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Explaining the ACT Helium Abundance tension via Large Lepton Asymmetry from Axion Inflation

The generation of helical magnetic fields and associated chiral asymmetry via the chiral anomaly is a generic feature in pseudoscalar inflation models. In this talk, we explore a scenario where the inflaton ϕ is coupled to a gauged lepton flavor symmetry $U(1)_{L_\mu - L_\tau}$ through a Chern-Simons term $\frac{\alpha}{4f}\phi F\tilde{F}$.

The homogeneous evolution of the inflaton will case a tachyonic instability in one helicity mode of the gauge field, leading to the exponential production of helical magnetic fields. While this process naturally induces a lepton asymmetry, the resulting magnitude in standard setups is typically suppressed by the fermion production during inflation, causing it to be too small to yield observable consequences.

We demonstrate that this limitation can be overcome by implementing a specific mechanism to suppress fermion production during the inflationary era. This suppression allows for a much larger quantity of magnetic helicity. Focusing on the gauged $U(1)_{L_\mu - L_\tau}$ symmetry, we show that our mechanism can produce relatively large lepton asymmetry. Furthermore, to avoid baryon overproduction via Sphaleron process, we postpone the $U(1)_{L_\mu - L_\tau}$ symmetry breaking until after EWPT. This result provides a scenario for the Y_p tension recently hinted at by the ACT cosmic microwave background observations.

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