Neutrino-Mass Effect on CMB Anisotropies in A Cosmological Model with Primordial Magnetic Field

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It is one of the biggest challenge in particle physics and cosmology to determine the mass of neutrinos. Although recent successive detections of the neutrino oscillation phenomena have indicated that the three light-neutrino family have almost degenerate masses, their absolute values are still unknown.

Current effort of the neutrino mass hunting is being made mostly on laboratory experiments of measuring yet undetected event of the neutrinoless double beta decay of the atomic nuclides. Experimentally, the total neutrino mass is smaller than 1 – 6 eV. In recent years the precise WMAP 3rd data of the cosmic microwave background (CMB) made it possible to constrain the sum of the neutrino masses cosmologically. Neutrinos are one of the dark matter candidates, and massive neutrinos have virtually a large effect on the structure formation of the Universe as hot dark matter because of their free streaming. Solving the Friedman equation coupled with the Boltzmann equation, one can compare the calculated the CMB anisotropies with those of the WMAP 3rd data. As a result, an upper limit to the total neutrino mass turns out to be $< 2\text{eV (2}\sigma\text{ C.L.)}$. In the early Universe, however, the CMB anisotropies are affected by the other important physical processes such as the matter fluctuations induced by the primordial magnetic field (PMF). Since the effect of the PMF on the CMB anisotropies was shown to be as strong as the gravitational wave in large scales (of multipole $\ell < 20$) and even much larger than the SZ effect in small scales (of multipole $\ell > 1000$), one has to include the effect of the PMF in constraining the mass of neutrinos.

The purpose of this paper is to show for the first time the cosmological constraint on the total neutrino mass based on careful and precise theoretical analysis of the CMB power spectrum from WMAP-3yr data, by taking account of the effect of the PMF. We will critically discuss the dependence of the neutrinos mass limit on the PMF, and compare the result with the mass constraint obtained from the other measurements.

References