the single-particle model;[5] those from the 8.93- and 9.19-Mev levels, supposed by the scheme to be of multiple excitation, show preferred $E2$ transitions[6] to be expected from such states of more general excitation.

(b) The splittings of the supposed p, d, and f doublets are 2.1, 2.4, and 2.0 Mev, respectively, all of the correct order.

(c) The separation of the supposed $1d_{5/2}-2s_{\frac{1}{2}}$ levels is 0.57 Mev, in good accord with the nearest known examples of this separation in O^{17} and F^{17} of 0.55 and 0.87 Mev, respectively.[7]

We would like to point out the considerable interest that attaches to the parity assignments which would be available from a study of $B^{10}(d,p)B^{11}$ stripping.

A full account of this work is in preparation.

[1] Bennett, Roys, and Toppell, Phys. Rev. **82**, 20 (1951).
[2] From the $B^{10}(d,p)B^{11}$ reaction by Van Patter, Buechner, and Sperduto, Phys. Rev. **82**, 248 (1951).
[3] G. A. Jones and D. H. Wilkinson, Phil. Mag. (to be published).
[4] $\alpha-\gamma_n$ means the angular distribution of γ_n relative to the alpha-particle beam; $\gamma_n-\gamma_m$ means the angular correlation between γ_n and γ_m.
[5] V. F. Weisskopf, Phys. Rev. **83**, 1073 (1951).
[6] M. Goldhaber and A. W. Sunyar, Phys. Rev. **83**, 906 (1951).
[7] R. A. Laubenstein and M. J. W. Laubenstein, Phys. Rev. **84**, 18 (1951).

The Quenching of *Ortho*-Positronium Decay by a Magnetic Field*

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We have measured the quenching of three-quantum annihilation from positronium by a magnetic field.[1] This effect has been detected by Deutsch and Dulit[2] and by Pond and Dicke[3] using different methods. Positronium was formed in SF_6 gas in a chamber placed between the poles of a magnet. The positron source was ~0.01 mC Na^{22} on a Zapon film. The decay of the $^3S_1$ positronium was detected by three NaI scintillation counters placed with their axes 120° apart in the plane perpendicular to the magnetic field.[4] The background triple coincidence rate was found by letting nitric oxide into the gas chamber. Generally, the background was about ten percent of the total triple coincidence rate. The magnet was specially designed and the 5819 photomultipliers magnetically shielded to eliminate magnetic field effects on the counters. At a given pressure we measured the ratio $n(H)$ of the true triple coincidence rate at the field H to that at $H=0$.

If one plots $n(H)$, against $(1-n)/H^2$, one should obtain—at low enough gas densities—a straight line whose intercept is the fraction of the rate contributed by the $^3S_1$, $m_J=\pm1$ states. A typical experimental curve is shown in Fig. 1 for a density of 0.052 g/cm³. It is clear that the $m_J=\pm1$ states supply less than two-thirds of the zero field rate. This is in agreement with calculations by Drisko[5] who finds that the probability for annihilation from any

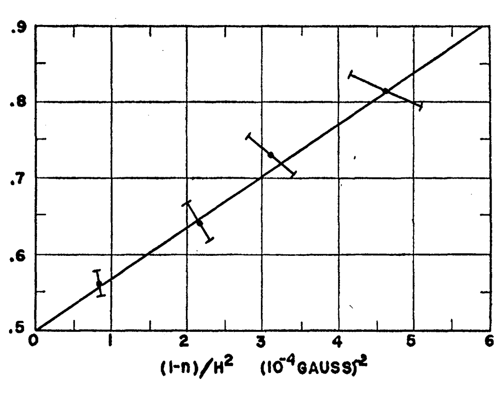

FIG. 1. A quenching plot for an SF_6 density of 0.052 g/cm².

