Astro 301/ Fall 2005

(48310)

Introduction to Astronomy

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TAs: David Fisher, Donghui Jeong, and Miranda Nordhaus

Lecture 24 =   Tu Nov 22
Th Nov 24 = Happy Thanskgiving!

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

Lecture 24: Announcements

-- Quiz 5 today,

-- Pick up homework 5: due next *THURSDAY* Dec 1,

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

1) Collecting Area: Current and Next Generation Largest telescopes. GMT
2) Resolving power
3) Space-based vs ground-based
   NASA's four Great Observatories : Hubble, Compton, Chandra, Spitzer
4) Operating Wavelength:

-- Using observations at different wavelengths to unveil mysteries of the Universe

- Gamma-ray, X-ray, Ultra Violet , Visble,
- Near-Infrared, Mid-Infrared,
- Radio 3mm line to trace molecular hydrogen
- Radio 21cm line to trace atomic hydrogen

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 IR background (glare) emission from Earth's atmosphere: can see faint IR sources

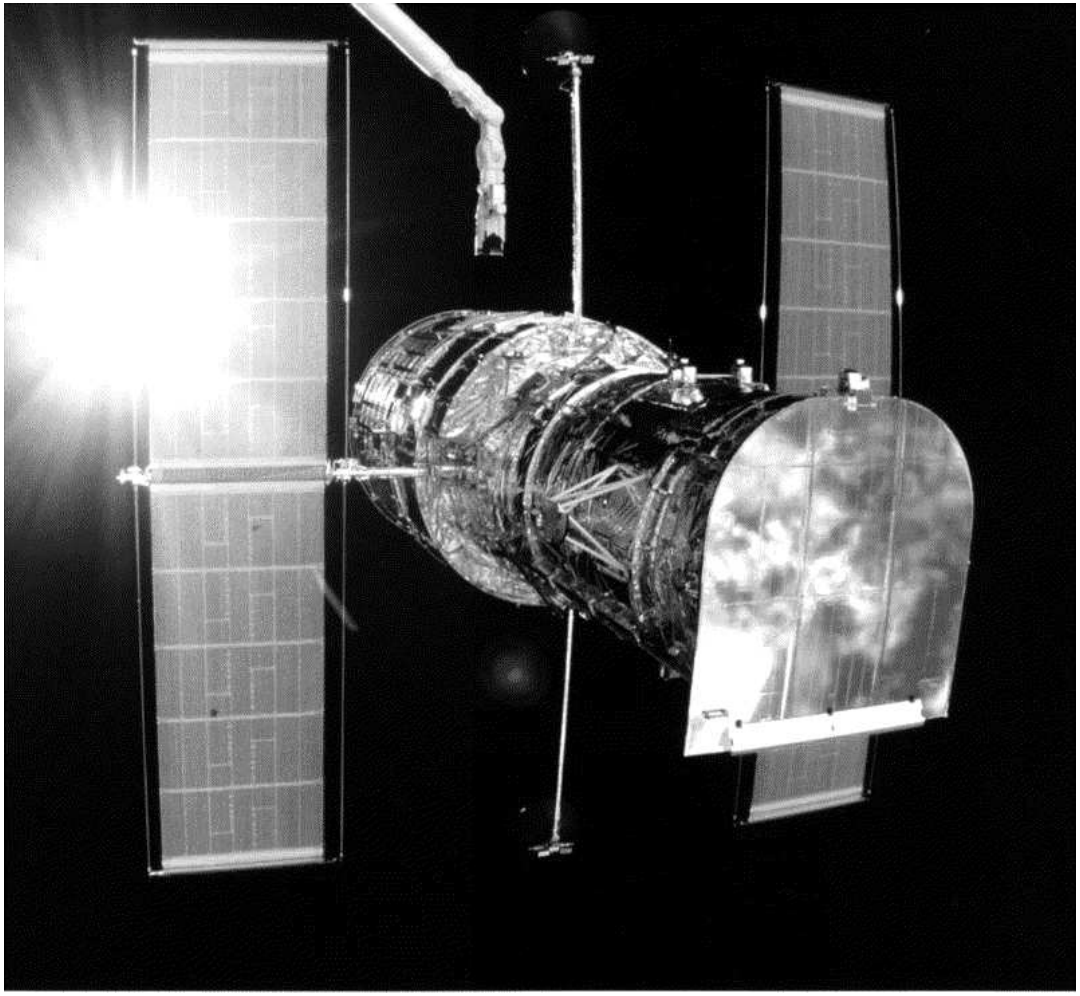
--- Disadvantages of space-based telescopes?

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!)

Hubble Space Telescope (HST)



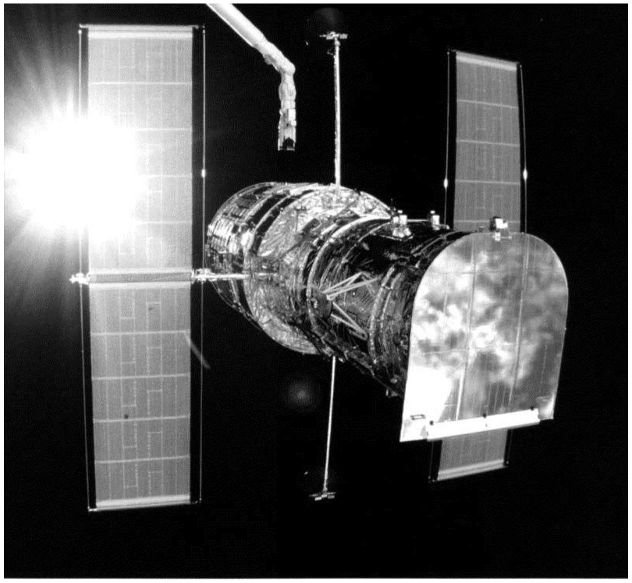
- Launched in 1990
- Mirror diameter= 2.5-m
- Orbits 600 km above Earth
- Powered by solar batteries
- Instruments on board :
   uv, optical, infrared

à No blurring by Earths’s atmosphere à high angular resolution.

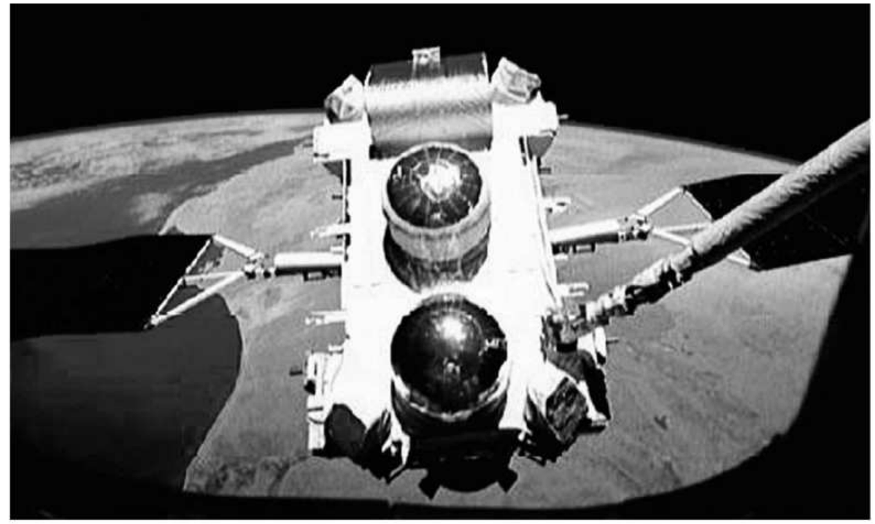
à Can observe UV photons without absorption by E’s atmosphere

