

# The train experiment in Einstein's Theory of Relativity

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## Basics:

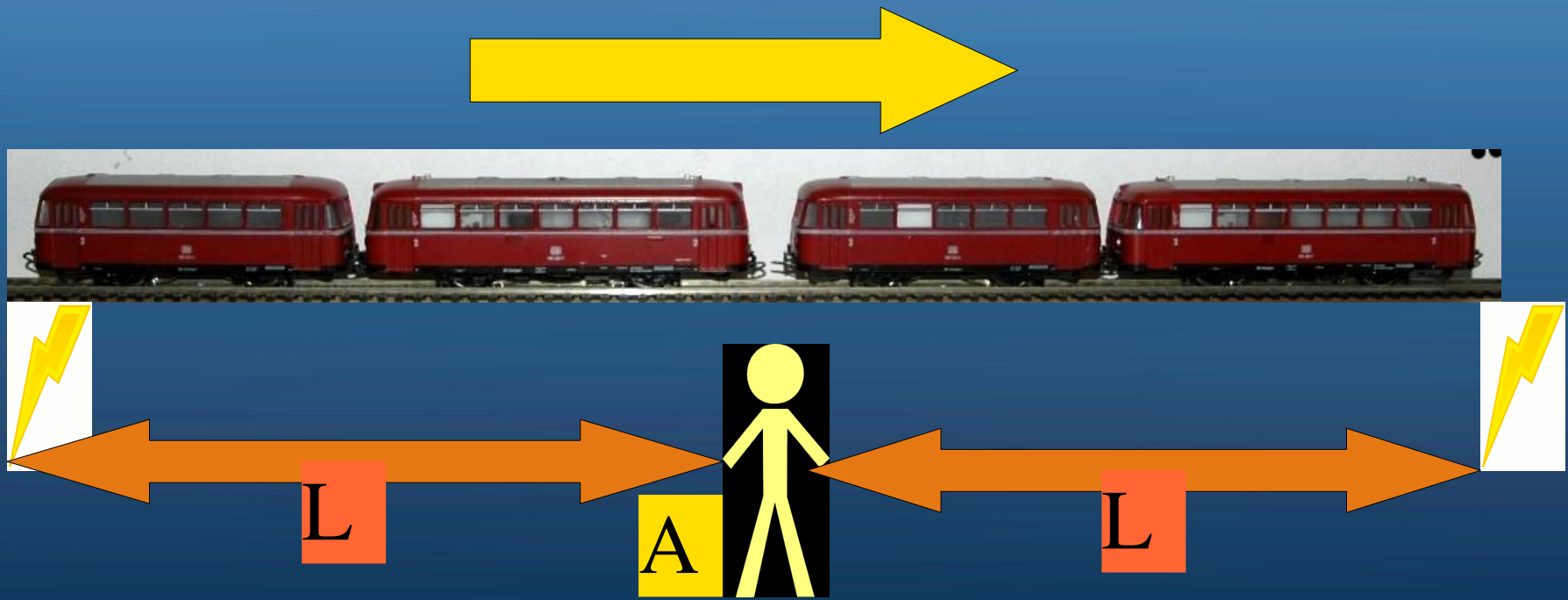
**1. The speed of light is constant =  $c$   
independent from:**

- motion of the observer**
- motion of light source**
- direction of light**

**2. All observers have equal rights.  
There is no absolute motion. One  
observer moves relative to another one.**

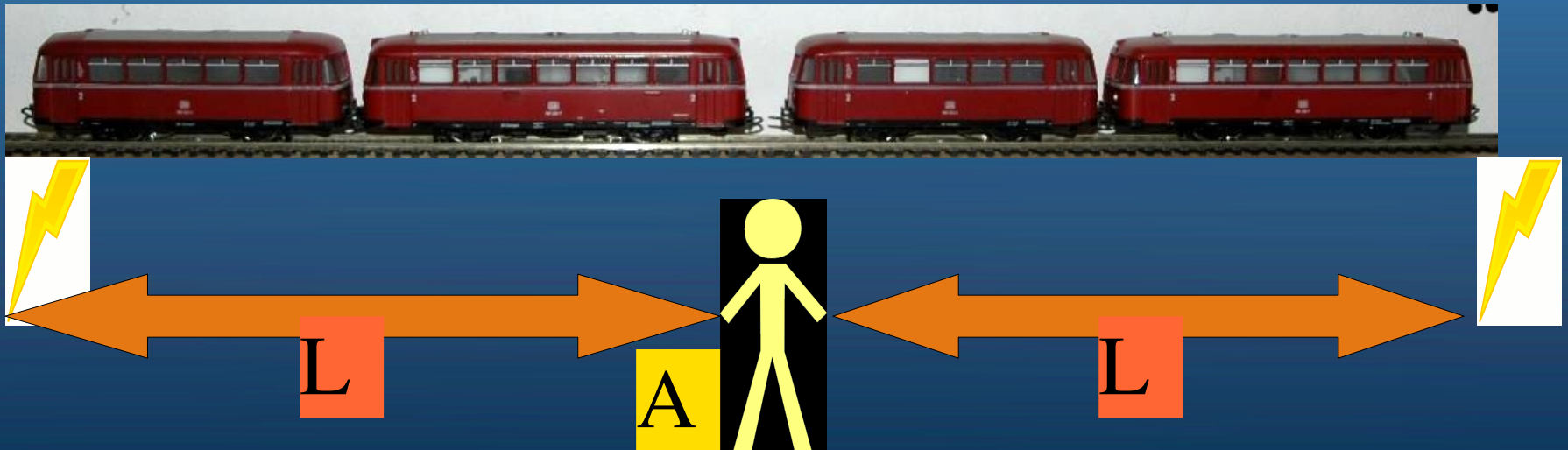
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- Train moves to the right
- Two lightnings at the train's heads hit the ground
- Observer A rests on ground in the mid between the lightnings



