Mathematical Physics

Quantum mechanical potentials exactly solvable in terms of higher hypergeometric functions. I: The third-order case

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We present a new six-parameter family of potentials whose solutions are expressed in terms of the hypergeometric functions 3F2, 2F2 and 1F2. Both the scattering data and the bound states of these potentials are explicitly computed and the peculiar properties of the discrete spectrum are depicted in a suitable phase diagram. Our starting point is a third-order formal eigenvalue equation of the hypergeometric type (with a suitable solution known) which is transformed to the Schr\"odinger equation by applying the reduction of order technique as the crucial first step. The general preconditions allowing for the reduction to Schr\"odinger form of an arbitrary eigenvalue equation of higher order, are discussed at the end of the article, and two universal features of the potentials arising this way are also stated and discussed. In this general scheme the Natanzon potentials are the simplest special case, those presented here the next ones, and so on for potentials arising from equations of fourth or higher order.

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