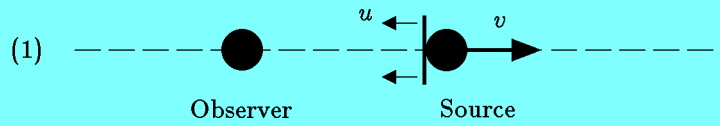
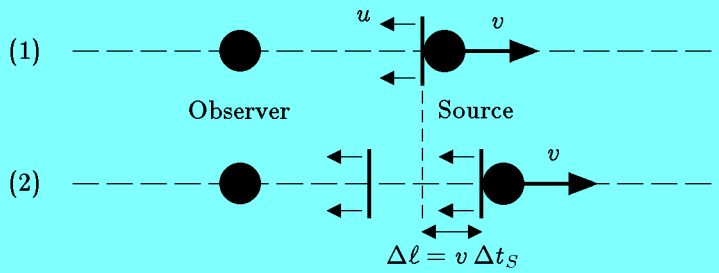
8.286 Lecture 3
September 12, 2013

THE DOPPLER EFFECT and SPECIAL RELATIVITY



–1–



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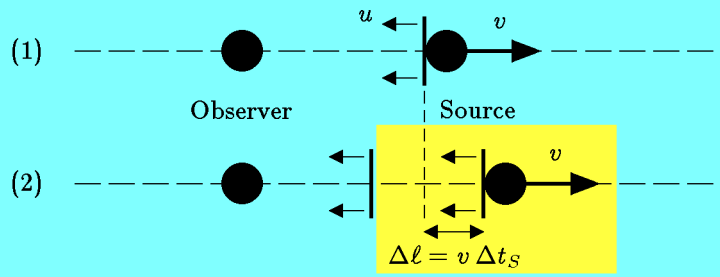

