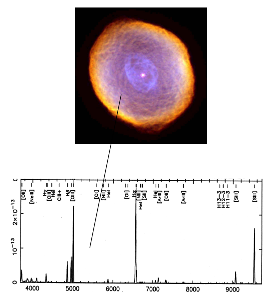
Telescopes–January 31

- First test is next Wed
  - Covers atoms & light.
  - Does not cover telescopes.
  - Practice test on angel.
  - “Missouri Club” (Show me)
    - Mon, 31 Jan, 7:00-8:00pm, 1415 BPS (next door)

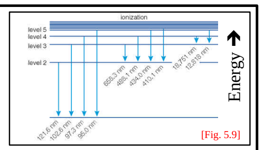
- **Atoms emit and absorb light (left over from Fri)**
- **Telescopes**

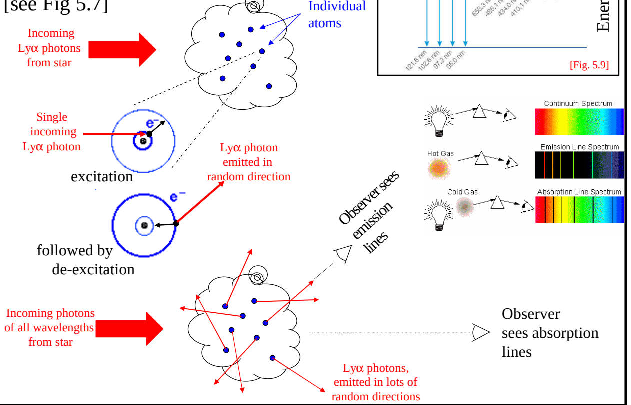
3. The spectrum of the outer parts of a planetary nebula is very different from that of a black body because the planetary nebula is
   a. very hot
   b. very cool
   c. not black
   d. black



Formation of spectral lines

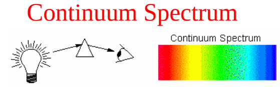
[see Fig 5.7]

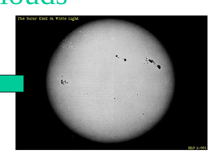




Stars vs. Gas Clouds

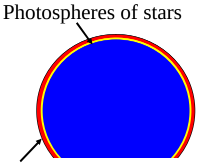
Continuum Spectrum





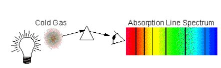
The Sun’s photosphere)

Photospheres of stars

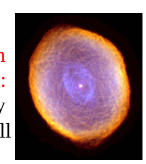


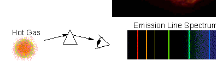
Outer, cooler layers

Absorption Spectrum



Emission spectrum: Planetary nebula shell

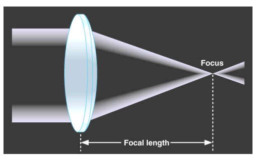




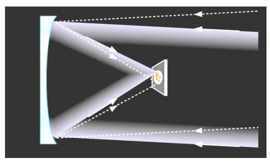
Telescopes [5.3]

Galileo's telescopes: ~1" in diameter x 24-30" long

- Magnify images ➔ see details
- Gather light over large surface area ➔ see fainter objects.



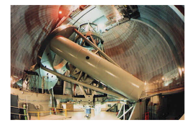
Using a lens (refractor)



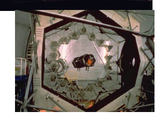
Using a mirror (reflector)

Some large ground-based optical telescopes

Lick 36" Refractor
1888



Mt. Palomar 200" Reflector
1948



Light-gathering power:

∝ (mirror area)

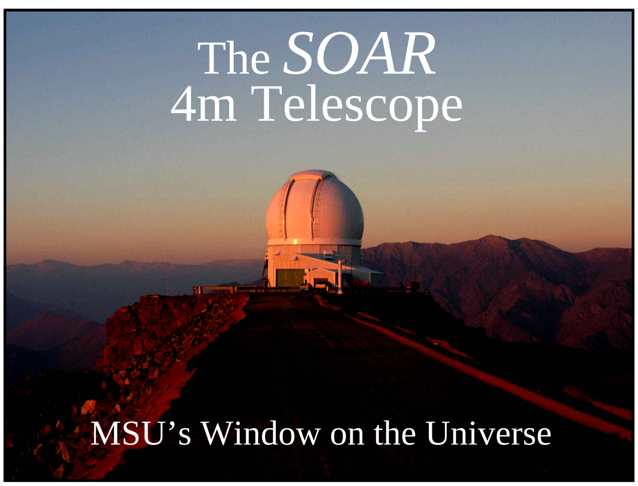
∝ (mirror diameter)²

Technological advances:

