Prof. Hannah Jang-Condell
University of Wyoming

# Astronomy Merit Badge

# Schedule

- Tuesday
  - How to prepare for observing
  - Light pollution
  - Tools of astronomy
  - How to use a star chart
- Friday
  - Phases demonstration
  - Planets
  - The Moon
  - Observing Session
- Saturday
  - Service Project
  - The Sun
  - Observing Session
  - Leonids

# First Aid

- Hypothermia
- Frostbite
- Dehydration (esp. high altitudes)
- Snake bites
- Insect stings
- Damage to eyes

# Safe Observing

- NEVER LOOK DIRECTLY AT THE SUN!
- ALWAYS use a filter when viewing the sun
  - Solar eclipse glasses
  - 99.999% light-blocking filters for telescopes and binoculars
  - Pinhole projection
- NEVER POINT LASERS AT SOMEONE'S FACE!
- There is no first aid for eye damage

# Proper Clothing

- Can get below freezing, even in summer!
  - Summer night time temps in 40s
- Thermal Underwear
- Warm Pants and Shirt
- Heavy socks
- Hat
- Gloves (but not limiting dexterity)
- Winter Coat

# Proper Clothing

Special note for WIRO: be prepared to hike 5 miles down the mountain if necessary!

# About WIRO

- WIRO = Wyoming InfraRed Observatory
- Located at the summit of Mt. Jelm
- Elevation: 9656 ft – stay hydrated!
- Primitive camping: no facilities
- Electricity, phone, limited water only at WIRO. Poor cellphone reception.

