



## Forces and Elements

In ancient times people believed there were four elements. The air and the earth, water and fire. And they thought there were two forces interacting on these elements: love and strife.

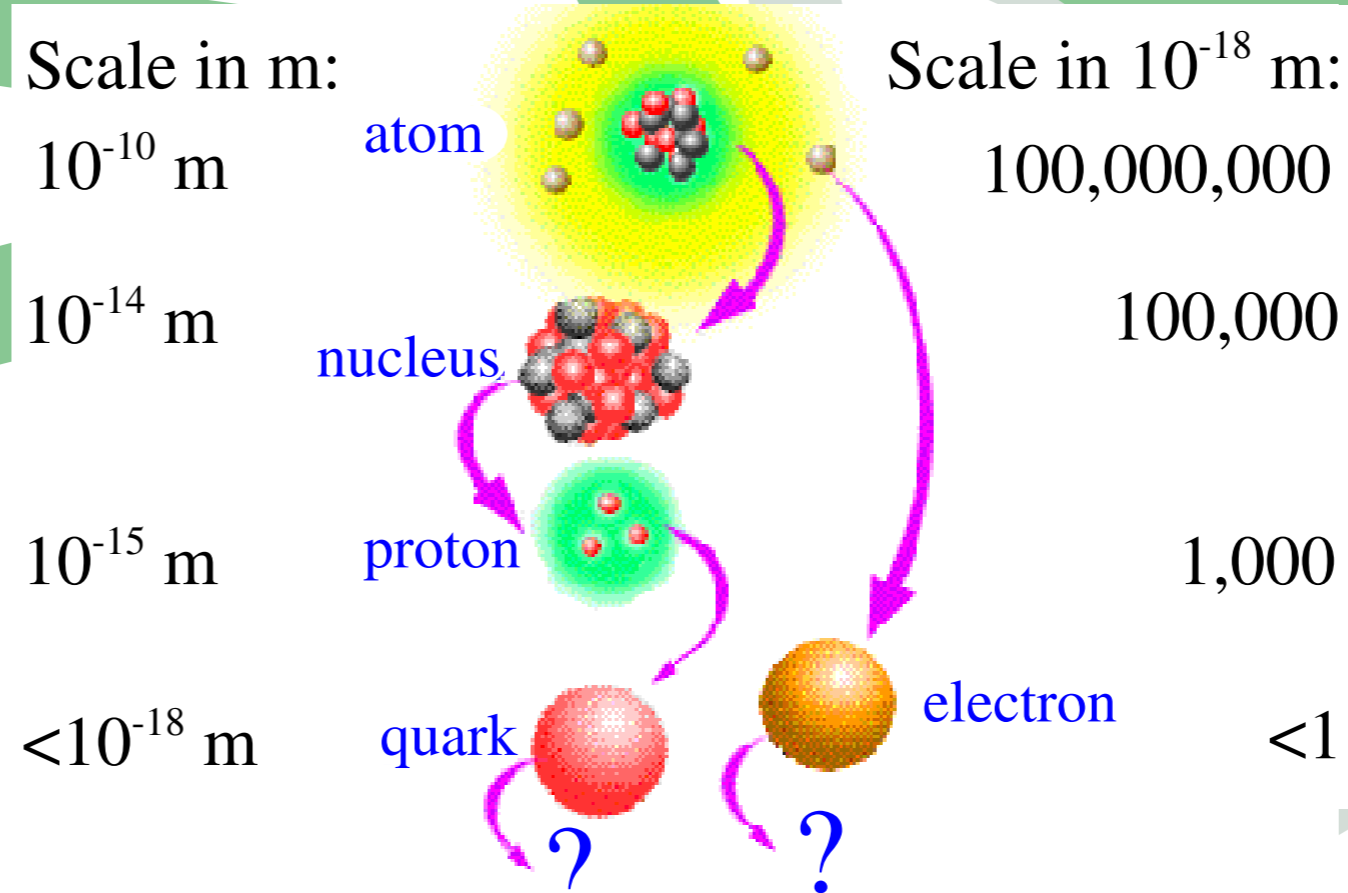
Nowadays we believe that there are four forces and many more primary element (particles)#.