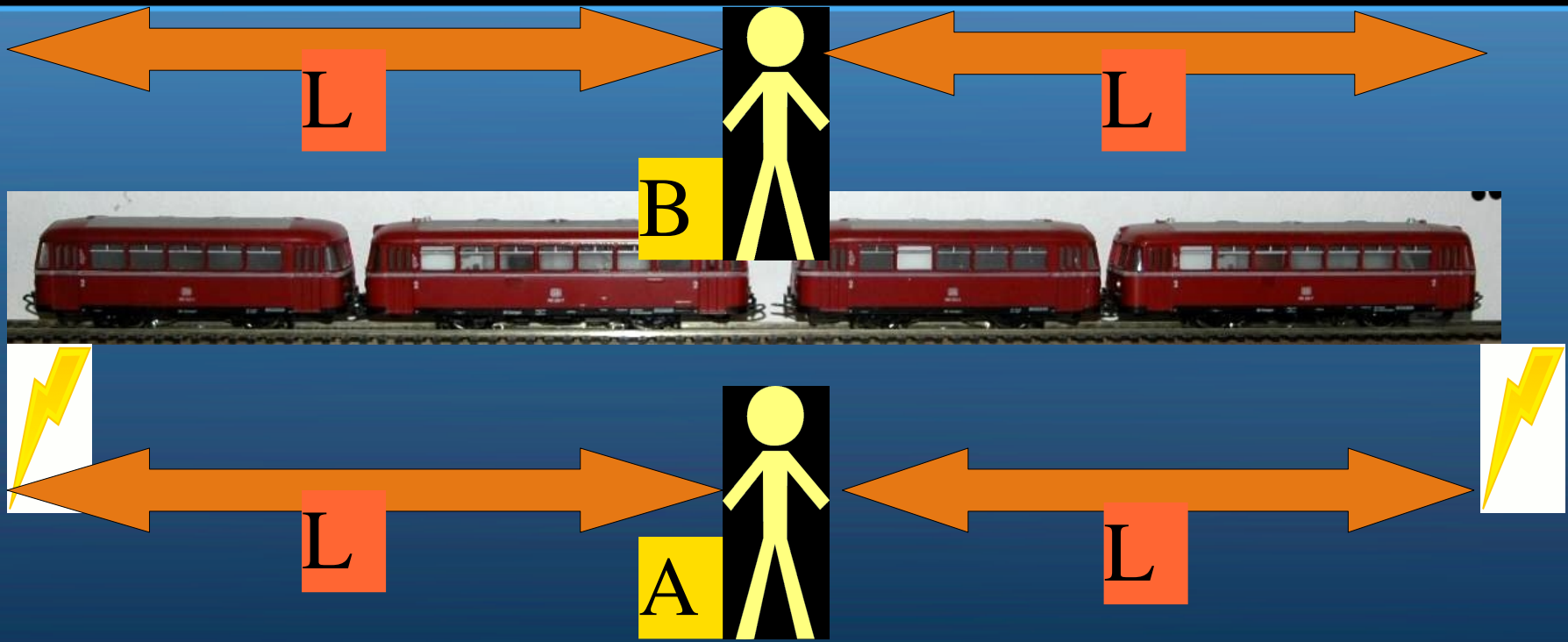
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- A **VIEW**S the lightnings simultaneously
- The distances  $L$  to the lightnings being equal and light speed ( $=c$ ) equal from both, A **CONSIDERS** them to be simultaneous



