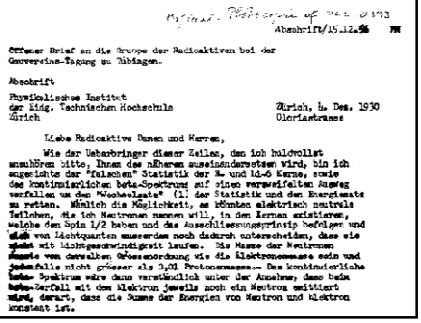
- magspektrum: β sugárzás → neutrino - Wolfgang Pauli (1900-1958), 1926-1931


Abschrift/15.12.56

Offener Brief an die Gruppe der Radioaktiven bei der Gauvereins-Tagung zu Tübingen.

Abschrift

Physikalisches Institut
der Eidg. Technischen Hochschule
Zürich

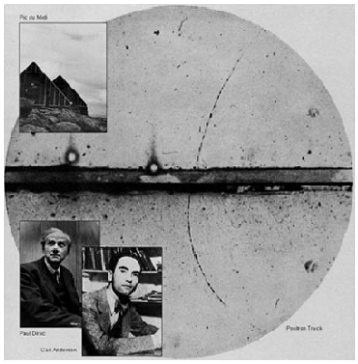
Zürich, 4. Dez. 1930
Gloriastrasse

Liebe Radioaktive Damen und Herren,

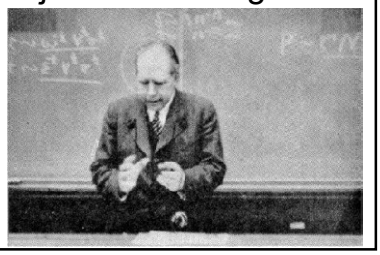
Wie der Ueberbringer dieser Zeilen, den ich huldvollst anzuhören bitte, Ihnen des näheren auseinandersetzen wird, bin ich angesichts der "falschen" Statistik der N- und Li-6 Kerne, sowie des kontinuierlichen beta-Spektrums auf einen verzweifelten Ausweg verfallen um das "Wechselsatz" (1. der Statistik und den Energiesatz zu retten. Nämlich die Möglichkeit, es könnten elektrisch neutrale Teilchen, die ich Neutronen nennen will, in den Kernen existieren, welche den Spin 1/2 haben und das Ausschliessungsprinzip befolgen und sich von Lichtquanten ausserdem noch dadurch unterscheiden, dass sie nicht mit Lichtgeschwindigkeit laufen. Die Masse der Neutronen müsste von derselben Grossenordnung wie die Elektronenmasse sein und jedenfalls nicht grösser als 0,01 Protonenmasse.- Das kontinuierliche beta- Spektrum wäre dann verständlich unter der Annahme, dass beim beta-Zerfall mit dem Elektron jeweils noch ein Neutron emittiert wird, derart, dass die Summe der Energien von Neutron und Elektron konstant ist.

- Bohr magfizikával foglalkozik (1930-)
- John Douglas Cockroft (1897-1967) és Ernest Walton (1903-1995) protonbomázással felhasítják a litium (majd a bór) magját (1932)
  p + Li-7 → $\alpha + \alpha$
- neutron - James Chadwik (1891-1974), 1932

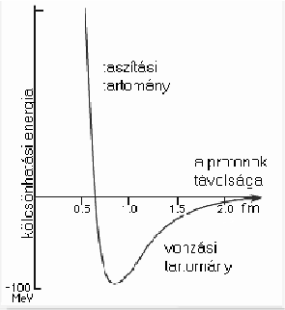
- kozmikus sugárzás, pozitron – P. A. M. Dirac (1902-1984), C. D. Anderson (1905-1991), 1932



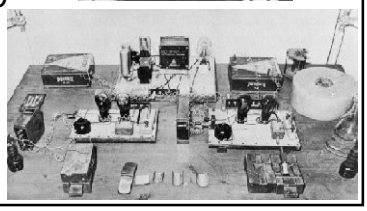
- Rutherford igazolja a tömeg-energia ekvivalenciát ($E = mc^2$) magátalakuláskor (1933)
- Bohr felvázolja az atommag folyadék-csepp modelljét (1936)



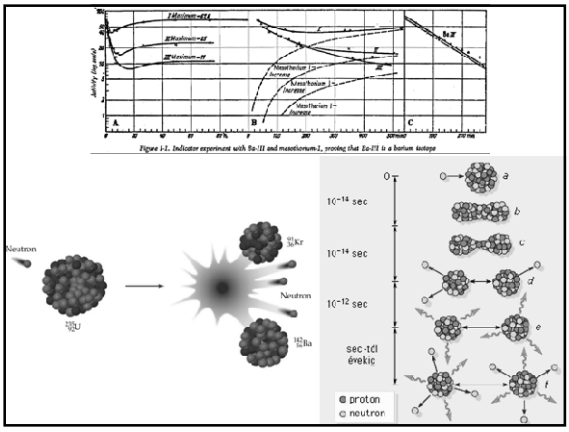
- Magerők, mezonok (1936-): H. Yukawa (1907-1981)