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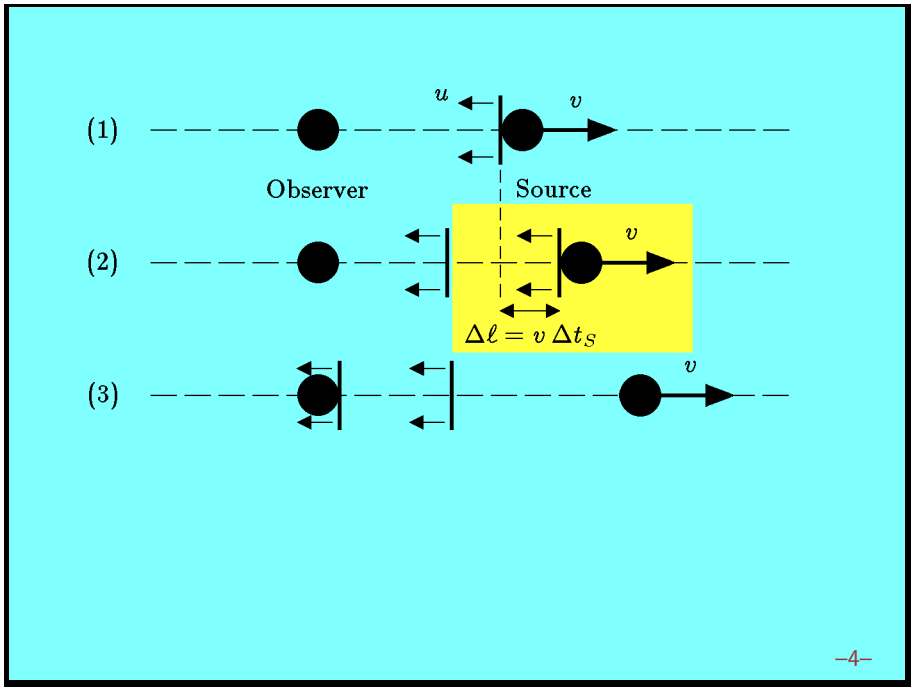
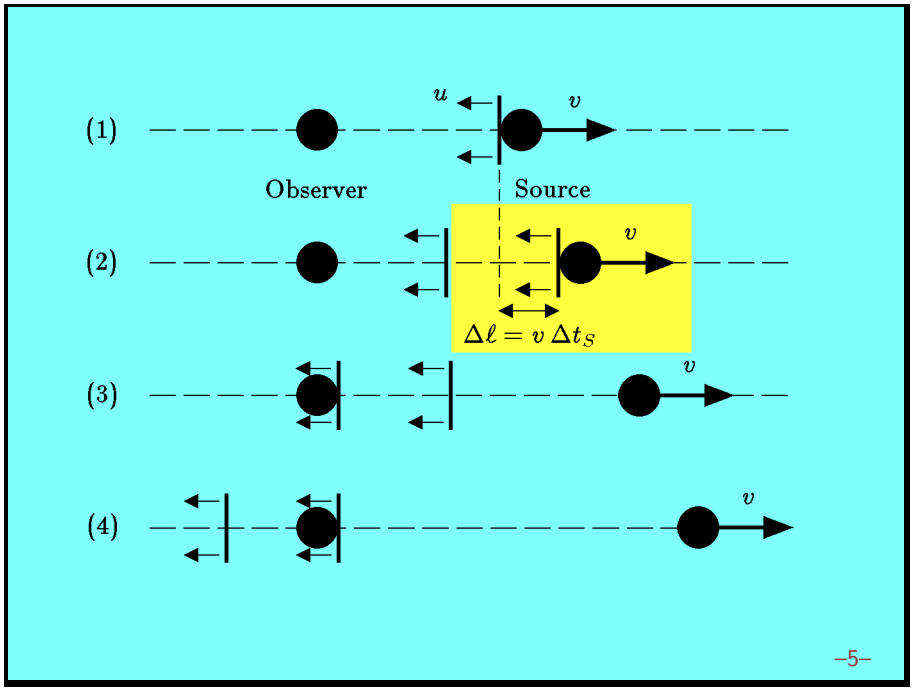
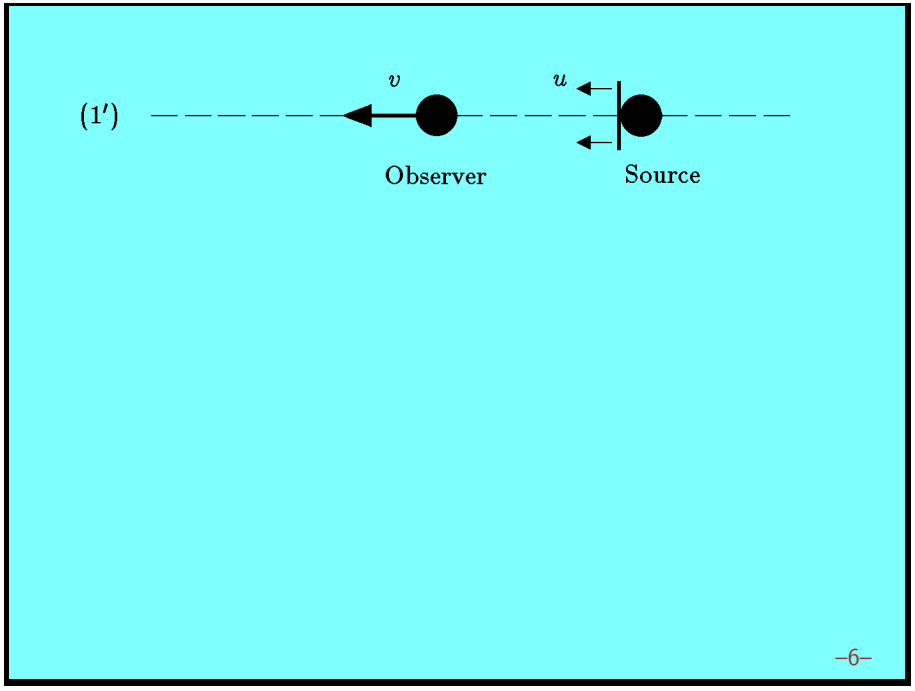