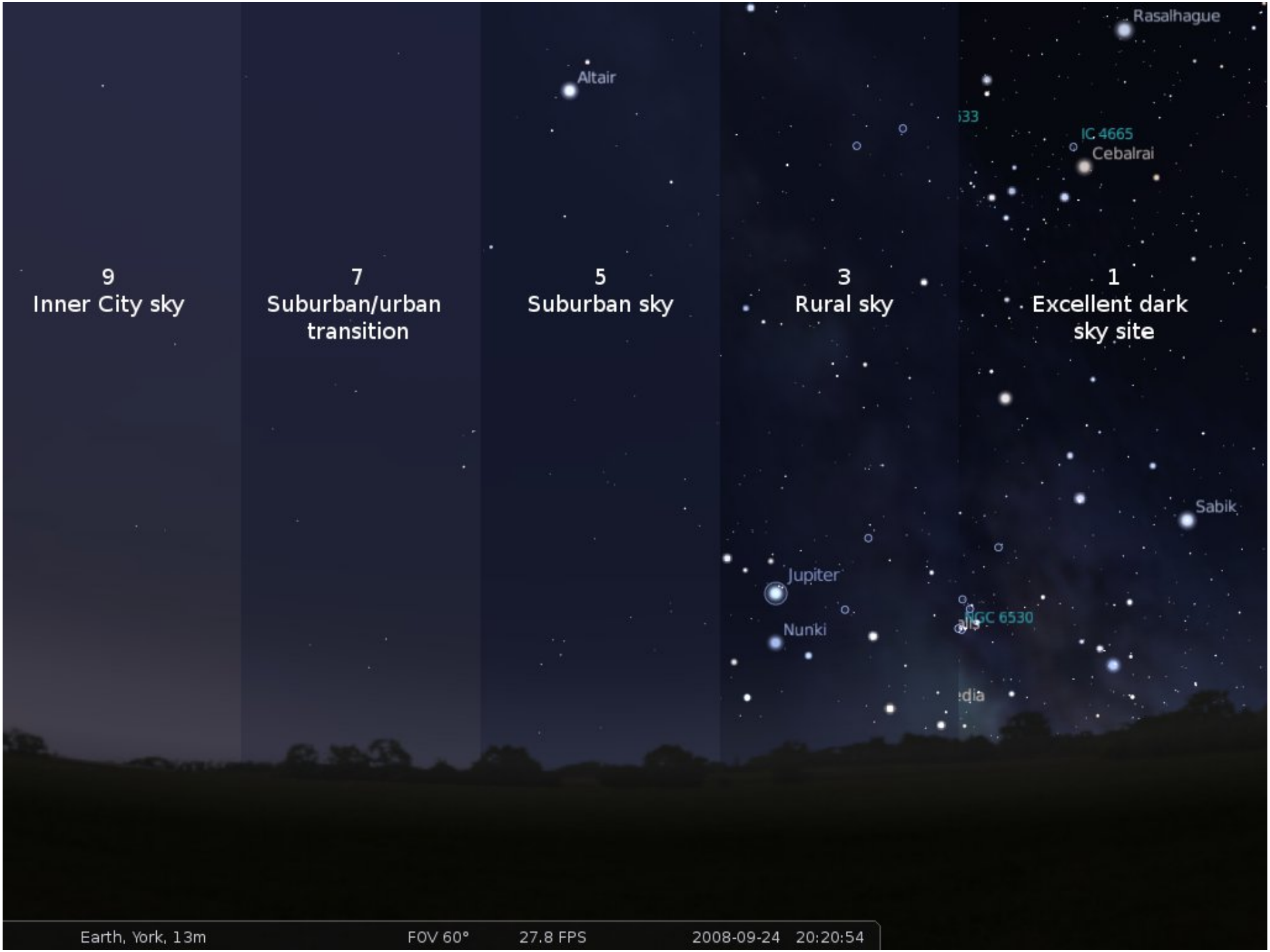
# Night on Jelm Mountain

- Never go anywhere alone
- **DO NOT WALK** on the road between the campsite and the observatory at night
- If you plan to stay up really late (past 1 am)
  - Bring snacks
  - Take a nap


# Light Pollution

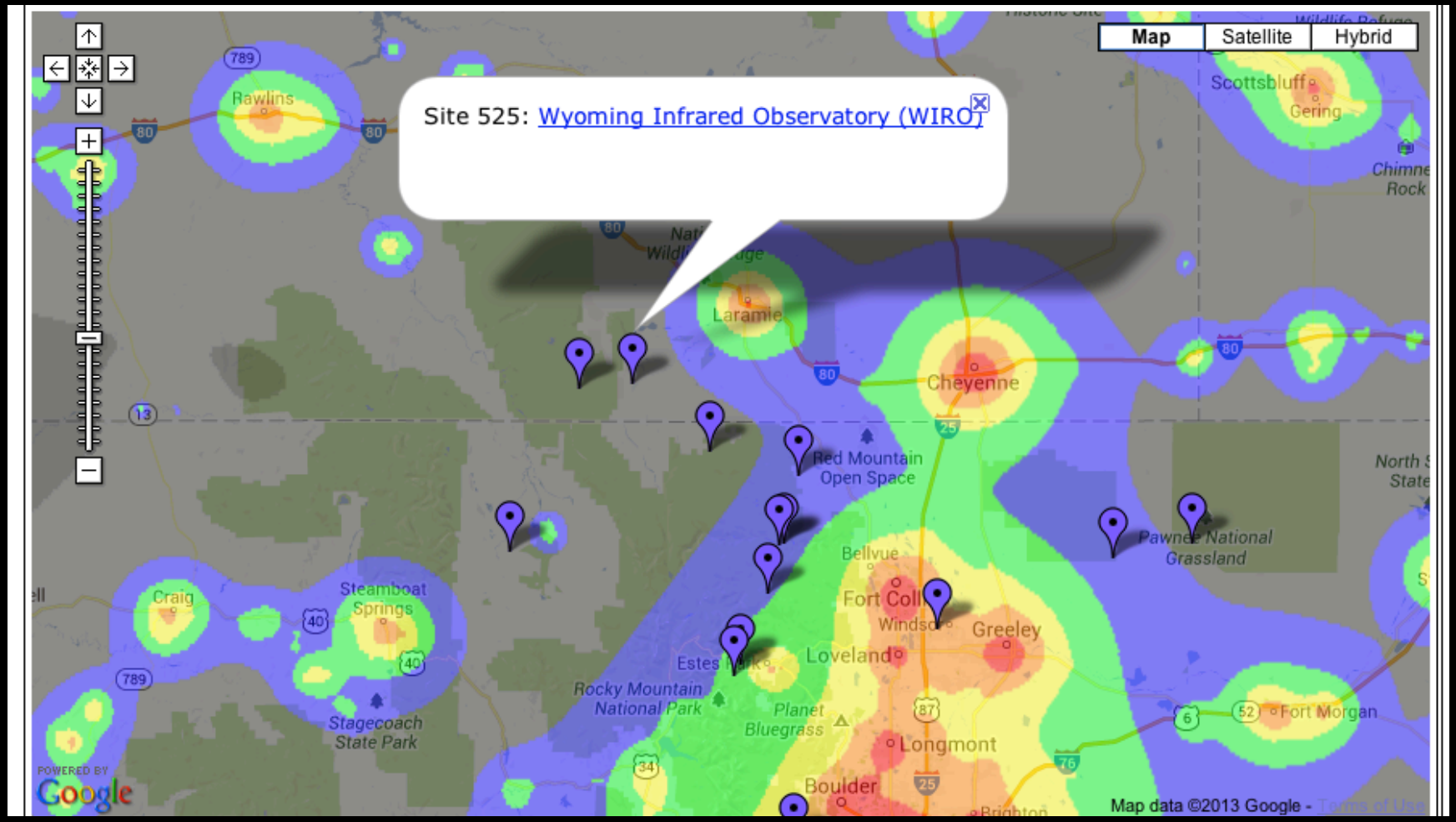
- What is it?
  - The International Dark-Sky Association (IDA) defines *light pollution* as:

"Any adverse effect of artificial light including sky glow, glare, light trespass, light clutter, decreased visibility at night, and energy waste".


