ASTR 1040 Accel Astro: Stars & Galaxies

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Lecture 5     Tues 31 Jan 06
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Topics for Today

• Twinkle and absorption by our atmosphere
• What light gets through, what does not
• Telescopes in space -- and why
• Radio and x-ray telescopes do it differently
• Finish reading Chap 15 [14] (Our Star)
• Discuss: What are pros and cons of a Lunar Astronomical Observatory

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Clicker Q: Radio Waves

• You are listening to a radio station broadcasting at a FM frequency of 97 Mhz. Which is true?
  • A. The radio waves from the station have a wavelength of 97 million meters.
  • B. The "radio waves" received by your radio are not light waves, but rather a special kind of sound wave.
  • C. The radio station broadcasts its signal with a power of 97 million watts.
  • D. The radio waves are causing electrons in your radio's antenna to move up and down 97 million times per second.

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D. \( c = \lambda \cdot f \)

Radios

• You are listening to a radio station broadcasting at a frequency of 97 Mhz. Which is true?
  • D. The radio waves are causing electrons in your radio's antenna to move up and down 97 million times per second.

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Wavelength = \frac{Speed\ of\ light}{frequency} = \frac{3.0 \times 10^{10} \ cm\ sec^{-1}}{9.6 \times 10^{7} \ sec^{-1}} = 312 \ cm
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Problems in Looking Through Our Atmosphere

• Many wavelengths are **absorbed** (just don’t make it through to surface)
• Turbulence in atmosphere distorts light:
  – stars appear to “twinkle”
  – angular resolution is degraded
• Man-made light is reflected by air particles, yielding bright night sky
  – this is **light pollution**

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Light Pollution

90% of Earth’s population cannot see the Milky Way
How many light bulbs does it take to screw up an astronomer?

An immediately curable pollution: simply turn the lights off!

Stop “uplight”, glare: wastes billions of $$ in energy, use “low pressure sodium”

Several famous observatories are now useless...

LA Basin View from Mt. Wilson Observatory, 1908 and 1998

Quest for Good Weather and Seeing

- Mauna Kea, Big Island of Hawaii, 14,000’ elevation, middle of the Pacific

- Dry, high, dark and isolated. Best on the planet?

Adaptive Optics (AO) – “de-twinkle” stars

- Wavefronts of star light are deformed by atmosphere
- Can distort shape of mirror (very fast) to correct for distortions by atmosphere – hot new technology

Two stars!

Atmospheric Absorption of “Light”

- Earth’s atmosphere absorbs most types of light (not entirely bad, or we would be dead!)
- Only visible, radio, and some IR and UV light get through to the ground

To observe other wavelengths, must put telescopes in space!
So what gets through our atmosphere?

- **RADIO WAVES**: mostly get through
  - Thus radio telescopes are built on the ground
  - Weather is not an issue - radio waves come right through the clouds

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**Infrared Telescopes**

- **INFRARED** can be absorbed by molecules like H₂O, CO₂, CO, etc.
  - Absorption is in specific wavebands, leaving "windows" where we can see above the atmosphere
  - Combination of ground-based, airplane, balloon, rockets, satellite...

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**UV, X-rays and Gamma-rays**

- These all have *enough energy to ionize electrons* out of atoms or *break apart* molecules
  - Heavily absorbed by the atmosphere
- Space or high altitude (balloon, rocket) observatories are necessary

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**Space Based Telescopes**

- **VISIBLE and UV**: atmosphere is transparent but turbulent (seeing)
  - **HST**: Small (2.5 meters), *diffraction-limited*
  - Low orbit accessible by Shuttle, refurbishing means long lifetime (1990-2007+?)
  - Costs: $5 billion over 20 years, or 10 - 100 times more than ground scopes

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**SIRTF: Space Infrared Telescope Facility now SPITZER**

- Launched 25 August 03
- Trails behind Earth to get away from Earth's thermal spectrum
- 0.85m aperture, T ~ 5.5 K
- Cooled with liquid helium, 2-5 years worth

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**Chandra X-ray Observatory**

**Hubble Space Telescope (HST)**

**Optical, UV**
How do you point a space telescope in orbit?

1. **Squirt from jets** to change direction (hydrazine)
2. **Torque by electric currents in big coils** while flying through Earth’s magnetic field
3. **Torque by electric motors spinning up or down “reaction wheels”**

**ANGULAR MOMENTUM DEMONSTRATION**

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**HST Sharpness of Images**

- **HST Resolution:** 0.05 arcseconds (D)
- Compare with “best seeing” ground-based observations at 0.5 arcseconds (B), and “typical” 2 arcsecond seeing (A). Pre-fix of HST image is (C).

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**X-Ray Telescopes – do it their own way!**

- X-ray photons can pass right through a mirror
- Such photons can only be reflected at shallow angles, like “skimming stones” off water surface

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**HUBBLE TROUBLE**

repaired by astronauts inserting corrective optics from Boulder

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**Bigger view of Chandra’s X-ray Imaging**

“grazing reflections”
"Nonvisible" Light – X-ray, UV, IR, Radio
- Most light is invisible to human eye
- Special detectors can record such light
- Digital images built using false-color coding

Radio Telescopes – Biggest Single Dish
305 m Arecibo

Radio Interferometry – many small look big!
- Two (or more) radio dishes observe the same object
- Signals from each "interfere" with each other
- Can construct image whose angular resolution is like that from a huge dish!

Next to Our Nearest Star  Chap 15