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Resolution of discrepancy in SFR at Cosmic Noon using Diffuse Supernova Neutrino Background

Content

Multiple astrophysical probes of the star formation rate (SFR) yield widely different inferences of this rate at redshifts greater than 1. While all probes seem to indicate a period of peak star formation known as cosmic noon, the detailed inferences from these probes are in disagreement. The peak indicated by the UV/IR data is significantly lower than the peak indicated by Hα data. The knowledge of the mass range of stars ending with core-collapse supernovae (CC SNe) enables us to estimate SFR using the measurement of CC SNe rate. In this work, the potential of measurement of the diffuse supernova neutrino background (DSNB) at HyperKamiokande to measure CC SNe rate and consequently resolve the discrepancy in the magnitude of the SFR peak, is explored.

The simulation results of the detected neutrino flux at Hyper Kamiokande show that above 10 MeV, it will be able to detect around 450 neutrinos in 20 years, if actual SFR is as indicated by UV+IR, else a higher value of 750 neutrinos. The cutoff of 10 MeV is chosen because, at lower energy ranges, neutrinos due to the DSNB cannot be differentiated from reactor neutrinos. χ^2 test using the simulated detected rate indicates that the hypotheses can be excluded in the absence of background noises. The profile likelihood method is used to include the background in the χ^2 test. The results imply that with the current knowledge of background noises, the hypotheses can not be excluded. However, with improved knowledge of background noises and tighter limits on the uncertainty, the results are improved. The result obtained on repeating the χ^2 test with the assumption that uncertainty in the total background is half the current value, indicates that the hypotheses can be excluded at a 99 percent confidence level.

At present, the knowledge of parameters used to characterize neutrino emission from CC SNe is uncertain. The parameters can be better determined with an improved observation of core-collapse supernova events happening in the nearby universe. Changes in the value of these parameters will affect the results of this paper. Nevertheless, one deduction that remains unchanged is that as the detectors become more significant in volume and the noise rejection or determination capability improves, DSNB measurement will be able to put stringent limits on the parameters involved in the defining equation of global SFR. The improved determination of the SFR equation, in turn, will improve our understanding of cosmic noon.

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