CHAPTER OVERVIEW

4: Special Relativity

Albert Einstein invented the special and general theories of relativity early in the 20th century, though many other people contributed to the intellectual climate which made these discoveries possible. The special theory of relativity arose out of a conflict between the ideas of mechanics as developed by Galileo and Newton, and the theory of electromagnetism. For this reason relativity is often discussed in textbooks after electromagnetism is developed. However, special relativity is actually a valid extension to the Galilean world view which is needed when objects move at very high speeds, and it is only coincidentally related to electromagnetism. For this reason we discuss relativity before electromagnetism.

The only fact from electromagnetism that we need is introduced now: There is a maximum speed at which objects can travel. This is coincidentally equal to the speed of light in a vacuum, $c = 3 \times 10^8$ m s^{-1}. Furthermore, a measurement of the speed of a particular light beam yields the same answer regardless of the speed of the light source or the speed at which the measuring instrument is moving.

This rather bizarre experimental result is in contrast to what occurs in Galilean relativity. If two cars pass a pedestrian standing on a curb, one at 20 m s^{-1} and the other at 50 m s^{-1}, the faster car appears to be moving at 30 m s^{-1} relative to the slower car. However, if a light beam moving at 3×10^8 m s^{-1} passes an interstellar spaceship moving at 2×10^8 m s^{-1}, then the light beam appears to occupants of the spaceship to be moving at 3×10^8 m s^{-1}, not 1×10^8 m s^{-1}. Furthermore, if the spaceship beams a light signal forward to its (stationary) destination planet, then the resulting beam appears to be moving at 3×10^8 m s^{-1} to instruments at the destination, not 5×10^8 m s^{-1}.

The fact that we are talking about light beams is only for convenience. Any other means of sending a signal at the maximum allowed speed would result in the same behavior. We therefore cannot seek the answer to this apparent paradox in the special properties of light. Instead we have to look to the basic nature of space and time.