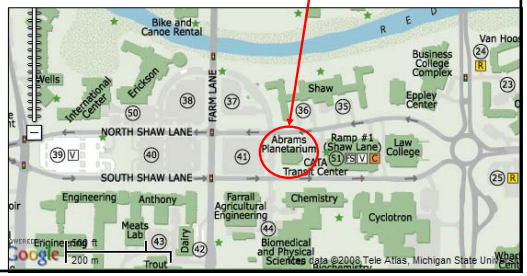
Free Public Lecture about Eclipses

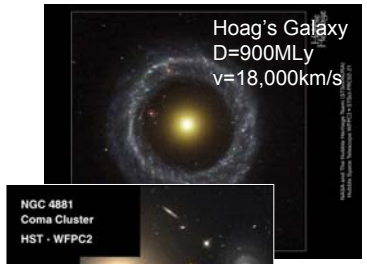
Black Hole Sun: A Total Eclipse

by Dr. Megan Donahue
Tomorrow (Thursday)
7:30 PM
Abrams Planetarium



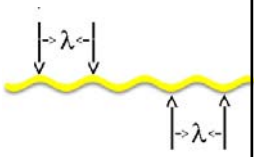
Measuring Motion, Doppler Effect—15 Oct

- Hubble's Law
- Universe is expanding
- Universe started with a Big Bang
- Age of the universe



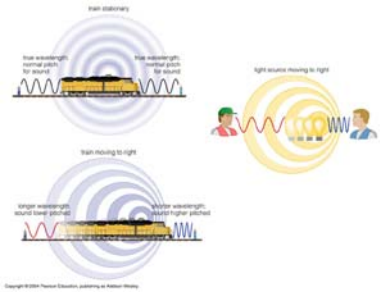
Wavelength, Frequency

- Wavelength λ = distance between successive crests.
  - m meter
  - nm nanometer (10^{-9}m)
  - Å angstrom (10^{-10}m)
- Wave moves at speed of light c.
- Frequency is rate at which crests pass.
  - f = c/λ
  - Cycles/second; Hertz



Measuring Motion: Doppler effect

- How do you measure the velocity of a star?
- Velocity = (change in position)/time
  - Measuring how much star moves is not possible, since we cannot go to the star.
- Velocity is encoded in the light that the stars emits.
- Waves emitted from a star moving towards us are bunched together.
  - Star moves between emitting one wave crest and another. Therefore wavelength is shorter.



Measuring Motion: Doppler effect

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- Waves emitted from a star moving towards us are bunched together.
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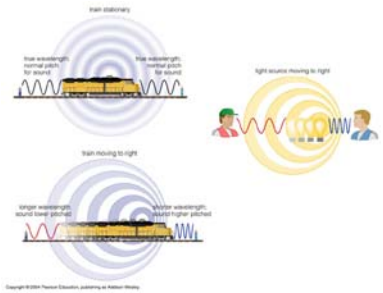
- $\lambda_{observed} / \lambda_{rest} = 1 + v/c$
  - v is speed, positive if star is moving toward us.
  - c is speed of light.
- $\Delta\lambda = \lambda_{observed} - \lambda_{rest}$ is called the shift in wavelength.



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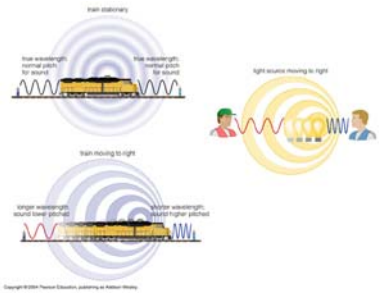
- Key idea: If motion is perpendicular to the line of sight, there is no change in wavelength.
  - In the formula, v is the component of the velocity towards or away from the observer.



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- Terminology
  - $v/c = (\lambda_{observed} - \lambda_{rest}) / \lambda_{rest}$
  - is called a redshift if positive (star is moving away)
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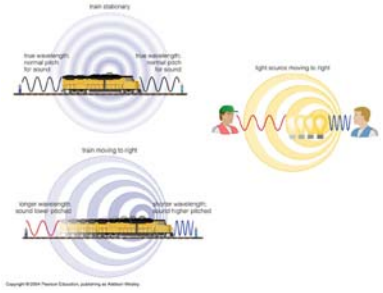
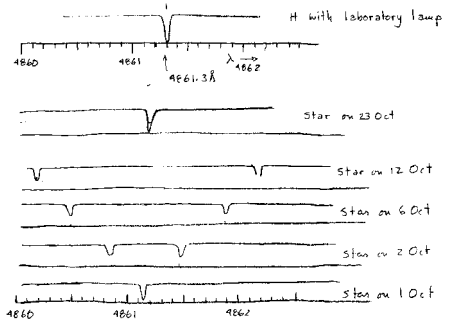


Pickering's discovery

- We are interpreting E. C. Pickering's (A. J. Cannon's boss) spectra of Mizar (a star in the Big Dipper) in 1889.
  - Spectra showing the Hβ line of hydrogen, which is the blue-green line that we saw with the hydrogen tubes.
  - These are *absorption* spectra: The amount of light is high except at wavelengths where hydrogen absorbs.
- Describe the changes in the spectra. (3 min)



