Astro 301/ Fall 2005

(48310)

Introduction to Astronomy

Instructor: Professor Shardha Jogee

TAs: David Fisher, Donghui Jeong, and Miranda Nordhaus

Lecture 22 = Tu Nov 15
Lecture 23 = Th Nov 17

http://www.as.utexas.edu/~sj/a301-fa05/

Lecture 22: Announcements

-- Extra Credit option: if you have not started, you may run out of time
check website

-- "Guidelines on how to study for a science class"

Last Weeks

-- Waves
-- Basic properties of waves: Wavelength, Frequency, Speed, Energy
-- Types of waves: sound, surface, electromagnetic

-- Light as Electromagnetic Waves
-- Dual nature of light: light as electromagnetic waves or as photons
-- The electromagnetic spectrum: wavelengths, frequency, speed
-- Processing of Electromagnetic Waves
-- Luminosity and Total Flux of a distant object
-- Using the continuum spectrum of a star to estimate its **surface temperature, total surface flux and radius**
à Wien's Law: Relating surface temperature and color of the continuum emission
à Stefan-Boltzmann law: Relating surface temperature and surface continuum flux

-- Using the particle model of light and the discrete energy levels in an atom to explain emission and absorption lines
- Light as a steam of photons.
- Dependence of a photon's energy on its wavelength or frequency
- Discrete energy levels in an atom
- Using emission and absorption lines to trace **chemical composition** of a star

Recent and Upcoming topics in class

-- Using the Doppler shift of an emission line to infer the distance of the source

- Doppler shift of a wave: redshift and blueshift
- Using the Doppler redshift of an emission line to get the recession speed of a source
- Using the recession speed of a source to get its distance (Hubble's law)

---Telescopes : Our Eyes on the Universe

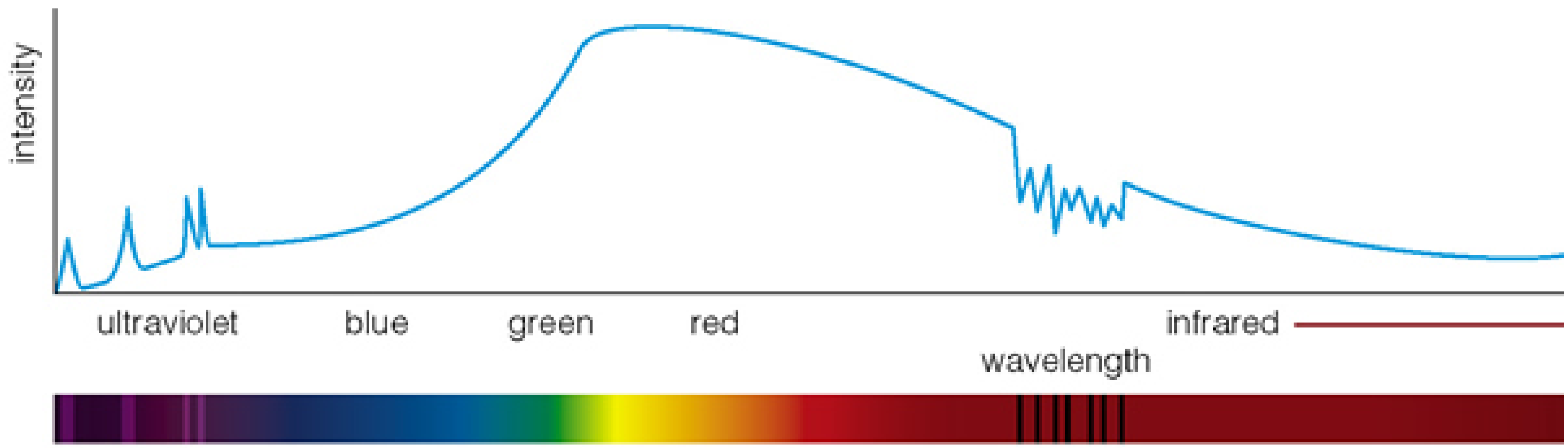
-- Important properties of a telescope
  - Collecting Area: Current and Next Generation Largest telescopes. GMT
  - Gound-based or space-based : NASA's four Great Observatories
  - Resolving power
  - Operating Wavelength

-- NASA's four Great Observatories : Hubble, Compton, Chandra, Spitzer

-- Unveiling the mysteries of the Universe at different wavelengths

Recapitulation from last time

Information we can extract from the spectrum of an object

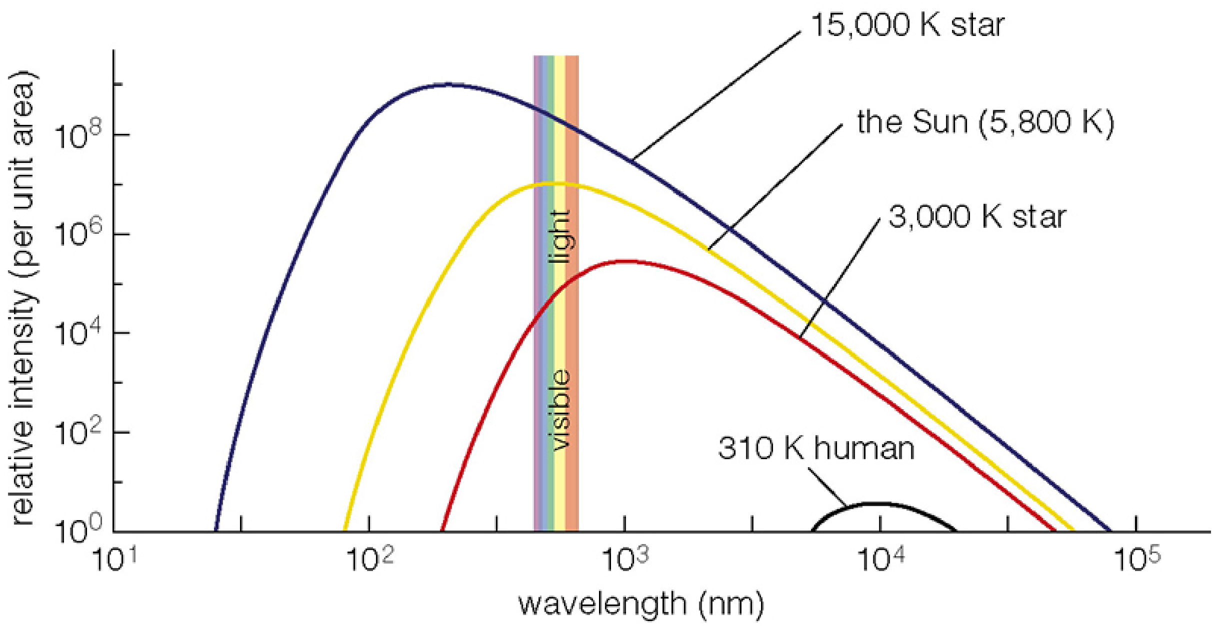


1) When the total flux from an object is separated into the flux at different wavelengths, and the intensity of the flux is plotted against wavelength, we get a spectrum for that object e.g., The figure above shows a spectrum.

2) The spectrum has 3 types of features:

continuum ermission , emission lines, absorption lines.

