Fission

Fission

Chart of Nuclides

Click on a nucleus for information

Color code	Half-life	Decay Mode	$Q_{\beta-}$	Q_{EC}	$Q_{\beta+}$	S_n	S_p	Q_α	S_{2n}	S_{2p}	$Q_{2\beta-}$	Q_{2EC}	Q_{ECp}
$Q_{\beta-n}$	BE/A	(BE-LDM Fit)/A	$E_{1st\ ex.\ st.}$	E_{2+}	E_{3-}	E_{4+}	E_{4+}/E_{2+}	β_2	$B(E2)_{42}/B(E2)_{20}$	$\sigma(n,\gamma)$	$\sigma(n,F)$	235U FY	239Pu FY

Z, number of protons

Z=82

N=126

Z=50

N=82

Z=28

N=50

Z=20

N=28

Z=8

N=20

N=8

N, number of neutrons
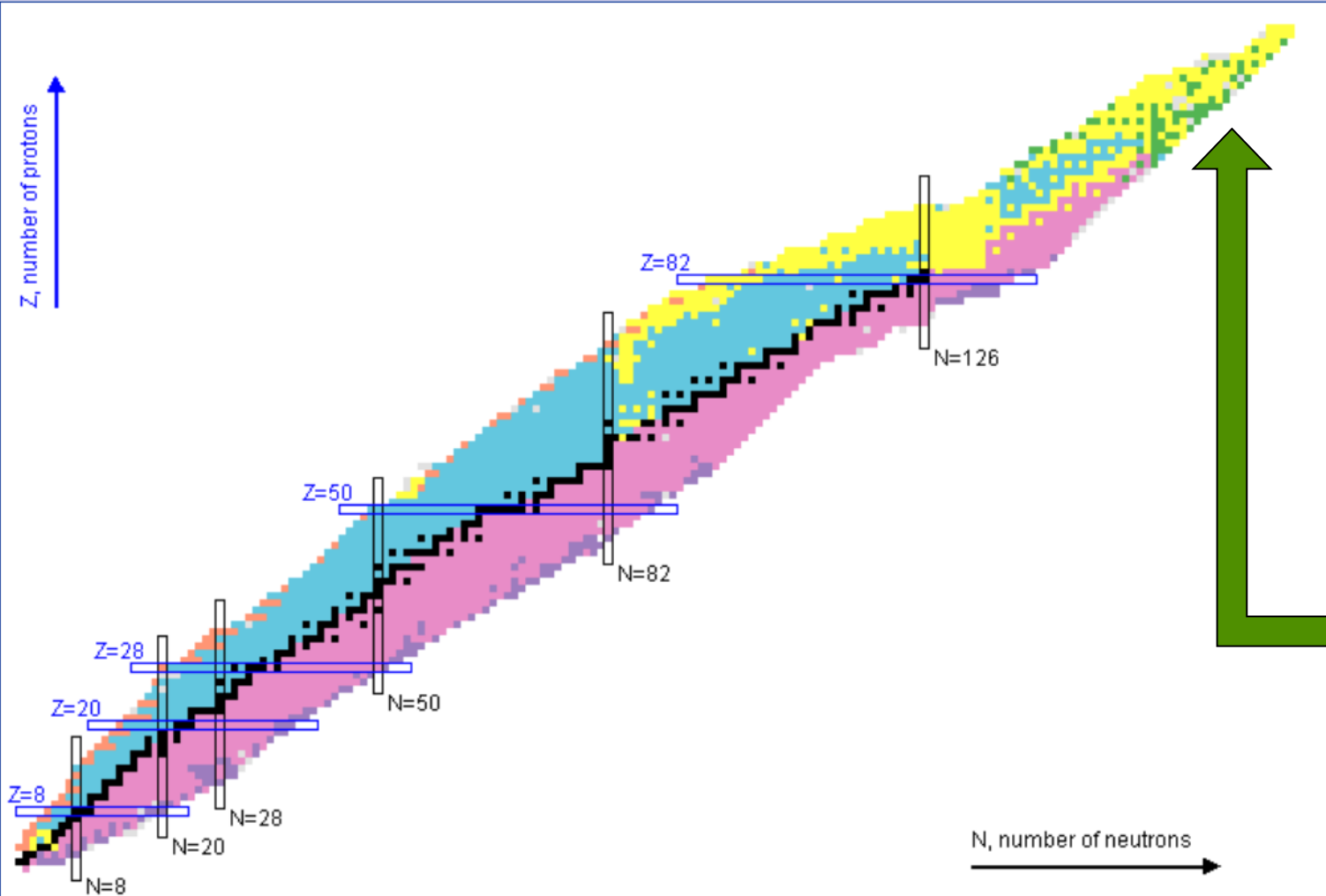
Tooltips
On
Off

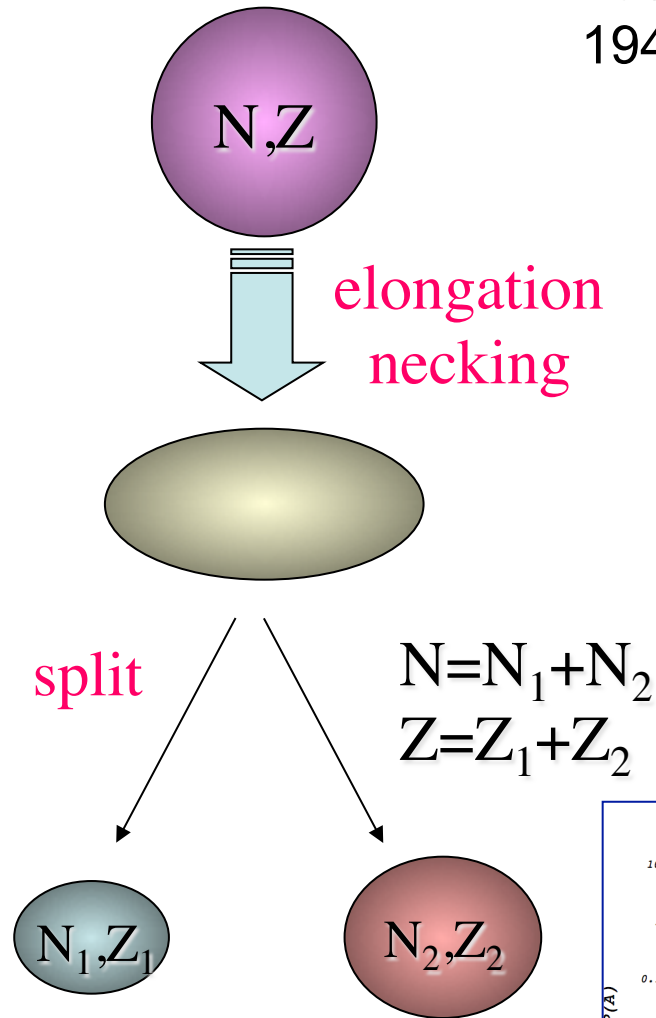| Zoom	Uncertainty
1	NDS
2	Standard
3	Screen
4	Size
5	
6	Narrow
7	Wide

Nucleus

go

- Stable
- EC+β+
- β-
- α
- P
- N
- SF
- Unknown

Search options:

Levels and Gammas
Nuclear Wallet Cards
Decay Radiation

Help - Glossary

1938 Hahn & Strassmann
1939 Meitner & Frisch
1939 Bohr & Wheeler
1940 Petrzhak & Flerov

N,Z

elongation
necking

split

$N = N_1 + N_2$
$Z = Z_1 + Z_2$

N_1, Z_1 N_2, Z_2

Fission yields (fragments)

The neutron strikes the nucleus and is absorbed.

The absorbed neutron causes the nucleus to undergo deformation.
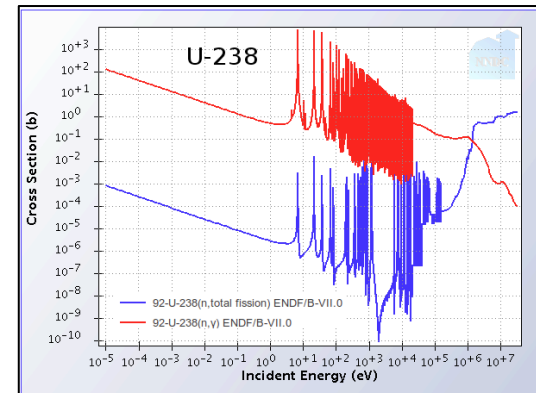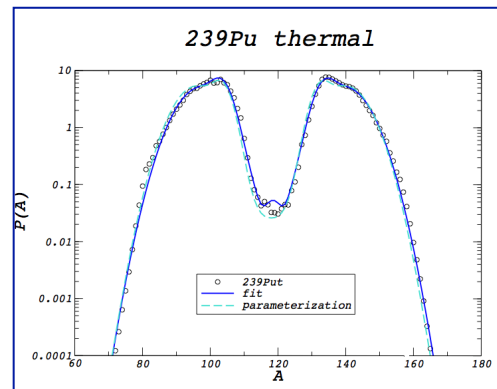
In about 10^{-14} second, one of the deformations is so drastic that the nucleus cannot recover.

The nucleus fissions, releasing two or more neutrons.

In about 10^{-12} second, the fission fragments lose their kinetic energy and come to rest, emitting a number of gamma rays. Now the fragments are called fission products.

The fission products lose their excess energy by radioactive decay, emitting beta particles and gamma rays over a lengthy time period (seconds to years).

neutrons   protons   beta particles   gamma rays

239Pu thermal

P(A)

239Put
fit
parameterization

A

U-238

Cross Section (b)

92-U-238(n,total fission) ENDF/B-VII.0
92-U-238(n,γ) ENDF/B-VII.0

Incident Energy (eV)

Understanding the fission process is crucial for many areas of science and technology:

- Fission governs the production and existence of many transuranium elements, including the predicted long-lived super-heavy species.
- Fission influences the formation of heavy elements in a neutron rich environment.
- Fission produces reactor antineutrinos
- Improved understanding of the fission process will enable scientists to enhance the safety and reliability of nuclear reactors.
- Fission is important for stockpile stewardship

