

Peer Review

Review of: "Parity Violation and Magnetic Helicity on Cosmological Scales: From Turbulent Baryogenesis to Galaxy Clusters"

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I have reviewed the manuscript "*Parity Violation and Magnetic Helicity on Cosmological Scales: From Turbulent Baryogenesis to Galaxy Clusters*" by Alexander Bershadskii. The author discusses how turbulent dynamics associated with parity violating processes during the epoch of baryogenesis and/or leptogenesis in the early Universe can be related to magnetic helicity.

I have the following comments about the manuscript:

1. I believe the first sentence maybe better expressed by stating that the generation of magnetic fields during the EW phase transition epoch is one of the major scenarios, and many models in this scenario involve the violation of parity (P) and charge-parity (CP) violation, thus linking them naturally to baryogenesis.
2. It is to be noted that both P and CP violation are necessary for baryogenesis, and helical magnetic fields emerge as a consequence of generating magnetic fields in such models.
3. The author should clarify what they mean by "point-wise helicity", since helicity is not a local quantity, owing to the non-uniqueness of the magnetic vector potential.
4. I believe Eq. (1) should be better written as $\exp(-k/k_\beta)\beta$.
5. The author discusses that the parameter β characterizes the chaos, and cites some sources. It would be helpful if a discussion is provided in a few sentences how β is related to chaotic behavior.
6. It is a little unclear what the author means by CMB photons being generated during the baryogenesis/leptogenesis epoch. Is it a reference to the EW PT epoch, or is it the reheating epoch?

7. The author mentions (start of Pg. 3): “*one can expect that the level of the randomness of the magnetic field generated at the lepto/baryogenesis epoch will be imprinted on the level of randomness of the temperature of the CMB-to-be photons*” the randomness in the photon background and the magnetic fields generated are expected to be Gaussian, as from inflation. It needs to be clarified whether the author is referring to deviations from Gaussianity or additional randomness?
8. The author mentions (end of Sec. II): “*The observational estimates of the magnetic fields of the galaxy clusters turned out to be much larger than those predicted for the primordial magnetic fields.*” This is not necessarily true for inflationary magnetic fields.
9. Eq. (7) should have $\exp(-k/k_c)$ instead of $\exp(-(k/k_c)^2)$; similarly for Eqs. (9) and (10).
10. I would urge the author to elaborate on the statement (end of Sec. V) “*Fig. 5 can be considered as an indication that the remnant spectrum from the lepto/baryogenesis epoch can indeed be seen in the CMB spectrum*”, i.e., to justify the assertion made here in a few more sentences.

Overall, I would like to see some motivation for considering chaotic dynamics, and some more discussion about the physical ramifications of such chaos, and how it relates to the observables.

Declarations

Potential competing interests: No potential competing interests to declare.