The α^5 correction to the 2^1S_0 (2^3S_1) level may be broken down as follows: 112 (61) Mc/sec arise from recoil effects; 261 (295) Mc/sec come from vertex parts; -16 (-124) Mc/sec are due to the annihilation interaction. All these effects are much smaller in P states.

It is hoped that work now in progress elsewhere will provide experimental level shifts sufficiently accurate to compare with those predicted theoretically. The details of this calculation will be published later. We wish to thank Professor R. Karplus, Professor J. Schwinger, and Dr. A. Klein for helpful discussions.

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The Nuclear Magnetic Moments of Xe^{129} and Xe^{131}

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The nuclear magnetic resonances of Xe^{129} and Xe^{131} in pure Xe gas at a pressure of approximately 50 atmos have been detected with a nuclear induction spectrometer similar to the one described by Weaver.[1] A sample of ordinary Xe gas at 50 atmos without any catalyst was used. The signal of Xe^{131}, abundance 21.17 percent which from hfs is known to have a spin $I=\frac{3}{2}$, and a quadrupole moment $Q\approx -0.15$, appeared as a slow-passage signal with a signal-to-noise ratio of about 40:1. The nature of the signal caused by Xe^{129} ($I=\frac{1}{2}$; abundance $f=26.23$ percent) in the same sample, indicated that the experimental conditions for this isotope were not these of slow passage, the relaxation time T_1 being at least several minutes. Comparison of the proton resonance frequency in water containing 0.1-molar $MnSO_4$ with the resonance frequencies of Xe^{129} and Xe^{131} in the same magnetic field yielded the following results:

$$\nu_{129}/\nu_p=0.276633\pm0.000005, \quad \nu_{131}/\nu_p=0.081976\pm0.000001.$$

Using the value of the proton moment of Sommer, Thomas, and Hipple[2] ($\mu_p=2.79268\pm0.00006$ nm) the above frequency ratios lead to the following magnetic moments for Xe^{129} and Xe^{131}:

$$\mu_{129}=-0.77255\pm0.00002 \text{ nm}, \quad \mu_{131}=+0.68680\pm0.00002 \text{ nm}.$$

Both values are given without diamagnetic corrections. From these values the ratio of the magnetic moments is obtained as

$$\mu_{129}/\mu_{131}=-1.12485\pm0.00002.$$

The value of μ_{129} agrees within the experimental error with that obtained by Proctor and Yu[3] ($\mu_{129}=-0.7726\pm0.0001$ nm) in a sample of Xe gas at 12 atmos and containing Fe_2O_3 powder as paramagnetic catalyst. The ratio of the magnetic moments is also in fair agreement with the value of Bohr, Koch, and Rasmussen[4] ($\mu_{129}/\mu_{131}=-1.131\pm0.005$) obtained by hfs measurements.

The mechanism of relaxation is apparently caused by strong van der Waals forces since pure nuclear dipole-dipole interaction would lead to enormous relaxation times ($\sim10^6$ sec). This explanation is corroborated by the work of Proctor and Yu, who were unable to detect signals of either odd isotope in pure Xe at a pressure of 12 atmos without catalyst. In our experiment, the van der Waals forces are appreciable since at a pressure of 50 atmos the density of the gas is roughly 1.6 times that to be expected for an ideal gas. It is also worth noting that the relaxation time for Xe^{131} is several orders of magnitude smaller than that of Xe^{129}, indicating that strong electric interaction takes place with the quadrupole moment of Xe^{131}. Further studies of these processes are in progress.