9
Inner City sky
7
Suburban/urban transition
5
Suburban sky
3
Rural sky
1
Excellent dark sky site
Rasalhague
Altair
IC 4665
Cebalrai
Sabik
Jupiter
Nunki
NGC 6530
Earth, York, 13m
FOV 60°
27.8 FPS
2008-09-24 20:20:54

# Dark Sky Map

http://www.jshine.net/astronomy/dark_sky/



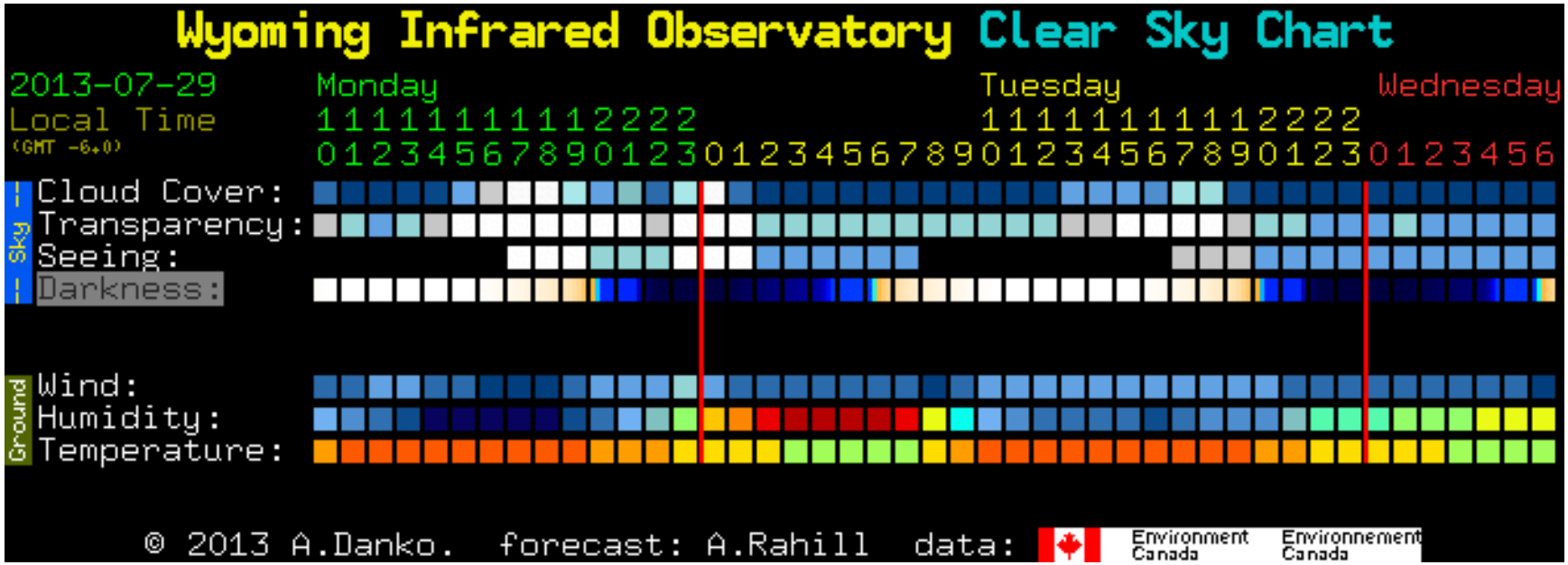
# Air Pollution

- **What is it?**
  - Air Pollution is any object or air current, large or small, which degrades seeing conditions.
- **What are the effects?**
  - Air pollution will directly effect "seeing"
  - Atmospheric movement (air currents), particulates stirred up by wind, exhaust from factories, even heat emitted by a close passer-by will all decrease image contrast.
  - Visual and photographic detail suffers.

