

The next card demonstrates that time is perceived differently by observers moving at different velocities. Assume that a person in the rocket turns on a light at a given time. The observer on the ground sees the light a short time later. When the rocket pilot turns off the light after the rocket has travelled some distance it takes time for the observer on the ground to perceive that the light has been turned off.

The person in the rocket turns the light on for 10 sec (for him).

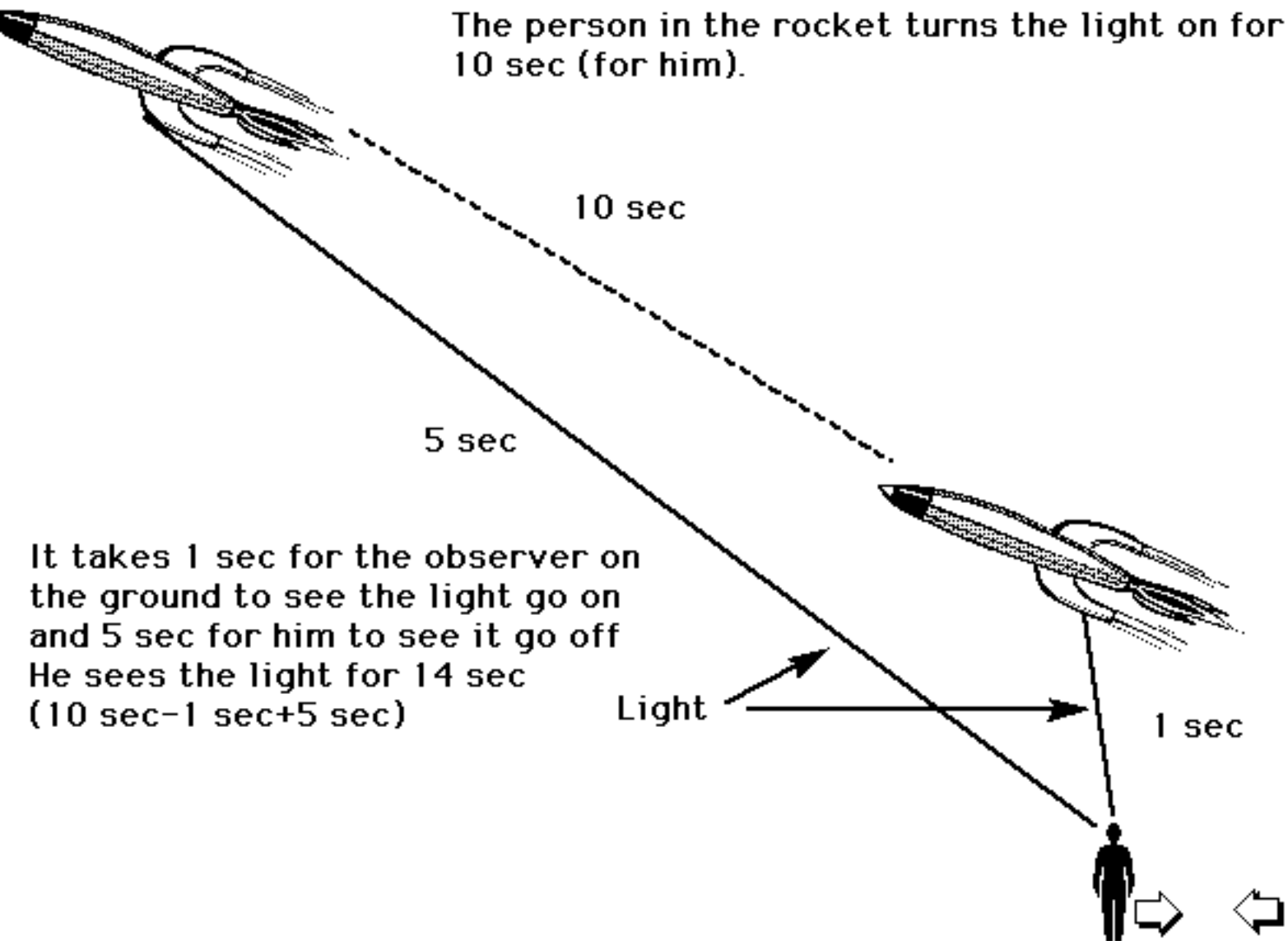
10 sec

5 sec

It takes 1 sec for the observer on the ground to see the light go on and 5 sec for him to see it go off. He sees the light for 14 sec (10 sec - 1 sec + 5 sec)

Light

1 sec



## **NUCLEAR ENERGY.**

**Nuclear or "atomic" energy results from the conversion of mass into energy, a possibility predicted by the theory of relativity, which produced this equation for the equivalence of mass and energy:**

$$E = mc^2$$

**Since the velocity of light is a very large number, a great deal of energy can be made from a very small mass.**

Albert Einstein  
Old Grove Road  
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 a 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 this 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 vast 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 phenomena 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.