à Can observe infrared emission without high background (glare) from sky

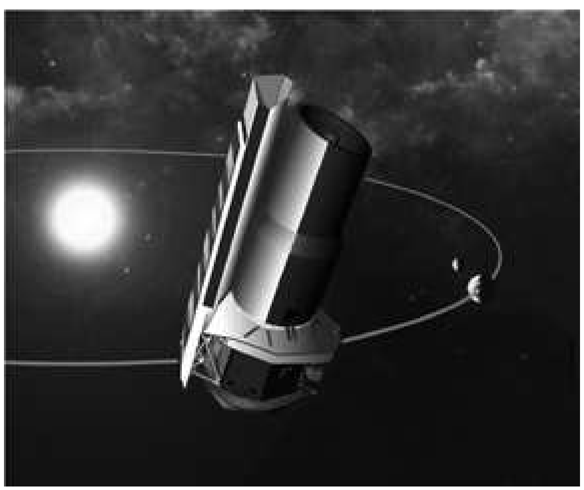
NASA's Four Great Observatories



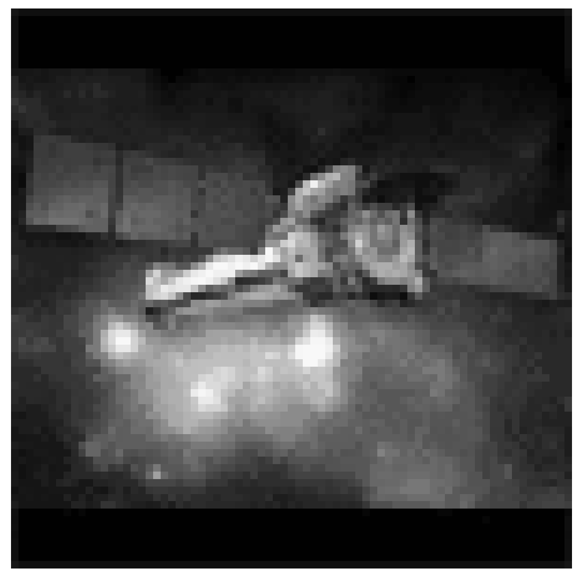
Hubble Space Telescope (HST; 1990)
for UV, optical and near-infrared



Compton Gamma-Ray Observatory (CGRO)



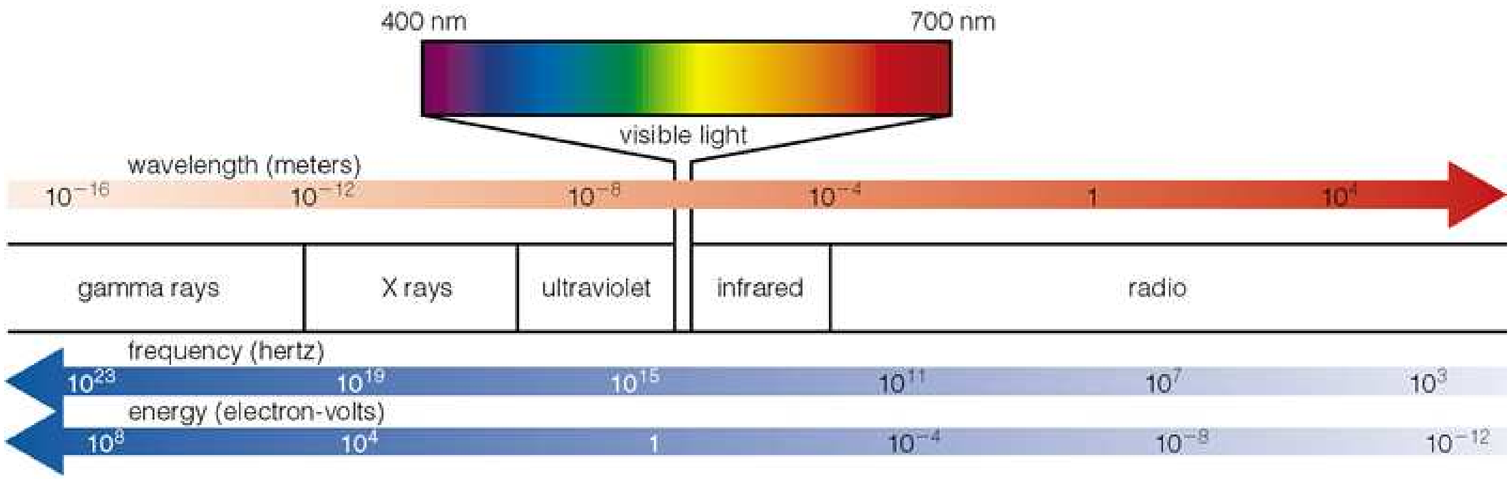
Chandra X-ray Observatory (CXO; 1999)



Spitzer Infrared SpaceTelescope (2003)

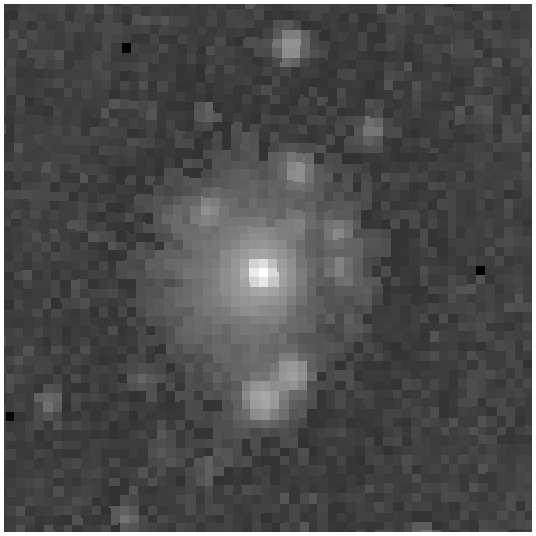
What phenomena/objects do different wavelengths trace?

