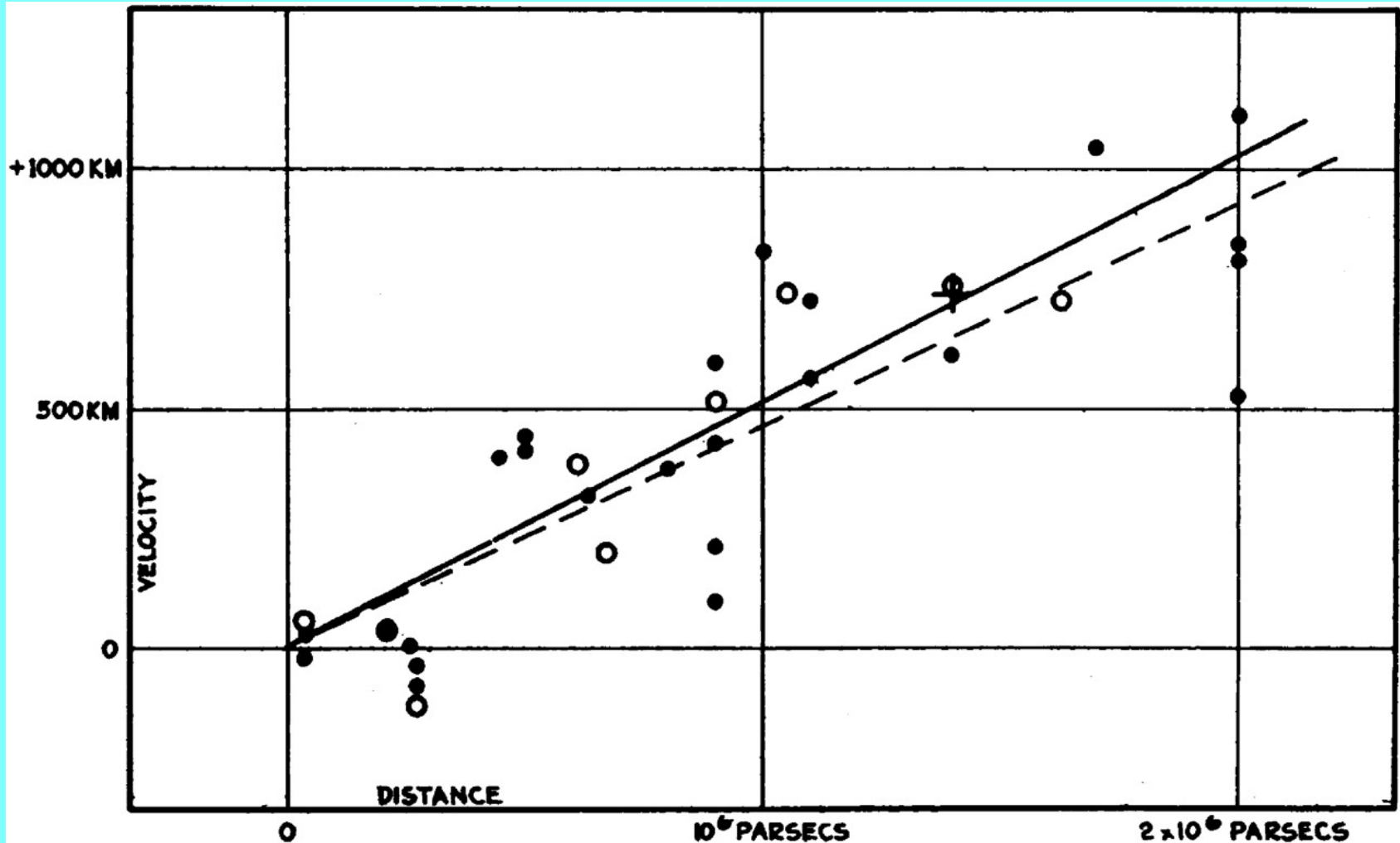
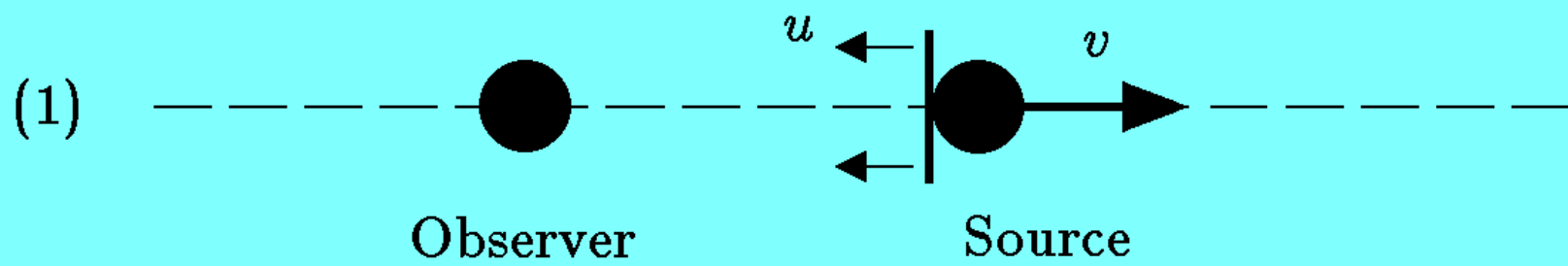


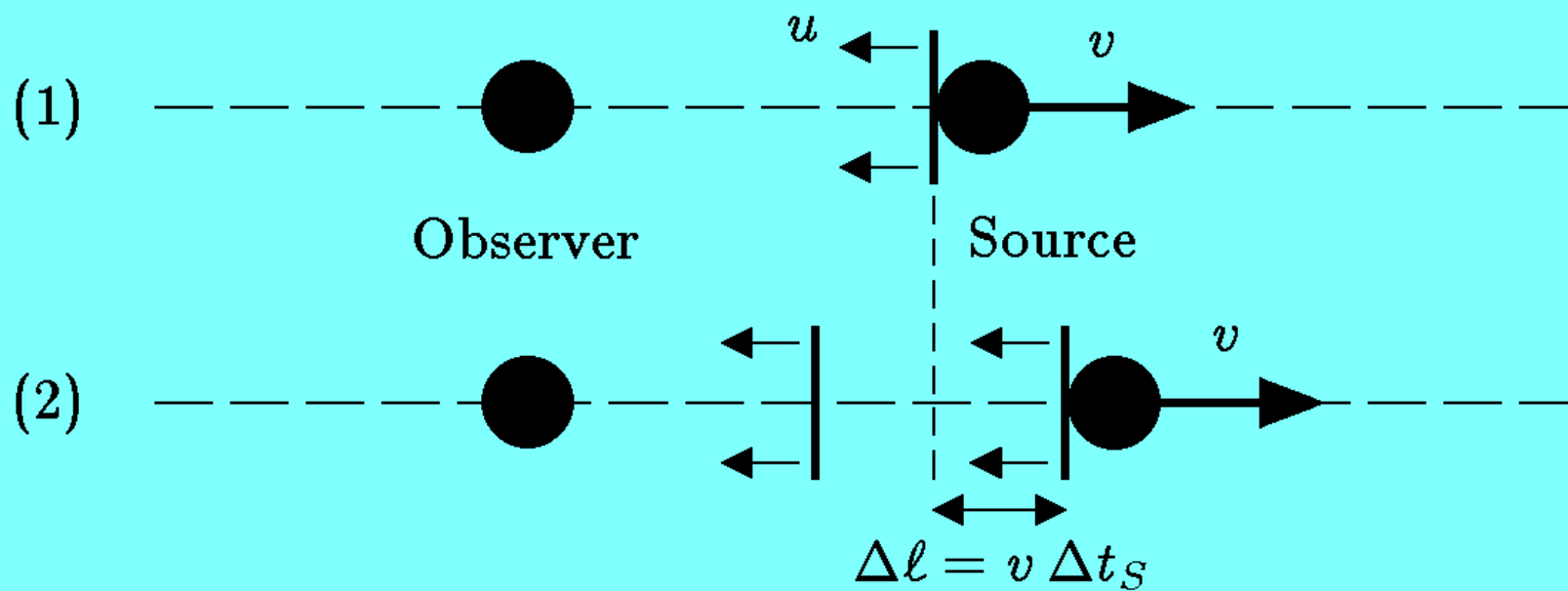
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September 12, 2018

