ASTR 1040 Recitation: Telescopes and Special Relativity

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February 5 & 6, 2019

Announcements

- Next Observing: Thurs, Feb 7 (8pm or 9pm at SBO)
- Next week is at Fiske, Tues/Wed Feb 12/13
- Optional review session: Wed, Feb 13 6-8pm, G126
- Midterm 1: Thurs, Feb 14 in class

Single Slit Diffraction

Shine light through a small hole, what do you see?

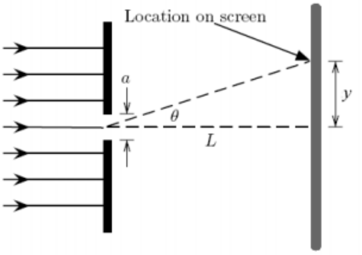
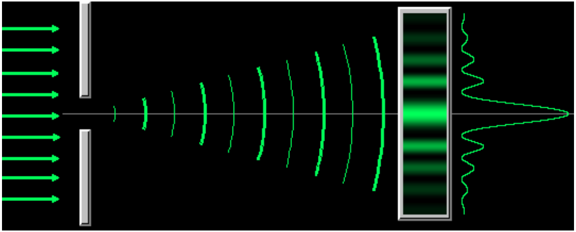


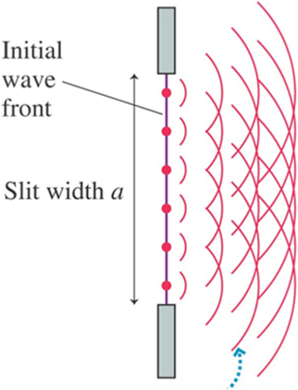
Figure 3: A schematic diagram for the light diffraction setup.

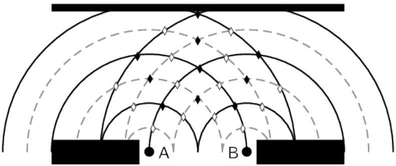
Single Slit Diffraction

Many maxima/minima, with a central maximum



Wave Fronts





What About Circular Openings?

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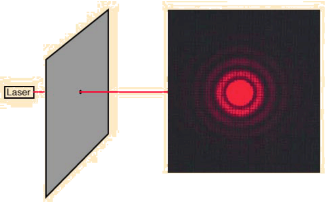
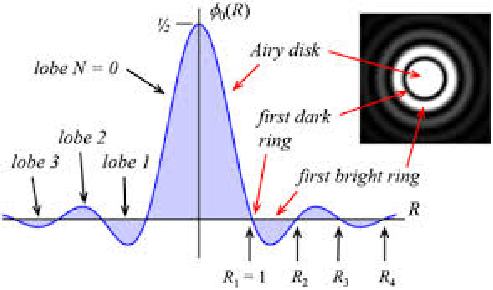
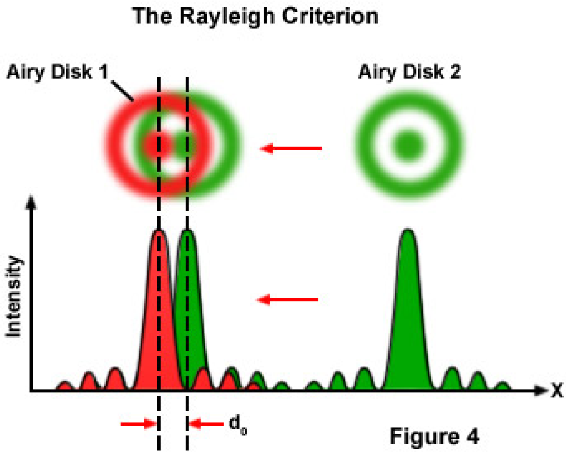




Diffraction Limit

Resolved when first minima lines up with central maxima

Diffraction Limit



$$\theta = \frac{1.22\lambda}{D}$$

Special Relativity

- Speed of light is the same for all observers

- Laws of physics are the same for all observers

Newton vs Einstein

Frame S' moves in the x direction with velocity u

- $x' = x - ut$
- $y' = y$
- $z' = z$
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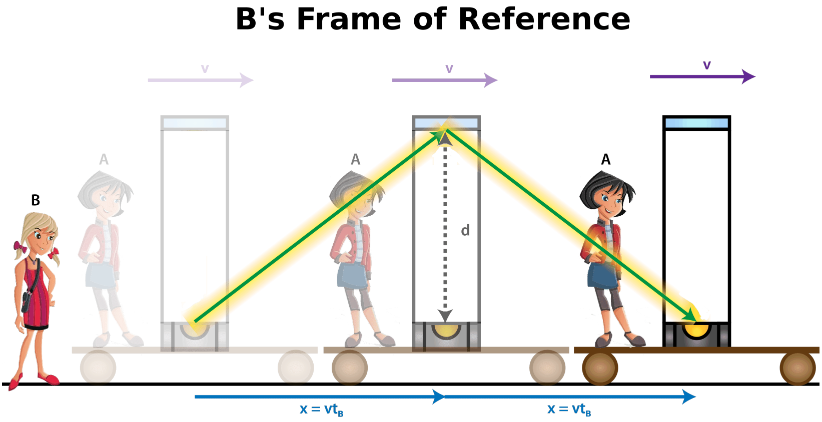
- $x' = \gamma x - \gamma ut$
- $y' = y$
- $z' = z$
- $t' = \gamma t - \gamma ux/c^2$