(1)
u
v
Observer
Source
(2)
v
$\Delta\ell = v\,\Delta t_S$
(3)
v

–4–


(1)
u
v
Observer
Source
(2)
v
$\Delta\ell = v\,\Delta t_S$
(3)
v
(4)
v

–5–


(1′)
v
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Observer
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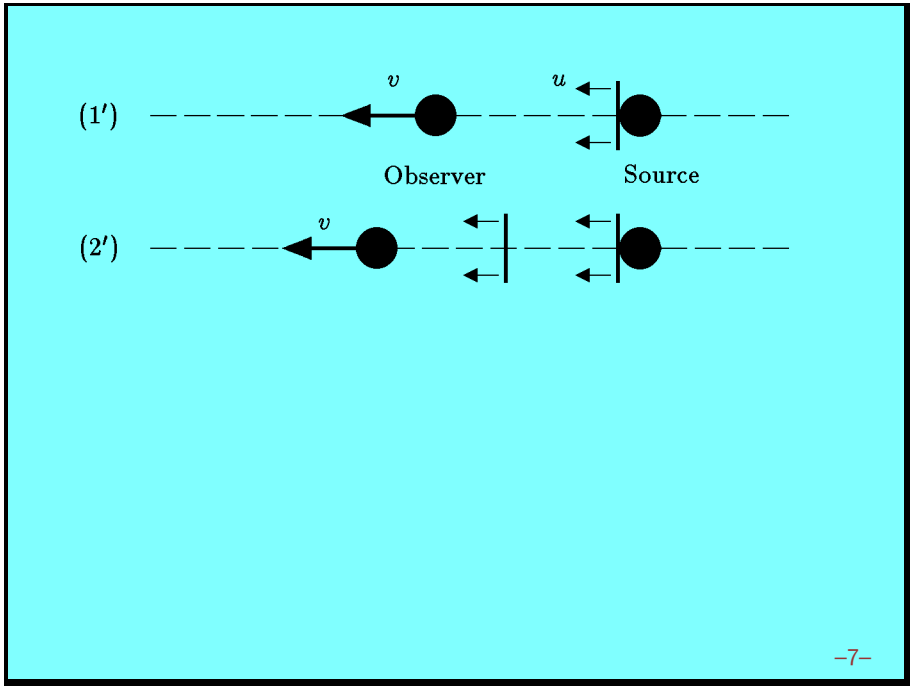
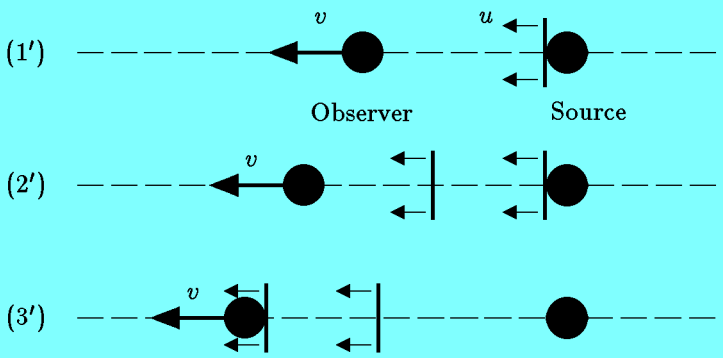
–6–


(1′)
v
u
Observer
Source
(2′)
v

–7–



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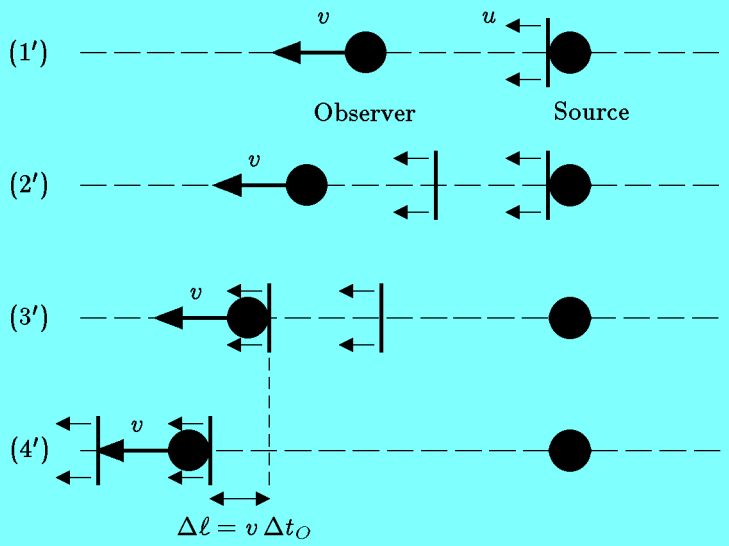

