14.5: Gauge Theories and Other Theories

The theory of potential momentum is only one of three ways in which the idea of potential energy can be extended to the relativistic case. This theory is called **gauge theory** for obscure historical reasons. Gauge theory is important because electromagnetism as well as the theories of weak and strong sub-nuclear interactions are all of this type.

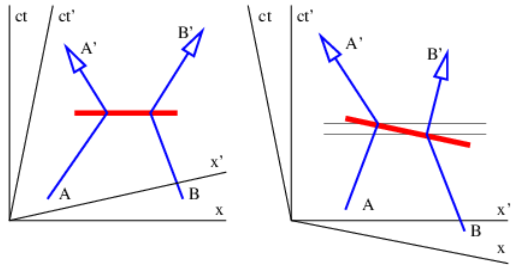

Figure 14.5.4:: The trouble with action at a distance. View of the remote exchange of four-momentum from the point of view of two different coordinate systems. The fat line in both pictures is the line of simultaneity in the unprimed frame which is coincident with the exchange of four-momentum between the two particles.

Gravity is the only fundamental force that does not take the form of a gauge theory. Instead, gravity takes the form of one of two other possible relativistic extensions of potential energy. This theory is called general relativity. The gravitational force in general relativity can be interpreted geometrically as a consequence of the curvature of spacetime. Mathematically, it is far too difficult to pursue here.

The third relativistic extension of potential energy considers potential energy to be a field which alters the rest energy of particles. High energy physicists believe that the elementary particles gain their mass by this mechanism. The field is called the **Higgs field** after the English physicist who first proposed this theory, Peter Higgs. The recent discovery of the Higgs boson at CERN's Large Hadron Collider in Geneva, Switzerland supports this idea.