# What else affects "seeing?"

- Clouds
- Humidity
- Wind

# Weather/Sky Data



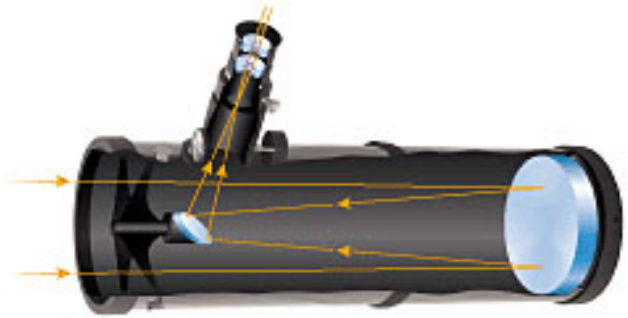

http://www.cleardarksky.com/c/WIROQYkey.html

# Telescopes

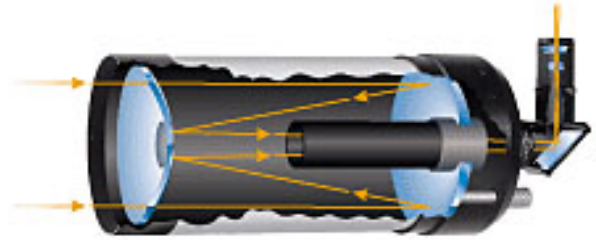
# Telescope types

skyandtelescope.com

