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Department of Physics

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the Degree of Master of Science in Particle Physics and Field Theory

Baryogenesis through leptogenesis in non-standard cosmologies

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Declaration of Authorship

Mehran Dehpour hereby affirms that the thesis titled “Baryogenesis through leptogenesis in non-standard cosmologies” and the research presented therein are entirely his original study. In instances where he has referenced the published works of others, he has ensured to provide proper attribution. The thesis has been constructed upon the following papers:

- M. Dehpour, *Thermal leptogenesis in nonextensive cosmology*, *Eur. Phys. J. C* **84** (2024) 340 [[2401.00229](#)]
- M. Dehpour, *Thermal leptogenesis in anisotropic cosmology*, *Int. J. Mod. Phys. A* **38** (2023) 2350181 [[2312.10677](#)]

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Abstract

It is usually assumed that the Universe was produced initially without matter asymmetry or that the initial matter asymmetry was washed away by inflation. This implies that after the inflation, for every particle there was a corresponding antiparticle. One might then expect that this would result in the total annihilation of matter and antimatter as the temperature decreased, leading to our non-existence. However, fortunately, there is an excess of matter over antimatter which, nonetheless, is a problem that begs an explanation. Some researchers try to solve this problem by extending the standard model of particle physics. Some believe that the answer may lie in the neutrinos. The introduction of the sterile neutrinos, in conjunction with the seesaw mechanism, presents a viable explanation for the nonzero neutrino masses, which is beyond the standard model. In this framework, the mechanism of leptogenesis can also help address the matter asymmetry problem. However, the leptogenesis scenario, which relies on these components, has its drawbacks, such as the necessity for a large mass scale. It can lead to gravitino overproduction, in conflict with the supersymmetric models, and make the model untestable because of its inaccessible energy. In this work, we explore two methods for achieving low-scale leptogenesis through non-standard cosmologies. First, as we know, conventional statistical mechanics is not universal, and here we concentrate on the effects of Tsallis nonextensive statistical mechanics in the early Universe. Second, as we do not have signatures of isotropy before the big bang nucleosynthesis, we forsake the isotropic cosmological principle for a Bianchi type-I metric in the early Universe. We show that the use of nonextensive statistical mechanics can affect the production of baryon asymmetry in thermal leptogenesis by modifying the equilibrium abundance of particles, decay, and washout parameters. Also, our results show that for specific values of the anisotropy, the modified thermal leptogenesis can generate more baryon asymmetry than the standard one. In this way, our findings suggest that these approaches can facilitate low-scale leptogenesis.

Keywords: baryogenesis; thermal leptogenesis; nonextensive Tsallis statistical mechanics; Bianchi type-I.

Bibliography

- [1] M. Dehpour, *Thermal leptogenesis in nonextensive cosmology*, *Eur. Phys. J. C* **84** (2024) 340 [2401.00229].
- [2] M. Dehpour, *Thermal leptogenesis in anisotropic cosmology*, *Int. J. Mod. Phys. A* **38** (2023) 2350181 [2312.10677].