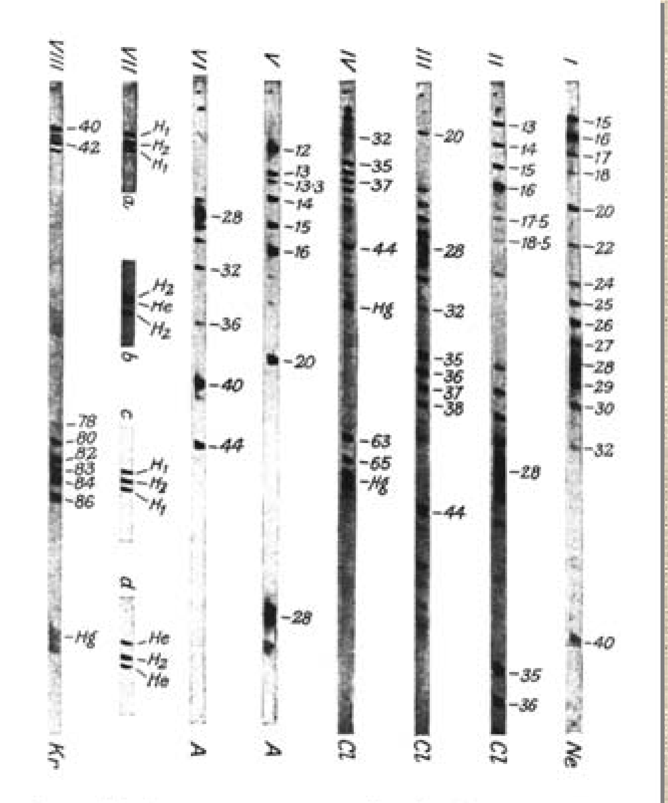
Francis Aston (1877-1945) with his mass spectrograph at the Cavendish laboratory

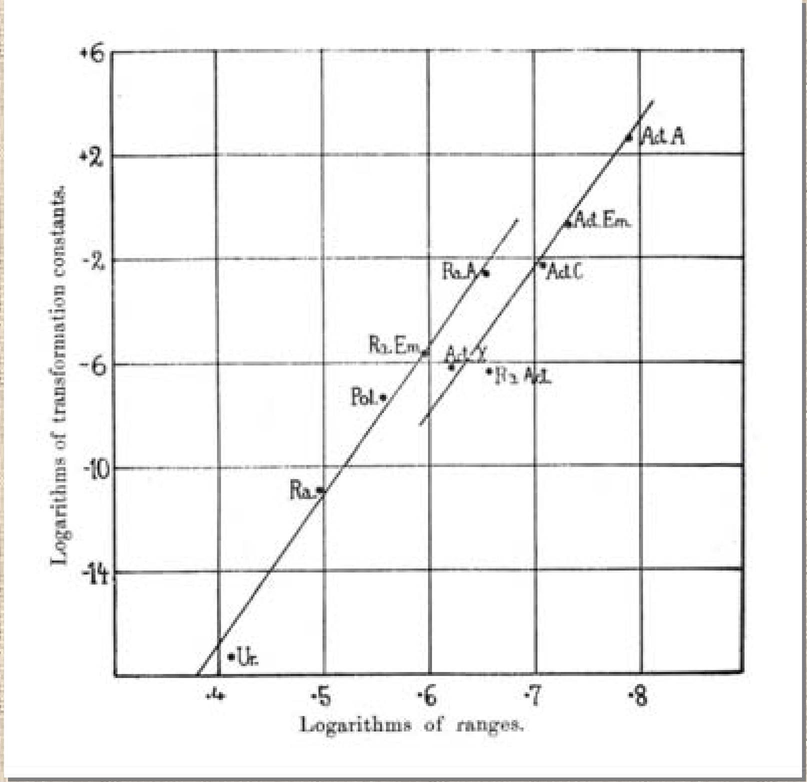


Typical Mass-Spectra obtained with the First Mass-Spectrograph, 1920.

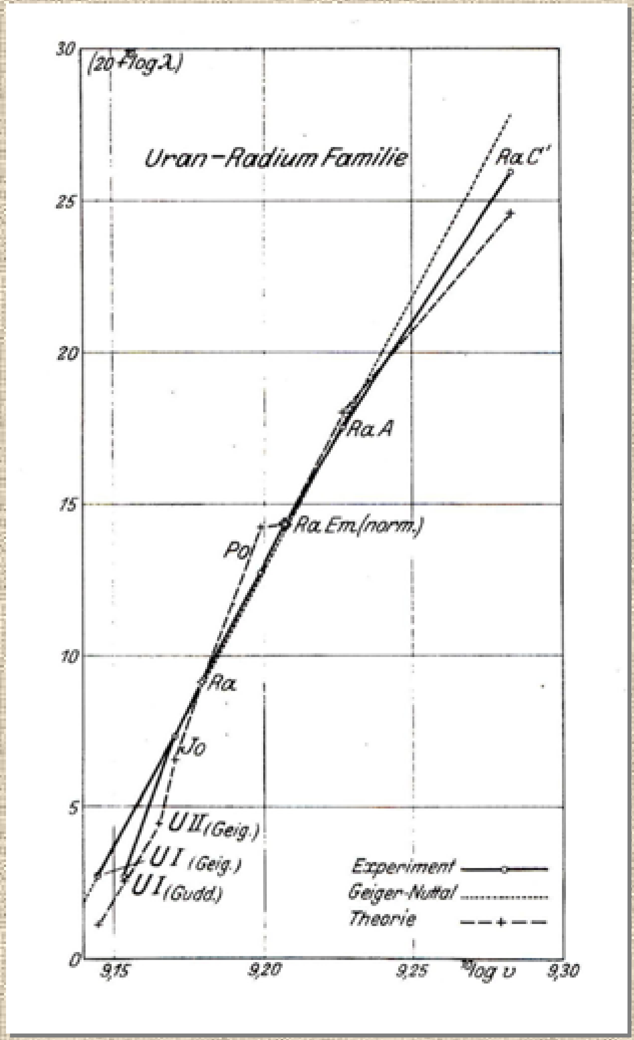
Typical mass spectra obtained with the first mass spectrograph in 1920

