LINKED $\mathcal{PT}$-SYMMETRY TO SUPERSYMMETRY IN A CLASS OF NON-HERMITIAN HAMILTONIANS

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Abstract:
We introduce and study a class of non-Hermitian Hamiltonians which have velocity dependent potentials. Since stability cannot be advocated directly from the classical potential, we show that the energy spectra are real and bounded from below which proves the stability of the spectra of all members in the class. We find that the introduced class of non-Hermitian Hamiltonians do have a corresponding superpartner class of non-Hermitian Hamiltonians. We were able to introduce supercharges which in conjunction with the corresponding super Hamiltonians constitute a closed super algebra. Among the introduced Hamiltonians, we show that non-$\mathcal{PT}$-symmetric Hamiltonians can be transformed into their corresponding superpartner Hamiltonians via a specific canonical transformation while the $\mathcal{PT}$-symmetric ones failed to be mapped to their corresponding superpartner Hamiltonians via the same canonical transformation. Since canonical transformations preserve the spectrum, we conclude that non-$\mathcal{PT}$-symmetric Hamiltonians out of the introduced class of Hamiltonians have the same spectrum as the corresponding superpartner Hamiltonians and thus supersymmetry (Susy) is broken for such Hamiltonians. This kind of intertwining of $\mathcal{PT}$-symmetry and Susy is new as all the so far discussed cases concentrate on Hamiltonians of broken $\mathcal{PT}$-symmetry that have broken Susy too while we showed that Susy can be also broken for non-$\mathcal{PT}$-symmetric and non-Hermitian Hamiltonians.
Keywords: Supersymmetry-pseudo-Hermitian Hamiltonians, $\mathcal{PT}$-symmetric theories☐

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REPRESENTATION DEPENDENCE OF SUPERFICIAL DEGREE OF DIVERGENCES IN QUANTUM FIELD THEORY

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Abstract:
In this work, we investigate a very important but unstressed result in the work of C. M. Bender, J.-H. Chen, and K. A. Milton, *J. Phys. A* **39**, 1657 (2006). These authors have calculated the vacuum energy of the $i\phi^3$ scalar field theory and its Hermitian equivalent theory up to g^4 order of calculations. While all the Feynman diagrams of the $i\phi^3$ theory are finite in 0+1 space–time dimensions, some of the corresponding Feynman diagrams in the equivalent Hermitian theory are divergent. In this work, we show that the divergences in the Hermitian theory originate from superrenormalizable, renormalizable and nonrenormalizable terms in the interaction Hamiltonian even though the calculations are carried out in the 0+1 space–time dimensions. Relying on this interesting result, we raise a question: Is the superficial degree of divergence of a theory is representation dependent? To answer this question, we introduce and study a class of non-Hermitian quantum field theories characterized by a field derivative interaction Hamiltonian. We showed that the class is physically acceptable by finding the corresponding class of metric operators in a closed form. We realized that the obtained equivalent Hermitian and the introduced non-Hermitian representations have coupling constants of different mass dimensions which may be considered as a clue for the possibility of considering nonrenormalizability of a field theory as a nongenuine problem. Besides, the metric operator is supposed to disappear from path integral calculations which means that physical amplitudes can be fully obtained in the simpler non-Hermitian representation.
Keywords: Pseudo-Hermitian Hamiltonians; metric operators; non-Hermitian models; nonrenormalizable theories; PT-symmetric theories.

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Nonperturbative tests for asymptotic freedom in the PT-symmetric (-phi(4))(3+1) theory

Author(s): Shalaby, A (Shalaby, Abouzeid)[1,2]; Al-Thoyaib, SS (Al-Thoyaib, Suleiman S.)[3,4]

