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# Bessel functions as basis for the Coulombic three-body problem

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Recently[1], we have calculated the hyperradial-adiabatic potential for the highly rotational state with $J = 35$ and parity $p = -1$ of the hydrogen molecular ion $H_2^+$. In this investigation the rotational part of the total wave function has been treated exactly, and the quasi-rotational part analytically. The variational basis used consisted of a kind of symmetrized hydrogenic orbitals. The convergence was rather fast (as expected), but was saturated at a value of the energy that was not as accurate as desired.
Clearly, the hydrogenic radial wave functions $R_{nl}(r_{pe})$ are well suited to account for the structure of the adiabatic wave function in the region of the $ep$-collisions. However, in order to more properly treat the other possible configurations we now make use of the Bessel functions

$$x_i^{-1/2} J_{2l+1}(\sqrt{8x_i}), \quad y_i^{-1/2} J_{2l+1}(\sqrt{8y_i})$$

and

$$x_i^{-1/2} K_{2l+1}(\sqrt{8x_i}), \quad y_i^{-1/2} K_{2l+1}(\sqrt{8y_i}).$$

Here, $(x_i, y_i)$ denote the absolute values of Jacobi vectors in the channel $i$ $(i = 1, 2, 3)$, and $l$ the value of the corresponding pair angular momentum. The advantage of this choice is that the first two functions of this set are known to compensate the Coulombic attraction at zero energy, while the next two are compensating the Coulomb repulsion in the same limit[2]. Moreover, both sets are as specifically adjusted to the Coulomb force as the $R_{nl}(x_i)$ are.
We plan to report the result of the experiment of using these functions as variational primitives for the same problem[1].

## References

1. A. Matveenko, E.O. Alt and H. Fukuda, Few-Body Syst. Suppl. **13**, 140 (2001).
2. L.D. Landau and E.M. Lifshitz, *Quantum Mechanics* (Oxford: Pergamon) (1965).

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