

Chapter 12

Fundamental Particles and Interactions

12.1 How Forces Act

- What is a *mediating particle* and how is it related to forces?
- Why are such particles considered to be *vertical particles*?
- Why would a mediating particle's mass limit its range?

12.2 Antiparticles

- What is the difference between a particle and its *antiparticle*?
- If e^- is the symbol for an electron, what two symbols might we use for a positron?
- What is the *Klein-Gordon equation*? How is it similar to the Schrodinger equation, and how different?
- What is the difference between the Klein-Gordon equation and the *Dirac equation*?
- Explain the problems of “negative energy” and “negative density” with respect to the Klein-Gordon equation.
- Explain how an antiparticle may be thought of as a “hole”? (A hole in what?)

12.3 Forces And Particles: How Many?

- What is *quantum electrodynamics*?
- What are the three fundamental interactions?
- What would the *unified theory* do?

The Strong Force

- What are *quarks*? What holds them together?
- What are the six types of quarks, and their charges?
- What are protons and neutrons comprised of?
- What are *hadrons*?

- How does the strong force change when two quarks are separated?
- What happens if you succeed in pulling two quarks apart?
- How do we know quarks exist, and have nonintegral charge?
- What is a *gluon*? What is its mass and spin? Boson or fermion?
- Why do gluons have such a short range?
- What is *color*? How many types of color are there?
- What colors can gluons have?
- What colors can a hadron have?
- What is *quantum chromodynamics*?
- Explain how the existence of the Δ^{++} particle (three identical up quarks) argues for the existence of color.
- Why does a proton have a much larger mass than its component quarks?
- What are *baryons* and *mesons*? Give an example of each. What are their possible spins?
- What is the *residual strong force*? Why is it important? Why does it explain the limited range of the strong force in the nucleus?

The Electroweak Force

- What are *leptons*? How many are there?
- What are the *weak bosons*? When are they equivalent to the photon?
- Which leptons have *weak charge*?
- What is the *Standard Model*?
- What does the *Higgs boson* do?

12.4 Particle Production and Detection

- What was the first subatomic particle detected?
- What is a *particle accelerator* used for?
- What is a *synchrotron*?
- What is a *scintillation counter* and how does it work?
- What is a *multiwire proportional counter* and how does it work?
- How about a *Cerenkov detector*?

12.5 Decay Modes and Conservation Rules in the Standard Model

- Which fundamental particles are stable?
- What is *baryon number*? When is it conserved?
- What is *lepton number*? When is it conserved?
- What is *strangeness*, and when is it conserved?

Feynman Diagrams

- What is a *Feynman diagram*?
- What is a *vertex*?
- How are fermions and bosons represented?
- What kinds of fermions interact with a gluon? How do they change?
- What kinds of fermions interact with a photon? How do they change?
- What kinds of fermions interact with a W^\pm boson? How do they change?
- What kinds of fermions interact with a Z^0 boson? How do they change?
- How do you represent pair creation or annihilation with Feynman diagrams?

- How does the decay time differ for electromagnetic decays, weak decays, and strong decays?
- What is a *resonance*?

12.6 Parity, Charge Conjugation, and Time Reversal

- What do we mean by *parity inversion*?
- What do we mean by *charge conjugation*?
- What do we mean by *time reversal*?
- When is parity symmetry violated?
- When is charge conjugation symmetry violated?
- What is *CP symmetry*?
- What is the *CPT theorem*?

12.7 Unified Theories and Cosmology

- What is a *GUT*? A *TOE*?
- What does a GUT have to do?
- What are three predictions that GUTs have made?
- What does *superstring theory* do?
- What is *supersymmetry*?
- What happened when the early universe cooled to 3000 K? What sign do we have that this occurred?
- What does the *Friedmann equation* describe, and what other equation does it resemble?
- What problem does the *inflation* hypothesis solve?