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The impact of chiral effects on lepton flavor asymmetry in the early Universe

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Anomalous transport phenomena, such as the chiral magnetic effect, arise from the chiral anomaly in gauge theories and have recently gained attention in hadron and condensed matter physics. These effects can also lead to intriguing phenomena in the early Universe, where chirality is well-conserved at temperatures above 100 TeV. One example is the chiral plasma instability, in which helical hypermagnetic fields are amplified due to chiral asymmetry, ultimately contributing to baryon asymmetry through the decay of hypermagnetic helicity.

In particular, we highlight that a large lepton flavor asymmetry, possibly present before electroweak symmetry breaking and consistent with a vanishing total B-L, generally corresponds to a significant chiral asymmetry. This asymmetry induces the amplification of strong helical magnetic fields, leading to baryon overproduction. Our findings suggest that this mechanism imposes a stricter constraint on lepton flavor asymmetry than those derived from Big Bang Nucleosynthesis (BBN). Similar to how large lepton asymmetry before electroweak symmetry breaking is constrained by the SU(2) chiral anomaly through electroweak sphalerons to prevent baryon overproduction, we conclude that large lepton flavor asymmetry is also constrained by the U(1) hypergauge chiral anomaly.

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