John Cockcroft and George Gamow in 1930

George Gamow and Wolfgang Pauli on a steam boat on a lake in Switzerland

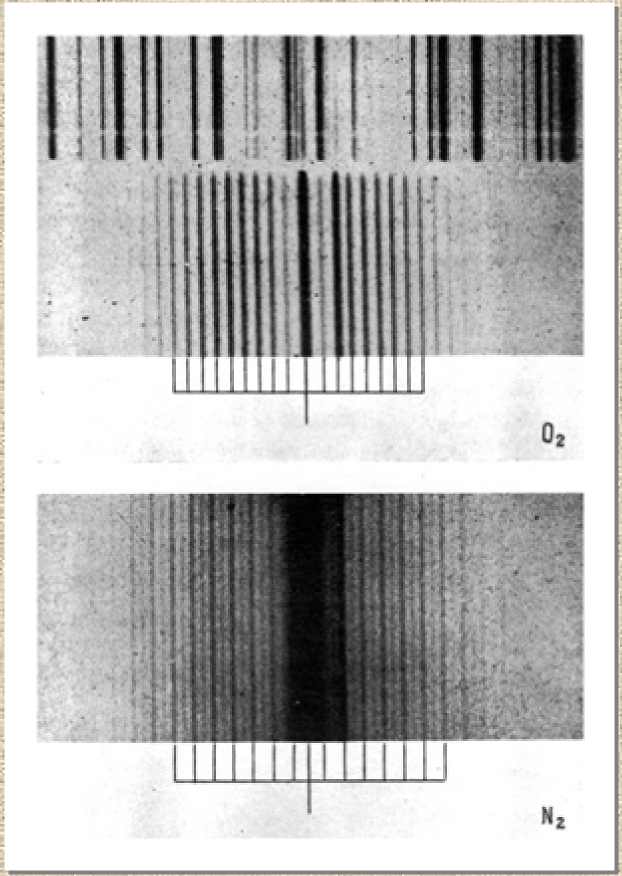


+6
+2
-2
-6
-10
-14
·4
·5
·6
·7
·8
Logarithms of transformation constants.
Logarithms of ranges.
Ad.A
Ad.Em.
Ra.A
Ad.C
Ra.Em.
Ad.X
Ra.Ad.
Pol.
Ra.
Ur.

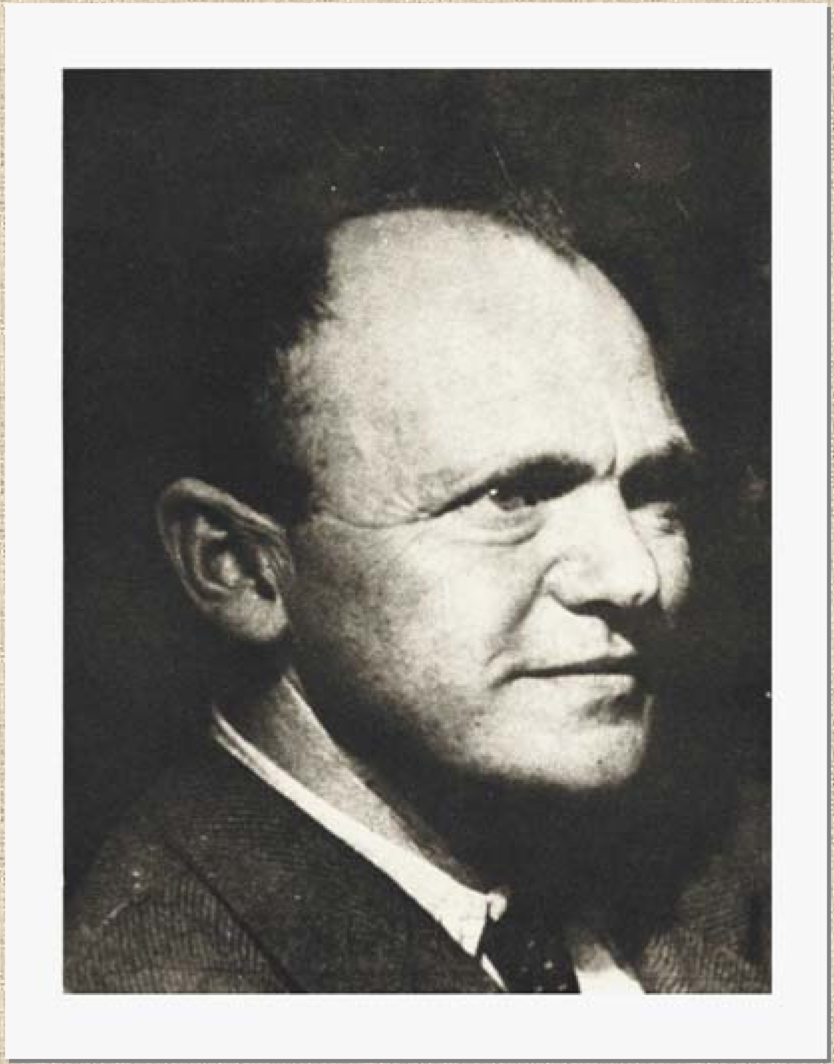


Uran-Radium Familie
(20+log λ)
Ra C'
Ra A
Ra Em.(norm.)
Po
Ra
Jo
U II (Geig.)
U I (Geig.)
U I (Gudd.)
Experiment
Geiger-Nuttal
Theorie
log υ
30
25
20
15
10
5
0
9,15
9,20
9,25
9,30

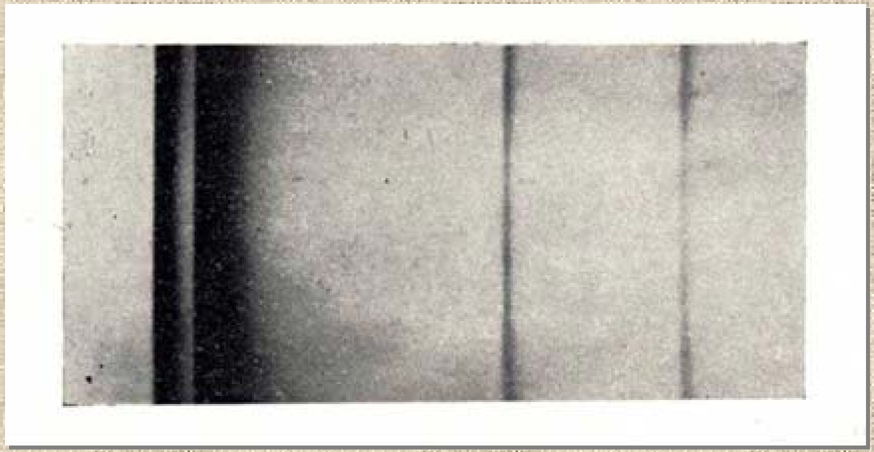
Franco Rasetti (1901-2001) in California in 1928



