Prof. Horstmann and nuclear Fusion & Fission, Enrichment Uranium and Nuclear Power Plant

Introduction to Fusion

The appeal of fusion ... Nuclear fusion as a means of energy generation is very appealing. The products of fusion are generally not radioactive and therefore fusion is a 'greener' process than fission. A fusion reaction of particular appeal to nuclear scientists is the reaction between the two heavier isotopes of hydrogen - deuterium (hydrogen-2) and tritium (hydrogen-3).

The potential fusion reaction between these Isotopes is represented as:

$$^{2}_{1}H + ^{3}_{1}H \rightarrow ^{4}_{2}He + ^{1}_{0}n$$

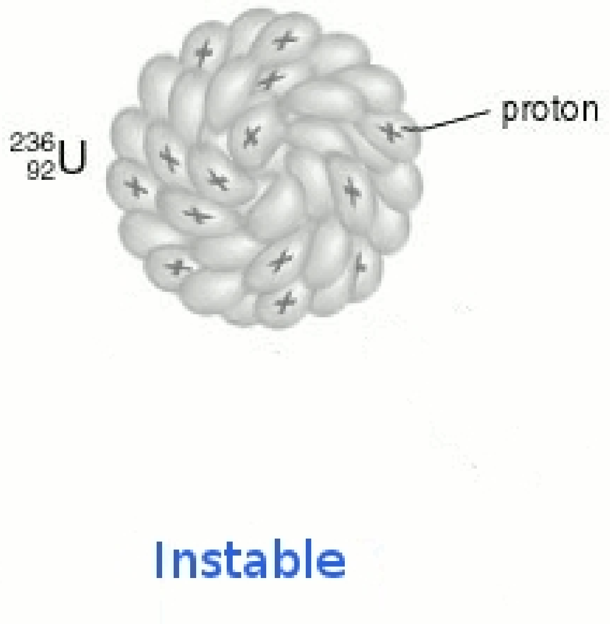
The current difficulty with fusion is the high temperature needed to overcome the electrostatic repulsion between nuclei. Not only is it very difficult to achieve these high temperatures, but finding materials to contain such high temperatures is also a challenge.

Intoduction to Fission

Chadwick's discovery of the neutron, opened new avenues of research into reactions. The fact that neutrons had no charge encouraged their use in bombarding the nuclei of atoms. The idea was that if the nucleus of an atom of a particular element could absorb an extra neutron, then a different isotope of that element should be produced.

Neutron bombardment of uranium was also considered to be a way of producing elements heavier than uranium - the trans-uranium elements.

Otto Hahn, Fritz Strassmann and Lise Meitner worked together on the neutron bombardment of uranium in Germany in the 1930s. Eventually Meitner, being Jewish, had to flee Germany and went to work with Bohr.
Hahn and Strassmann continued to work on the neutron bombardment of uranium (atomic number 92) and were stunned to discover barium (atomic number 56) as a product of this bombardment.
Within weeks, it was discovered that neutrons were also released during the fission of uranium and that these neutrons could cause the splitting of more uranium nuclei and lead to a chain reaction.
The first step in the fission of uranium-235 involves the formation of unstable U-236 nuclei by bombardment with neutrons.
Each unstable U-236 nucleus breaks down into a Kr-97 nucleus and a Ba-137 nucleus accompanied by the release of three neutrons.



Animation by Prof. Horstmann. Simple animation of nuclear fission. In the first frame, a neutron is about to be captured by the nucleus of a U-235 atom. In the second frame, the neutron has been absorbed and briefly turned the nucleus into a highly excited U-236 atom. In the third frame, the U-236 atom fission, resulting in two fission fragments (Ba-56 and Kr-36) and three neutrons, all with large amounts of kinetic energy. Skip this part, if to technical, continue reading below. Nice animations etc.

1. Uranium - 92-U-235
Spin and half-life

Level energy(keV) Spin & Parity Half-life -- ground state 7/2- 703.8E+6Y 5 7.50000E-02 1/2+ 25M

Mass (taken from Audi et al. (April 2011))

235.043931368 ± 0.000001962 (amu) [mass excess = 40921.807 ± 1.828 (keV)]

Beta-decay energy (calculated as M(A,Z)-M(A,Z+1), taken from Audi et al. (April 2011))

-124.033 ± 0.855 (keV)

Strong Gamma-rays from Decay of U-235 (Compiled from ENSDF as of March 2011)
[Iintensities before May 23th of 2013 were values when total intensity of the decay mode was 100(%) and a branching ratio of each decay mode was not multiplied.]

γ-ray energy(keV) Intensity(%) Decay mode / Half-life
--- 143.76 10.96 Alpha 703.8E+6 Y 163.33 5.08 Alpha 703.8E+6 Y 185.72 57.2 Alpha 703.8E+6 Y --- *: relative, ~ approximate, ? calculated or estimatted >: greater than or equal to, : greater than or equal to, : greater than or equal to,