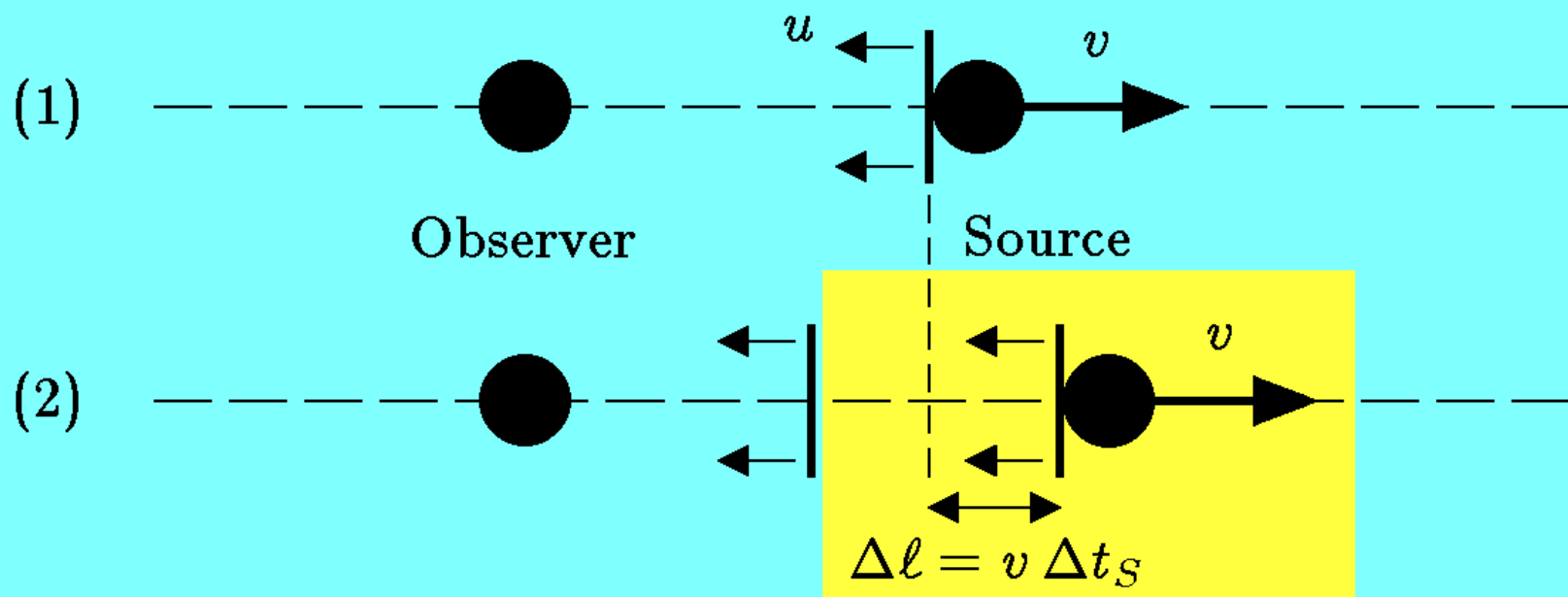
THE DOPPLER EFFECT
and
SPECIAL RELATIVITY

