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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 the exact QED wave equation for a two-fermion system [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 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.

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