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Electric Excitation of Low-Lying Levels in Separated Wolfram Isotopes*

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Electric excitation of heavy nuclei was first observed simultaneously by two groups.[1,2] Subsequently, this has been confirmed by a number of others[3] and a major improvement in the technique for determination of the energy of the excited state has been achieved by Huus and Bjerregaard[4] using magnetic analysis of the internal conversion electrons. These investigators established that the broad peak observed[1] at 105–125 kev (see Fig. 1)[5] is composed of three separate peaks at 102, 113, and 124 kev. The Bohr-Mottelson theory[6] predicts that each even-even isotope of wolfram has a 2+ low-lying rotational level above the 0+ ground state, that these levels should have nearly the same energy, and that in this element the energy of the level in a given isotope should increase with atomic weight. It is known that W^{186} has a 2+ level at about 123 kev.[7] Accordingly Huus and Bjerregaard tentatively assigned the above three levels to the

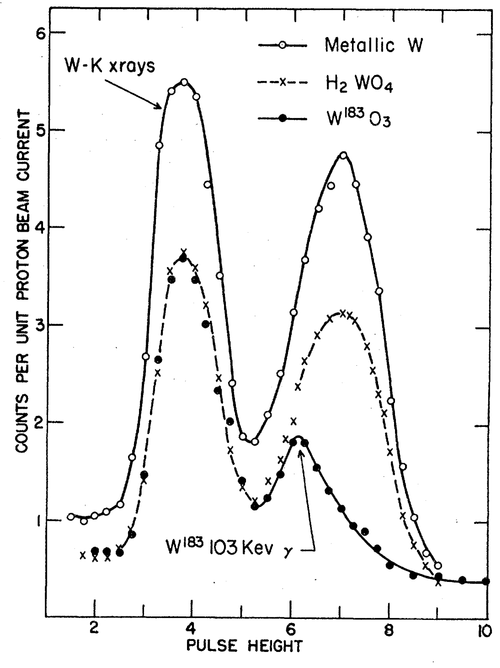

FIG. 1. NaI(Tl) scintillation spectrometer pulse spectra from three wolfram targets during bombardment with 2.5-Mev protons. The broad gamma photopeak shown for metallic wolfram and H_2WO_4 is produced by unresolved gammas from all wolfram isotopes. The pulse spectrum from W^{183} is shown for comparison. Spectra from even-even wolfram isotopes are displayed in Fig. 2. The energy of the W^{183} gamma is given to an accuracy of ±8 kev. The breadth of this peak on the high-energy side results from the appreciable concentrations of the heavier isotopes as impurities (see Table I). In each case a 0.1-inch copper absorber was used to reduce the intensity of the K x-ray background. The intensity of the W^{183} gamma has not been corrected for absorption in copper.

TABLE I. Isotopic composition of WO_3.

Target designation	Mass analysis in atom percent 180	182	183	184	186
W^{182} [a]	0.017	92.33	3.62	2.71	1.31
W^{183} [a]	0.098	4.19	86.21	7.14	2.36
W^{184} [a]	0.056	0.902	1.25	95.72	2.07
W^{186} [a]	0.013	0.501	0.379	1.57	97.54
W [b]	0.143	26.09	14.24	30.68	28.85

[a] As reported by Isotopes Division, U. S. Atomic Energy Commission.
[b] R. F. Hibbs, U. S. Atomic Energy Commission Report AECU-556 (1949), from National Bureau of Standards Circular 499.

three major even-even isotopes of nearly equal abundance: W^{182}, W^{184}, and W^{186}, respectively. We have confirmed this assignment by measurements on isotopically enriched wolfram (see Table I) obtained as WO_3.

Thick targets of the powdered WO_3 as received were prepared by compression into lead disks. Targets of natural W in the form of powdered H_2WO_4(cp) were also prepared in the same way. The data for W^{183} appear in Fig. 1, and that for the even-even isotopes of wolfram in Fig. 2.

The theory[6] predicts that the cross sections for electric excitation of the three even-even isotopes of wolfram should decrease in the order of W^{182}, W^{184}, W^{186}. After correction for absorption in copper, and rough estimates of the effects of internal conversion from the data of Huus and Bjerregaard[4] and Steffen,[8] our measured intensities support this theory. We hope to be able to give quantitative values for the relative cross sections in the near future.

Absolute reaction cross-section measurements have not yet been completed, but the experimental gamma intensity from the even-even W isotopes appears to be of the same order as that for Ta, reported previously.[1,2] After correction for absorption in copper, the yield of the W^{183} gamma is substantially smaller than that of the even-even isotopes.

