1.9 Einstein's relativity

In 1905 the framework of the classical world, the assumption that distances and times were universally consistent came to an end. Albert Einstein derived a new theory. In classical physics space is the framework that allows you to determine the distances between things. It was long understood that something had to change for the theory of motion to be consistent. In classical physics this freedom to change was inherent in the speed of things. Einstein realized that for the theory of electromagnetism of Maxwell to be consistent the speed of light had to be the same for everyone, no matter how fast they were moving. This seems a strange idea, but if it were not true then someone riding a light wave would experience light coming to a stop, and this is not consistent with reality. Thus, Einstein reasoned, it is space and time that are free to change. In fact we understand that space and time are so interconnected that one depends upon the other in what we now call *spacetime*.

The ramifications of this theory, what we call the *special theory of relativity*, are so far-reaching that we cannot give it justice in this small section. Special relativity made it apparent that spacetime was an active participant in all of physics, it was not simply a coordinate system that stayed fixed as a background. It is understood that there is a property of matter that represents its ability to avoid changing its motion that we call mass. One consequence of the special theory of relativity is the direct connection between the mass of an object and a quantity of energy that it has within it. Thus it is now understood that mass and energy have an equivalence.

This idea was expanded to include the notion that spacetime becomes distorted by the presence of mass and/or energy. This distortion is what we understand to be gravity. This idea is the basis for the *general theory of relativity*. The general theory of relativity turns out to be the best theory we have for describing the classical world of the very large. By the very large we mean on the scale of planets, stars, galaxies, and the universe itself.