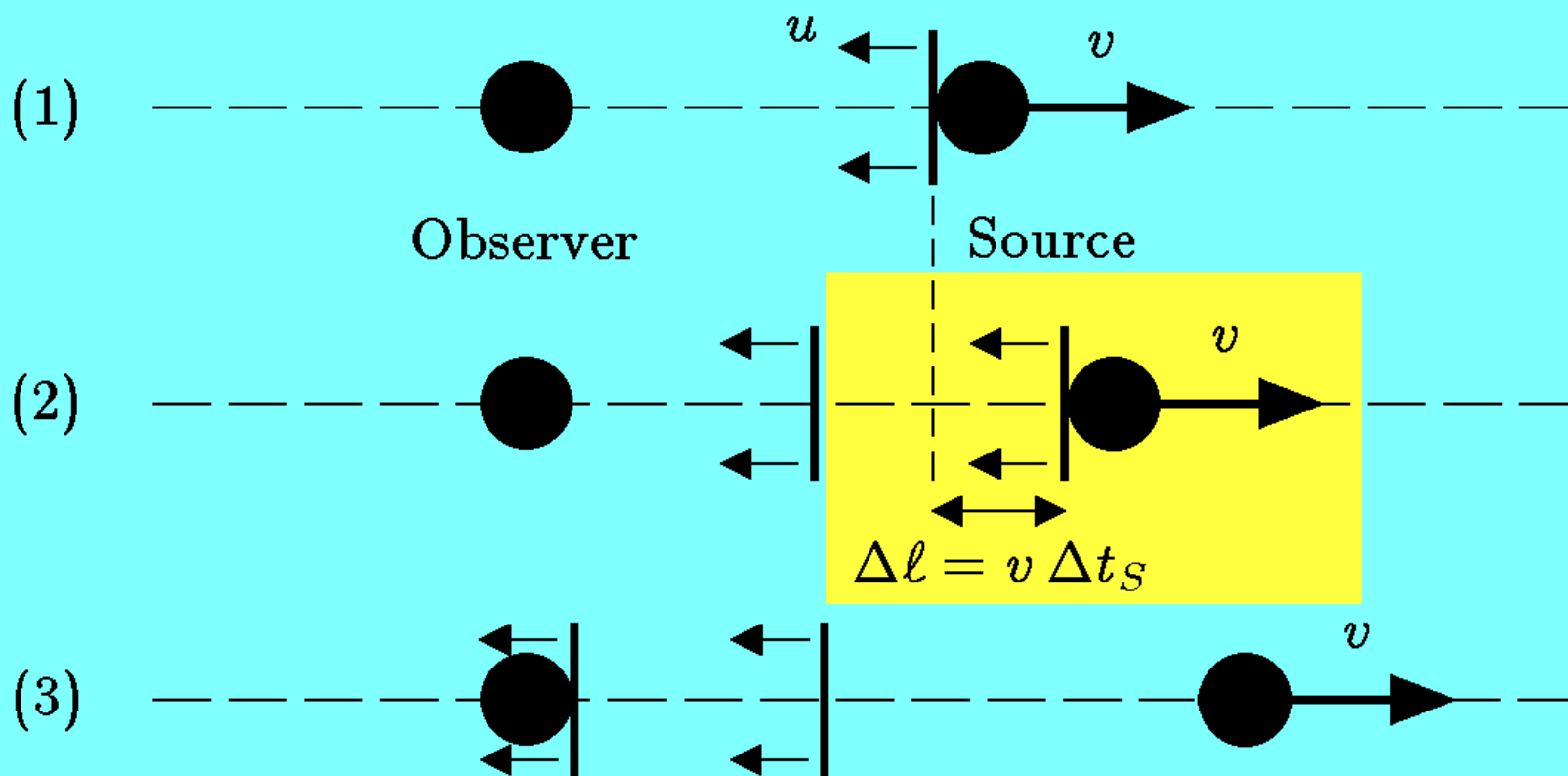
Hubble's Original 1929 Graph

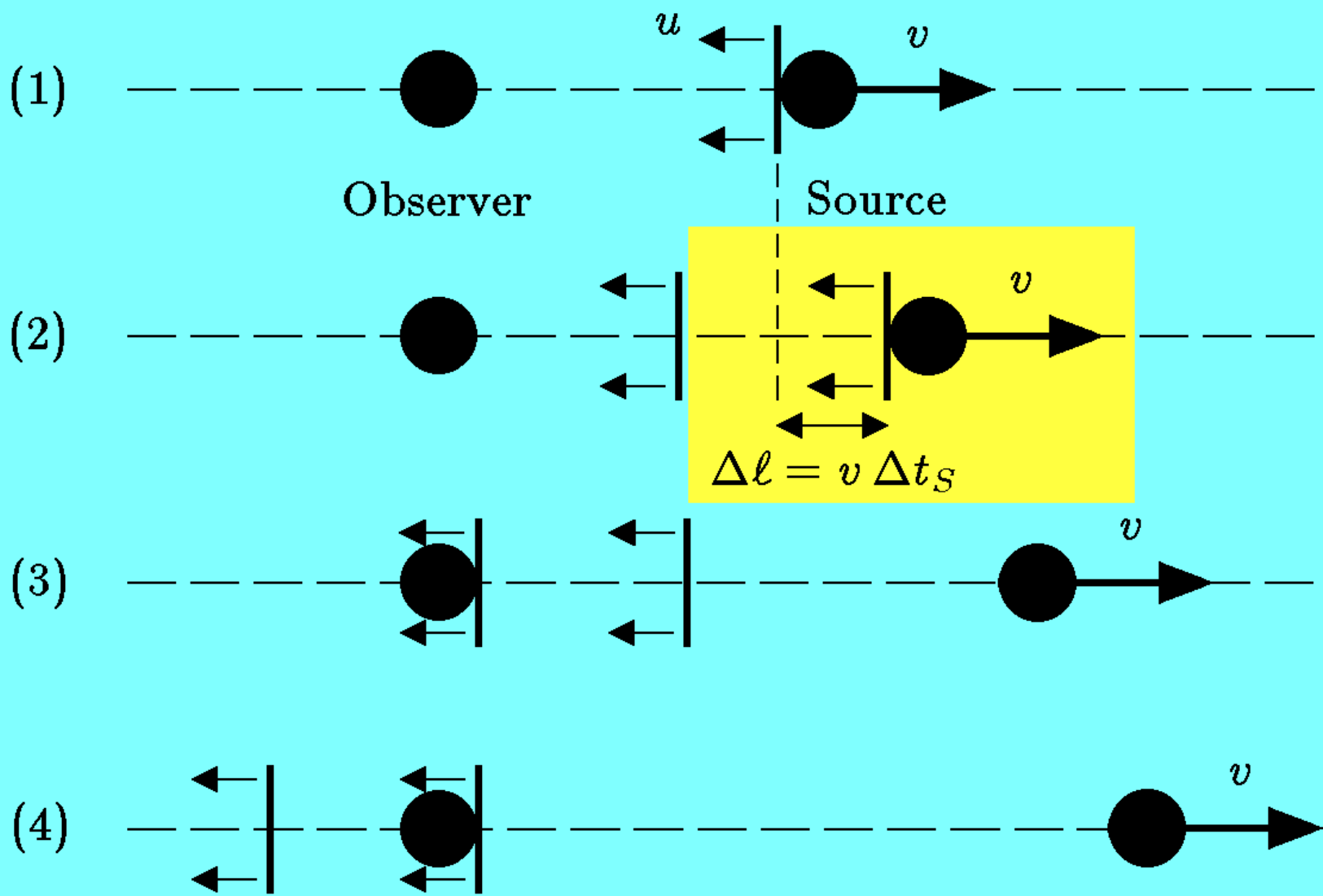


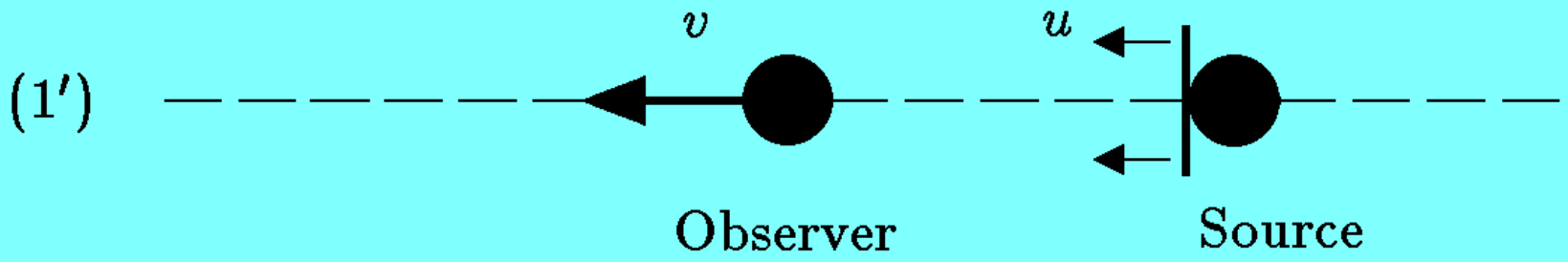


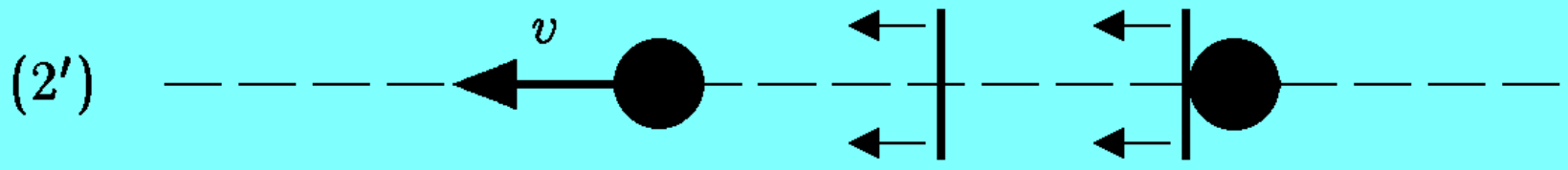
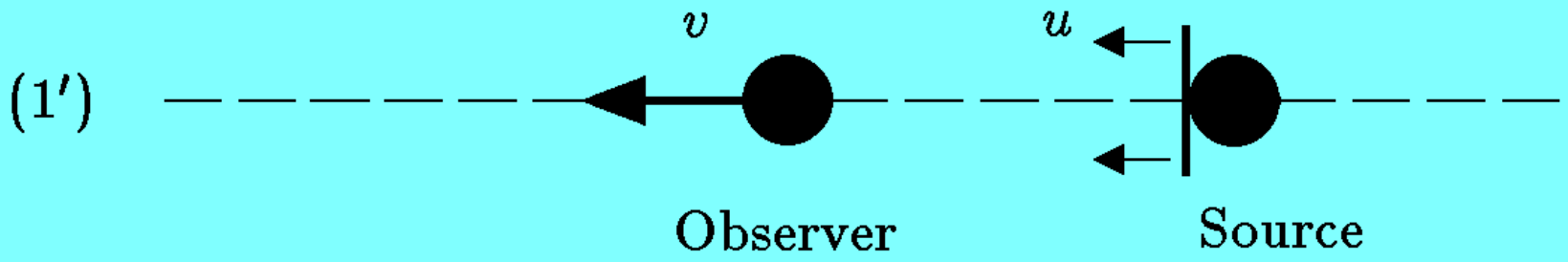


