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Novel Ways to Determine the Neutrino Mass Hierarchy

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Abstract: The traditional method to determine the neutrino mass hierarchy is to compare $\nu_\mu \rightarrow \nu_e$ to $\text{anti-}\nu_\mu \rightarrow \text{anti-}\nu_e$ in long baseline superbeam experiments or $\nu_e \rightarrow \nu_\mu$ to $\text{anti-}\nu_e \rightarrow \text{anti-}\nu_\mu$ using neutrino factories or beta beams. In this seminar I will discuss two novel ways to determine the neutrino mass hierarchy: the first is by using ν_e disappearance of Mossbauer neutrinos where the special monochromatic nature of the source is particularly important. I will also argue that this method is extremely challenging if one uses a non-monochromatic source such as reactor neutrinos. The second method is to use CPT conjugate channels such as $\nu_\mu \rightarrow \nu_e$ from a superbeam compared to $\text{anti-}\nu_e \rightarrow \text{anti-}\nu_\mu$ from a beta beam. Since these two channels are CPT conjugates the difference in the appearance probabilities can only come from the matter effect which is opposite in sign for these two channels. This sign determines the hierarchy. A possible scenario using beamlines from Fermilab will be discussed. The strength of both of these methods is that they completely untangle the effects of the mass hierarchy from CP violation compared to the traditional method which has these effects intertwined.