The United States has only very poor ores of uranium in 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 comprise 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 or 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.

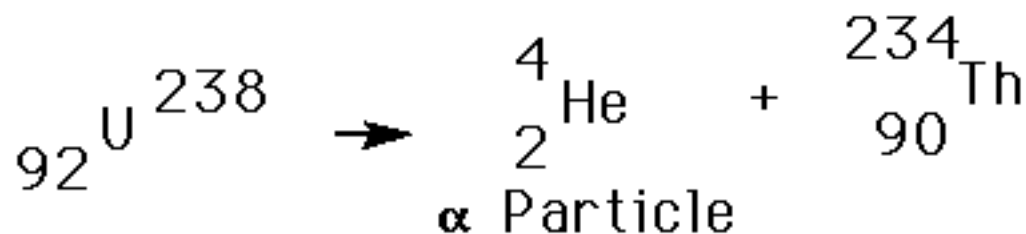
I understand that Germany has actually stopped the sale of uranium from the Czechoslovakian mines which she has taken over. That she should have taken such an early action might perhaps be understood on the ground that the son of the German Under-Secretary of State, von Weizsacker, is attached to the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

Yours very truly,

[Einstein's Signature]

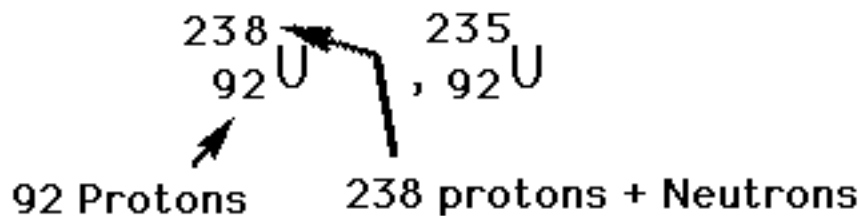
(Albert Einstein)

The first natural phenomenon in which such an interconversion was observed to occur was radioactivity. The great energy with which alpha and beta particles were emitted, as well as the extremely high energy of gamma rays, could be accounted for if some of the mass of the decaying nucleus was being lost as energy. Subsequent careful measurements showed that indeed the total mass of the particle emitted and the "daughter" nucleus left behind was less than the mass of the original nucleus by just the amount that was equivalent to the energy of the emitted particle and of the recoil nucleus.



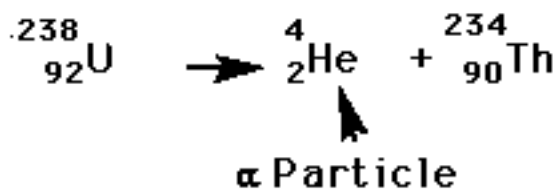


In writing an equation for a nuclear reaction, we must observe two conservation laws. Two quantities that are always conserved are electric charge and "baryon number." That is, no charges can be created or destroyed in any nuclear (or other) reaction, and the total number of baryons, a term which includes both protons and neutrons, must not change.

