Motivation and basic idea

- Several problems unsolved in the standard model require some extension of it.
- As such an example, we propose a model which has Peccei-Quinn symmetry and results in the scotogenic model in lepton sector at low energy regions.
- Strategy adopted in this study is summarized in the right table.  
  - How to solve these in a simple and unified way?
  - Strong CP problem
  - Mass and mixing of quarks
  - Neutrino mass
  - Dark matter
  - Baryon number asymmetry
  - Peccei-Quinn (PQ) mechanism
  - Froggat-Nielsen mechanism
  - Scotogenic model as lepton sector

PQ symmetry which satisfies the above requirements

- Scotogenic model as leptonic sector
- PQ symmetry which satisfies the above requirements
- Quark sector with Froggat-Nielsen mechanism based on PQ symmetry
- Motivation and basic idea

Leptonic sector reduced to Scotogenic neutrino mass model

- Leptonic sector invariant under the imposed $U(1)$
- Scotogenic model invariant under $Z_2$
- Low energy phenomena could be described in the same way as the scotogenic model.

Neutrino mass

- Neutrino mass is generated by one-loop effect.
- Leptogenesis
  - Baryon number asymmetry could be explained through the out-of-equilibrium decay of $N_1$.

Consistency of model parameters with vacuum stability and perturbativity

- Model parameters used to explain the above issues should be consistent with the vacuum stability and the perturbativity up to the cut-of-scale $M$.
- Initial values at $M_1$
  - Higgs mass
  - neutrino mass, leptogenesis
  - DM abundance
  - a free parameter

Axion physics

- Axion-photon coupling predicted for this PQ charge assignment
- Axion could not be a dominant component of DM.
- Components of $\eta$ are degenerate for $m_\eta = 1$ TeV
- Their coannihilation reduces the abundance effectively.

RGE study for $\lambda^{2,3,2}$, $\lambda_I$ to find $M$.  

Some theory at high energy regions might give an answer to this point.