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Semirelativistic Bound States: (Pseudo-) Spinless-Salpeter Approaches Reassessed

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Within quantum field theory, the homogeneous Bethe–Salpeter formalism offers a Poincaré-covariant (albeit not always easy-to-handle) description of bound states. Driven by the desire to arrive at a (hopefully more easily controllable) analytic approach to bound states, various instantaneous reductions of the Bethe–Salpeter equation have been proposed. Among these are the well-known spinless Salpeter equation as well as various further (yet to some extent still semirelativistic) simplifications in the direction of the (nonrelativistic) Schrödinger equation. We subject the reliability of such kind of bound-state equations to rigorous scrutiny by formulation of exact constraints on the implied spectra, such as bounds on the number of discrete states or on their energy eigenvalues. In order to cover a wide variety of instances, we illustrate the application of these tools for a class of interaction potentials that has found frequent utilization in several areas of science, in particular, in both physics and chemistry, namely, the generalized Hellmann potentials, each of which consists of an attractive Coulomb term and an either attractive or repulsive Yukawa term. Clearly, not all proposed approximations pass this test.

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