Astro 233: Coming Attractions

• The first paper will be due on Thursday Sep 14th.
  • The version posted on the web site will contain some useful links.
  • It will be graded as a draft.
  • See Melissa for help! Send her email if you need to meet with her at another time.
• Look at newspaper/magazine science articles and follow their style.
• Beware of unscholarly/unofficial websites
• Know what plagiarism is! If the words aren’t yours, either quote them or summarize them in your own words (and then attribute them).
• Questions about it???
The 200-inch telescope


What are the major advances that Hubble predicts the 200-inch telescope will offer to astronomers?

Was he correct?
1. Canals on Mars
   • High quality photographs/images
   • Resolution (details) and exposure time (deep)
2. Relative abundances of the elements in different kinds of stars
   • Spectroscopic details
3. Structure and behavior of the universe as a whole
   • Resolution, deep imaging
   • Spectroscopic details
<table>
<thead>
<tr>
<th>Telescope</th>
<th>Location</th>
<th>Diameter</th>
<th>Access</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hubble</td>
<td>space</td>
<td>2.4 m</td>
<td>National/international</td>
</tr>
<tr>
<td>VLT</td>
<td>Chile</td>
<td>4 x 8 m</td>
<td>Europe</td>
</tr>
<tr>
<td>Keck</td>
<td>Mauna Kea</td>
<td>2 x 10 m</td>
<td>Caltech/U California</td>
</tr>
<tr>
<td>Gemini</td>
<td>Mauna Kea and Chile</td>
<td>2 x 8 m</td>
<td>National/international</td>
</tr>
<tr>
<td>Subaru</td>
<td>Mauna Kea</td>
<td>7 m</td>
<td>Japan</td>
</tr>
<tr>
<td>Magellan</td>
<td>Chile</td>
<td>2 x 6.5 m</td>
<td>Carnegie, Harvard, MIT, Michigan</td>
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<tr>
<td>Palomar</td>
<td>Calif.</td>
<td>5 m</td>
<td>Caltech, Cornell, JPL</td>
</tr>
</tbody>
</table>
Not all electromagnetic radiation reaches the surface of the Earth; some blocked by atmosphere
=> Space telescopes (Hubble, Chandra, Spitzer, Compton Gamma Ray Observatory, etc.)

=> 100 microns to 1 mm = Far IR/Submillimeter
The Arecibo radio telescope

The National Astronomy and Ionosphere Center
**Diffraction Limit**

Example: Arecibo 305 meter telescope
The diameter of the telescope is 305 m = 30500 cm
Let's find the diffraction limit at 21 cm.

\[
\Theta = \frac{1.22 \times 21 \text{ cm}}{30500 \text{ cm}} = 8.4 \times 10^{-4} \text{ radians}
\]

\[
= 8.4 \times 10^{-4} \text{ radians} \times 206,265 \text{ arcsec/radian}
\]

\[
= 173 \text{ arc seconds} = 2.88 \text{ arc minutes}
\]
Arecibo Observatory

Located in northwestern Puerto Rico in a region of karst limestone sinkholes and “haystacks”.
How Arecibo works
Rays are reflected off two additional mirrors in the radome.
ALFA: Arecibo L-band Feed Array “Camera”

• 7 pixels (beams)
Radio Astronomers need Big Telescopes

How big would a radio telescope have to be to have a diffraction limit of 1 arc second at a wavelength of 21 cm?

\[ \theta = \frac{1.22 \times 21 \text{ cm}}{\text{Diameter cm}} = \frac{1 \text{ arcsec}}{206,265 \text{ arcsec/radian}} \]

Diam (cm) = 1.22 X 21 X 206,265 = 5.2 X 10^6 cm
= 52 km (!)
Interferometry:

- Combine information from several widely-spread radio telescopes as if they came from a single dish
- Resolution will be that of dish whose diameter = largest separation between dishes
Aperture Synthesis or Interferometry

Use an array of smaller telescopes to achieve the image detail of a larger one that covers (sparsely) the area of the array.

Sir Martin Ryle: 1974 Nobel prize in physics
Aperture Synthesis or Interferometry

Sir Martin Ryle: 1974 Nobel prize in physics

Use an array of smaller telescopes to achieve the image detail of a larger one that covers (sparsely) the area of the array.
The Very Large Array

- 27 antennas, each one 25 m (85 ft) in diameter
- Array in “Wye” (Y) shape; 4 configurations of “Wye” from compact to very spread out.
- Located 70 miles west of Socorro New Mexico, which is about 70 miles south of Albuquerque.
- Part of the National Radio Astronomy Observatory.
The Very Large Array

- The resolution of the VLA is set by the size of the array.
- 4 “configurations”, from compact to spread out by up to 22 miles.
- Operates from 0.7 cm to 4 meters.
IRAS (1980s) Infrared

Chandra (operational) X-rays

Spitzer (operational) Infrared

Hubble (operational) Optical
The advantages of space

- No atmosphere
  - Photons not absorbed!
  - Mandatory for Gamma-rays, X-rays, UV, Far-IR
- No “weather”
- Dark sky (no ambient light)
- No atmospheric seeing; diffraction limited imaging

The disadvantages of space

- High cost of launch
  - Smaller mirrors
- Difficult to fix/change equipment
- Must avoid looking at Sun and Earth, so efficiency is actually not that high
Hubble Space Telescope

• 2.4 meter reflecting telescope
• Image resolution ~ 0.1 arc second
• Deployed in low Earth orbit on 25 April 1990

• Current instruments
  • Advanced Camera for Surveys (ACS: optical)
  • Near Infrared Camera & Multiobject Spectrograph (NICMOS: infrared)
  • Wide Field Planetary Camera 2 (WFPC2: UV to optical)
  • Space Telescope Imaging Spectrograph (STIS: UV, optical; not functional currently)
5.7 Space-Based Astronomy

Infrared telescopes can also be in space; this is the *Spitzer* telescope:
5.7 Space-Based Astronomy

Infrared observations of M81 at different wavelengths:
Spitzer Space Telescope

• Launched on 25 August 2003
• 0.85-m (85 cm) telescope (largest ever in space!)
• Observations at wavelength range from 3 to 180 microns
• Because infrared radiation arises principally from thermal sources ("heat"), the telescope itself must be kept very cold.
• Drifting heliocentric orbit ("deep space") with solar shield => cannot be serviced (3-5 year lifetime).
Spitzer Space Telescope

What is Spitzer observing?
- Cool/cold objects
  - Planets
  - Forming planets
  - Cool, low luminosity/mass stars
- Dusty clouds
  - Sites of star formation, near and far
  - Envelopes around old stars
  - Colliding galaxies
- Distant universe
  - Objects moving away from us at high speed => distant objects (“Hubble’s Law”)
The James Webb Space Telescope

The Next Generation Space Telescope (NGST)