Lecture 8: Special Relativity

Einstein came up with the theory of Special Relativity to make Maxwell's theory of electromagnetism compatible with the principle of the equivalence of inertial frames (remember Galilean relativity: the rules of physics are the same in all inertial frames).

See magnet and coil experiment.

Maxwell: The speed of light is the same in all directions.

i.e. **The speed of light in vacuum is independent of the velocity of an observer.**

The constancy of the speed of light is confirmed by experiments (Michelson-Morley). Galilean relativity cannot explain this result since relative velocities are additive.

In order to accommodate this, our picture of the three fundamental quantities of classical physics - **length, time and mass** - has to change.

Einstein's theory of Special Relativity results from two statements - the **two basic postulates of Special Relativity**:

- **The speed of light is the same for all observers, no matter what their relative speeds.**
- **The laws of physics are the same in any inertial (that is, non-accelerated) frame of reference.** This means that the laws of physics observed by a hypothetical observer traveling with a relativistic particle must be the same as those observed by an observer who is stationary in the laboratory.

Assumptions of galilean relativity:

- Laws of physics are unchanged in all inertial frames of reference

- the rate at which time passes is also unchanged in all frames of reference.

Assumptions of special relativity:

- Laws of physics are unchanged in all inertial frames of reference

- the speed of light in vacuum is also unchanged when measured in all inertial frames of reference.

- The Principle of Relativity – The laws by which the states of physical systems undergo change are not affected, whether these changes of state be referred to the one or the other of two systems in uniform translatory motion relative to each other.

- The Principle of Invariant Light Speed – "... light is always propagated in empty space with a definite velocity [speed] *c* which is independent of the state of motion of the emitting body." That is, light in vacuum propagates with the speed *c* (a fixed constant, independent of direction) in at least one system of inertial coordinates (the "stationary system"), regardless of the state of motion of the light source.

OR

Special principle of relativity: If a system of coordinates K is chosen so that, in relation to it, physical laws hold good in their simplest form, the *same* laws hold good in relation to any other system of coordinates K' moving in uniform translation relatively to K