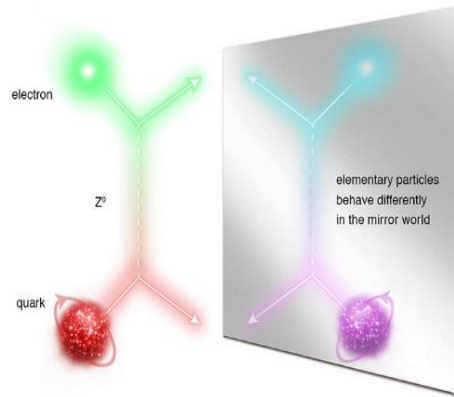


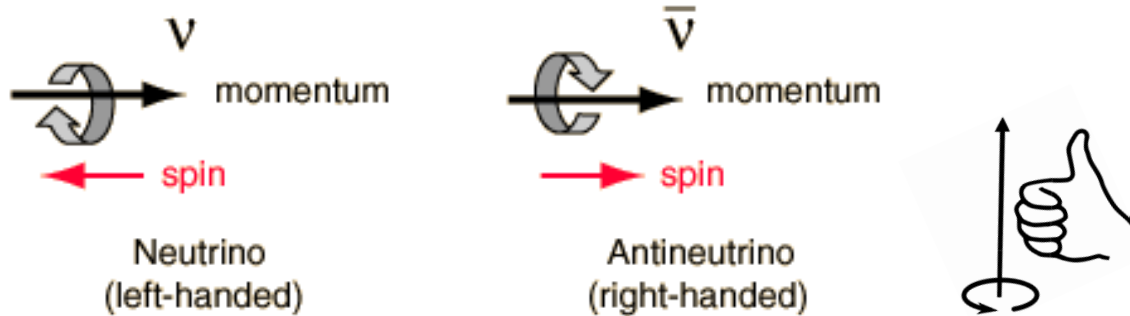
Do neutrinos violate symmetries?

There is an amazing beauty in nature. A snowflake, a daisy, a butterfly—the shapes of these and other natural objects have underlying patterns and symmetries. Symmetries are imprinted in the structure of our universe. This helps us organize our world conceptually. When a symmetry of nature exists, there is a physical law attached to it. Physicists look for symmetries in laws to uncover nature's secrets. Scientists expected nature to have mirror symmetry. A left-handed glove is the mirror image of a right-handed glove, but they both follow the same rules. Surprisingly, this does not seem to be true for neutrinos.



All neutrinos that have been observed are left-handed; the directions of the spin and motion are opposites. However, no right-handed neutrinos have ever been observed. Also, all antineutrinos that have been observed are right-handed; the directions of the spin and motion are the same.

This activity explains what it means for a particle to be left-handed or right-handed.



Materials:

2 beach balls (or any lightweight balls of equal size)
String

Activity:

Attach two pieces of string (~1 ft) to each ball and hold them up next to each other. Twist the strings so that the balls start spinning in opposite directions. Now, start lifting the spinning balls upwards slowly. Watch their movements, use the graphics above, and decide which ball represents a neutrino and which an antineutrino. Remember, neutrinos are left-handed, and antineutrinos are right-handed.

Fermilab scientists study the differences between the behavior of neutrinos and antineutrinos to explain the matter/antimatter asymmetry in our universe.

Useful link:

https://ed.fnal.gov/lsc_exhibits/list.html