Order α^2 corrections to the decay rate of orthopositronium

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The discrepancy between theory and experiment for the decay rate of orthopositronium has long been one of the outstanding problems in precision QED. The calculated decay rate is [1, 2, 3]

$$\Gamma_{\rm o-Ps} = \Gamma_0 \Big[1 + A\frac{\alpha}{\pi} + \frac{1}{3}\alpha^2 \ln\alpha + B\Big(\frac{\alpha}{\pi}\Big)^2 - \frac{3\alpha^3}{2\pi}\ln^2\alpha + \cdots \Big] \quad ,$$

where the lowest order contribution is $\Gamma_0 = \frac{2}{9}(\pi^2 - 9)\frac{m\alpha^6}{\pi} = 7.211169 \mu s^{-1}$ [4]. The one-loop correction is known to be $A = -10.286606(10)$ [5]. The result of the present calculation is a value for the two-loop correction B.

Our calculation was done in the context of Nonrelativistic Quantum Electrodynamics (also known as NRQED) [6] following the approach outlined by Labelle, Lepage, and Magnea [7]. This method allows the high-energy part of the calculation to be treated as an on-shell scattering process. The high-energy calculation is part of a "matching" procedure in which a set of nonrelativistic interaction operators is defined. These operators are used to work out the bound-state aspects of the problem. Our calculation of the high-energy process followed by a bound-state calculation using the effective interaction operators allowed us to complete the determination of B [8].

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