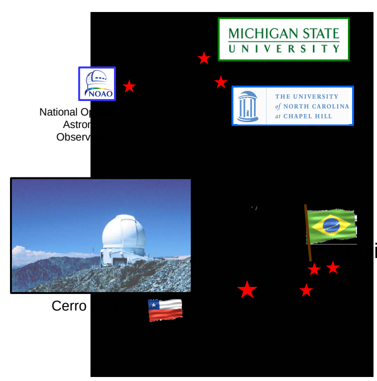
- Lenses ➔ mirrors.
- Thick mirrors ➔ thin mirrors.
  passive ➔ active support.
- Improved image quality.
- Now working on designs for 30m diameter telescopes.

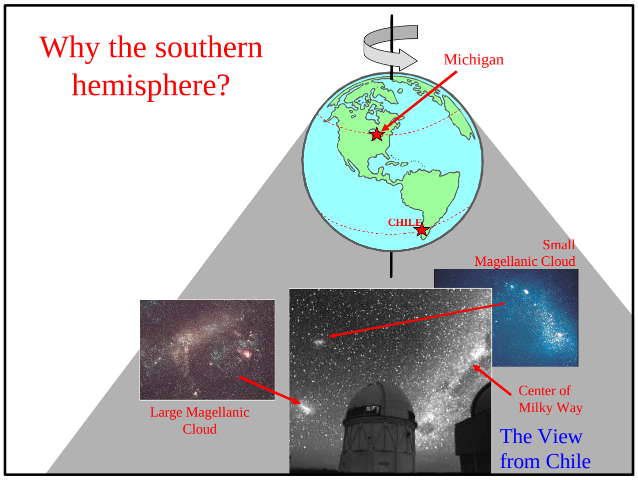
Europe's Very Large Telescope
(Four 8m telescopes)

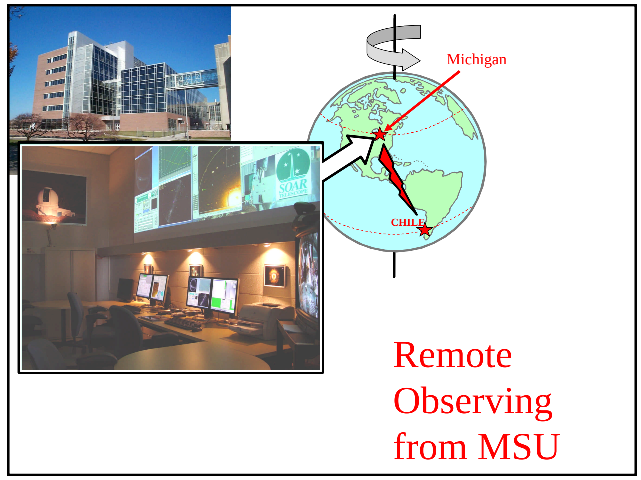
Mirror for Gemini 8m Telescope

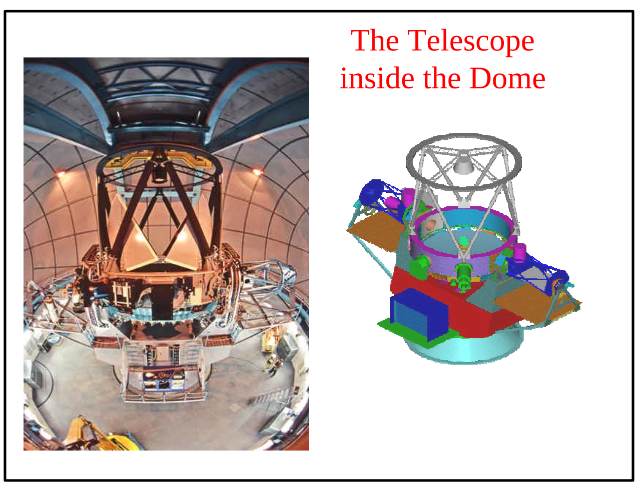


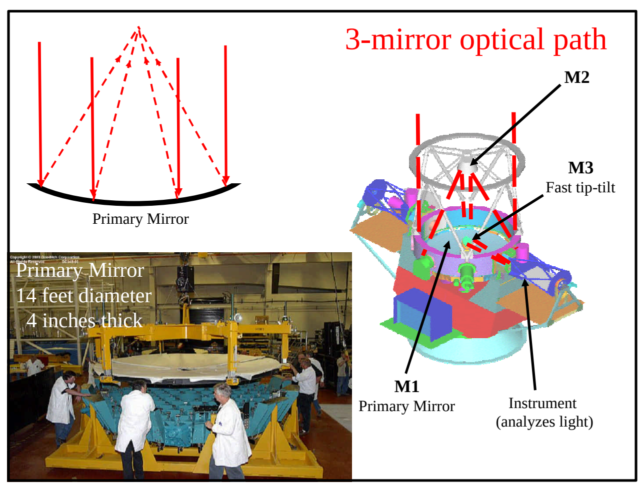
An International Partnership

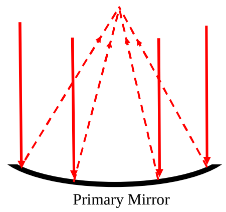



Why the southern hemisphere?
Michigan
CHILE
Small Magellanic Cloud
Large Magellanic Cloud
Center of Milky Way
The View from Chile

