Rescuing grand unification scenario for neutrino mass

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Abstract

The see-saw mechanism for neutrino masses based on the Grand Unification leads to the mass of the heaviest neutrino ($\nu_3$) in the range $2 \times 10^{-3}$ eV and hence to a solution of the solar neutrino problem through the $\nu_\mu \rightarrow \nu_e$ conversion. We suggest the existence of a light singlet fermion $S$ which mixes predominantly with muon neutrino through the mixing $m_{\mu S}$; $O(1)$ eV. The introduction of such a singlet allows one (i) to solve the atmospheric neutrino problem via the $\nu_e \leftrightarrow S$ oscillations, (ii) to explain the LSND result and (iii) to get two component hot dark matter in the Universe. The phenomenology of this scenario is considered and the origin of the singlet as well as of the scale $m_{\mu S}$ is discussed.

1. Introduction

Grand Unified Theories containing heavy right handed neutrinos provide a natural framework for generation of small neutrino masses. Their generic properties are

(i) the lepton number violation at the Grand Unification (GU) scale $A_{GU}$;

(ii) the (approximate) quark-lepton symmetry which relates the quarks mass matrices and the Dirac neutrino mass matrix at the scale $A_{GU}$: $m_D^2(A_{GU}) \sim m_S(A_{GU})$. The relation could be exact for particles of the third generation, so that $m_D^2 = m_S$ at $A_{GU}$.

These properties realize the see-saw mechanism of the neutrino mass generation with the Majorana masses of the right handed neutrinos at the GU scale: $M_R \sim A_{GU} \sim 10^{16}$ GeV. The mass $m_3$ of the heaviest active neutrino turns out to be in the range $(1 - 3) \times 10^{-3}$ eV required for a solution of the solar neutrino problem via $\nu_e \rightarrow \nu_\mu$ resonance conversion [1]. Moreover, the $\nu_e - \nu_\mu$ mixing can also be [2] in the correct range. The parameters of the $\nu_e - \nu_\mu$ system can be such that the solar neutrinos undergo also long range vacuum oscillations on the way to the Earth [2,3]. The interplay of conversion and oscillations leads to certain observable effects [2]. We will refer to this possibility as the Grand Unification scenario.

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