4/5/16 Lecture 3 outline / summary

- Last time: Get $p^\mu \rightarrow p^\mu - (q/c)A^\mu$ when a charged particle is in an $\vec{E}$ and $\vec{B}$ field. For QM, $p^\mu \rightarrow i\hbar \partial^\mu$ 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 $\psi$.
- Path integral description of QM, solenoids and observability of flux inside. Dirac’s magnetic monopoles and quantization rule.


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