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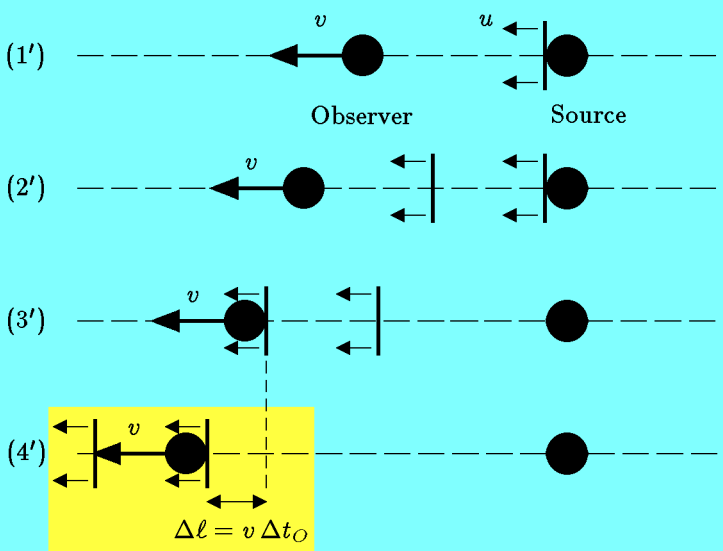
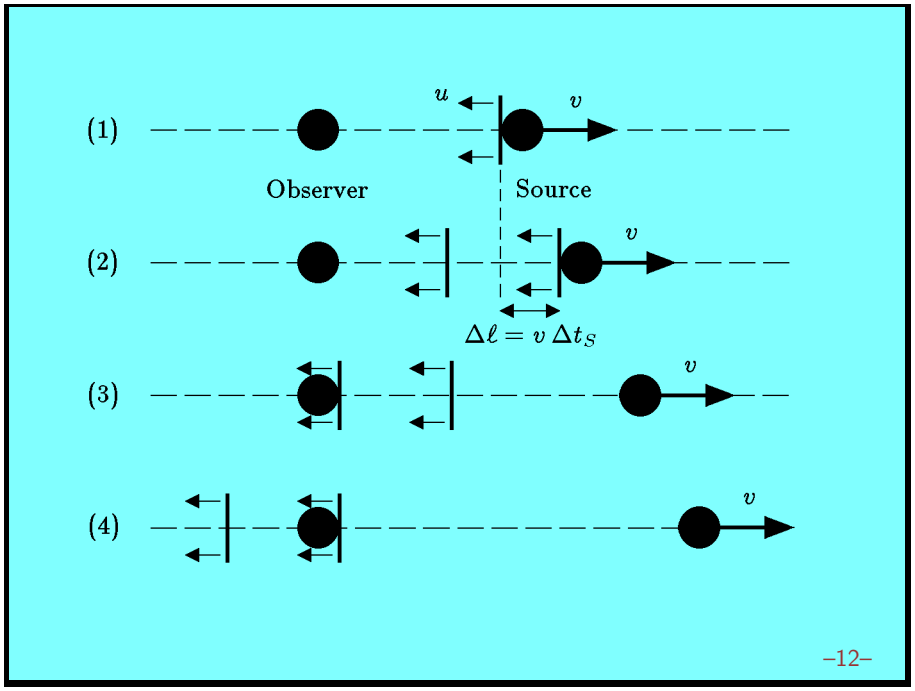


