Compact objects and dark matter dynamics in astroparticle physics

Abstract

Our Universe seems to be full of objects which elude common interpretation. The quark star is such an exotic star of our Universe. The limiting mass for quark stars essentially depends on rotational frequency apart from bag constant and other fundamental parameters. The analytical results obtained agree with the results of several relevant numerical estimates as well as observational evidence. It is evident that, at higher frequencies, such stars become extremely compact, but never behave like a black hole.

Primordial black hole (PBH) is another hypothetical candidate of compact astrophysical objects, which has been the centre of interest for several decades in cosmology and astrophysics. We explore the combined effect of PBH evaporation and the baryon-dark matter (DM) interaction in the 21cm scenario. We address both upper and lower bounds on PBH initial mass fraction ($\beta_{\rm BH}$) and the same for DM mass (m_χ) and baryon-DM scattering cross-section ($\overline{\sigma}_0$) using the observational excess $\left(-500^{+200}_{-500}\,\text{mK}\right)$ of EDGES's experimental results.

A similar investigation has been carried out in the framework of interacting dark energy (IDE) models. We consider three IDE models which are well constrained by the observational evidence and eventually measure the allowed limits of IDE coupling parameters for individual cases.

Keeping in view of the 21cm scenario, we also explore the multimessenger signals from possible rare decay of fundamental Heavy Dark Matters (HDM). HDM can undergo QCD cascade decay to produce leptons or γ as end products. One of the multimessenger signals could be the source of ultra high energy neutrino ($\sim$ PeV) signals at the IceCube detector whereas the other signal attributes to the cooling/heating of the baryons due to HDM decay and corresponding influences in the global 21cm signal. Here the effect of PBH evaporation and baryon-DM scattering are also considered.

The consequence of late time decay of such HDMs may also have significant implications on the aspect of matter-antimatter asymmetry. This matter-antimatter asymmetry may give rise to baryon and lepton number asymmetry, which satisfies Sakharov's conditions for baryogenesis. The mass and lifetime of such Dark Matter particles have been obtained by performing a χ^2 analysis with the PeV neutrino data of IceCube and finally, the amount of baryon asymmetry produced in the Universe is estimated if caused by Dark Matter decay.

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