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Addendum

Addendum to "Leptogenesis in an SU(5) × A_5 golden ratio flavour model" [Nucl. Phys. B 896 (2015) 311–329]

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Abstract

We derive and discuss the solution of the Boltzmann equations for leptogenesis in a phenomenologically viable SU(5) × A_5 golden ratio flavour model proposed in [1,2]. The model employs, in particular, the seesaw mechanism of neutrino mass generation. We find that the results on the baryon asymmetry of the Universe, obtained earlier in [2] using approximate analytic expressions for the relevant CP violating asymmetry and efficiency factors, are correct, as was expected, up to 20–30%. The phenomenological predictions for the low energy neutrino observables, derived using values of the parameters of the model for which we reproduce the observed value of the baryon asymmetry, change little with respect to those presented in [2]. Among the many predictions of the model we find, for instance, that the neutrinoless double beta decay effective Majorana mass m_{ee} lies between 3.3 meV and 14.3 meV.

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1. Introduction

The origin of flavour is one of the most challenging unresolved fundamental problems in particle physics. The questions of why there are three generations (not more and not less), of the origin of the hierarchies of the fermion masses and of the very different quark and neutrino mixing patterns are still far from having received a satisfactory explanation.

In recent years an approach to the problem of flavour based on discrete flavour symmetries became widely used especially in treating the flavour problem in the lepton sector, for a recent review see, e.g., [3]. A large number of models employing discrete flavour symmetries have been proposed. However, many of these models focus only on leptons and only reproduce the observed neutrino mixing angles with possibly a few additional predictions for the leptonic CP violation phases and/or the absolute neutrino mass scale.

Here we will focus on a particular model [1] which reproduces *all flavour information in the quark sector* and in addition to reproducing the mixing angles in the neutrino sector, provides predictions for the absolute neutrino mass scale and the leptonic CP violation phases. In [2] we discussed a slight modification of the original model, which allowed us to accommodate successfully the generation of the baryon asymmetry of the Universe within the leptogenesis scenario [4]. In that previous publication [2] we used analytic approximations to calculate the baryon asymmetry, which can be expected to be correct only up to 20–30%. In the present article we go beyond these approximations and calculate the baryon asymmetry by solving the relevant system of Boltzmann equations numerically. We show that using this more precise method of calculation of the baryon asymmetry one can still generate successfully the observed value of it in the model considered. We discuss also the impact of the new results on the baryon asymmetry on the predictions of the low energy observables of the model – on the correlation between the angles θ_{13} and θ_{23}, on the values of the leptonic CP violation phases, on the value of the effective Majorana mass in neutrinoless double beta decay, m_{ee}, etc.

The article is organised as follows. In Section 2 we review the model constructed in [1] and its modification proposed in [2]. In Section 3 we discuss the Boltzmann equations and the solutions for the baryon asymmetry we obtain. We update the results on the neutrino masses and mixing angles previously obtained in [1,2] in Section 4. Section 5 contains summary and conclusions.

2. The leptonic Yukawa and Majorana mass matrices

In this section we briefly recapitulate the Yukawa couplings and Majorana mass matrices in the lepton sector of the model of interest to fix notations. The structure of these matrices is justified by the flavour symmetries of the model and is discussed extensively in [1,2]. The interested reader is referred to these articles for details.

The right-handed neutrino Majorana mass matrix reads

$$M_{\mathrm{RR}} = y_2^n \begin{pmatrix} 2\sqrt{\frac{2}{3}}(v_2+v_3) & -\sqrt{3}v_2 & -\sqrt{3}v_2 \\ -\sqrt{3}v_2 & \sqrt{6}v_3 & -\sqrt{\frac{2}{3}}(v_2+v_3) \\ -\sqrt{3}v_2 & -\sqrt{\frac{2}{3}}(v_2+v_3) & \sqrt{6}v_3 \end{pmatrix} \quad (2.1)$$

where v_2 and v_3 are complex (vevs) of a flavon breaking the A_5 family symmetry. This matrix is of the golden ratio pattern type A [5], i.e., it is diagonalised by