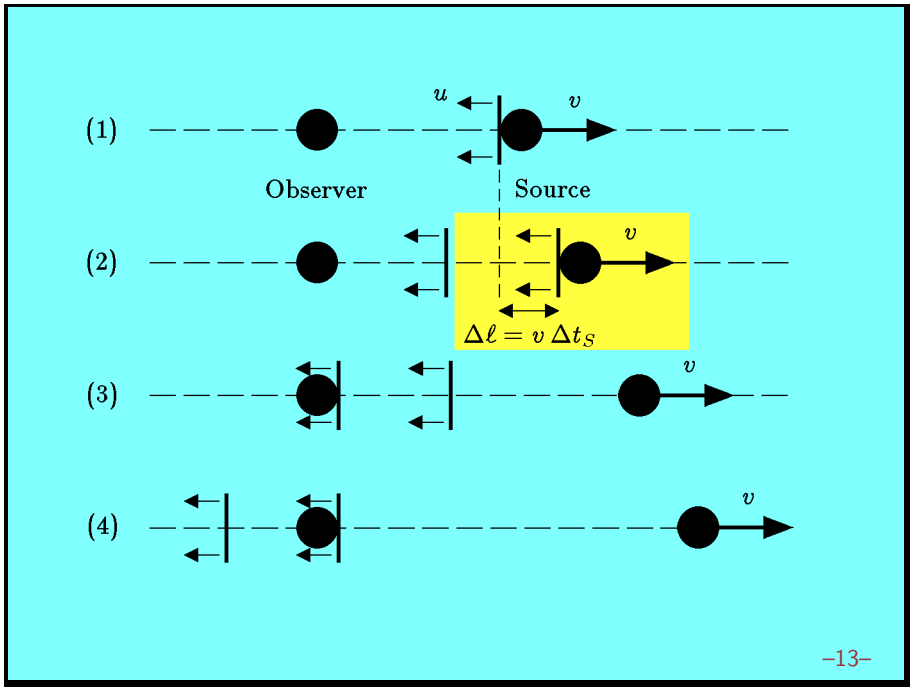
–10–

(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

$$\gamma \equiv \frac{1}{\sqrt{1-\beta^2}}\,, \qquad \beta \equiv v/c\,. \tag{1.10}$$

–11–


(1)
u
v
Observer
Source
(2)
v
$\Delta\ell = v\,\Delta t_S$
(3)
v
(4)
v
–12–


(1)
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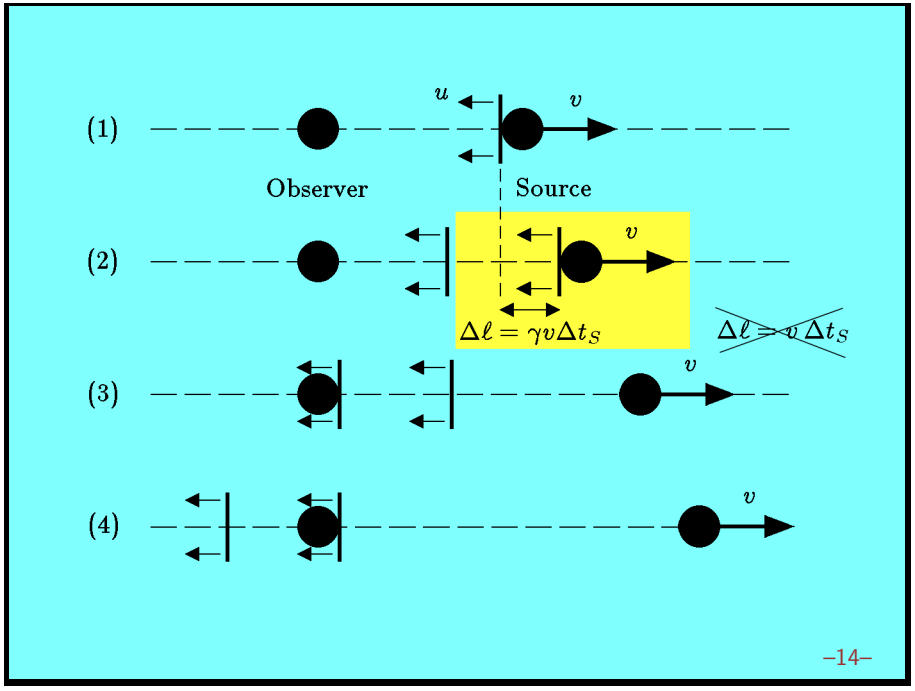
v
Observer
Source
(2)
v
$\Delta\ell = v\,\Delta t_S$
(3)
v
(4)
v
–13–