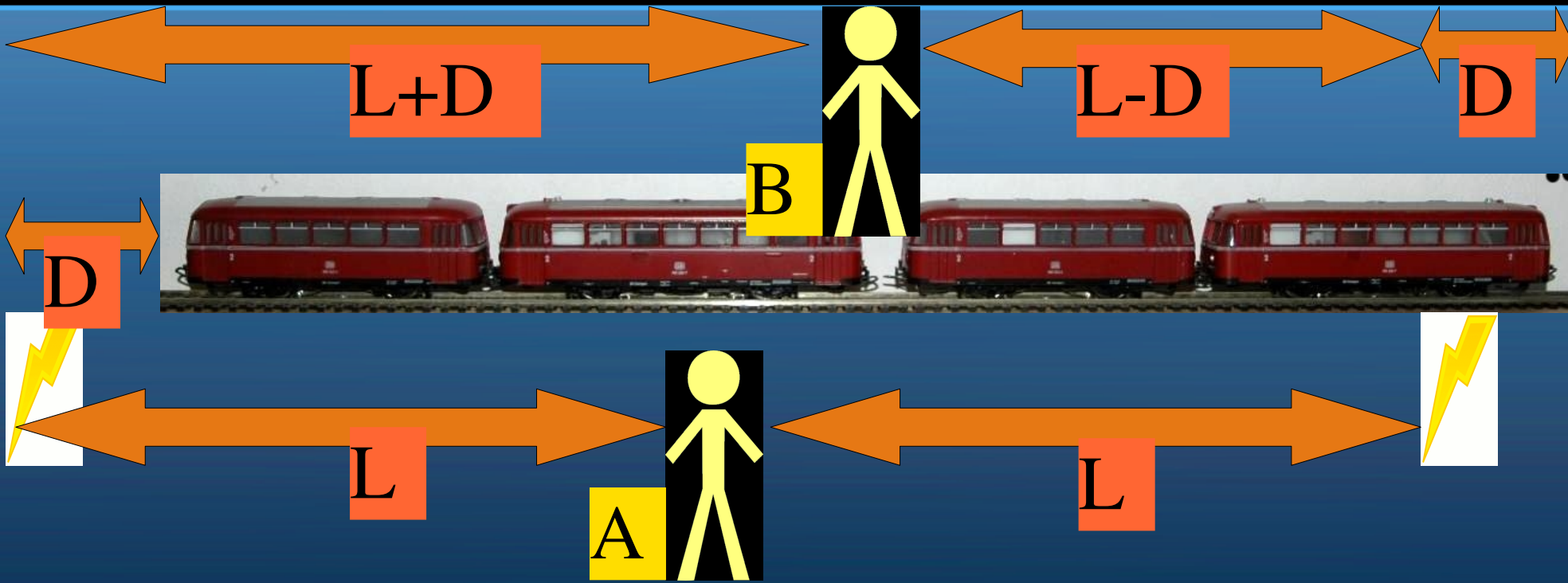
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- Observer B rests in the mid of the train
- When the lightnings hit the ground, B is at same distance ( $=L$ ) from them



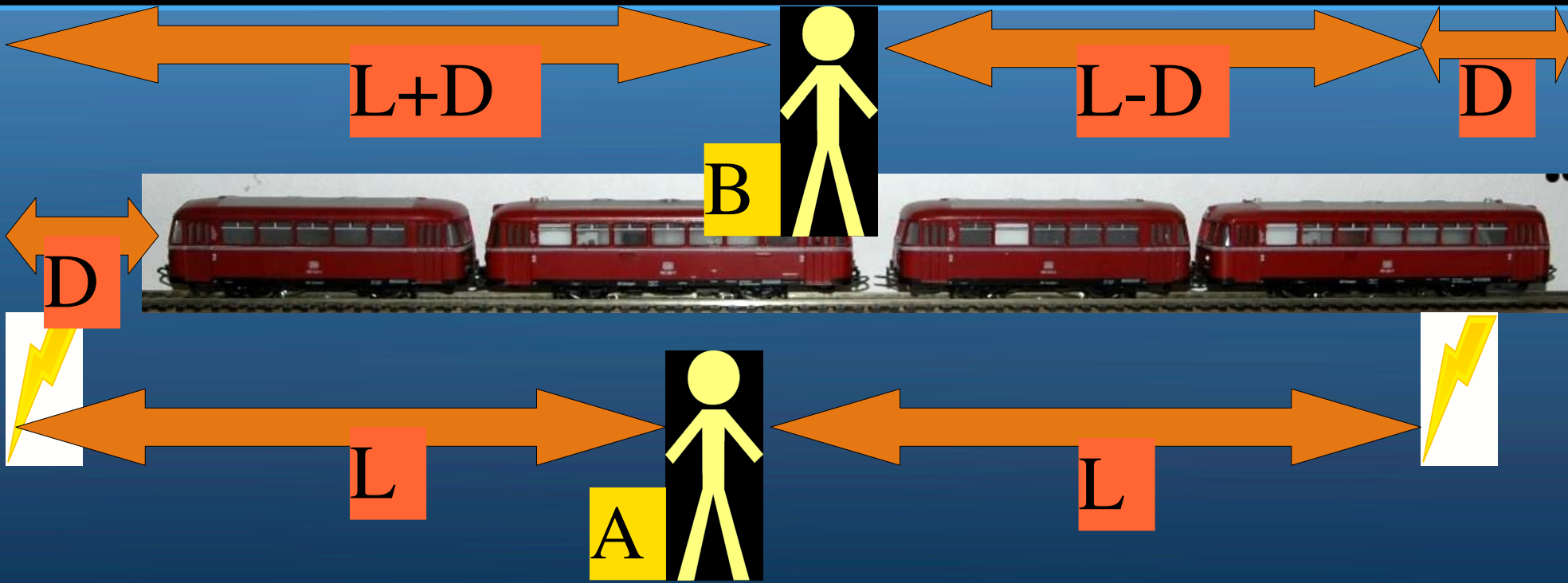
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- B VIEWS the right lightning after some time  $t > 0$
- During  $t$  the train has moved a distance  $D > 0$