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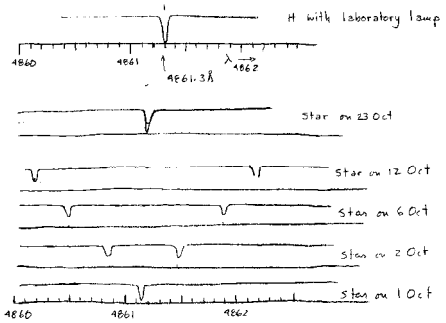

Pickering's discovery

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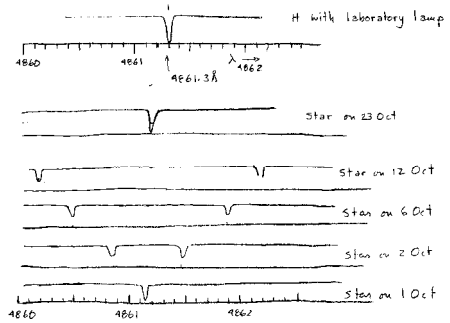
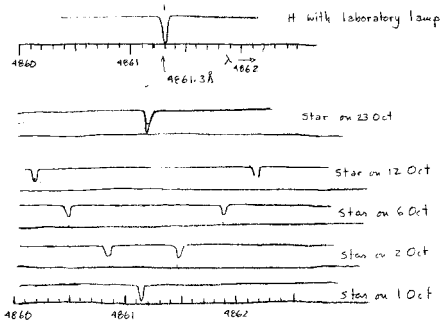
1. How can the spectral line of hydrogen appear at different wavelengths?
   A. The star is moving.
   B. Hydrogen emits at different wavelengths at different times.
   C. There was something wrong with Pickering's spectrometer.



Pickering's discovery

- We are interpreting E. C. Pickering's (A. J. Cannon's boss) spectra of Mizar (a star in the Big Dipper) in 1889.

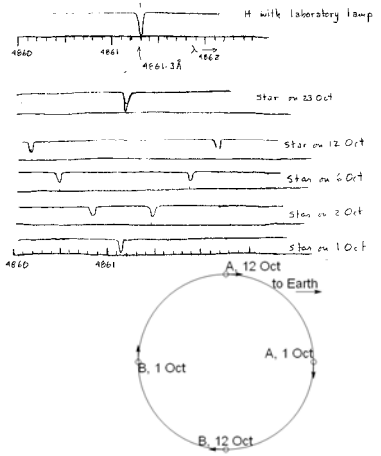
1. Devise a model for Mizar that explains the data. How can a star move at two speeds? (5 min)



Pickering's discovery

- We are interpreting E. C. Pickering's (A. J. Cannon's boss) spectra of Mizar (a star in the Big Dipper) in 1889.
- Provisional model: Two stars are in orbit. Test against evidence.

1. How can the two stars move so as to show the same wavelength, for example, as on Oct 1?
   A. The stars move in the same direction at the same speed on Oct 1.
   B. The Doppler effect is insensitive to the orbital motion on Oct 1.
   C. One star hides the other on Oct 1.



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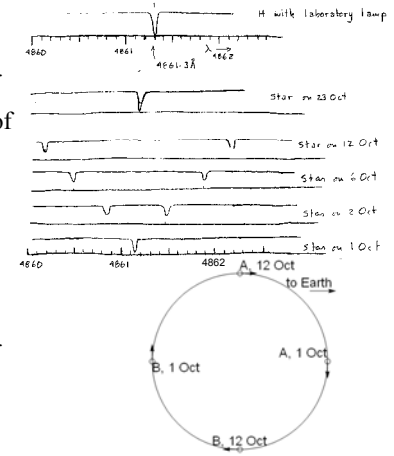
1. What is the wavelength of the Hβ line of hydrogen emitted by star A on 12 Oct?
   A. 4860.2Å.
   B. 4862.2Å.

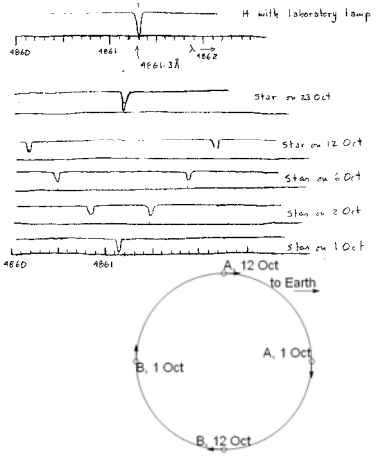


Pickering's discovery

- We are interpreting E. C. Pickering's (A. J. Cannon's boss) spectra of Mizar (a star in the Big Dipper) in 1889.

1. What evidence tells you whether the binary star system is moving toward or away from us?
2. What is v/c, where v is the velocity of the binary star system?
   A. $-0.17 / 4861.13 = -3.5\times10^{-5}$.
   B. $-0.17 / 4861.3 = -3.5\times10^{-5}$.
   C. $4861.13 - 4861.3 = -0.17$
   D. $4861.3 - 4861.13 = 0.17$
   E. $0.17 / 4861.3 = 3.5\times10^{-5}$

- Pickering discovered the first binary star where the evidence was in the spectra.



Doppler effect: Summary

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