Refractor



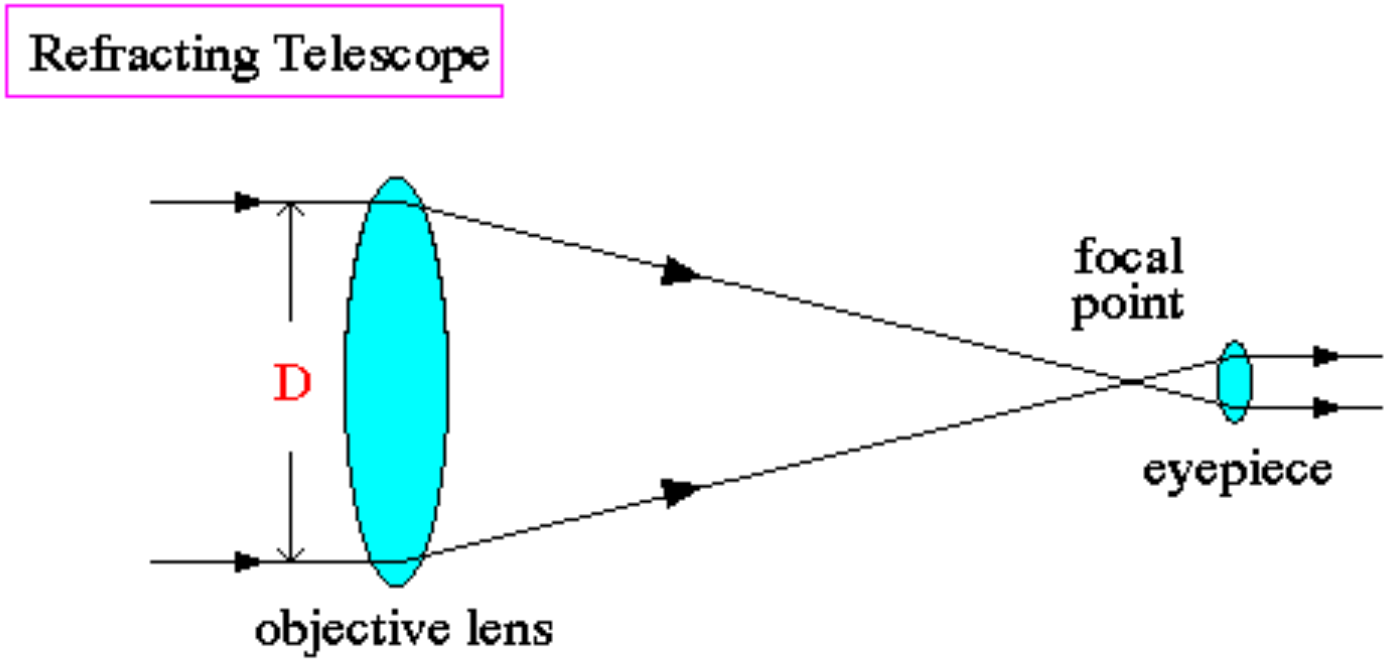
Reflector



Compound

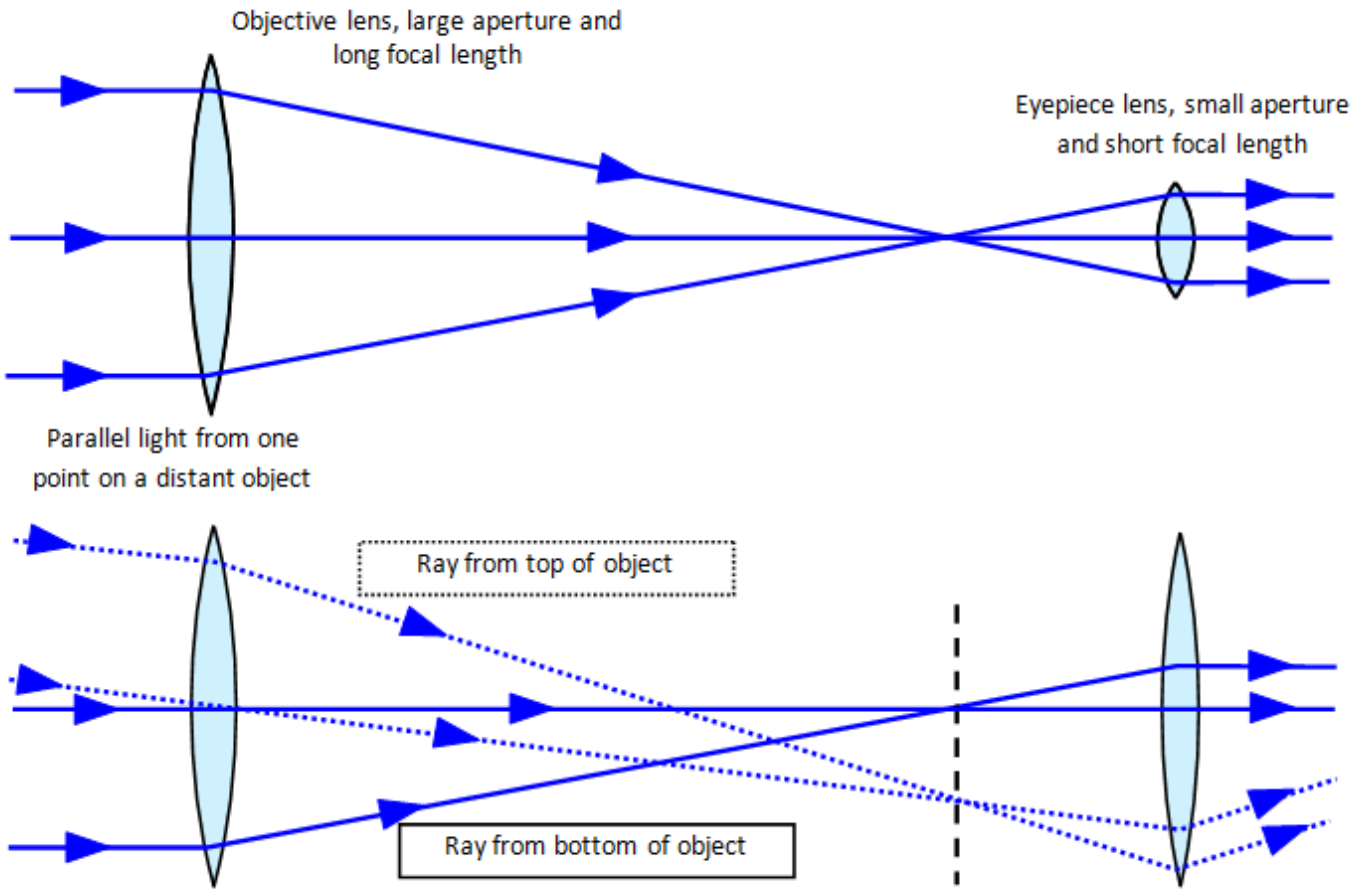
- Refractor:
  - Uses lenses
- Reflector:
  - Uses curved mirrors
- Compound:
  - Combination of lenses and mirrors