Different Wavelengths Trace Different Phenomena/Objects

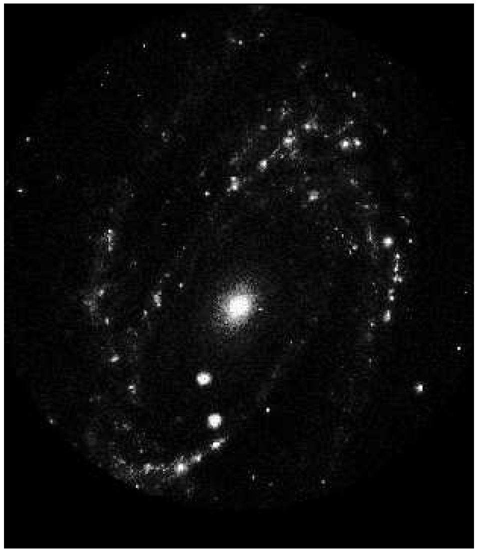


- See in-class notes

Multi-Wavelength view of M81



X-ray/ROSAT

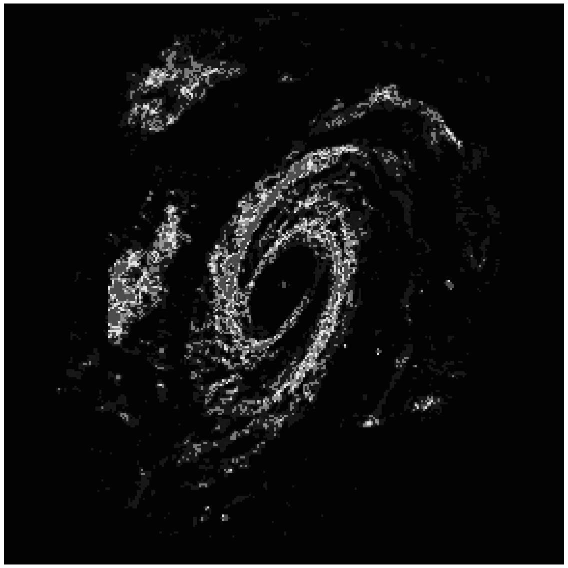


Ultraviolet/ASTR0-1

Visible light

Near infrared/Spitzer

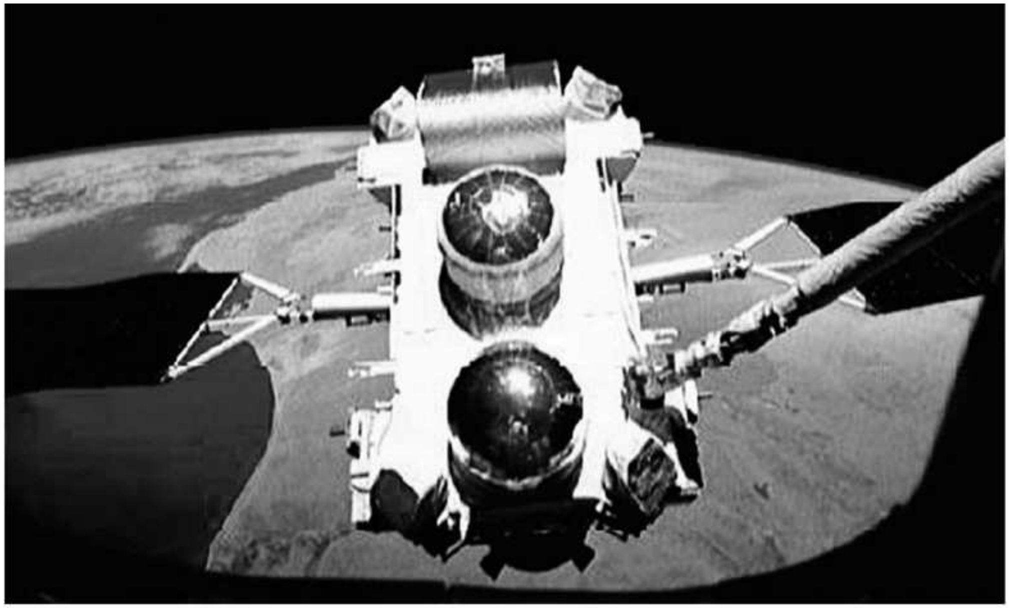
Far-infrared/Spitzer



Radio 21cm/VLA

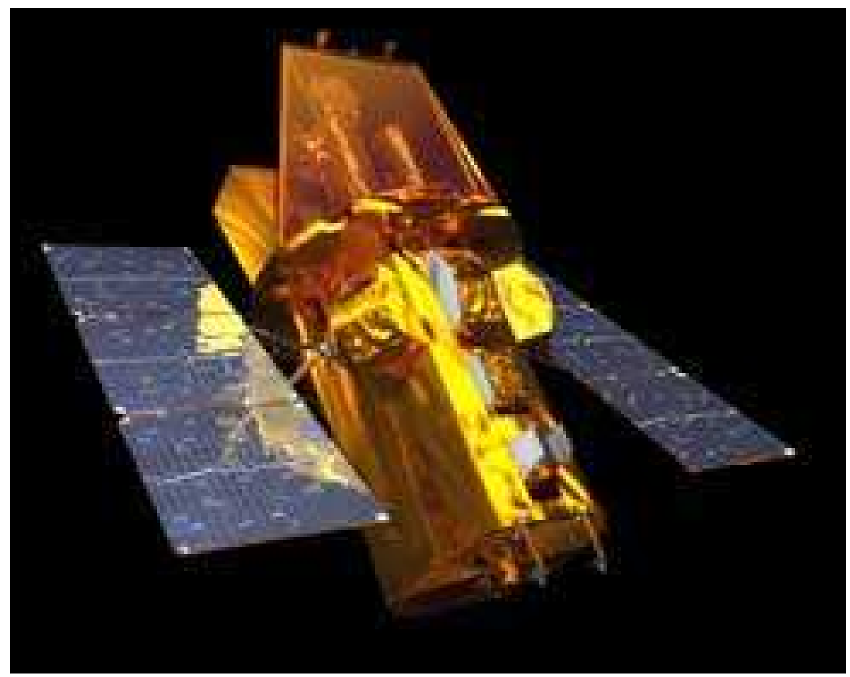
Imaging the Universe at Gamma-Ray and X-ray Wavelengths

Gamma-Ray Observatories



- Compton Gamma- Ray Observatory

- 1991 to 2000; deployed at 17 tons from Space Shuttle; 17 tons!



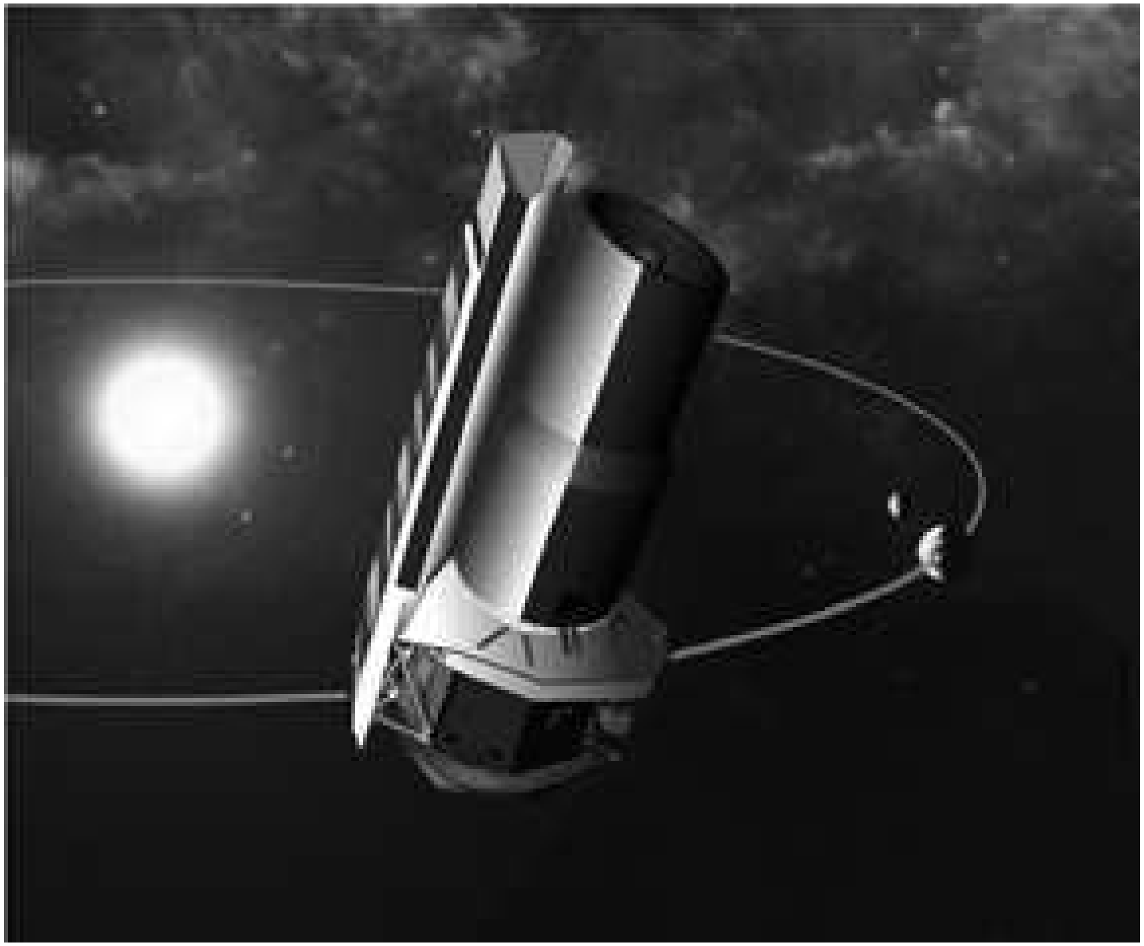
- NASA's Swift Gamma Ray Burst Explorer launched Nov 2004

- Dec 2004 : reported the brightest flash of light ever detected from beyond the solar system: more energy than the sun emits every 150,000 years!!!

