



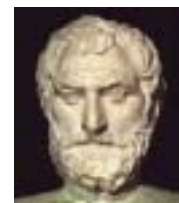
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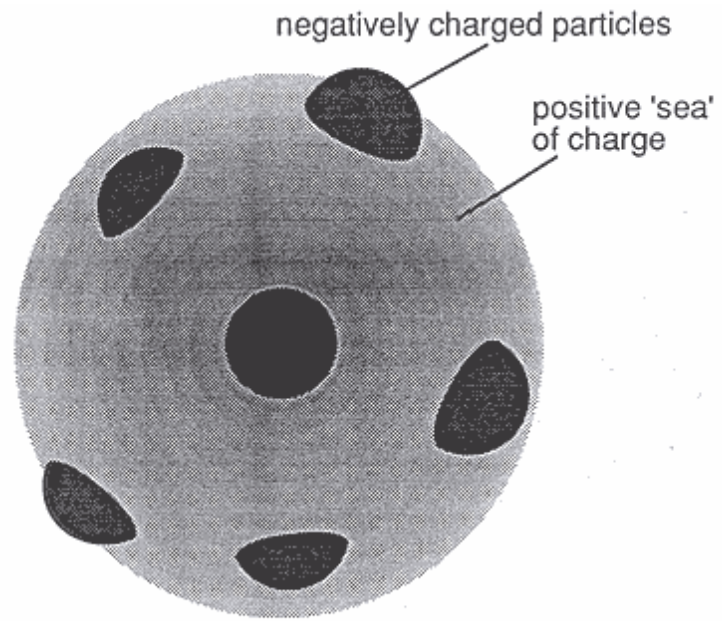
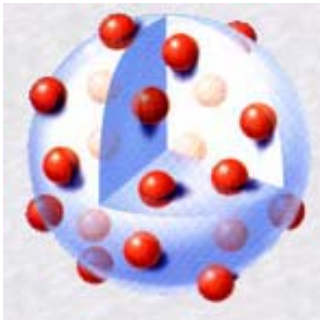
(jyu@phya.snu.ac.kr)

http://phya.snu.ac.kr/~mi_ma/



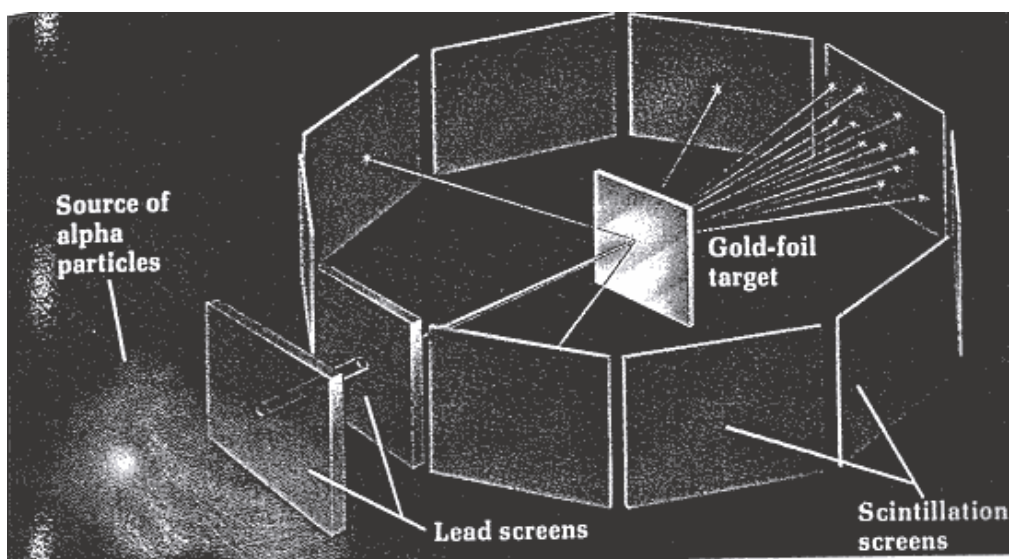
- Thales: water (水)
- Anaximandros: apeiron ()
- Anaximenes: air (空氣)
- Anaxagoras: (種子)
- Herakleitos: fire (火)
- Pythagoras: number (數)
- Democritus/Lucippus: Atom (原子)
- ...

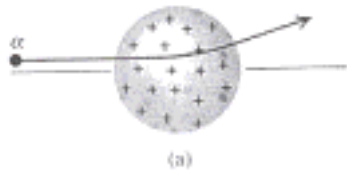




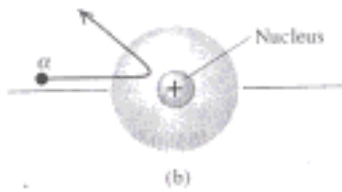
Thomson's
"plum pudding model"

Rutherford Experiment (1911)

