Historical background and experiments

- 19th century, electromagnetic
  - classical mechanics
  - classical electrodynamics
  - classical statistical mechanics

- Determinism vs. Free Will
- Experiments (cannot be explained by classical physics)
  - atomic nuclear physics

1. Stable atomic model
   - classical electrodynamics
     - charge with acceleration $\Rightarrow$ EM radiation
     - collapse of electrons $\Rightarrow$ continuous spectrum
   - Bohr's hydrogen atom
     - ground state $E_i = E_{n_i}$, $E_1 = -13.6 \text{ eV}$
     - electron, discrete

2. Black body radiation (thermal radiation)
   - Thermal radiator
     - visible light $350 \text{ nm} - 700 \text{ nm}$
   - Planck's radiation law
     - Wien Displacement Law
       $\lambda \alpha T = b$ (1911 Nobel)
     - $E = \hbar \nu$
     - Planck constant
     - $\hbar = \frac{h}{2\pi}$, reduced Planck constant
     - Wien's law
       $\lambda = \frac{b}{T}$
   - CMB (Cosmic Microwave Background Radiation) $3 \text{ K}$
     - Penzias - Wilson, Bell Lab, 1978 Nobel

3. Photoelectric effect
   - $E = h(\nu - \nu_0)$
   - Einstein 1921 Nobel
   - photo-multiplier, scintillation detector

4. Compton scattering
   - 1923 Nobel with Wilson
   - $E_0$, $E'$, $E_x$
   - $\cos \theta = \frac{m_e c^2}{E_0 - E'}$
   - momentum conservation $p_x = p_x' + \frac{m_e c^2}{\sqrt{1 - \frac{v^2}{c^2}}}$
   - energy conservation $h\nu + m_e c^2 = h\nu' + m_e c^2$
   - $\Delta \lambda = \lambda' - \lambda = \lambda_c (1 - \cos \theta)$, $\lambda_c = \frac{2.426 \times 10^{-6}}{\text{m}}$
   - Compton shift $\Delta \nu$
   - Compton wavelength