3) Amazingly, these features in the spectrum of an object can reveal to us many key properties of that object….. such as



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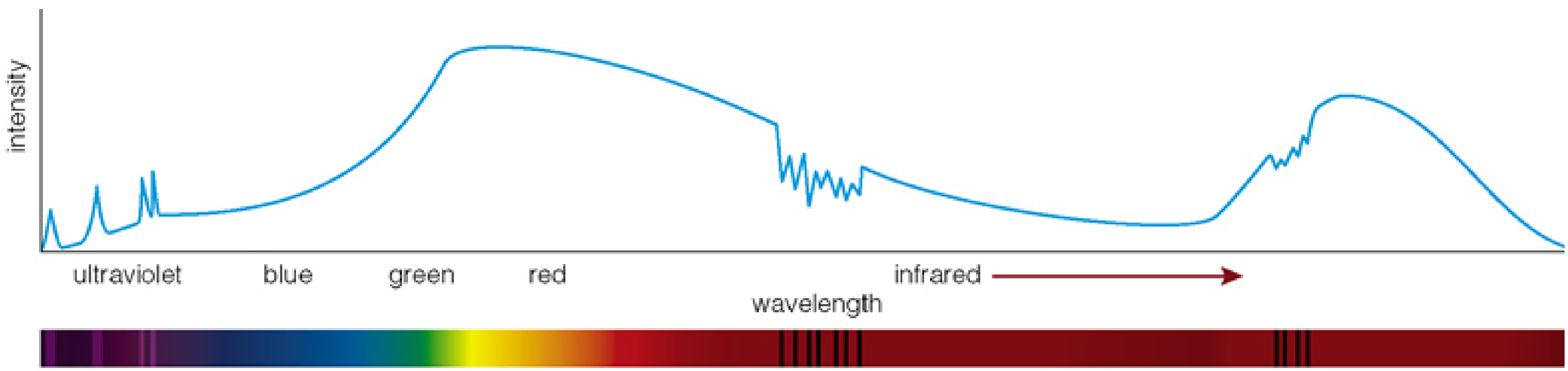
à its temperature , its total flux from the continuum à its chemical composition from emission and absorption lines

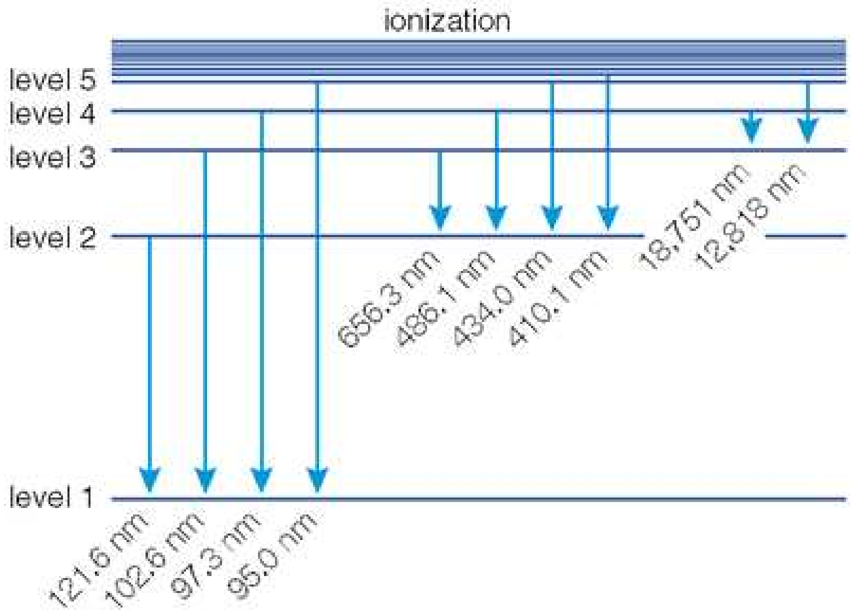


1) Atoms of different elements produce a <u>unique and characteristic set of discrete emission lines or absorption lines at specific wavelengths</u>

2) a discrete emission line is produced when electrons in a given atom move from a high energy level to to a low energy level by <u>emitting the energy difference as a photon of specific wavelength</u>

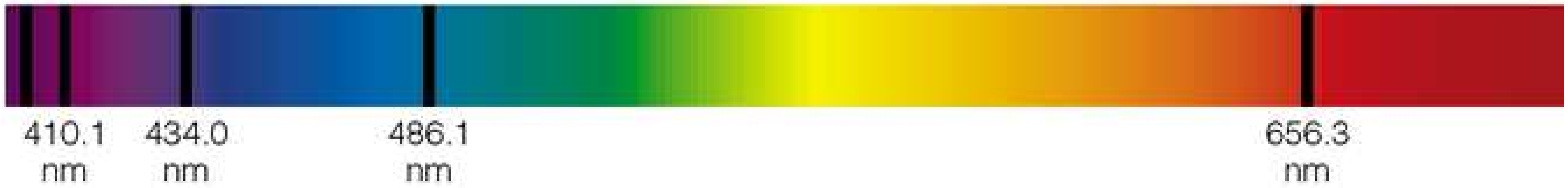
3) a discrete absorption line is produced when electrons in a given atom move from a low energy level to to a high energy level <u>by absorbing the energy difference as a photon of specific wavelength</u>

Emission and Absorption Lines from Atoms

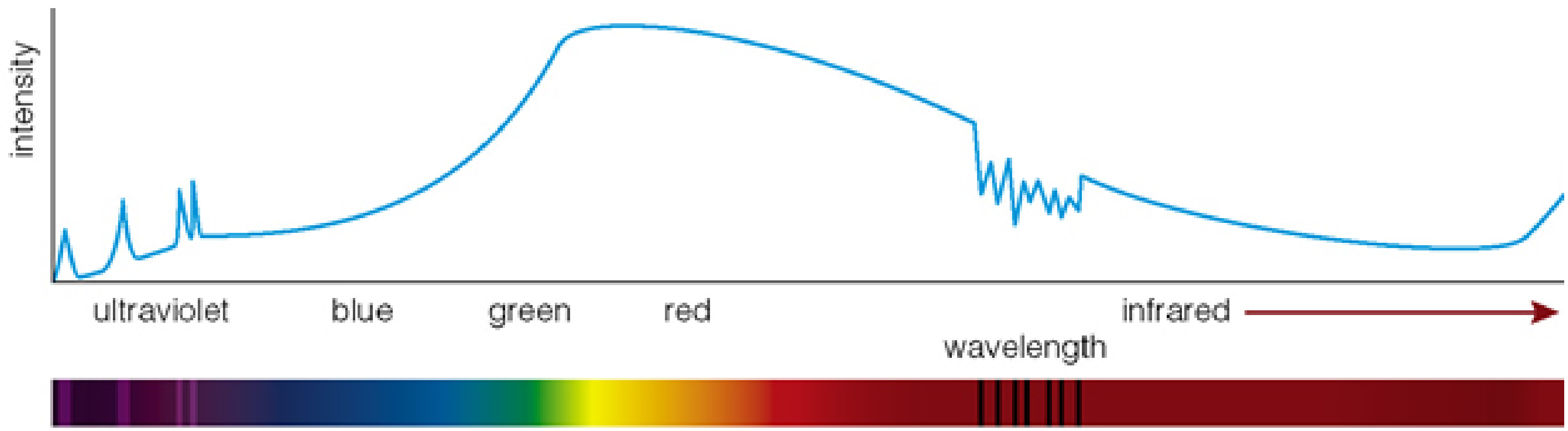


- Electrons only move between discrete energy levels

- So only photons of specific energies (i.e. wavelengths) are emitted or absorbed by a given atom



Information we can extract from the spectrum of an object



Today, you will leam how the spectrum of an object can give you one extra piece of information: the distance of that object !

