bility of much faster fluorescent components is not excluded. It is reasonable to expect that fluorescence in these crystals should be excited by fast ionizing particles, and in particular, by the radiations accompanying the natural radioactive decay of the uranium isotopes and their disintegration products, which are present in the crystals. The authors have, therefore, looked for fast fluorescent light pulses from pure hydrated uranyl nitrate crystals using an E.M.I. photomultiplier.

Scintillations were detected, although the amplitude of the pulses obtained were small and close to the thermionic background of the multiplier. An amplifier of rise time 0.5 μsec and clipping time 3 μsec was used. The crystal could quickly be moved away from the photocathode and back again so that an accurate comparison of the discriminator bias curves with and without the crystal near the photocathode could be obtained. Typical bias curves are shown in Fig. 1. These curves were taken when using a crystal whose approximate dimensions were 3×4×8 mm. It is seen, for example, that at a bias of 13 volts, the number of pulses from the crystal is about twice the background. The pulses which

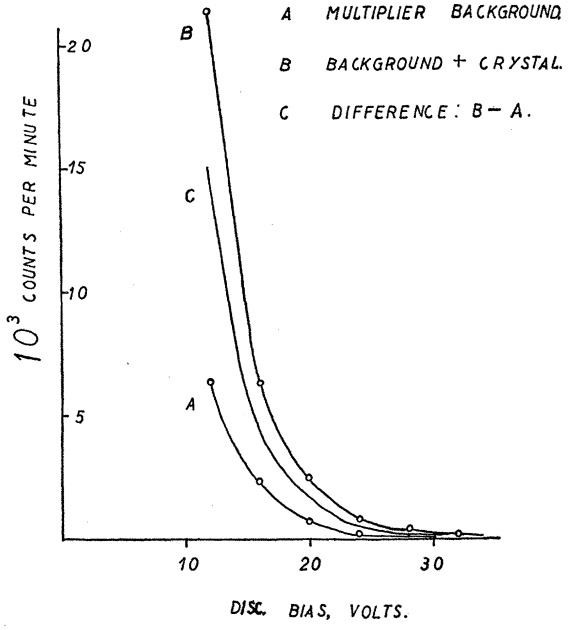

FIG. 1. Discriminator bias curves obtained with and without uranyl nitrate crystal near photocathode of multiplier.

were obtained in the presence of the crystal were not the effect of nuclear radiation impinging directly on the elements of the photomultiplier tube, since practically all the pulses were removed by interposing a very thin aluminium foil (0.37 mg/cm^2) between the crystal and the photocathode. It was also shown that the results cannot be explained in terms of a long period phosphorescence of the crystals, because similar results were obtained with crystals which were freshly recrystallized from aqueous solutions in the dark, and placed in the multiplier housing using a dark room red light.

Further experiments using small crystals indicate that the bias curve flattens out at a sufficiently low bias, where the scintillation rate approximately equals the calculated disintegration rate of α-particles from U I and U II. This shows that, as may be expected, the α-particles on the average produce much larger scintillations than the β-particles or secondary electrons from γ-rays. In general, however, the detection of the smaller pulses is difficult because of the multiplier background. It is hoped to overcome these difficulties using two multipliers in coincidence.

If a measure of proportionality exists between the amount of fluorescence and the energy of the individual ionizing particles up to high energies, it should be possible to detect scintillations induced by fission fragments. Such a detector might have a useful application in the study of cosmic rays, e.g., for the measurement of star energies, since an internal calibration of fluorescence as a function of energy would be provided. Experiments are being carried out to see whether neutron induced and spontaneous fission scintillations can be detected in large crystals.

The fluorescence excited by a 5 millicurie source of radium which is placed close to a large crystal of uranyl nitrate can easily be seen by a moderately dark adapted eye.

It is also interesting to note that these results provide a possible interpretation of some of the apparently unexplained observations of Becquerel[2] during his classical experiments on radioactivity, which he claimed show that the newly discovered radiations from uranium salts possess some of the properties of visible light.

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Magic Numbers and the Isotope Shift in Atomic Spectra of Heavy Elements

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IN a letter to this journal Murakawa and Ross[1] have recently reported a rise in the isotope shift at the magic neutron number 82. This conclusion had already been reached by us from a systematic study[2] of the isotope shift constants.[2,3] Measurements on Ce^{140}—Ce^{142} substantiated this view.[4]

More recently[5] it has been possible to show, from the isotope shift of RaD (Pb^{210}) relative to the stable lead isotopes, that a corresponding, though less pronounced, rise exists at the magic neutron number $N=126$.