à Gamma Ray Burst from a distant neutron star

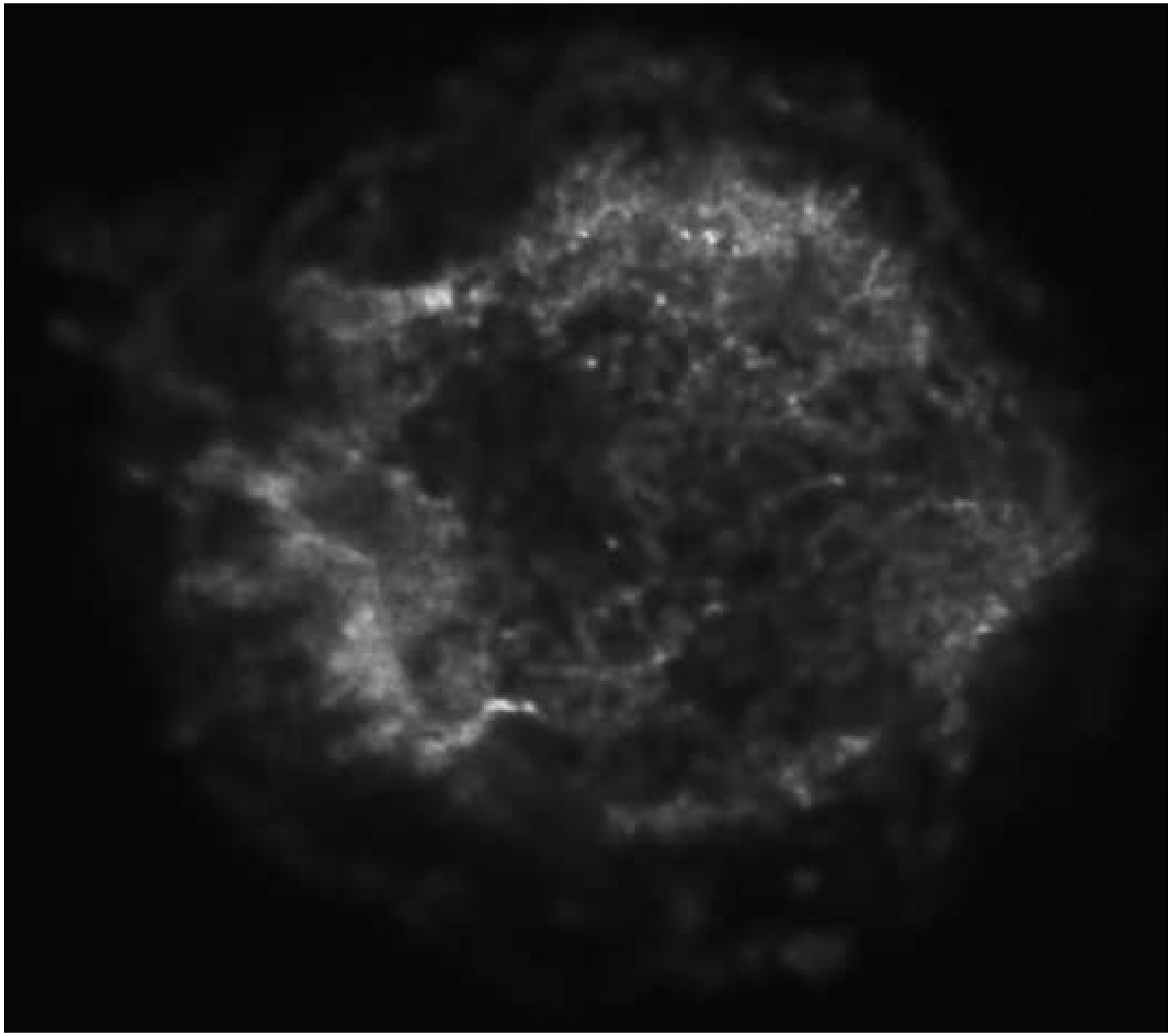
X-Ray Observatories

Early X-ray observatories: Einstein (1978-1980), ROSAT (1991-1999)



- Chandra X-Ray Observatory. Launched by NASA in1999
- Larger field of view, sensitivity,resolution than predecessors

X-Ray Wavelengths

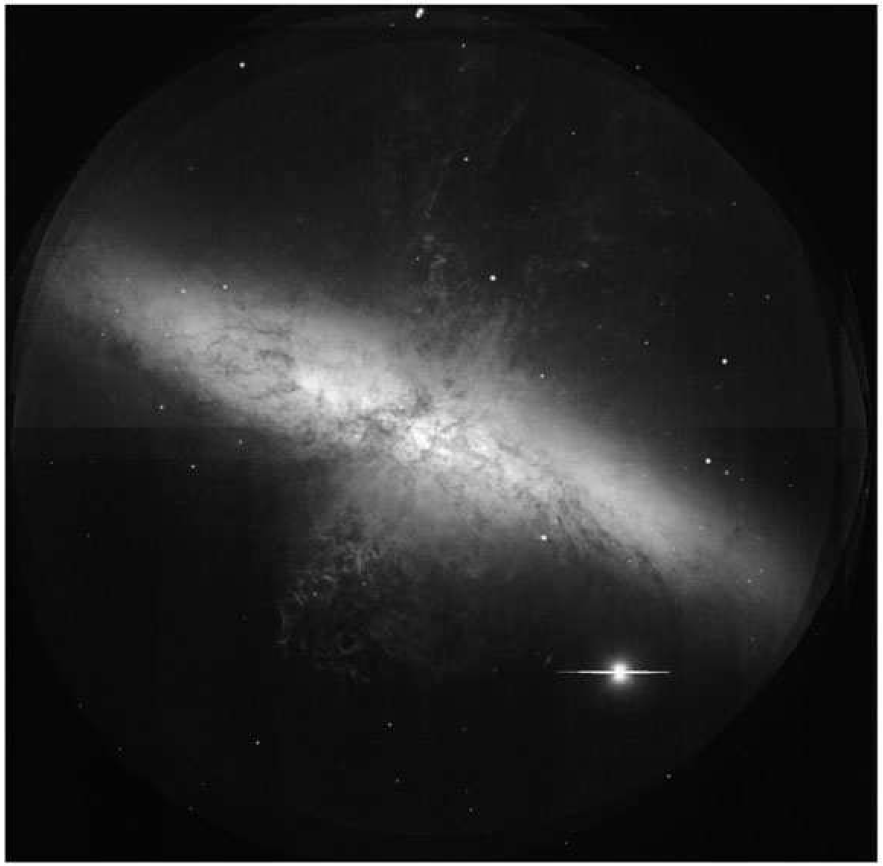


Supernova Remnant
Cassiopeia A

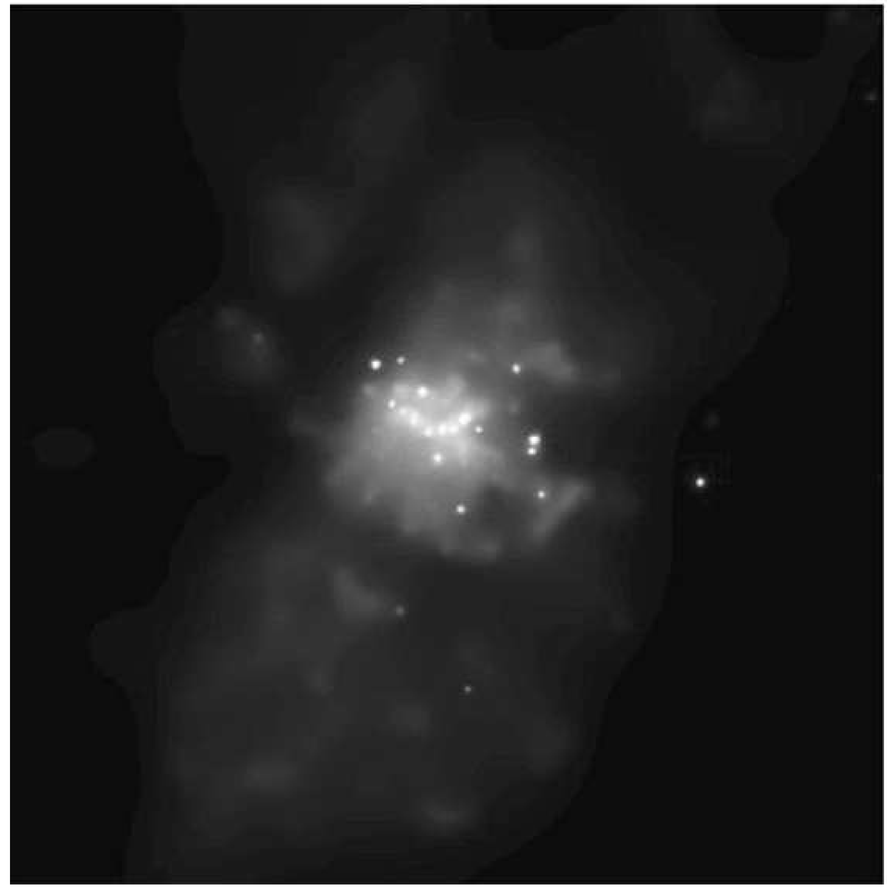
X-ray shows a hot bubble of 10^7 K gas that is heated by shocks from the supernova remnnant

