Invisible nuclear system

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In paper SUSY-hierarchies of one-dimensional potentials with continuous energy spectra are studied. Use of such hierarchies for analysis of reflectionless potentials is substantiated from the physical point of view. An interdependence (based on Darboux transformations) between spectral characteristics of potentials-partners is determined, an uniqueness of its solution in result of use of boundary conditions is shown. A general solution for a superpotential $W_{n+m}(x)$ with an arbitrary number $n+m$ in the studied hierarchy on the basis of only one known partial solution for the superpotential $W_n(x)$ with the selected number n is found. A general solution of a hierarchy of inverse power (reflectionless) potentials is obtained.

A consequent statement and analysis of *exactly solvable potentials*, which in spatial semi-axis have one hole and one barrier, after which they fall down to zero monotonously, are presented. It has shown, that such potentials, being as an isospectral expansion of SUSY-hierarchy of *inverse power potentials* (which can be *reflectionless*; its general solution was found in [1]), at their shape look qualitatively like radial scattering potentials in two-particle description of collisions between particles and nuclei or decay potentials in two-particle description of decay of compound spherical nuclear systems (at first, these potentials were found in [2]).

In SUSY QM standard approach [3], one can represent such potentials on the basis of Darboux transformations with use of the following superpotential $W(r)$ (see Fig. 1):

$$W(r) = \frac{2\beta - \alpha}{C(2\beta - \alpha)r^{2\beta/\alpha} + r} - \frac{\beta}{r}, \quad \text{at } 2\beta \neq \alpha, \tag{1}$$

where C, α and β are free parameters.

A preliminary analysis has shown, that at selected values of the parameters C, α and β the potentials become reflectionless. Then in the spherically symmetric consideration of a scattering of the particle in the potential field with a radial component in a form of such reflectionless potential, the particle propagates without the smallest reflection, and, therefore, without change of angle of its propagation (in spite of the fact that there is a singular solution in the case of exact fall of the particle into a center; in another case practically all part of the found potential does not influence on the propagation of the particle). One can conclude, that the found potential is reflectionless (though it has a barrier and, therefore, *tunneling* is possible here) at the spherically symmetric scattering of the particle on it, and a nuclear system with such a potential becomes *invisible* for the incident particle with arbitrary energy (with a possible exception of the exact fall down of the particle into the nuclear center).

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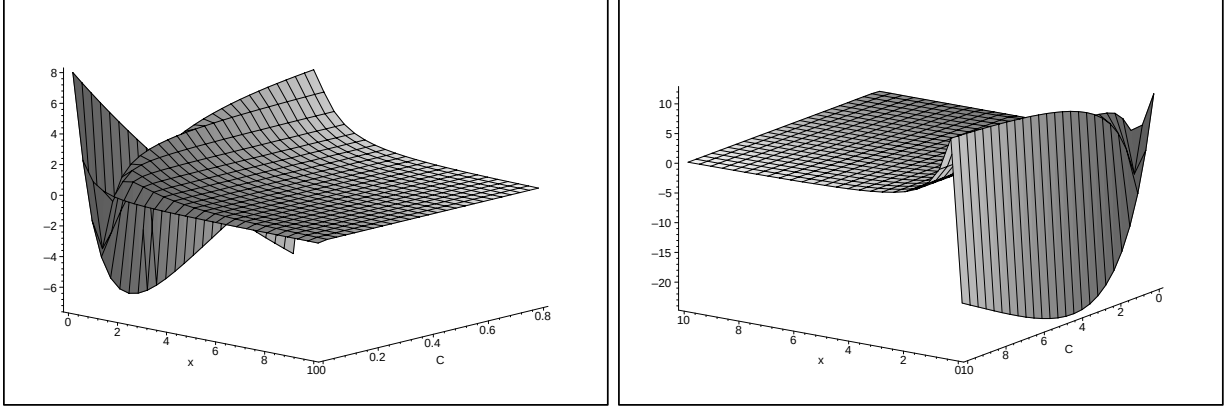

Fig. 1: Continuous change of the form of the reflectionless potential $V(x)$ of Gamov's type at variation of the parameter C_1 (according to [2], the parameters $\gamma = 6$, $x_0 = 0.5$ are selected at which the potential becomes reflectionless)

[1] S. P. Maydanyuk, *New exactly solvable reflectionless potentials of Gamov's type*, Talk in the XXXII Winter School of Physics, ITEP, Moscow, February 22 - March 2, 2005, 22 p. - in press (Proceedings); arXiv:nucl-th/0504077.

[2] S. P. Maydanyuk, *SUSY-hierarhy of one-dimensional reflectionless potentials*, Annals of Physics **316** (2), 440–465 (April, 2005); arXiv:hep-th/0407237.

[3] F. Cooper, A. Khare and U. Sukhatme, *Supersymmetry and quantum mechanics*, Physics Reports **251** (1995) 267–385; arXiv:hep-th/9405029.