Symmetric and non-symmetric muonic atoms-molecules Studies

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The muonic helium atom ($^3He^{+2}\mu^- e^-$ or $^4He^{+2}\mu^- e^-$) is the simplest example of a three body atomic system with bound particles of widely different masses. This simple system can provide a sensitive test for the three body Schrödinger wave function determination of the magnetic moment of the μ^- as a test of CPT (Charge conjugation-Parity-Time reversal) invariance. The atom is produced in the reaction of capture of the negative muon by the positive helium ion. It is one of the products in the process of muon catalyzed fusion, and its spectroscopic properties have to be therefore studied .carefully to understand the fusion reactions property

In this system, the negative muon is bound closely to the nucleus in the ground state of the atom; the orbital radius of the muon is about 400 times smaller than that of the electron due to their mass ratio and different charge screenings Therefore, in the simplest approximation, the muonic helium atom can be considered to be hydrogen-like with a pseudo nucleus $(\mu^3He)^+$ or $(\mu^4He)^+$. Also the hyperfine structure interval $\Delta\nu$ for the muonic helium atom provides interesting and unusual case of atomic hyperfine structure [1]. The major difference in the hyperfine structure of the ground state of the muonic ^3He and ^4He atoms arises from the spin and associated magnetic moment of the ^3He nucleus. The ^3He nucleus ($I = 1/2$) and μ^- ($I = 1/2$) have a total spin $F_1 = 1$ or 0, which interacts magnetically with the electron spin ($J = 1/2$) to yield .hyperfine levels with different total angular momenta $\mathbf{F} = \mathbf{F_1} + \mathbf{J}$

For the mentioned systems, the calculation of the hyperfine splitting and other properties has been developed from many approaches with varying degrees of sophistication and accuracy [2]. These calculations are generally based on the variational approach with a large number of variational parameters. However it is considerable to develop wave functions which illustrate some of the local properties, such as the behavior of the wave function when two particles are close to each other, or when they are far away from each other. These local properties have been found to be very useful in developing simple wave functions and also provide a deeper .understanding of the structure of system

In this work, we concentrate on the computation of the lowest order hyperfine splitting and other properties of muonic helium atoms ($^3He^{+2}\mu^- e^-$ and $^4He^{+2}\mu^- e^-$) in the ground state, with use of some local properties of the wave functions. We use a wave function which satisfies boundary conditions, such as when the two particles are close .to each other or far away from each other

References

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