Quantum three-body problem

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The quantum problem of three bodies with Coulomb interaction is one of the most notable nonintegrable problems in quantum mechanics. At the same time, extremely accurate numerical solutions for the problem of bound states for a system of three particles may be obtained with modern computers. For example, the nonrelativistic energy of the ground state of helium with a nucleus of an infinite mass is now known accurately to 46 significant digits. In the present study, a version of the variational method (the so called "exponential"expansion) that allows to numerically solve the quantum Coulomb three-body bound state problem with a very high precision, which is easily applicable as well to the states with a nonzero angular momentum, is considered. This method is used to calculate the nonrelativistic ionization energies of a helium atom for S, P, D, and F states. It is shown that the developed method is an efficient and flexible instrument for studying Coulomb systems. An analysis of convergence proves that the method is highly accurate and demonstrates that nonrelativistic energies accurate up to 28-35 significant digits may be obtained with rather moderate efforts. Calculations of the nonrelativistic ionization energy of the negative hydrogen ion H – are also presented.

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