present time.

We are grateful to Dr. J. O. Newton who participated in many of the early phases of this work. We are also greatly indebted to Dr. E. Hubbard and the operating crews of the Hilac for the indispensable help they have given us in carrying out these experiments.

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CAPTURE IN (K^-, p) ATOMS

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Day, Snow, and Sucher[1] have concluded that the reactions of K^- mesons at rest in liquid hydrogen almost invariably result from the interaction of the (K^-, p) system in states of zero relative orbital angular momentum. This conclusion results from a calculation, based on a suggestion by Madansky, that indicates that collisions of the protons in the liquid hydrogen with the (K^-, p) atom induce in the atom a strong Stark effect which mixes S-wave orbital states into states of higher orbital angular momentum. The very strong (K^-, p) S-wave absorption then depopulates these states before radiative transitions leading to the $2P$ state can occur. Previously, it had been generally believed that capture from the $2P$ state might be more important than radiative $2P \rightarrow 1S$ transitions, and that the (K^-, p) capture process might proceed predominantly through P-state capture. If it can be established that this view is incorrect and that capture almost invariably results from the S states, the parity of the K meson might be determined,[2] and other important conclusions might be reached, by a study of the $K^- - p$ and $K^- - d$ reactions for stopped K^- mesons. It is the purpose of this note to point out corrections to the specific calculations of Day et al. which appear to vitiate largely their specific conclusions that P-state capture cannot be important.

Day et al. consider the (K^-, p) atom moving essentially with thermal velocity through the liquid hydrogen. Frequent collisions with protons in the liquid result in the atom being subjected to intense electric fields which polarize the atom, or induce Stark transitions, for a period of time of the order of $2a_0/V$, where a_0 is the proton Bohr radius and V is the velocity of the atom. Dealing with the $n = 6$ level, largely for the sake of definiteness, they calculate the Stark transition rate due to an electric field, $E = e/a_0^2$, of a proton at a distance of one Bohr radius. These transition rates are large, and Day et al. then conclude that the mixing is such that P states are completely depopulated in a collision while the other angular momentum states are rearranged into a $2l + 1$ statistical population. They do not consider immediate capture from states of higher orbital angular momentum presumably because the collision time is not assuredly long compared to the time required to establish a complete mixing of states. Using these approximations, they follow an assembly of atoms through their history and conclude that, from statistically weighted $n = 6$ states, 1.4% eventually reach the $2P$ level by radiative transitions while 98.6% are captured in S states. From states of higher n even fewer reach the $2P$ level.

The collisions considered by Day et al. are collisions of the second kind with a negligible energy transfer but with the transfer, from the (K^-, p) atom to the system of the atom and the colliding proton, of one or more units of angular momentum. The DeBroglie wavelength characteristic of an average collision is about 2π A while the effective collision radius a_0 used by Day et al. is a Bohr radius or about $\frac{1}{2}$ A. Since the ratio a_0/λ is then about $\frac{1}{2}$, classically collisions with $l \geq 1$ are forbidden. An estimate of the correction to the results of reference 1 required by these considerations is easily made. The matrix element appropriate to a collision in which the (K,p) system in a state $\psi_{n,l}$ is changed to a state $\psi_{n,l-1}$, which can be the products of the $K-p$ interaction, is

$$\langle U_{L+1}{}^{*}\psi_{n,l-1}{}^{*}|H|U_{2}\psi_{n,l}\rangle,$$

where the U are the plane wave functions representing the relative (K,p) atom and proton coordinates and H, the Hamiltonian, will be equal to $(e^2/|R-r_p|)-(e^2/|R-r_k|)$, where R is the vector coordinate of the colliding proton and r_p and r_k are the coordinates of the proton and K meson in the atom. For $|R|>|r|$ a multipole expansion of H can be made. Setting $R=a_0$ as in reference 1, the matrix element can be rewritten as

$$\langle V_{L+1}{}^{*}(a_0)|V_L(a_0)\rangle\langle\psi_{n,l-1}{}^{*}|H'|\psi_{n,l}\rangle,$$

where, with appropriate averaging of geometric factors, the second term is precisely that evaluated by Day et al. In the first factor V represents the radial part of the wave functions U, and the square of this term has a value of 1/5 for S to P transitions which are the most favorable. Changes of more than one unit of angular momentum are much more strongly forbidden. These corrections modify the conclusions of reference 1 concerning the $n=6$ state in the following way. The depopulation of the P level in any collision is essentially unaffected but the reshuffling of other states is much reduced and their direct depopulation is largely forbidden. This greatly reduces the transfer into the P level and the average atomic lifetime is considerably increased, enhancing the importance of radiative transitions. Calculations of the same kind as reported in reference 1 lead then to the result that about 20% of atoms in a $n=6$ state reach the $2P$ state instead of the 1.4% stated in reference 1.

The uncertainties involved in the estimates made in this note, and also in reference 1, are quite large, and the conclusions reached in these calculations are not presented with the intention of establishing that P-wave capture is large, or that the Stark effect is unimportant. But we believe that these results do indicate the necessity of a more detailed examination of the problem.

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GRAVITATIONAL RED-SHIFT IN NUCLEAR RESONANCE

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It is widely considered desirable to check experimentally the view that the frequencies of electromagnetic spectral lines are sensitive to the gravitational potential at the position of the emitting system. The several theories of relativity predict the frequency to be proportional to the gravitational potential. Experiments are proposed to observe the timekeeping of a "clock" based on an atomic or molecular transition, when held aloft in a rocket-launched satellite, relative to a similar one kept on the ground. The frequency ν_h and thus the timekeeping at height h is related to that at the earth's surface ν_0 according to

$$\Delta\nu_h=\nu_h-\nu_0=\nu_0 gh/c^2(1+h/R)$$
$$\approx\nu_0 h\times(1.09\times10^{-18}),$$

where R is the radius of the earth and h is the altitude measured in cm. Very high accuracy is required of the clocks even with the altitudes available with artificial satellites. Although several ways of obtaining the necessary frequency stability look promising, it would be simpler if a way could be found to do the experiment between fixed terrestrial points. In particular, if an accuracy could be obtained allowing the measurement of the shift between points differing as little as one to ten kilometers in altitude, the experiment could be performed between a mountain and a valley, in a mineshaft, or in a borehole.

Recently Mössbauer has discovered[1] a new aspect of the emission and scattering of γ rays by nuclei in solids. A certain fraction f of γ rays of the nuclei of a solid are emitted without