The relativity of simultaneity

Suppose you are inside of a train moving left with a constant speed v. From your point of view, when the time t is 0, light is emitted at the middle of the train. See Fig. 1. From your perspective, the train is not moving, and you will never know whether the train is moving or not unless you look outside the window. Therefore, you will think that the light reach the two ends of the train, A and B, at the same time when $t = t_0$, as the light has to travel the equal distance.

Suppose your friend is outside of a train. From her perspective, when the time t' is 0, light is emitted at the middle of the train. Does she think that the light reaches the two ends of the train at the same time as well? See Fig. 2. No. At $t = t_1$ the light emitted from the middle reaches B, but not A yet; as the train is moving left, the distance that light has to travel to reach B is smaller than the distance that light has to travel to reach A.

Therefore, what is simultaneous to you is not simultaneous to your friend. This is the relativity of simultaneity. The notion of simultaneity depends on an observer's moving velocity. Notice that the constancy of the speed of light was crucial to arrive at this conclusion. Let's suppose that the speed of light were not constant, and non-relativistic Newtonian mechanics were obeyed. Then, for an outside observer like your friend, the speed of light traveling toward A would be given by $c+v$ while the speed of light traveling toward B would be given by $c-v$, if the speed of light measured inside the train is c. Then, despite the fact the distance that light has to travel to reach B is smaller than the one to A, the light would reach the both ends at the same time as the light would travel to B at a slower speed than it would travel to A.

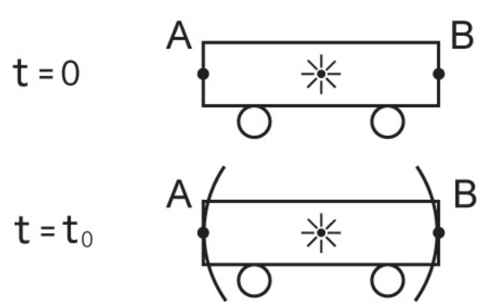

Figure 1: clock at rest

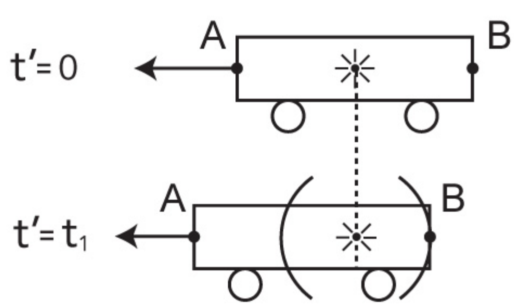

Figure 2: moving clock

Summary

- The simultaneity is not absolute. It depends on the motion of observer.