Raboy und Krohn geben unter Vernachlässigung der Schwächung den Wert $g = 1{,}20 \pm 0{,}12$ an[3]. Unter der Annahme $I(480\,\mathrm{keV}) = 5/2$ – die in der Arbeit[4a] ausführlich begründet wird – folgt aus unserer Messung für das magnetische Moment

$$\mu(480\,\mathrm{keV}, I = 5/2) = (3{,}25 + 0{,}17)\ \mu_K\,.$$

Diskussion

Die Bedeutung der Messung des magnetischen Momentes eines Kernniveaus liegt darin, daß sie es in vielen Fällen möglich macht, zu entscheiden, um was für eine Konfiguration der Nukleonen es sich handelt. Die Momente von reinen Einteilchenzuständen sollten alle (auch diejenigen angeregter Niveaus) auf einer der beiden Schmidt-Linien liegen (Abb. 6). Erfahrungsgemäß weichen aber die gemessenen Momente von diesen ab, gruppieren sich aber immerhin um eine „empirische Schmidt-Linie", für welche mehrere Erklärungsansätze vorliegen. In Abb. 6 haben wir die Schmidt-Linien und die Bereiche, in denen die meisten der gemessenen Momente liegen, eingetragen. Man erkennt, daß der von uns gefundene Wert für das magnetische Moment des 5/2-Niveaus von Ta^{181} sich sehr gut in die Gruppe der $d_{5/2}$-Zustände einfügt. Es liegt deshalb nahe, anzunehmen, daß dieser Zustand ein reiner Einteilchenzustand ist und nicht, wie De Waard[13] dies vorschlägt, durch drei oder fünf ungepaarte $g_{7/2}$-Protonen konstituiert wird. Für $(g_{7/2})^3$- oder $(g_{7/2})^5$-Konfigurationen ergibt sich nämlich nach dem Schalenmodell ein magnetisches Moment von ungefähr 2, im Widerspruch mit unserer Messung.

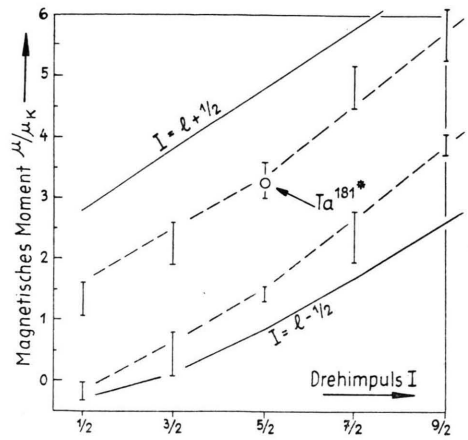

Abb. 6. Schmidt-Diagramm für Kerne ungerader Protonenzahl. Die Striche stellen die Bereiche dar, in denen die meisten der gemessenen Momente liegen, der Kreis das von uns bestimmte Moment des Ta^{181} (480 keV).

Wir sind den Herren F. Gimmi und Dr. H. Albers-Schönberg für viele anregende Diskussionen und Herrn W. Kündig für die Durchführung zahlreicher Messungen zu großem Dank verpflichtet.

The Branching Ratio of Kr^{85m} from Fission Yield Studies

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To J. Mattauch for his 60th birthday

The fission yield of the 85 mass chain has been determined both at Kr and Rb with a mass spectrometer using isotope dilution techniques. This has made possible a direct determination of the branching ratio of Kr^{85m} which turns out to be 0.28. Thus 22% of the metastable isomer (Kr^{85m}) decays to the Kr^{85} ground state.

There are two isomers of Kr^{85} known with half-lives of 4.4 hours and 10.27 years. The former activity was first noted by Snell in 1937 while studying the (d, p) reaction on krypton[1]. The 10.27-year isomer was discovered independently by Hoagland and Sugarman[2] and by Thode and Graham[3] in 1945. The first workers found an activity in fission product krypton with a mini-

[1] A. H. Snell, Phys. Rev. **52**, 1007 [1937].

[2] E. J. Hoagland and N. Sugarman, National Nuclear Energy Series, Division IV, Vol. 9, Part V, McGraw-Hill Book Co. Inc. 1951, p. 635.

