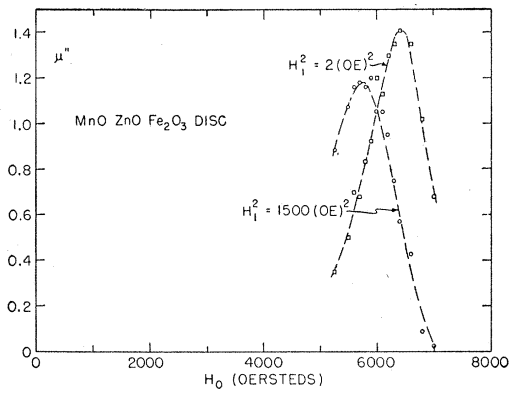

FIG. 2. The position of the resonance depends on the microwave power level in a disk-shaped specimen. No appreciable saturation can be obtained, as the constant field cannot be changed fast enough to satisfy the rapidly changing resonance condition during the microsecond pulse of the magnetron.

formed to exchange energy. This spin-spin damping process tends to keep the spin system in equilibrium within itself and at low microwave power the magnetization vector will always precess in a cone of very narrow opening, determined by the balance between absorbed power and spin-spin relaxation. When the microwave power is increased, the opening angle of the cone will increase. Strictly speaking, the magnetization vector will not even precess uniformly on a conical surface. It can be shown that the effective anisotropy field, i.e., the field which would produce the same torque as the anisotropy, depends on the angular deviation of the magnetization from the axis of the cone. The derivations of Kittel,[3] Van Vleck,[2] and Bickford,[3] of the influence of the anisotropy on the resonance condition, make the assumption that the vertex angle 2φ of the cone is very small. When we take for simplicity the case with H_0 is parallel to the 001 direction of the cubic crystal, the anisotropy will change the resonance value of the field approximately by an amount

$$H_{\text{anis}}{}^{z}=K_1M_s^{-1}\cdot\tfrac{1}{4}(7\cos 2\varphi+1)\cos\varphi.$$

For very small values of φ this reduces to the well-known expression

$$H_{\text{anis}}{}^{z}=2K_1/M_s.$$

For $\varphi=\pi/8$, the resonance field would differ by about 80 gauss from the value for $\varphi=0$, in nickel ferrite at room temperature. As the resonance line is rather narrow, this means that μ'' drops to 15 percent of its maximum value, if the magnetization is forced to precess in a wider cone. On the other hand, the component M_z has decreased by only 7 percent for this opening angle. Thus μ'' can decrease without an essential change in M_z. For other directions of H_0 the calculations become much more complicated, but effects of the same order of magnitude result.

If one starts off resonance at low microwave power, the change in the anisotropy torque with increasing power would produce an approach to the resonance maximum on one side of the absorption line. Although no actual increase of μ'' has been observed off resonance, it has been found that saturation occurs much more readily on one side of the resonance line than on the other.

In polycrystalline or irregularly shaped samples no apparent change in μ'' is caused by this effect, as the effective width of the resonance line is broad in these cases. Here we observe only the regular spin-lattice relaxation mechanism.

In samples of ellipsoidal shape or flat disks the spin-lattice relaxation is difficult to observe. Here the resonance condition depends on M_z through the demagnetizing factors. At the onset of saturation we get off resonance and thus only the initial small decrease of M_z can be observed. The shift in resonance through incipient saturation is shown in Fig. 2.

Saturation experiments in a spherical single crystal of $NiFe_2O_4$ have been carried out at 77°K. Preliminary data show that the decrease in μ'' occurs for microwave power levels which are six times lower than at room temperature. So the spin-spin relaxation time increases with decreasing temperature. The spin-lattice relaxation time is also increased by a factor of about 3, as can be derived from the decrease of M_s.

A prediction of our theory about the influence of anisotropy is that the saturation curves for μ'' and M_z should coincide near the Curie point, where the anisotropy is very small. Experiments at high temperatures to test this point are in the course of preparation.

* This work was supported by the ONR.

