# Using Big Bang Nucleosynthesis to Extend CMB Probes of Neutrino Physics

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We present calculations showing that upcoming Cosmic Microwave Background (CMB) experiments will have the power to improve on current constraints on neutrino masses and provide new limits on neutrino degeneracy parameters. The latter could surpass those derived from Big Bang Nucleosynthesis (BBN) and the observationally-inferred primordial helium abundance. These conclusions derive from our Monte Carlo Markov Chain (MCMC) simulations which incorporate a full BBN nuclear reaction network. This provides a self-consistent treatment of the helium abundance, the baryon number, the three individual neutrino degeneracy parameters and other cosmological parameters. Our analysis focuses on the effects of gravitational lensing on CMB constraints on neutrino rest mass and degeneracy parameter. We find for the PLANCK experiment that total (summed) neutrino mass $M_{\nu} > 0.29$ eV could be ruled out at $2\sigma$ or better. Likewise neutrino degeneracy parameters $\xi_{\nu_{e}} > 0.11$ and $| \xi_{\nu_{\mu/\tau}} | > 0.49$ could be detected or ruled out at $2\sigma$ confidence, or better. For POLARBEAR we find that the corresponding detectable values are $M_\nu > 0.75 {\rm eV}$, $\xi_{\nu_{e}} > 0.62$, and $| \xi_{\nu_{\mu/\tau}}| > 1.1$, while for EPIC we obtain $M_\nu > 0.20 {\rm eV}$, $\xi_{\nu_{e}} > 0.045$, and $|\xi_{\nu_{\mu/\tau}}| > 0.29$. Our forcast for EPIC demonstrates that CMB observations have the potential to set constraints on neutrino degeneracy parameters which are better than BBN-derived limits and an order of magnitude better than current WMAP-derived limits.

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