- Doppler shift of a wave: redshift and blueshift
- Using the Doppler redshift of an emission line to get the recession speed of a source
- Using the recession speed of a source to get its distance (Hubble's law)

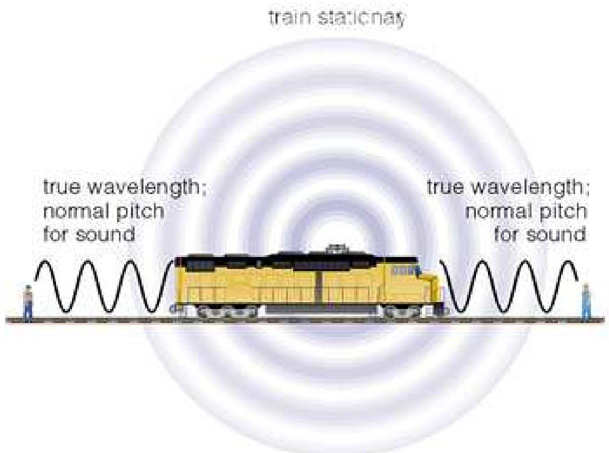
Doppler Redshift amd Blueshift

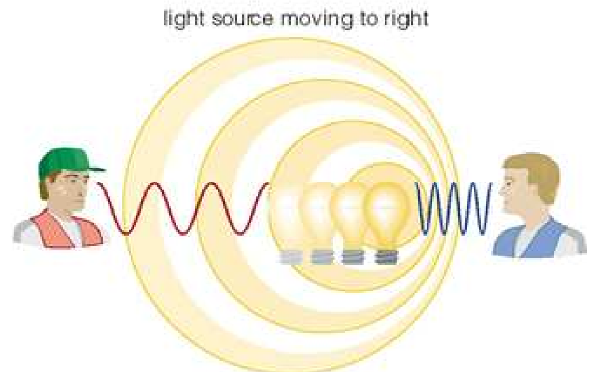
Doppler Shift

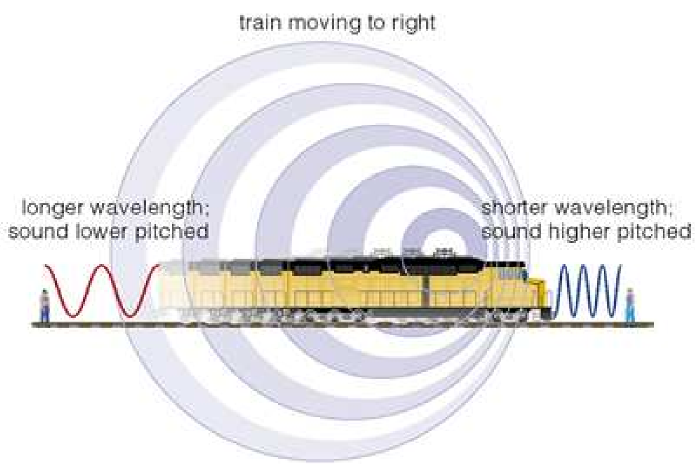
à In-class animation : Doppler shift of sound waves

