Tutorial-9
PH101

1)Let us consider the Michelson-Morley experimental set up as shown schematically in figure 1. The light source is the sun to the left of the figure. The light from the source is split by the partially silvered mirror placed at $O$. The two light beams then go to the good mirrors located at A and B. The beams are then reflected back from the mirrors and interfere. Depending on the path difference of the interfering beams an interference pattern can be observed. The experimental set up along with the observer are moving away from the sun with a velocity $v$.
(i) Assuming Newtonian relativity, calculate the following,
(a) The time taken by the light beam I to travel from $O$ to $A$ and back ?
(b) The time taken by the light beam II to travel from $O$ to $B$ and back ?
(c) The difference in transit times in (a) and (b) ($\Delta T$). A non-zero time difference will give us interference pattern.
(d) Suppose the instrument is rotated through $90°$, hence, the role of $l_1$ and $l_2$ will get interchanged. Find out the difference in transit time ($\Delta \bar{T}$) in the new setup. Hence, calculate $\Delta T - \Delta \bar{T}$, which is proportional to the shift in fringe pattern.
(ii) Show that no shift in the fringe pattern will be observed if we include the relativistic effects.

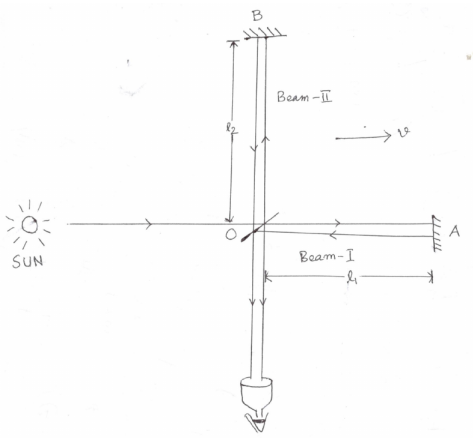


Figure 1:

2) An event occurs in $S$ at $x = 6 \times 10^8$ m, and in $S'$ at $x' = 6 \times 10^8$ m and $t' = 4$s. Find the relative velocity of the system.

3) Any quantity which is left unchanged by the Lorentz transformation is called Lorentz invariant. Show that $\Delta s$ is a Lorentz invariant which is given by

$$\Delta s^2 = -c^2 dt^2 + dx^2 + dy^2 + dz^2,$$

where $dt$ is the time interval between two events and $\sqrt{dx^2 + dy^2 + dz^2}$ is the distance between them in the same inertial frame.

4) A young man voyage to the nearest star, $\alpha$ Centouri, 4.3 light years away. He travels in a spaceship at a velocity of $c/5$. When he returns to earth, how much younger is he than his twin brother who stayed home ?