At $N=50$ the values of the isotope shift constants are considerably more uncertain because of the great influence of mass dependent effects, but there is some indication[3] of a rise at this magic number, too.

The discontinuities at the magic neutron numbers may be seen from Fig. 1 where we have plotted, as a function of the neutron number N, the experimental isotope shifts divided by those calculated from Breit's theory of the nuclear volume effect.[6] This kind of diagram gives a better representation of the nuclear properties as derived from isotope shifts than the plot given by

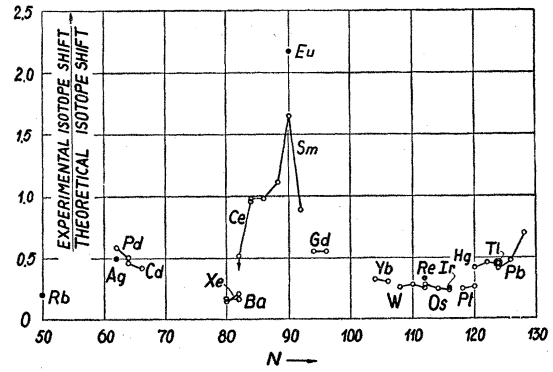

FIG. 1. Ratio of experimental to theoretical isotope shift for heavy elements as a function of the neutron number N. (Points are drawn for isotopic pairs with $N-2$ and N neutrons, and only for even N.) Black circles: Z odd. The measured shifts have been corrected for mass dependent effects; the theoretical values were calculated for homogeneously charged spherical nuclei with radii equal to $1.4A^{1/3}\times10^{-13}$ cm.

Murakawa and Ross, where the influence of the respective atomic electrons has not been eliminated.

The fact that most of the ratios in Fig. 1 are much smaller than unity can be explained by the assumption[3,7,8] that the addition of neutrons to a nucleus usually does not cause a uniform expansion of the nuclear charge distribution proportional to $A^{1/3}$ and that the added neutrons are mainly in the outer region of the nucleus. The exceptionally high points for $Eu^{151}-Eu^{153}$ and $Sm^{150}-Sm^{152}$ at $N=90$ have been related[2,7] to the quadrupole moments of europium.

Figure 1 also shows, as has been mentioned before,[3] that the values obtained for different isotopic pairs of the same element[9] show a tendency to follow the general trend of the values for different elements. The measurement of Murakawa and Ross[1] on the isotope shift $Ce^{138}-Ce^{140}$ can be considered an instructive example of this fact.

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[3] P. Brix and H. Kopfermann, Festschrift Akad. Wiss. Göttingen, Math.-physik. Kl., p. 17 (1951).
[4] P. Brix and H. Frank, Z. Physik **127**, 289 (1950).
[5] Brix, Buttlar, Houtermans, and Kopfermann, Nachr. Akad. Wiss. Göttingen, Math.-physik. Kl., Nr. 7 (1951).
[6] For detailed discussion, accuracy (on the average about 10–20 percent) and literature see reference 3. The points for cerium 138–140 (only upper limit known) and lead 208–210 have been added. The new values for Pd are from Steudel (to be published), the relative shifts of the osmium isotopes have been corrected according to Suwa [Phys. Rev. **83**, 1258 (1951)].
[7] P. Brix and H. Kopfermann, Nachr. Akad. Wiss. Göttingen, Math.-physik Kl., p. 31 (1947).
[8] M. F. Crawford and A. L. Schawlow, Phys. Rev. **76**, 1310 (1949).
[9] The corresponding points have been connected by full lines in Fig. 1.

An Attempt to Produce Nuclear Orientation in Mercury Vapor*

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THE absorption of polarized resonance radiation by a vapor produces unequal populations of the magnetic sublevels of the excited state, and also of the ground state after re-emission. Kastler[1] has suggested that, as a consequence of these facts, polarized light may be used to orient nuclei. An experimental demonstration of this effect was attempted, and yielded a negative result.