<u>See in-class notes for definition and examples</u>

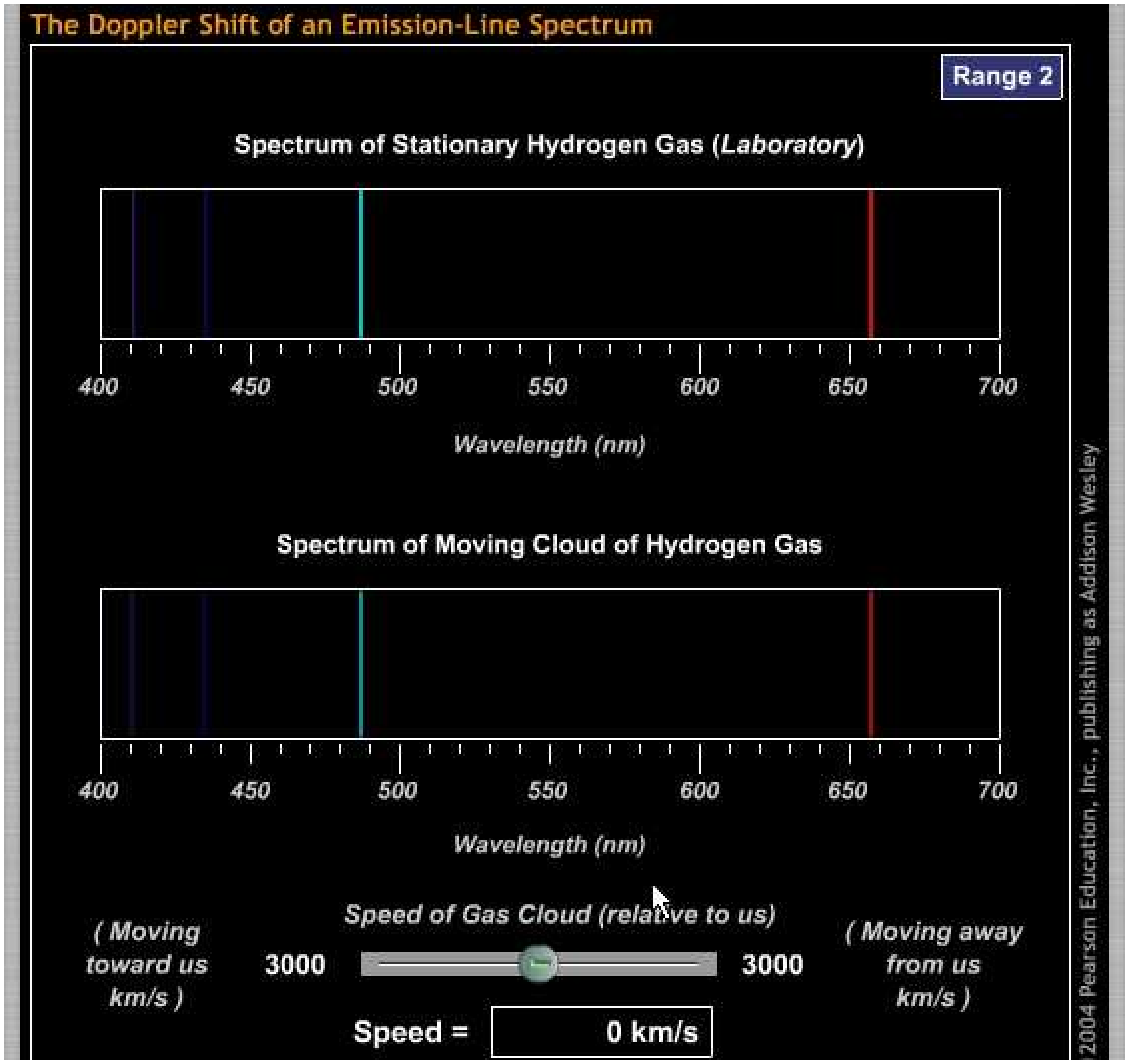
Doppler Shift





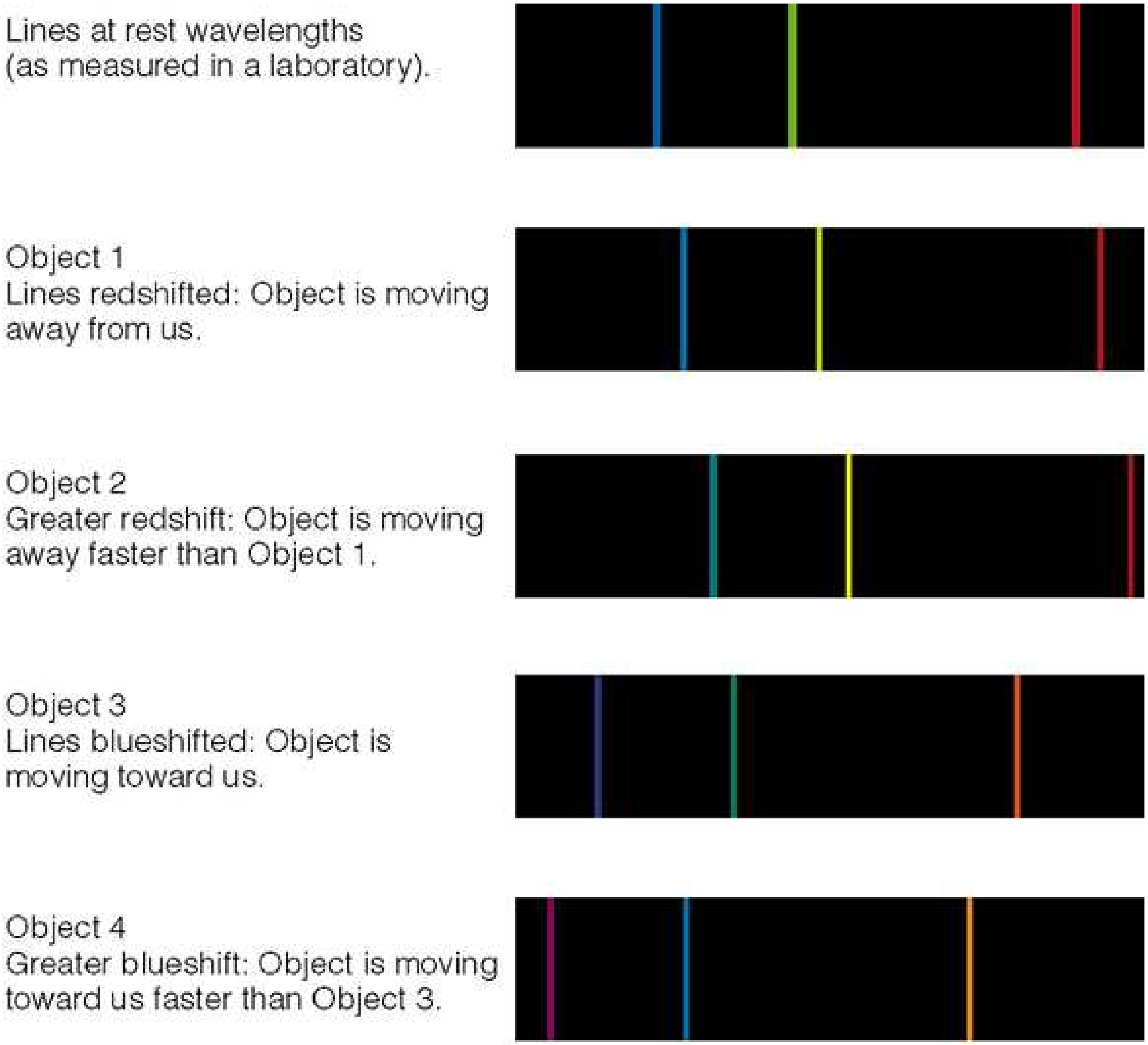


Doppler Shift

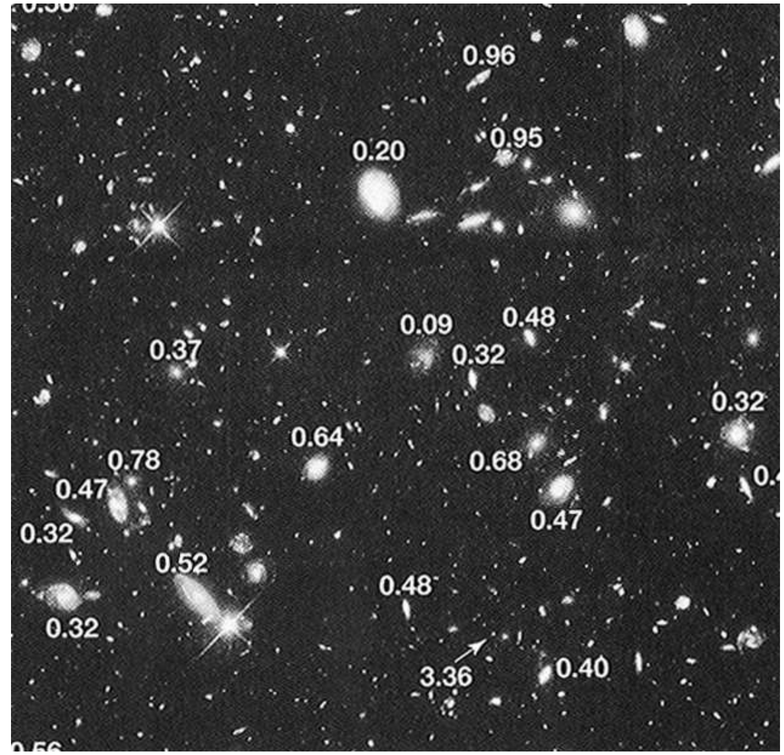


à In-class demo: Doppler shift of light waves : blueshift and redshift

Doppler Shift



Using Hubble's Law + Doppler Redshifts to get distances out to 10^{10} lyr



1) From the Doppler redshift of emission lines, we calculate recession speed v of a source.

e.g., in image each galaxy has a different redshift,

2) We then use the recession speed v in Hubble law to get distance

Hubble's law applies to distant galaxies, well outside the Local Group. It states that dueto the expansion of the Universe, distant galaxies are moving away from us with a recession speed v that is directly proportional to the distance d of the galaxy from us

v in km/s = (Hubble constant in km s-1 Mpc^{-1}) (d in Mpc)

where 1 Mpc = 1 Mega parsec = 3 Mega lyr

Hubble's constant = 70 km/s Mpc^{-1}

Lecture 23: Announcements

- Extra Credit option: Telescope Observing
- If you want to use this option, start now or you will run out of time
- The drive of the Painter Hall Telescope is now fixed

