Some Properties of Nuclei of Mass 19

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(Received August 20, 1954)

WE have sought to determine the properties of some of the states of nuclei of mass 19 since this region of the periodic table is of interest in illustrating competition between the $1d_{5/2}$ and $2s_{1/2}$ shells. This we have done by investigating (i) the Coulomb excitation of F^{19} by alpha particles; (ii) the positron decay of Ne^{19}; and (iii) the beta decay of O^{19}. Some results of (i) have been reported already[1] and similar work on Coulomb excitation has been published by other groups.[2,3] The results of investigations (ii) and (iii) are summarized in Fig. 1. Previous work on Ne^{19} has

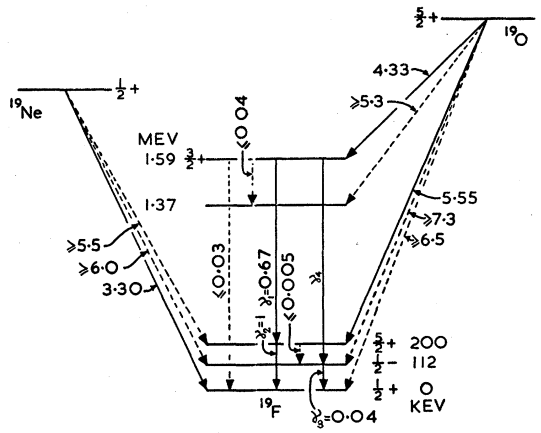

FIG. 1. Properties of Ne^{19}, F^{19}, and O^{19}. The numbers on the beta transitions are their $\log_{10} ft$ values; the numbers on the gamma transitions are their abundances in the decay of O^{19} relative to that of the 200-kev gamma ray as unity. The ground state of F^{19} has been assumed to be $(\frac{1}{2}+)$; the other assignments emerge from the present study. (The limit on the abundance of the transition between the 1.59- and 1.37-Mev states assumes that the decay of the latter is prompt.)

been confined to positron energy and lifetime measurements and to a search for high-energy gamma rays,[4] and on O^{19} to lifetime and beta energy and branching ratio measurements.[5]

Our observation that the decay of Ne^{19} leads to the ground state of F^{19} shows that no Coulomb cross-over of the F^{19} ground state triplet[6] has been induced and that the ground state of Ne^{19} is unquestionably $(\frac{1}{2}+)$. The limits on the ft values of the decay to the excited states of F^{19} are based on the absence of low-energy gamma rays. The large limit on the ft value for the decay of O^{19} to the 112-kev state of F^{19} makes it very probable that that transition is at least first forbidden as probably also, but with less certainty, is that to the F^{19} ground state. This observation, together with the Coulomb excitation data, the absence of the transition between the 200- and 112-kev states and our observations that the lifetime of the 200-kev state is $(1.0\pm0.2)\times10^{-7}$ sec while that of the 112-kev state is $\ll10^{-6}$ sec demand the spin and parity assignments shown for the first two excited states of F^{19}. These conclusions are identical with those reached by the California Institute of Technology workers[3,7-9] using largely different arguments. The assignment for the 1.59-Mev state we reach from the beta-decay of O^{19}, by a study of γ_4 and by an angular correlation measurement between γ_1 and γ_2 (some $\frac{2}{3}$ of the full correlation remains in Teflon). Our assignment for the ground state of O^{19} accepts the ft value of the ground-state beta transition as evidence against an allowed transition; $(\frac{3}{2}+)$ must remain a possible assignment since this evidence is not conclusive.

We may note that our direct lifetime measurement for the 200-kev state agrees with that determined by the recoil method[8] (0.8×10^{-7} sec with factor of 2 uncertainty) and with the matrix element as determined by Coulomb excitation.[1-3]

Our measurements of the gamma-ray energies are: $\gamma_1=1.366\pm0.008$ Mev; $\gamma_2=199.6\pm1.5$ kev; $\gamma_3=111.5\pm1.5$ kev.

The positions and properties of the even-parity states of the whole mass-19 system, including matrix elements for gamma and beta decay, are remarkably well described by a shell-model computation of Elliott and Flowers.[10]

A full account of this work will be presented shortly.

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Alpha-Gamma Directional Correlation Measurements with Liquid Film Sources

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(Received August 30, 1954)

A SERIES of earlier measurements[1-3] of alpha-gamma directional correlation in Th^{228}, Th^{230}, Ra^{224}, Ra^{226}, Pa^{238}, Am^{241}, and others has yielded anisotropies lower than theoretically predicted. These discrepancies have been explained on the basis of the electric quadrupole interaction due to the presence of large electric field gradients in the solid sources used. That these attenuations are due to external field interactions has been indicated by the experiments of Milton

and Fraser[3] where the anisotropy of Am^{241} was found to be a function of the time delay between the coincident radiations.