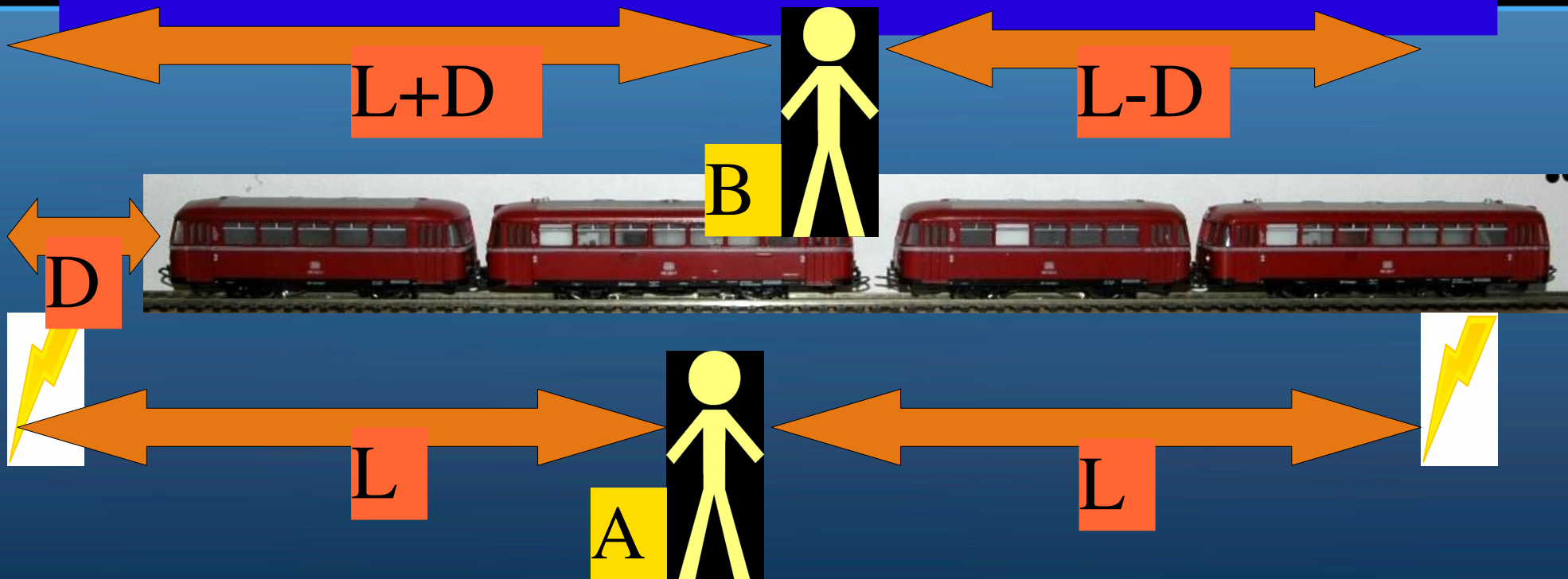


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- B VIEWS the right lightning earlier than the left one, because the distance  $L-D$  is shorter than  $L+D$ . Light having same speed from both sides, the light from right reaches B earlier

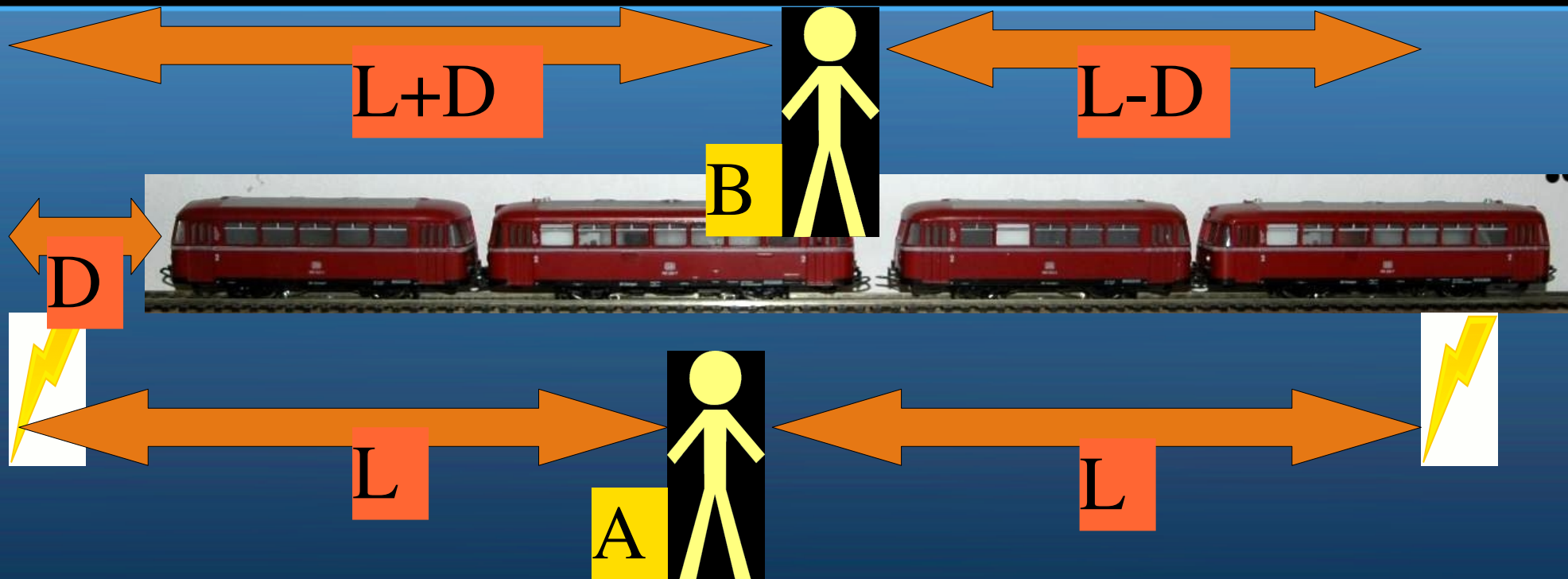


As B was at same distance ( $=L$ ) when the lightnings hit the ground and light has same speed from both sides, B concludes that the right lightning was earlier than the left

