
0.2
0
0.01
0.1
1
10
← T3
Ξ out of equilibrium
Equilibrium→
nΞ
ln(MΞ /T)

Baryon Number Asymmetry

$$L \supset m_\Xi^2 |\Xi|^2 + m_\xi^2 |\xi|^2 + \lambda_1 \Xi \bar{\chi}_1 \chi_2 + \lambda_2 \xi \chi_1 \bar{\chi}_2$$

χ_1, χ_2 will further decay to leptons

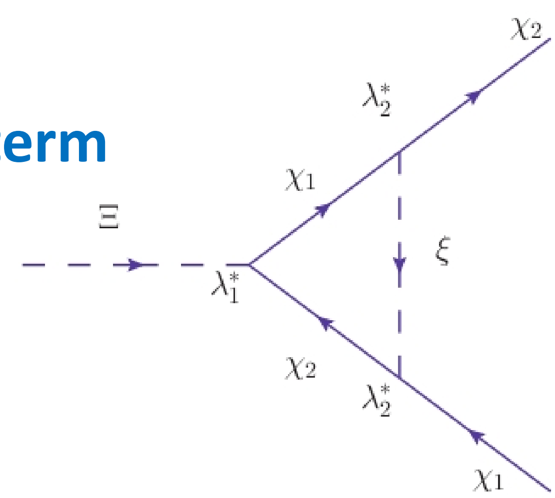


CP Asymmetry:

$$\varepsilon_\Xi = \frac{8\,\mathrm{Im}[\lambda_1^2 \lambda_2^2]\,\mathrm{Im}[I_{\Xi\xi}]}{\Gamma_\Xi}$$

$$\propto \lambda_2^2$$

Interference term



B Asymmetry:

$$\eta_B \sim n_{\nu_R} \sim (\varepsilon_\Xi \eta_\Xi + \varepsilon_\xi \eta_\xi)$$

