AD Research project

I. INTRODUCTORY STATEMENTS

The creation of antimatter regions has been analyzed in [1]. It is based on the analysis of a broken $U(1)$ symmetry. Also in a (broken) $SU(5)$ AD model, as analyzed in [2], the inclusion of terms χ^4, χ^6, $\tilde{\alpha}\chi^6$ do not affect the baryon number.
In, the features of the broken $U(1)$ AD symmetry, whose pertinent scalar field induced the creation of antibaryionic matter regions, are explained; the statistical distribution, the variance and the standard deviation
+ the for the creation of antimatter regions are calculated.

While the variance of the sum (or the difference) of uncorrelated random variables is the sum of their variances, the variance of the sum of correlated variables follows the usual rule.
Given a very large number of regions ruled by an AD potential (within the inflaton-field model).
In the single-filed approximation for the inflaton field

$$V(\phi) = (4\alpha - 3)2E_1\phi^2 + E_2\phi^3 - 4\alpha E - 3\phi^4 \tag{1}$$

has been considered in [7] after [8] for instantons.
Different rescaling of the inflaton field can produce different scenarios for inflation.
Other kinds of inflation-generating potentials ruling the scalar field can be considered, i.e. the Coleman-Weinberg potential, and spontaneously broken local $U(1)_{bl}$ potentials [3] [1].
Given a scalr-field generating scenario, [1] the number of baryons n_B is given as

$$n_b \equiv \widetilde{\theta} m [A(t)]^2 \frac{\phi_0^2}{M_G^2}, \tag{2}$$

ϕ_0 being the value of the minimum of the potential ruling the dynamics of the scalar field, $\widetilde{\theta}$ the CP-violation angle(s), $A(t)$ the amplitudes of the oscillations at the time t, out of the flat regions, at a distance M_G form the origin.
For CP-violations $O(1)$, the baryon number per particle is of order 1. At thermal equilibrium

$$\frac{n_B}{n_\gamma} \simeq 10^2\theta \left(\frac{\phi_0}{M_G}\right)^2 \tag{3}$$

As in [4], given a field $f(x)$ in a region V, $\tilde{f}(x) = \sum_{\vec{k}} \tilde{f}_{\vec{k}} e^{i\vec{k}\vec{k}}$, the coefficients $a_{\vec{k}}$ and $b_{\vec{k}}$ can assume different values in different N spatial regions. For large values of N,

$$d\bar{N} = N a'_{\vec{k}} b'_{\vec{k}} da_{\vec{k}} db_{\vec{k}} \tag{4}$$

for a homogeneous Gaussian process

$$p(a_{\vec{k}}, b_{\vec{k}}) = \frac{1}{2\pi\sigma_k^2} e^{-\frac{a_{\vec{k}}^2}{\sigma_k^2}} e^{-\frac{b_{\vec{k}}^2}{\sigma_k^2}} \tag{5}$$

where the variance σ_k depends only on $k =\mid \sigma_k \mid$, is the same for bot the the independent variables $a_{\vec{k}}$ and $b_{\vec{k}}$ and the correlation functions depend on σ_k only. The expectation value

$$< \tilde{f}_{\vec{k}} \tilde{f}_{\vec{k}'} >= \sigma_k^2 \delta_{\vec{k},-\vec{k}'} \tag{6}$$

For a superposition generalizing the Yukawa coupling [5], in a NMSSM, th CP violation depends on the chargino mass matrix, which generates non-thermal electro-weak baryogenesis and preheating.
As in [**?**], strong $U(1)$ mixing induces a magnetic moment responsible for the shift of the corresponding particle and produces interactions for which the baryon charge and the lepton charge is fractional (1/2).

II. FURTHER APPLICATIONS

In [11], At the cosmological time for galaxy-formation, after the time $\tilde{t}_a$ the variance $< \delta\theta >^2$ assumes a fixed value [11],

$$< \delta\theta >^2 = \frac{t^2}{4\pi^2 f^2} \tag{7}$$

with a dispersion

$$\sqrt{< \delta\theta >^2} = \frac{t^{-1}}{4\pi f} N \tag{8}$$

with N the number of e-folds. A Gaussian probability distribution id found as

$$P(\theta) \frac{1}{\sqrt{2\pi}\sigma_l} e^{-\frac{(\theta_{60}\theta_l)^2}{2\sigma_l^2}} \tag{9}$$

with

$$\sigma_l = \frac{t^-2}{4\pi^2} \ln \frac{L_U e^{N-N_0}}{l} \tag{10}$$

with l the size of the Universe at the time of Galaxy formation, and N the number or e-folds.

The number of regions containing antimatter is evaluate form after Eq. 4 considering the phase in $\tilde{f}_k$ expansion. The phase expansion is evaluated as from [12], with a phase $f = (12t^{-2})^{3/4}\xi x$. i.e. from [13] normalized within the volume $V_\theta$as from [4].

[1] For potentials in other kinds of theories, it is possible to consider also i.e. [9], [10].

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