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
- Read Chap 14 (Our Star .. the Sun)
- Homework Set # 1 due today
- Respond to next discussion Q on CULearn: "What are pros and cons of a lunar observatory?"

Clicker Q: Radio Waves

D. You are listening to a radio station broadcasting at a 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.

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

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\[
Wavelength = \frac{\text{Speed of light}}{\text{frequency}} = \frac{3.0 \times 10^{10} \text{ cm sec}^{-1}}{9.6 \times 10^7 \text{ sec}^{-1}} = 312 \text{ cm}
\]
**Keck 10 m Twins (Segmented Reflectors)**

*Mauna Kea, HI*

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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

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**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

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**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?
Two Properties of Any Telescope

1. Resolution
   - smallest angle which can be seen:
   \[ \theta = \frac{1.22 \lambda}{2R} \]

2. Light-Collecting Area
   - think of telescope as a "photon bucket"
   - its area: \[ A = \pi R^2 \]

(\(\lambda\) is light wavelength, \(R\) is mirror or lens radius)

Nick will discuss RESOLUTION in Monday recitation

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

Why big aperture telescopes are reflectors

- Can support mirror from back, not just at edges as with lenses (biggest: 1 m lens, 10 m diam mirror)
- Mirror needs only one good optical surface to be ground, not four as with achromatic (2 elem) lens
- Can recoat mirror surface easily with highly reflective aluminum (even silver)
- Lens has to be optically pure and uniform, but mirror can be made of anything that holds its shape (fuzed quartz, zero expans pyroceramics, even beryllium)
**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

**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”

**Next to Space Astronomy, then Radio Astronomy – then Our Nearest Star (the Sun) Chap 14**