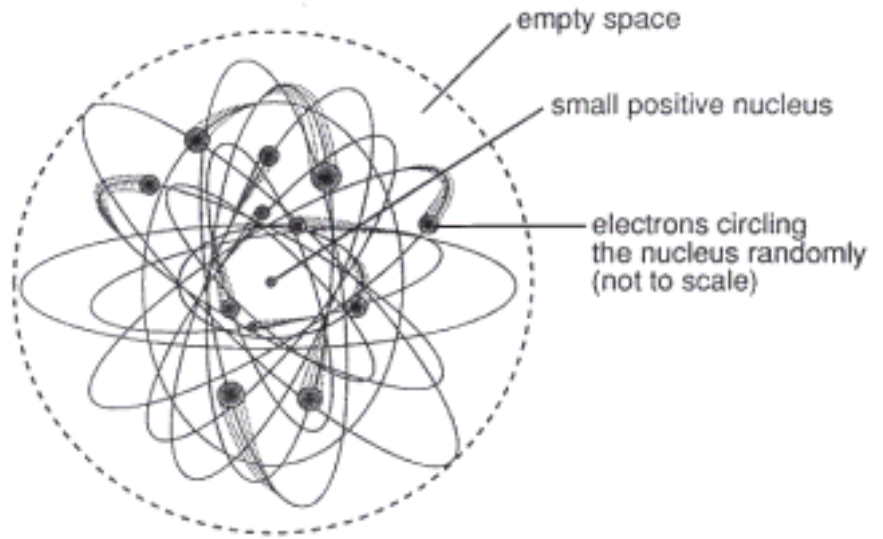




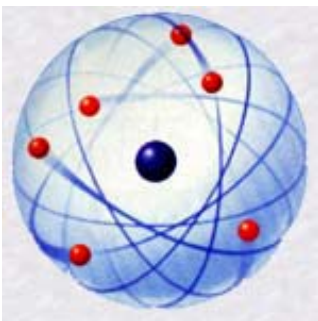
(a)



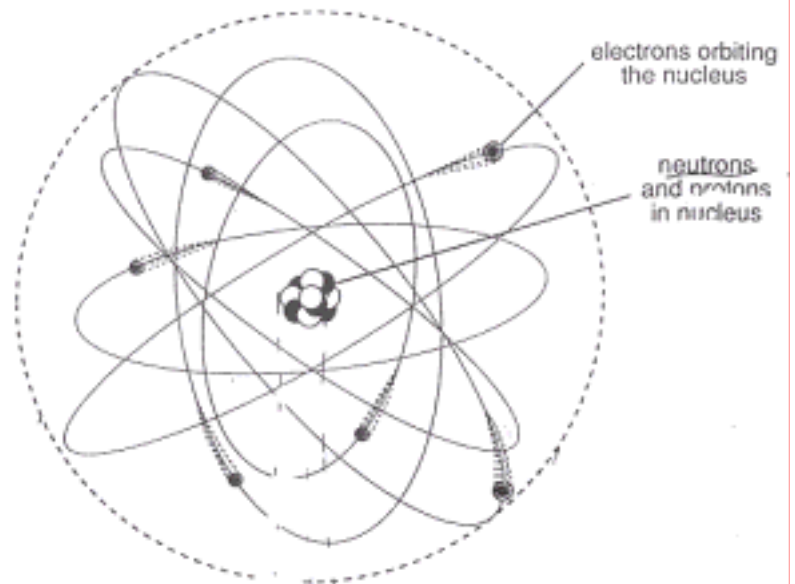
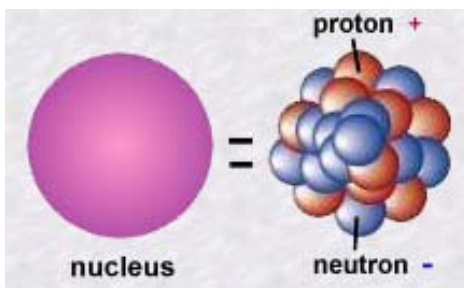
(b)



Rutherford's model

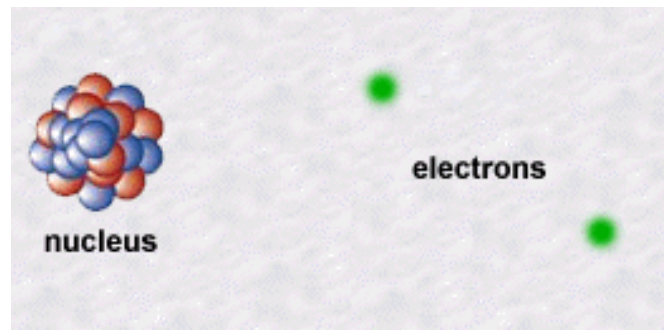
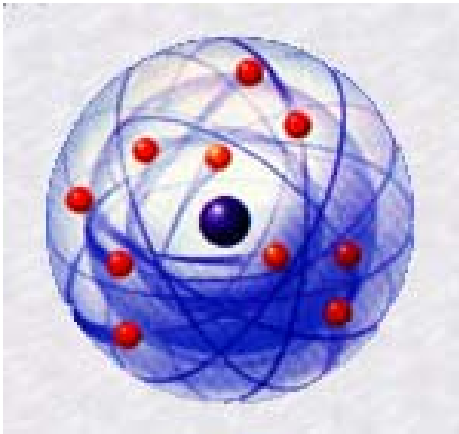


Chadwick (1932)



