Posudek práce

předložené na Matematicko-fyzikální fakultě
Univerzity Karlovy

☐ posudek vedoucího ☑ posudek oponenta
☑ bakalářské práce ☐ diplomové práce

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Název práce:	Effects of additional scalar decaplet in the RG evolution of the running gauge couplings in the minimal SO(10) grand unified theory
Studijní program a obor:	Fyzika, Obecná fyzika (FOF)
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Odborná úroveň práce:
☑ vynikající ☐ velmi dobrá ☐ průměrná ☐ podprůměrná ☐ nevyhovující

Věcné chyby:
☐ téměř žádné ☑ vzhledem k rozsahu přiměřený počet ☐ méně podstatné četné ☐ závažné

Výsledky:
☐ originální ☑ původní i převzaté ☐ netriviální kompilace ☐ citované z literatury ☐ opsané

Rozsah práce:
☑ veliký ☐ standardní ☐ dostatečný ☐ nedostatečný

Grafická, jazyková a formální úroveň:
☑ vynikající ☐ velmi dobrá ☐ průměrná ☐ podprůměrná ☐ nevyhovující

Tiskové chyby:
☐ téměř žádné ☑ vzhledem k rozsahu a tématu přiměřený počet ☐ četné

Celková úroveň práce:
☑ vynikající ☐ velmi dobrá ☐ průměrná ☐ podprůměrná ☐ nevyhovující

Slovní vyjádření, komentáře a připomínky oponenta:

My understanding is that there are three important parts in this thesis:

(A) A text composed by the author based on various sources in order to set the background for his calculations. This includes sections 1, 2 and appendixes, together with fragments of sections 3 and 4.

(B) The derivation of a known formula in section 3, which involves complicated calculations. This formula is then applied to a particular model (the Standard Model) in section 4.

(C) The author's original contribution in section 5.

In my opinion, the selection of material included as background (part A) as well as its structure is excellent. Furthermore, the sources used are clearly indicated. Concerning part B, the author derives the generic expression of the 1-loop beta function of the gauge couplings in a Yang-Mills theory. This is a known formula, but its derivation is well beyond what is required of a bachelor student.

The author's original contribution (part C) consists on quantifying the impact on the running of the gauge couplings due to a scalar field transforming as the 10-dimensional representation of the $SO(10)$ group. By changing the energy scale at which the values of the 3 gauge couplings unify, this scalar field can have a significant impact on the proton lifetime. While there are some aspects of the analysis which are not entirely clear to me (I mention them below as questions to the author), they do not interfere with the overall conclusion that the proton lifetime can change up to around 30% under the assumptions made in the thesis.

The overall quality of the text seems very good, even though there are minor grammatical issues and a few misprints in some formulas. Finally, the graphical presentation of the thesis is beyond reproach.

Případné otázky při obhajobě a náměty do diskuze:
Here is a list to questions which I would consider interesting for a discussion.

- Table 5.1 contains some of the fields in the minimal SO(10) model (not all of them). Presumably, this table contains all fields which are not in the Standard Model, so it should not contain the vector bosons $(1,1,0)$, $(1,3,0)$ and $(8,1,0)$, nor a scalar $(1,2,1/2)$ (the Higgs doublet), nor any fermion. If so, the table seems to be missing the vector bosons $(\overline{3},1,-2/3)$ and one more complex scalar representation $(8,2,1/2)$ (on top of the one already in the table). Does the author agree that some scalars and vectors are missing (for example by just counting the total number of components of the SO(10) representations and subtracting the Standard Model ones)? And does this affect in any way the results in figures 5.3 and 5.4?

- It is stated on page 33 that the combined impact of the scalars $(3,1,1/3)$ and $(1,2,-1/2)$ is to change the b coefficients by $(1/6,1/6,1/6)$. This is true. Can the author find a simple argument to explain why these 3 numbers are the same?

- The two plots in figure 5.3 contain the most important results of the thesis. Concerning the plot on the left, showing α_{GUT}^{-1} versus $\log(\Delta M)$, I do not understand how α_{GUT}^{-1} can depend only on $\Delta M = m_{triplet}/m_{doublet}$. It should depend on both $m_{triplet}$ and $m_{doublet}$. For example, if $\Delta M = 0$ and $m_{triplet} = m_{doublet} \equiv m$, one gets perfect unification by just shifting α_{GUT}^{-1} (as the author states in the text), but this shift should depend on the value of m. Does the author have any comment on this? Also, the nature of the kink/non-linearily in the α_{GUT}^{-1} versus $\log(\Delta M)$ plot is unclear to me. I encourage the author to explain the non-linearily of the plot in some detail; there is already a paragraph in the text about this right after figure 5.3, but it is not very elucidating.

Práci:
☑ doporučuji
☐ nedoporučuji
uznat jako bakalářskou.

Navrhuji hodnocení stupněm:
☑ výborně ☐ velmi dobře ☐ dobře ☐ neprospěl

Místo, datum a podpis oponenta:

Praha, 18. června 2019 Renato Miguel Sousa de Fonseca