Posudek práce

předložené na Matematicko-fyzikální fakultě
Univerzity Karlovy v Praze

☒ posudek vedoucího ❑ posudek oponenta
❑ bakalářské práce ☒ diplomové práce

Autor: ***Roman Derco***
Název práce: ***Instantons and unitarily inequivalent quantum vacua***
Studijní program a obor: ***Physics – Nuclear and Subnuclear Physics***
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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 vedoucího: *The candidate studied the difficult problem of finding a relationship between unitarily inequivalent quantum vacua and topologically distinct vacua, especially those arising in the presence of instantons. Although both phenomena are very well studied, the interplay between them has not been investigated so far and, being the matter a very fundamental one (violation of the von Neumann theorem on the one hand, solitonic excitations on the other) results in this direction would surely be of interest. For instance, the understanding of how and when the topological vacua enter the description of the infinitely many vacua of a quantum (gauge) field theory could provide a ``super-selection`` rule to single-out the relevant (physical) vacua and how they are connected. The advanced nature of the investigation and the necessity of original solutions are the core of the difficulty of this problem. Derco's thesis, although does not provide a solution to the problem, constitutes a progress in the understanding of what needs to be done in order to solve the problem in future work.*

In the second and third Chapters he introduces all the building blocks and refers to the relevant literature that, in some cases, he has found and studied following his own intuition. The second Chapter is dedicated to the explanation of the origin of the unitarily inequivalent representations and of how they have been turned from a problem (in the early days of quantum field theory) to a tool to treat phenomena like dissipation in a quantum context. In the third Chapter he provides a thought-of introduction to solitonic excitations in field theory and refers to a vast enough selection of the literature.

It is in the fourth Chapter that he faces the problem of finding the wanted link. First of all he focuses on quantum mechanical examples of instantons, namely those arising in the path integral treatment of a quantum particle in various potentials (this way he can avoid the complications of gauge field theories but still have genuine instantons). The road that is outlined there (Section 4.2) towards the solution of the problem is quite original and consists in a multi-step procedure that first approximates the system of a particle in the double well potential with its near vacua behavior, then, by a suitable doubling of the degrees of freedom, it should manage to rephrase this into a system of two non-interacting harmonic oscillators, finally, it should move to a system of two interacting oscillators, one dumped one amplified. In the last step of this procedure the help of the instantonic treatment of the decay from a metastable state (Section 4.1) should provide guidance on how to import the instantonic formalism in this dissipative case. Accomplishing the latter goals would mean to have a dumped harmonic oscillator treated with instantons, but this system, as explained in some details in Section 2.3, naturally exhibits the unitarily inequivalent vacua hence, one would be in a good position to provide a partial solution. Derco managed to at least set-up the stage of this procedure and moved some steps in the right direction by attempting to find the correct doubling of the degrees of freedom (see the discussion about going back and forth from one variable q to two variables x and y in Section 4.2) but the problem proved to be too difficult for a solution within the time-frame of a Master thesis.

Also in Chapter four he provides a different example of how to find the link and that is the quantization of an extremely simple system made of a particle constrained to move in a circle. To my surprise, that system indeed presents unitarily inequivalent representations of the canonical commutations relations fully due to the U(1) (compactified time) to U(1) (angle variable) mapping underlying the quantization. Unfortunately, Derco came to this problem only too late to be able to produce any interesting results. Indeed, there are no attempts made in his thesis to use this system to explicitate the link that (according to practitioners in the field, such as Kastrup, Strocchi and Isham) should be there. Nonetheless, Derco manages to give a good introduction to the topic and to refer to the relevant literature explaining in some details the important steps. This will surely be quite useful to the next scholar that would like to initiate her/his search for the solution of the general problem.

For the above illustrated reasons I consider this thesis a very good thesis and recommend that Roman Derco be awarded his title of Magister.

Případné otázky při obhajobě a náměty do diskuze:

Focusing on the quantum particle on a circle: what needs to be done there to explicitly see how topologically distinct vacua are also unitarily inequivalent?

Práci
☒ doporučuji
❑ nedoporučuji
uznat jako diplomovou.

Navrhuji hodnocení stupněm:
❑ výborně ☒velmi dobře ❑ dobře ❑ neprospěl/a

Místo, datum a podpis vedoucího: **Prague, 6th January 2012, Alfredo Iorio**