The attenuations due to quadrupole interaction can also be reduced or eliminated by the use of thin liquid film sources. This allows the correlations to be studied at more convenient resolving times. The Am^{241} alpha—60-kev gamma correlation has been studied in this way.[4]

The sources were prepared by placing a small drop ($\leqq 1$ mm^3) of aqueous solution on a rubber hydrochloride film (0.6 mg/cm^2) mounted on an aluminum ring, and covering with a thin glass or mica disk 1 cm^2 in area. Capillary action spreads a liquid film over the defined area. The alpha particles can penetrate the 0.001-in. solution layer and the plastic film and can be detected by a scintillating crystal without serious scattering.

The source was mounted in a vertical plane in the plastic vacuum chamber of the angular correlation apparatus previously described.[5] The chamber was filled with hydrogen bubbled through a solution of the same composition as the source in order to inhibit source evaporation and to reduce alpha absorption in the gas. A coincidence resolving time $2\tau=0.3$ microsecond was used.

Experiments were made with $6N$ H_2SO_4 and $1N$ $HClO_4$ solutions as well as with a dried source of americium nitrate. The results, Table I, show isotropy

TABLE I. Alpha—60-kev gamma anisotropy in Am^{241} solid and liquid sources.

Source	Anisotropy, A
Am^{241} nitrate, dry	0.003 ± 0.007
Am^{241} in $6N$ H_2SO_4	$0.07\ \pm0.02$
Am^{241} in $1N$ $HClO_4$	$0.16\ \pm0.02$

from the polycrystalline source, partial attenuation in the H_2SO_4 source, and a maximum experimental correlation in the $HClO_4$ source in agreement with the value of Milton and Fraser[3] for very short resolving time. It may be noted here that apparently the nuclear recoil does not cause an appreciable attenuation, probably because of its very short duration. The form of the correlation is that expected for a decay involving a dipole gamma transition, $W(\theta)=1+A\cos^2\theta$ or $W(\theta)=1+a_2P_2(\cos\theta)$ with $A=-0.16$ or $a_2=-0.11$.

A typical run is shown in Fig. 1 by plotting $W(\theta)$ *versus* $\cos^2\theta$.

The change in anisotropy with the two acids may indicate an effect due to an asymmetry in the coordination group surrounding the americium ions. Sulfuric acid is a weaker acid than perchloric in the sense that sulfate ions would tend more readily to complex the metal ion and displace one or more water molecules from its coordination sphere. This could produce an asymmetrical grouping and a corresponding electric field gradient at the nucleus that does not vary rapidly

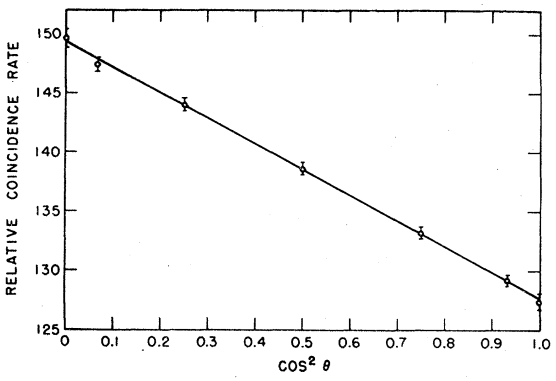

FIG. 1. Alpha-gamma directional correlation, Am^{241} in $1N$ $HClO_4$, $W(\theta)=1+A\cos^2\theta$, $A=-0.15$.

compared to the lifetime of the intermediate state and thus will not average out even in the liquid state. One might expect larger attenuations with stronger complexing agents such as chloride ions, acetate ion, or versene.

The use of this type of source should allow measurement of the undisturbed correlation in the even-even heavy element decays and determination of the magnetic moments of the excited states associated with the 10^{-6} to 10^{-9} second electric dipole transitions in odd-even heavy elements by the use of an external magnetic field. Measurements of this type are in progress as well as studies of the effect of complexing upon the quadrupole interaction.

The author is grateful to Dr. H. Frauenfelder for helpful discussion of this work and to R. Pairs for aid in these measurements.

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New Long-Lived Isotopes of Lead

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(Received August 23, 1954)

MINIMUM half-lives of 500 years were set for Pb^{202} and Pb^{205} on the basis of assumed counting efficiencies and estimated yields of these lead isotopes from a deuteron bombardment of thallium.[1] Duckworth *et al.*[2] set an upper limit of abundance of 0.0004 percent for Pb^{202} in natural lead and concluded that stable Pb^{202} probably does not exist. If the elements are assumed to be 4×10^9 years old and the original cosmic abundance of Pb^{202} equal to that of Pb^{204}, the half-life