#) graviton, 2xW + Z + photon + 8 gluons + 2x6 leptons/antileptons + 2x6 quarks/antiquarks

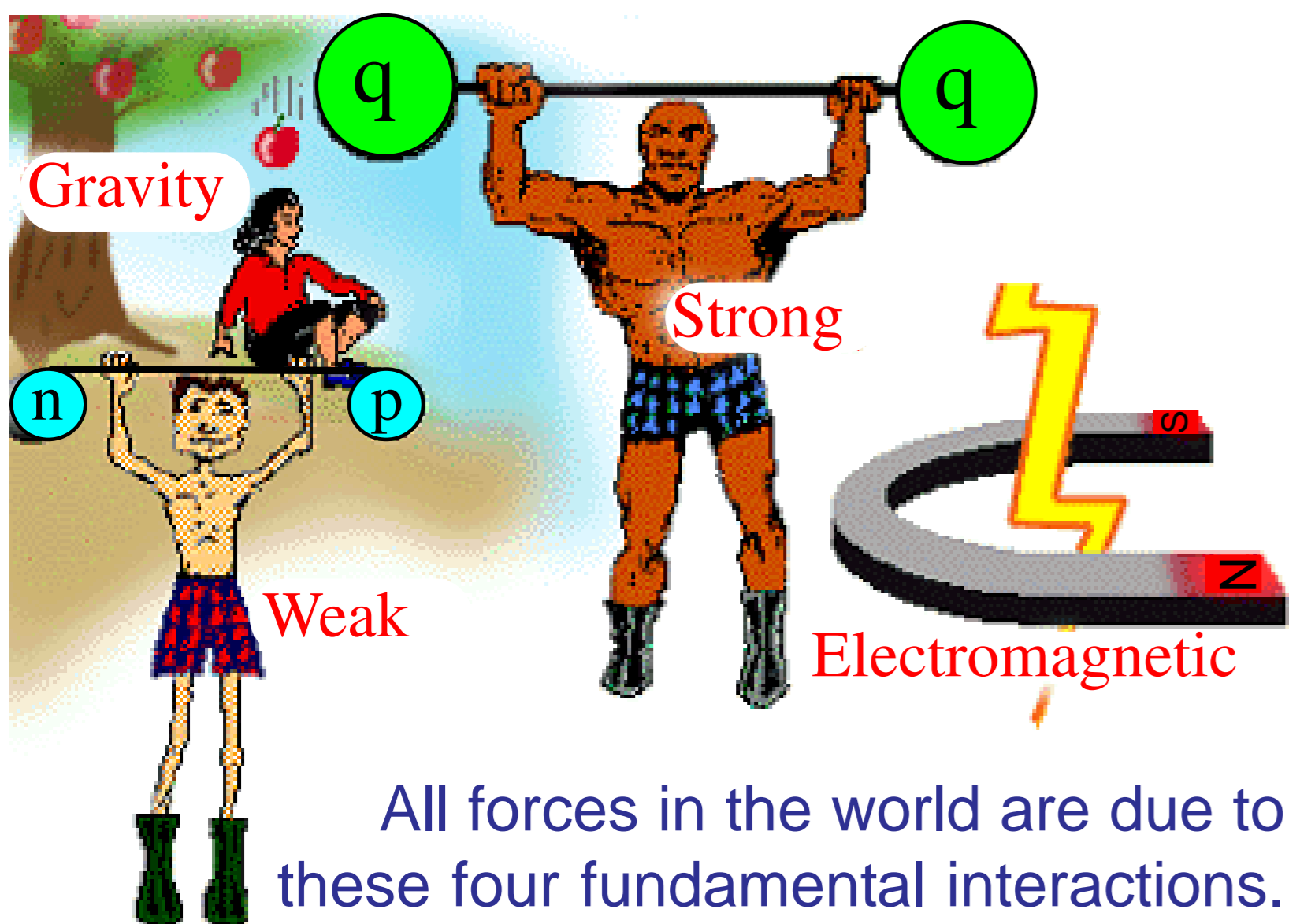
What we want to study:

- what is a particle?
- how do particles interact?
- how is the universe constructed?

