4/17/17 Lecture 5 outline

- Where we left off last time: Klein Gordon theory, SHO, and Euler Lagrange equations for field theory.

- Charged Klein Gordon theory via $D^\mu = \partial^\mu + iqA^\mu$ covariant derivatives and minimal substitution.

- Spin 1: theory are gauge fields. Example: $S = \int d^4x (-1/4) F_{\mu\nu} F^{\mu\nu} - j^\mu A_\mu/c$.

- Quantization: quantum field in terms of creation and annihilation operators. For KG field,

$$\phi = \int \frac{d^3k}{(2\pi)^3 2\omega_k} (a_k e^{-ikx} + a_k^\dagger e^{ikx})$$

where $[a_k, a_k^\dagger] = (2\pi)^3 2\omega_k \delta^3(k - \vec{k}')$. The fields have $[\phi(\vec{x}, t), \Pi(\vec{y}, t)] = i\delta^3(\vec{x} - \vec{y})$, where $\Pi = \dot{\phi}$.

- Quantize spin 1, photon creation and annihilation operators

$$A_\mu(x) = \sum_{r=1}^2 \int \frac{d^3k}{(2\pi)^3 (2\omega_k)} [a_k^r e_{\mu}^re^{-ikx} + a_k^r^\dagger e_{\mu}^r e^{ikx}] .$$