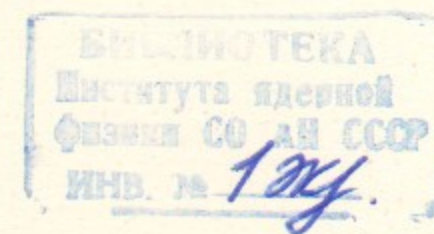


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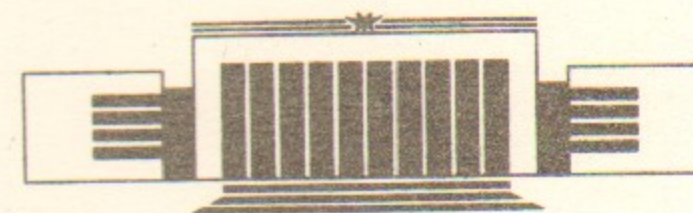
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RELATIVISTIC CORRECTIONS
TO THE POSITRONIUM DECAY RATE
REVISITED



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НОВОСИБИРСК

Relativistic Corrections to the Positronium Decay Rate Revisited

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Abstract

We rederive here in a simple and transparent way the master formula for the dominant part of large relativistic corrections to the positronium decay rate.

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1. The strong disagreement between the experimental value of the orthopositronium decay rate [1]

$$\Gamma_{exp}^{o-Ps} = 7.0482(16) \mu s^{-1} \quad (1)$$

and its theoretical value which includes the order α and $\alpha^2 \log(1/\alpha)$ corrections [2-6]

$$\begin{aligned} \Gamma_{th}^{o-Ps} &= m\alpha^6 \frac{2(\pi^2 - 9)}{9\pi} \left[1 - 10.2866(6) \frac{\alpha}{\pi} - \frac{1}{3} \alpha^2 \log \frac{1}{\alpha} \right] \\ &= 7.038236(10) \mu s^{-1} \end{aligned} \quad (2)$$

is a real challenge to the modern QED. For the disagreement to be resolved within the QED framework, the correction $\sim (\alpha/\pi)^2$, which has not been calculated completely up to now, should enter the theoretical result (2) with a numerical factor 250(40), which may look unreasonably large.

Though the result of more recent experiment [7]

$$\Gamma_{exp}^{o-Ps} = 7.0398 \pm 0.0025(\text{stat}) \pm 0.0015(\text{syst}) \mu s^{-1} \quad (3)$$

does not demand by itself such a large second-order correction, the problem of evaluating $\sim (\alpha/\pi)^2$ terms certainly exists.

One class of large second-order corrections arises as follows [8]. The large, ~ -10 , factor at the α/π correction to the decay rate (see (2)) means that the factor at the α/π correction to the decay amplitude is roughly -5 . Correspondingly, this correction squared contributes about $25(\alpha/\pi)^2$

So, expression (10) can be used as a regulator, and in the now rapidly converging integral

$$\int \frac{d\vec{p}}{(2\pi)^3} 8\pi a^3 \left[\frac{1}{(p^2 a^2 + 1)^2} - \frac{1}{p^4 a^4} \right] [M(\vec{p}) - M(0)] \quad (12)$$

we can safely expand $M(\vec{p})$ up to $(p/m)^2$ included. In this way we obtain

$$\int \frac{d\vec{p}}{(2\pi)^3} 8\pi a^3 \left[\frac{1}{(p^2 a^2 + 1)^2} - \frac{1}{p^4 a^4} \right] \left(\frac{p}{m} \right)^2 = -\frac{3}{4} \alpha^2. \quad (13)$$

This is an alternative derivation of the master formula (5) used in our article [12]. In our opinion, it leaves no doubts in the correctness of this prescription.

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