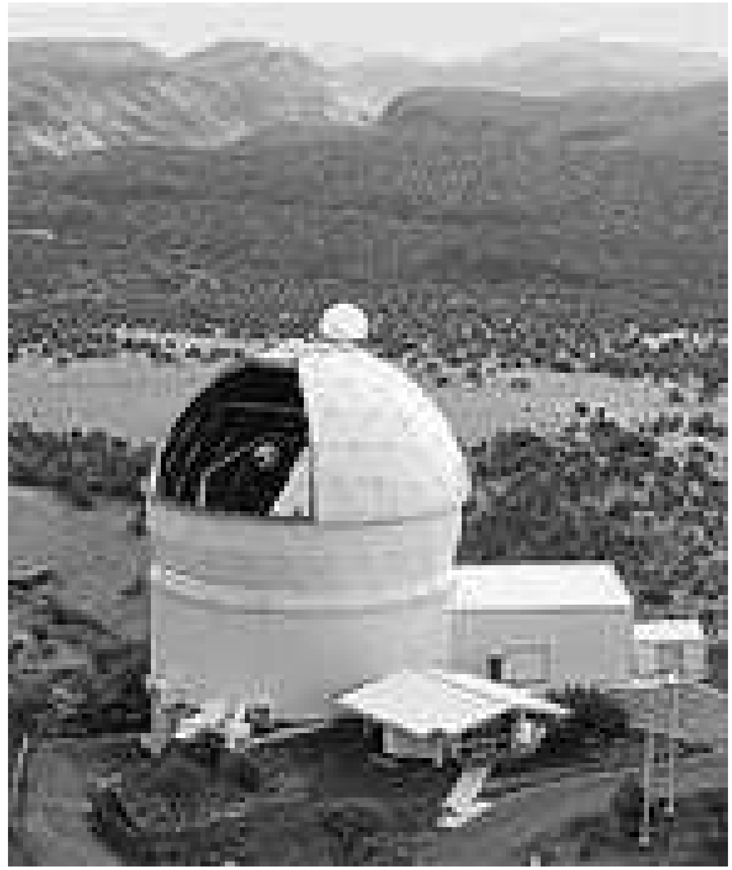
- Tue Nov 22: Quiz 5 based on **lectures 22, 23 and Chapter 20** of the book
- Tue Nov 22: Exam2 will be returned
- Tue Nov 22: Hkw 5 will be handed out, due back Tue Nov 29

Picture of the day

Collecting Area of a Telescope

Largest Optical and Infrared Telescopes

Keck 10-m telescope at 5000 feet
on Mauna Kea in Hawaii



9.2m Hobby Eberly Telescope of UT
Austin at the Mac Donald Observatory

Largest Optical and Infrared Telescopes

Concrete base, 40 ft diameter, that supports the 9.2m Hobby Eberly Telescope

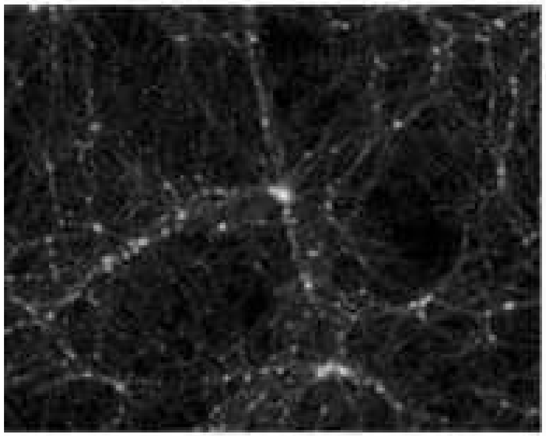
Next Generation Largest Ground-Based Telescopes

Giant Magellan Telescope
GMT

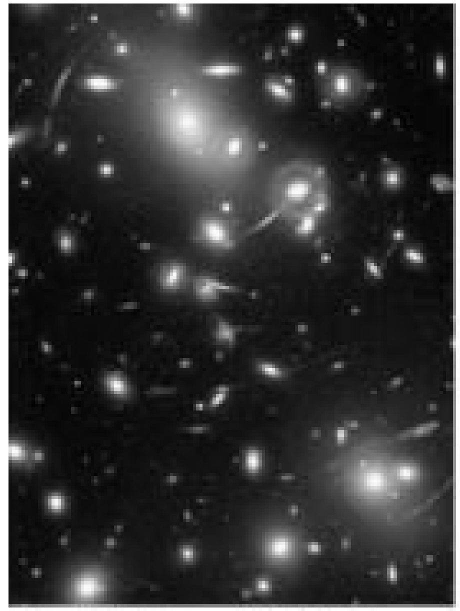
- 7 mirrors of size 8.4 m giving an aperture of diameter 22 m
- Works at visible, near-IR, mid-IR
- Location = Northern Chile
- First light in 2014

- Partner Universities include
  Arizona
  UT Austin
  Carnegie Observatories
  Harvard
  MIT
  Michigan

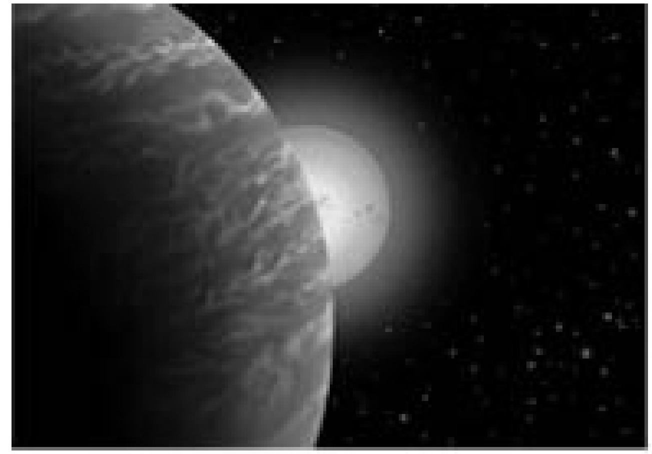
Next Generation Largest Ground-Based Telescopes



The Early Universe



Dark Matter & Dark Energy



Young Planets

Science goals of the Giant Magellan Telescope (GMT)

- Understanding the formation and evolution of the first galaxies
- Probing the dark matter and dark energy content of the Universe
- The detection of extrasolar planets
- Finding the link between black holes and galactic bulges

Next Generation Largest Ground-Based Telescopes

Giant Magellan Telescope (GMT)

Casting of the first mirror of the GMT completed last week (27 Oct 2005) !

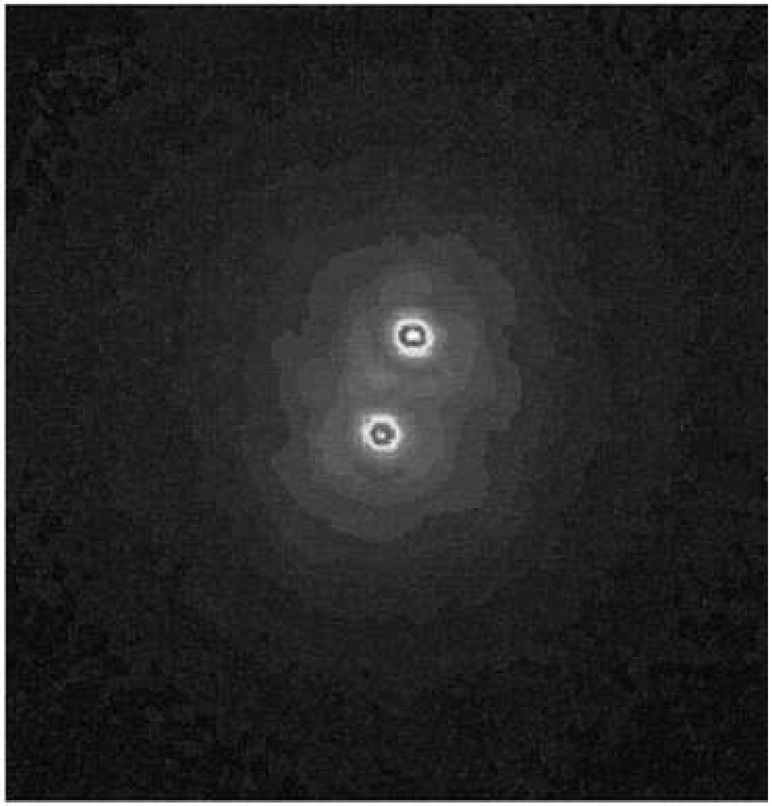
For the casting last July, Mirror Lab workers used 40,000 pounds of Ohara E-6 borosilicate glass. The furnace hit peak temperature, 2,150 degrees Fahrenheit (1,178 Celsius) on July 23.