X-Ray Wavelengths

Starburst Galaxy M82: central starburst driving an outflow



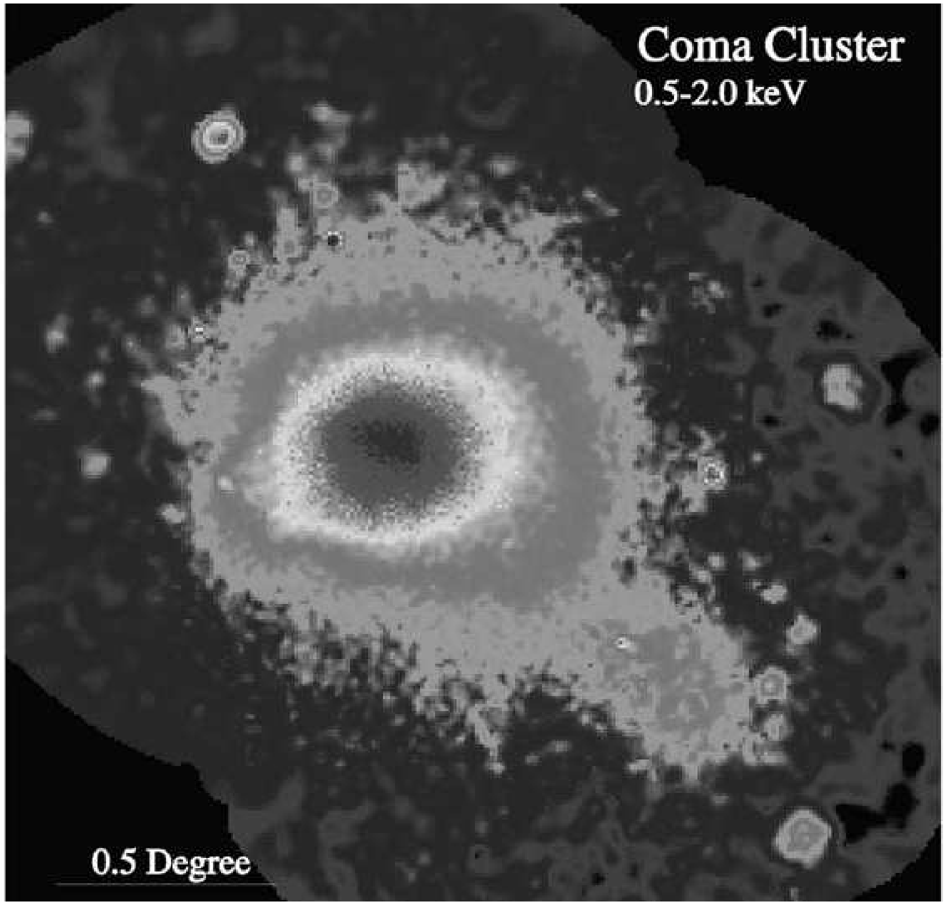
Visible light



X-ray

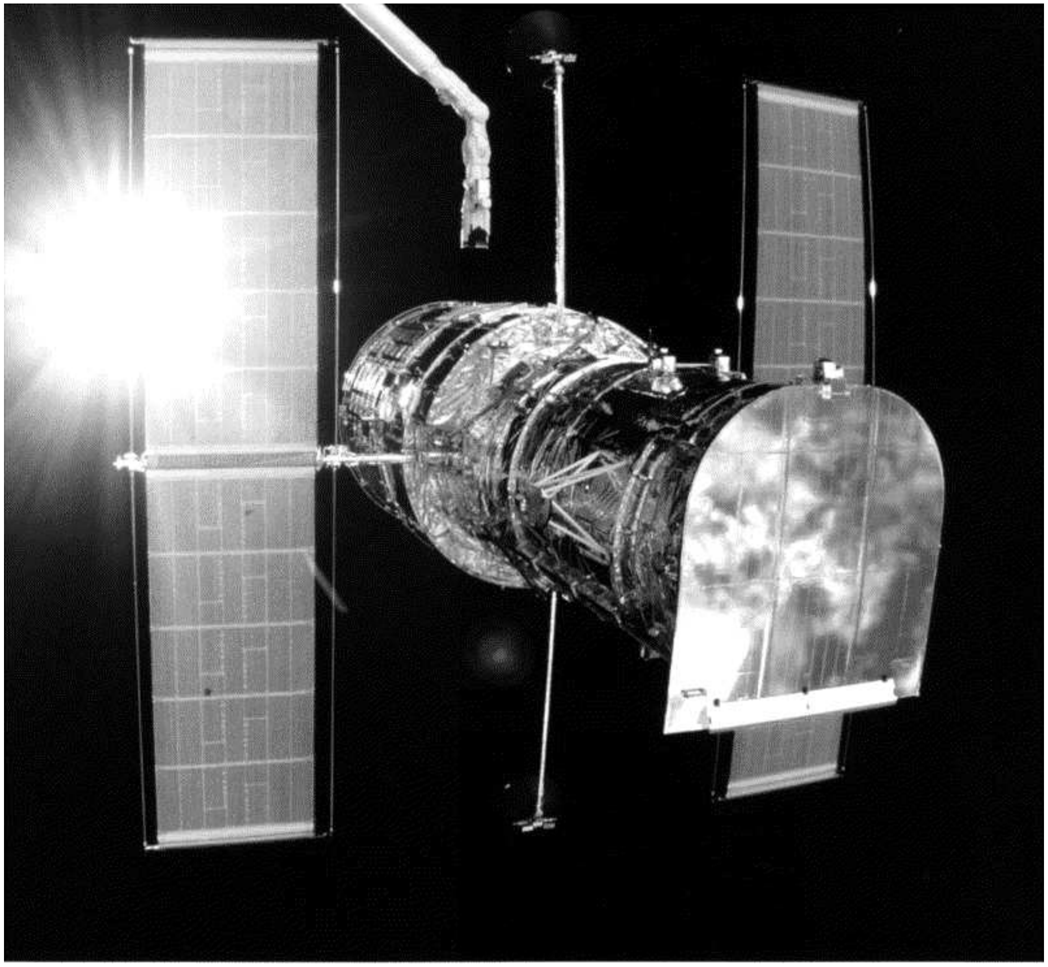
X-Ray Wavelengths

X-ray observations reveal hot (10^7 to 10^8 K) gas between galaxies in a cluster



Imaging the Universe at Optical Wavelengths

Hubble Space Telescope (HST)



HST observes at UV, optical and near-IR wavelengths

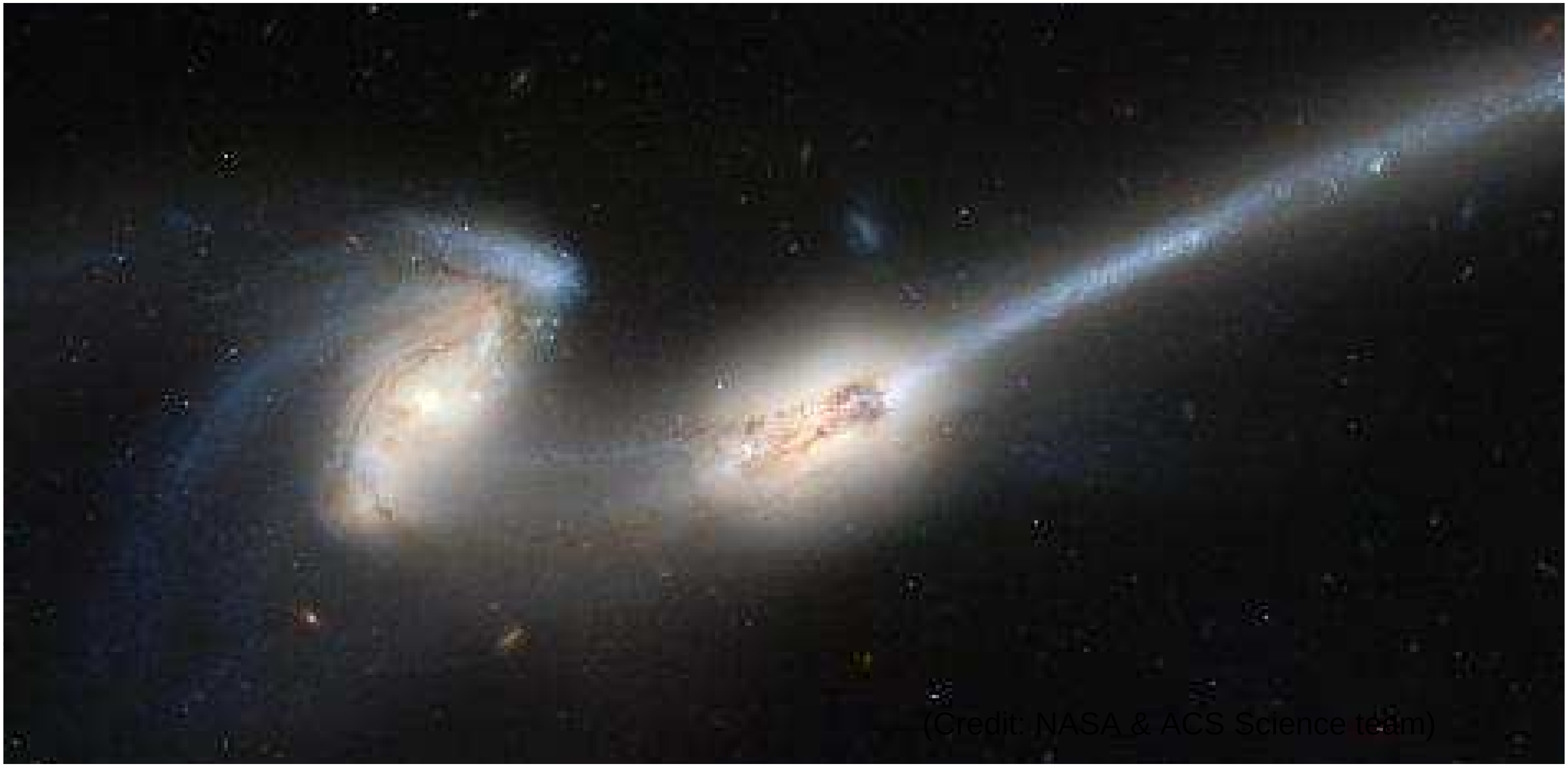
Latest optical camera on borad is called the Advanced Camera for Surveys (ACS)

