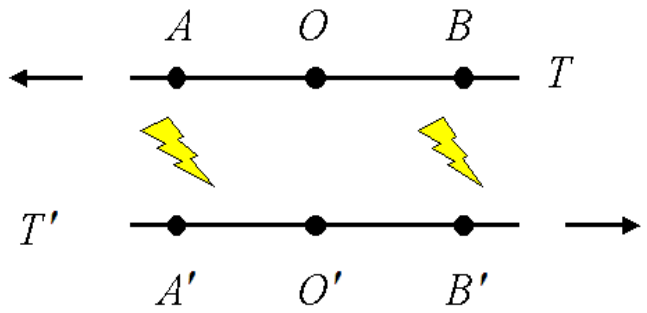
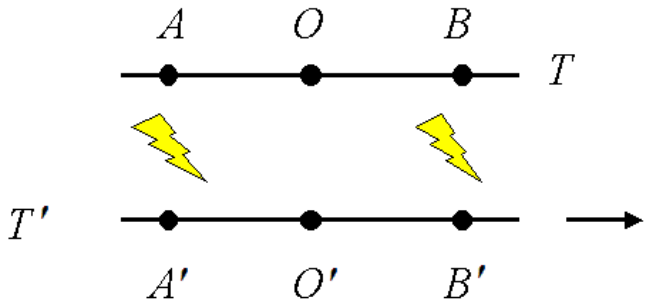
2.4 Relativity of Simultaneity

Note. Suppose two trains T and T' pass each other traveling in opposite directions (this is equivalent to two inertial frames moving uniformly relative to one another). Also suppose there is a flash of lightning (an emission of light) at a certain point (see below). Mark the points on trains T and T' where this flash occurs at A and A' respectively. "Next," suppose there is another flash of lightning and mark the points B and B'. Suppose point O on train T is midway between points A and B, AND that point O' on train T' is midway between points A' and B'.

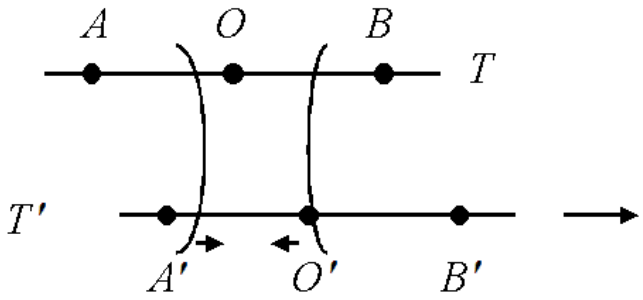


Suppose an observer at point O sees the flashes at points A and B occur at the same time. From the point of view of O the sequence of events is:

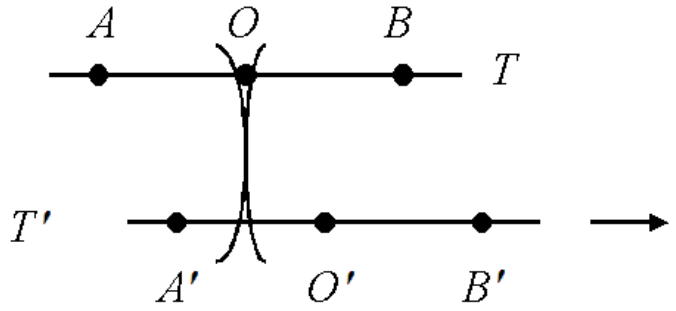
(1) Both flashes occur, A, O, B opposite A', O', B', respectively



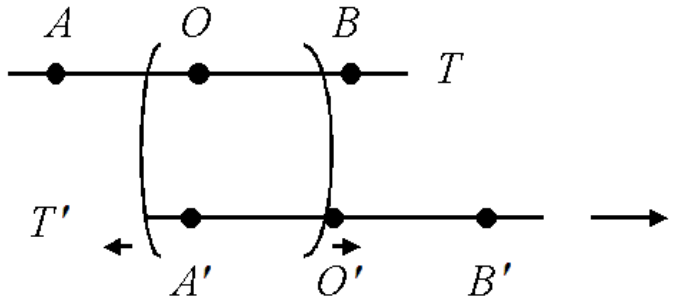
(2) Wavefront from BB' meets O'



