ASTR 1120: Stars & Galaxies

Prof. Juri Toomre TA: Ben Brown

Lecture 5 Fri 21 Jan 05

zeus.colorado.edu/astr1120-toomre

Topics for Today

- Doppler effect and "redshift"
- Basic principles of eyes, cameras and telescopes
- Why big reflectors and not refractors?
- Instruments in the focal plane – the business end!
- Telescopes in space – and why

- *Observatory Night #2* was last night, with pretty good observing. *Homework #1* turned in today.
- New *Homework #2* given out today

Reading for Next Class

- Start reading Chap 15, *Our Star: The Sun* in detail
- Monday lecture continues on *telescopes*, next Friday turns to *our nearest star*
- Wed 26 Jan: class in Fiske Planetarium

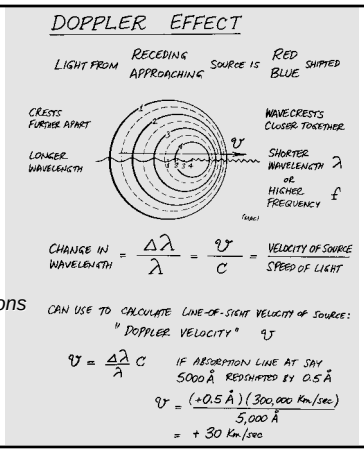
- *Come see us if you need any help or advice about anything in this course*

Reading Clicker Q -- spectra

- *Visible light from a distant star can be spread into a spectrum by using a glass prism or _____ ?*
- A. a telescope
- B. adaptive optics
- C. a diffraction grating
- D. a flat glass mirror
- E. a compound lens

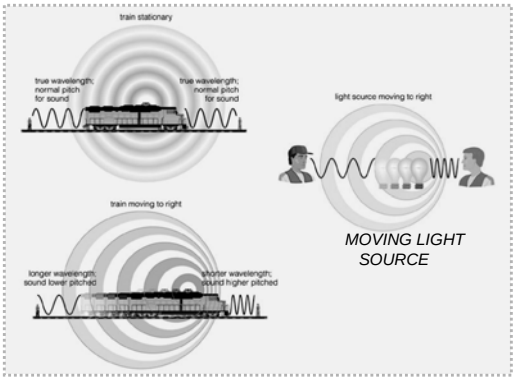
C.

DOPPLER EFFECT



Applied to positions of spectral lines

Doppler Effect: Trains and Light

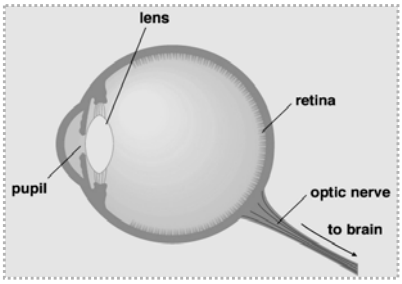


Now On to Telescopes

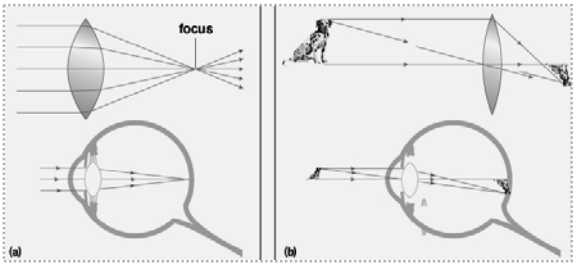
VLA – Scicorro, NM

Imaging with our Eyes

- **pupil** – allows light to enter the eye
- **lens** – focuses light to create an image
- **retina** – detects the light and generates signals sent to brain

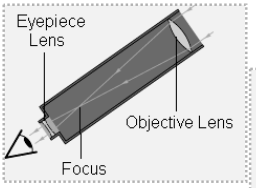


Bending of Light to Focus
(Form an Image)

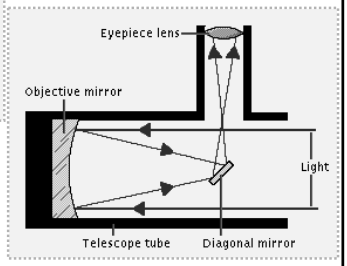


Telescopes and cameras work much like our eyes

Optical Telescopes of Two Types



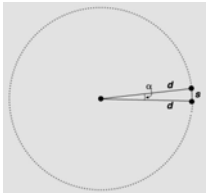
REFRACTOR (LENS)

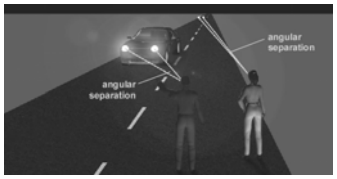


REFLECTOR (MIRROR)

Concept of "Angular Resolution"

- Ability to separate two objects
- Angle between two objects decreases as your distance to them increases
- Smallest angle at which you can distinguish two objects is your *<u>angular resolution</u>*



