Square-integrable basises in the few-body Coulomb scattering problem

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The three-body continuum Coulomb problem is one of the fundamental unsolved problems of theoretical physics. In atomic physics, a prototype example is a Two-Electron Continuum (TEC) which arises as a final state in electron-impact ionization and double photoionization of atomic systems. Several approaches for treating these two processes have been developed. The time independent ones include the Convergent Close Coupling (CCC) approach [1, 2], the Coulomb-Sturmian Separable Expansion method [3, 4], the *J*-Matrix method [5-7], the *R*-Matrix method with Pseudo-States (RMPS) [8] and the Exterior Complex Scaling (ECS) approach [9, 10]. In all these approaches, the TEC wave function is described either on a finite grid or in a finite basis of square- integrable functions (see also [11]). Despite the enormous progress made so far in trying to solve numerically the partial derivative or the integro-differential equations satisfied by the TEC wave function, a number of related mathematical problems remain open. In many of the above-mentioned approaches, the TEC wave function is approximated by an uncorrelated product of two fixed charge Coulomb waves. In this case, a long-range potential appears in the kernel of the corresponding Lippmann-Schwinger equation. Since this kernel is non-compact, its solution diverges as the size of the grid or the L^2 basis used to describe the potential increases.

On the other hand, it is well known that asymptotically, the Hamiltonian that determines the wave function behavior when all interparticle distances are large (i.e. in the Ω_0 domain), is separable in terms of generalized parabolic coordinates [12]. The corresponding Green's function can be expressed in closed form [13]. Thus, an appropriate square-integrable basis functions could be obtained as solutions to driven equations with the asymptotic Hamiltonian by using the three-body Coulomb Green's function. We expect that the resulting Sturmian functions to provide a basis of expansion for certain kinds of three-body problems.

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