**Constraints of Total Mass and Mass Hierarchy of Neutrinos from Cosmological Observations with Bayesian Analysis**

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ABSTRACT

Neutrinos are fermions that come in three spesies (flavors) and are massless in the standard model. However, solar neutrino problem that was solved by neutrino oscillations requires non-zero neutrino mass. Solar and atmospheric neutrino experiments give us the squared mass differences between mass eigenstates, while from kinematic experiments we get upper limits of individual mass of each neutrino flavor. Oscillation experiments give rise to a further problem regarding the order of neutrino mass known as neutrino mass hierarchy problem, i.e. whether it is normal or inverted hierarchy.

Massive neutrinos in cosmology affect Cosmic Microwave Background (CMB) and Large Scale Structure (LSS) formation, besides Big Bang Nucleosynthesis (BBN) that will not be discussed further in this work. The impact of massive neutrinos appears in the power spectrum of CMB, and in the LSS matter power spectrum as well. Since neutrinos affect events in the universe, we can constrain neutrino properties based on cosmological observations.

This work is aiming at constraining neutrino total mass from cosmological observations in two hierarchy scenarios, i.e. normal and inverted hierarchies, and also determining neutrino mass hierarchy. To constrain neutrino total mass CosmoMC was employed to perform Bayesian analysis with MCMC algorithm, while neutrino mass hierarchy was determined based on Bayes factor, in which likelihoods of the two hierarchy scenarios were compared. Besides, neutrino individual mass was estimated following Xu and Huang (2018) but in reverse order.

Depending on the data set used, different total mass constraints were obtained, the tightest constraint comes from combination of CMB + LSS +BAO +Supernova data, i.e. < 0.183 eV (normal hierarchy) and < 0.188 eV (inverted hierarchy) with 95% C.L. The Bayes factor analysis prefers normal hierarchy, although with weak evidence. A global analysis (incorporating data from oscillation and kinematic experiments) is therefore suggested for a more reliable hierarchy selection. For the selected normal hierarchy, individual mass of neutrinos was determined by incorporating neutrino oscillation data derived from Nu-fit global analysis.

*Keywords: neutrinos, total mass, mass hierarchy, cosmology*

References

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