Letters to the Editor

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Experimental Upper Limit for the Mean Life of the 478.5-Kev Excited State of Li^7

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October 28, 1948

THE γ-ray accompanying the reaction $B^{10}(n,\alpha)Li^7$ is known to arise from the de-excitation of the Li^{7*} nucleus formed when the short range α-group is emitted. This γ-ray has been studied in a magnetic lens-type β-ray spectrometer. The γ-ray source was a cylindrical pellet of B_4C of length 2 mm and diameter 8 mm placed in a beam of thermal neutrons from the Chalk River pile. A 7.2-mg/cm^2 Au foil of diameter 6 mm was mounted as a radiator on the end of the pellet away from the neutron beam and facing into the spectrometer. Photoelectrons ejected from this Au foil were then studied with a spectrometer line-width of about 2 percent in momentum.

The energy of the Li^{7*} γ-ray was measured by comparison with the γ-ray from radioactive Au^{198} (2.7 day). The result is 478.5 ± 1.5 kev based on DuMond, Lind, and Watson's energy value[1] of 411.2 ± 0.1 kev for the Au^{198} γ-ray. This value agrees well with the value 480 ± 2 kev obtained by Rubin, Snyder, Lauritsen, and Fowler[2] by measurement of the energy of the inelastically scattered protons from $Li^7(p,p')Li^{7*}$, and with the value 479 ± 2 kev, obtained by Hornyak and Lauritsen[3] by measurement of the energy of the γ-ray from $Li^7(p,p')Li^{7*}$.

The Q of the reaction $B^{10}(n,\alpha)Li^7$ is 2.83 ± 0.11 Mev from the masses, so that in the case in which Li^7 is left in the excited state the Li particle has a kinetic energy of 0.85 Mev, corresponding to a particle velocity 1.61 percent of the velocity of light. If the mean life of the Li^7 excited state is very short compared with the time (order of 10^{-13} sec.) for an appreciable slowing of the Li particles in the B_4C source material, the γ-rays would be emitted while the Li nuclei are still moving with their initial velocity. The γ-ray quanta would then have a distribution in energy given by the maximum Doppler broadening 3.22 percent and corresponding to a total spread of 15.4 kev. The photoelectrons ejected by such a γ-ray would have the same spread in energy and would produce a line in the spectrometer which is broader than that due to a γ-ray of the same energy from an ordinary radioactive source.

The experimental shapes of the K photoelectron lines produced by the Au^{198} 411.2-kev and ThC″ 585-kev γ-rays used for comparison are shown in Fig. 1a. The tail on the low energy side of each curve is due to the finite thickness of the photoelectron radiator and is more marked in the case of the lower energy γ-ray. By interpolating to the energy 478.5 kev the shape of the line due to the Li^{7*} γ-ray if no Doppler broadening were present (i.e., if the mean life $\gg10^{-13}$ sec.) has been obtained and is shown as a dotted curve in Fig. 1b. Using this curve, the line shape to be expected in the spectrometer if the full Doppler broadening were present (i.e., if the mean life $\ll10^{-13}$ sec.) has been calculated by numerical integration and is shown as a full line in Fig. 1b. The shape corresponding to any given mean life τ of the excited state of Li^7 may be calculated from the range and initial velocity of the Li particles if one assumes a relation between the rate of loss of energy of the Li particles and their residual range. Since a Li particle of 0.85 Mev ionizes according to the last part of the Bragg curve for a single particle, the rate of energy loss is roughly proportional to the residual range. Using Gilbert's range value[4] of 0.48 air-cm, the range in the B_4C source material as calculated from the Bragg-Kleeman rule is 1.97×10^{-4} cm. The curve for a mean life of 2.0×10^{-13} sec. has been computed and is shown as a broken line in Fig. 1b. The experimental points lie between this curve and the curve corresponding to the full Doppler broadening in a position corresponding to a mean life of about 1×10^{-13} sec. Taking the experimental errors into account, an upper limit for the mean life of the Li^7 excited state is 2.0×10^{-13} sec.

