

Intro to Lecture 25

(Dec. 7, 2016)

Last time we explored special relativistic formulations for the electric current density and the energy-momentum tensor and their conserved charges.

In his first (special) relativity paper of 1905, Einstein explained that the interaction between a conductor and a magnet in relative motion could be explained in either rest frame, but with different explanations, and then surely a single explanation should apply to both, but this required a modification of the relativistic transformation of space-time. Today we will turn to the equivalence principle, Einstein's assertion that gravity can be viewed as a pseudoforce due to being in an accelerating reference frame. This will require an even more radical change in our understanding of space-time. First we will show that geometry is not flat even without GR as long as noninertial frames are allowed, by looking at a rotating turntable. Then we will use the equivalence principle to show that time is affected by gravity. We will formalize the equivalence principle to say that at any point in spacetime, the coordinates of a freely falling observer is as if inertial at that point, with no gravity. We will examine what that means in terms of a more general chart, with vierbeins as transition functions, and how the freely falling observer is following the geodesic equation we derived in Lecture D (5). We will then see how the metric describes Newtonian gravity, and in the process derive the gravitational red shift.

Probably on Friday, we will turn to the question of parallel transport, or really the question of whether two vectors at nearby points are the same or not. This will define the covariant derivative, which we will generalize to act on any tensor field. We will also describe the analogue in electromagnetism, where the covariant derivative involves the vector potential A^μ , and perhaps even consider non-Abelian gauge theory, where the $A^\mu(x)$ is not a real number but a generator of a group transformation. In both cases, considering the integral of the covariant derivative around an infinitesimal loop gives a variation by the field strength 2-form \mathbf{F} or tensor $F^{\mu\nu}$. Following the analogue back to space-time, we will see how the curvature $R^\mu{}_{\nu\rho\sigma}$ is analogous to $F^{\mu\nu}$.

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- classes left: Friday Dec. 9 at 1:40, Wednesday Dec. 14 at noon.
 - homework #11 due Monday Dec. 12 at 5:00 as usual.
 - final exam Dec. 20 at 8:00 AM in our usual room, Hill 009. I will try to be more reasonable about the timing, but the exam is three hours. We need to discuss what you can use.