(1)
u
v
Observer
Source
(2)
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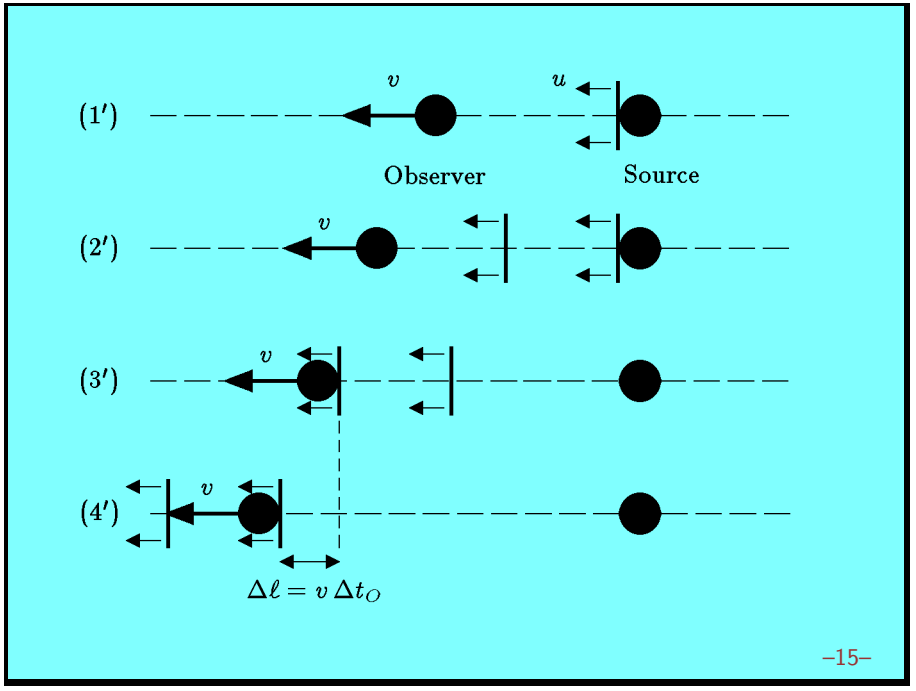
$\Delta\ell = \gamma v \Delta t_S$
$\Delta\ell = v\,\Delta t_S$
(3)
v
(4)
v
–14–


(1′)
v
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Observer
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(2′)
v
(3′)
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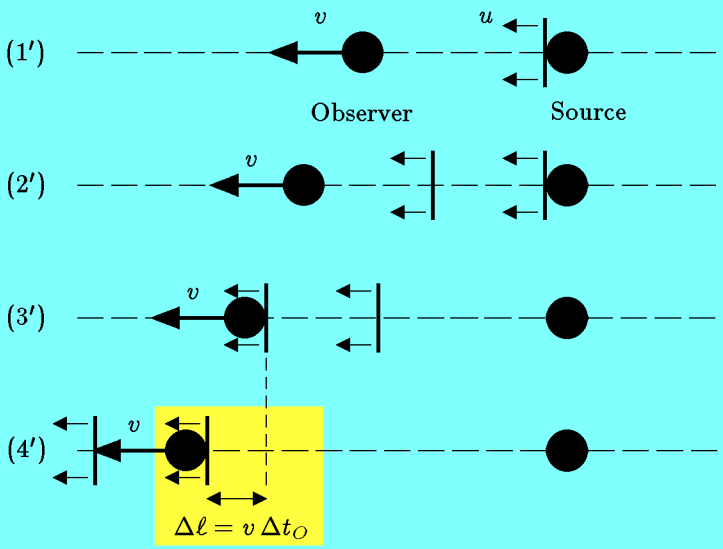
(4′)
v
$\Delta\ell = v\,\Delta t_O$
–15–



