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On the Fine Structure and the Other Coupling Constants at the Planck Scale

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Abstract

It is shown that the fine structure constant at Planck times α_P tends to one as well as those of the weak and strong interactions. This results by constraining them at the Planck force. That seems to provide interesting new results which confirm that at the beginning of space time (Planck scale) all fundamental forces converge to the same unit value.

Keywords

Fine Structure Constant, Fundamental Interactions Coupling Constants, Unification at Planck Scale

1. Introduction

It is well known that the smaller the energy into play, the more the interactions involved diversify. Undisputed examples are the electric and magnetic forces, seemingly two unrelated phenomena in the electron- and magneto-static domain, but successfully unified in higher energy electromagnetism. The same applies to electroweak interactions at the 100 GeV scale.

Thus conversely the higher the energy the more all interactions seem to unify.

The aim of the present note is to show that also electromagnetism determined by the fine structure α turns out to be one at the Planck scale as all other interactions as opposed to their present values[1] (Table 1).

2. GUT for Pedestrians

Planck units [1] are thought to represent the limits of our present theoretical

[1]The above numbers should be taken just as an indication, except for α_{em} determined from QED. All the other ones are determined from their ratio to the Coulomb potential. Thus for instance the strength of strong interactions is assumed to be given by the one pion Yukawa potential and therefore by $\alpha_{st} \simeq 14$ leaving open the problem of the treatment of the shorter ranged heavier mesons. Analogous comments about the weak interaction.

Table 1. Coupling constants of the fundamental interactions at present.

Interaction	Symbol	Value
strong	α_{st}	≥ 1
electromagnetic	α_{em}	1/137
weak	α_{wk}	10^{-8}
gravitational	α_{gr}	10^{-39}

treatment *i.e.* the origin of space time. As well known the units of mass, length and time where originally derived by Planck, whereas electromagnetism was not considered. This can probably be explained by the fact that mechanical quantities can be derived in two alternative ways: as the smallest quantum black hole and by explicitly re-scaling ordinary units. Thus the derivation of the Planck charge seems to be more questionable than that of the previous three mechanical units also because of the value of the Planck charge, which turns out to differ considerably from the elementary one.

Indeed [2]

$$q_P \simeq 11.7e \tag{1}$$

where e stands for the electric charge $\simeq 1.6 \times 10^{-19}$ C.

The implications of this result seem to have been however overlooked.

The Planck charge is derived by equating gravitational Planck force to the electric one

$$\frac{GM_P^2}{R_P^2} = \frac{1}{4\pi\varepsilon_0}\frac{q_P^2}{R_P^2} \tag{2}$$

Notice that the result does not depend on the Planck length *which implies that the same holds true also for the corresponding potentials.*

However from the explicit form of the Planck mass ($M_P = \sqrt{\frac{\hbar c}{G}}$) one immediately obtains

$$\hbar c = 1 = \frac{q_P^2}{4\pi\varepsilon_0} \tag{3}$$

Thus the result of Equation (1) is not at all fortuitous but just tell us that the fine structure constant at Planck scales is also unity as it can also trivially obtained by squaring Equation (1).

$$\alpha_P \simeq 137\alpha = 1 \tag{4}$$

So, in a sense, GM_P^2 *plays the role of a Planck coupling constant which determines the fine structure one.* This provides interesting results also for the weak and strong coupling constants at the Planck scale. As a matter of fact the relevant quantity being

$$\frac{g^2}{4\pi}\frac{1}{q^2-M^2} \to \frac{g^2}{4\pi}\exp{-M/r} \tag{5}$$

where M stands both the pion and for the weak boson mass, it is obvious that by the same considerations which led to Equation (2) (this time for the potential) one straightforwardly obtains

$$\frac{GM_P^2}{R_p} = \frac{g^2}{4\pi}\exp{-M/r} \tag{6}$$

where at the Planck radius the exponential can be safely approximated to 1 so that

$$GM_P^2 = \frac{g^2}{4\pi}$$

Thus

$$\hbar c = 1 = \frac{g^2}{4\pi} \tag{7}$$

and

$$1 = \alpha_{st} = \alpha_{wk} = \alpha_{em} \tag{8}$$

Thus gravitation, electromagnetism and strong interactions unify at the Planck scale. It is remarkable how the effect works respectively to increase and decrease the present values of the coupling constants.

The statement [2] "that at the Planck length scale it has been theorised that all the fundamental forces are unified but the exact mechanism of this unification remains unknown" gets here a partial rebuttal (**Figure 1**).

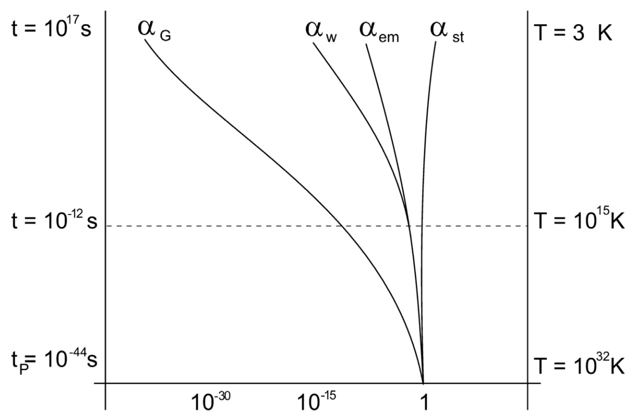

Figure 1. Time and temperature dependence of the different interactions. Not in scale. This shows how from the present very different values, the coupling constants tend to one at the Planck origin of space-time.

Needless to say the above results, as well as the description of a black hole, depend on the assumption of the validity of the Coulomb and Newton equations. This is anyhow in line with the theoretical instruments used in the derivation of

Planck units.

Similar conclusions have also been explicitly obtained in a description of gravitation below CMB as a QED black body [3] thus unifying gravitation and electromagnetism whose combined effect is a strong interaction one.

A related problem has been addressed by Pellis [4] with a different approach.

3. Conclusion

Therefore in addition to the unit Planck coupling constants $G, \hbar, c = 1$ also the coupling constants of the different interactions α appear in their own right with the same value.

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Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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