ANALYSIS OF THE EXPERIMENTAL τ'^{+} DECAY SPECTRUM AS A TEST OF THE $\Delta T = \frac{1}{2}$ RULE*

S. Bjorklund, E. L. Koller, and S. Taylor
Department of Physics, Stevens Institute of Technology, Hoboken, New Jersey

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A further test of the isotopic spin selection rule $\Delta T = \frac{1}{2}$ has been recently proposed by Weinberg.[1] For the form of the energy spectrum of the odd pion in τ or τ' decay, Weinberg writes:

$$p\left(\frac{T_3}{m_K}\right) \sim \frac{3m_K}{Q}\left(\frac{1}{1+aQ/3m_K}\right)\left(1+\frac{aT_3}{m_K}\right)x_{\max}\left(\frac{T_3}{m_K}\right), \qquad (1)$$

where T_3 is the kinetic energy of the odd pion, Q is the total kinetic energy of the three pions, m_K is the mass of the K meson, and $x_{\max}$ is the maximum value of the x coordinate of the Dalitz plot. Weinberg shows that if the decay follows the $\Delta T = \frac{1}{2}$ rule, then the value of a for the τ' decay is uniquely determined by the value of a for the τ decay. From a recent study of 959 τ events[2] Weinberg obtains $a_\tau \approx 4.9$ and predicts $a_{\tau'} = -2a_\tau \approx 9.8$.

However, this value for $a_{\tau'}$ is not consistent with taking only a linear term in T_3 in Eq. (1), as p would become negative for large T_3. Hence, the smallest value of $a_{\tau'}$ consistent with p remaining everywhere positive, $a_{\tau'} = -9.3$, has been used in this communication as the predicted value. This value is well within the errors, since the intrinsic uncertainty in Weinberg's prediction, due to neglect of quadratic terms in Eq. (1), is stated to be about 20%, while the experimental error is also about 20%.

Seventy-two τ' decays, previously reported by the Columbia Emulsions Group,[3] have been reanalyzed to measure the value of $a_{\tau'}$. The likelihood function obtained from Eq. (1), after normalization, is

$$P = \prod_{i=1}^{72} p_i$$

$$= \left(\frac{K}{1+a_{\tau'}/17.76}\right)^{72} \prod_{i=1}^{72}\left(1+\frac{a_{\tau'}T_{3i}}{m_K}\right)x_{\max i}\left(\frac{T_{3i}}{m_K}\right), \qquad (2)$$

where K is a constant which does not depend on $a_{\tau'}$. The relativistic boundary of the Dalitz plot was used in the normalization. A plot of the likelihood function is shown in Fig. 1. The maximum likelihood value for $a_{\tau'}$ is -7.1, as compared to the value of -9.3 predicted by Weinberg's analysis. At $a_{\tau'} = -9.3$, the likelihood function has dropped by a factor of about 6. At a value of $a_{\tau'} = 4.6$ (minus one half the predicted value of -9.3 and hence corresponding to the τ value), the likelihood function is down by a factor of about 270.