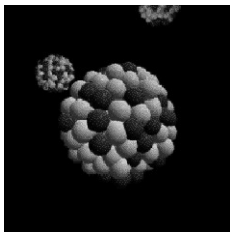
- Maghasadás (urán + neutron, 1938): O. Hahn (1879-1968), L. Meitner (1878-1968)



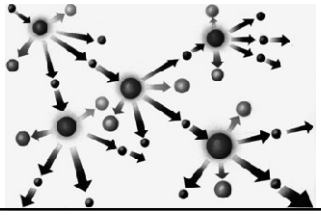
- kitérő
  - a nők szerepe a (mag)fizikában II.
    - Lise Meitner élete
    - 2. nőként doktorált fizikából Bécsben (tanára Boltzmann volt)
    - berlini fogadtatása Plancknál és az Intézetben
    - kísérleti és elméleti tevékenysége a maghasadás kapcsán



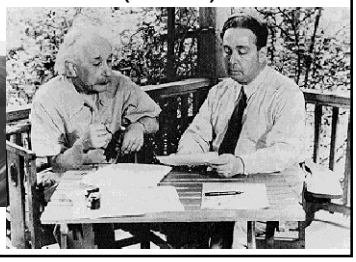
- Bohr és John A. Wheeler (1911-2008) a cseppmodelben értelmezik a maghasadást (1939)

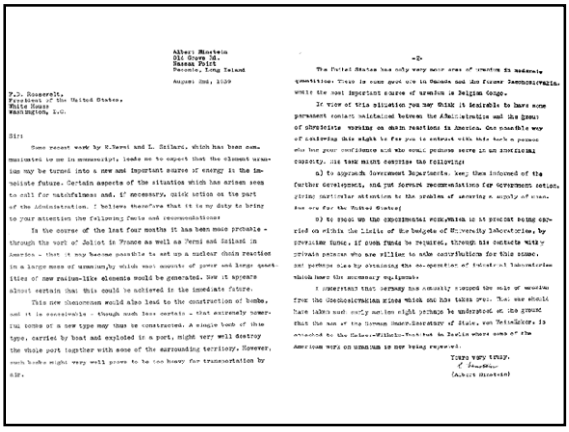


- Enrico Fermi (1901-1954), Frédérick Joliot-Curie (1900-1958), Szilárd Leó (1898-1964) és mások – a láncreakció (1933-1934-1936-1939)



- Albert Einstein (1879-1955), Szilárd, Teller Ede (1908-2003) és Wigner Jenő (1902-1995) – levél F. D. Roosevelthez (1939)





Albert Einstein
Old Grove Rd.
Nassau Point
Peconic, Long Island

August 2nd, 1939

F.D. Roosevelt,
President of the United States,
White House
Washington, D.C.

Sir:

Some recent work by E.Fermi and L. Szilard, which has been communicated to me in manuscript, leads me to expect that the element uranium may be turned into a new and important source of energy in the immediate future. Certain aspects of the situation which has arisen seem to call for watchfulness and, if necessary, quick action on the part of the Administration. I believe therefore that it is my duty to bring to your attention the following facts and recommendations.

In the course of the last four months it has been made probable - through the work of Joliot in France as well as Fermi and Szilard in America - that it may become possible to set up a nuclear chain reaction in a large mass of uranium, by which most amounts of power and large quantities of new radium-like elements would be generated. Now it appears almost certain that this could be achieved in the immediate future.

This new phenomenon would also lead to the construction of bombs, and it is conceivable - though much less certain - that extremely powerful bombs of a new type may thus be constructed. A single bomb of this type, carried by boat and exploded in a port, might very well destroy the whole port together with some of the surrounding territory. However, such bombs might very well prove to be too heavy for transportation by air.

-2-

The United States has only very minor ores of uranium. A moderate quantities. There is some good ore in Canada and the former Czechoslovakia, while the most important source of uranium is Belgian Congo.

In view of this situation you may think it desirable to have some permanent contact maintained between the Administration and the group of physicists working on chain reactions in America. One possible way of achieving this might be for you to entrust with this task a person who has your confidence and who could perhaps serve in an unofficial capacity. His task might consist the following:

a) To approach Government Departments, keep them informed of the further development, and put forward recommendations for Government action, giving particular attention to the problem of securing a supply of uranium ore for the United States.

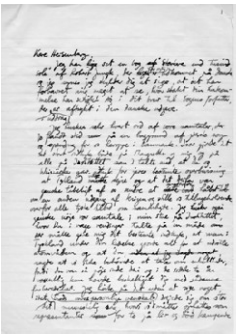
b) To speed up the experimental work which is at present being carried on within the limits of the budgets of University laboratories, by providing funds, if such funds be required, through his contacts with private persons who are willing to make contributions for this cause, and perhaps also by obtaining the co-operation of industrial laboratories which have the necessary equipment.