- Launched in 1990
- Mirror diameter= 2.5-m
- Orbits 600 km above Earth
- Powered by solar batteries

Images from the ACS camera aboard Hubble Space Telescope

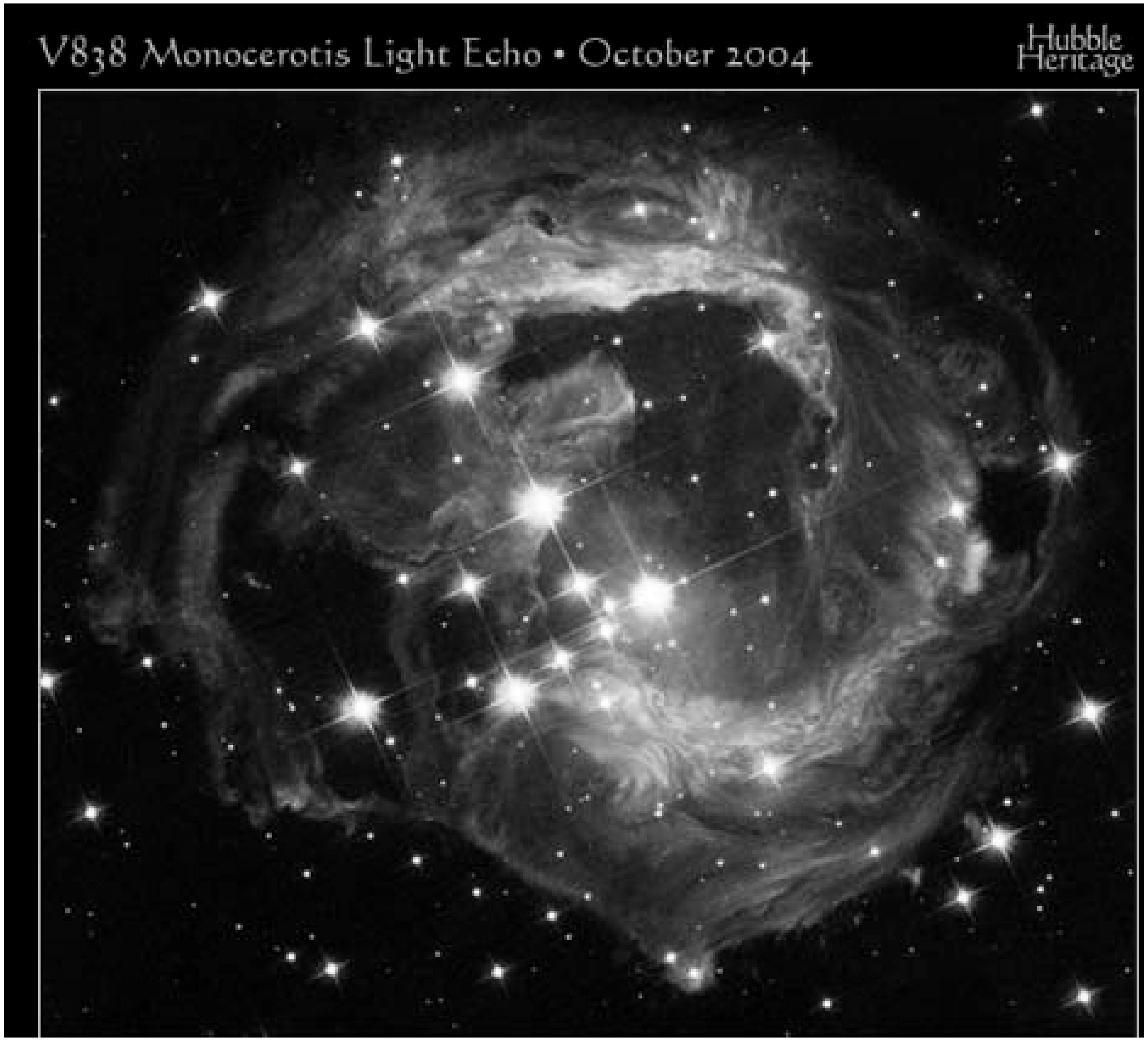
ACS image shows the dust lanes (shocks) on the two edges of the bar. These shocks show how the bar transports gas from the outer disk of a spiral galaxy down to the center, where the gas fuels huge episodes of star formation and maybe even black holes

Images from the ACS camera aboard Hubble Space Telescope



ACS image shows details of a collision between 2 spiral galaxies, 100,000 light years apart

Images from the ACS camera aboard Hubble Space Telescope



ACS image of star V838 Mon reveals dramatic changes in the illumination of surrounding dusty cloud structures. The effect, called a light echo, has been unveiling never-before-seen dust patterns ever since the star suddenly brightened for several weeks in early 2002.

Imaging the Universe at Infrared Wavelengths

Infrared Wavelengths

Movie: From optical to IR view of M81 (Courtesy: NASA/Spitzer)

à Near-IR at 1 to 3 micron: penetrate the dust and shows **old stars**

à Mid and far-IR from 10 to 100 micron shows **hot dust and gas forming young stars**

