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The impact of massive neutrinos on Cosmology and Particle Physics

The observation of neutrino flavor oscillations by various experiments involving both natural (solar and atmospheric) and man-made (accelerators and reactors) neutrino sources firmly indicates that neutrinos are massive particles.

In fact, all these experiments can be well understood if we assume the so-called {\it Standard Paradigm} that is, that the three known neutrino interaction eigenstates (ν_e, ν_μ, ν_τ) are a mixture of three neutrino mass eigenstates (ν_1, ν_2, ν_3). We need two different mass squared difference scales $\Delta m^2_{21} \approx 7.5 \times 10^{-5}$ eV^2 and $|\Delta m^2_{31,32}| \approx 2.5 \times 10^{-3}$ eV^2 to explain the oscillation data.
These measurements give rise to two possible mass ordering: $m_1 < m_2 < m_3$ (normal) or $m_3 < m_1 < m_2$ (inverted).

In principle, other particle physics non-oscillation neutrino experiments can measure the total neutrino mass, but these are fairly difficult experiments. Tritium β-decay experiments can measure (or limit) the so-called effective electron neutrino mass m_β, while neutrinoless double β-decay ($0\nu\beta\beta$) experiments can measure (or limit) the effective Majorana neutrino mass $m_{\beta\beta}$.

Cosmological observations, however, seem to be more prone to measure the total neutrino mass and even contribute to the determination of the mass ordering.
Massive neutrinos leave distinct signatures on the Cosmic Microwave Background (CMB) and large-scale structure (LSS) at different epochs of the evolution of the Universe.

Moreover, they are also sensitive to the number of effective relativistic degrees of freedom $N_{\rm eff}$ and so to the number of relativistic neutrino species.

In this work, we aim to combine all available neutrino particle physics data from oscillation and non-oscillation experiments with state-of-the-art cosmological observations (SDSS and DES in our case) to try to determine the neutrino mass spectrum.

We present our preliminary study of it, including the acquiring data, mask selection, Cl and Pseudo-Cl analysis, and the likelihood used in this case.
The analysis aims to use the Cl (which is a more powerful statistical tool than just the BAO measurement) generated by PseudoPower from the SDSS or DES galaxy data in order to constrain cosmological parameters relates to massive neutrinos such as m_1, Δm^2_{21}, $\Delta m^2_{31,32}$ and the Hierarchy.
The constraints are done in the UCLCl code (MCMC estimator) which uses Polychord sampler (Slice Sampling) to do the cosmological constraint.

Primary author: Dr FORNAZIER , KARIN SILVIA FRANZONI (IFUSP)

Co-authors: SANTOS, AMANDA FARIAS (IFUSP); Prof. ABDALLA, FILIPE BATONI (IFUSP); HOERNING , GABRIEL (IFUSP); Prof. FUNCHAL, RENATA Z. (IFUSP)

Presenters: SANTOS, AMANDA FARIAS (IFUSP); Prof. ABDALLA, FILIPE BATONI (IFUSP); HOERNING , GABRIEL (IFUSP); Dr FORNAZIER , KARIN SILVIA FRANZONI (IFUSP); Prof. FUNCHAL, RENATA Z. (IFUSP)

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