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Description of particle-antiparticle bound systems via numerical solutions of the Dirac-Coulomb equation

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In this talk we discuss binary particle-antiparticle atomic systems starting from the formulation (in 16×16 matrix form) of the relevant 2-body Dirac-Coulomb Hamiltonian. Then, we apply the separation of the radial dependence from the angular-spin dependence of the Dirac-spinor components based on the conservation laws that must be full filled as: the well-defined charge-conjugation, the particle-exchange symmetries and the existence of Dirac-spinor components with positive and negative energy that must respect the positive and negative particle/antiparticle) rest masses. The radial wave functions are obtained: (i) through the reduction of the above eigenfunction problem to equivalent ordinary differential equations of (two-body) Klein-Gordon- and Schr\"oedinger type, and (ii) by solving these differential equations by utilizing the recently developed algorithms (in Python language) which are based on neural network techniques and use modern activation functions. We specifically focus on the calculations of the wave functions and energies of the low-lying states of lepton-antilepton (of equal masses $m_1 = m_2$) atoms. Such prominent binary systems with are the Positronium (e^-, e^+), the true Muonium ($\mu^-\mu^+$) and the true Tauonium ($\tau^-\tau^+$)) purely leptonic atoms. Our goal is to make theoretical predictions for the low-lying energy spectra of these systems by assuming that the lepton and antilepton interact via a static Coulomb potential plus the Gaunt (magnetic) part of the known Breit interaction.

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