CP symmetry violation in neutrinos

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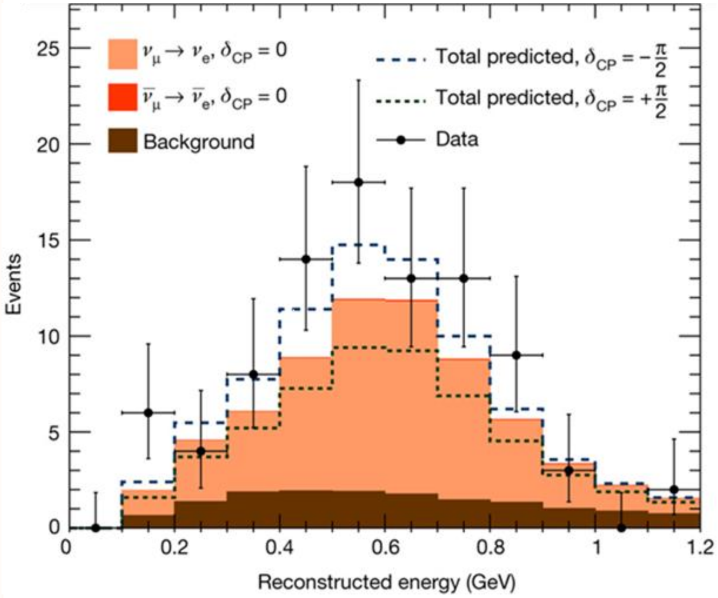
Abstract

Neutrinos have long been recognised as a leading candidate to explain why the universe contains **matter** and **energy**, but almost no **antimatter**. The mechanism—*Leptogenisis*—requires that (1) neutrinos come in three distinguishable eigenstates; (2) that these eigenstates mix in free space; and finally (3) that this mixing be different between neutrinos and anti-neutrinos.

The first two facts are well-established, and recently the **T2K experiment** has produced strong indications that there is also a difference between the neutrino and the anti-neutrino.



Project Description

The Standard Model of elementary particle physics allows very little difference between matter and antimatter. Formally known as **Charge-Parity (CP) symmetry**, it only appears as a phase offset (δ_{CP}) in oscillations between neutral fundamental particles such as neutrinos.

T2K produces a beam of (anti-)neutrinos and which oscillates between types as they travel 295km through the rock of the Japanese Alps. If the phase $\delta_{CP} > 0$, oscillations of the anti-neutrinos are enhanced, while neutrinos are reduced, while the opposite is true if $\delta_{CP} < 0$. **If CP symmetry is conserved, δ_{CP} must be 0 or (a multiple of) π.**

At 295km some of the neutrinos interact in the 40m-tall **Super-Kamiokande detector**, and the relative numbers of (anti-)neutrinos can be compared.

Key Results

- The number of **neutrinos** is found to be **significantly enhanced** compared to the CP-conserving predictions. **Anti-neutrinos** (not shown) are **reduced** by a similar ratio.
- The effect is *large*, currently indistinguishable from the maximum.
- **Both CP-symmetric points are disfavoured at the 95% confidence level.**

Future work

- T2K is still running, and hopes to reach the traditional "3σ" (99.73% C.L.)
- An even larger successor, **Hyper-Kamiokande**, is approved to begin in the mid-2020s, which will allow us to study the mechanism in greater detail, and several other topics in particle physics and astrophysics.

Refs & links Nature 580, 339 (2020) No-paywall URL **https://rdcu.be/b2Aq6**