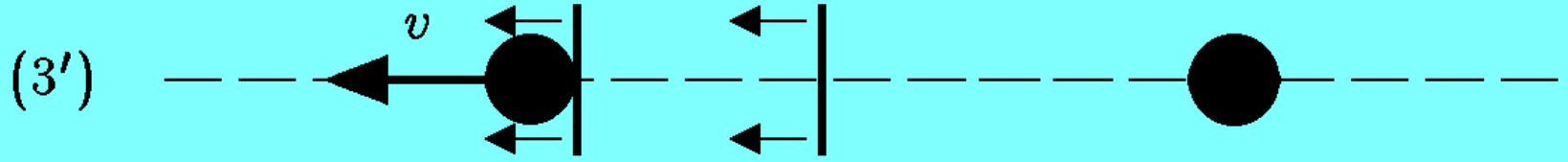
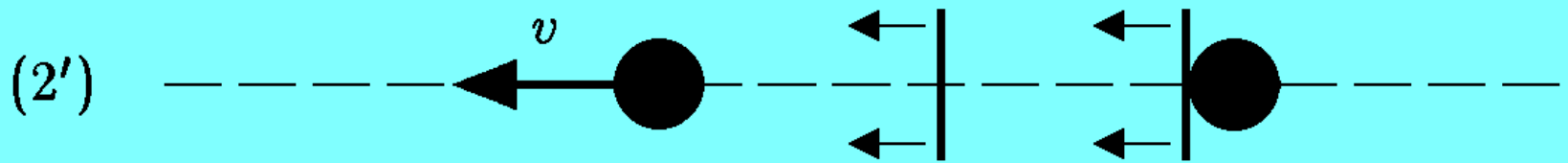
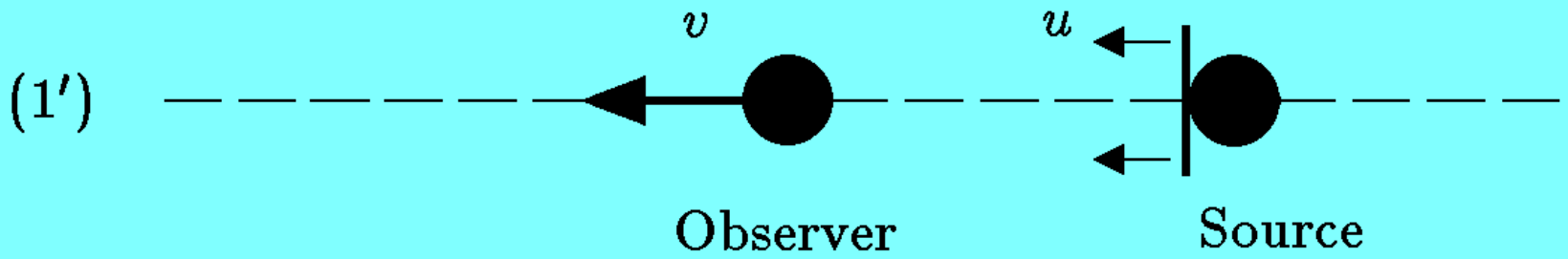


