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## Probing the properties of relic neutrinos using the cosmic microwave background, the Hubble Space Telescope and galaxy clusters

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We investigate the observational constraints on the cosmic neutrino background (CNB) given by the extended  $\Lambda$ CDM scenario ( $\Lambda$ CDM +  $N_{\text{eff}}$  +  $\sum m_\nu$  +  $c_{\text{eff}}^2$  +  $c_{\text{vis}}^2$  +  $\xi_\nu$ ) using the latest observational data from *Planck* CMB (temperature power spectrum, low-polarisation and lensing reconstruction), baryon acoustic oscillations (BAOs), the new recent local value of the Hubble constant from *Hubble Space Telescope* (*HST*) and information of the abundance of galaxy clusters (GCs). We study the constraints on the CNB background using CMB + BAO + *HST* data with and without the GC data. We find  $\Delta N_{\text{eff}} = 0.614 \pm 0.26$  at 68 per cent confidence level when the GC data are added in the analysis. We do not find significant deviation for sound speed in the CNB rest frame. We also analyze the particular case  $\Lambda$ CDM +  $N_{\text{eff}}$  +  $\sum m_\nu$  +  $\xi_\nu$  with the observational data. Within this scenario, we find  $\Delta N_{\text{eff}} = 0.60 \pm 0.28$  at 68 per cent confidence level. In both the scenarios, no mean deviations are found for the degeneracy parameter.

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