Sphalerons and baryogenesis in cosmological electroweak transition of the minimal standard model

E.Shuryak

Stony Brook

Abstract:

We start by introducing sphalerons and analytic solutions for magnetic "sphaleron path" configurations,
and then proceed to time-dependent sphaleron explosions, in symmetric phase $T>T_{EW}$ when Higgs fields can be ignored.
Then we review what is known about sphaleron rates near the electroweak phase transition from lattice studies,
and discuss sphalerons size distribution. Sphaleron explosions generate sound and even gravity waves,
when nonzero Weinberg angle make them non-spherical.
Then a concept of "sphaleron freezeout", at $T\approx 130\, GeV$, is introduced:
whereby the sphaleron production rate matches the Hubble Universe expansion rate.
At freezeout the sphalerons are out of equilibrium.
We then turn to the magnitude of CP violation induced by the CKM quark matrix during the sphaleron explosions.
A ``topological stability" is introduced: Dirac zero modes are topological and
cannot be removed by plasma effects. We find that CP violation at the sphaleron freezeout is roughly in the range
needed to generate the observed magnitude of baryon asymmetry of the Universe.