Chadwick's model

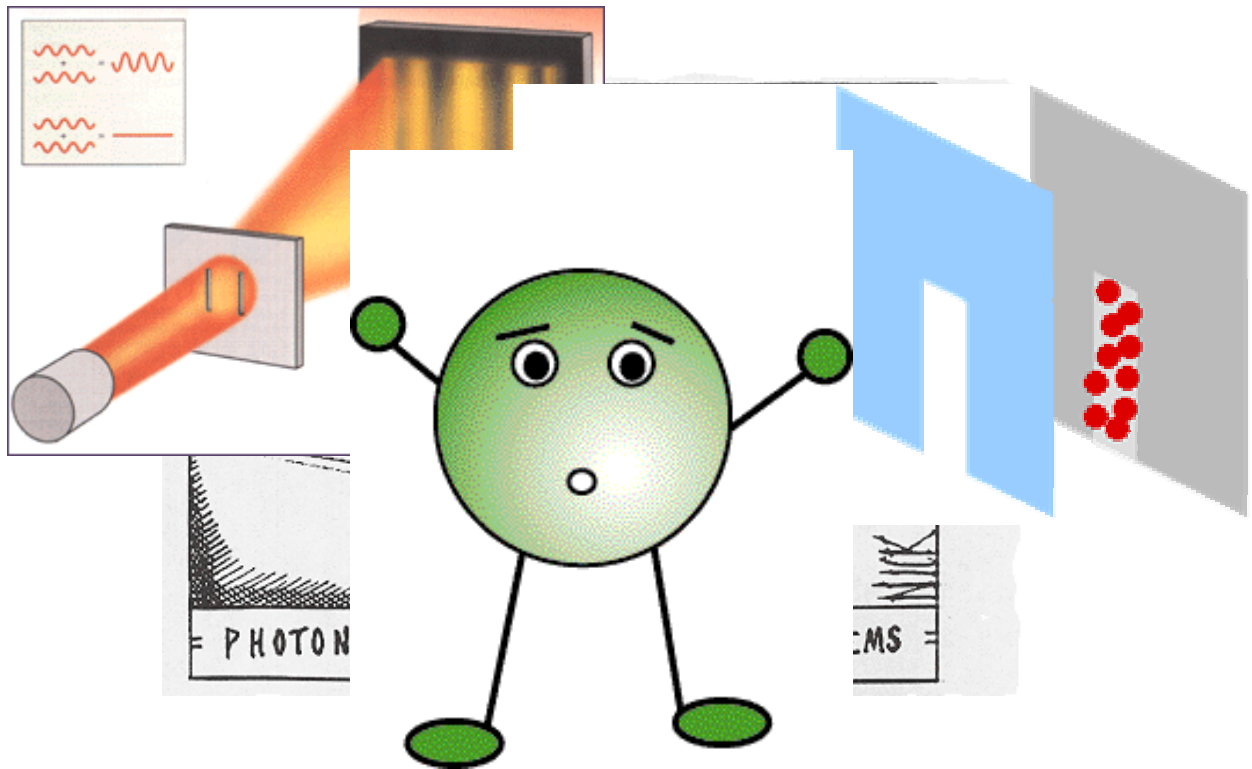
Bohr's atom



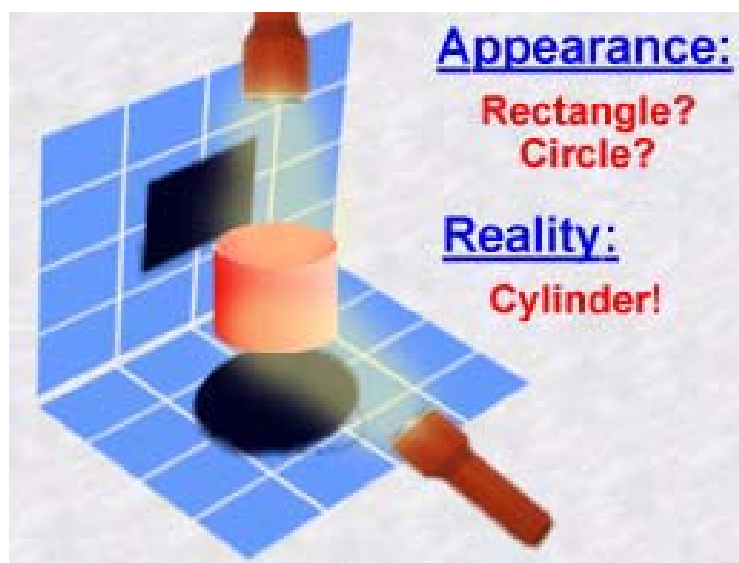
"Quantum Physics"