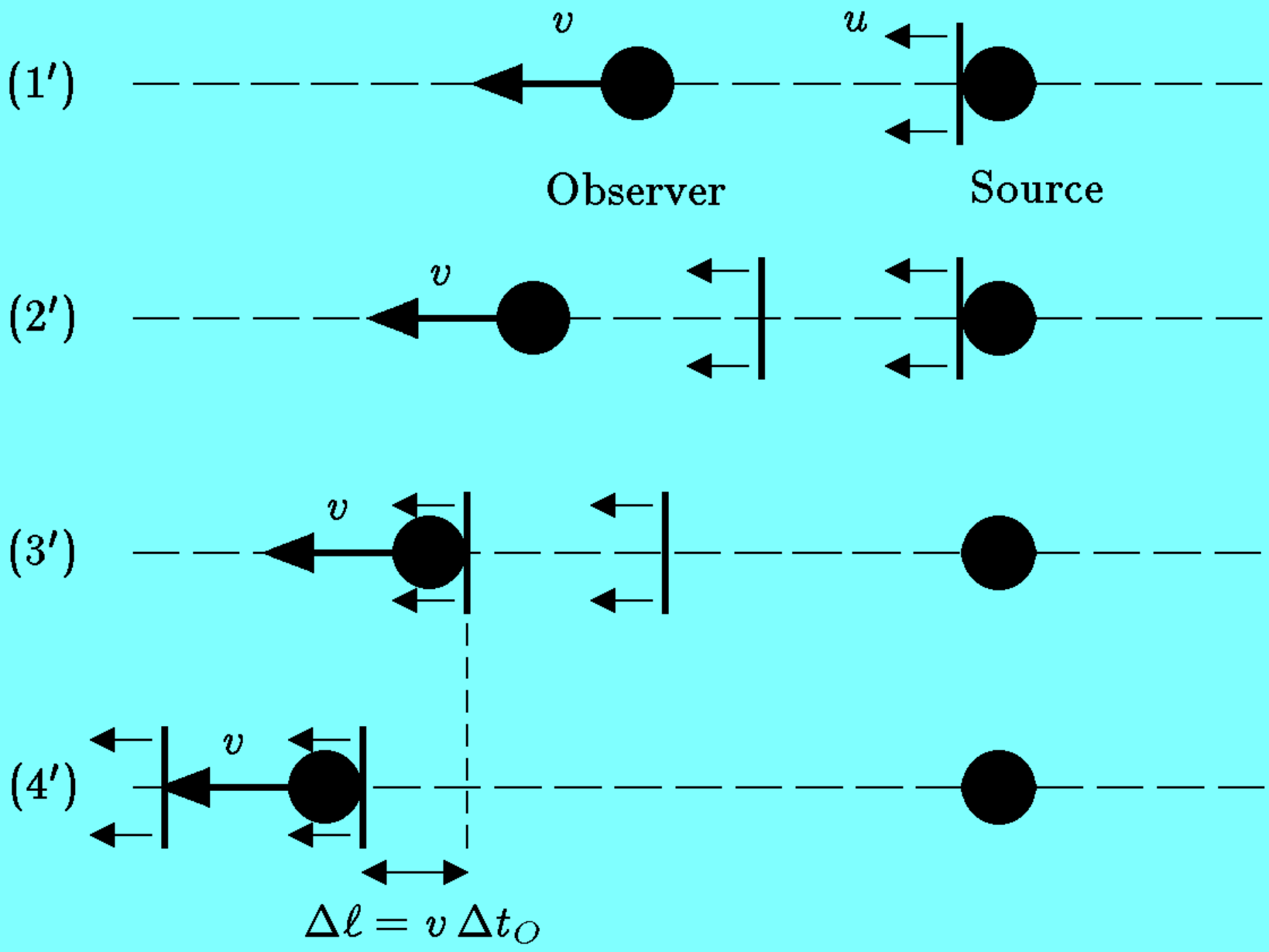


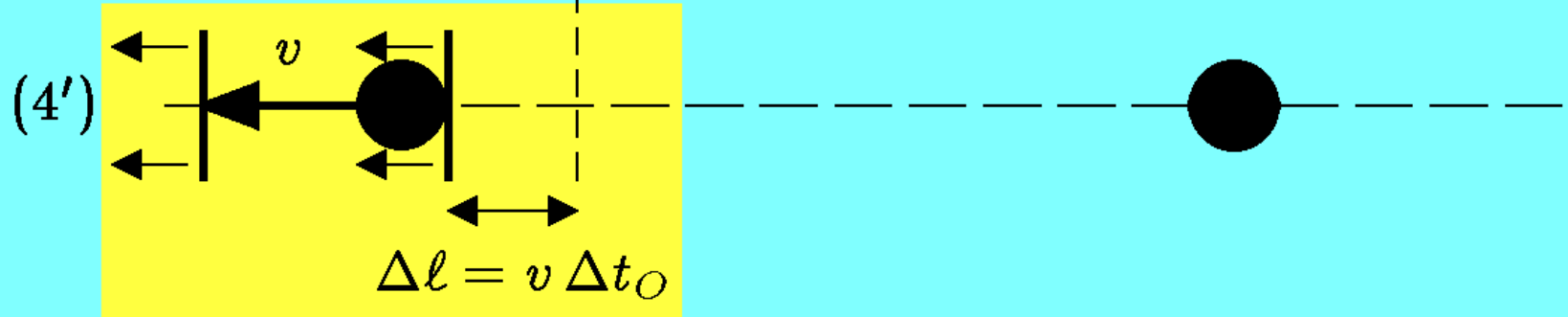
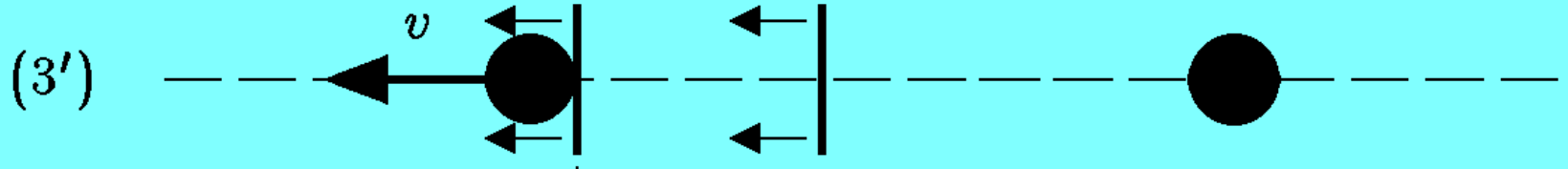
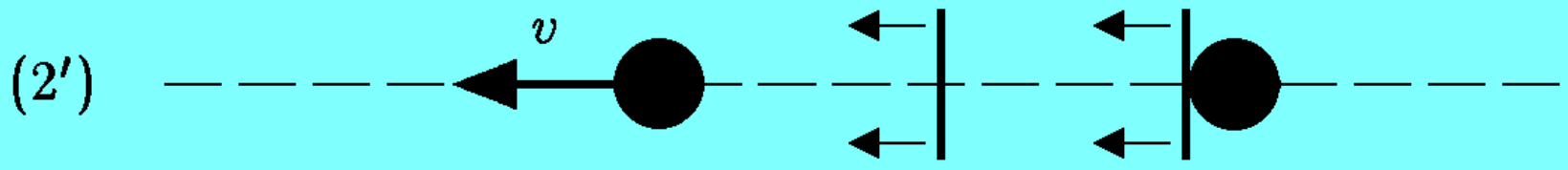
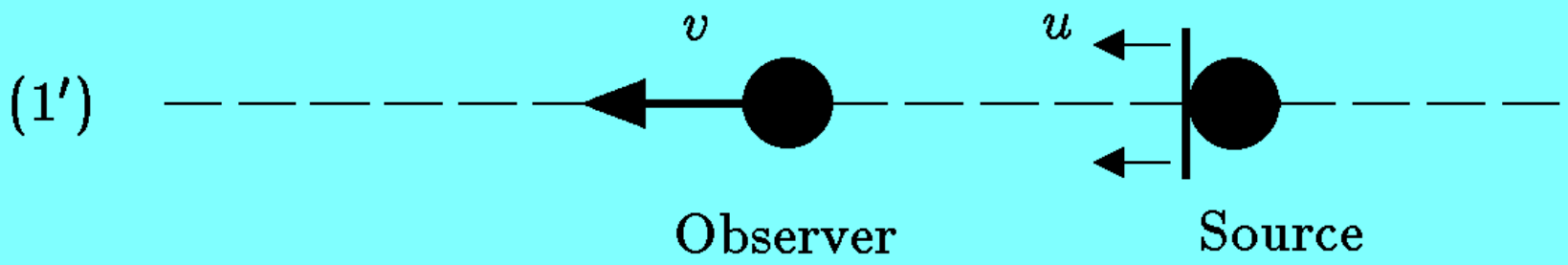