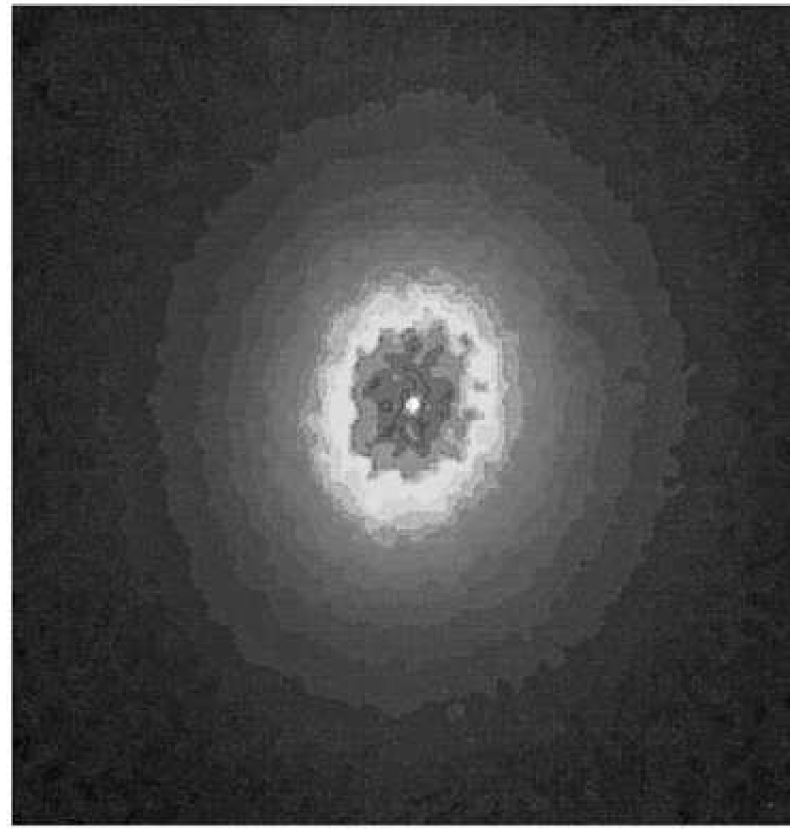
As the furnace rotated at 5 revolutions per minute, glass melted around the 1,681 hexagonal cores in the mold. This created a 'honeycomb' mirror blank with a faceplate of the desired curvature.

The honeycomb mirror weighs only a fifth as much as would a solid mirror of the same size.

Resolving Power or Angular Resolution of a Telescope

Resolving Power of Telescopes

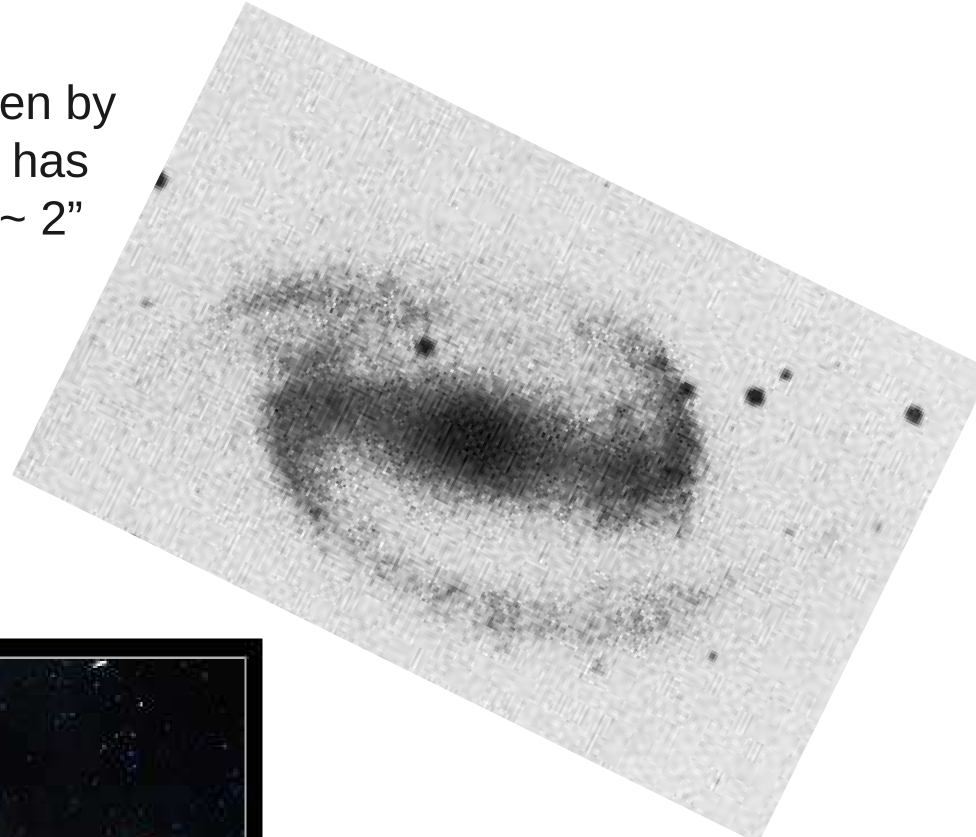




A double star with a true angular separation of 0.5” is imaged by two telescopes having different angular resolutions
LEFT: The image has a high angular resolution of 0.1”. The 2 stars are resolved into separate sources
RIGHT: The image has a poor angular resolution of 3”. : the 2 stars are blurred ino one source

Resolving Power of Telescopes

NGC 1300 : this image was taken by a ground-based telescope and has an angular resolution s(eeing) ~ 2”

