Problem set 2

Problem 1

The NEMO-3 experiment observed 15 candidates for neutrino-less double β decays, while 18.0 ± 0.6 background events are expected. Knowing that the experimental efficiency is 4.7%, and that the exposure is 34.3 kg·yr, compute the upper limit at 90% C.L. ($\approx 1.3\sigma$) for the half-life time of the ^{100}Mo (atomic mass = 95.94 g/mol) $\beta\beta - 0\nu$ decay. Compare the result with the published result : $\tau_{1/2} > 1.1 \times 10^{24}$yr at 90% C.L.

Note: we can simplify the computation considering that the uncertainty for the Poisson distribution ($\sigma(N) = \sqrt{N}$) is gaussian $\Rightarrow 1.3\sigma = 1.3\sqrt{N}$.

Problem 2

(a) Determine the eigenvalues of the mass matrix of the see-saw Lagrangian, without neglecting the value of m_L.

$$-\frac{1}{2}\begin{pmatrix}\bar{\nu}_L^c & \bar{\nu}_R\end{pmatrix}\begin{pmatrix}m_L & m_D \\ m_D & m_R\end{pmatrix}\begin{pmatrix}\nu_L \\ \nu_R^c\end{pmatrix}$$

(b) Why can one neglect m_L in the mass hierarchy?

Problem 3

Considering the flavor basis for the neutral mesons ($\left|P^0\right\rangle$, $\left|\bar{P}^0\right\rangle$), the mass matrix can be written as:

$$\begin{pmatrix}m & \Delta m \\ \Delta m & m\end{pmatrix}$$

(a) Calculate the mass eigenvalues M_H and M_L and the corresponding eigenstates $|P_H\rangle$ ("heavy") and $\left|\bar{P}_L\right\rangle$ ("light").

(b) Discuss how this property of the neutral mesons can be detected by experiments ("mixing"). Consider for instance the creation of a neutral meson in a strong interaction, followed by its desintegration via the weak interaction. Draw the corresponding Feynman diagrams.