[3] H. G. Thode and R. L. Graham, Report MX-129, National Research Council of Canada, 1945; Canad. J. Res. A **25**, 1 [1947].

mum half-life of 10 years which they were able to show was due to Kr^{85} or Kr^{87}. On the other hand, the mass spectrograms of the isotopes of krypton in fission gas obtained by Thode and Graham showed the definite existence of a long-lived isotope of krypton at mass 85 and hence an isomer of the then-known 4.4-hour krypton of that mass. The half-life of this isomer was determined mass spectrometrically by following the decay of the Kr^{85} relative to a stable isotope[3], the latest value being 10.27 years[4]. The decay scheme for Kr^{85m} worked out by Bergstrom[5] and reviewed by Goldhaber and Hill[6] is illustrated in Fig. 1. According to this scheme, a fraction of the mass 85 fission chain will decay through the 4.4-hour Kr^{85m} directly to Rb^{85} in a relatively short period of time, and a smaller fraction will decay from Kr^{85m} through the 10.27-year ground state of Kr^{85} to Rb^{85}. The first

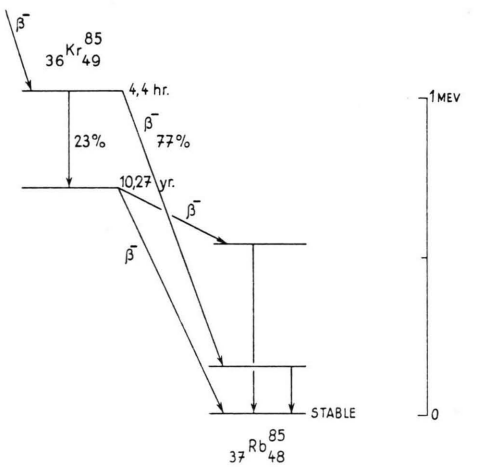

Fig. 1

indication of the branching ratio of Kr^{85m} came from mass spectrometer studies of the fission product krypton[3,7]. Isotope abundance measurements made on fission gas samples several months old involve only the 10.27-year isomer and the fission yield for Kr^{85} obtained is for one branch of the chain only. By subtracting this yield from the overall yield for mass 85 read from a smooth mass yield curve which may be drawn through the accurately-determined yields for Kr^{83} an Kr^{86}, one obtains the yield for the other branch of the chain. This procedure, which assumes that the yields fall on a smooth curve in this mass range for U^{235} fission, gives a branching ratio for Kr^{85m} of 0.29 using the most recent krypton isotope abundance data for thermal neutron fission[8] of U^{235}. More recently, Bergstrom reported a branching ratio of 0.30 for the decay of Kr^{85m} (cf. l. c.[5,6]). He measured the ratio of the internal conversion electrons to β-rays and corrected it for the conversion probability of an M 4 isomeric transition. During the past year, absolute fission yields have been determined for $Kr_{(10.27\,yr.)}$ and Rb^{85} with a mass spetrometer using isotope dilution techniques. From these measurements the ratio of $Kr^{85}{}_{(10.27\,yr.)}/Rb^{85}$ (from Kr^{85m} direct) can be calculated to give the branching ratio of Kr^{85m} directly.

Experimental

Two pieces of natural uranium metal weighing 2.97 and 6.7 grams were irradiated simultaneously with thermal neutrons in the same pile position in the N. R. X. reactor. These samples were used for rubidium and krypton fission yield determinations respectively. Details of the irradiation data and rubidium yield determinations using isotope dilution techniques have been described previously[9]. The 2.97 gram piece of uranium was found to contain $7.518 \cdot 10^{14}$ atoms of fission Rb^{85} per gram of uranium. This yield of Rb^{85} reported by Petruska, Thode and Tomlinson[10] included all of the 85 mass chain which had decayed directly from the Kr^{85m} to Rb^{85} in addition to that part of the 10.27 year Kr^{85} which had decayed in 2.55 years; 2.55 years having elapsed between the time of irradiation and the time of extraction.

The fission product krypton was extracted from small pieces of the 6.7 gram sample by reaction of the uranium metal with chlorine. In each case, a measured amount of normal krypton gas was added to the reaction flask as a spike. The yields of the various fission isotopes of krypton were then determined from a comparison of the isotope pattern of the mixture with that of the fission gas krypton and normal krypton separately, the isotope patterns for the latter two having been obtained previously. Using this isotope dilution procedure, the yield of the stable isotope Kr^{83} was found to be $3.817 \cdot 10^{14}$ atoms per gram of uranium. The yield of the 10.27-year Kr^{85} isomer in the irradiated piece

