3/31/16 Lecture 2 outline

• Review: $x^{\mu'} = \Lambda^{\mu'}_{\nu} x^{\nu}$ and inverse. $ds^2 = ds'^2$ and metric. $ds^2 = c^2 d\tau^2$ for timelike. 4-vectors more generally. Examples: p^μ, k^μ, $u^\mu = dx^\mu/d\tau$, j^μ, $A^\mu = (\phi, \vec{A})$. Upper and lower indices, and 4-dot products, example of ∂_μ and conservation $\partial_\mu j^\mu = 0$. Invariance of d^4x and $j^0 d^3x$. (Some asides on $g_{\mu\nu}$ in GR vs $\eta_{\mu\nu}$ here.)

• $S = -mc^2 \int d\tau$ and L for relativistic particle. Relativistic charged particle $S \supset -(q/c) \int A_\mu dx^\mu$ and term in $L \supset -q\phi + (q/c)\vec{v} \cdot \vec{A}$. Canonical momentum $\vec{p} = \partial L/\partial \vec{v} = \gamma m\vec{v} - q\vec{A}/c$ and $H = \vec{p} \cdot \vec{v} - L = \gamma mc^2 - q\phi$ (magnetic fields do no work). But H should be expressed in terms of $\vec{p}$.

• QM: replace $\widehat{p}^\mu \to i\hbar\partial^\mu$ in position space. Consider the S.E.

• Punchline: in non-rel limit get $i\hbar D^0\psi = (\hbar^2/2m)\vec{D}^2\psi$, where $D^\mu \equiv (D^0, \vec{D}) = \partial^\mu - (q/i\hbar c)A^\mu$.