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Determination energy spectrum H_2^+, D_2^+ and T_2^+ molecular ions with orbital excitation

Abstract. On the basis of the investigation of the asymptotic behavior of the correlation functions of the corresponding field currents with the necessary quantum numbers the analytic method for the determination of the energy spectrum of the three-body Coulomb system is suggested. In the framework of this analytical approach we determine the energy spectrum of the molecular hydrogen ions with orbital excitation. In our case, relativistic corrections are taken into account by the constituent mass of the constituent particles, as well as by the interaction potential. Our results showed that the masses of the constituent particles differ from the masses of the particles in the free state. The insreasing of constituent mass of the electron is comparatively larger than the insreasing of constituent mass of the proton, deuteron and triton. Found that the constituent masses of the electron for the molecular ions of hydrogen H_2^+, D_2^+ and T_2^+ are different. Thus, our results on the energy spectrum of molecular hydrogen ions very well agreement with existing results of a precision spectroscopy, this is achieved, taking into account the value of the constituent masses of particles.
Keywords: molecular hydrogen ions, bound states in the functional approach

Introduction

The energy spectrum of the bound state can be determined with good precision in the framework of nonrelativistic quantum mechanics (NRQM) when a good selection of the potential is made. However, the nonrelativistic Schrodinger equation (SE), which gives mathematically correct description of the bound state, is no longer sufficient since for the description of modern experimental results, obtained in both atomic [1] and hadronic physics [2], it is necessary to take into account the relativistic correction. Nevertheless, the non-relativistic SE is the reliable tool for the bound state energy research and its determination. In this case real relativistic corrections are small, so the theoretical problem reduces to obtaining the relativistic corrections to a nonrelativistic interaction potential in the formalism of quantum field theory (QFT). This idea underlies the Breit potential [3] and the effective nonrelativistic quantum field theory of Caswell and Lepage [4]. These both approach use the scattering matrix as a source of required corrections. The authors of [4] studied in the framework of quantum electrodynamics (QE) the scattering matrix with appropriate Feynman diagrams by taking into account renormalization and then taking the non-relativistic limit. So they obtained the interaction potential with the relativistic corrections. Thus, the nonrelativistic QED or NRQED method for the determination of the energy spectrum, taking into account relativistic corrections, was formulated. Subsequently, this method was improved in [5]. However, in these works, the relativistic corrections in the framework of the perturbation theory were taken into account mainly by the interaction potential, and the correction to the kinetic part the interaction Hamiltonian is almost ignored. Including the relativistic correction into the kinetic part of the Hamiltonian in the usual quantum mechanical formalism carried out only in the framework of the relativistic SE. It is known that the determination of the energy spectrum and the wave functions of the bound state consisting of few bodies from the relativistic SE, from the point of view of mathematical calculations is almost impossible. Therefore, the inclusion of the relativistic corrections into the determination of the properties of the relativistic bound state as a potential and kinetic part of the interaction Hamiltonian is one of the most urgent problems of modern theoretical study. Our work is devoted to studying this problem.

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