The mechanism of particle interaction (forces) and mass might tell us more about the history and fate of the universe.



The Generations of Matter			
Quarks	<i>u</i> up	<i>c</i> charm	<i>t</i> top
	<i>d</i> down	<i>s</i> strange	<i>b</i> bottom
	<i>v<sub>e</sub></i> e-neutrino	<i>v<sub>μ</sub></i> μ-neutrino	<i>v<sub>τ</sub></i> τ-neutrino
Leptons	<i>e</i> electron	<i>μ</i> muon	<i>τ</i> tau
	I	II	III



## The Four Forces

The electromagnetic force causes many everyday phenomena like friction and magnetism. It also keeps atoms and molecules together.

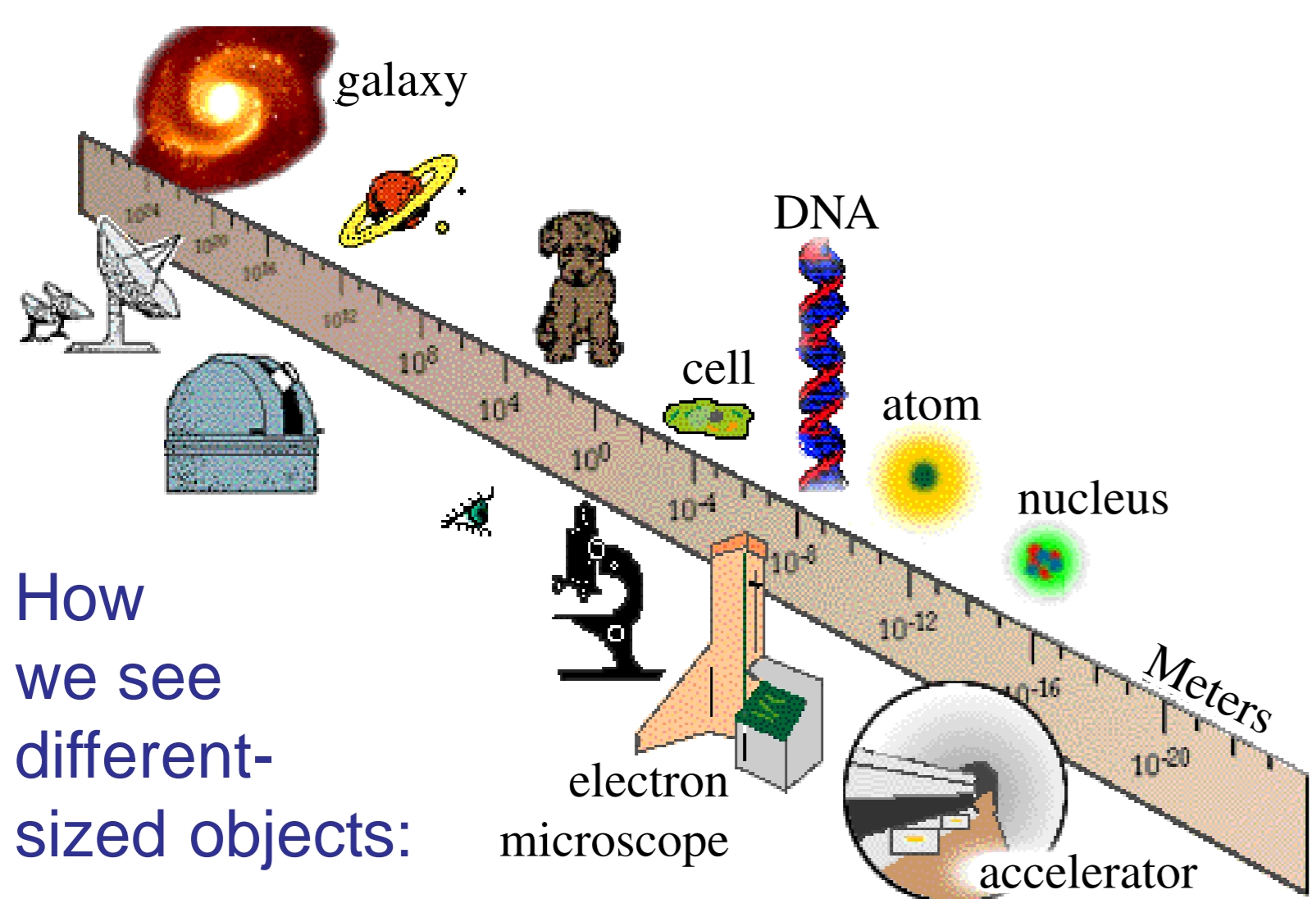
The weak force is e.g. responsible for natural radioactivity and burning of stars.