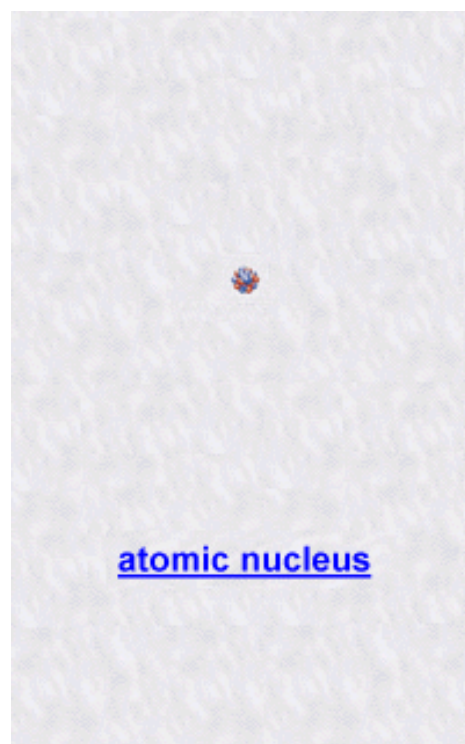
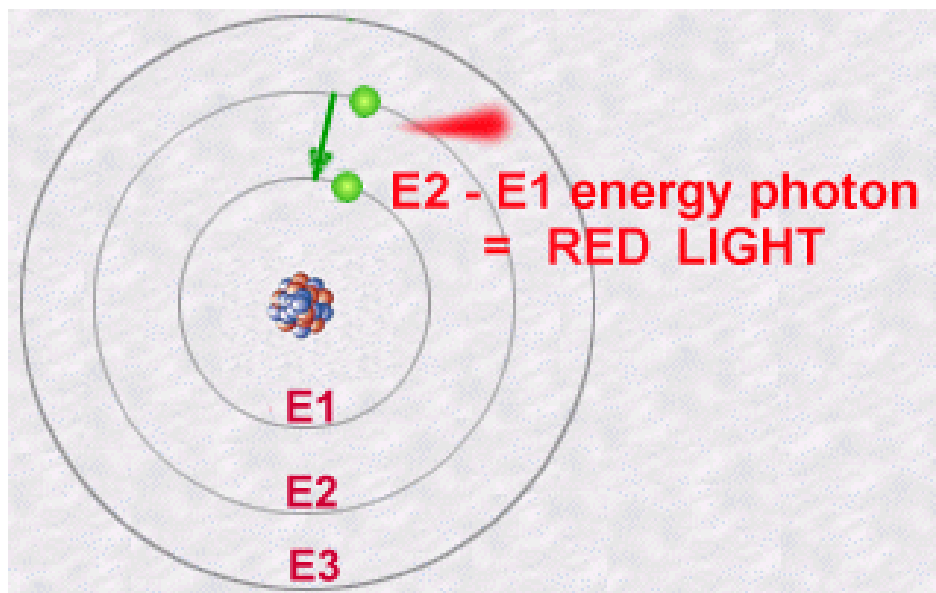
"Classical" vs. "Quantum"



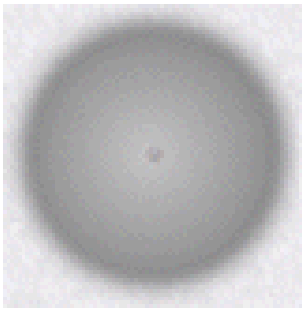
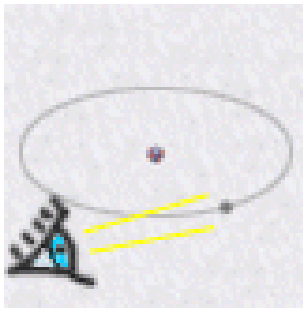


Particle-Wave Duality

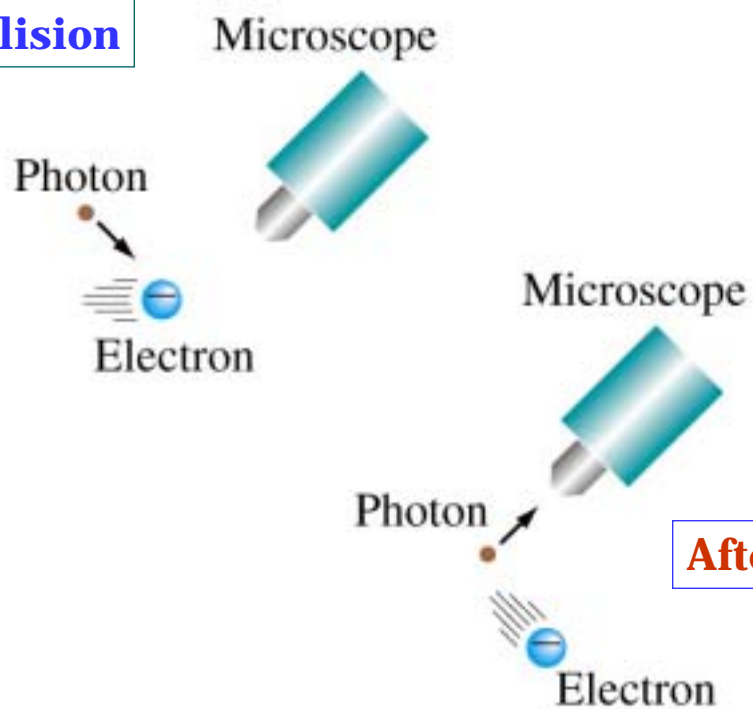




Uncertainty ()

electronic orbital	observed electron
<i>wave like nature</i>	<i>particle like nature</i>
	

Before collision



After collision

(Uncertainty Principle)



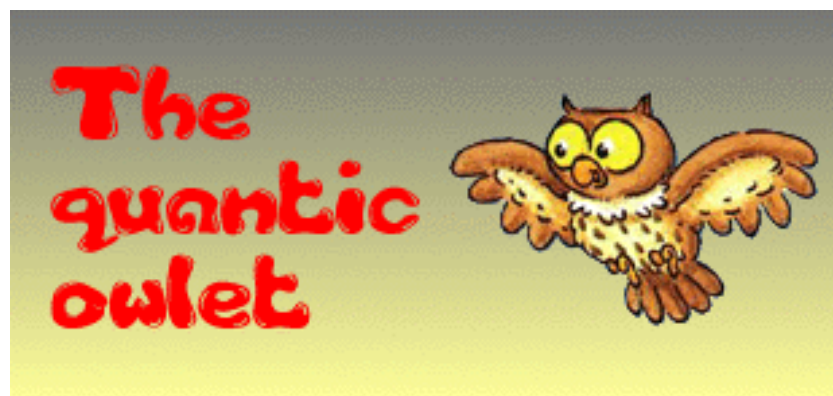
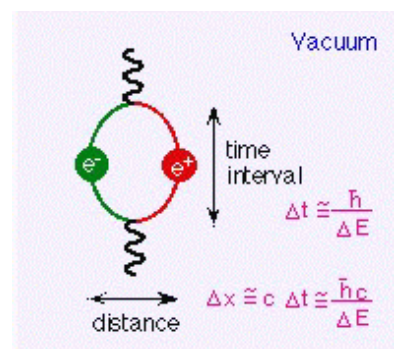
$$\Delta x \Delta p \geq \hbar/2$$