A sample of mercury enriched in the isotope with mass number 199 and spin $\frac{1}{2}$ was supplied by the Atomic Energy Commission. The level structure of this isotope is shown in Fig. 1. The sample was placed in a quartz resonance lamp in a magnetic field of a few hundred gauss and illuminated by circularly polarized resonance radiation incident in a direction parallel to the field. Atoms in the ground state with $m=\frac{1}{2}$ can be excited only to the $^3P_1$ level with $F=\frac{3}{2}$ and $m=\frac{3}{2}$, and, in the absence of collisions, can return only to the ground state sublevel from which they came. On the other hand, atoms originally in the ground state sublevel with $m=-\frac{1}{2}$ are excited exclusively to levels with $m=+\frac{1}{2}$, and may return by radiating to either of the two ground levels. The net result is an optical "pumping" as Kastler suggests, from $m=-\frac{1}{2}$ to $m=+\frac{1}{2}$, or a tendency in the direction of nuclear orientation. This is in competition with a disorienting tendency caused by collisions.

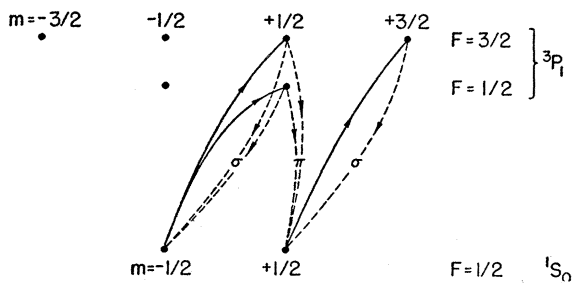

FIG. 1. Optically induced transitions in Hg^{199}.

If an appreciable degree of preferred nuclear orientation is produced, the intensity of the π-component of the resonance radiation with $\Delta m=0$ is less than for a disoriented vapor because fewer atoms are in the $m=-\frac{1}{2}$ ground level. This criterion was used to detect nuclear orientation. A radiofrequency field, of such frequency as to induce transitions between the ground state magnetic sublevels, was applied to the resonance lamp. We estimate that when the magnetic resonance condition $\omega=\gamma H$ is fulfilled, a change in the intensity of the π component of the optical resonance radiation should be observed if the polarized light has produced an excess of $m=\frac{1}{2}$ over $m=-\frac{1}{2}$ of at least a few percent. No such effects were observed.

Further experimentation is under way in an attempt to isolate the reasons for the negative results reported.

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The Scattering of 9.6-Mev Protons by Carbon, Aluminum, and Magnesium

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A REMOTELY controlled scattering chamber, which will be described in detail later, has been used to investigate the scattering of 9.6-Mev protons by some light nuclei. The source of protons was the extracted beam of the Birmingham 60-in. cyclotron. The beam passes through a steering magnet which brings it to a focus just in front of the chamber. After collimation to $\frac{1}{2}°$ by rectangular slits, the beam passes through a scattering foil and is collected in a Faraday cup. The foils were about 4 mg/cm² in thickness, and the proton currents varied between 1 and 5×10^{-9} amp.

The scattered particles were detected by a counter telescope consisting of three proportional counters which fed a flexible coincidence or anticoincidence circuit. A set of fifty graded aluminum absorbers before counter 1, and a further set of five between counters 2 and 3, could be used to measure the ranges of the scattered particles. The proton current entering the Faraday cup was passed through a high resistance, and the resulting dc potential integrated electronically to give an absolute measure of the charge collected during a run.

Differential range curves were taken by observing coincidences between pulses in the first two counters for different thicknesses of absorber in front of counter 1. Counter 1 was biased low enough to count all particles which traversed it, while counter 2 was biased high so as to count only those particles which stopped in counter 2. This arrangement was insensitive to the large background of pulses because of fast neutron recoils in the counter gas. Figure 1 shows a range distribution curve for 9.6-Mev protons scattered through 60° (lab. angle) by a magnesium foil of normal isotopic constitution, set so that the normal to the foil bisected the scattering angle.

The three large peaks correspond, respectively, to elastic scattering and to excitation of the 1.38- and 4.14-Mev levels of Mg^{24}. The widths of these peaks are only slightly greater than those to be expected from range straggling in the absorber alone, so that the effects of energy spread of the incident beam, thickness of the scattering foil, range of energies accepted by counter 2, and the spread in scattering angle are small, as anticipated from detailed calculations.

Particle ranges in aluminum, corrected for energy loss in the scattering foil and the counter, were converted to energies by