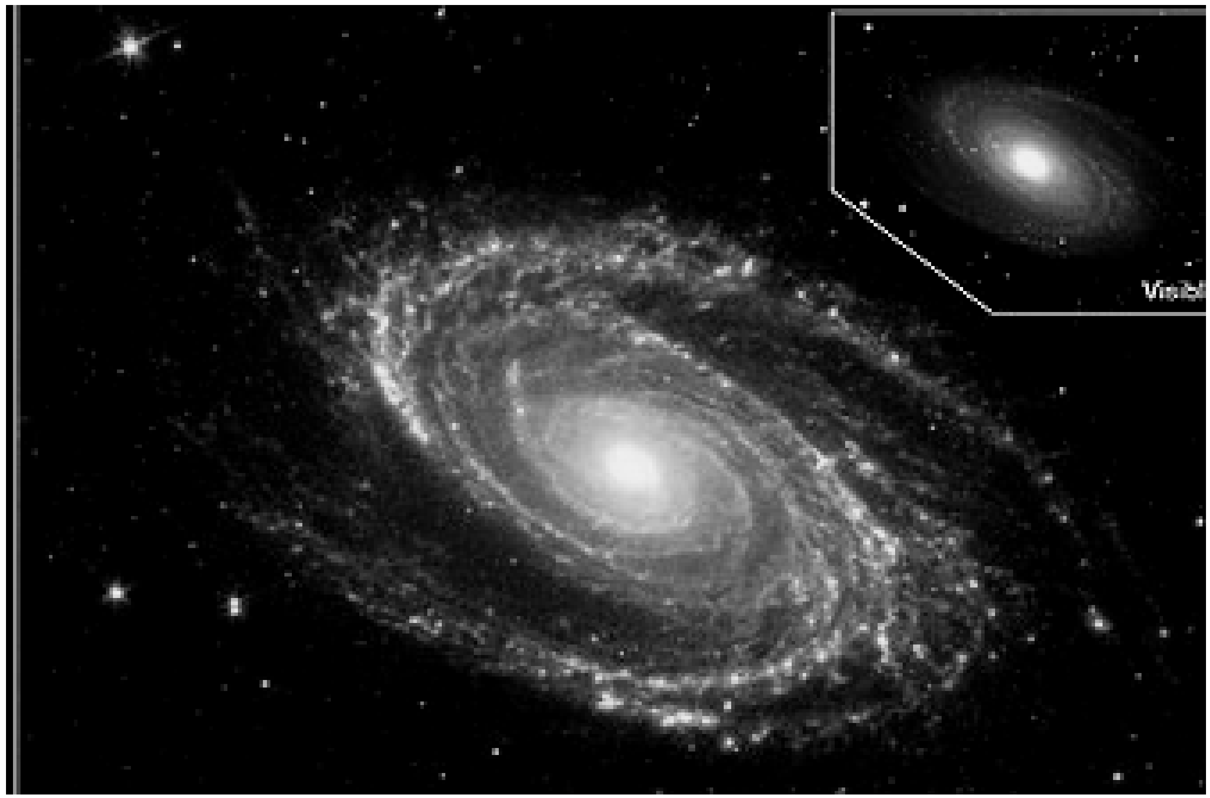
Infrared Wavelengths

M81 galaxy

(Courtesy: NASA/Spitzer)

Underlying low mass stars

Regions with hot dust and gas heated by young stars



Infrared composite made from 3.6, 8.0, 24 micron images

Infrared Wavelengths

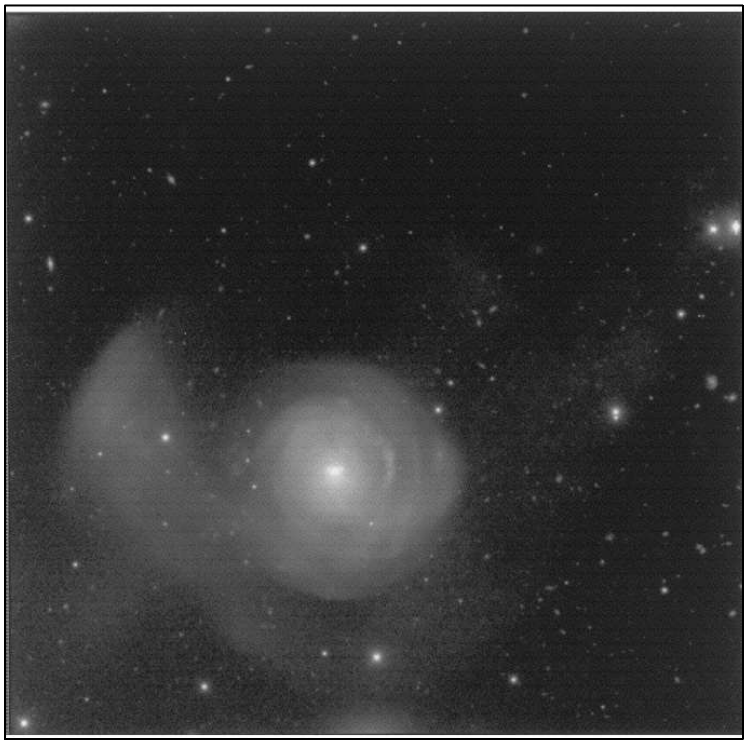
Movie : From visual to infrared look at dark globule in IC 1386
(Courtesy:NASA/Spitzr)

- Visual image shows one star + dark patch of dust in globule head
- Near-IR 3.6 mu image penetrates the dust to show 2nd star and cavity in globule head
- Mid IR 8 and 24 mu images trace hot dust+ gas filaments made when winds from massive stars compress gas à Thick dusty discs around young stars = precursor of planetary systems

Radio Wavelengths

Radio: 21 cm atomic hydrogen line

Maps of the emission line at 21 cm (radio wavelengths) trace atomic hydrogen.
à reveal tidal tails at large radii, and unravels the interaction history
à reveal atomic gas in outer parts of disks galaxies: may form stars if compressed



The visible light image shows
- a relatively undisturbed disk
- a 20,000 pc tail to the left
- NO disturbance to the right

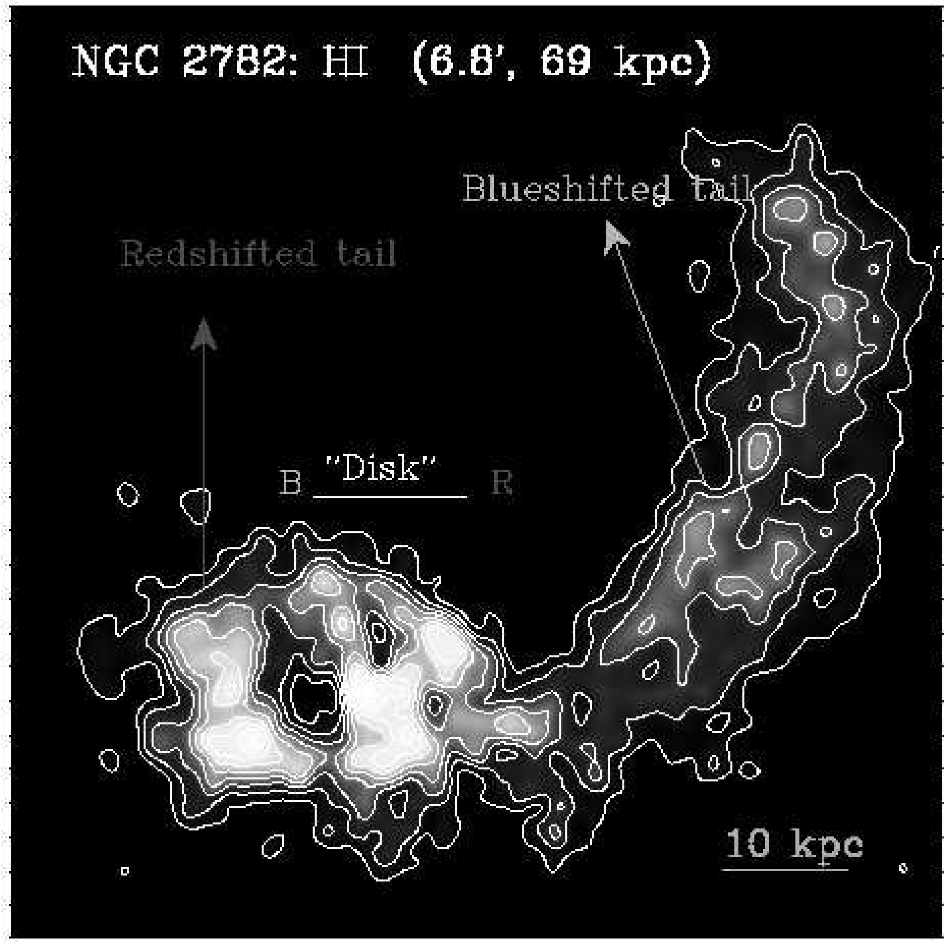
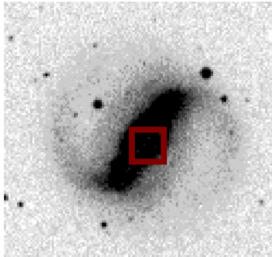
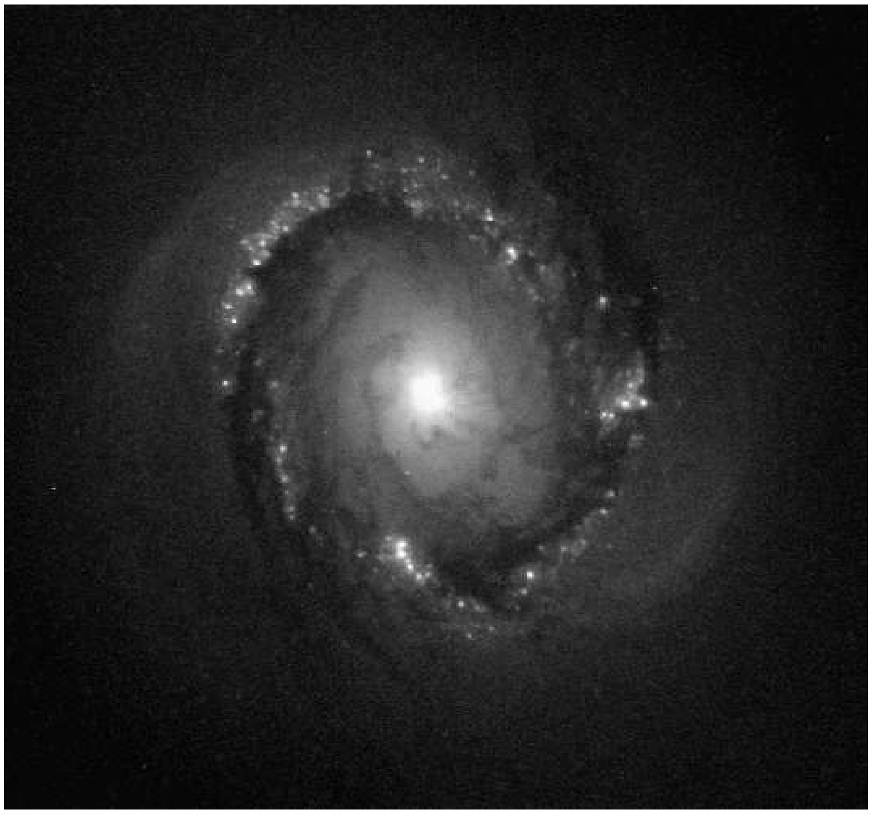