$$\Delta E \Delta t \geq \hbar/2$$

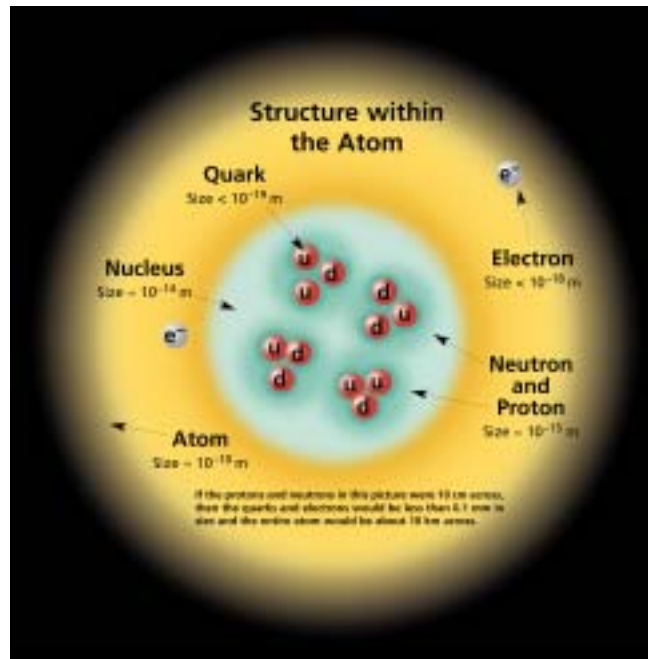
"The more precisely the **POSITION** is determined, the less precisely the **MOMENTUM** is known"

Heisenberg (1927)

<http://www.synaptic.bc.ca/ejournal/uncertin.htm>



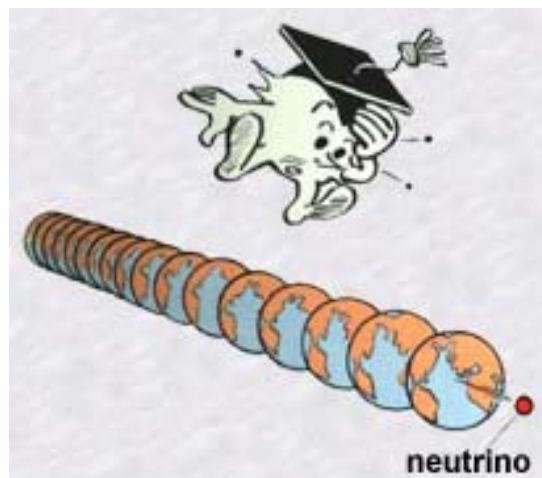
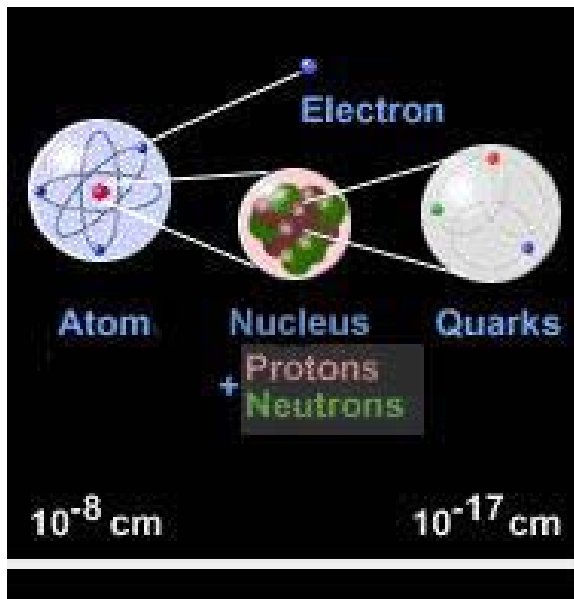
?



