Quasi-exact solutions for the Bohr Hamiltonian with sextic oscillator potential

P. Buganu[1], R. Budaca[1,2], M. Chabab[3], A. Lahbas[3,4] and M. Oulne[3]

[1] *Department of Theoretical Physics, Institute of Physics and Nuclear Engineering, P.O.B. MG-6, RO-077125, Romania*

[2] *Academy of Romanian Scientists, 54 Splaiul Independentei, Bucharest 050094, Romania*

[3] *High Energy Physics and Astrophysics Laboratory, Department of Physics, Faculty of Science Semlalia, Cadi Ayyad University, P. O. B. 2390, Marrakesh 40000, Morocco*

[4] *ESMAR, Faculty of Sciences, Mohammed V University, P.O.B. 1014, Rabat, Morocco*

Contact email: *buganu@theory.nipne.ro*

Quantum models whose energy levels and corresponding wave functions can be determined algebraically are known as Exactly Solvable Models, otherwise they are referred as Exactly Non-Solvable Models. There is also an intermediate class of models between these two cases, called Quasi-Exactly Solvable Models (QESM) [1]. According to Ref. [1], ”QESM implies the situation where the infinite-dimensional Hamiltonian matrix can be reduced explicitly to a block-diagonal form with one of the block being finite. In this case the infinite dimensional matrix version of the Schrödinger problem breaks up into two completely independent spectral problems, one which is finite dimensional and can be solved algebraically, while the other one is infinite dimensional and nothing about its solutions is known”. An example of QESM, which will be discussed here, is the solution of the Schrödinger equation for a sextic oscillator potential with a centrifugal barrier [1]. As applications, one chose the quadrupole nuclear collective motion comprised of surface vibrations and rotations described by the Bohr model [2,3]. The radial-like part of the Bohr Hamiltonian, for different axial deformations, can be easily brought to a Schrödinger form [4,5] and therefore to the quasi-exactly solvable equation for the sextic oscillator potential [6,7,8,9,10,11]. Due to its special properties, the sextic potential can simulate either a spherical minimum or a deformed one, simultaneous spherical and deformed minima or a flat shape. All these features recommend it as being very suitable for the description of nuclear shape phase transitions.

References

[1] A. G. Ushveridze, Quasi-Exatly Solvable Models in Quantum Mechanics, IOP, Bristol, 1994.
[2] A. Bohr, Mat. Fys. Medd. Dan. Vid. Selsk. 26 (1952) 14.
[3] A. Bohr and B. R. Mottelson, Mat. Fys. Medd. Dan. Vid. Selsk. 27 (1953) 16.
[4] L. Fortunato, Eur. Phys. J. A 26 (2005) 1.
[5] P. Buganu and L. Fortunato, J. Phys. G: Nucl. Part. Phys. 43 (2016) 093003.
[6] G. Levai and J. M. Arias, Phys. Rev. C 69 (2004) 014304.
[7] A. A. Raduta and P. Buganu, Phys. Rev. C 83 (2011) 034313.
[8] A. A. Raduta and P. Buganu, J. Phys. G: Nucl. Part. Phys. 40 (2013) 025108.
[9] P. Buganu and R. Budaca, Phys. Rev. C 91 (2015) 014306.
[10] P. Buganu and R. Budaca, J. Phys. G: Nucl. Part. Phys. 42 (2015) 105106.
[11] R. Budaca, P. Buganu, M. Chabab, A. Lahbas and M. Oulne, Ann. Phys. (NY) 375 (2016) 65.