Fifteenth International Conference on
Geometry, Integrability and Quantization
June 7–12, 2013, Varna, Bulgaria
Ivaïlo M. Mladenov, Andrei Ludu
and Akira Yoshioka, Editors
Avangard Prima, Sofia 2014, pp 242–248
doi: 10.7546/giq-15-2014-242-248

ALGEBRAIC APPROACH TO THE MORSE OSCILLATORS

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Abstract. In this paper we obtain the ladder operators for the $1D$ and $3D$ Morse potential. Then we show that these operators satisfy $\mathrm{SU}(2)$ commutation relation. Finally we obtain the Hamiltonian in terms of the $\mathfrak{su}(2)$ algebra.

1. Introduction

In the recent years, Lie algebraic methods have been the subject of interest in many of fields of physics. For example the algebraic methods provide a way to obtain wave functions of polyatomic molecules [15, 16, 18, 20–22]. These methods provide a description to Dunham-type expansions and to force-field variational methods [17]. It is clear that systems displaying a dynamical symmetry can be treated by algebraic methods [1, 2, 19, 23]. For details concerning the ladder operators of quantum systems with some important potentials such as Morse potential the Pöschel-Teller one, the pseudo harmonic one, the infinitely square-well one and other quantum systems we refer to [3–13].

The Morse potential is a solvable potential, hence the interest to deal with it using different approaches, in particular factorization approach [1, 4, 19]. According to these methods as $\mathfrak{su}(1,1)$ algebra has been found in [4,9,19]. The Morse potential has been studied in terms of $\mathrm{SO}(2,1)$ and $\mathrm{SU}(2)$ groups [8, 13]. In fact $\mathrm{SU}(2)$ is the symmetry group associated with the bounded region of the spectrum [12].

In this paper we study the dynamical symmetry for the one and three-dimensional Morse oscillator by another algebraic approach. We establish the creation and annihilation operators directly from the eigenfunctions for this system, and that the ladders operators construct the dynamical algebra $\mathfrak{su}(2)$.