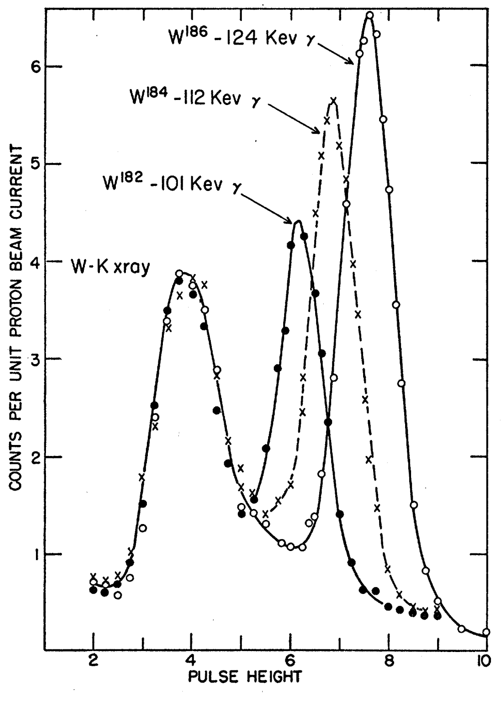

FIG. 2. Superposition of the pulse-height spectra obtained during bombardment of the three even-even isotopes of wolfram with 2.5-Mev protons. The gamma rays observed result from de-excitation of the first level in the isotope after electric excitation. Gamma energies are considered reliable to ±4 kev. In each case an absorber of 0.1-inch copper was used to reduce K x-ray background. The figure does not include correction for gamma absorption in the copper or internal conversion which have been estimated in the text. Counting statistics at the photopeaks are about twice the size of the symbols used.

The scintillation spectrometer was calibrated with the gamma from electric excitation of the first level in tantalum taken as 136.5 kev[9] and with the K x-ray series peak from W taken as 60 kev. The energy assigned this peak results from graphical analysis of our experimental data combined with measurements of the relative intensities of the K series from wolfram.[10]

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On H. Alfvén's Theory of the Effect of Magnetic Storms on Cosmic-Ray Intensity*

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THE theory of Alfvén[1] envisages a stream of gas shot out from a place on the sun where there is a large magnetic field. The gas, supposed highly conducting, carries the magnetic field H with it, and the field is supposed to be perpendicular to the velocity v. A stationary observer observes an electric polarization perpendicular to H and v, and the potential change across the beam of width h is calculated as Hvh/c. A cosmic ray crossing the beam is supposed to change its energy by $Hvhe/c$, and by making H or h large this change of energy can be made as great as is desired. Alfvén calculates a 10 percent change for the energy of a 3×10^{10} ev ray on crossing a beam of width 5×10^{12} cm carrying a magnetic field of 3×10^{-4} gauss and travelling with a velocity of 2×10^{8} cm/sec.

The present paper recognizes that an observer moving with the beam observes no change of energy, and by a relativity transformation, it is shown that a fixed observer cannot observe a change of energy greater than $2vW/c$, where W is the energy of the cosmic ray. This change amounts to only about 1.4 percent.

The essence of this matter is the following: If v is along the axis of x, if u is the velocity of the particle, W the total energy of the particle, and $\beta=(1-v^2/c^2)^{-\frac{1}{2}}$, then Wu_x, Wu_y, Wu_z, Wic constitute a 4 vector. If S and S' refer, respectively, to the fixed axes and the axes moving with the system, it results that if W' is the energy in S', which energy does not change with time, the change W_2-W_1 in crossing the beam as measured in S is:

$$W_2-W_1=\beta W'(u_{x2}'-u_{x1}')v/c^2,$$

so that

$$(W_2-W_1)<2\beta W'v/c,$$

from which it can readily be shown that

$$(W_2-W_1)<(2v/c)W_1.$$

The discrepancy between the conclusions from relativity and those drawn by Alfvén are shown to arise from the fact that the cosmic-ray path in the example considered by Alfvén would have, in the beam, a radius of curvature 15 times smaller than the beam width and so could never cross it. Thus relativity gives for the change of energy of the beam an upper limit of the order