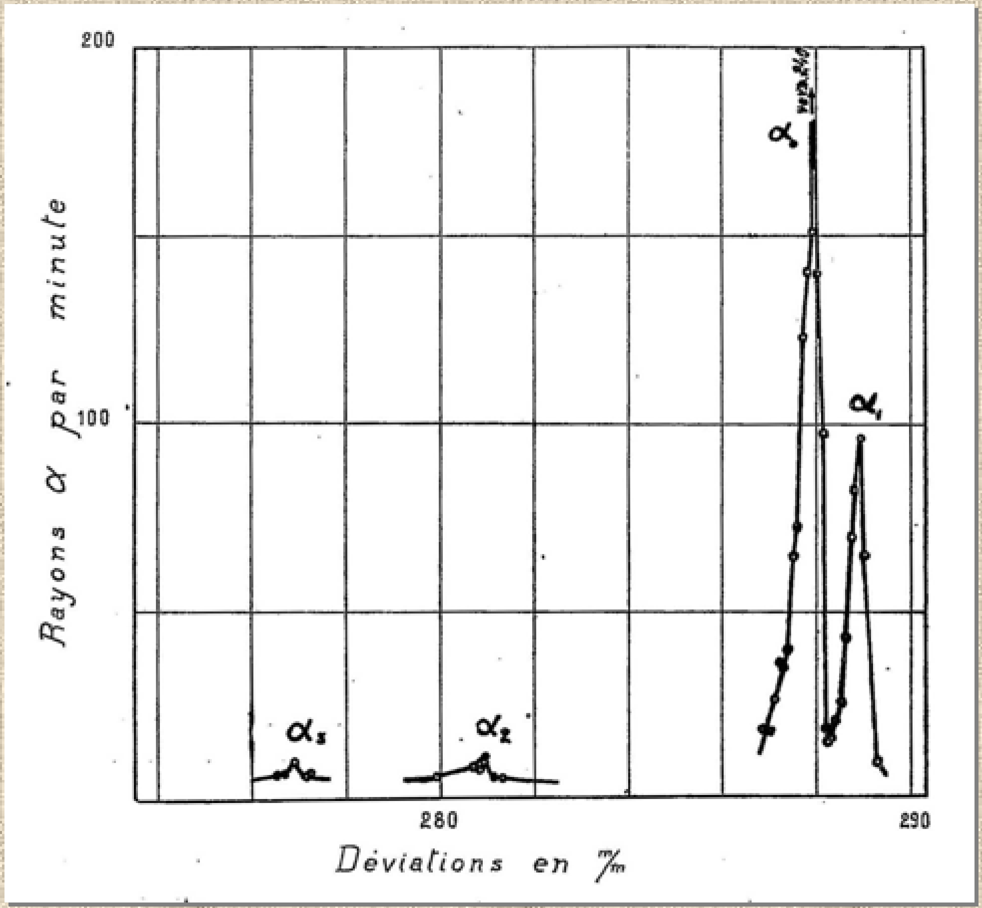
F. Rasetti, "Über die Rotations-Ramanspektren von Stickstoff und Sauerstoff", *Zeitschrift für Physik* **61**, 598-601, 1930.



Salomon Rosenblum (1896-1959)

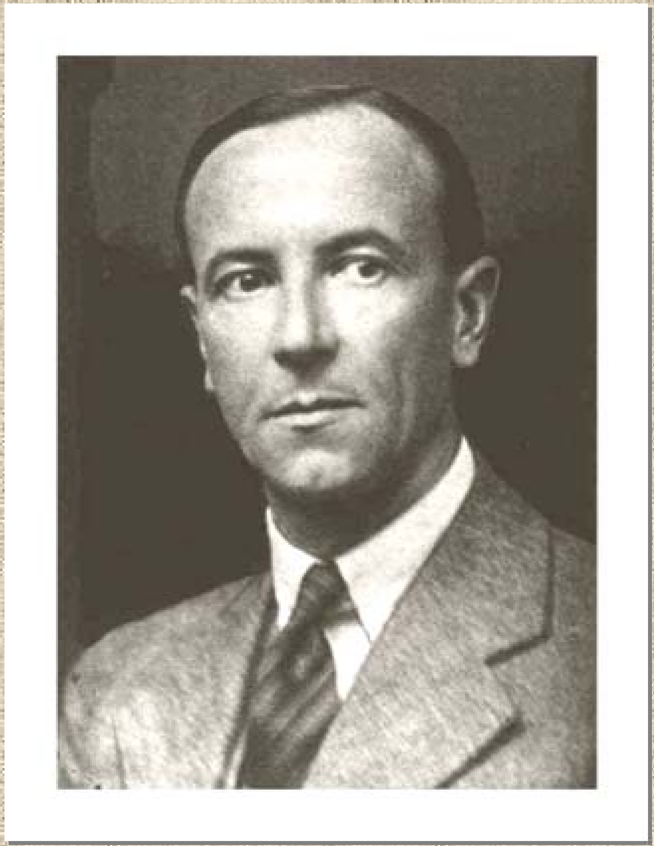


The α-spectrum of ThC (^{212}Bi) as observed by Rosenblum



Fine structure of Thorium C

S. Rosenblum and P. Chevallier, "Mesure directe des intensités de la structure fine des rayons α", *Comptes rendus de l'Académie des Sciences* **196**, 1484-1486,1933.



Letters to the Editor

[The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, nor to correspond with the writers of, rejected manuscripts intended for this or any other part of NATURE. *No notice is taken of anonymous communications.]*

Possible Existence of a Neutron

IT has been shown by Bothe and others that beryllium when bombarded by α-particles of polonium emits a radiation of great penetrating power, which has an absorption coefficient in lead of about 0·3 (cm.)$^{-1}$. Recently Mme. Curie-Joliot and M. Joliot found, when measuring the ionisation produced by this beryllium radiation in a vessel with a thin window, that the ionisation increased when matter containing hydrogen was placed in front of the window. The effect appeared to be due to the ejection of protons with velocities up to a maximum of nearly 3×10^9 cm. per sec. They suggested that the transference of energy to the proton was by a process similar to the Compton effect, and estimated that the beryllium radiation had a quantum energy of 50×10^6 electron volts.

I have made some experiments using the valve counter to examine the properties of this radiation excited in beryllium. The valve counter consists of a small ionisation chamber connected to an amplifier, and the sudden production of ions by the entry of a particle, such as a proton or α-particle, is recorded by the deflexion of an oscillograph. These experiments have shown that the radiation ejects particles from hydrogen, helium, lithium, beryllium, carbon, air, and argon. The particles ejected from hydrogen behave, as regards range and ionising power, like protons with speeds up to about $3·2 \times 10^9$ cm. per sec. The particles from the other elements have a large ionising power, and appear to be in each case recoil atoms of the elements.

If we ascribe the ejection of the proton to a Compton recoil from a quantum of 52×10^6 electron volts, then the nitrogen recoil atom arising by a similar process should have an energy not greater than about 400,000 volts, should produce not more than about 10,000 ions, and have a range in air at N.T.P. of about 1·3 mm. Actually, some of the recoil atoms in nitrogen produce at least 30,000 ions. In collaboration with Dr. Feather, I have observed the recoil atoms in an expansion chamber, and their range, estimated visually, was sometimes as much as 3 mm. at N.T.P.

These results, and others I have obtained in the course of the work, are very difficult to explain on the assumption that the radiation from beryllium is a quantum radiation, if energy and momentum are to be conserved in the collisions. The difficulties disappear, however, if it be assumed that the radiation consists of particles of mass 1 and charge 0, or neutrons. The capture of the α-particle by the Be^9 nucleus may be supposed to result in the formation of a C^{12} nucleus and the emission of the neutron. From the energy relations of this process the velocity of the neutron emitted in the forward direction may well be about 3×10^9 cm. per sec. The collisions of this neutron with the atoms through which it passes give rise to the recoil atoms, and the observed energies of the recoil atoms are in fair agreement with this view. Moreover, I have observed that the protons ejected from hydrogen by the radiation emitted in the opposite direction to that of the exciting α-particle appear to have a much smaller range than those ejected by the forward radiation. This again receives a simple explanation on the neutron hypothesis.

If it be supposed that the radiation consists of quanta, then the capture of the α-particle by the Be^9 nucleus will form a C^{13} nucleus. The mass defect of C^{13} is known with sufficient accuracy to show that the energy of the quantum emitted in this process cannot be greater than about 14×10^6 volts. It is difficult to make such a quantum responsible for the effects observed.

