4/5/16 Lecture 3 outline / summary

• Last time: Get $p^\mu \to p^\mu - (q/c)A^\mu$ when a charged particle is in an $\vec{E}$ and $\vec{B}$ field. For QM, $p^\mu \to i\hbar\partial^\mu$ in position space, so get e.g. $i\hbar D^0\psi = (-\hbar^2/2m)\vec{D}^2\psi$, where (punchline) $D^\mu \equiv (D^0, \vec{D}) = \partial^\mu - (q/i\hbar c)A^\mu$ is the covariant derivative.

• $S = \ldots - q/c \int A_\mu dx^\mu$ and gauge invariance.

• Gauge transformations and local $U(1)$ phase rotation of ψ.

• Path integral description of QM, solenoids and observability of flux inside. Dirac's magnetic monopoles and quantization rule.

• Klein Gordon theory, SHO, and charged Klein Gordon theory. Covariant derivatives and minimal substitution. Euler Lagrangian equations for field theory.

• $S = \int d^4x(-1/4)F_{\mu\nu}F^{\mu\nu} - j^\mu A_\mu/c$.

• Dirac equation and Lagrangian