

Lecture 4 - FUNDAMENTAL INTERACTIONS - 17 Jan 2001

- A. The **Newtonian Synthesis** included the **three laws of motion** and the **law of gravitational interaction**. Later (19th century), the **law of electromagnetic interaction** was added. The synthesis brought about a major revolution in the way people viewed the world. It was a physics based on causes and a representation of the world that was not proven false for nearly two hundred years. It is **still a useful approximation** to our everyday world.
- B. What determines the strength of gravitational forces?
1. **Do heavy and light objects accelerate differently when only the gravity force is acting on them?** Experimental evidence shows that all objects in the same location near the earth that are subject to only the gravitational force accelerate at the same, constant rate. Therefore, it can be reasoned that the gravitational force on an object (called weight) is exactly proportional to the mass of the object. If the mass is large, the weight is large.
 2. **How does the acceleration of the moon toward the earth compare to the acceleration of an apple falling near the earth?** The same object at different distances from the earth accelerates at different rates. Experiments show that an object as far away as the moon only accelerates 1/3600 the rate of the same object near the surface of the earth. The moon is 60 times farther from the center of the earth than objects at the earth's surface. 3600 equals 60 squared. The acceleration due to the earth's gravitational force is inversely related to the square of the distance to the object from the center of the earth.
 3. Every object in the universe attracts every other object by a long-range gravitational interaction, which obeys Newton's Third Law. The strength of the attractive forces varies with the masses of the two objects (m and M) and the distance between their centers (d) according to the relationship (called the **universal law of gravitation**):

$$\text{Force of gravity} = GmM/d^2.$$

- C. What determines the strength of the forces in the electromagnetic (or electrical) interaction?
1. The **electrical model of matter** includes the following:
 - a. Matter contains **two kinds of electrically charged particles**: negatively charged electrons and positively charged protons. Electrons have little mass and can be easily transferred from one object to another. Protons are far more massive and are often bound into nuclei.
 - b. Many objects have **equal numbers of protons and electrons**. Such objects are electrically **neutral**.
 - c. Objects with **more electrons than protons are negatively charged**. Those with **fewer electrons than protons are positively charged**. The amount of extra charge of either kind is called the charge of the object.
 2. Charged objects exert forces on each other in an interaction. The forces are described by Newton's Third Law. The strength of the forces depends on the charges (q and Q) and the distance between them according to:

$$\text{Electrical force} = KqQ/d^2.$$