# Refracting telescopes

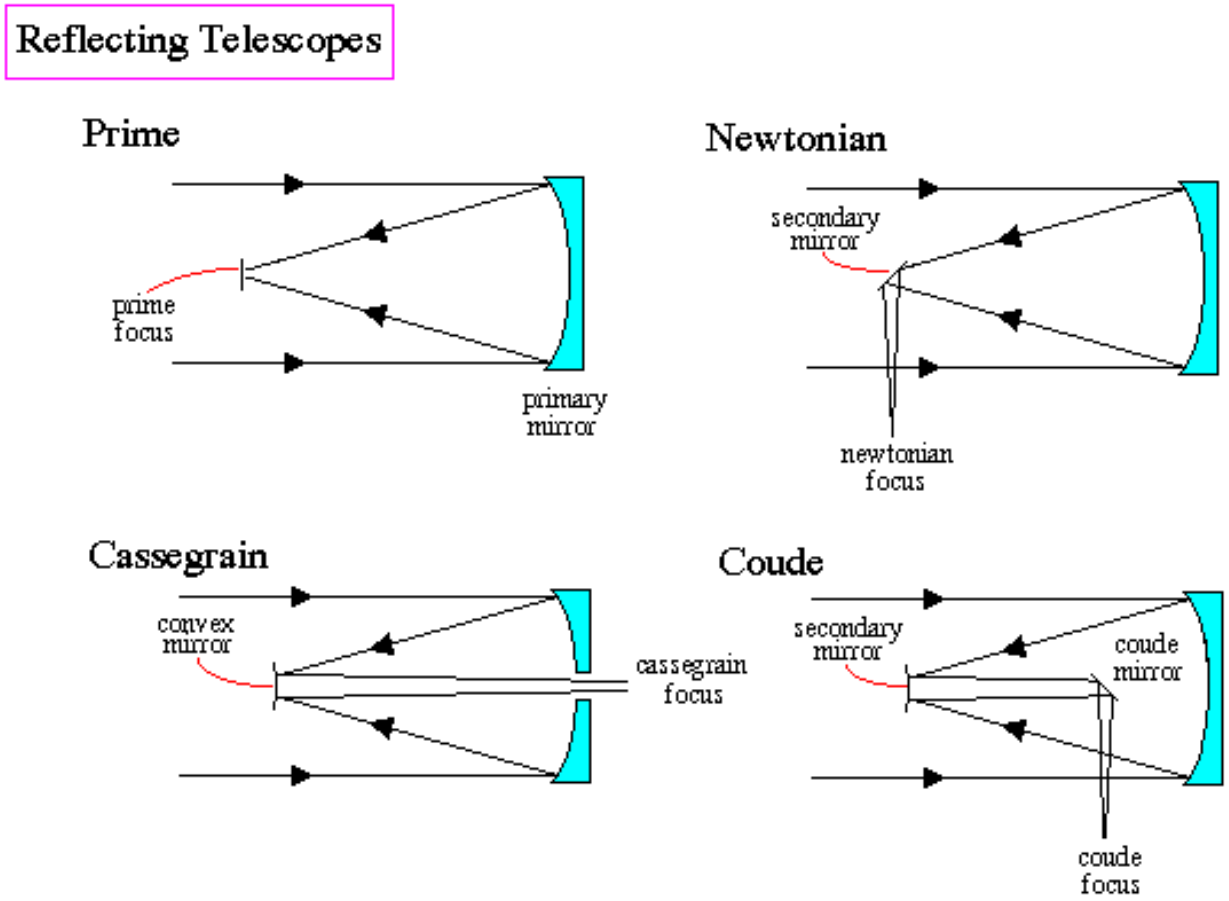



The light gathering power of a refracting telescope is given by the diameter of the objective lens, D. The power goes as $D^2$.

magnification = (objective focal length)/(eyepiece focal length)


Objective lens, large aperture and long focal length
Eyepiece lens, small aperture and short focal length
Parallel light from one point on a distant object
Ray from top of object
Ray from bottom of object

# Reflecting Telescopes



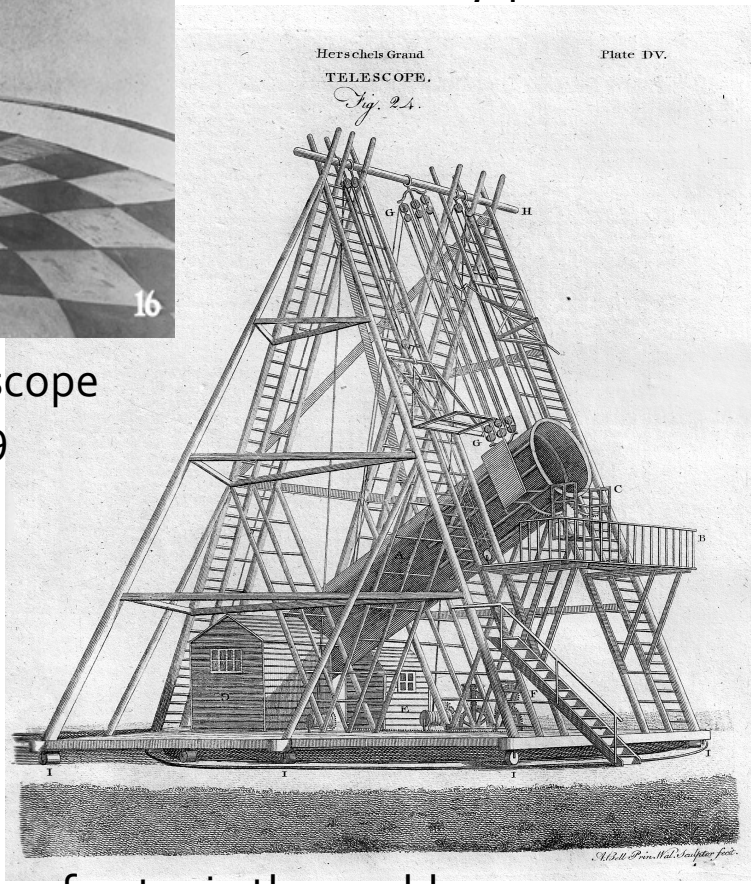
# What is meant by a "powerful" telescope?