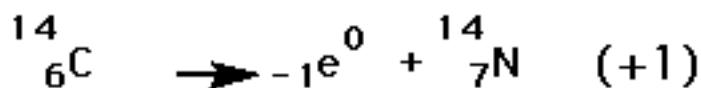


## Nuclear Reactions: $\alpha$ Emission

Curie



## $\beta$ Emission



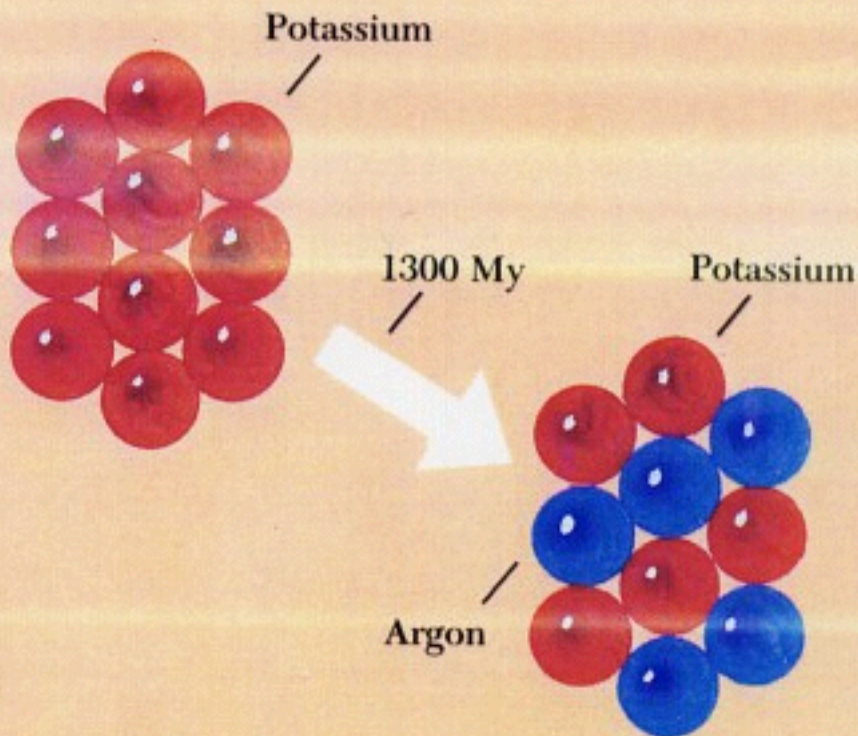
## Fission



+ Energy

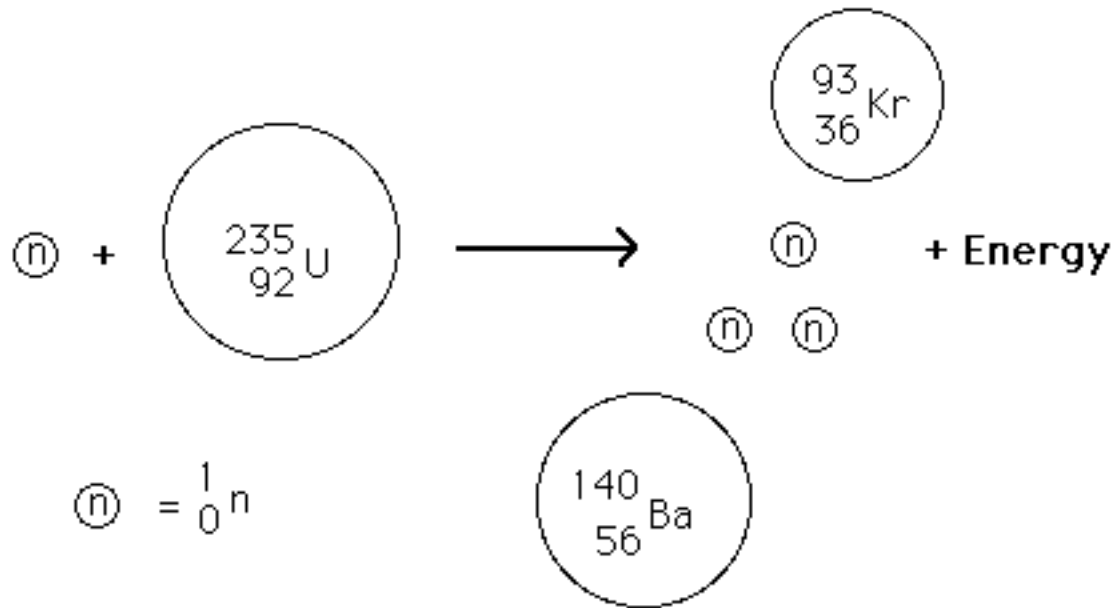
Radioactive Decay

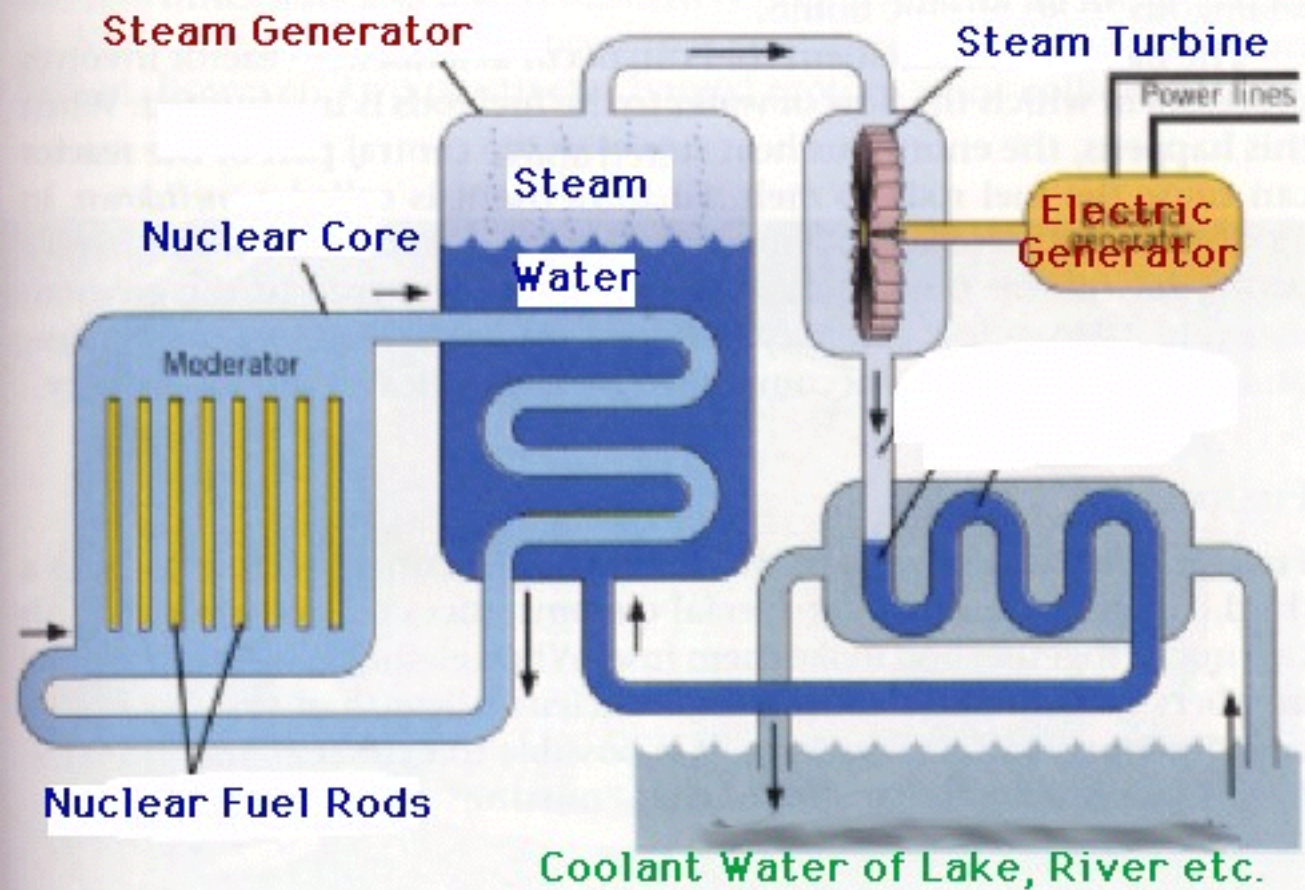




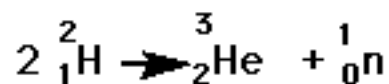
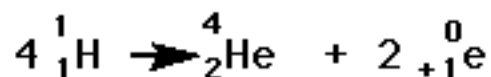
Radioactive decay. After one half-life, half of the original radioactive atoms (red) have decayed to form stable daughter atoms (blue). Dating of rocks can be done by counting the number of daughter atoms relative to the number of parent atoms.

HALF-LIFE OF K-40 IS  $1.25 \times 10^9$  YEARS





## Nuclear Fusion



Tritium, with a half-life of 12.26 years, decays by beta emission to stable He-3

The product of fusion, helium, is a lightweight inert gas that would simply diffuse out of the atmosphere into space. There would be some radiation to deal with, from tritium and from neutron-induced radioactivity in the reactor itself, but there would be no massive amounts of waste to guard for centuries.

