Letter of Interest for Snowmass 2021

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(1) Probing baryon and lepton number violation via gravitational wave experiments (RF4)

The stochastic gravitational wave background is the key to unraveling the symmetry breaking pattern in the first instances after the Big Bang. It provides information about the physics at the highest energy scales, inaccessible directly in any other experiment. The two main sources of such gravitational waves come from cosmological phase transitions and cosmic strings.

In Ref. [1], we proposed to look for a unique signature of this type, which arises in models with a vast hierarchy between the symmetry breaking scales. An interesting example are models with gauged baryon and lepton number, in which the high-scale lepton number breaking is motivated by the seesaw mechanism, whereas the low scale of baryon number breaking is required to explain the dark matter relic abundance. Such models naturally explain the nonobservation of proton decay.

In our analysis we focused on the model constructed in Ref. [2]. Extending the analysis to other models will provide more insight into the detection possibilities of existing and upcoming gravitational wave experiments like LIGO, Virgo, LISA, Big Bang Observer, DECIGO, Einstein Telescope and Cosmic Explorer. Such a cosmic search for a combined signature of baryon and lepton number violation is complementary to collider efforts. An observation of the proposed gravitational wave signal would be a strong motivation for building the 100 TeV collider, which could independently search for the leptophobic gauge boson associated with baryon number breaking.

(2) Scalar and vector mediators for the neutron dark decay at the LHC and FCC (EF09)

The neutron lifetime anomaly is an outstanding puzzle in particle and nuclear physics. It can be explained by the neutron decaying to dark matter particles with a branching fraction 1% [3]. Such neutron dark decays are mediated by scalars or vectors coupled to quarks and dark matter. The mass of those colored particles can be as low as $\sim$ TeV. An analysis of the LHC and FCC reach for those particles has not been performed in the context of the neutron lifetime anomaly. This is especially interesting to explore, since the neutron dark decay channel provides a direct portal to the dark sector.

(3) Pati-Salam gauge leptoquark at the FCC (EF09)

The LHCb flavor anomalies can be explained by $\sim$ 10 TeV Pati-Salam gauge leptoquark [4]. Models with such a vector particle give rise to unique signals in gravitational wave detectors [5]. The gauge leptoquark can also be searched for at the FCC, where it would lead to striking signatures. An analysis of such FCC signatures would be very interesting to perform, especially due to its complementarity with gravitational waves experiments.

References

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[3] B. Fornal and B. Grinstein, "*Dark Matter Interpretation of the Neutron Decay Anomaly*," *Phys. Rev. Lett.* **120** no. 19, (2018) 191801.

[4] B. Fornal, S. A. Gadam, and B. Grinstein, "*Left-Right SU(4) Vector Leptoquark Model for Flavor Anomalies*," *Phys. Rev. D* **99** no. 5, (2019) 055025.

[5] B. Fornal, "*Gravitational Wave Signatures of Lepton Universality Violation*," `arXiv:2006.08802 [hep-ph]`.