

Lecture Outline

The Heritage of All Mankind

- I. There are four fundamental forces in physics, defined as forces that act between particles of matter: gravitational, electromagnetic, strong and weak forces. These forces involve the exchange of force carrier particles.
 - A. Gravitational force
 - Strength is determined by the mass of the objects and the distance between them
 - If desired, introduce the theory of general relativity:
 - o Consider gravity as a result of the shape of space-time (determined by mass, affected by changes in the distribution of mass). View a useful demonstration [here](#).
 - B. Electromagnetic forces
 - Forces between charged particles
 - Opposite charged attract (eg. magnets)
 - Two components: electric and magnetic.
 - o Electric fields exist around charged particles.
 - o Magnetic forces are the result of charged particles in motion.
 - C. Strong nuclear force
 - Acts within the nucleus of an atom
 - Binds the components of protons and neutrons together, even though the positive charges of protons repulse each other (electromagnetically)
 - D. Weak nuclear force
 - Acts on subatomic particles
 - Responsible for fusion and particle decay (which changes an atom of one element to an atom of another)
- II. Unification of Forces
 - A. Electromagnetic force
 - James Maxwell realized that electricity and magnetism were two components of the same force, appropriately named the electromagnetic force
 - B. Electroweak force
 - Abdus Salam, along with Sheldon Glashow and Steven Weinberg, conducted work showing that electromagnetic forces and weak nuclear forces were subsets of the same force, the electroweak force. Electromagnetic and weak forces look the same at high energies.
- III. Ranges of Forces
 - Even though we experience gravity, it is the weakest force (from the perspective of particles in a nucleus).
 - o From strongest to weakest: gravity, weak nuclear force, electromagnetism, strong nuclear force
 - Gravity and electromagnetism act at all ranges (but become weak at large distances), the strong and weak forces only act at short ranges. For the strong force, this is about size of a nucleus, for the weak force, it is only about 0.1% of the diameter of a proton.

Sources:

CERN, “Unified Forces” < <https://home.cern/science/physics/unified-forces> > (Accessed 26 June 2020).

SciShow, “Weak Interaction: The Four Fundamental Forces of Physics #2”
<https://www.youtube.com/watch?v=cnL_nwmCLpY> (Accessed 26 June 2020).

Hyperphysics, “Fundamental Forces” <<http://hyperphysics.phy-astr.gsu.edu/hbase/Forces/funfor.html#c5>>
(Accessed 26 June 2020).

The Editors of Encyclopaedia Britannica, “Fundamental Interaction”
<<https://www.britannica.com/science/fundamental-interaction>> (Accessed 26 June 2020).