Image at 21 cm (atomic H) shows the disk and a HUGE 50,000 pc tail to the right

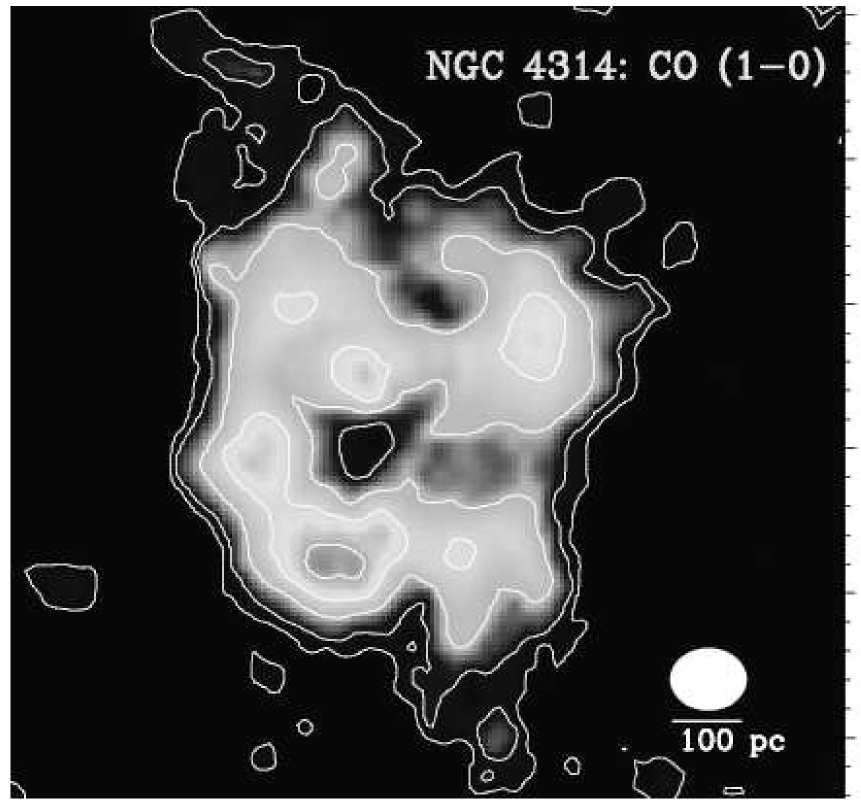


Radio (mm) Wavlengths

Radio observation at 3 mm trace molecular hydrogen. When the latter is compressed to high enough densities, gravity makes it collapse into new stars

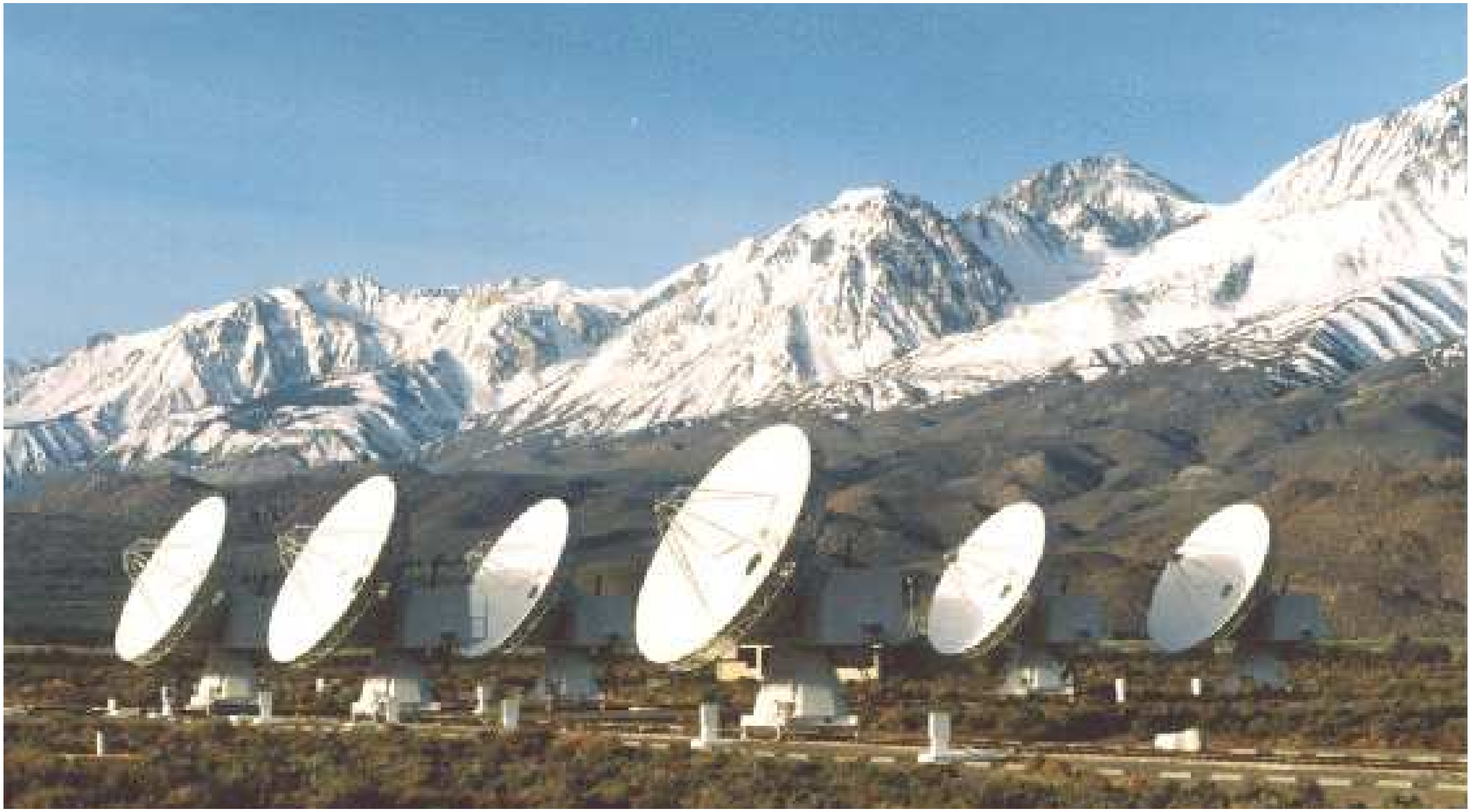


UV and visible images from HST show a speactacular ring of young stars, a few millon yrs old. Courtesy: Benedict/ NASA)



Radio observation at 3 mm trace molecular hydrogen from which the stars are forming. (Jogee et al . 2004)

Radio (mm) Wavlengths



Caltech's Owens Valley Radio Observatory (OVRO) has a mm array made of 8 radio telescopes, each 10.2 meters in size,

Located on east side of the Sierra Nevadas in California, ~250 miles north of Los Angeles.

At radio λ : observe 24 hrs a day. Only shut down in the summer when humidity is high….