27th International Symposium on Particles, Strings and Cosmology

PASCOS
PARTICLES
STRINGS
COSMOLOGY
25-29 JULY 2022 - MPIK - HEIDELBERG - GERMANY

Contribution ID: **77** Type: **not specified**

S.M.A.S.H.E.D- Standard Model Axion Seesaw Higgs (Inflation) Extended (for) Dirac (Neutrinos)

Tuesday 26 July 2022 14:18 (18 minutes)

Inspired by the S.M.A.S.H framework we construct a model that adresses the strong CP problem, axion dark matter, inflation and Dirac neutrino masses as well as Leptogenesis. The model possesses only two dynamical scales, namely the SM breaking scale v_H and the PQ breaking scale v_σ.
We introduce heavy vector-like quarks in the usual KSVZ fashion to implement the Peccei Quinn (PQ) mechanism for the strong CP problem. To generate neutrino masses via a dimension six operator scaling as $m_\nu \sim v_H^3/v_\sigma^2$ we add heavy triplet and doublet leptons, which are vector-like under the SM but chiral under PQ symmetry. The model is free from the cosmological domain wall problem and predicts an axion to photon coupling which is about an order of magnitude larger than in conventional DFSZ and KSVZ models. Thus our scenario can be probed and potentially excluded by current and next generation axion experiments such as ORGAN or MADMAX.
In addition we numerically demonstrate that our construction can generate the observed baryon asymmetry by realizing a version of the Dirac-Leptogenesis scenario. As a consequence of our neutrino mass mechanism we find that the asymmetry in triplet fermion decays can also be significantly enhanced by up to six orders of magnitude when compared to typical Seesaw scenarios without needing to invoke a resonant enhancement. In passing we note that a decaying Dirac fermion with multiple decay modes contains all the necessary ingredients required for the "quasi optimal efficiency"-scenario previously encountered in the context decaying scalar triplets. The impact of the active right handed neutrinos and the axion on the amount of dark radiation ΔN_{eff} is estimated, which lies within current bounds and can also be diluted via entropy generation from the decay of a potentially long lived scalar responsible for the spontaneous breaking of PQ symmetry.

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Session Classification: Parallel Session B

Track Classification: Particle Physics