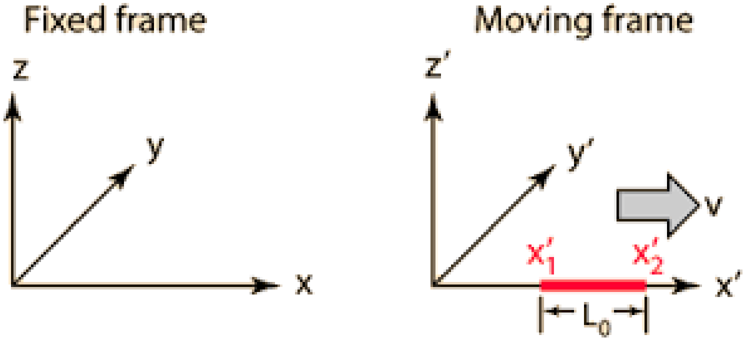
$$\gamma = \frac{1}{\sqrt{1 - u^2/c^2}}$$

Time Dilation



$$\Delta t_{\text{moving}} = \gamma \Delta t_{\text{rest}}$$

Length Contraction



$$x' = \gamma x - \gamma u t$$

Simultaneity

Two light bulbs go off at the same time, in different locations. What does a moving observer see (S' frame)?

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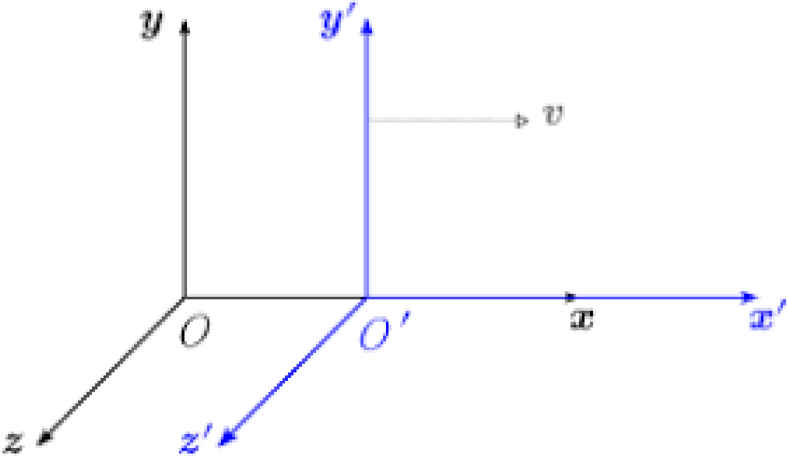
Events that are simultaneous for one observer are not simultaneous for all observers!

Frames of Reference



What happens if S' and S swap roles? Can we derive the "inverse" transforms without any math?

Practice Problem: Velocity Transforms

What are the S' velocity components $(v'_x,\ v'_y)$ in terms of the S velocity components $(v_x,\ v_y,\ v_z)$? Frame S' moves with respect to S at velocity u.

- $x' = \gamma x - \gamma u t$
- $y' = y$
- $z' = z$
- $t' = \gamma t - \gamma u x / c^2$

- $v'_x = ?$
- $v'_y = ?$
- $v'_z = v_z / \left[\gamma \left(1 - u v_x / c^2\right)\right]$
- $\gamma = \frac{1}{\sqrt{1 - u^2/c^2}}$

Practice Problem: Doppler Beaming

Consider a light ray with velocity components in S' of $v'_x{=}0$, $v'_y = c$, and $v'_z = 0$. What is the ratio of v_y/v in the S frame? Sketch the velocity in the S' and S frames.

- $v'_x = \frac{v_x - u}{1 - uv_x/c^2}$
- $v'_y = \frac{v_y\sqrt{1-u^2/c^2}}{1-uv_x/c^2}$
- $v'_z = \frac{v_z\sqrt{1-u^2/c^2}}{1-uv_x/c^2}$
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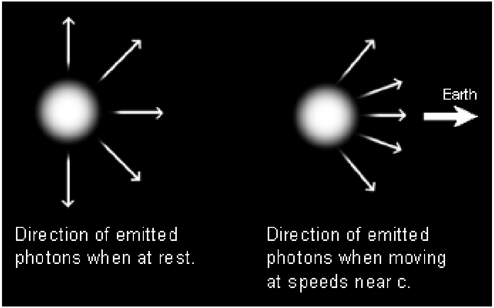

$$\sin\theta = v_y/v = 1/\gamma$$