quantum number, but is not the effect observed here by many orders of magnitude. Nonradiative transitions in which muon energy is transformed into nuclear excitation have been observed for U and Th by Muhkin *et al.*[25] Dipole photoexcitation was postulated to explain this experiment, i.e.,

$$\mu(2p\text{ state})+\text{nucleus (ground state)}$$

$$\xrightarrow[Q=6\text{ MeV}]{E_1}\mu(1s\text{ state})+\text{nucleus (excited)}.$$

Zaretskii and Novikov[26] have theoretically analyzed this situation and obtained a formula relating the N.R. transition probability to the dipole photoexcitation cross section for 6-MeV photons. Insofar as a "reasonable" cross section can be inferred from existing photoexcitation data, the mechanism is plausible.

In the case of Ta, however, it is difficult to see how this process can be realized. The $2p\rightarrow 1s$ energy is 5.4 MeV while the neutron binding energy is 7.6 MeV. The Coulomb effect of the muon on the nucleus is not expected to reduce this binding energy appreciably. Since it is then impossible to excite the nucleus to a continuum state, the N.R. dipole process is ruled out.

We believe the most likely process to be

$$\mu(3d\text{ state})+\text{nucleus (ground state)}$$

$$\xrightarrow[Q=9\text{ MeV}]{E_2}\mu(1s\text{ state})+\text{nucleus (excited)}.$$

If the E_2 N.R. transition is competitive with the $3d\rightarrow 2p$ radiative transition, an absence of $2p\rightarrow 1s$ x-rays would result. Russell[27] has recently proposed and calculated this process. Again, the mechanism is plausible to the extent that a "reasonable" quadrupole photoexcitation cross section is used.

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Muon Capture in Neon*

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By exploiting the transfer process $(\mu^-p)+\text{Ne}\rightarrow p+(\mu^-\text{Ne})$, we have measured the disappearance rate of negative muons bound to neon nuclei. We find $\lambda=(0.658\pm0.010)\times10^6$ sec^{-1}.

A MEASUREMENT of the total rate of nuclear muon capture by neon has been carried out. The measurement was facilitated by the fact that muons stopped in liquid hydrogen with a relatively small admixture of neon, will form neon muonic atoms by irreversible transfer from hydrogen muonic atoms.[1]

Starting with pure hydrogen having a 25% D_2 concentration, we observed a yield of 0.16 fusion γ rays per stopped muon.[2] Upon the addition of 1% neon, the fusion γ-ray yield dropped to $(2\pm2)\times10^{-4}$, indicating that essentially all of the muons transferred to neon. The fusion γ yield as a function of time and neon and deuterium concentration was measured with a 33-Mc/sec digital time sorter (digitron). Simultaneously, the time spectrum of decay electrons from the (μNe) atoms was recorded with a 10-Mc/sec digitron. The electron data is shown in Fig. 1. The disappearance rate of muons is given by the slope of the exponential curve. A χ^2 analysis yields a value $\lambda_{\text{decay}}+\lambda_c=(0.658\pm0.010)\times10^6$ sec^{-1}. If we take the bound decay rate equal to 0.454×10^6 sec^{-1},

$$\lambda_c=(0.204\pm0.010)\times10^6\text{ sec}^{-1}.$$

This is in fair agreement with the recently reported value of $(0.167\pm0.03)\times10^6$ sec^{-1} of Conforto, Rubbia, and Zavattini.[3] They used a similar technique for forming (μNe) but measured only the decrease in the time integrated yield of decay electrons.

In order to compare the result with other nuclei we interpolate the Primakoff curve as given in the compila-

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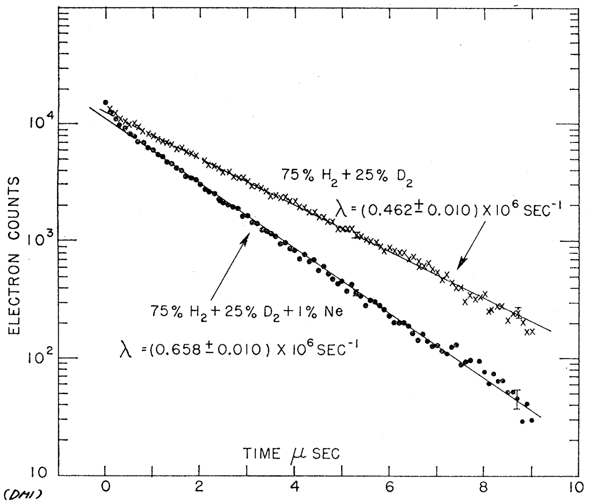

FIG. 1. The disappearance rate of muons in pure liquid hydrogen with a 1% admixture of neon. A small, time-dependent background has been subtracted. The data for the pure case have been normalized to the same number of stopping muons as for the neon case.

tion of Telegdi.[4] The prediction is $\lambda_c = 0.27 \times 10^6$ sec^{-1}. We would not characterize the agreement as good. However, no claims for detailed predictions have ever been advanced for the Primakoff formula.

Since the principal isotope of neon is the 91% abundant $_{10}\mathrm{Ne}^{20}$, it is interesting to compare the neon capture rate with that of $_9\mathrm{F}^{19}$, the two nuclei being isotopes. While there is a large hyperfine effect in fluorine capture, the work of Winston[5] permits the extraction of the spin-averaged capture rate, $\bar{\lambda}_c(_9\mathrm{F}^{19}) = (0.153 \pm 0.012) \times 10^6$ sec^{-1}. In contrast to neon, this is in excellent agreement with the Primakoff curve. The analysis of Überall[6] and the data of Winston[5] indicate that approximately one-third of the F^{19} capture proceeds via the single outer shell proton with the oxygen core contributing $\sim 2/3$. The fact that the two outer protons of neon apparently provide less capture than the single proton of fluorine, is probably the result of the nuclear pairing effect.

According to the well-known empirical rule of the shell model, the pairing energy increases with higher j. The outer proton wave functions are configurations of $2s_{1/2}$, $2d_{5/2}$, and $2d_{1/2}$. Thus the two outer protons of Ne^{20} are expected to be largely $(2d_{5/2})^2$ while the odd proton of $_9\mathrm{F}^{19}$ contains appreciable $2s_{1/2}$.

The form of the weak interaction favors capture transitions involving $\Delta j = 0$, 1 and $\Delta l = 0$. Since low angular momentum neutron emission is favored on energetic grounds, reduced capture from high j states is expected.

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