Wednesday, October 31

Ford Final Chapter (10)

Agenda

- Announce:
  - Test Wednesday
  - Office Hours probably busy…better book appt.
  - Read Chs. 1-3 of Vilekin for class day after test
- Project Ideas
- Ch. 10
  - Superposition & Entanglement
  - Qbit
  - EPR
  - Delayed Choice

The Nature of the Quantum

- Introduces "unobservables" (e.g. wavefunction)
- Quantum effects seem:
  - distant (small stuff)
  - strange (probabilities)
  - against commons sense (e.g. tunneling)

…perhaps not to any lifeforms at atomic size

QM in Your Life

- Properties of materials (color, texture, hardness, transparency…why are somethings transparent?)
- Fluorescent lights
- Heat from interior of Earth
- Electron tunneling (circuits, STMs)
- Sun shining
- Superconductivity and SQUIDs
- MRI, modern medicine

Superposition

- Properties of objects (e.g. spin, momentum, position) are obtained from its wavefunction
- The answer one gets can be definite ($x=0$) or probabilistic (10% chance between $x=0$ and $x=10$)
- So an object could be described by a wavefunction which is the sum (I.e. superposition) of the wavefunctions for particles w/ momenta $+/-p$

The Measurement Problem

- What happens when we measure the momentum of object on previous slide?
- Does our equipment say "There is a 50% chance the momentum is $+p$"?
- Or does it say "The momentum is $+p$"?
- If the latter, what happens to the wavefunction?

Entangled States

- Multiple objects described by one state/wavefunction
- Electron annihilates with a positron producing two photons
- Photons must have opposite spin
- No way to tell which has "up" spin and which "down" until you measure
- Single state describes photon pair…they are said to be "entangled"
- Probability that left one has spin up is 50%

EPR Paradox/Measurement

- Take entangled photon pair and let photons fly apart to Alice in LA and Bob in NY
- Alice measures spin of her photon and gets "up"
- What will Bob measure?
- Can Alice send Bob information instantaneously?
- Einstein called this "spooky action at a distance"

spooky   action
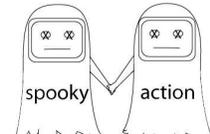
Qubit

- Classical Bit: 0 or 1 (off or on)
- Quantum Bit: some probability of being on

- For some problems
- With certain algorithms
- With difficult, new hardware
- Possibilities of tremendous speedup
- Fundamental CS questions

Delayed Choice
Paradox/Experiment

- Provide two paths for photons (1st base or 3rd base)
- Allow "decision" as to whether one can tell which path photon took
- If it's possible to tell, then no interference
- If impossible, then interference
- But, you can delay this decision until photon should have already traveled much of its path
- Our choice can't "affect the past" right?