It is to be expected that many of the effects of a neutron in passing through matter should resemble those of a quantum of high energy, and it is not easy to reach the final decision between the two hypotheses. Up to the present, all the evidence is in favour of the neutron, while the quantum hypothesis can only be upheld if the conservation of energy and momentum be relinquished at some point.

J. CHADWICK.

Cavendish Laboratory,
Cambridge, Feb. 17.

The Oldoway Human Skeleton

A LETTER appeared in NATURE of Oct. 24, 1931, signed by Messrs. Leakey, Hopwood, and Reck, in which, among other conclusions, it is stated that "there is no possible doubt that the human skeleton came from Bed No. 2 and not from Bed No. 4". This must be taken to mean that the skeleton is to be considered as a natural deposit in Bed No. 2, which is overlaid by the later beds Nos. 3 and 4, and that all consideration of human interment is ruled out.

If this be true, it is a most unusual occurrence. The skeleton, which is of modern type, with filed teeth, was found completely articulated down even to the phalanges, and in a position of extraordinary contraction. Complete mammalian skeletons of any age are, as field palæontologists know, of great rarity. When they occur, their perfection can usually be explained as the result of sudden death and immediate covering by volcanic dust. Many of the more or less perfect skeletons which may be seen in museums have been rearticulated from bones found somewhat scattered as the result of death from floods, or in the neighbourhood of drying water-holes. We know of no case of a perfect articulated skeleton being found in company with such broken and scattered remains as appear to be abundant at Oldoway. Either the skeletons are all complete, as in the *Stenomylus* quarry at Sioux City, Nebraska, or are all scattered and broken in various degrees, as in ordinary bone beds. The probability, therefore, that the Oldoway skeleton represents an artificial burial is thus one that will occur to palæontologists.

The skeleton was exhumed in 1913, and published photographs show that the excavation made for its disinterment was extensive. It is, therefore, very difficult to believe that in 1931 there can be reliable evidence left at the site as to the conditions under which it was deposited. If naturally deposited in Bed No. 2, the skeleton is of the highest possible importance, because it would be of pre-Mousterian age, and would be in the company of *Pithecanthropus* and the Piltdown, Heidelberg, and Peking men, all of whose remains are fragmentary to the last degree. Of the few other human remains for which such antiquity is claimed, the Galley Hill skeleton and the Ipswich skeleton are, or apparently were, complete. The first of these was never seen *in situ* by any trained observer, and the latter has, we believe, been withdrawn by its discoverer. The other fragments, found long ago, are entirely without satisfactory evidence as to their mode of occurrence.

recoil atoms in an expansion chamber, and their range, estimated visually, was sometimes as much as 3 mm. at N.T.P.

These results, and others I have obtained in the course of the work, are very difficult to explain on the assumption that the radiation from beryllium is a quantum radiation, if energy and momentum are to be conserved in the collisions. **The difficulties disappear, however, if it be assumed that the radiation consists of particles of mass 1 and charge 0, or neutrons.** The capture of the α-particle by the Be^9 nucleus may be supposed to result in the formation of a C^{12} nucleus and the emission of the neutron. From the energy relations of this process the velocity of the neutron emitted in the forward direction may well be about 3×10^9 cm. per sec. The collisions of this neutron with the atoms through which it passes give rise to the recoil atoms, and the observed energies of the recoil atoms are in fair agreement with this view. Moreover, I have observed that the protons ejected from hydrogen by the radiation emitted in the opposite direction to that of the exciting α-particle appear to have a much smaller range than those ejected by the forward radiation.

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Werner Heisenberg (1901-1976) in 1927

W. Heisenberg, "Über den Bau Der Atomkerne. I."
Zeinschrift für Physik **77**, 1-11, 1932.

Über den Bau der Atomkerne. I.

Von **W. Heisenberg** in Leipzig.

Mit 1 Abbildung. (Eingegangen am 7. Juni 1932.)

Es werden die Konsequenzen der Annahme diskutiert, daß die Atomkerne aus Protonen und Neutronen ohne Mitwirkung von Elektronen aufgebaut seien. § 1. Die Hamiltonfunktion des Kerns. § 2. Das Verhältnis von Ladung und Masse und die besondere Stabilität des He-Kerns. § 3 bis 5. Stabilität der Kerne und radioaktive Zerfallsreihen. § 6. Diskussion der physikalischen Grundannahmen.

Durch die Versuche von Curie und Joliot[1]) und deren Interpretation durch Chadwick[2]) hat es sich herausgestellt, daß im Aufbau der Kerne ein neuer fundamentaler Baustein, das Neutron, eine wichtige Rolle spielt. Dieses Ergebnis legt die Annahme nahe, die Atomkerne seien aus Protonen und Neutronen ohne Mitwirkung von Elektronen aufgebaut[3]). Ist diese Annahme richtig, so bedeutet sie eine außerordentliche Vereinfachung für die Theorie der Atomkerne. Die fundamentalen Schwierigkeiten, denen man in der Theorie des β-Zerfalls und der Stickstoffkernstatistik begegnet, lassen sich nämlich dann reduzieren auf die Frage, in welcher Weise ein Neutron in Proton und Elektron zerfallen kann und welcher Statistik es genügt, während der eigentliche Aufbau der Kerne nach den Gesetzen der Quantenmechanik aus den Kraftwirkungen zwischen Protonen und Neutronen beschrieben werden kann.

§ 1. Für die folgenden Überlegungen wird angenommen, daß die Neutronen den Regeln der Fermistatistik folgen und den Spin $\frac{1}{2}\frac{h}{2\pi}$ besitzen. Diese Annahme wird notwendig sein, um die Statistik des Stickstoffkerns zu erklären, und entspricht den empirischen Ergebnissen über die Kernmomente. Wollte man das Neutron als zusammengesetzt aus Proton und Elektron auffassen, so müßte man daher dem Elektron Bosestatistik und Spin Null zuschreiben. Es erscheint aber nicht zweckmäßig, ein solches Bild näher auszuführen. Vielmehr soll das Neutron als selbständiger Fundamentalbestandteil betrachtet werden, von dem allerdings angenommen wird, daß er unter geeigneten Umständen in Proton und Elektron auf-

