

A note on gravitational baryogenesis within Bianchi type I universe

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Abstract The mechanism of gravitational baryogenesis, based on the CPT-violating gravitational interaction between the derivative of the Ricci scalar curvature. We study the gravitational baryogenesis in the Bianchi type I universe. We find out the effect of anisotropy of the universe on the baryon asymmetry for the different models of cosmology.

Keywords Anisotropic universe · Baryon asymmetry · Baryogenesis · Gravitational interaction

1 Introductions

Nowadays it is well known that the Minimal Standard Model (MSM) of elementary particles cannot explain the baryon asymmetry observed in the universe. The high degree of symmetry between matter and antimatter in our theories has long seemed in contradiction with the overwhelming presence of matter (baryons) round us. The absence of γ ray emission from matter-antimatter annihilation (Cohen et al. 1998), measurements of cosmic microwave background (Bennett et al. 2003), and Big Bang nucleosynthesis (Burles et al. 2001), all indicate an asymmetry between matter and anti-matter in the universe. The origin of this problem (baryon asymmetry) remains a big puzzle in particle physics and cosmology. The mechanism of generation of this asymmetry from the initially symmetric state was proposed by A.D. Sakharov (Sakharov 1967, see also review

Rubakov and Shaposhnikov 1996a, 1996b) and today is formulated as three baryogenesis conditions:

1. Baryon number non-conservation.
2. C- and CP-symmetry violation.
3. Deviation from thermal equilibrium.

Of course, the first of these is obvious—no B violation, no baryon production. To understand the second condition, note that, roughly speaking, if C and CP are conserved, the rate for any process which generates baryons is equal to that for the conjugate process, which produces antibaryons, so no net excess is generated on average. Finally, in thermal equilibrium the number density of a particle species is determined purely by its energy, and since the masses of particle and antiparticle are equal by the CPT theorem, the number density of baryons equals that of antibaryons. It is well known the Sakharov's conditions can be realized in the minimal standard model (SM) of particle physics. But In SM CP violation is not enough and the first order phase transition is too small to account for the value observed, $n_b/s \sim 10^{-10}$. Therefore, people tried to find many possible ways in or beyond the SM to explain the origin and predicted value of baryon asymmetry (Cohen and Kaplan 1987; Lambiase and Scarpetta 2006; Colladay and Kostelecký 1997, 1998).

In Cohen and Kaplan (1987), by introducing a scalar field coupled to baryon number current it was suggested that the baryon asymmetry may be generated in thermal equilibrium while the CPT invariance is dynamically violated. Similarly, in Davoudiasl et al. (2004), by introducing an interaction between Ricci scalar curvature and baryon number current which dynamically violates CPT symmetry in expanding Friedman-Robertson-Walker (FRW) universe, a mechanism for baryon asymmetry was proposed. It is well known that anisotropy is more important in the early

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