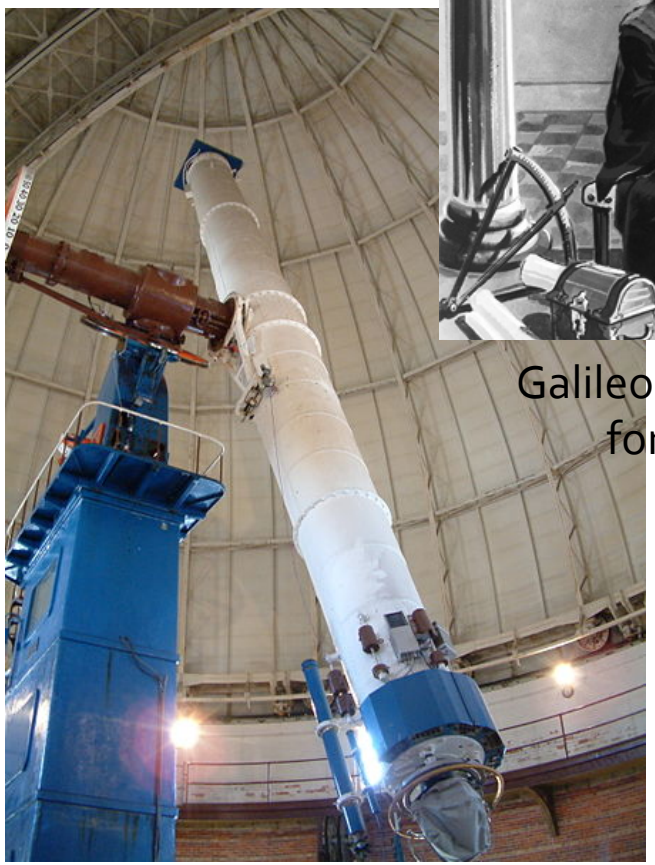
- Aperture size is more important than magnification (D=diameter)
  - Collecting area = $\pi D^2/4$
  - Angular resolution = $\lambda/D$
- Magnification and aperture: rule of thumb: a telescope's maximum useful magnification is 50X its aperture in inches

# Historical Telescopes


Galileo: first to use telescope for astronomy 1609

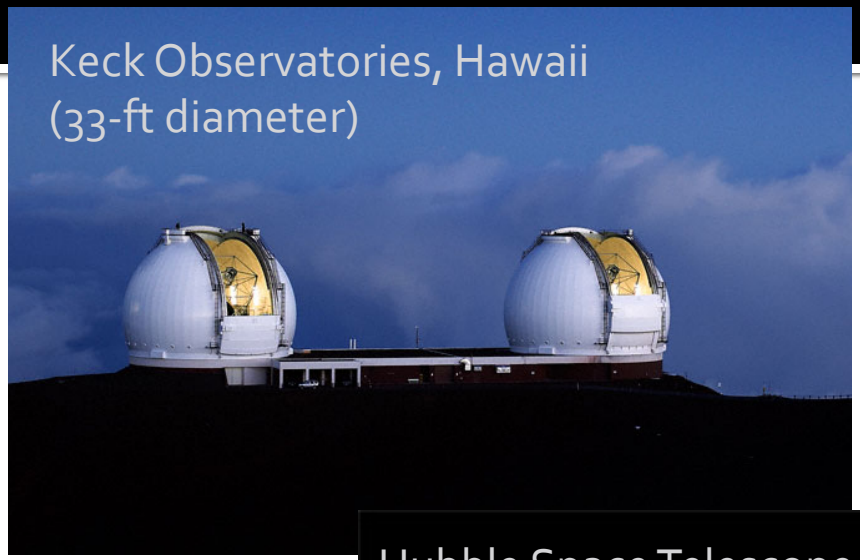
Herschel 40-foot Newtonian reflector, 48" diameter