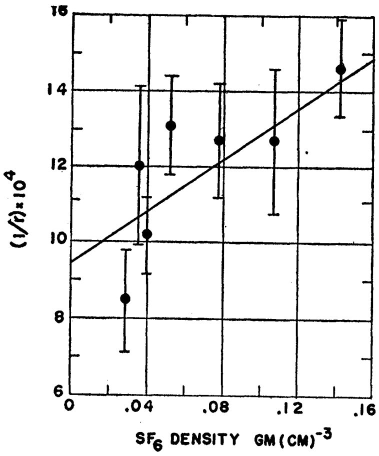

FIG. 2. A least squares line whose intercept gives r_0 and whose slope gives σ.

particular m_J substate of the $^3S_1$ state depends on the angle of the plane of the annihilation with the external field. In the special case corresponding to our geometry, Drisko finds that the $m_J=0$ state contributes one-half of the zero field rate. All our data are in agreement with this result.

If collisions are ignored, the theoretical expression for $n(H)$ for our geometry is

$$n(H)=(2+a^2r_0)/(2+2a^2r_0),$$

where $r_0=\tau_3/\tau_1=1120$ as given theoretically by Ore and Powell,[6] and $a=2\mu_0H/\Delta E$ with ΔE the ground state splitting as determined recently by Deutsch and Brown.[7] If one includes the possibility that collisions with gas atoms can cause transitions from $J=1$ to $J=0$ (probability per unit time $\lambda=Nv\sigma$) and transitions in which m_J changes with $\Delta J=0$ (probability per unit time $\lambda'=Nv\sigma'$), the situation is more complicated.[8] Transitions of the latter type cause $n(H)$ to approach a high field limit of less than $\frac{1}{2}$.

At high fields the quenching is relatively more sensitive to λ' than to λ. We found by measuring $n(H)$ as a function of gas density at $H=7100$ gauss that $\sigma'<\frac{1}{4}\sigma$. This conclusion depends on making use of a value of σ reported by Siegel and De Benedetti[9] for SF_6 ($\sigma\cong10^{-21}$ cm²). Using this approximate limit for σ', we find that for $H<3000$ gauss and for gas densities less than 0.15 g/cm³ the effect of the λ' transitions on the quenching is negligible and that, in fact, the quenching is given by Eq. (1) with r_0 replaced by $r=r_0/(1+\tau_3\lambda)$.

In order to obtain an experimental value for r_0 and to check σ, we make the definite assumption that λ' transitions are negligible. For each density we then determine the best value for r, using only data with $H<3000$ gauss. Consequently, the plot shown in Fig. 2 should be linear. The probable errors are large because $1/r$ is relatively sensitive to n; a one percent change in n produces at least a six percent change in $1/r$. The intercept and slope of the least squares line fitted to the data give the values of r_0 and σ. Our procedure requires only that Siegel and De Benedetti's value of σ be correct as to order to magnitude, justifying neglect of the λ' transitions; in this sense only is our value of σ independent. In computing σ from λ, we have assumed the dominance of single collisions. We find $r_0=1050\pm140$ compared with Ore and Powell's theoretical result of $r_0=1120$, and we find $\sigma=8\times10^{-22}$ cm² compared with $\sigma=10^{-21}$ cm² obtained by Siegel and De Benedetti.[9]

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[1] J. Wheatley and D. Halliday, Phys. Rev. **87**, 235 (1952).
[2] M. Deutsch and E. Dulit, Phys. Rev. **84**, 601 (1951).
[3] T. A. Pond and R. H. Dicke, Phys. Rev. **85**, 489 (1952).
[4] S. De Benedetti and R. Siegel, Phys. Rev. **85**, 371 (1952).
[5] R. Drisko, private communication.
[6] A. Ore and J. L. Powell, Phys. Rev. **75**, 1696 (1949).
[7] M. Deutsch and S. C. Brown, Phys. Rev. **85**, 1047 (1952).
[8] O. Halpern, Phys. Rev. **88**, 232 (1952).
[9] R. Siegel and S. De Benedetti, Phys. Rev. **87**, 235 (1952).