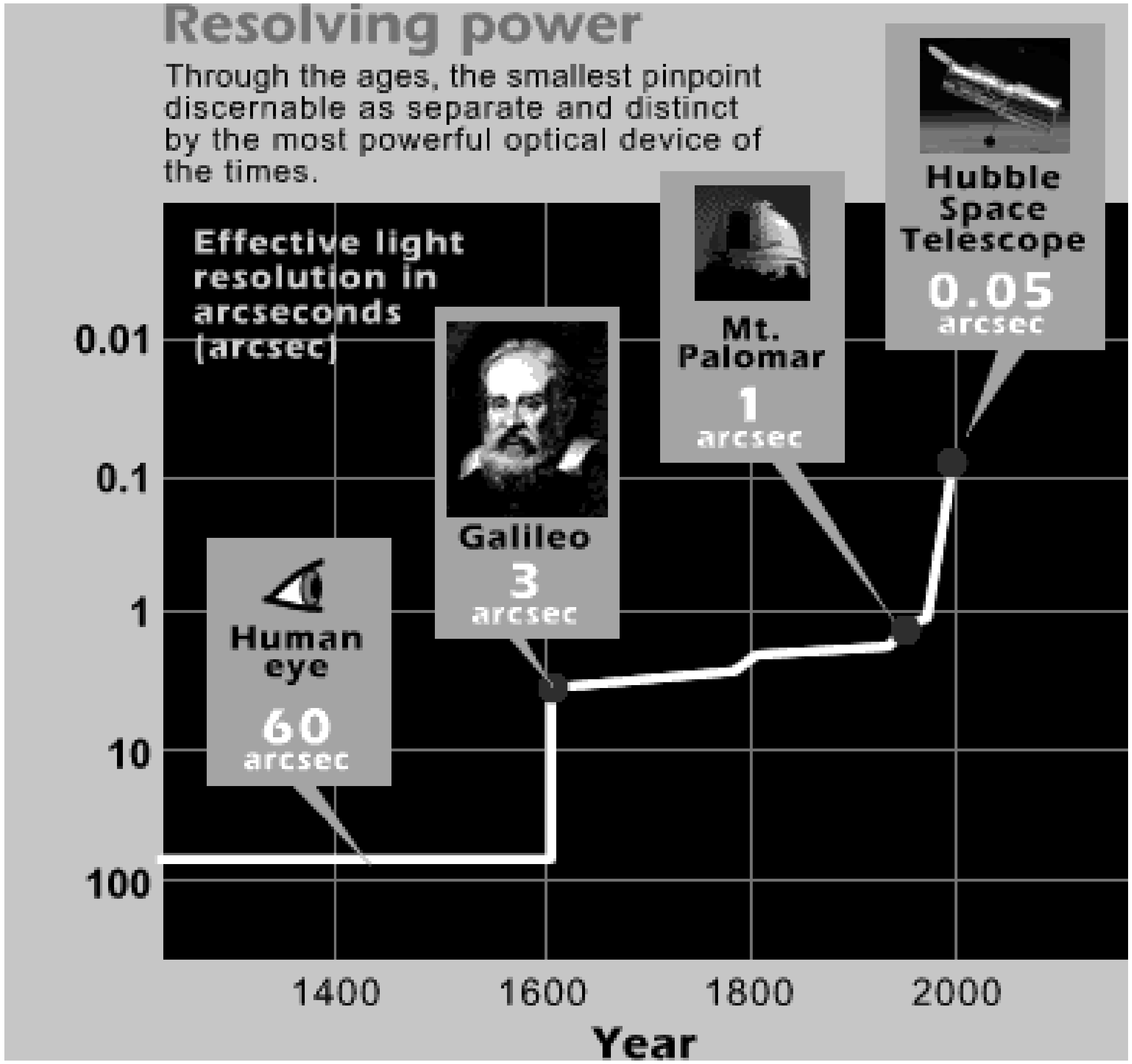


NGC 1300 : this image was taken by Hubble and has an angular resolution (seeing) ~ 0.05” . It shows much higher level of details within the galaxy

Resolving Power of Telescopes

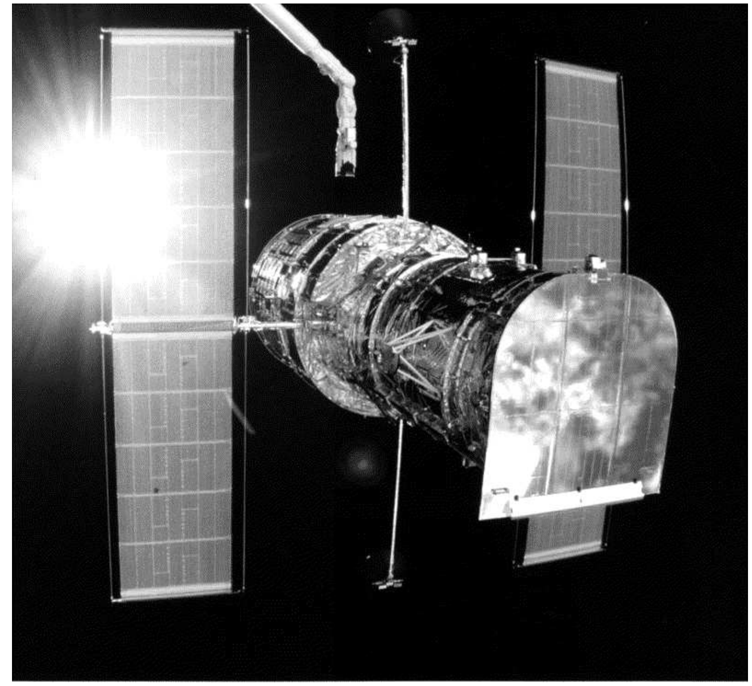
HST image of spiral galaxy pair: seeing ~ 0.05”

Resolving Power of Telescopes



Why do we put telescopes in space?

Why do we put telescopes in space?



---Advantages of putting a telescope in space ?

à No blurring by Earths's atmosphere: images have high angular resolution.

à No absorption by Earth's atmosphere of Gamma-ray, X-ray, UV, some IR, submm

à Avoid infrared background (glare) emission from Earth's atmosphere and sky : can see faint IR sources

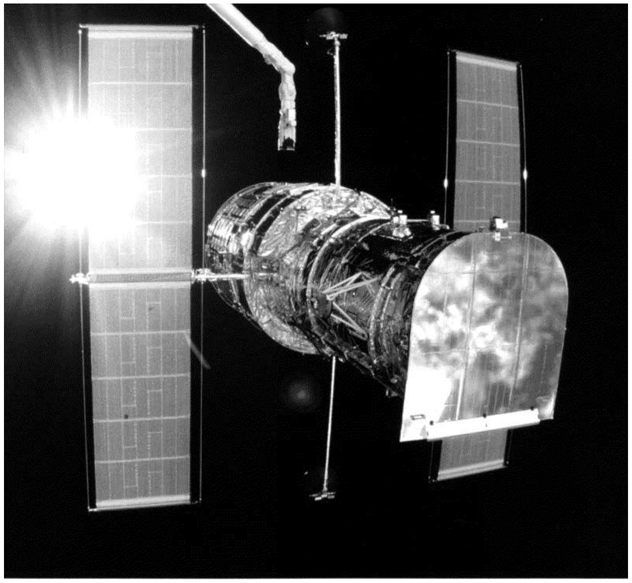
-- Disadvantages of space-based telescopes?

à Cannot have large collecting area (else unstable and would need high power)

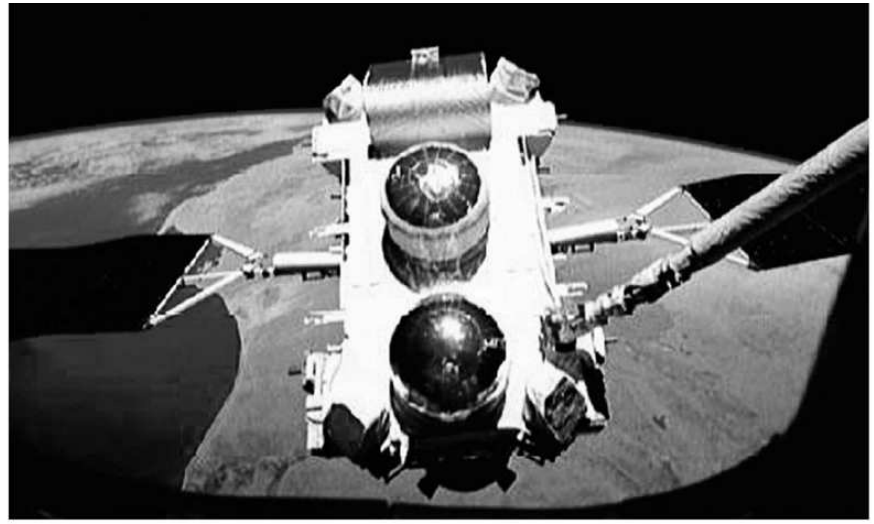
à Costly to repair and upgrade : servicing missions by astronauts

à Re-entry for larger telescopes can be dangerous (e.g., CGRO was 17 tons!)

