Wednesday, October 17
Ford Chs: 6&7

Agenda

• Announce:
  – Read Chs. 8 & 9
  – Project Ideas due by Halloween
  – Another project idea: Modern Physics in Modern Medicine
• Ch. 6
• Ch. 7

Probability Pre-Quantum

• Physicists accepted probability even before quantum mechanics, but where? And how was it “different” from that in QM?

Probability In QM

• Can be computed precisely
• All that one can compute…fundamentally limited in ability to predict (nondeterministic universe)
• Mathematics describes a probability wave
• Examples:
  – Jumps of electron to different states
  – Radioactive decays

Radioactivity

• Geiger counter makes activity at the level of the nucleus apparent!
• Characterized by half-life
• Wide range of half-lives
• All unstable particles follow same exponential curve

Nuclear Waste (spent fuel)

• Lots of nasty radioactive material left over from nuclear reactors
• Half-lives of years to hundreds of years
• Can’t fix chemically
• Essentially never safe
• Need nuclear furnace (e.g. Sun, nuclear reactor)
Quantum Tunneling

- Object can pass through barriers which classically they could not

Uncertainty Principle

- Fundamental limit to how well we can “know” certain pairs of quantities
- The better you know one, the less well you know the other
- E.g. position/momentum or energy/time
- Already saw when trying to compress electrons…so knew where they were meant we knew little about momentum
- Will see later on in the book (w/ waves)

Is quantum probability real or just reflect our ignorance?
### Fermion/Boson
- Fermions—half-odd-integer spin (e.g. electron, proton, neutron)
- Bosons—integer spin (e.g. photon)
- Very different behavior

### Quantum States
- Particles can be in specific states
- Such states have specific, quantized values for certain physical quantities (even if their motions are “fuzzy”)
- Each state has certain quantum numbers \((n, \ell, m)\)

### Pauli’s Exclusion Principle
- No two fermions exist in the same state
- No two fermions share the same quantum numbers
- Predicted a fourth quantum number for the electron, spin
- Responsible for chemistry, why?

### Bose-Einstein Condensate
- Einstein predicted that bosons, at low enough temperature, would share the same state
- Race in early 1990s to create one
- Won by Wieman and Cornell in 1995 (shared in the 2001 Nobel Prize)
- Practical applications?
  - Superfluidity
  - Atom lasers
  - Superconductivity

### Keys to QM so far…
- Interactions governed by?
- Interactions & Jumps determined by?
- Knowledge of these processes limited by?

### Keys to QM so far…
- Interactions governed by?
  - Fundamental particles
  - Absorbing and emitting force carriers
  - Following certain conservation laws
- Interactions & Jumps determined by?
  - Probabilities
- Knowledge of these processes limited by?
  - Uncertainty principle