Abstract:

n the literature, the asymptotic freedom property of the (-phi(4)) theory is always concluded from realline calculations while the theory is known to be a non-real-line one. In this article, we test the existence of the asymptotic freedom in the (-phi(4))(3+1) theory using the mean field approach. In this approach and contrary to the original Hamiltonian, the obtained effective Hamiltonian is rather a real-line one. Accordingly, this work resembles the first reasonable analysis for the existence of the asymptotic freedom property in the PT-symmetric (-phi(4)) theory. In this respect, we calculated three different amplitudes of different positive dimensions (in mass units) and find that all of them go to very small values at high energy scales (small coupling) in agreement with the spirit of the asymptotic freedom property of the theory. To test the validity of our calculations, we obtained the asymptotic behavior of the vacuum condensate in terms of the coupling, analytically, and found that the controlling factor Lambda has the value $(4 \pi)(2)/6 = 26.319$ compared to the result Lambda = 26.3209 from the literature, which was obtained via numerical predictions. We assert that the nonblowup of the massive quantities at high energy scales predicted in this work strongly suggests the possibility of the solution of the famous hierarchy puzzle in a standard model with the PT-symmetric Higgs mechanism.

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Author(s): Bender, CM; Milton, KA

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Author(s): Bender, CM; Chen, JH; Milton, KA

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Author(s): Bender, CM; Brody, DC; Jones, HF

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Author(s): Bender, CM; Meisinger, PN; Yang, HT

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Author(s): WESS, J; ZUMINO, B

Abouzeid Shalaby May 2009

New ansatz for metric operator calculation in pseudo-Hermitian field theory

Author(s): Shalaby, AM (Shalaby, Abouzeid M.)[1,2]

Abstract:

In this work, a new ansatz is introduced to make the calculations of the metric operator in pseudo-Hermitian field theory simpler. The idea is to assume that the metric operator is not only a functional of the field operator phi and its conjugate field pi but also on the field gradient del phi. The ansatz enables one to calculate the metric operator just once for all dimensions of the space-time. We calculated the metric operator of the i phi(3) scalar field theory up to first order in the coupling. The higher orders can be conjectured from their corresponding operators in the quantum mechanical case available in the literature. We assert that the calculations existing in literature for the metric operator in field theory are cumbersome and are done case by case concerning the dimension of space-time in which the theory is investigated. In fact, with the aid of this work a rigorous study of a PT-symmetric Higgs mechanism can be reached.

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Author(s): Bender, CM; Berry, M; Meisinger, PN; et al.
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Author(s): Bender, CM; Boettcher, S
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Author(s): Delabaere, E; Trinh, DT
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Author(s): Mostafazadeh, A
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Author(s): Mostafazadeh, A
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22. Title: Effective field calculations of the energy spectrum of the PT-symmetric (-x(4)) potential Author(s): Shalaby, Abouzeid M.
Source: PHYSICAL REVIEW D Volume: 79 Issue: 6   Article Number: 065017 DOI: 10.1103/PhysRevD.79.065017 Published: MAR 2009

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Author(s): Shin, KC
Source: JOURNAL OF PHYSICS A-MATHEMATICAL AND GENERAL Volume: 38 Issue: 27 Pages: 6147-6166 DOI: 10.1088/0305-4470/38/27/005 Published: JUL 8 2005

Possible treatment of the ghost states in the Lee-Wick standard model

Author(s): Shalaby, AM (Shalaby, Abouzeid M.)[1,2]

Abstract:

In this work, we employ the techniques used to cure the indefinite norm problem in pseudo-Hermitian Hamiltonians to show that the ghost states in a higher derivative scalar field theory are not real ghosts. For the model under investigation, an imaginary auxiliary field is introduced to have an equivalent non-Hermitian two-field scalar theory. We were able to calculate exactly the positive definite metric operator eta for the quantum mechanical as well as the quantum field versions of the theory. While the equivalent Hamiltonian is non-Hermitian in a Hilbert space characterized by the Dirac sense inner product, it is, however, a Hermitian in a Hilbert space endowed with the inner product << n vertical bar eta vertical bar m >>. The main feature of the latter Hilbert space is that the propagator has the correct sign (no Lee-Wick fields). Moreover, the calculated metric operator diagonalizes the Hamiltonian in the two fields (no mixing). We found that the Hermiticity of the calculated metric operator to lead to the constrain $M > 2m$ for the two Higgs masses, in agreement with other calculations in the literature. Besides, our mass formulas coincide with those obtained in other works (obtained by a very different regime but with the existence of ghost states), which means that our positive normed Hamiltonian form preserves the mass spectra.

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