Abundance

Numerical Example

Fix the masses

$$m_{\Xi} = 10^{15} GeV$$

$$m\xi = 10^{14} GeV$$

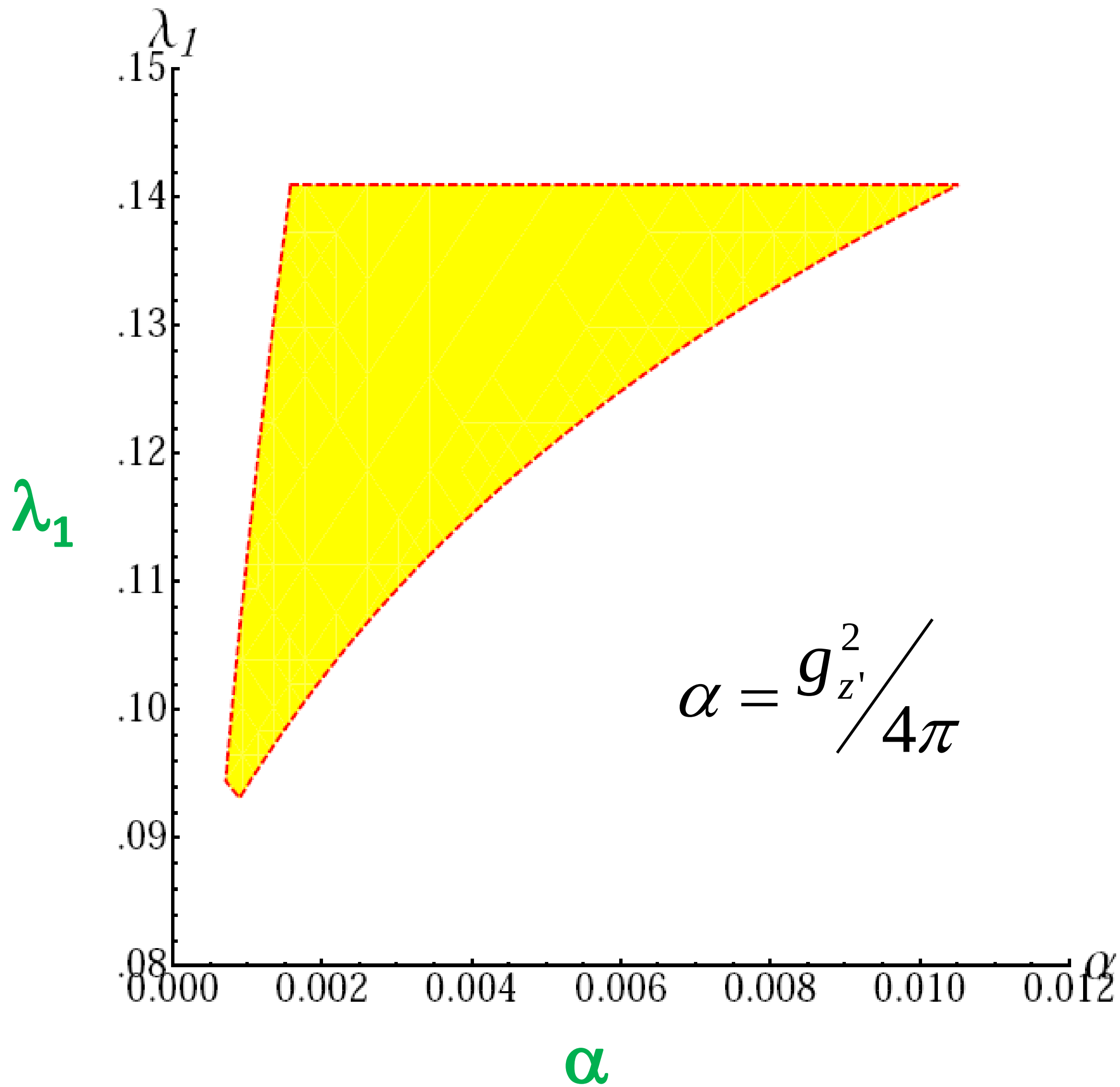
$$m_{\chi} = 10^{13} GeV$$

Degenerate Couplings

Maximal CP Phase

$$\lambda_1 = \lambda_2$$

$$\mathrm{Im}[\lambda_1^2 \lambda_2^2] = |\lambda_1|^4$$



$$\alpha = g_{z'}^2 / 4\pi$$

Numerical Example (Cont.)

Fix the masses + gauge coupling

$$m_{\Xi} = 10^{15} GeV$$

$$m\xi = 10^{14} GeV$$

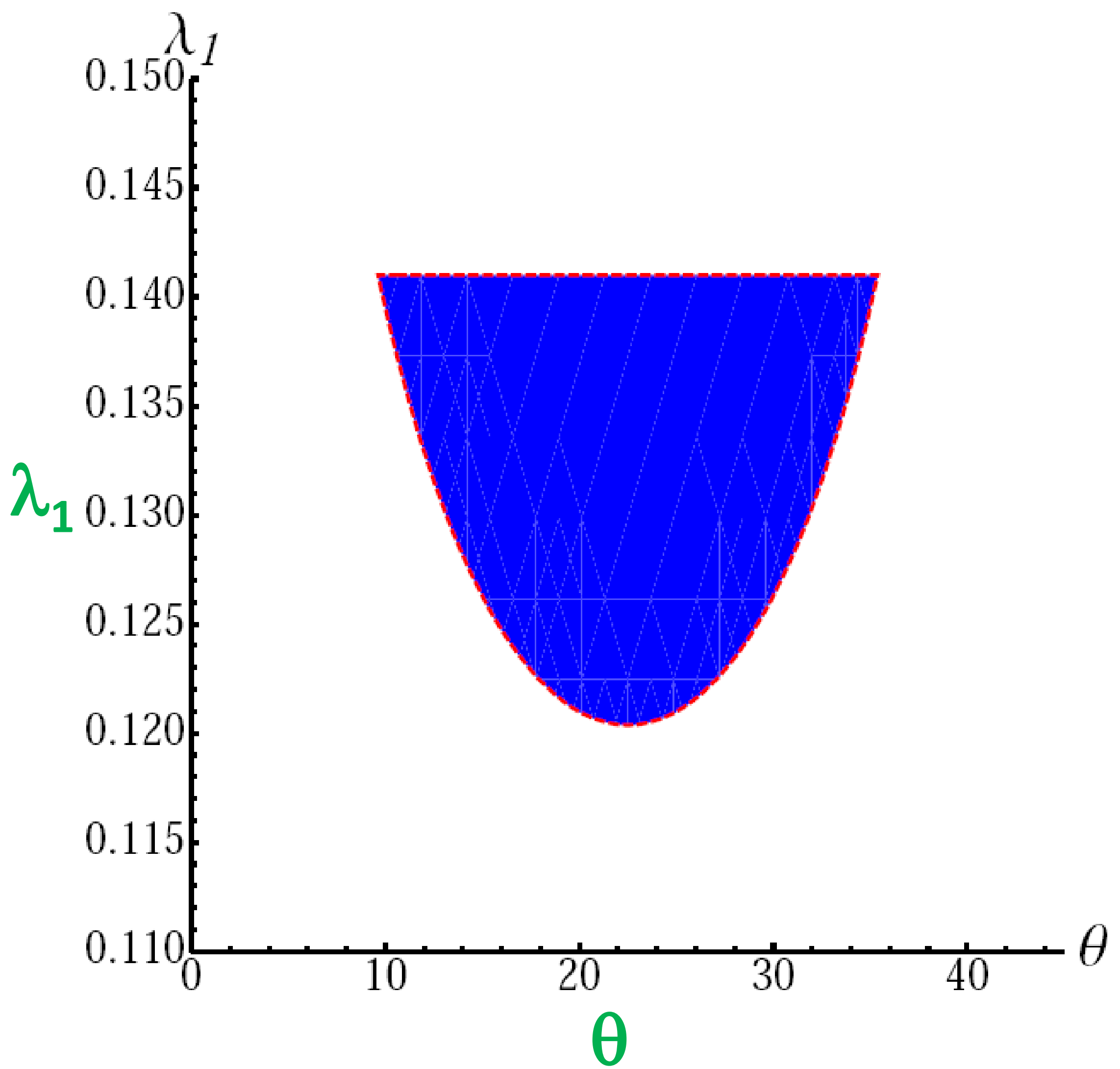
$$m_{\chi} = 10^{13} GeV$$

$$\alpha = 0.005$$

Degenerate Couplings
Vary CP phase

$$\lambda_1 = \lambda_2$$

$$\mathrm{Im}[\lambda_1^2 \lambda_2^2] = |\lambda_1|^4 \sin(4\theta)$$



Conclusion

- The non-anomalous U(1)’ symmetry can play a role of family symmetry which gives rise to the fermion mass hierarchy and mixings.
- Realistic Dirac Leptogenesis can be realized naturally within this framework.