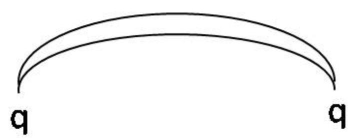
Lecture Topics

- Announcements, introduction
- Lorentz transformations
- Light-cone coordinates

Reading: Zwiebach, Sections 2.1-2.3

Strings at Many Scales

Classical strings, cosmic strings
QCD strings, gluons or flux tubes hold quarks together as qq^+



Flux tube - String of 0.2 fm
AdS/CFT
Anti-desiltem/conformal field theory

Fundamental Strings
Standard model of particle physics, cosmology, inflation
Zero thickness, mass, measure

Relativistic Strings

Intervals:

$$(ct, x, y, z) \equiv (x^0, x^1, x^2, x^3) \equiv x^\mu$$

	S	S^1
Event 1	x^μ	x'^μ
Event 1	$x^\mu + \Delta x^\mu$	$x'^\mu + \Delta x'^\mu$

$$-\Delta s^2 = -\Delta x^{0^2} + \sum_i \Delta x^{i^2} = g_{\mu v} x^v = x_\mu x^v \quad = -\Delta x'^{0^2} +_i \Delta x'^{i^2} = -\Delta s^{i^2}$$

$$\Delta s^2 = \Delta s^{i^2}$$

$$\Delta s^2 = \begin{matrix} > 0 & \text{timelike separated} \\ = 0 & \text{lightlike separated} \\ < 0 & \text{spacelike separated} \end{matrix}$$

Again, the interval:

$$-ds^2 = \eta_{\mu v} dx^{\mu} dv^{v}$$

$\eta_{\mu v}$ symmetric by definition:

$$\eta_{\mu v} = \begin{pmatrix} -1 & & & \\ & 1 & & \\ & & 1 & \\ & & & 1 \end{pmatrix}$$

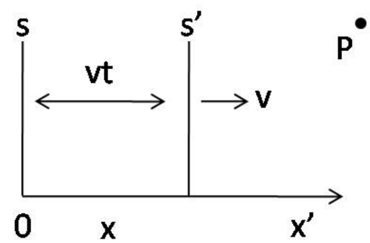
$$a^{\mu} \to a_{\mu} = \eta_{\mu v} a^{v} \forall a$$

Given a^{μ}, b^{μ}, $a \cdot b = a^{\mu} b_{\mu} = \eta_{\mu v} a^{\mu} b^{v}$
Inverse metric: $\eta^{\mu v} = (\eta_{\mu v}^{-1})$

$$\eta^{v\rho}\eta_{\rho\mu} = \delta^{v}_{\mu}(\text{summed over } \rho)$$

$$\eta^{\rho\mu} b_{\mu} = \eta^{\rho\mu}\eta_{\mu v} b^{v} = \delta\rho_{v} b^{v} = b^{\rho}$$

Lorentz Transformation:



$$\beta = \frac{v}{c}; \gamma = \frac{1}{\sqrt{1-\beta^{v}}}$$

$$\begin{aligned} x' &= (x - \beta ct)\gamma \\ y' &= y \\ z' &= z \\ ct' &= \gamma(ct - \beta^{x}) \end{aligned}$$

$$\begin{aligned} x^{0'} &= \gamma(x^0 - \beta x^1) \\ x^{1'} &= \gamma(-\beta x^0 + x^1) \\ x^{2'} &= x^2 \\ x^{3'} &= x^3 \end{aligned}$$

A linear invertible transform between x^μ and x'^μ that satisfies $\Delta s^2 = \Delta s'^2$

$$x'^\mu = L^\mu_v x^v$$

L is a Lorentz transfer of $L^T \eta L = \eta$

Light cone coordinates:

$$x^0, x^1, \quad \underbrace{x^2, x^3}_{\text{Keep these two}}$$

$$x^+ = \frac{1}{\sqrt{2}}(x^0 + x^1)$$

$$x^- = \frac{1}{\sqrt{2}}(x^0 - x^1)$$

$$x^\pm = \frac{1}{\sqrt{2}}(x^0 \pm x^1)$$