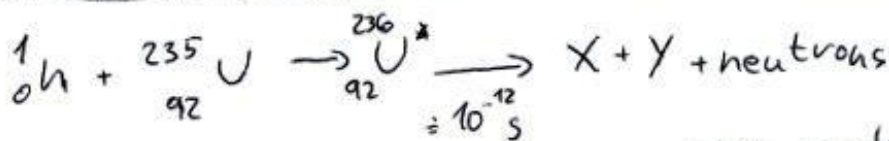
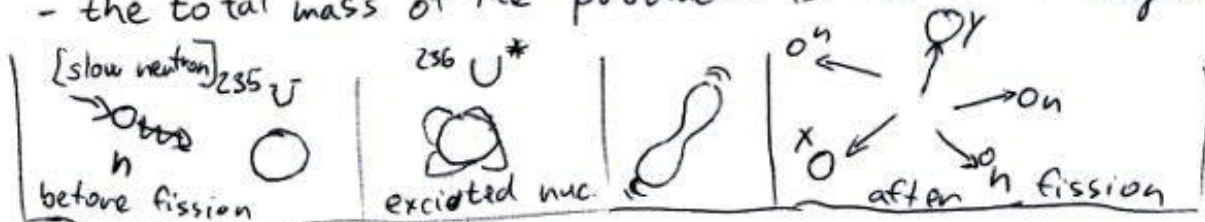


(9) Nuclear Energy

2 types of nuc. reactions to derive an energy: \leftarrow fission $0 \rightarrow 20$ [štěpení]
 \leftarrow fusion $2 \rightarrow 1$ [syntéza]

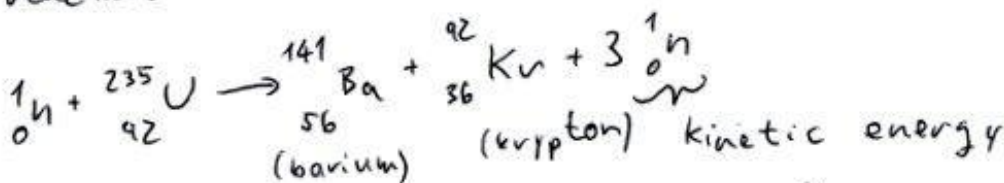
A1 Nuclear Fission I

- heavy nucleus splits into two smaller nuclei
- the total mass of the products is less than original mass of the heavy nucleus



X, Y... 90 different daughter nuclei can be formed

typical reaction:



mass of ($1n + \text{U}$) > mass of ($\text{Ba} + \text{Kr} + 3n$)

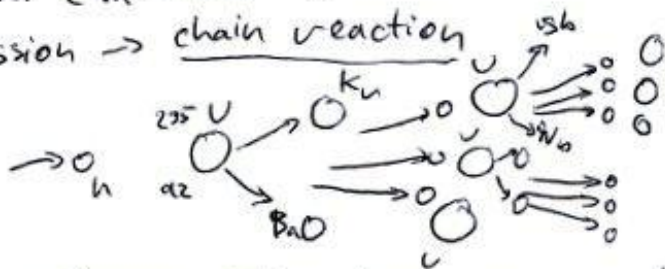
\Rightarrow difference \rightarrow kinetic energy

$$\Delta E = c^2 \Delta m$$

Energy from 1 kg of $^{235}\text{U} \approx$ energy from $2 \cdot 10^7$ kg of TNT.

Nuclear Reactors

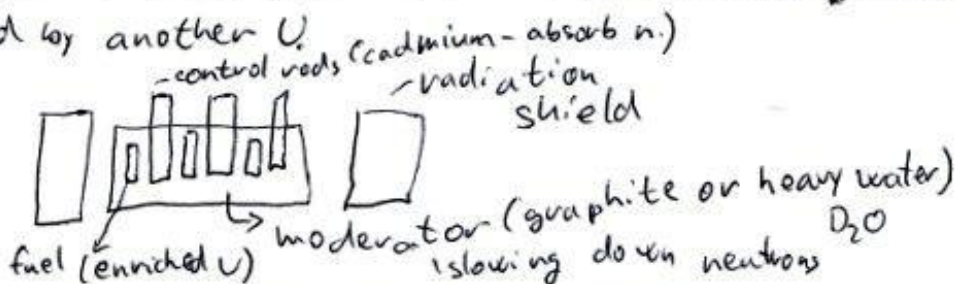
neutrons emitted by ^{235}U fission can ~~start~~ ^{make} other nuclei to fission \rightarrow chain reaction



on average 2.5 neutrons are emitted in each fission event of ^{235}U

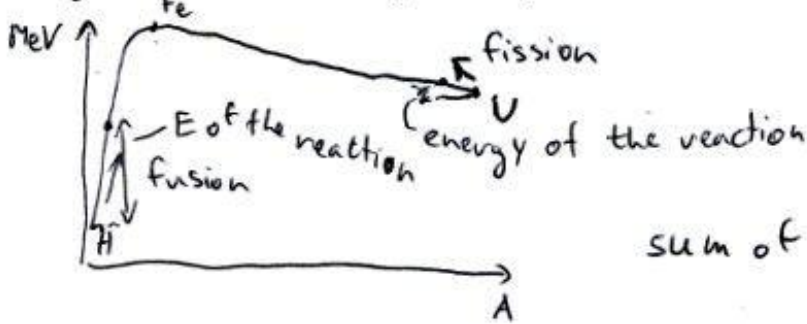
To achieve self-sustained chain reaction exactly one of these neutrons must be captured by another U.

nuclear reactor:



B Nuclear Fusion → 2 light nuclei combine to form a heavier nucleus.

graph of Binding energy per nucleon



$$E_{\text{fusion}} \gg E_{\text{fission}}$$

sum of

Big Bang → ~~the~~ only Hydrogen atoms → fusion → Helium, ^{more heavy} atoms
 ↓
 in sun/stars

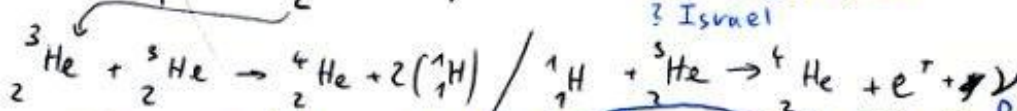
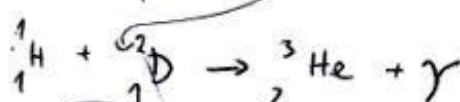
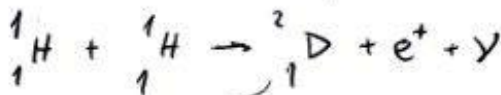
Fusion in the Sun

- all stars generate their energy through fusion process.
- About 90% stars fuse H (older stars could fuse helium)
- Energy produced by fusion increases pressure inside the star and prevents its collapse due to gravity

2 conditions for fusion in stars:

- temperature - $> 10^7 \text{ K}$
- density of nuc. - high enough to collisions to occur
- ↳ it happened just because of quantum tunnelling

proton - proton cycle:



5 states under NPT (Nuclear non-proliferation treaty):

US, Russia, UK, France, China

not NPT

India, Pakistan

escaped from NPT

North Korea

3 Israel

$$\int_0^{\infty} E$$

atoll tests

US, UK, France, China, India, Pakistan, North Korea, Israel

→ bomb → first exploded in 1952

fusion bomb by US in Pacific "Atoll" islands 450x Nagasaki

→ reactor → fuel = water; end-product = non-radioactive He

concretely deuterium - very unexpensive to extract
 temperatures cca. 10^8 K alternative fuel He³ → mine on the Moon