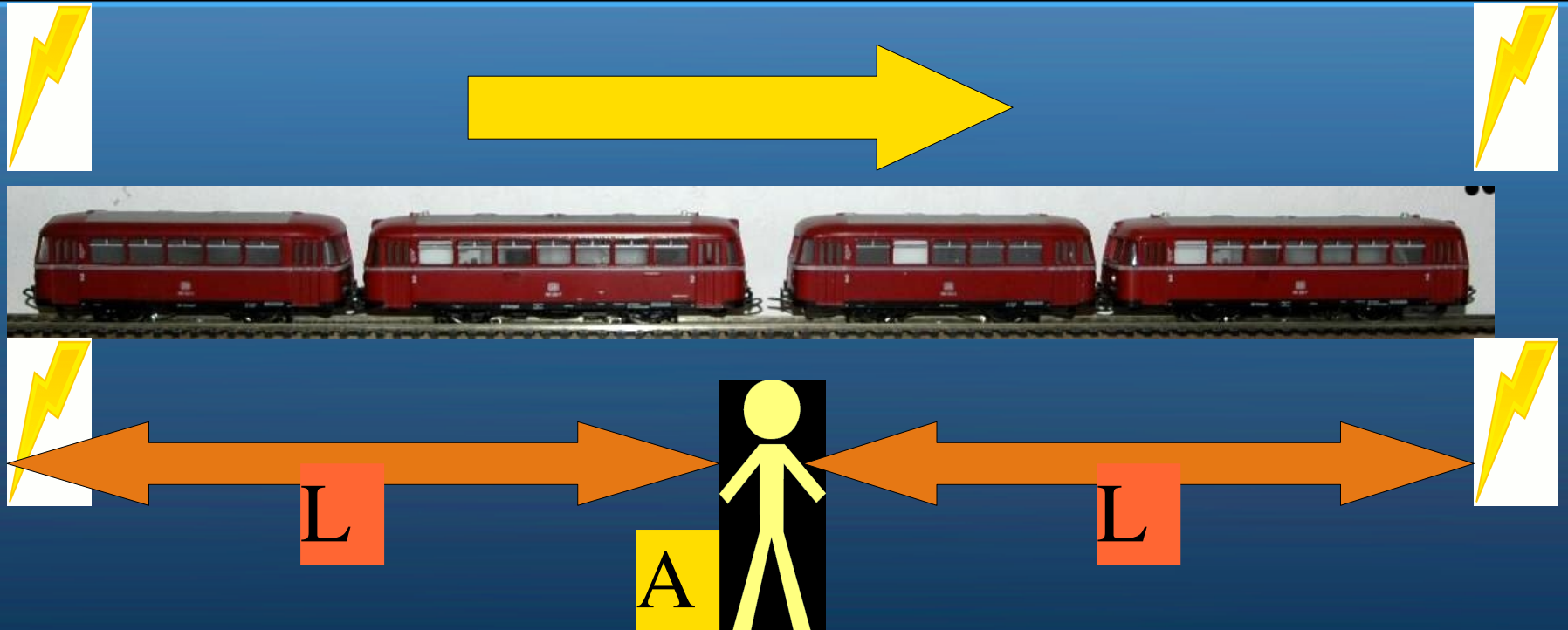


## Conclusion:

- The decision about simultaneity depends on the motion of the observer
  - simultaneity is relative
- > So far Einstein's reasoning <---