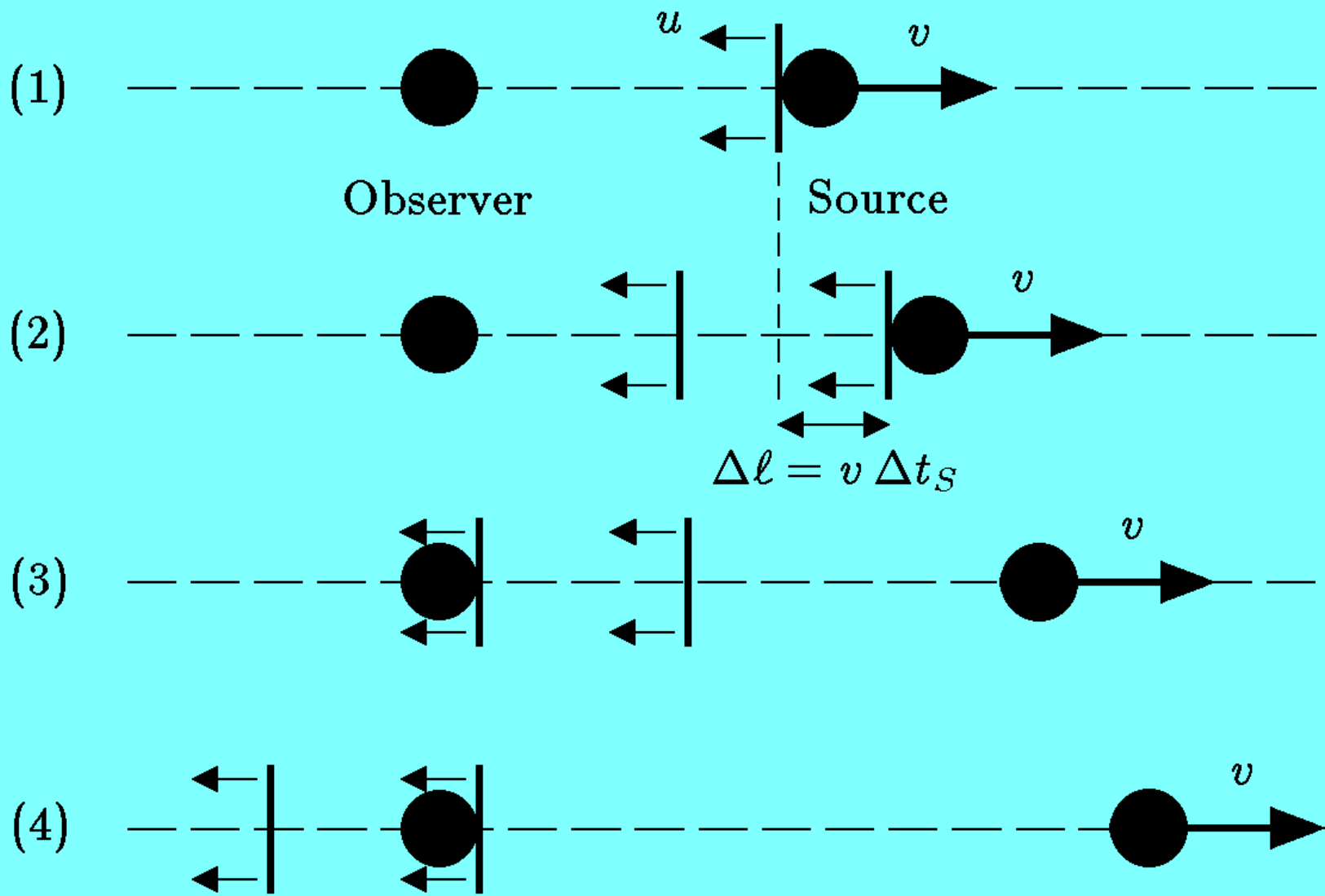


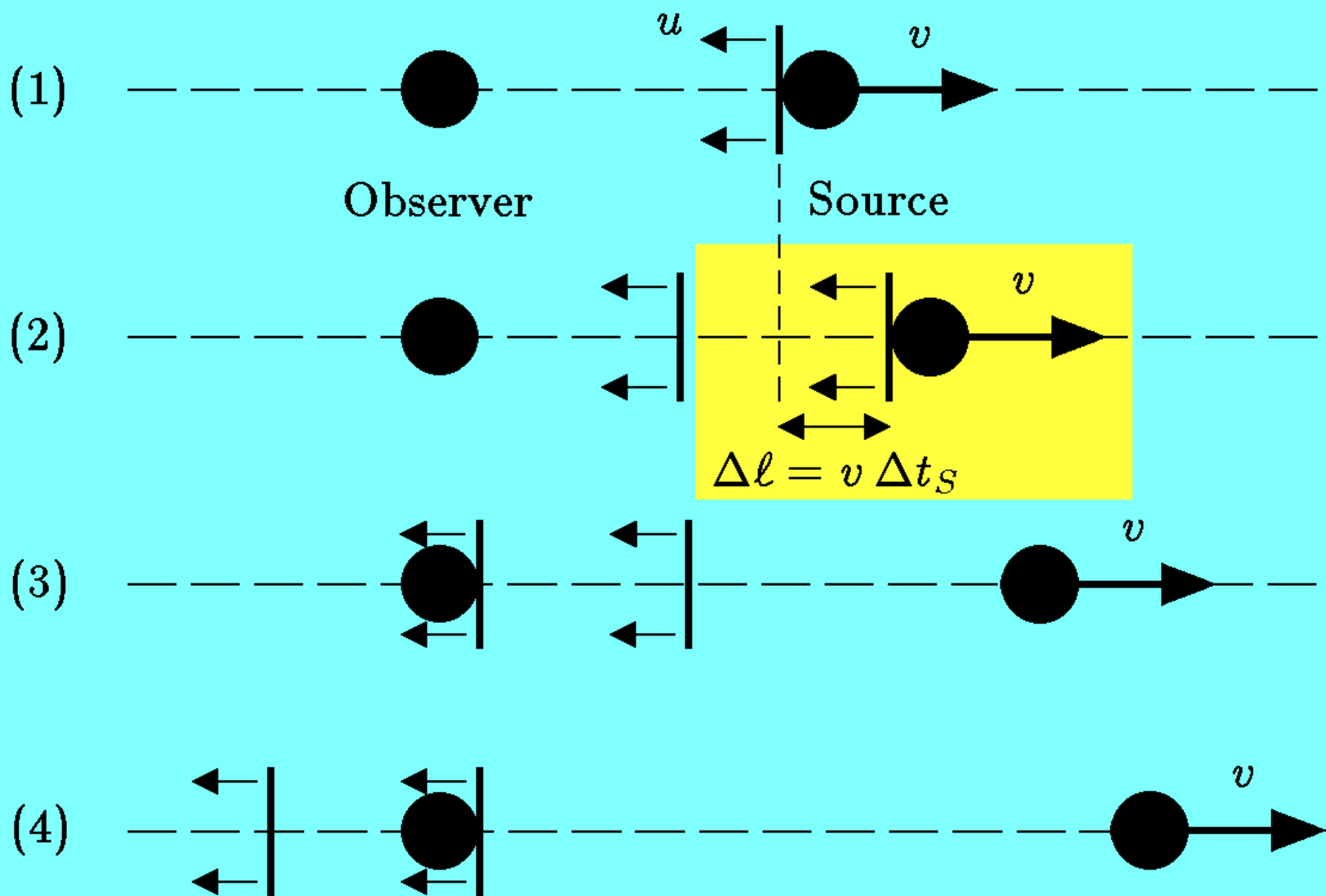


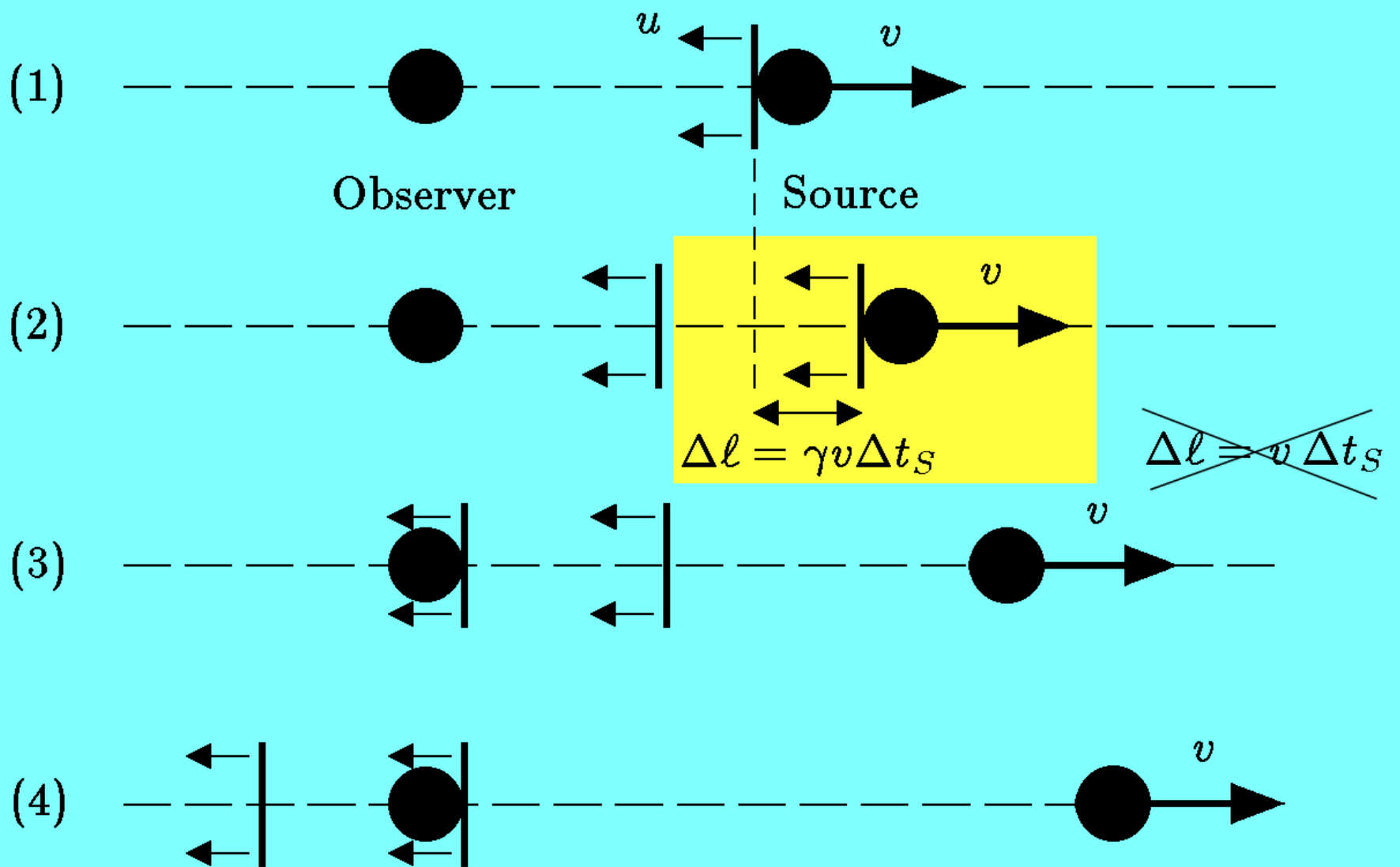


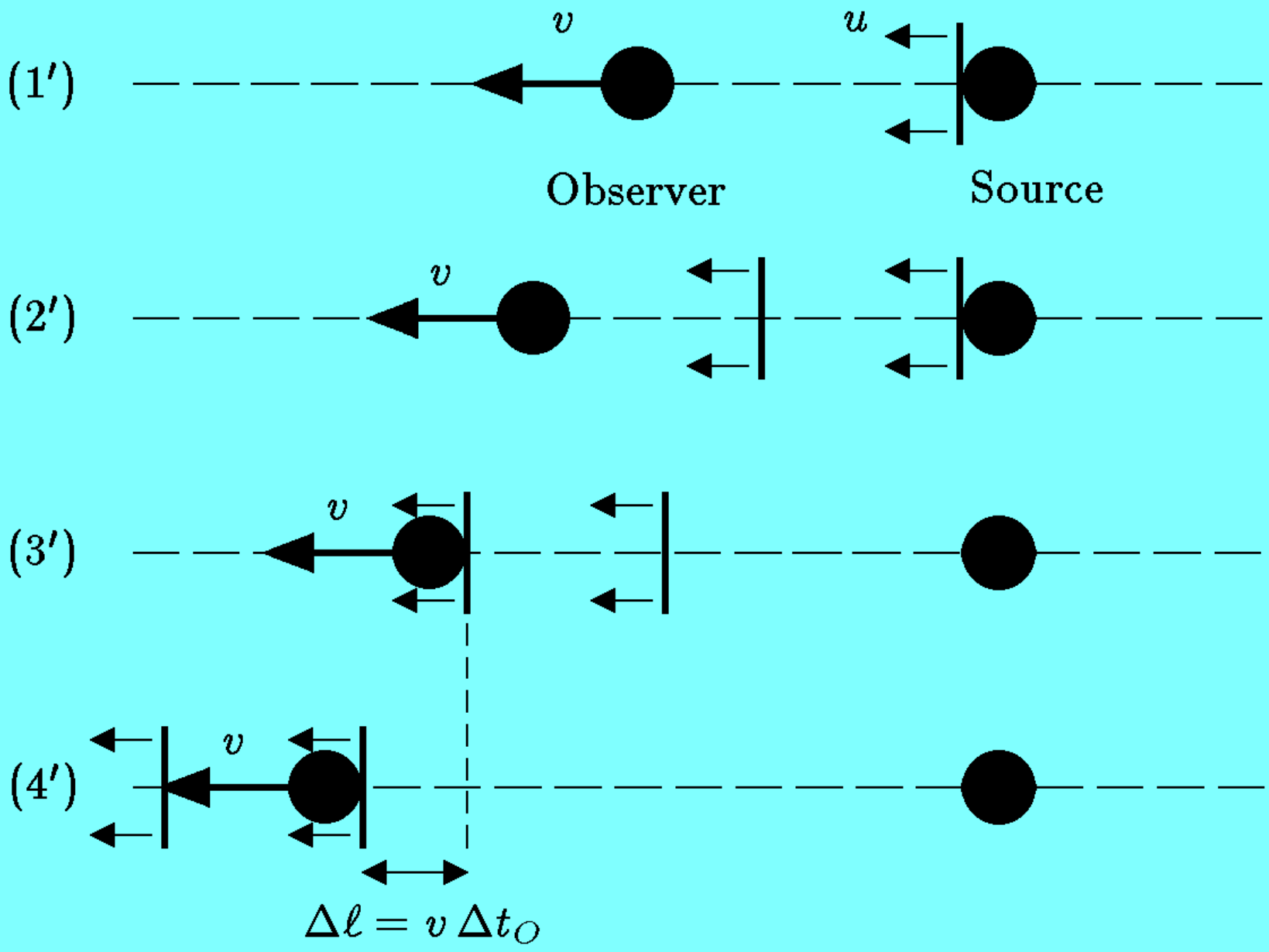
(1) **TIME DILATION:** Any clock which is moving at speed v relative to a given reference frame will “appear” (to an observer using that reference frame) to run slower than normal by a factor denoted by the Greek letter γ (gamma), and given by

