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Bound states of a Yukawa-Coulomb-type potential with a 1/r^3 spin-orbit coupling

This work investigates the bound states of the Yukawa–Coulomb potential, considering the effects of spin-orbit coupling on energy levels and wavefunctions, supersymmetric quantum mechanics (SUSY QM) is combined with time-independent perturbation theory.
Initially,the unperturbed problem is addressed using the formalism of SUSY QM, through Hamiltonian factorization and an expansion in the screening parameter, approximate expressions for the energy levels and radial wavefunctions up to third order and radial.
Subsequently, spin–orbit coupling is introduced as a $1/r^3$-type perturbation, yielding analytical expressions for the first-order energy corrections. Furthermore, the Dalgarno–Lewis method is employed to derive the first-order correction to the wavefunctions, identifying convergence difficulties associated with the singular behavior of the interaction.
The results provide an approximate description of the Yukawa–Coulomb system and allow the effects of spin–orbit coupling to be analyzed.

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