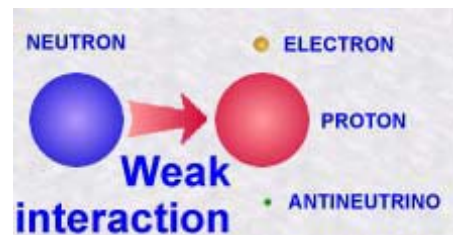
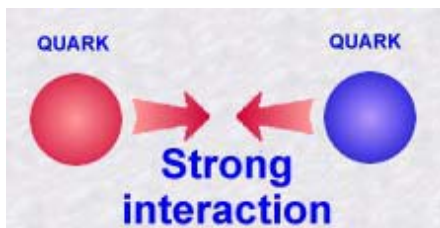
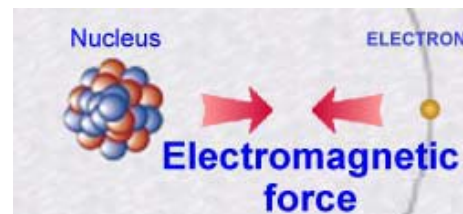
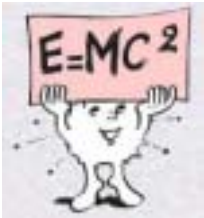
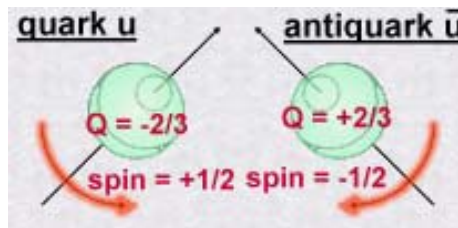
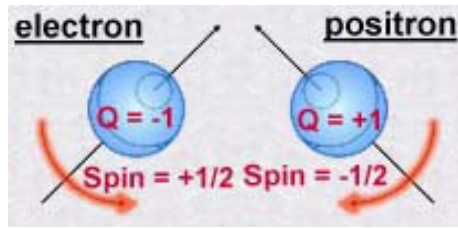
FERMIONS			matter constituents spin = 1/2, 3/2, 5/2, ...		
Leptons spin = 1/2			Quarks spin = 1/2		
Flavor	Mass GeV/c ²	Electric charge	Flavor	Approx. Mass GeV/c ²	Electric charge
ν_e electron neutrino	$<1 \times 10^{-8}$	0	u up	0.003	2/3
e electron	0.000511	-1	d down	0.006	-1/3
ν_μ muon neutrino	<0.0002	0	c charm	1.3	2/3
μ muon	0.106	-1	s strange	0.1	-1/3
ν_τ tau neutrino	<0.02	0	t top	175	2/3
τ tau	1.7771	-1	b bottom	4.3	-1/3

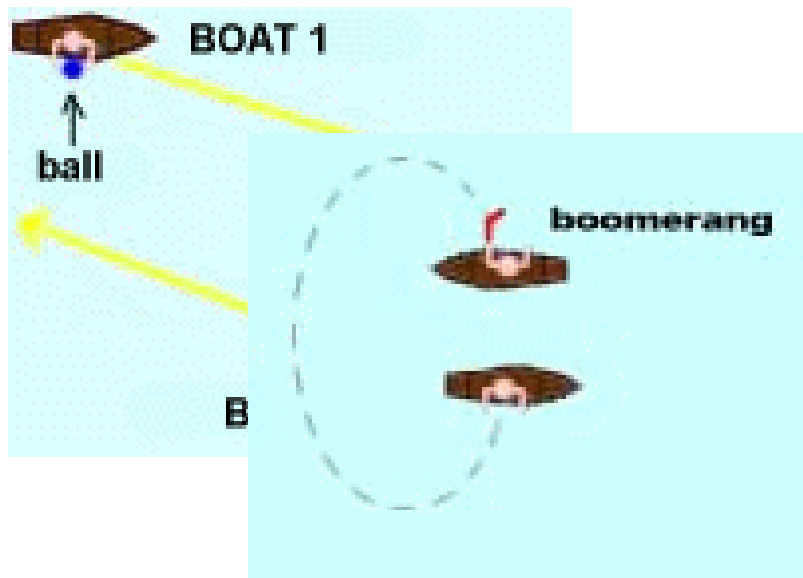
BOSONS			force carriers spin = 0, 1, 2, ...		
Unified Electroweak spin = 1			Strong (color) spin = 1		
Name	Mass GeV/c ²	Electric charge	Name	Mass GeV/c ²	Electric charge
γ photon	0	0	g gluon	0	0
W^-	80.4	-1			
W^+	80.4	+1			
Z^0	91.187	0			

()



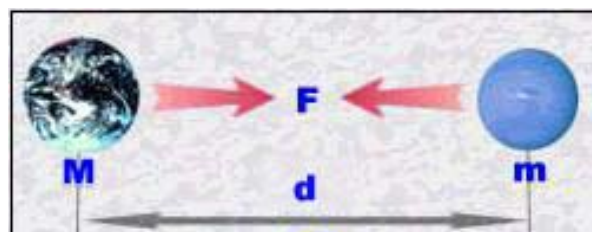
(anti-particle)

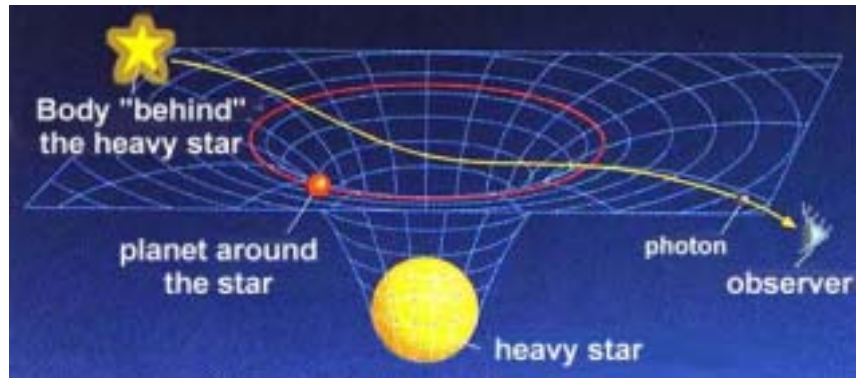
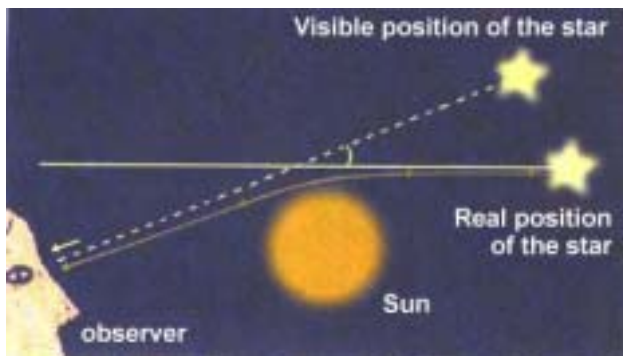




