Lecture #9 Thurs 25 Feb 2010 Relativity

Today: relativity Next: quantum mechanics Both began around 1900.

Michelson and Morley expt (1887) used an "interferometer" to measure differences in velocities in two different directions simultaneously. It failed to detect the ether.

Einstein and relativity
Some tentative "explanations" put forward by H. Poincaré (1897) and H. Lorentz (1904).
In 1905 a patent clerk (3rd class) wrote a clear and compelling explanation: Albert Einstein (1879-1955). As a teenager, Einstein imagined riding a beam of light

In 1905 Einstein took Galileo's thought experiment about ships and relative motino further: he postulated there is no way to do an experiment to measure absolute velocity. (For example, detection of the ether would constitute measuring absolute velocity.)
Today physicists say there is no preferred rest frame.
Einstein postulated that the speed of light would be the same for all observers.

If the speed of light is constant for everyone, then…two observers moving relative to each other cannot agree (even comparing with a beam of light) on how fast time passes.
In fact, they both think the other one's clock runs slower. (Time dilation)
They also think the other one's ruler is shorter (length contraction).

One can actually measure time dilation. The radioactive decay of subatomic particles act as a natural stopwatch (half-life).

The fixed Newtonian framework of space and time is incorrect.

Mass and *energy* are interchangeable: $E = mc^2$.

Another victim of relativity: *simultaneity*. Two observers moving relative to each other cannot agree if two events occurred simultaneously or not. (Important in *Timescape*.)

Summary of special relativity:
- Einstein did not invent it, but gave clearer arguments
- Deals only with observers with constant linear velocity
- "Cannot do an experiment to measure absolute velocity"
- Speed of light constant for everyone

Experimental evidence for special relativity:
- Michaelson-Morley experiment: failure to detect "ether"
- slowing of natural subatomic "clocks" (decay half-life) particles moving at high speed + others

Consequences of special relativity:
- Time dilation and length contraction (always for the other guy)
- Mass can be converted into energy and vice versa
- Cannot agree on simultaneity of events