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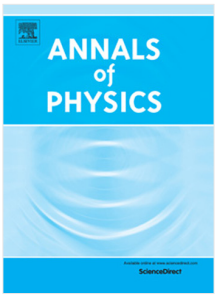

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Higher Order Supersymmetric Truncated Oscillators

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Abstract

We study the supersymmetric partners of the harmonic oscillator with an infinite potential barrier at the origin and obtain the conditions under which it is possible to add levels to the energy spectrum of these systems. It is found that instead of the usual rule for non-singular potentials, where the order of the transformation corresponds to the maximum number of levels which can be added, now it is the integer part of half the order of the transformation which gives the maximum number of levels to be created.

Keywords: supersymmetric quantum mechanics, spectral design, truncated oscillator

1. Introduction

The so called spectral design in quantum mechanics basically consists in producing a Hamiltonian with a prescribed spectrum, departing from an initial one whose spectrum is already known. Among the various techniques available to implement the spectral design, supersymmetric quantum mechanics has proven to be a powerful one, since its defining equation gives the relation between the energy spectrum of the initial and new Hamiltonians (usually called supersymmetric partners) in a straightforward manner [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31]. While first investigations focused on non-singular potentials, it is important to study the way that supersymmetric quantum mechanics works for potentials with singular terms, e.g. infinite walls, centrifugal barriers, etc. [4, 9, 14, 17, 25, 29]. In this paper we will see that the so-called truncated oscillator plays a special role for this kind of studies.

Let us note that a truncation for the harmonic oscillator was introduced in [32], where the infinite-dimensional matrices representing the position and momentum operators were replaced by the corresponding finite-dimensional matrices generated from the first Fock states. Later, in [33, 34] its parasupersymmetric partners were studied and its quasicoherent states were obtained, respectively. On the other hand, a different truncation, in the domain of definition of the potential, is also possible: in [14] it was shown that an infinite potential barrier added to the harmonic oscillator modifies the domain of its supersymmetric partners, according with the position where the infinite barrier is placed. In [35, 36, 37] we started to study the possibilities of spectral design for the harmonic oscillator with an infinite potential barrier at the origin, or *truncated oscillator* for short. It was found that a first order supersymmetric transformation produces only isospectral partners, while a second order transformation allows to add at most one level to the spectrum of the new Hamiltonian. Let us recall that a non-singular higher order supersymmetric transformation can be decomposed as an iteration of first and second order non-singular transformations [38, 39, 40]. This suggests that, in order to add n new levels to the spectrum of the truncated oscillator, it is necessary to use a supersymmetric transformation of order $2n$ at least.

In this work we continue the study of spectral design for the supersymmetric partners of the truncated oscillator, by generalizing the conditions under which such singular systems can acquire additional energy

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