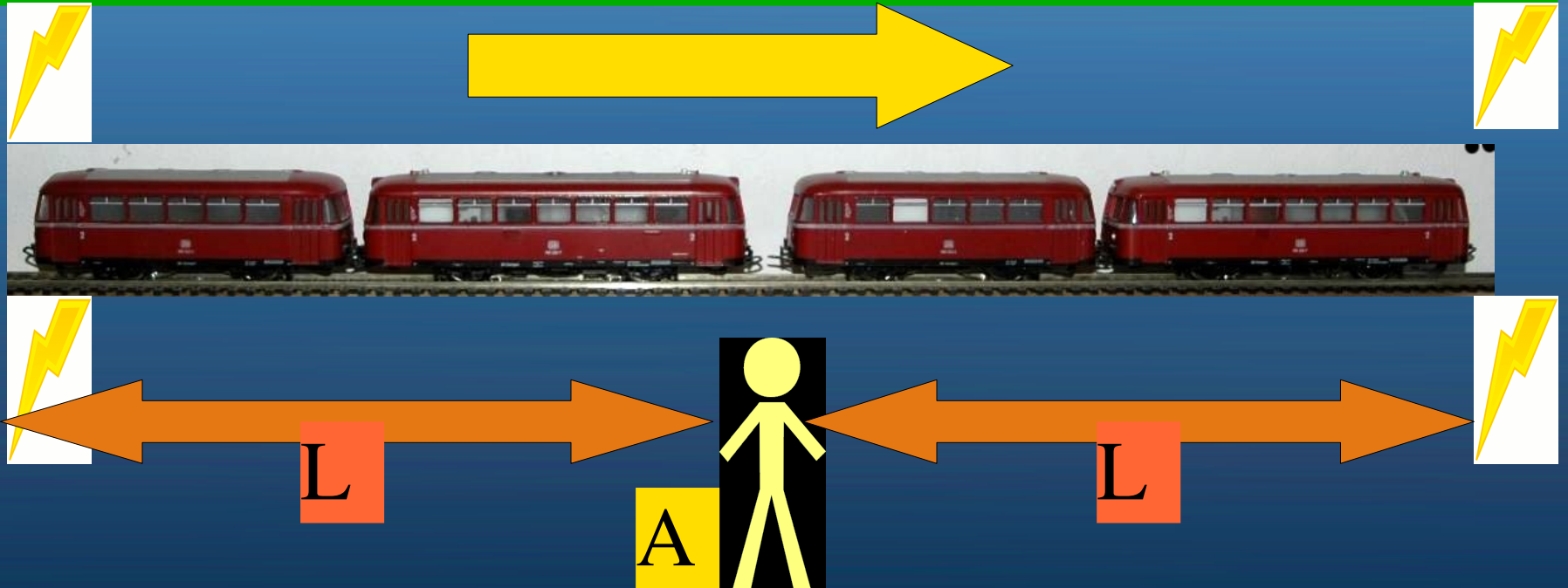
What happens if lightnings would hit not the ground only but the train also ?



- The left two lightnings can be thought of a single one which hits both the ground and the train
- Same thing holds for the two right lightnings

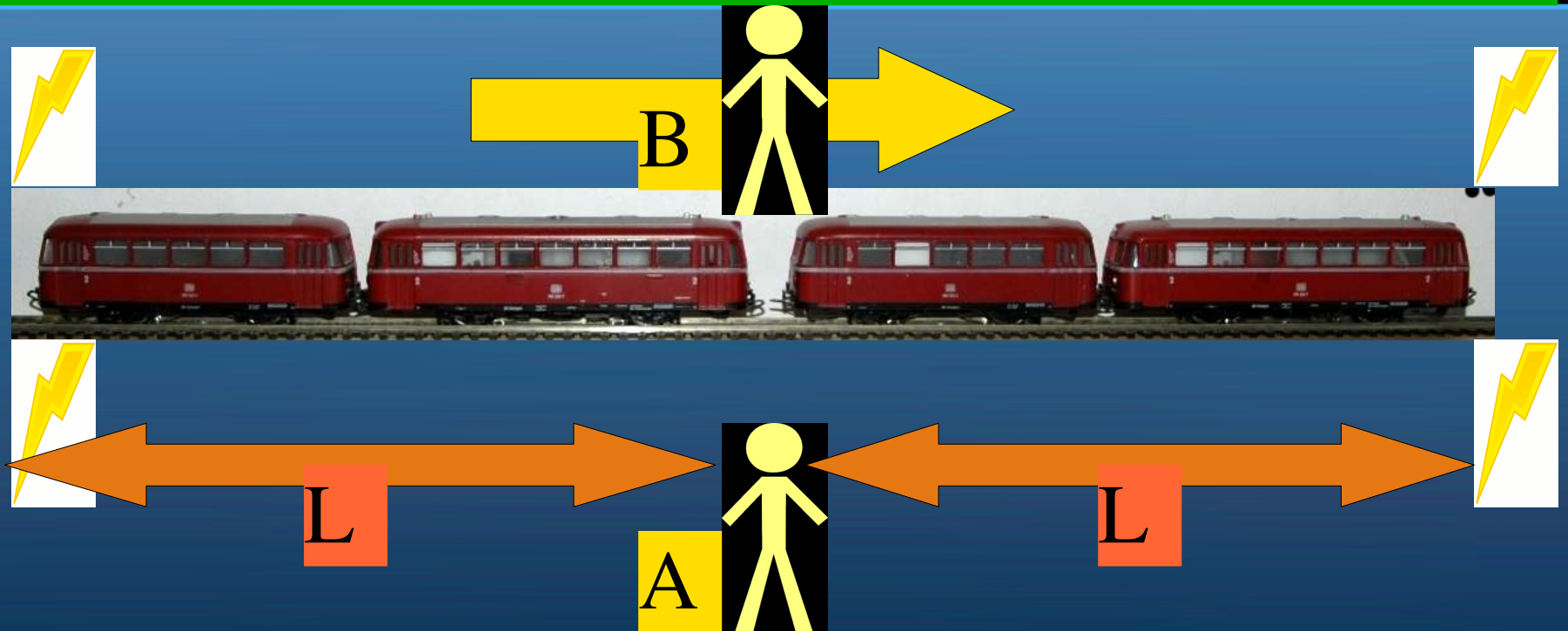


- A views the left two lightnings at the same time ( cf p.2 )
- A views the two right lightnings at the same time
- Following p.4 A views the left and the right ground-lightnings at the same time and thus all 4 lightnings