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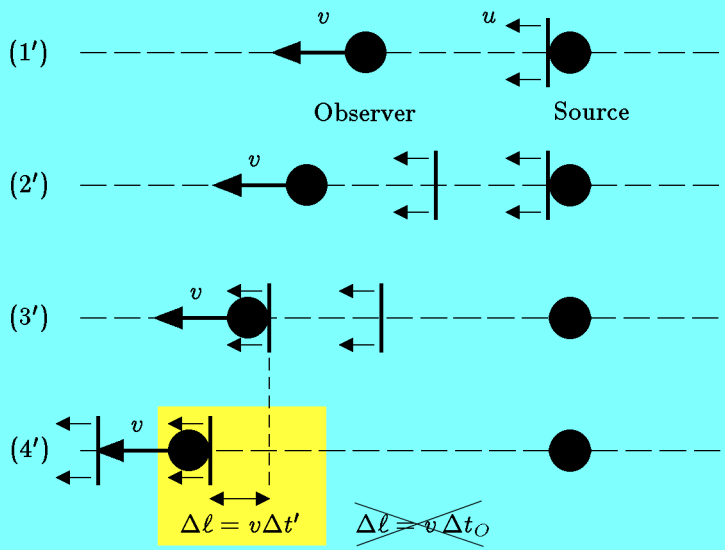

$\Delta t'$ = time between reception of two pulses in frame of the slide.

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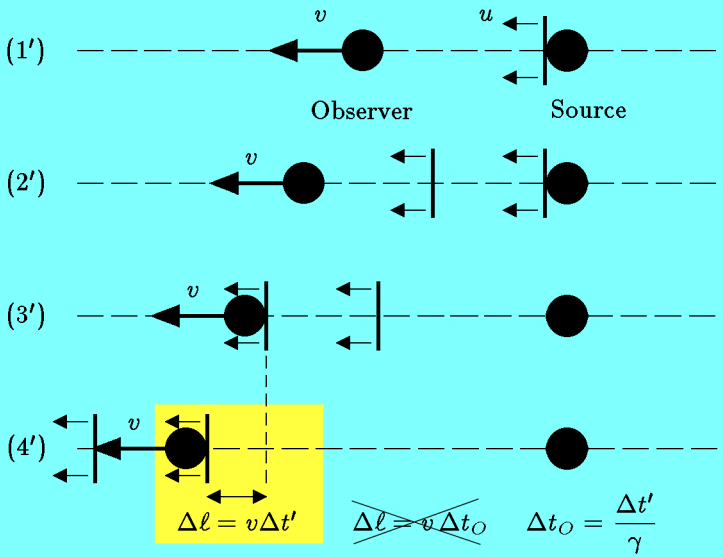

$\Delta t'$ = time between reception of two pulses in frame of the slide.

–18–

(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

$$\gamma \equiv \frac{1}{\sqrt{1-\beta^2}}\,, \qquad \beta \equiv v/c\,. \tag{1.10}$$

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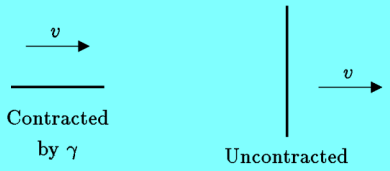
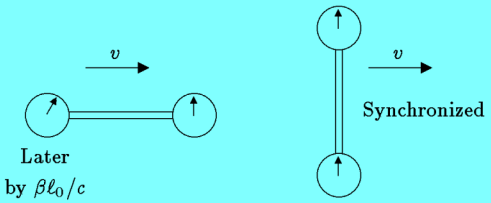
(2) LORENTZ-FITZGERALD CONTRACTION: Any rod which is moving at a speed v along its length relative to a given reference frame will "appear" (to an observer using that reference frame) to be shorter than its normal length by the same factor γ. A rod which is moving perpendicular to its length does not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



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8.286 The Early Universe

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