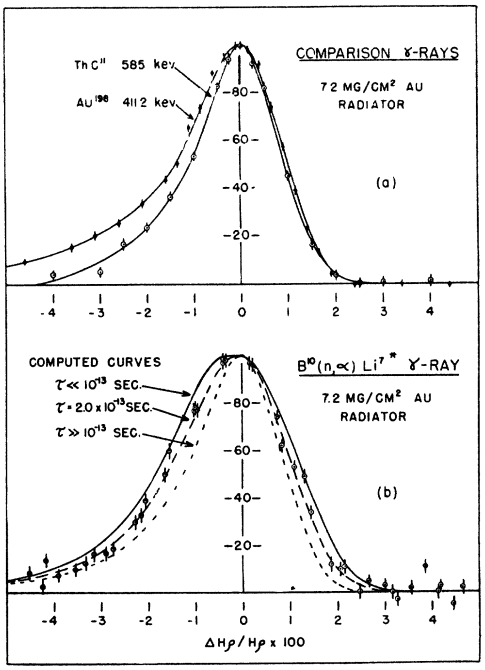

FIG. 1. (a) The shape observed in the spectrometer for the K photoelectron lines due to the comparison γ-rays. (b) The experimental points corresponding to the observed shape of the K photoelectron line due to the $B^{10}(n,\alpha)Li^{7*}$ γ-ray are shown as circles. The curves have been computed. All experimental points have the background subtracted, are normalized to 100, and plotted as a function of percent deviation from the $H\rho$ at the maximum.

The time of slowing of the Li particles in FeB is smaller by a factor of about 0.5 than in B_4C. A further experiment using this compound as a γ-ray source together with an improved spectrometer resolving power may make it possible to give a definite value for the mean life of this excited state in Li^7 rather than only an upper limit.

The angular momentum of Li^7 in the ground state is $\frac{3}{2}$ and the 478.5-kev excited state is commonly supposed[5] to have angular momentum $\frac{1}{2}$ forming with the ground state a doublet, $^2P_{3/2}$ and $^2P_{1/2}$. On this basis the transition takes place by magnetic dipole radiation. The transition probability for this case may be calculated closely by considering the interaction of the magnetic moment $(e/2Mc)(L+5.6S)$ of the $2p$ proton in Li^7 with the radiation field. The square of the matrix element[6] representing this interaction is

$$\frac{8}{3}\left(\frac{2.3eh}{4\pi Mc}\right)^2,$$

which together with the energy 478.5 kev available for the transition gives a calculated mean life for the Li^7 excited state of 1.5×10^{-13} sec. This is seen to be consistent with the experimental upper limit of 2.0×10^{-13} sec.

[1] DuMond, Lind, and Watson, Phys. Rev. **73**, 1392 (1948).
[2] Rubin, Snyder, Lauritsen, and Fowler, Bull. Am. Phys. Soc. **23**, No. 5, 15 (1948).
[3] W. Hornyak and T. Lauritsen, Bull. Am. Phys. Soc. **23**, No. 5, 16 (1948).
[4] C. W. Gilbert, Proc. Camb. Phil. Soc. **44**, 447 (1948).
[5] G. Breit and J. R. Stehn, Phys. Rev. **53**, 459 (1938).
[6] We are indebted to Dr. J. A. Spiers for help with this calculation.

Microwave Determination of the Molecular Structure of Chlorosilane

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October 28, 1948

THE second rotational transition, $J=1$ to $J=2$, of SiH_3Cl^{35} and SiH_3Cl^{37} has been measured and analyzed. The Hughes-Wilson Stark modulation technique was used for detection of the absorption lines, and absorption frequencies were determined by comparison with a crystal-controlled secondary frequency standard.

