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Comment

Comment on Introducing a new family of short-range potentials and their numerical solutions using the asymptotic iteration method by I.A. Assi, A.J. Sous

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In ref. [1], the authors use the Asymptotic Iteration Method (AIM) to obtain a numerical evaluation of the bound state energies for a class of radial short-range singular potentials for nonzero angular momentum. They connect with the Tridiagonal Representation Approach (TRA) by using a square integrable basis in which the matrix representation of the wave operator is $(2k+1)$-diagonal, where k is a nonnegative integer. That is, the matrix is nonzero only on the diagonal, which is a band of width $2k+1$, where $k \geq 2$. It is true that the TRA refers to $k=1$, where the matrix is tridiagonal [2]. However, the authors of [1] state that they were "going beyond the TRA" and that they "developed it beyond its limitation". This is not true since they did not identify the objects that satisfy the $(2k+1)$-term recursion relation resulting from the matrix wave equation. In the proper mathematics literature, only objects that satisfy three-term recursion relations (*i.e.*, $k=1$) like the following:

$$xP_n(x) = a_n P_n(x) + b_{n-1} P_{n-1}(x) + b_n P_{n+1}(x), \tag{1}$$

are associated with a well-posed problem that could be solved in terms of orthogonal polynomials $\{P_n(x)\}$, starting with the initial values $P_0(x)$ and $P_1(x)$. The corresponding wave operator matrix is tridiagonal and the recursion relation is three-term, hence the name TRA. However, for $k \geq 2$ no such objects were found. For example, in the case of penta-diagonal matrix representations (*i.e.*, $k=2$), there are no established solutions for the corresponding five-term recursion relation

$$xQ_n(x) = a_n Q_n(x) + b_{n-1} Q_{n-1}(x) + b_n Q_{n+1}(x) + c_{n-2} Q_{n-2}(x) + c_n Q_{n+2}(x), \quad n \geq 2, \tag{2}$$

along with the given initial values $Q_0(x)$, $Q_1(x)$, $Q_2(x)$ and $Q_3(x)$.

Nonetheless, the authors are commended for associating $(2k+1)$-diagonal infinite symmetric matrices with Hamiltonians containing generalized potential functions.

References

1. I.A. Assi, A.J. Sous, Eur. Phys. J. Plus **133**, 175 (2018).
2. A.D. Alhaidari, J. Math. Phys. **58**, 072104 (2017).

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