The new phase in fission theory is expected to rely heavily on advanced modeling and simulation capabilities utilizing massively parallel leadership-class computers

1939: Bohr's paper on fission

Letters to the Editor

Disintegration of Heavy Nuclei

THROUGH the kindness of the authors I have been informed of the content of the letters[1] recently sent to the Editor of NATURE by Prof. Meitner and Dr. Frisch. In the first letter, these authors propose an interpretation of the remarkable findings of Hahn and Strassmann as indication for a new type of disintegration of heavy nuclei, consisting in a fission of the nucleus into two parts of approximately equal masses and charges with release of enormous energy. In the second letter, Dr. Frisch describes experiments in which these parts are directly detected by the ionization they produce. Due to the importance of this discovery, I should be glad to offer a few comments on the mechanism of the phenomenon from the point of view of the general ideas developed in recent years, to account for the properties of the nuclear reactions hitherto studied.

According to these ideas, any nuclear reaction initiated by collisions or radiation involves as an intermediate stage the formation of a compound system in which the excitation energy is distributed among the various degrees of freedom in a way resembling the thermal agitation of a solid or liquid body. The relative probabilities of the different possible courses of the reaction will thereafter depend on the facility with which this energy may be released as radiation or converted into kinetic energy so produce the disintegration of the nucleus. In the case of ordinary reactions, such a disintegration consists in the escape of a single particle of the nucleus, and resembles therefore the evaporation of a molecule from a liquid drop. If the type of disintegrations comparable to the division of such a drop into two droplets, it is evidently necessary, however, that the quasi-thermal distribution of energy be largely converted into some mode of vibration of the compound system involving a considerable deformation of the nucleus. In some cases, the course of the disintegration may even result from a fluctuation in the distribution of the energy between the various degrees of freedom of the system, the probable occurrence of which is essentially determined by the amount of energy to be concentrated on the particular type of motion considered and by the 'temperature' corresponding to the nuclear excitation. Since the effective cross-sections for the phenomena for neutrons for ordinary velocities are about the same order of magnitude as the cross-sections for ordinary nuclear reactions, we may conclude that for the heaviest nuclei the excitation energy sufficient for the fission is of

the same order of magnitude as the energy necessary for the escape of a single nuclear particle. For somewhat lighter nuclei, however, where only evaporation-like disintegrations have so far been observed, the former energy should be considerably larger than the binding energy of a particle.

These circumstances find their straightforward explanation in the fact, stressed by Meitner and Frisch, that the mutual repulsion between the electric charges in a nucleus will for highly charged nuclei counteract to a large extent the effect of the short-range forces between the nuclear particles in opposing a deformation of the nucleus. The nuclear problem concerned reminds us indeed in several ways of the question of the stability of a charged liquid drop, and in particular, any deformation of a nucleus, sufficiently large for its fission, may be treated approximately as a classical mechanical problem, since the corresponding amplitude must evidently be large compared with the quantum mechanical zero-point oscillations. Just this condition would in fact seem to provide an understanding of the remarkable stability of heavy nuclei in their normal state or in the states of low excitation, in spite of the large amount of energy which would be liberated by an imaginable division of such nuclei.
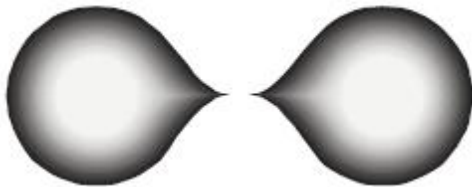
The continuation of the experiments on the new type of nuclear disintegrations, and above all the closer examination of the conditions for their occurrence, should certainly yield most valuable information as regards the mechanism of nuclear excitation.

N. BOHR.

At the Institute for Advanced Study,
Princeton, N.J. Jan. 20.

[1] [NATURE, 143, 239 and 275 (1939)].

Photoactivation of Solids and its Effect on Adsorption

CONSIDERABLE attention has been given recently to chemical processes involving an activating influence of a crystal excited by irradiation[1]. The mechanism of such photosensitized reactions, although unknown in detail, is generally believed to be a more or less complete transfer of the energy absorbed by the crystal to the reacting components, physically or chemically. Accordingly, the essential difference between photosensitized processes and real photochemical ones is the distance between the place of absorption and the place of reaction. But there must also be another, more general, effect of irradiation on the activity of crystals. Due to the change in the electronic state of the particles in the lattice by the absorption of light (change in charge and degree of polarization, formation of space charges, etc.), the forces between the particles are changed and, consequently, there is also a change in potential of the

Deformed liquid drop (Bohr & Wheeler, 1939)

fission of nuclear droplet

$$E_{LDM}(def) = E_S(0)\left[B_S(def) - 1 + 2x\left(B_C(def) - 1\right)\right]$$

$$B_S(def) = \frac{E_S(def)}{E_S(0)}, \quad B_C(def) = \frac{E_C(def)}{E_C(0)}$$

$$x = \frac{E_C(0)}{2E_S(0)} = \frac{Z^2/A}{\left(Z^2/A\right)_{crit}} \approx \frac{Z^2}{50A}$$

x: fissility parameter