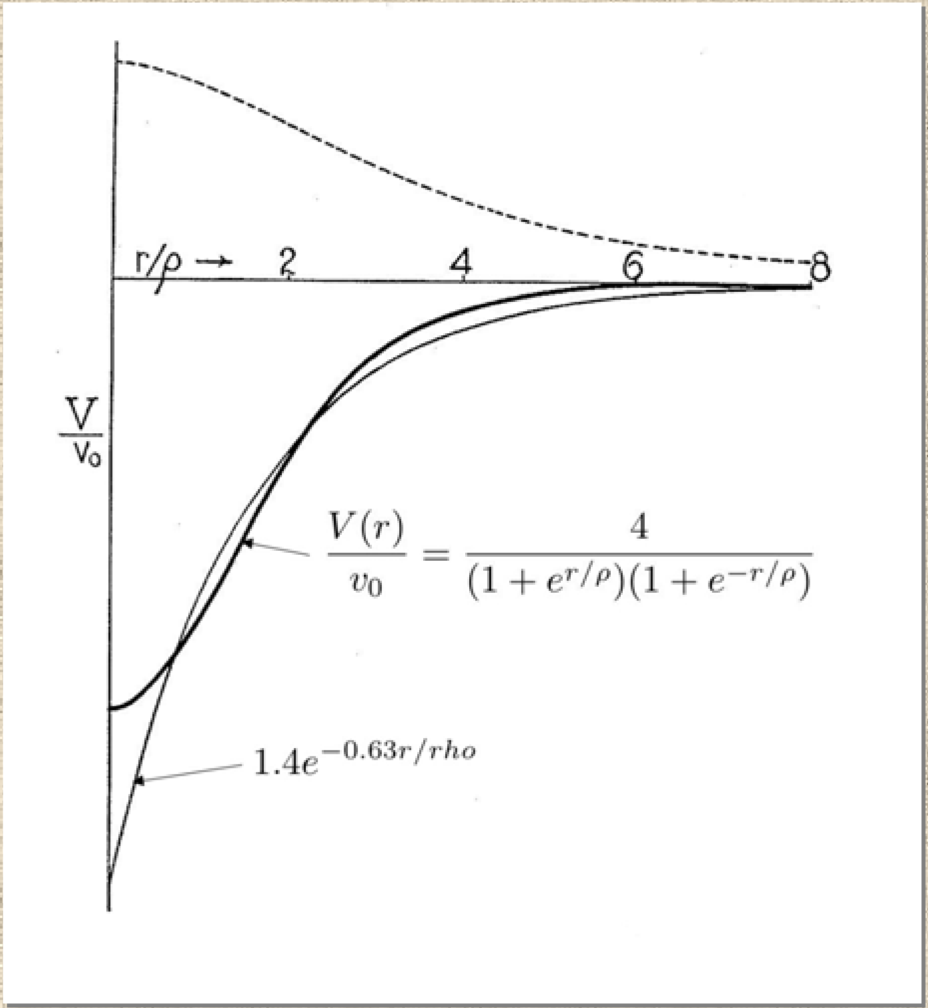
[1]) I. Curie u. F. Joliot, C. R. **194**, 273, 876, 1932.
[2]) J. Chadwick, Nature **129**, 312, 1932.
[3]) Vgl. auch D. Iwanenko, ebenda S. 798.

spalten kann, wobei vermutlich die Erhaltungssätze für Energie und Impuls nicht mehr anwendbar sind[1]).

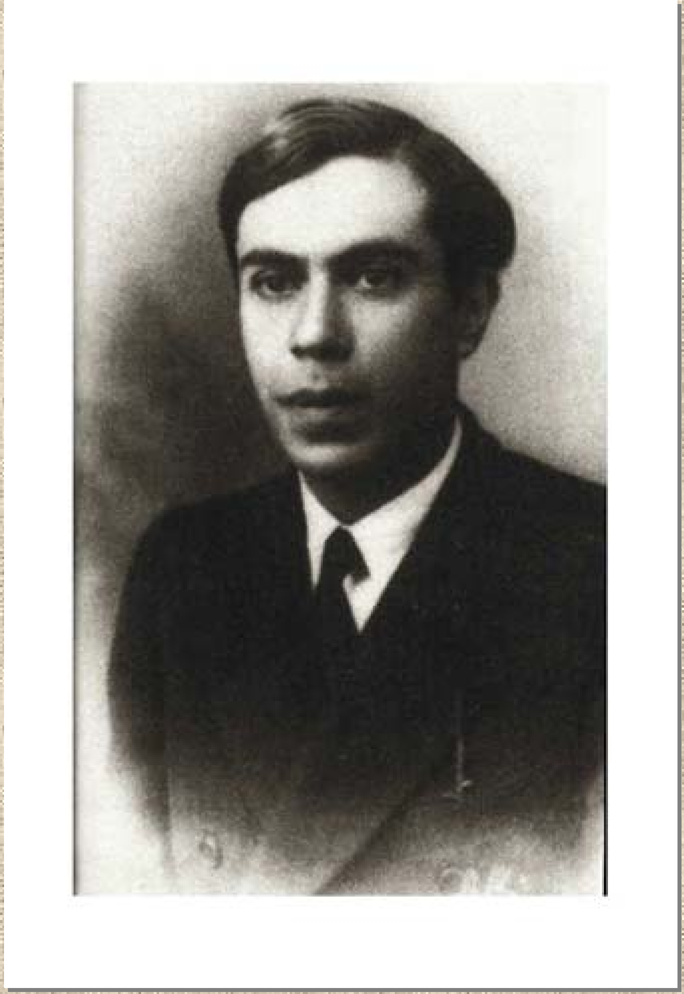
Von den Kraftwirkungen der elementaren Kernbausteine aufeinander betrachten wir zunächst die zwischen Neutron und Proton. Bringt man Neutron und Proton in einen mit Kerndimensionen vergleichbaren Abstand, so wird — in Analogie zum H_2^+-Ion — ein Platzwechsel der negativen Ladung eintreten, dessen Frequenz durch eine Funktion $\frac{1}{h} J(r)$ des Abstandes r der beiden Teilchen gegeben ist. Die Größe $J(r)$ entspricht dem Austausch- oder richtiger Platzwechselintegral der Molekültheorie. Diesen Platzwechsel kann man wieder durch das Bild der Elektronen, die keinen Spin haben und den Regeln der Bosestatistik folgen, anschaulich machen. Es ist aber wohl richtiger, das Platzwechselintegral $J(r)$ als eine fundamentale Eigenschaft des Paares Neutron und Proton anzusehen, ohne es auf Elektronenbewegungen reduzieren zu wollen.

Ähnlich wird die Wechselwirkung zweier Neutronen durch eine Wechselwirkungsenergie $-K(r)$ beschrieben werden, wobei man wegen der Analogie zum H_2-Molekül annehmen kann, daß diese Energie zu einer Anziehungskraft zwischen den Neutronen führt[2]). Endlich bezeichnen wir den Massendefekt des Neutrons relativ zum Proton (im Energiemaß) mit D. Es wird

Eugene P. Wigner (1902-1995) in 1950



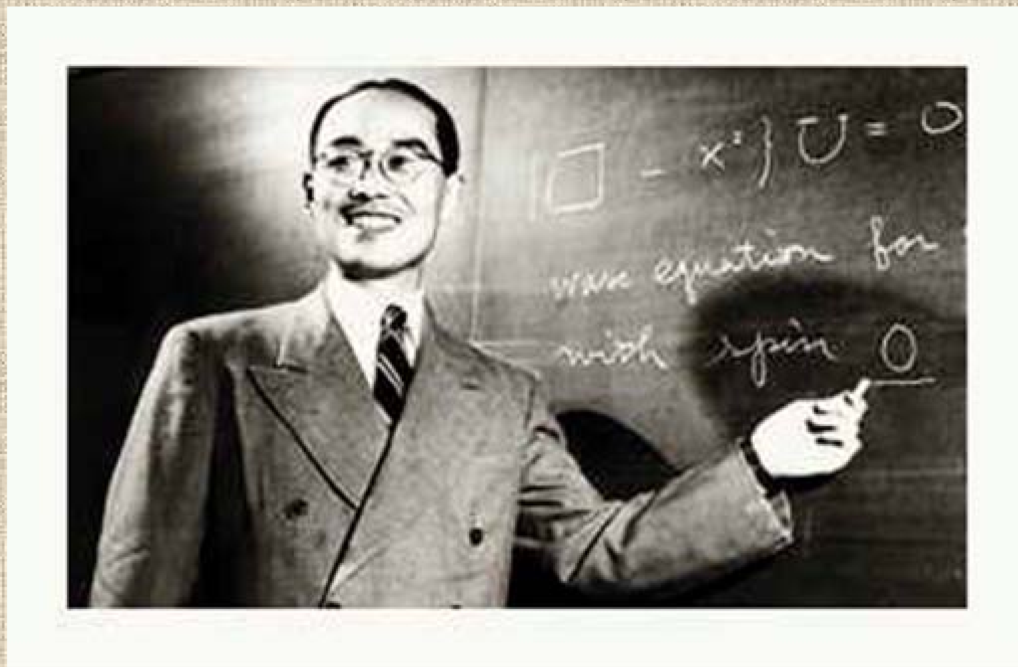
Eugene P. Wigner, "On the mass defect of Helium",
Physical Review **43**, 252-257, February 15, 1933.