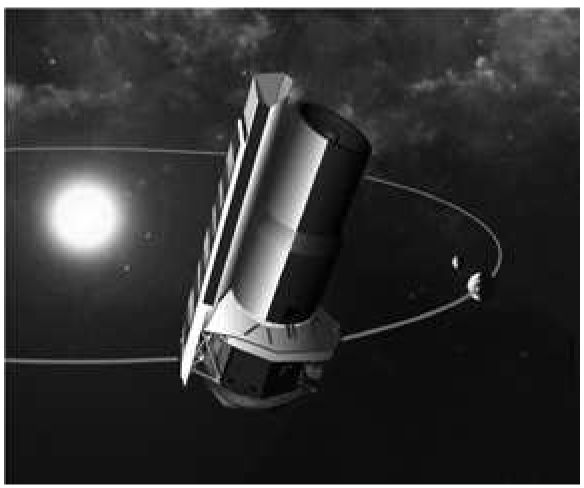
NASA's Four Great Observatories



Hubble Space Telescope (HST; 1990)
for UV, optical and near-infrared



Compton Gamma-Ray Observatory (CGRO)

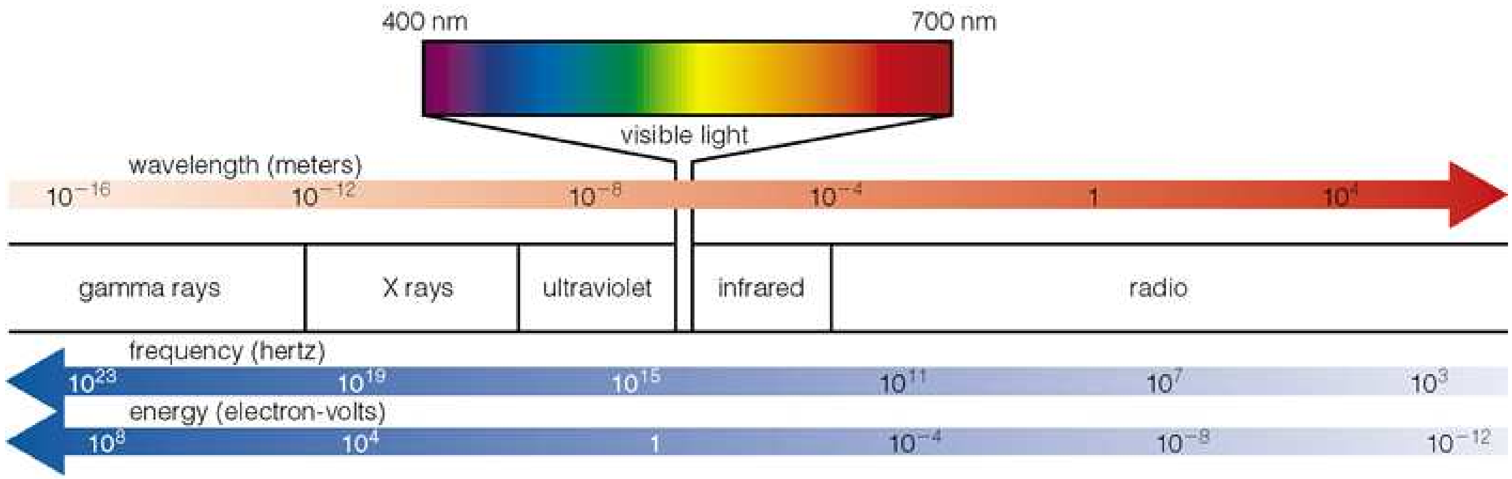


Chandra X-ray Observatory (CXO; 1999)

Spitzer Infrared SpaceTelescope (2003)

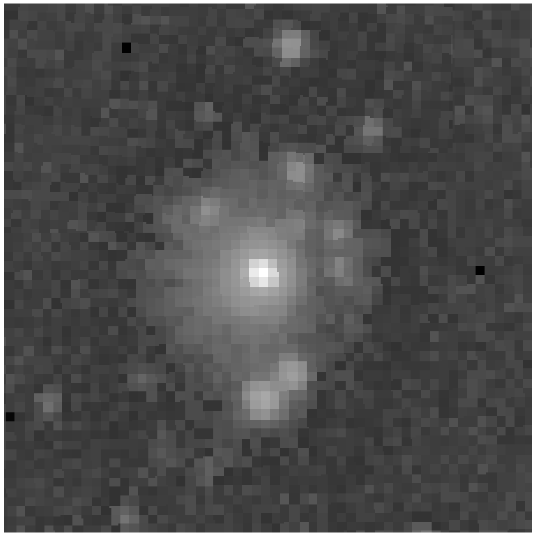
What phenomena/objects do different wavelengths trace?

Different Wavelengths Trace Different Phenomena/Objects

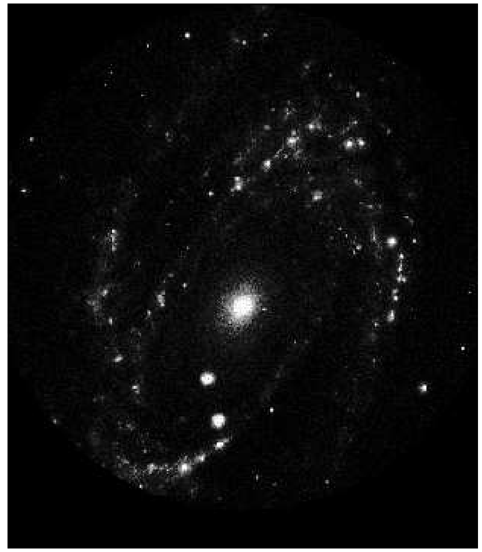


- See in-class notes

Multi-Wavelength view of M81



X-ray/ROSAT

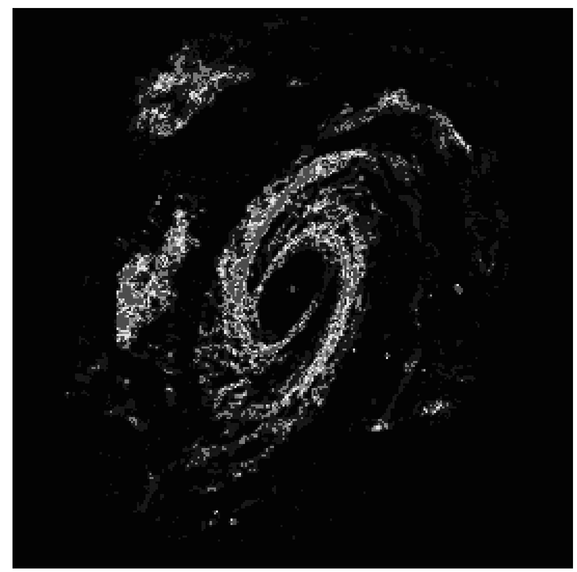


Ultraviolet/ASTR0-1

Visible light

Near infrared/Spitzer

Far-infrared/Spitzer



Radio 21cm/VLA