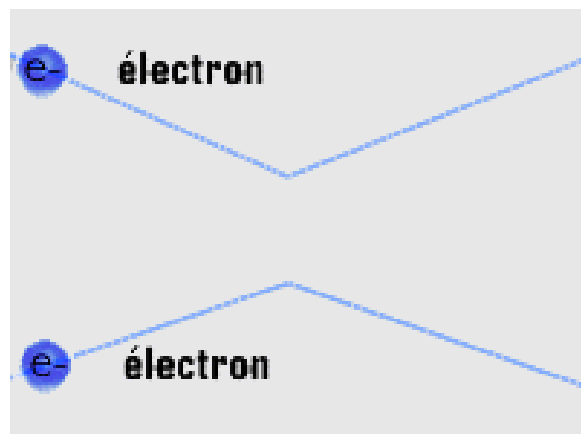
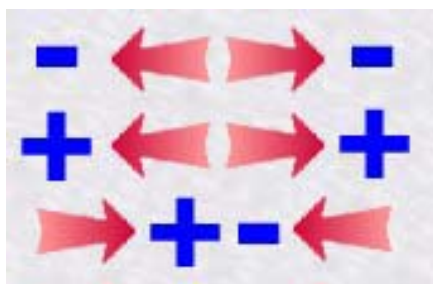
F = Gravitational force
G = Universal gravitational constant
d = Distance between **M** and **m**

$$F = G \frac{Mm}{d^2}$$

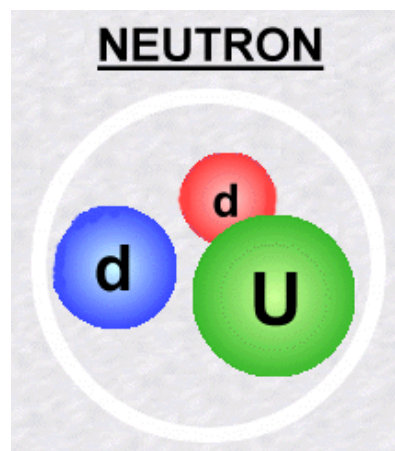
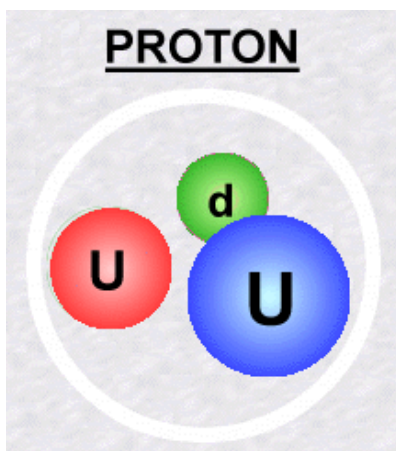
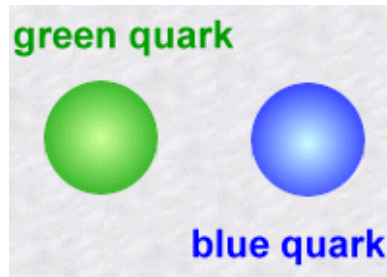
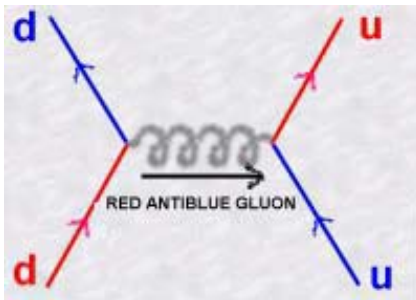
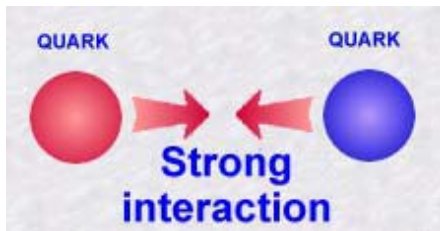


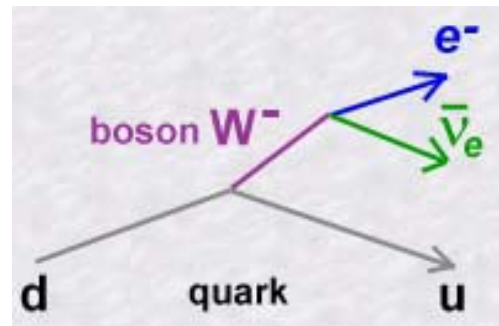
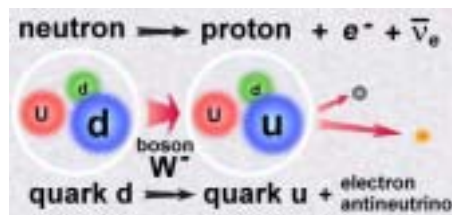
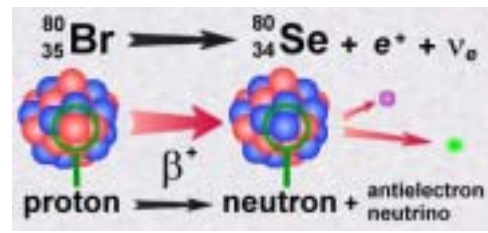
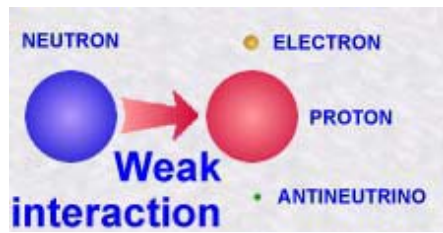


Graviton? ?



