Last Lecture

- Showed that the LH Majorana mass term is zero in the SM

- Forced to introduce a heavy RH Majorana neutral lepton to the theory

$$N = N_R^c + N_R$$

with Majorana mass term $\mathcal{L}_R = m_R \overline{N_R^c} N_R$

- General mass term includes all fields

$$\mathcal{L} = \begin{pmatrix} \bar{\nu}_L & \overline{N_R^c} \end{pmatrix} \begin{pmatrix} 0 & m_D \\ m_D & M_R \end{pmatrix} \begin{pmatrix} \nu_L^c \\ N_R \end{pmatrix}$$

- Lagrangian is written in chiral basis, not mass basis

- Converting to mass basis gives physical particles with masses

$$m_1 = \frac{m_D^2}{M_R} \qquad m_2 = M_R$$

- See-Saw mechanism ⇒ can explain light mass of observed neutrino mass.

So how heavy would m_R be?

$$m_1 = \frac{m_D^2}{m_R} \Rightarrow m_R = \frac{m_D^2}{m_1} \simeq \frac{(10^6)^2}{0.1}$$

$$= 10^{13}\ eV$$

⇒ can't make this in accelerators

⇒ can try to study this by studying the light neutrino and using the see-saw mechanism.

- Neutrino mass is the first BSM (Beyond Standard Model) evidence.

One further consequence of this mechanism.

- Most GUT theories conserve B-L
- Suppose N exhibits CP violation

$$\Gamma(N \rightarrow e^- + H^{(+)}) \neq \Gamma(N \rightarrow e^+ + \bar{H}^{(-)})$$

Over ~~...~~ time, this leads to more e^- ~~to~~ than e^+ (say). ⇒ ~~...~~ lepton number asymmetry. But B-L is conserved, so B must also be non-conserved.

L asymmetry ⇒ B asymmetry

"Leptogenesis": CP violation in N decays generates baryon asymmetry.

so understanding baryon asymmetry may involve understanding CP violation in N decays as by extension ν ~~&~~ interactions.

This all depends on:

1. Neutrino has mass ✓
2. A heavy RH neutrino partner exists
3. The neutrino is Majorana ✓
4. Neutrinos exhibit CP violation ✓