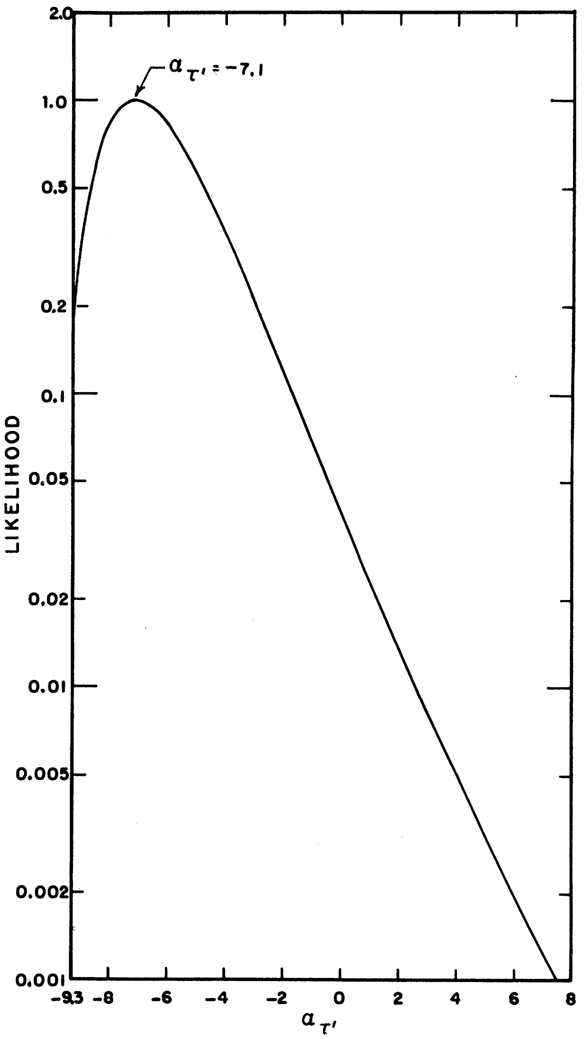

FIG. 1. The likelihood function, or the relative probability that our seventy-two events turn out the way they did, has been plotted as a function of the parameter $a_{\tau'}$.

Six-division χ^2 tests have also been carried out for various values of $a_{\tau'}$, yielding the results given in Table I. The sensitivity of the data to

Table I. Results of the χ^2 tests of the data for various assumed values of the parameter $a_{T'}$.

$a_{T'}$	χ^2	Probability	Remarks
4.6	13.6	0.017	τ value
0.0	8.8[a]	0.12	
-7.1	3.8	0.57	maximum likelihood value
-9.3	8.2	0.14	predicted value

[a] This value of χ^2 differs from that in reference 3, since here the relativistic boundary of the Dalitz plot was used, while reference 3 used the nonrelativistic approximation.

errors in measuring the kinetic energies has been tested by recalculating the maximum likelihood value of $a_{T'}$ using the upper and lower error limits of the most sensitive event of the data, which also happens to have large errors. This event has $T_3 = 49.0^{+4.3}_{-6.0}$ Mev. The maximum likelihood values so obtained are $a_{T'} = -6.8$ and $a_{T'} = -7.4$ for the upper and lower limits, respectively.

The measured value $a_{T'} = -7.1$ is in satisfactory agreement with the predicted value of -9.3. Hence, the present data, as tested by Weinberg's analysis, are consistent with a $\Delta T = \frac{1}{2}$ rule. It is unlikely that $a_{T'}$ is as large as a_T, although the possibility cannot be completely excluded by the present data.

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AUGER EFFECT IN MESONIC ATOMS

Richard A. Ferrell*
University of Maryland, College Park, Maryland and CERN, Geneva, Switzerland

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The Auger effect is important in numerous experiments dealing with the capture of negative particles by nuclei, because of the dependence of the interpretation of such experiments on the details of the atomic cascade process. It is often essential to know, in the case of a strongly interacting negative particle, in which state it undergoes interaction with the nucleus. The answer to this question depends in turn upon the transition rates out of the various states. Therefore it is necessary to have a reliable theory of the Auger transition rate. Unfortunately, although the usual perturbation theory of the Auger effect is straightforward, it has been put into doubt by the serious discrepancies found by Stearns and Stearns[1] for the x-ray yields in μ- and π-mesonic atoms. The purpose of the present note is to point out an alternative way of computing the Auger effect which makes it clear that the usual perturbation treatment is absolutely reliable. In fact, we demonstrate a quantitative relationship between the Auger rate on the one hand and the photoelectric cross section on the other. From this relationship, it is possible to calculate the Auger effect directly from the empirical x-ray absorption data. As the Auger rate is too small and no other significant radiationless process exists, it follows that the effect found by Stearns and Stearns must have its origin outside the target. This conclusion is supported by noting that the discrepancies for the μ-K, μ-L, and π-L series, although usually considered separately, are really the same and are a function of only the photon energy, and independent of the target.[2] For example, the targets of boron, fluorine, and sodium give, respectively, μ-K, π-L, and μ-L x rays all with photon energies within 5 kev of 47 kev, and all with a yield of only one-half of the expected yield.

The Auger rates for the μ-K and μ-L series have been computed by Burbidge and de Borde.[3] These rates are too small by factors of 300 and of 30, respectively, to explain the drop in x-ray yield found by Stearns and Stearns. It might be