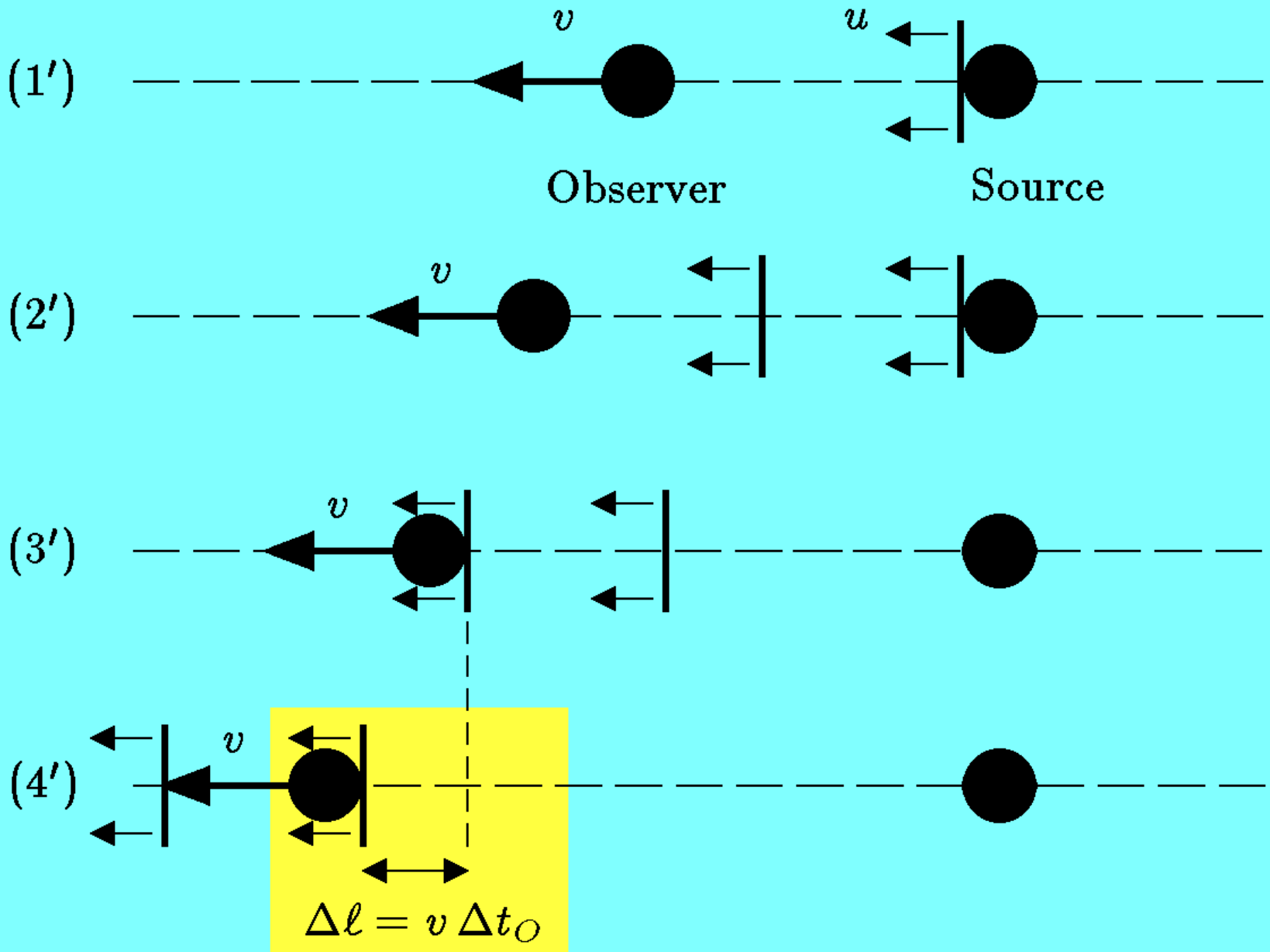
$$\gamma \equiv \frac{1}{\sqrt{1 - \beta^2}} , \quad \beta \equiv v/c . \quad (1.10)$$