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First Excited States of Even-Even Nuclides in the Heavy Element Region

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(Received June 3, 1952)

THIS communication aims to amplify some observations on regularities of the complex spectra of even-even alpha-emitters particularly as they apply to the location of nuclear energy levels.[1,2] Most of the alpha-emitters of this type examined in this laboratory have shown two alpha-groups and the ratio of intensities of the two groups for a particular nuclide is, in good approximation, that expected for the energy difference according to simple alpha-decay theory. For lack of good evidence to the contrary, we have been assuming that the energy level reached by the low energy group is the first excited state and that the laws

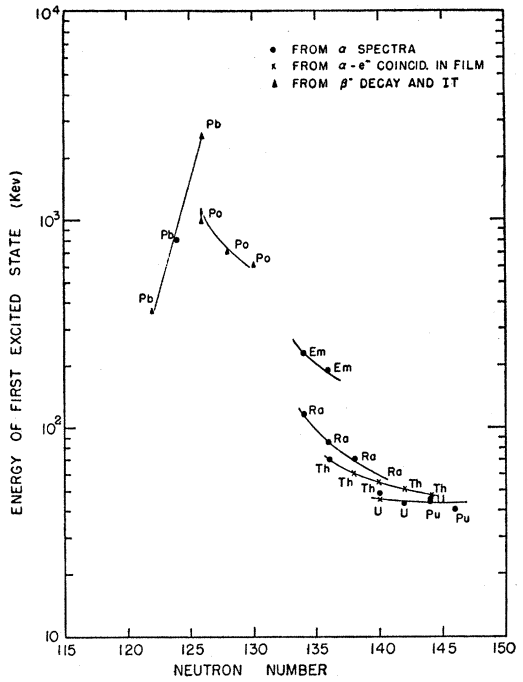

FIG. 1. First excited states of even-even nuclides.

governing the alpha-decay rate are the same as for the ground-state transition with only the energy operating to fix its relative abundance. For the few instances in which but a single alpha-group has appeared, the working hypothesis has been adopted that the first excited state is so high that the correspondingly low abundance of the alpha-group has prohibited its detection. To the extent that these assumptions are valid, the examination of complex alpha-spectra leads to the definition of the first excited states of the even-even nuclides.

The examination with our alpha-particle spectrograph of a number of nuclides in the region of uranium and higher atomic numbers yielded the curious result that the energy levels reached were all in a narrow range. For example, the energy differences between the two alpha-groups for each of the nuclides Cm^{244}, Cm^{242}, Pu^{240}, Pu^{238}, U^{234} all fell between 41 and 47 kev. It was also noted that nuclides of lower mass numbers showed higher energies for their first excited states.

The data are summarized in Fig. 1, in which are plotted the energy levels of the "first excited states" against neutron numbers with isotopes of each element joined. Most of the data were obtained from alpha-spectra taken in this laboratory, others were obtained by Rosenblum and co-workers, and some were measured by conversion electron ranges in photographic emulsions both in this laboratory and elsewhere. Data for excited states of polonium and lead were taken from the literature concerning principally beta-decay processes leading to these states. For the sake of brevity, references are omitted for both the published and unpublished data but these will be included in a later paper.

It is seen that the levels for plutonium, uranium, and the heaviest thorium isotopes are all bunched within a range of about 10 kev. The progressively higher energy for lower elements is consistent with the experienced difficulty of finding such states in alpha-spectra because of the low abundance which would accordingly be expected for the low energy alpha-groups. For example Em^{222}, Em^{220}, and Em^{218} have not yet revealed low energy groups which, according to our present expectations for the energies of the excited states of the corresponding polonium isotopes, would have abundances in the range $\sim 0.03-1$ percent.

The wide level spacing encountered at the region of 126 neutrons is obvious and it is interesting to note that lead isotopes show a decrease going away from 126 neutrons on the low mass side. It is possible that all of these correlations may be based primarily on departures from closed neutron and proton shells. Recently, there have been communications from several sources pointing out this same relationship surrounding closed shells.[3,4]

It is difficult to interpret these data on the single particle model which has been so successful in correlating transitions and energy states of nuclides having odd nucleons. The marked regularity of the first excited states and their low energies suggest some type of excitation involving the nucleus as a whole.

There are a number of apparent steps which may be taken in pursuing further these correlations and their interpretation. One of these, of course, is to extend the data to a wider range and, as one example, to see if energy level spacings increase at still higher mass numbers as might be expected for the approach to a new closed shell. Another point is the examination of the lifetimes of these states and the measurement of conversion coefficients and angular dependence of the gamma-rays. Goldhaber and Sunyar[5] have concluded that the first excited states of most even-even nuclides have spin 2 and even parity. With the low energies encountered for most of these transitions the lifetimes should be in the measurable range.

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