[4] R. K. Wanless and H. G. Thode, Canad. J. Phys. **31**, 517 [1953].
[5] I. Bergstrom and M. Siegbahn, Commemorative Volume, Uppsala, 1951.
[6] M. Goldhaber and R. D. Hill, Rev. Mod. Phys. **24**, 190 [1952].
[7] H. G. Thode, Nucleonics **3**, 14 [1948].
[8] R. K. Wanless and H. G. Thode, Canad. J. Phys., Sept. 1955 (in press).
[9] J. A. Petruska, E. A. Melaika and R. H. Tomlinson, Canad. J. Phys. (in press).
[10] J. A. Petruska, H. G. Thode and R. H. Tomlinson, Canad. J. Phys. (in press).

of uranium was then calculated to be $2.01 \cdot 10^{14}$ atoms per gram of uranium using 1.868 for the $Kr^{38}/Kr^{85}_{(10.27\ yr.)}$ ratio (corrected for decay) obtained by Wanless and Thode[8] for the thermal neutron fission of U^{235}.

The branching ratio of Kr^{85m} may now be calculated from the Rb^{85} and Kr^{85} yield data. From the rubidium yield data we have the equation

$$Y(1-X) + XY(1-e^{-\lambda t}) = 7.518 \cdot 10^{14},$$

where Y is the total yield of the 85 mass chain in atoms per gram of uranium, λ is the decay constant for the 10.27-year Kr^{85}, t is 2.55 years and X and $(1-X)$ are the fractions of the Kr^{85m} decaying to the ground state of the Kr^{85} and directly to Rb^{85} respectively, and $X/(1-X)$ is taken as the branching ratio for Kr^{85m}.

Now from the krypton yield data we have

$$XY = 2.01 \cdot 10^{14}.$$

Solving for the branching ratio we have

$$\frac{X}{1-X} = \frac{2.01 \cdot 10^{14}}{7.518 \cdot 10^{14} - 2.01 \cdot 10^{14}(1-e^{-\lambda t})} = 0.277.$$

Since the flux in the larger 6.7 gram piece of uranium will be slightly lower than in the smaller 2.97 gram piece because of a slightly greater self-shielding, a small correction is necessary. The difference in flux in the two samples is calculated to be 1.7% assuming the two pieces to be spheroids[11]. Thus the Kr^{85} yield should be raised by 1.7% in comparison with the Rb^{85} yield and the final branching ratio then becomes 0.28. Since the individual yields are probably good to 2%, the branching ratio should be accurate to better than 4%.

This value is in excellent agreement with the earlier value (0.30) obtained by Bergstrom and is therefore confirmation of the decay scheme ascribed to Kr^{85m}. On the other hand, the agreement with the early mass spectrometer yield value (0.29) based on krypton isotope yields indicates that the total yield of the 85 mass chain falls on a smooth yield curve in this mass region for the thermal neutron fission of U^{235}, an assumption made in the early determination. It is of interest to note here that Wanless and Thode have recently reported extensive fine structure in the yield curve at mass 85 for the neutron fission of U^{238}. In this case, the low yield at mass 85 is accompanied by a high yield at mass 84.

If this fine structure is due to neutron emission in the 85 mass chain at, for example, As^{85} as has been suggested, then the extent of this chain branching will depend on the distribution of charge in fission. This will in turn vary considerably from U^{235} to U^{238} fission and will therefore account for the quite different results obtained in the two cases.

[11] K. M. Case, F. De Hoffman and G. Placzek, Introduction to Theory of Neutron Diffusion, Vol. 1, U.S. Government Printing Office, Washington, 1953.

Concerning the Masses of the Stable Zinc Isotopes

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To J. Mattauch for his 60th birthday

The masses of Zn^{64}, Zn^{66}, Zn^{67} and Zn^{68} have been studied mass spectroscopically by means of the O_2^{16}–1/2 Zn^{64}, 1/2 Xe^{132}–Zn^{66}, 1/2 Xe^{134}–Zn^{67} and 1/2 Xe^{136}–Zn^{68} doublets. These studies suggest that the currently accepted masses of Zn^{64} and Zn^{66} are too large by ~ 0.4 mMU. If these revisions are made several existing discrepancies between transmutation and mass data disappear.

1. Introduction

Since the war the precision with which atomic masses can be determined mass spectroscopically has greatly improved, as have also the techniques for studying the energy balance in nuclear reactions. As a result, it is frequently possible to make meaningful comparisons between mass spectroscopically-derived masses and those computed from transmutation Q-values. Among the lighter atoms such comparisons have been of great value in assessing the reliability of the mass spectroscopic work as, for example, in the case of C^{12}. Here, for a period of time, the transmutation-derived value was signifi-

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