The strong force keeps the nucleus of the atom together.

The gravity keeps us on the earth, and keeps the solar system and universe together.

force	carrier	acts on	particle
gravitation	graviton		
weak	W <sup>+</sup> , W <sup>-</sup> , Z <sup>0</sup>		leptons*
electromagnetic	photon		quarks
strong	gluon		

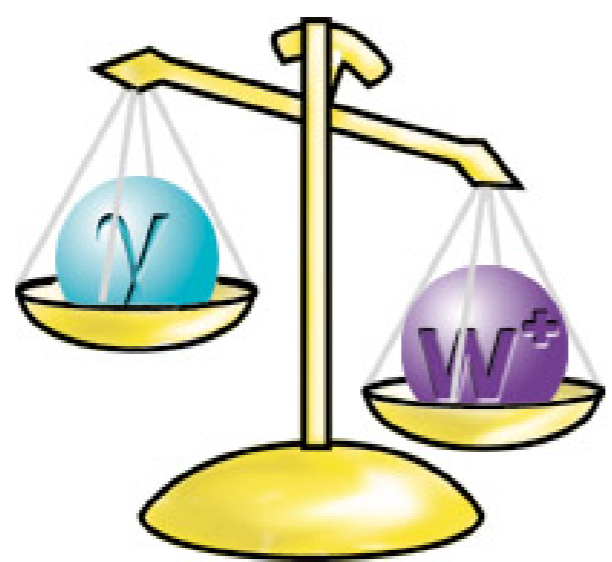
\*) neutral leptons (=neutrinos) do not interact electromagnetically



How we see different-sized objects:

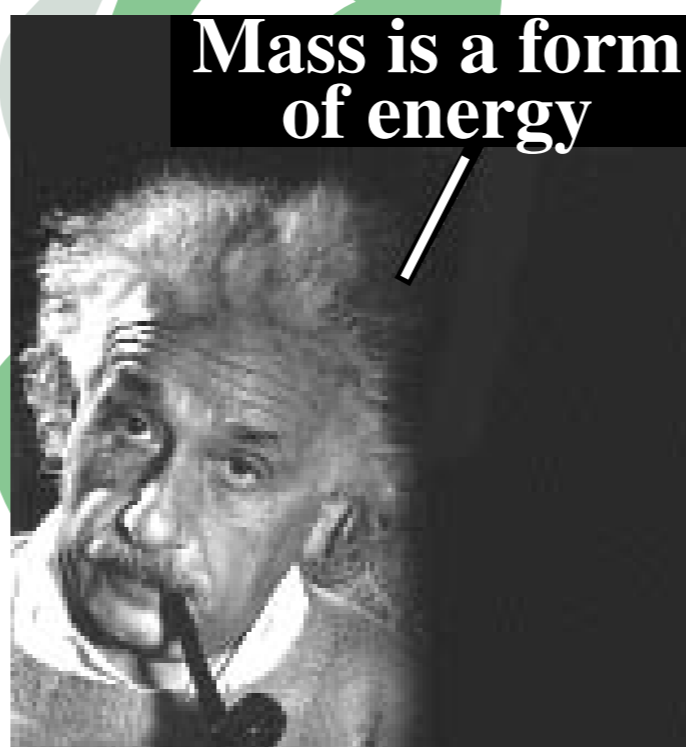
## The mystery of mass

Particles have different masses. But why? And where does the mass come from???