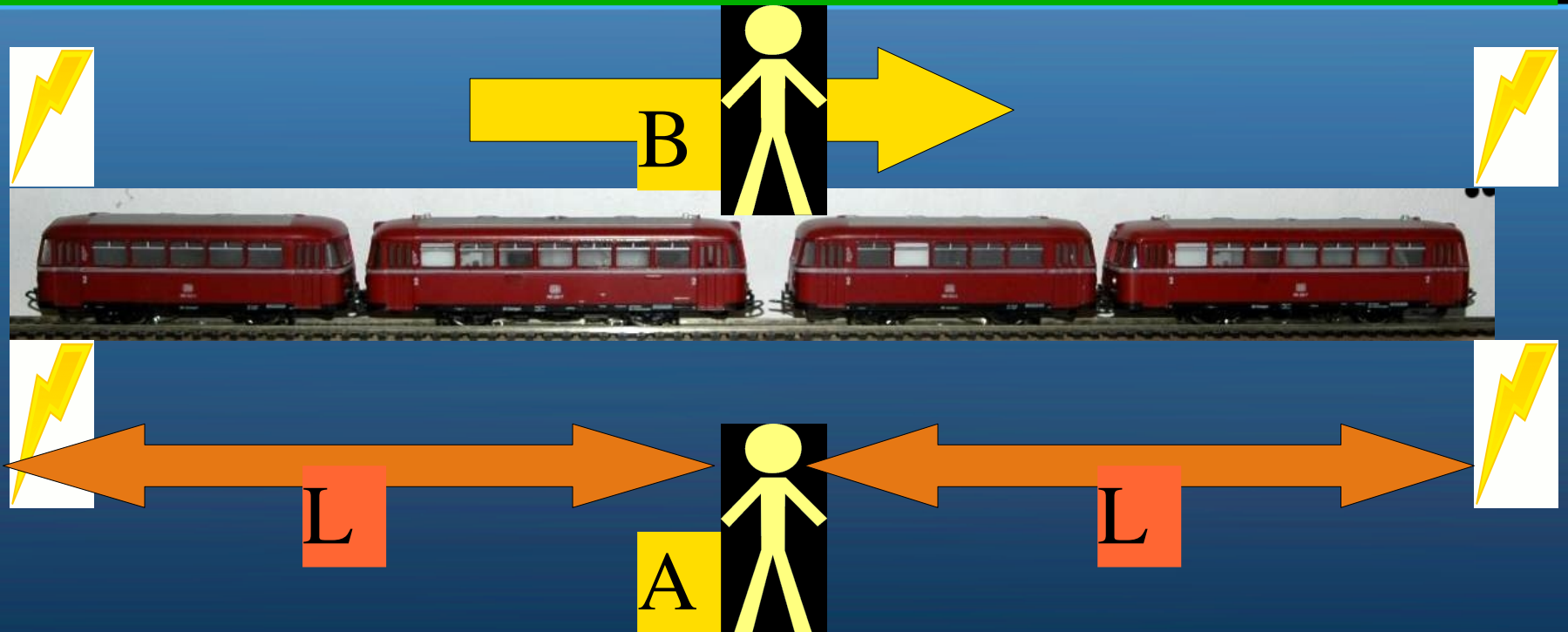


- What does B see ?
- He must see the train-lightnings at the same time

Why ?