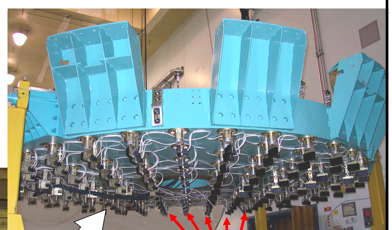

Michigan
CHILE
Remote Observing from MSU


The Telescope inside the Dome


3-mirror optical path
Primary Mirror
Primary Mirror
14 feet diameter
4 inches thick
M2
M3
Fast tip-tilt
M1
Primary Mirror
Instrument
(analyzes light)

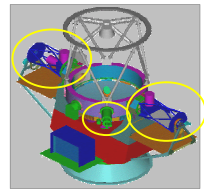


Must maintain mirror shape to 0.000001 inches.



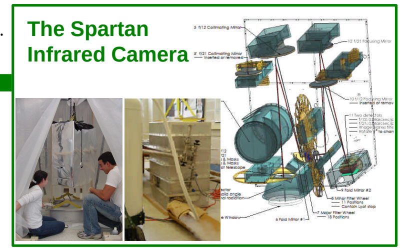
120 computer-controlled force actuators.

Telescopes carry many different instruments to analyze light.



SOAR's instruments:

- Optical spectrographs (2).
- Infrared spectrographs (2).
- Optical imager.
- Infrared imager.



Spartan Infrared Camera

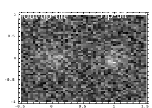
High Resolution Imaging for the SOAR Telescope

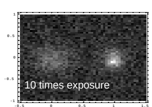
www.pa.msu.edu/~loh/SpartanIRCamera

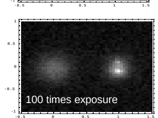
- The Spartan Infrared Camera is a $2.0M instrument funded by MSU, Brazil, SOAR, and the National Science Foundation.
- Primary technical goal:
  - Imaging with high angular resolution in the near infrared (1000-2500 nm) where
  - Tip-tilt correction of atmospheric turbulence produces sharpest images.
- Primary science goal for infrared:
  - Observe distant galaxies & supernovae
  - Center of Milky Way galaxy
- Designed and built by the MSU Physics-Astronomy Dept.

Tip-tilt Correction of Atmospheric Turbulence

- Tip-tilt correction
  - Method:
    - Sense the position of a bright star
    - Move a mirror 60 times per second to keep bright star centered
- Why use tip-tilt correction?
  - Simulated image of a double star.
  - Where is the double star?
  - Where is the fainter companion star?
  - In image with 10 & 1000 the exposure time
    - Do you see the companion?
    - Is the companion visible with natural seeing?
- With tip-tilt correction
  - Detail become visible
  - Fainter stars become visible





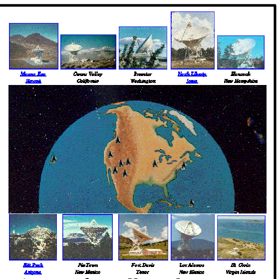


Radio telescopes

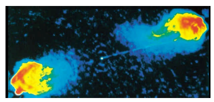
Angular resolution = $\frac{\text{wavelength}}{\text{mirror diameter}}$

- Radio wavelengths are large ➔ need large mirror diameter to see small-angle details.

- Arecibo, Puerto Rico….
  - **1000 ft. diameter, but same angular resolution as 0.01 ft optical telescope.**



Array of smaller telescopes simulates a huge aperture.



Radio galaxy Cygnus A

Very Large Array

Radio Telescope in New Mexico

Key parameters of telescopes

- Fainter objects are visible with a larger telescope because
  - R1: a larger telescope collects more light.
  - R2: with the sharper images of a larger telescope, the light is more concentrated.

1. The primary motivation for the VLA is
   a. R1
   b. R2
   c. Both R1 & R2 equally
2. The primary motivation for 4-m SOAR vs 0.6-m MSU is
   a. R1
   b. R2
   c. Both R1 & R2 equally