I understand that Germany has actually stopped the sale of uranium from the Czechoslovakian mines which she has taken over. That she should have taken such early action might perhaps be understood on the ground that the son of the German Under-Secretary of State, von Weizsäcker, is attached to the Kaiser-Wilhelm-Institut in Berlin where some of the American work on uranium is now being repeated.

Yours very truly,

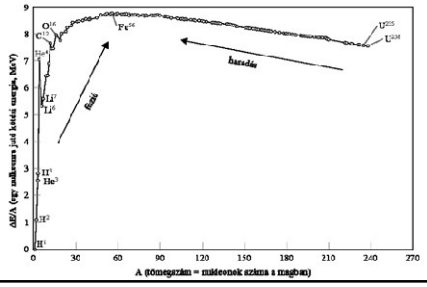
(Albert Einstein)

- Louis A. Turner (1898-1977) és Glenn T. Seaborg (1912-1999) a plutóniumról (1940-41)
- Bohr és Heisenberg találkozója a megszállt Koppenhágában (1941) [Michael Frayn: Copenhagen]



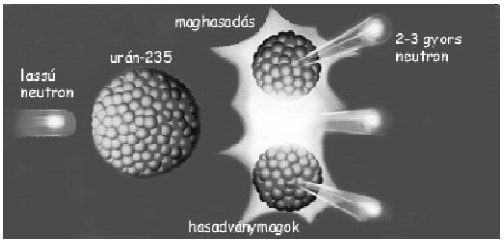
A Manhattan-terv

- energia-előállítás atommagok átalakításával



- az energiatermelés mértéke
  - hasadás: 1 db urán-235⇨200 MeV=3,2x10^{-11} Joule
    - Mo. éves energiaszükséglete: kb. 20 t urán-235 = 50 Mt szén
    - 1 kg urán-235⇨176 US polgár 1 évi energiaszükséglete
  - fúzió
    - 1 kg deutérium-trícium⇨676 US polgár 1 évi energiaszükséglete

- a maghasadás problémái
  - a láncreakció megvalósításának nehézségei

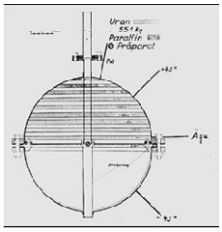


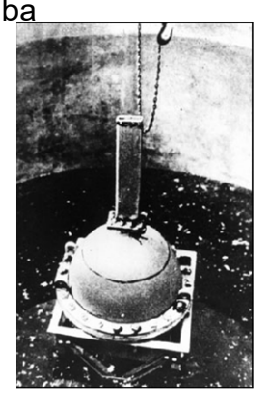
  - izotóparány
    - természetes urán-235: 0,7%; urán-238: 99,3%

- dúsítás
  - 0,86%-os tömegkülönbség⇨kaszkád-módszer
- neutronlassítás (moderálás)
  - H-1, hidrogén – víz
  - H-2, deutérium – nehézvíz
  - Be-9, berillium
  - C-12, grafit
  - paraffin viasz (20-40 n-es C_nH_{2n+2})

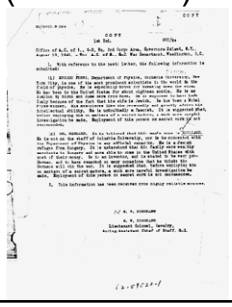
- a kritikus tömeg
- a folyamat vizsgálata
  - szabályozott láncreakció
    - reaktorépítés
      - » neutronelnyelők: kadmium, bór

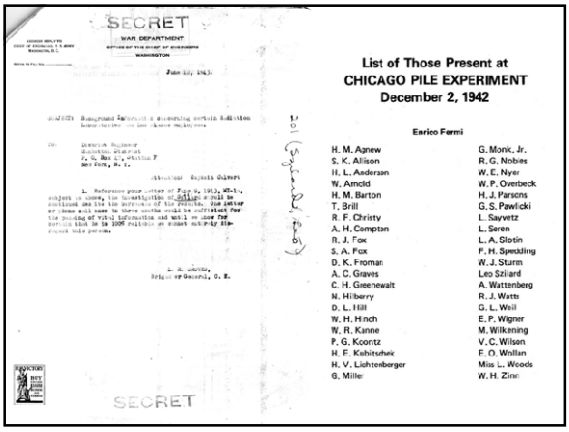
- A német atombomba
  - kritikus tömeg
  - grafit moderátor
  - idő és pénz





- Fermi (Szilárddal és Wignerrel) megépíti az első atomreaktort (1940-1942)





- Szilárd „máglya” ötlete
  - grafittéglákban (315 t) urániumgömbök (6 t)
- szabályzórendszer
  - kadmiumrudas automatika
  - kadmiumrudas vészleállító (Safety Control Reserve Axed Man)
  - bóros vizesvödrök