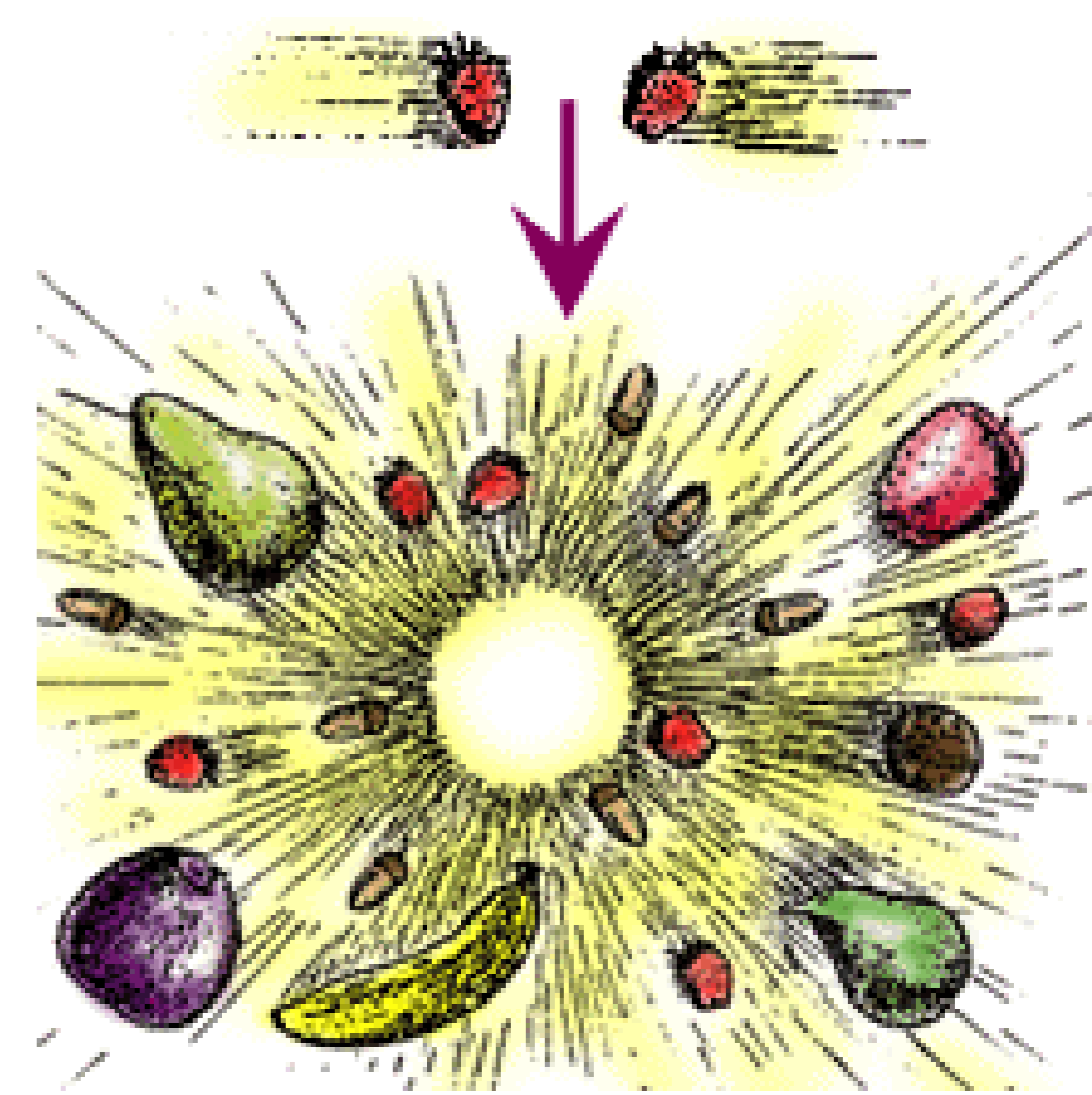
## Testing the hypothesis of Peter Higgs ...

