Telescopes

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Opening Discussion

- Have you seen anything interesting in the news?
- Measuring tangential motion.
- Measuring gravity.
- Doppler radar. Hearing radio waves and relation between sound a light.
- Polarized sunglasses.
- How can you tell light is shifted if you only see light from an object that is shifted?
- Doppler shift, speed of light, and relativity.
- http://news.yahoo.com/s/space/20050930/sc_space/newpicturesofs

Vision and Telescopes

- To get an image of something we must focus the light from that object onto something that can detect the light.
- In your eye, a camera, and some telescopes, the focusing is done by a lens. The lens is made from a substance with a higher index of refraction than air or vacuum so light is bent toward normal.
- Large telescopes use mirrors instead of lenses for numerous reasons. The mirrors are front silvered so light never goes into glass or anything else. These can be built larger, lighter, and with multiple pieces.

Telescope Configurations

- Refracting telescopes have a fairly standard configuration with a lens at the openings and another at the eyepiece.
- Reflector telescopes can have several configurations. Newtonians put a secondary mirror near the opening before the focus that reflects the light out the side. Cassegrains have a secondary that sends light back through a hole in the primary. Coudés are like a Cassegrain but a third mirror redirects the light back out the side.
- Newtonian configuration is only used for smaller telescopes.

Photodetectors

- The back of your eye is covered with structures called rods and cones that detect photons and send signals to your brain which processes the signals into the cognition of sight.
- In a film camera the light is sent back to a substance that reacts to light exposure by changing its properties.
- Digital cameras use chips called CCDs (charge-coupled devices) that turn photons into charges in a grid and then count those charges. These have the advantage that they have a higher quantum efficiency and don't saturate easily.

Angular Separation

- When we look at things we don't see/measure distance directly, we see/measure angular separation. That is, we measure how large the angle is between one object and another.
- For small angles, the separation in degrees is given by the following formula:

$$\alpha = \frac{s}{2\pi d} \times 360^\circ$$

- For arcminutes multiply by 60 and for arcseconds multiply by 3600.

Telescope Specifications

- In general, we don't care about the magnification level of telescopes. What matters more is the light-collecting area and the angular resolution.
- The light-collecting area is just a measure of the area of the primary refractor or reflector. The larger it is, the dimmer objects that can be seen or the more detail that can be pulled out of spectra and images.
- The angular resolution is a measure of how far apart two light sources can be distinguished. This depends on a number of things. Better optics help, but there is a fundamental limit.

The Diffraction Limit

- Because light is a wave, the light from two nearby sources will interfere and make it impossible to distinguish them no matter how good your optics are. Optics of the best quality are called diffraction limited.
- The diffraction limit of a telescope depends on the wavelength of light it is looking at and the size of the telescope.

$$diffraction\ limit\,[\,arcseconds\,] = 2.5 * 10^5 * \frac{\lambda}{telescope\ diameter}$$

- Notice you want a big telescope for this too. It also helps to observe shorter wavelengths.

•Telescope Observing

- Telescopes can measure various different things depending on where they are and what instrument is attached to them.
- You are most familiar with imaging where we make a picture of what the telescope is aimed at. This can be done for visible or non-visible parts of the spectrum. Filters can be used to get only a narrow range of wavelengths.
- It is also very common to spread light out over a spectrum to do spectral analysis. Higher resolution is ideal, but requires that more light be gathered as the light must be spread out further.

Minute Essay

- A disgruntled grad student once took a gun and a sledgehammer to the reflector of a 2m telescope at the McDonald Observatory. While the act was frowned upon, it didn't hurt use of the telescope much. Why doesn't having a few dents from a 3 inch sledgehammer head hurt observing much?
- Make sure that you don't leave without having handed me assignment #3.