In Fig. 1 is shown the theoretical hyperfine pattern for a nuclear spin of $\frac{3}{2}$ for chlorine which is in satisfactory agreement with the observed spectrum. No lines caused by excited vibrational states were observed. The unperturbed transition frequency ν_0 is 26,695.2_4 Mc for SiH_3Cl^{35} and 26,049.6_0 Mc for SiH_3Cl^{37}. From these frequencies, the I_B and B_0 values were calculated and listed in Table I. Since the quadrupole moments of Cl^{35} and Cl^{37} have been measured to be $-7.921\pm0.05\times10^{-26}$ and $-6.189\pm0.05\times10^{-26}$ cm^2,[1] respectively, we may evaluate $\partial^2V/\partial Z^2$ at

TABLE I. Nuclear and molecular constants of chlorosilane.

	ν_0(Mc/sec.)	I_B(g-cm^2) $\times10^{40}$	$eQ\left(\frac{\partial^2V}{\partial Z^2}\right)$(Mc)	B_0(cm^{-1})
SiH_3Cl^{35}	26,695.2_4	125.7_1	−40.0_0	0.2226$_3$
SiH_3Cl^{37}	26,049.6_0	128.8_3	−30.3_3	0.2172$_3$

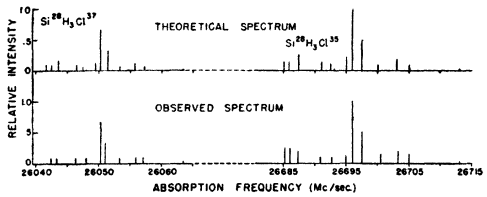

FIG. 1. Microwave absorption spectrum of monochlorsilane (SiH_3Cl).

the chlorine nucleus of chlorosilane to be about 7×10^{15} e.s.u. This is to be compared with the value 13×10^{15} e.s.u. as determined by Gordy[2] and his co-workers for methyl chloride.

Assuming the value of 1.456A for the Si−H distance determined from infra-red measurements on silane,[3] we may calculate from the I_B values in Table I, the Si−Cl internuclear distance to be 2.035A, and the H−Si−H angle to be 103° 57′. These are to be compared with the value 2.16A for Si−Cl computed from Pauling's covalent single-bond radii and the tetrahedral angle of 109° 28′. Electron diffraction measurements[4] on this compound yield a value of 2.06±0.05A for the Si−Cl distance.

The lines arising from $K=0\rightarrow0$ and $K=1\rightarrow1$ transitions were expected from theory to show second- and first-order Stark effect, respectively. This was strikingly observed in the experiment when only the $K=1\rightarrow1$ lines appeared at field of 10–20 volts/cm, being augmented by the $K=0\rightarrow0$ lines when the field was increased to several hundred volts/cm. The determination of the quadrupole coupling constants, $eQ(\partial^2V/\partial Z^2)$, was based on the frequencies of the $K=0\rightarrow0$ lines only, since these could be measured more accurately than the $K=1\rightarrow1$ lines because of experimental considerations.

The author makes grateful acknowledgment to Dr. A. E. Newkirk of this laboratory for the preparation of the chlorosilanes, Dr. Paul Zemany of this laboratory for purity checks on the mass spectrometer, and Dr. Robert Karplus of the Institute for Advanced Study for his helpful advice.

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[3] C. H. Tindal, J. W. Straley, and H. H. Nielsen, Phys. Rev. **62**, 151 (1942).
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Argon and Neon (pn) Thresholds

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November 1, 1948

FROM mass values[1] one calculates a $Q=-1.1\pm1.1$ Mev for the reaction $A^{40}(pn)K^{40}$. Observation of the neutron threshold should give precisely the mass difference between the important isobars A^{40} and K^{40}. A gas target was recently available on the Wisconsin electrostatic generator so a quick search was made for this threshold. A BF_3 counter surrounded by paraffin served as neutron detector. The high resolution electrostatic analyzer[2] was