Masses arise from interaction with a, yet undiscovered, force carrier: Higgs. The action of the Higgs is analogue with a particle moving through a thick liquid. The stronger the interaction of a particle with the Higgs, the more mass it appears to have.



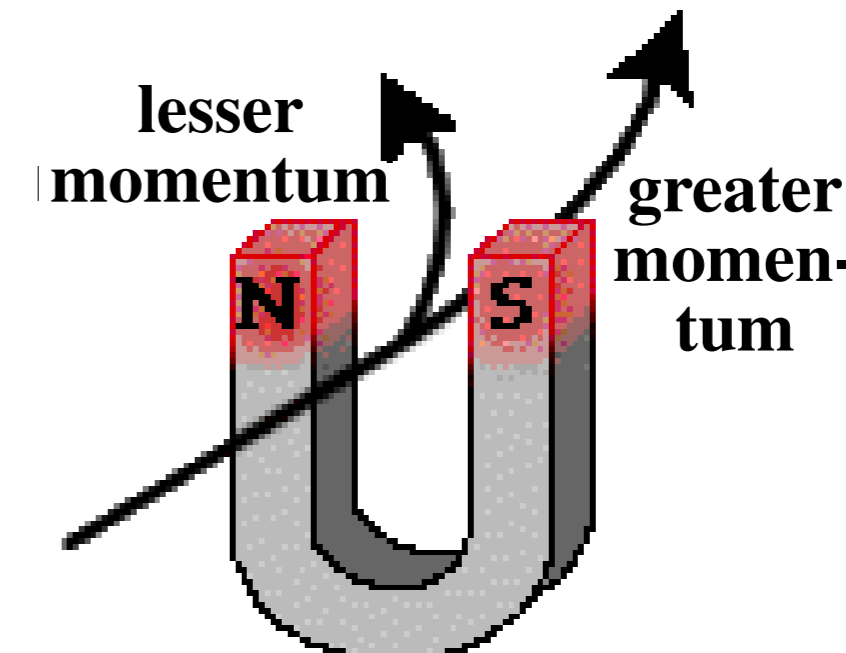
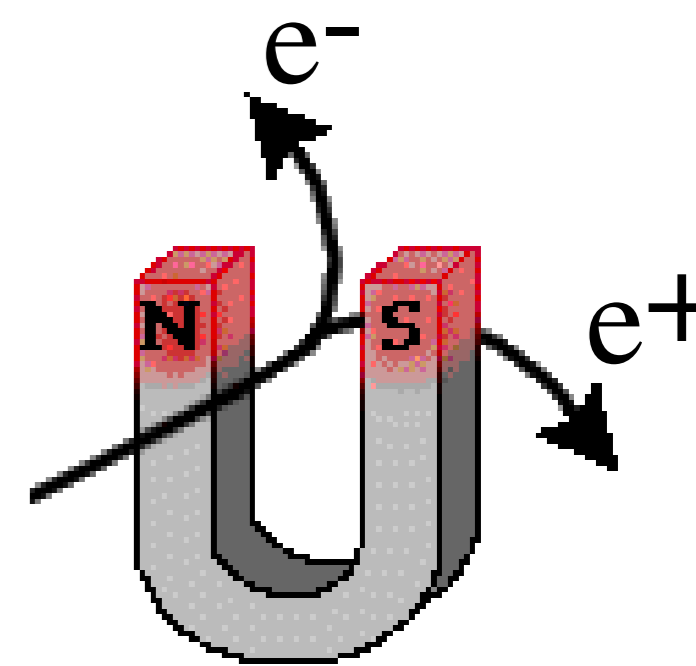
## Studying Particles

We can study the fundamental forces through particle collisions at high speed and energy. As mass and energy are related ( $E=mc^2$ ), the energy released in the collision can create new particles.



## Charged Particles in Magnetic Field

Opposite charges give opposite directions.



Different momenta give different bending radii.