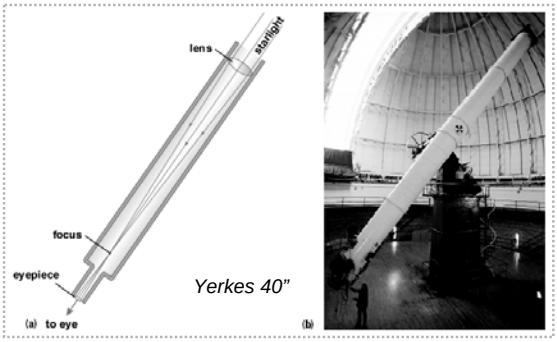


Two Properties of Any Telescope

1. *Resolution*
   - <u>smallest angle</u> which can be seen:
   - $\theta = 1.22\ \lambda / D$
2. *Light-Collecting Area*
   - think of telescope as a "photon bucket"
   - <u>its area</u>: $A = \pi\ (D/2)^2$

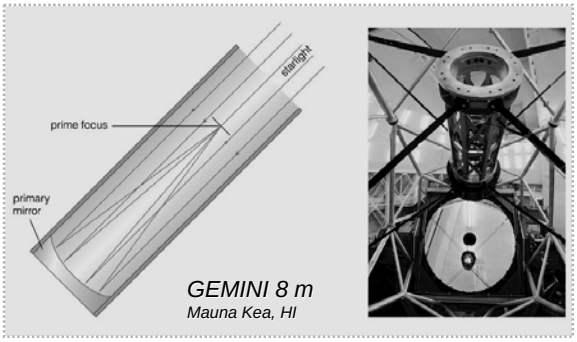
(λ is light wavelength, D is mirror diameter)

Largest Refractor



Yerkes 40"

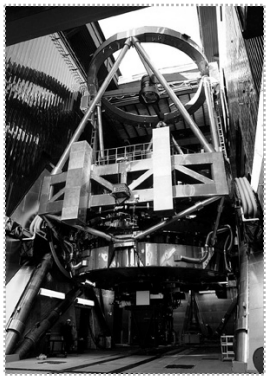
Modern 8 m Telescope (Reflector)



GEMINI 8 m
Mauna Kea, HI

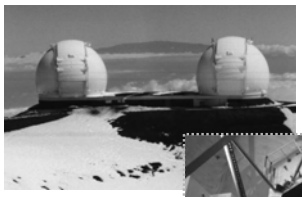
Modern Reflectors

6.5 m MMT – Mt. Hopkins, AZ

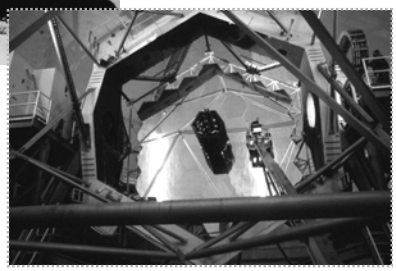


8.3 m SUBARU – Mauna Kea, HI

Keck 10 m Twins (Segmented Reflectors)



Mauna Kea, HI



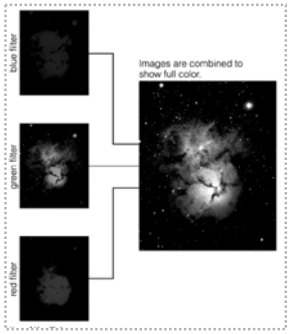
Instruments in the Focal Plane

How astronomers use light collected by a telescope:

1. *Imaging*
   - use camera to take pictures (images)
   - photometry → measure amount and color (with filters) of light from object
2. *Spectroscopy*
   - use spectrograph to separate light in detail into its different wavelengths (colors)
3. *Timing*
   - measure how amount of light changes with time (sometimes in a fraction of a second)

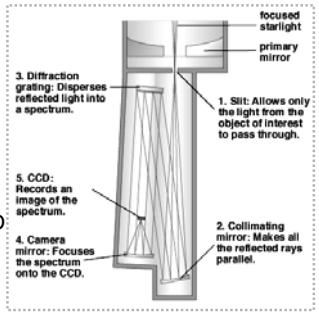
Imaging (Digital with CCDs)

- *Filters* are placed in front of camera to allow only certain colors to be imaged
- Single color images are superimposed to form "true color" images.

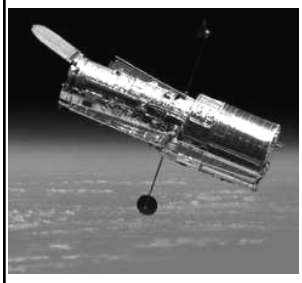


Spectroscopy – analyzing the light

- Spectrograph reflects light off a *grating*: finely ruled, smooth surface
- Light (by interference) disperses into colors
- This *spectrum* is recorded by digital CCD detector



Space Based Telescopes



Hubble Space Telescope (HST) optical, UV

Chandra X-ray Observatory

But how do you point space telescopes?

- Carefully!
- Mostly using *reaction wheels* (conserving angular momentum) --- demo is in order

- *ANGULAR MOMENTUM* issues will come up often in this course:
- orbits of binary stars,
- mass exchange between stars,
- matter falling into accretion disk around black hole (or white dwarf or neutron star)