Very Large Underground Detectors for Neutrino Physics and Nucleaon Decay Searches: Recent Discovery of Electron Neutrino Appearance from a Muon Neutrino Beam in T2K and Future Outlook for Discovery of CP Violation in the Lepton Sector

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Abstract:
Matter-antimatter asymmetry is one of the most outstanding mysteries of the universe that provides a necessary condition to our own existence. There have been various attempts to solve this mystery including 'Baryogenesis' hypothesis. However, the B-factory experiments during the last decade showed that the observed CP-violation (CPV) in the quark sector is not big enough for baryogenesis to be a viable solution to the matter-antimatter asymmetry. This leads us to the 'Leptogenesis' hypothesis, in which CPV in the lepton section plays a crtical role to create the matter-antimater asymmetry at the onset of the Big Bang. Thus, experimental observation of CPV in the lepton sector could prove to be tantamount to one of the most important discoveries in our understanding of the universe.

In 2013, the T2K experiment reported "Observation of electron neutrino appearance from a muon neutrino beam" at 7.3 sigma level of significance. While neutrino oscillation has been well-established since the discovery by the Super-Kamiokande experiment in 1998, there have not been a definitive observation of neutrino oscillation in a so-called "appearance mode", and this new T2K observation is the first time an explicit neutrino flavor (electron) appearance is observed from another neutrino flavor (muon). This observation also opens the door to study CPV in neutrinos. When incorporating recent precision measurements on θ_{13} by the reactor experiments along with other neutrino oscillation parameter measurements, T2K data show an intriguing initial result on the δ_{CP}.

In this talk I will present some details of this discovery and its importance to the future CP-violation measurements in the lepton sector. I will also present future outlook for discovering CPV as well as measuring other neutrino oscillation parameters using future very large underground detectors, DUNE in US and Hyper-Kamiokande in Japan.