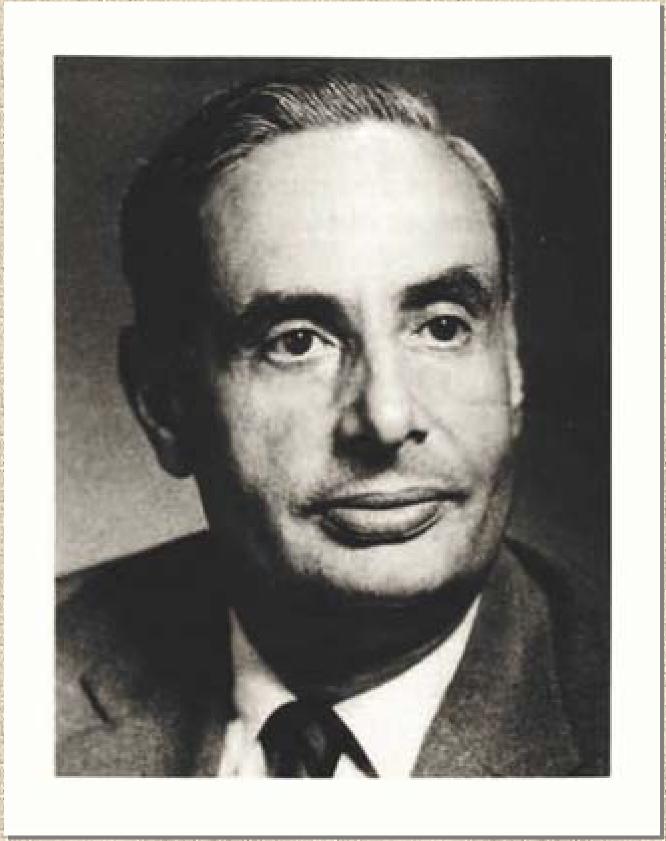
Ettore Majorana (1906-1938)

aufstellen. Infolge der schon hervorgehobenen, scheinbaren Ähnlichkeit zwischen der Kernstruktur und derjenigen der festen Körper oder der Flüssigkeiten könnte es plausibel scheinen, eine Wechselwirkung von demselben Typus wie für Atome und Moleküle, d. h. Anziehungskräfte bei großem Abstand und stark abstoßende Kräfte bei kleinem Abstand festzulegen, so daß die „Undurchdringlichkeit" der Teilchen gesichert ist (siehe Fig. 1). Außerdem müßte man aber noch Abstoßungskräfte zwischen Neutronen bei kleiner Entfernung annehmen, um die gewünschte Proportionalität zwischen Teilchenzahl und Kernvolumen zu erhalten. Eine solche Lösung des Problems ist aber vom ästhetischen Standpunkt aus unbefriedigend, denn man muß nicht nur Anziehungskräfte von unbekanntem Ursprung zwischen den Elementarteilchen annehmen sondern noch, bei kleinem Abstand, Abstoßungskräfte von ungeheurer Größenordnung, die von einem Potential von etwa einigen hundert Millionen Volt abhängen.

Fig. 1.
Potentielle Energie zwischen zwei Atomen.



Hideki Yukawa (1907-1981)



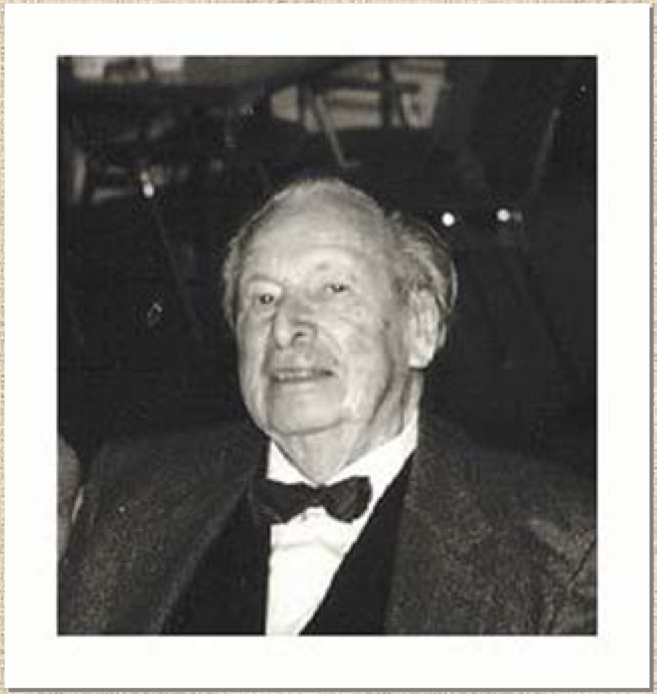
Walter M. Elsasser (1904-1991)

A discussion between Bohr, Heisenberg and Pauli in 1934.

Maria Goeppert-Mayer (1906-1972)

Maria Goeppert-Mayer (1906-1972)