(3) Both wavefronts meet O

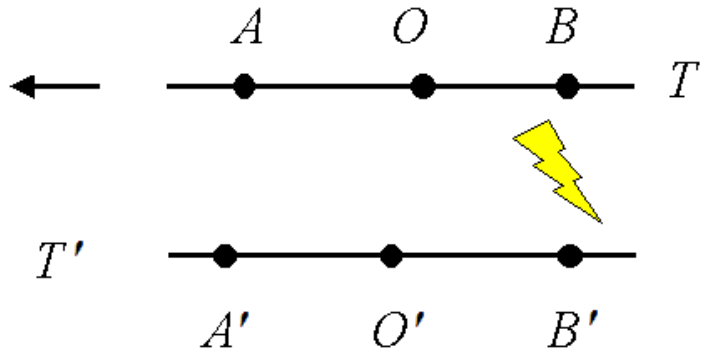


(4) Wavefront from AA' meets O'

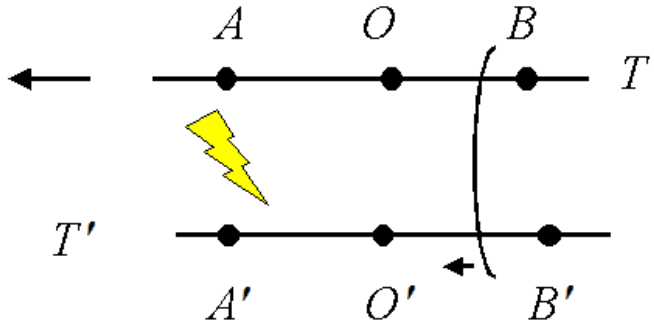


From the point of view of an observer at O', the following sequence of events are observed:

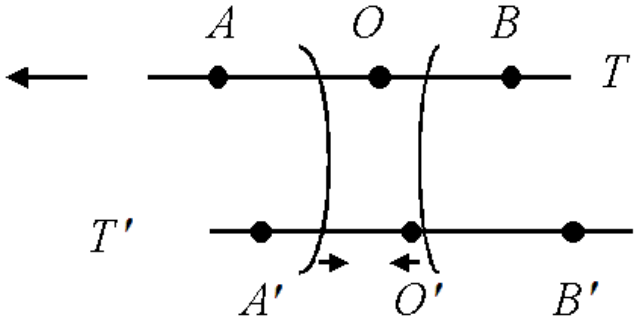
(1) Flash occurs at BB'



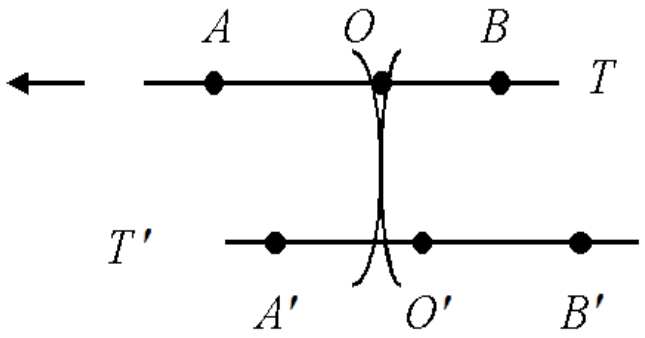
(2) Flash occurs at AA'



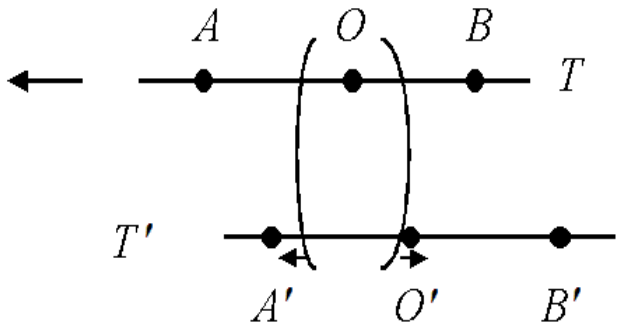
(3) Wavefront from BB' meets O'



(4) Wavefronts from AA' and BB' meet O



(5) Wavefront from AA' meets O'



Notice that the speed of light is the same in both frames of reference. However, the observer on train T sees the flashes occur simultaneously, whereas the observer on train T' sees the flash at BB' occur before the flash at AA'. Therefore, events that appear to be simultaneous in one frame of reference, may not appear to be simultaneous in another. This is the *relativity of simultaneity*.

Note. The relativity of simultaneity has implications for the measurements of lengths. In order to measure the length of an object, we must measure the position of both ends of the object *simultaneously*. Therefore, if the object is moving relative to us, there is a problem. In the above example, observer O sees distances AB and $A'B'$ equal, but observer O' sees AB shorter than $A'B'$. Therefore, we see that measurements of lengths are *relative*!

Revised: 6/24/2019