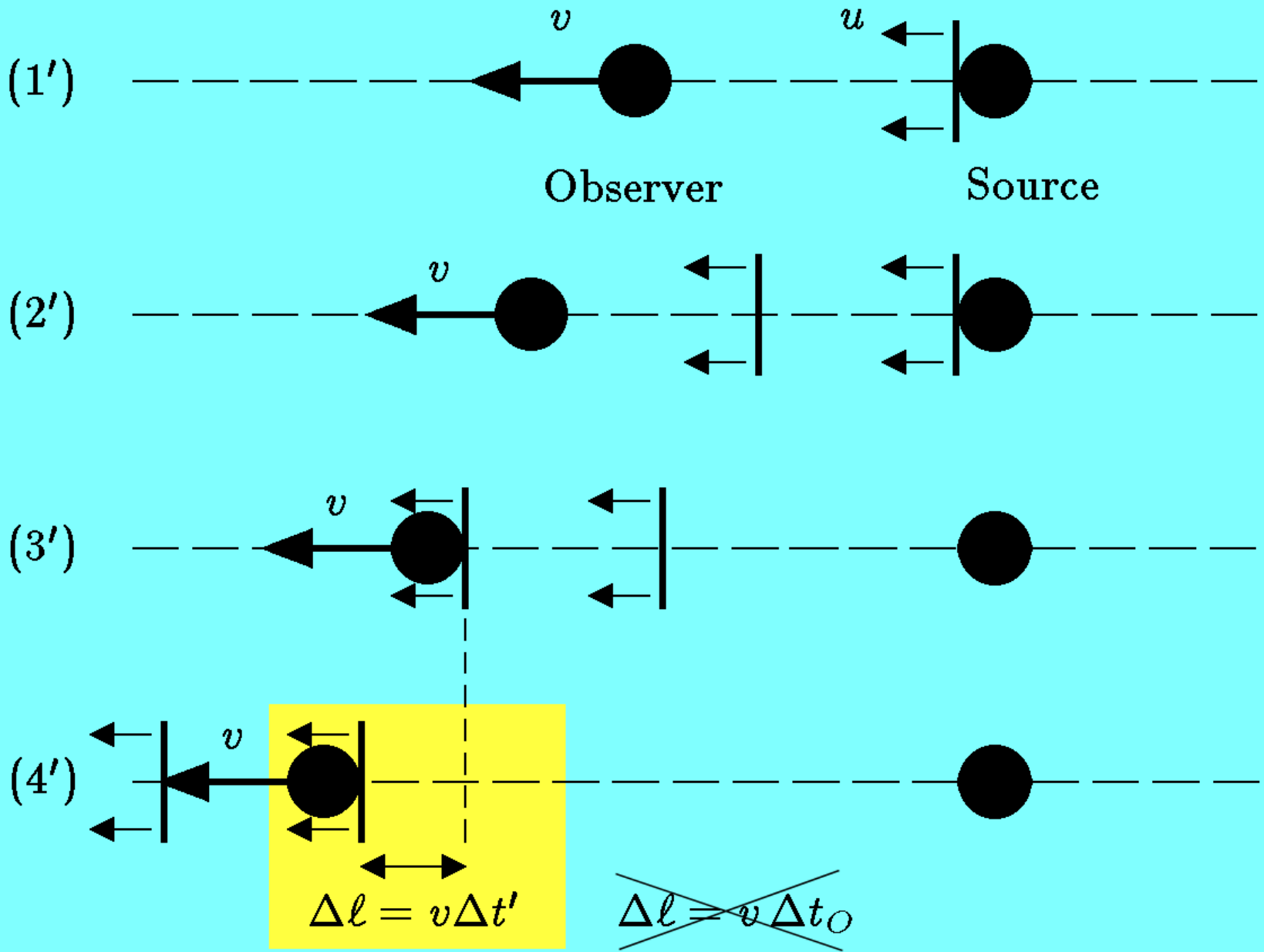




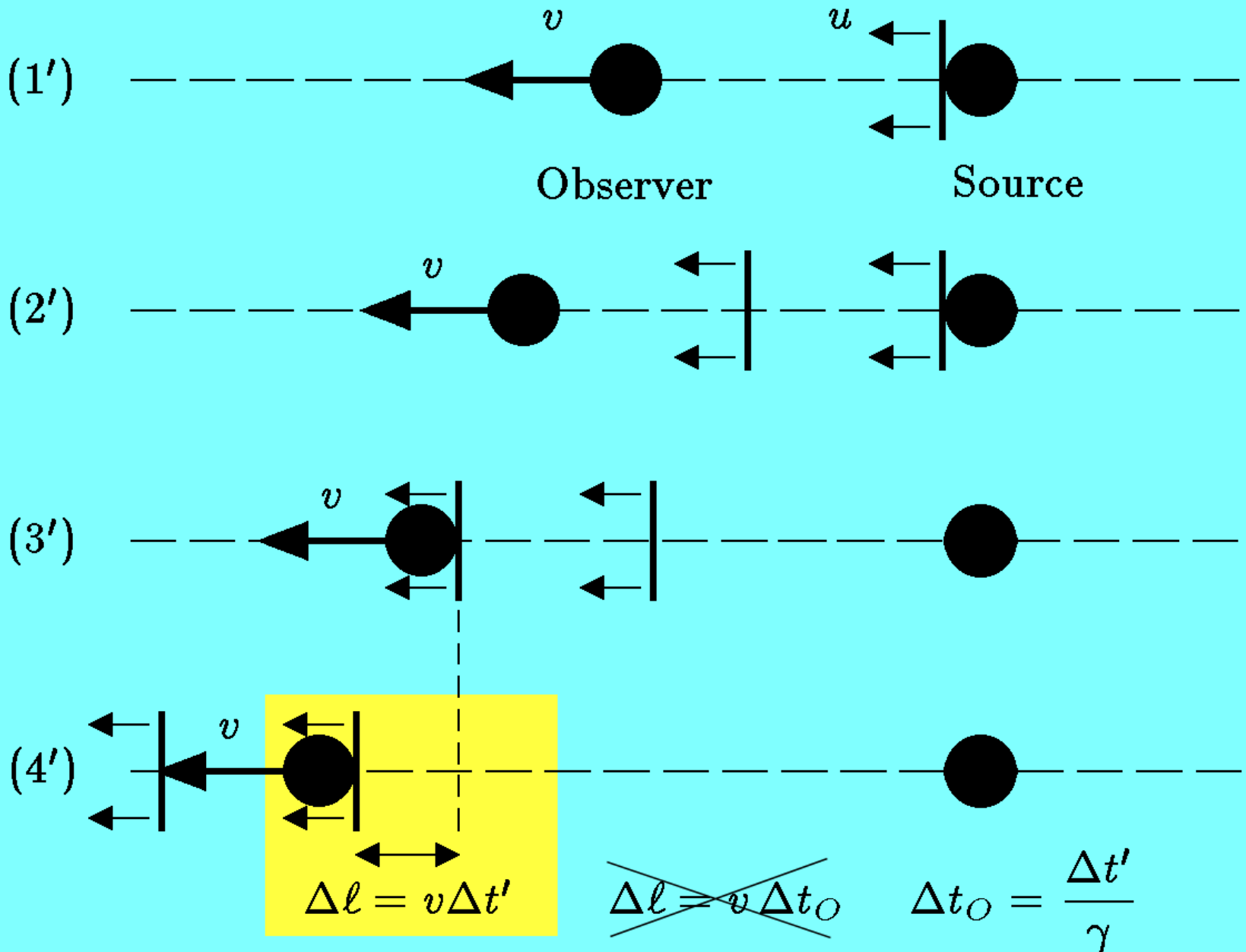








$\Delta t'$ = time between reception of two pulses in frame of the slide.

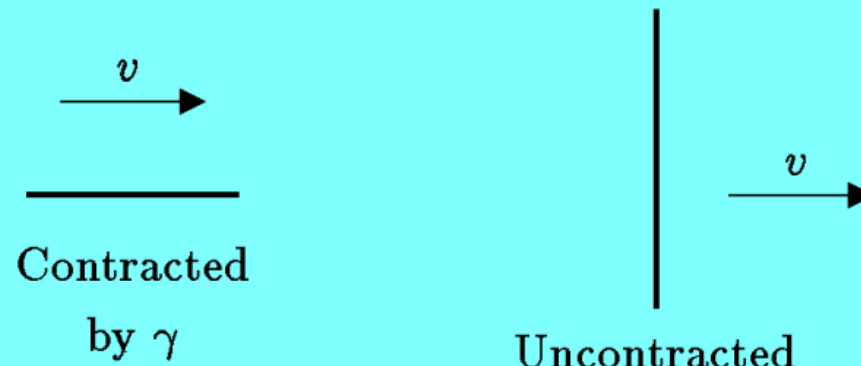


$\Delta t'$ = time between reception of two pulses in frame of the slide.

(1) **TIME DILATION:** Any clock which is moving at speed v relative to a given reference frame will “appear” (to an observer using that reference frame) to run slower than normal by a factor denoted by the Greek letter γ (gamma), and given by

$$\gamma \equiv \frac{1}{\sqrt{1 - \beta^2}} , \quad \beta \equiv v/c . \quad (1.10)$$

- (2) **LORENTZ-FITZGERALD CONTRACTION:** Any rod which is moving at a speed v along its length relative to a given reference frame will “appear” (to an observer using that reference frame) to be shorter than its normal length by the same factor γ . A rod which is moving perpendicular to its length does not undergo a change in apparent length.



- (3) **RELATIVITY OF SIMULTANEITY:** Suppose a rod which has rest length ℓ_0 is equipped with a clock at each end. The clocks can be synchronized in the rest frame of the system by using light pulses. (That is, a light pulse can be sent out from the center, and the clocks at both ends can be started when they receive the pulses.) If the system moves at speed v along its length, then the trailing clock will “appear” to read a time which is later than the leading clock by an amount $\beta\ell_0/c$. If, on the other hand, the system moves perpendicular to its length, then the synchronization of the clocks is not disturbed.

