Pair corrections to the no-pair Dirac–Coulomb(–Breit) energy of heliumlike systems

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The equal-time Bethe–Salpeter (Salpeter–Sucher) equation is used as a starting point for describing two-spin-1/2-fermion bound states [1, 2, 3, 13, 14]. The equation containing only the instantaneous part of the interaction is the with-pair Dirac–Coulomb(–Breit) equation (wpDC(B)), which includes the double-pair correction to the no-pair DC(B) equation (npDC(B)). The numerical results for these equations can be converged within ppb to ppt relative precision using an explicitly correlated Gaussian (ECG) basis set approach [4]-[12].

While the double-pair correction is a non-hermitian, but 'algebraic' term, which leaves the DC(B) equation linear in energy, the single-pair correction, represented by the irreducible crossed-Coulomb(–Breit) interaction kernel, appears within a complicated, energy-dependent operator in the Salpeter–Sucher equation. The inclusion of the crossed-Coulomb(–Breit) and other higher-order or radiative irreducible interaction kernels through this term renders the wave equation non-linear in energy.

A novel perturbative approach is therefore being considered for the treatment of these contributions, using the npDC(B) and wpDC(B) results as high-precision relativistic reference energies and wave functions [13, 14]. The results of this new relativistic QED (rQED) approach, including the single-pair correction, are expected to serve as a useful comparison to the well-established non-relativistic QED (nrQED) methodologies and the highest precision experimental results.

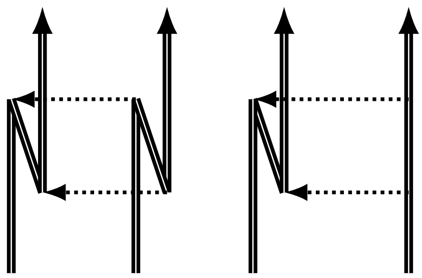

Figure 1: Time-ordered diagrams for the double-pair (left) and single-pair (right) corrections.

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