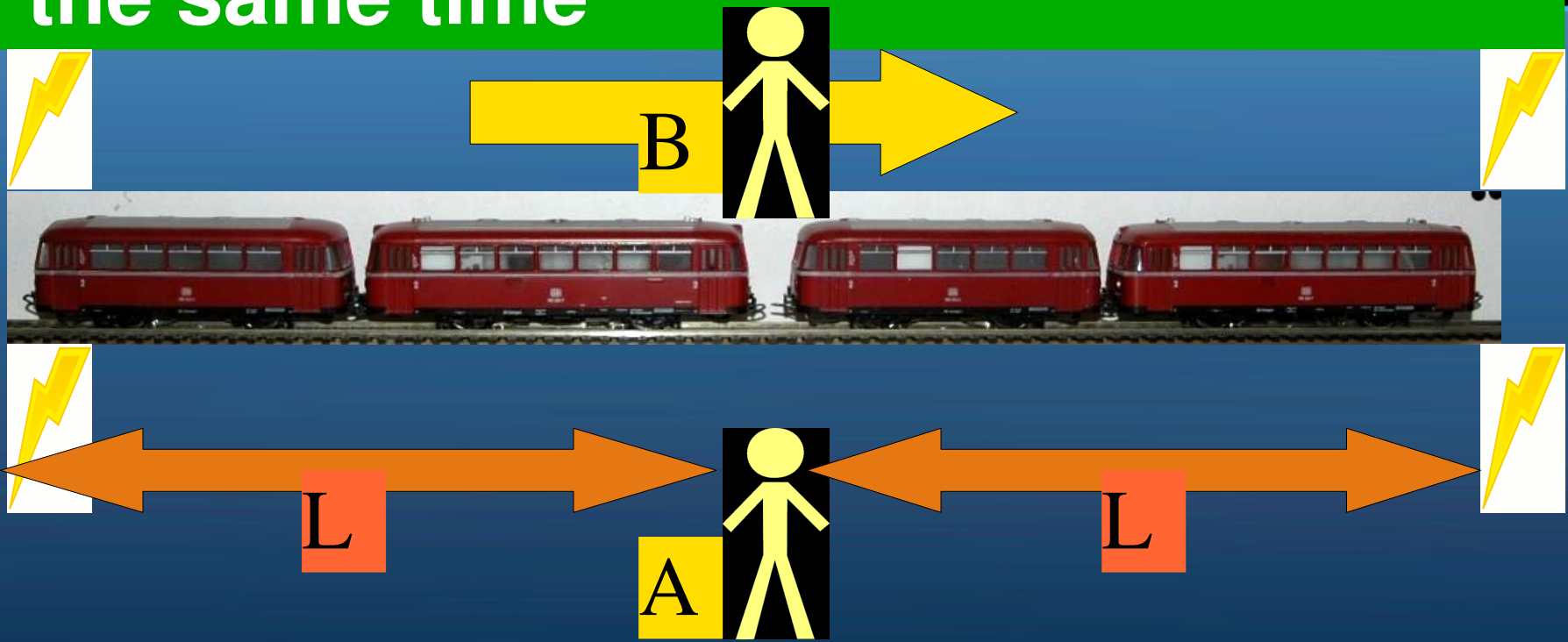


**System B (train, train-lightnings)**  
has equal rights as  
**System A (ground, ground-lightnings).**  
( think of System A having vanished ).



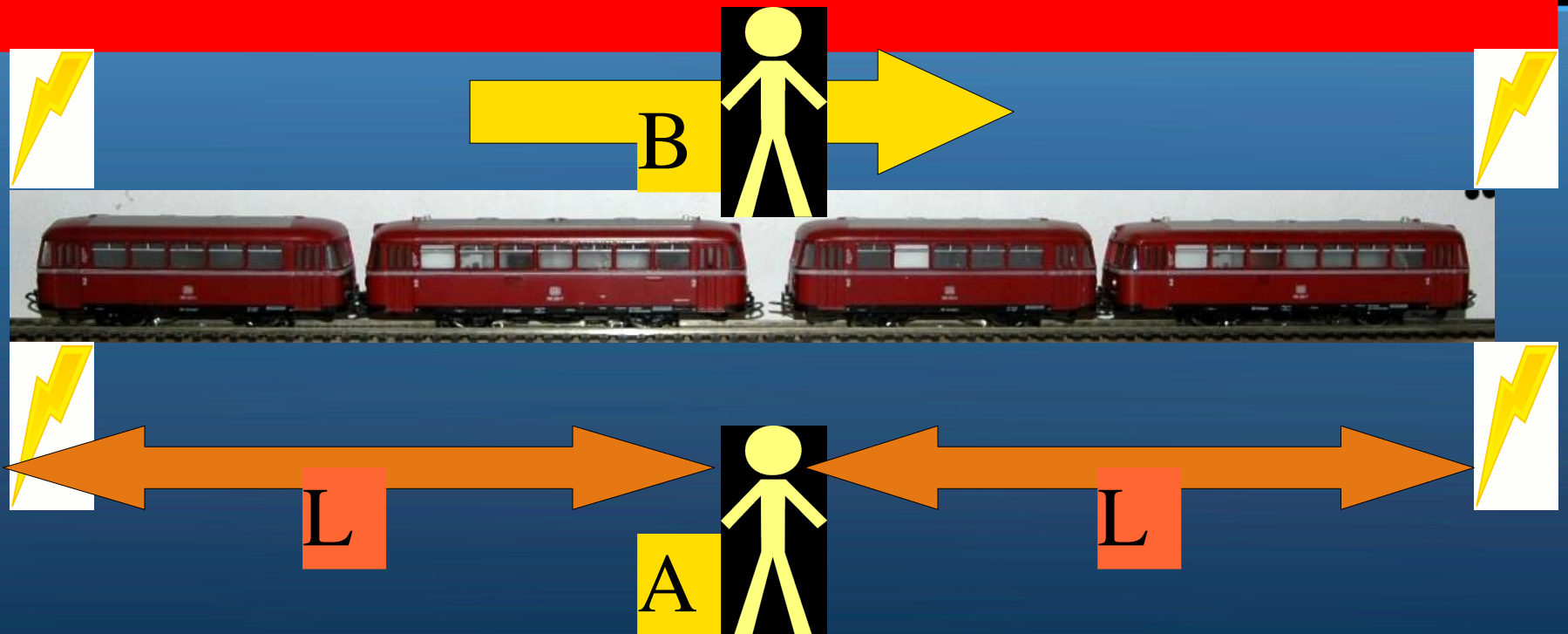
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- B must see the two left lightnings at the same time ( same reason why B did, following p.2 )
- B sees the two right lightnings at the same time
- Thus B sees also all four lightnings at the same time



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- It cannot be true that B sees the right ground-lightning earlier than the left one
- This would generate the contradiction we saw before, for which we used the basic assumptions of p.2 only



**What else then ? How can this contradiction be solved ?**

**Possible solution:**

**The light speed is NOT constant independently from source AND observer ( this is today a postulate and not considered to be proven ).**

**There is an absolute space ( ether or whatever we may call ) relative to which light speed is constant independently from the source but not from the observer.**