QED
(Quantum Electro-dynamics)

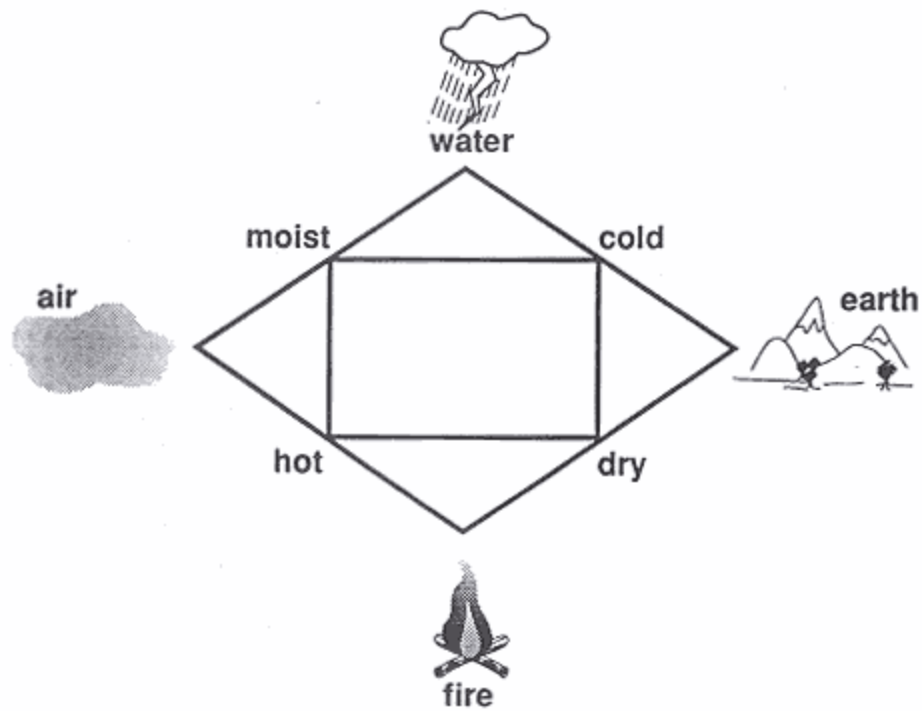




Ancient Greek Cosmology

- In 350 BC, Aristotle proposed a finite Universe - a system of crystalline spheres with Earth at centre.
- Four primal forces :

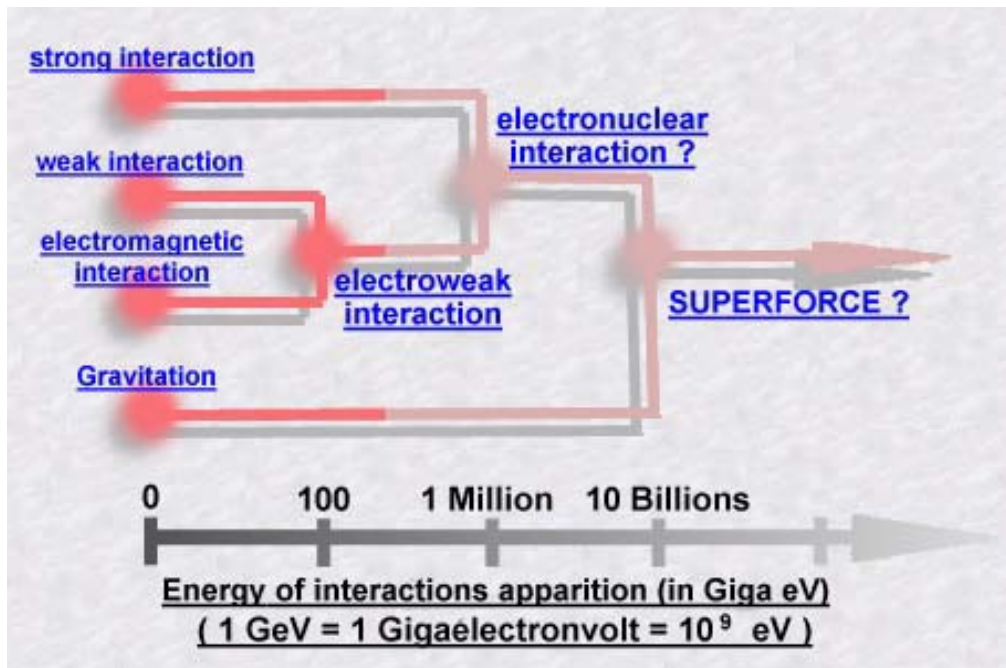




Aristotle's concept of 4 elements

Little change in basics...

<u>Ancient Greek</u>	<u>Modern</u>
defined using geometry	Relativistic space-time
4 basic elements -	4 basic forces -
earth	gravity
air	electromagnetism
fire	strong nuclear force
water	weak nuclear force
created by chance -	created by chance -
atomic collisions	quantum mechanics



(Superstring)