J. Hans D. Jensen (1907-1973)



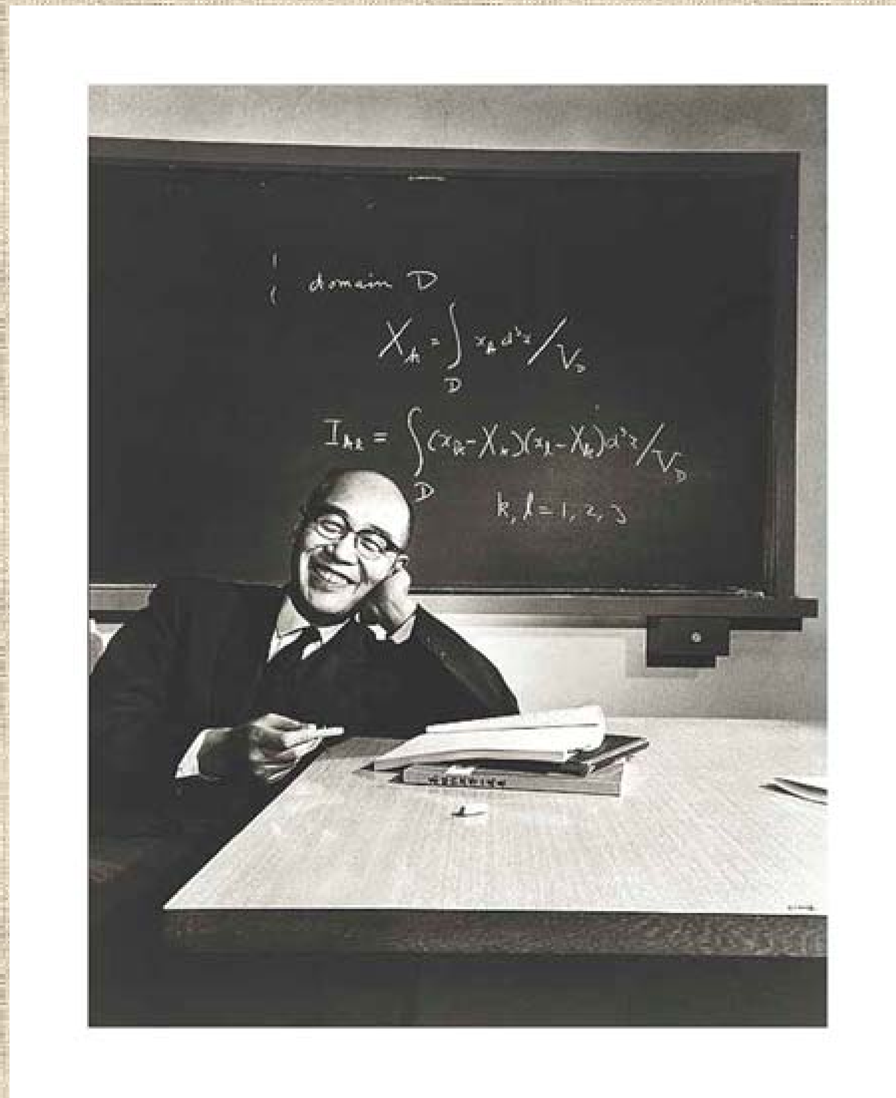
Otto Haxel (1909-1998)

Hans E. Suess (1909-1993)

‘Do you play the violin?’ He turned to the woodcarver.
‘Only gamma-ray tunes,’ answered the woodcarver. ‘It's a quantum violin, and It doesn't play anything else. Once I had a quantum-cello, for optical tunes, but somebody borrowed it and never brought it back.’
‘Well, play me a gamma-ray tune,’ asked Mr Tompkins. ‘Never heard it before.’
‘I will play you *“Nucléet in ThC Sharp”*, ’ said the woodcarver…

George Gamow, *Mr Tompkins explores the Atom,* Cambridge University Press, 1944

'This is our large cyclotron or "atom-smasher"'



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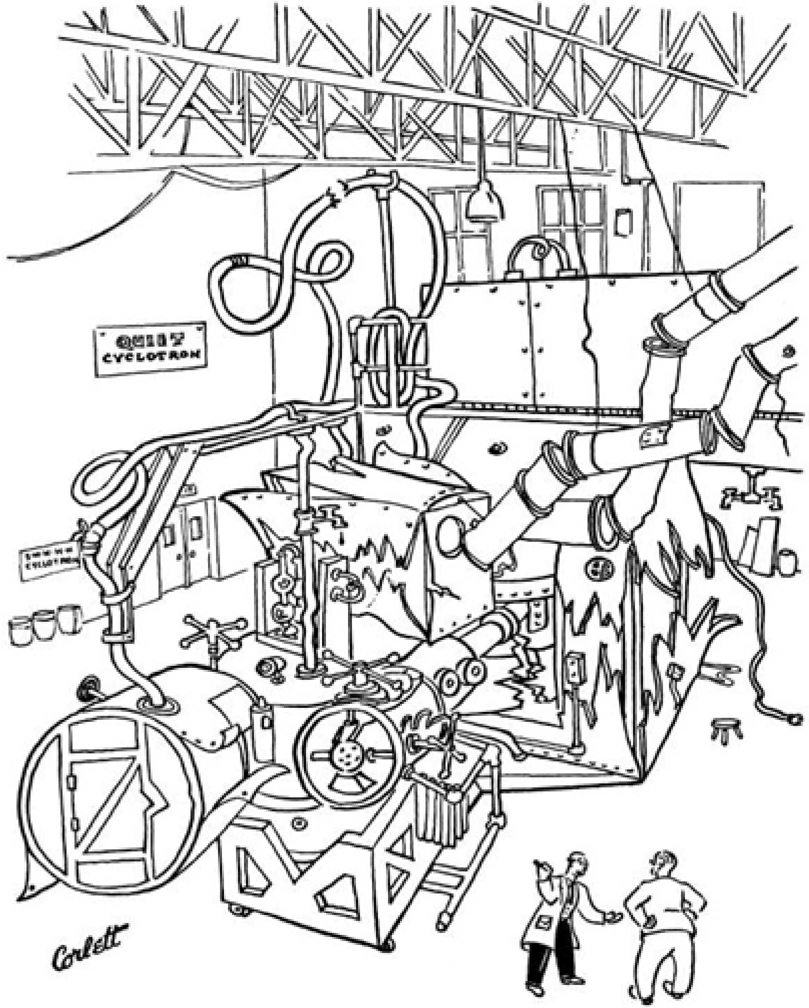
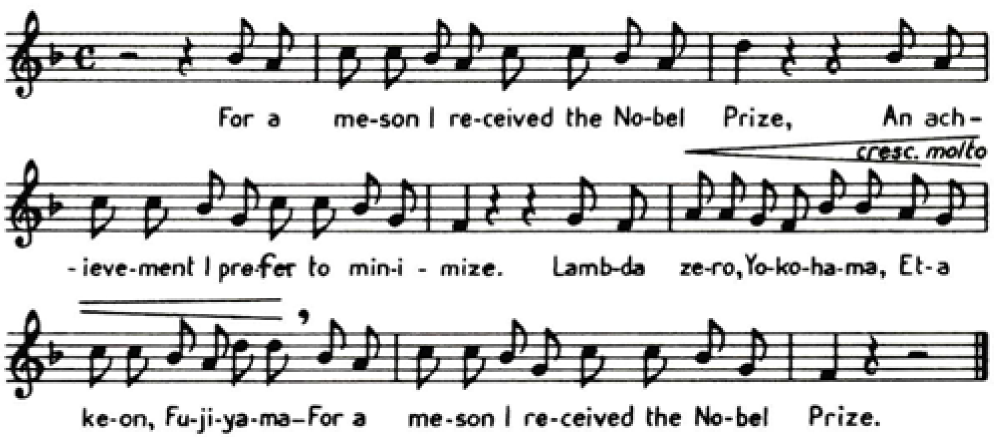


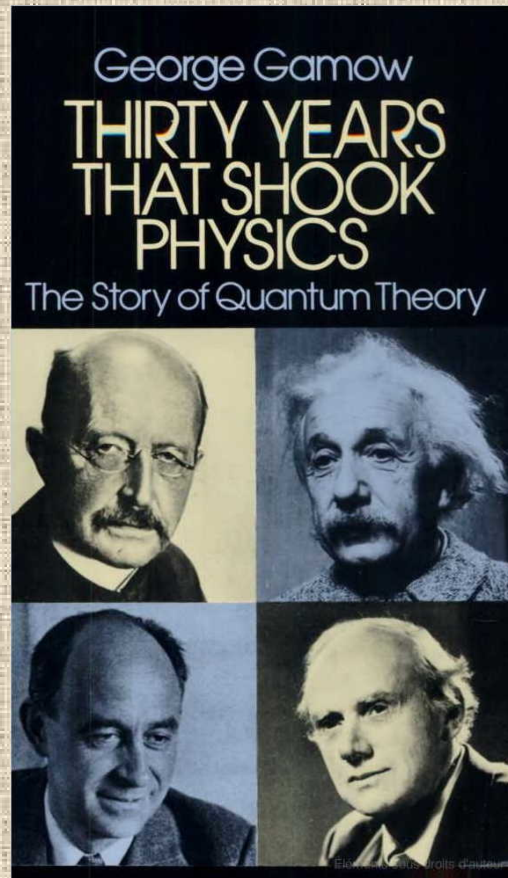
"Toughest damn atom I ever saw!"

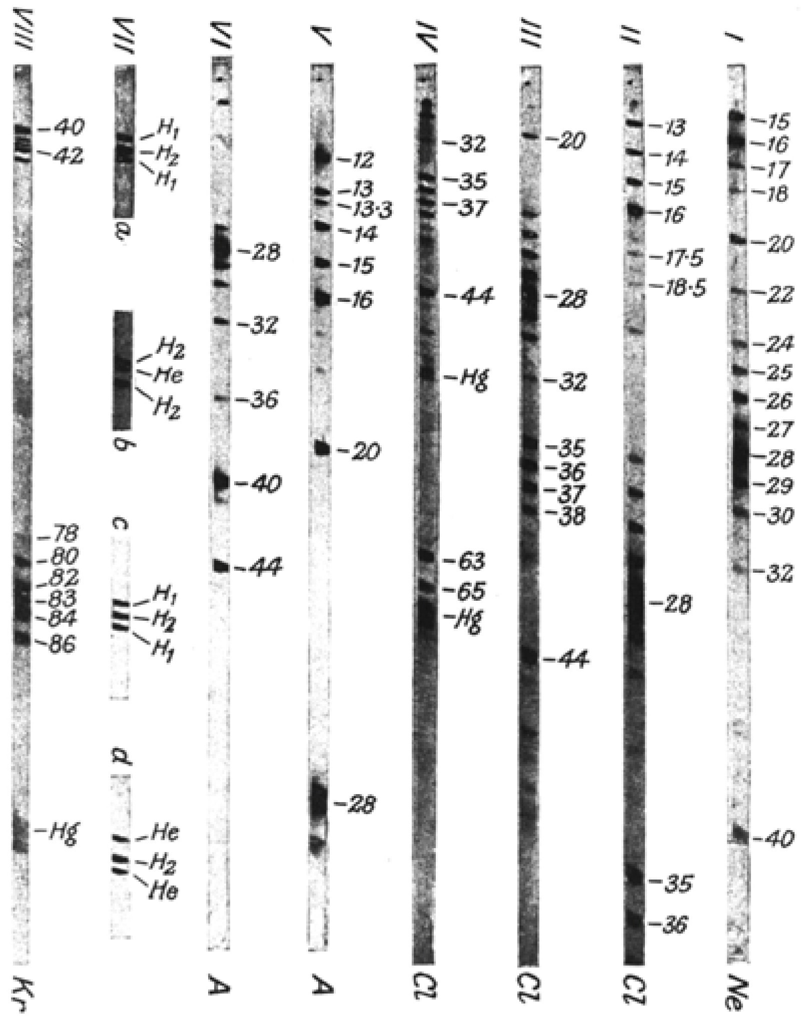
— *The California* PELICAN

For a meson I received the Nobel Prize,
An achievement I prefer to minimize.
Lambda zero, Yokohama,
Eta keon, Fujiyama—
For a meson I received the Nobel Prize.

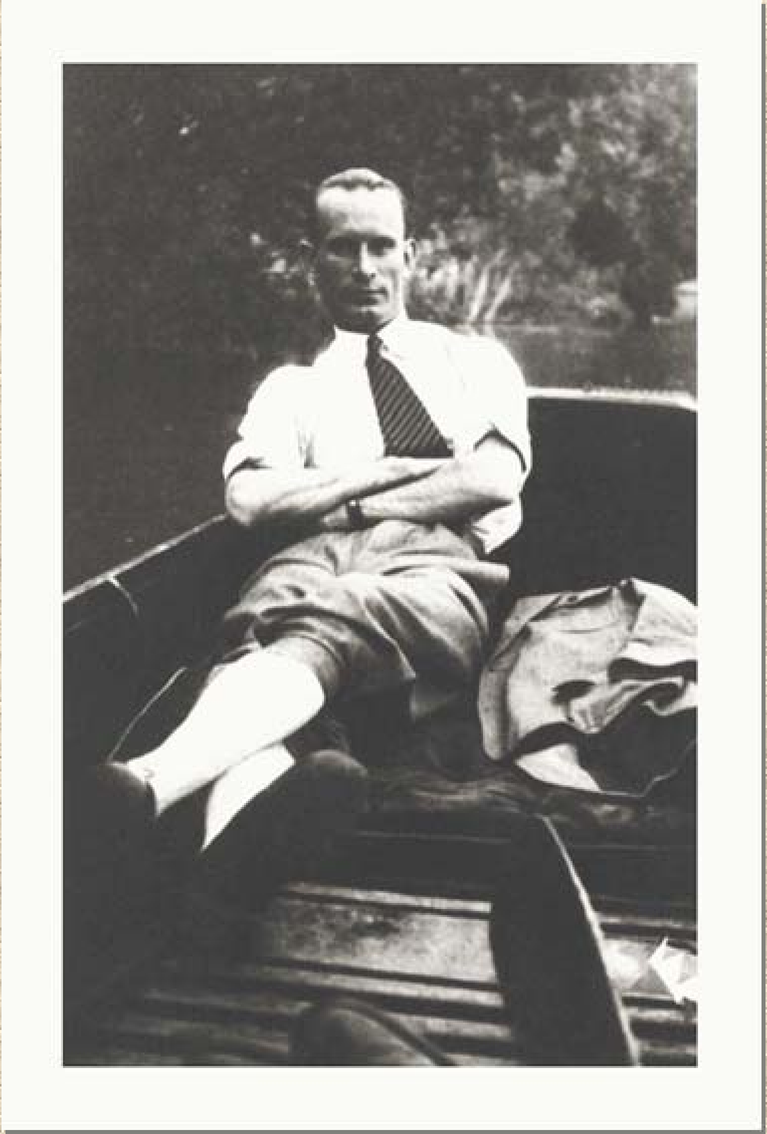
They proposed to call it *Yukon* in Japan.
I demurred, for I'm a very modest man.
Lambda zero, Yokohama,
Eta keon, Fujiyama—
They proposed to call it *Yukon* in Japan.




George Gamow
THIRTY YEARS THAT SHOOK PHYSICS
The Story of Quantum Theory



Typical Mass-Spectra obtained with the First Mass-Spectrograph, 1920.



Franco Rasetti (1901-2001) in Cambridge, England, in 1932.