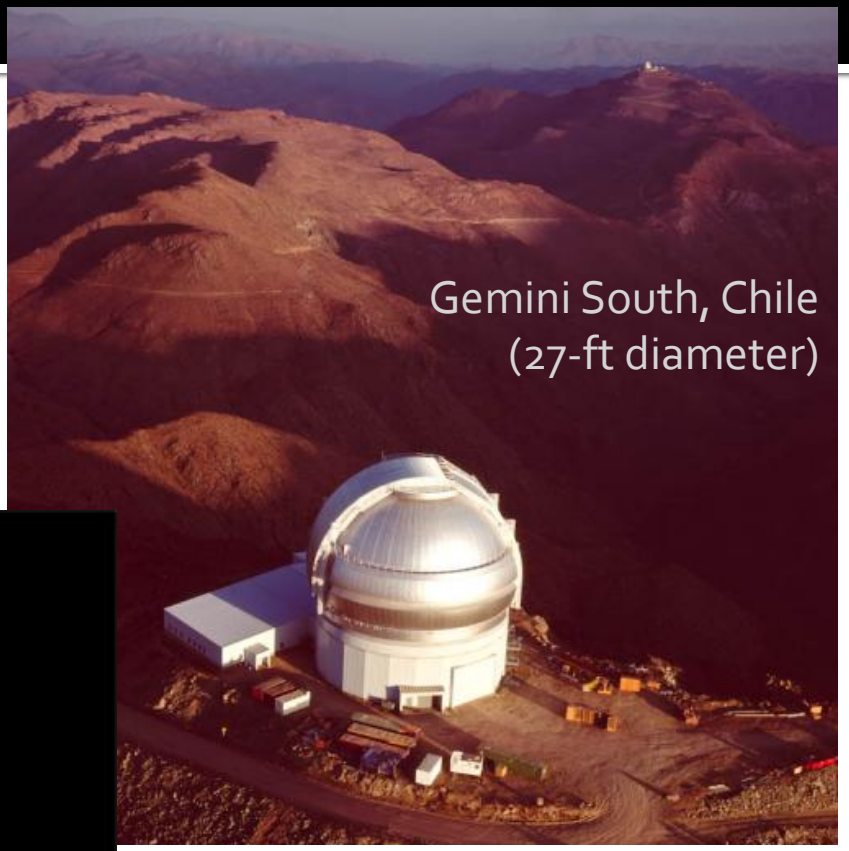


Yerkes 40-in refractor, largest currently operating refractor in the world

# Present-Day Optical Observatories




# Other Helpful Instruments

CCD Cameras

Off-Axis Guider

Computer

Telrad Finder Scope

Green Laser Pointer

Filter Wheel

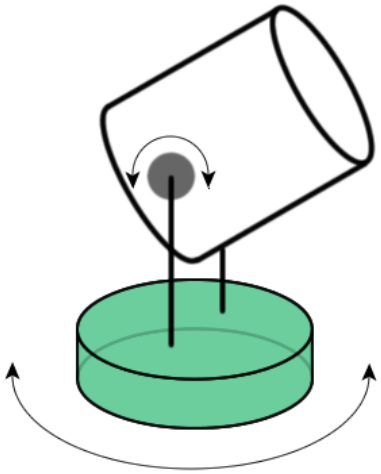

Dew Heater

Collimating Laser

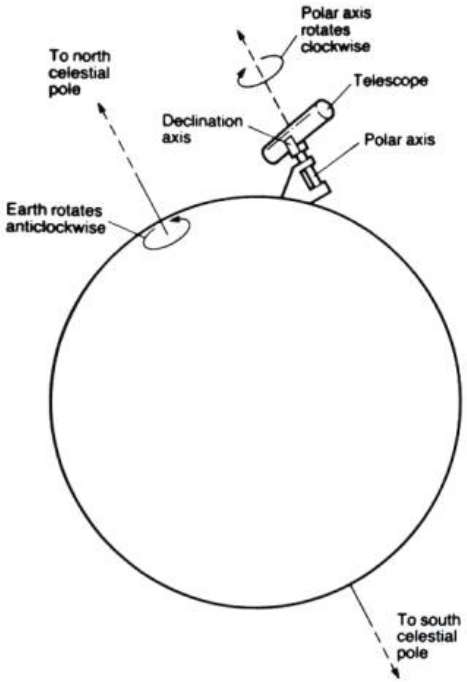
Dew Shield

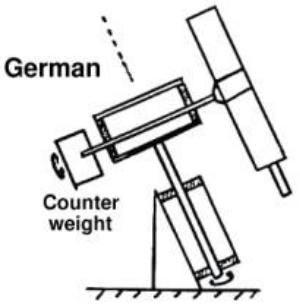
# Mounts

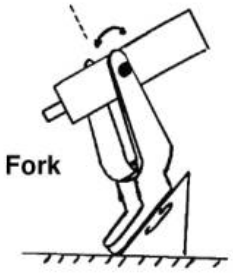
## ALTITUDE-AZIMUTH (ALT-AZ)



## EQUATORIAL



# Mounts

- Altitude-Azimuth


Dobsonian

- Equatorial


German Equatorial

Equatorial Fork

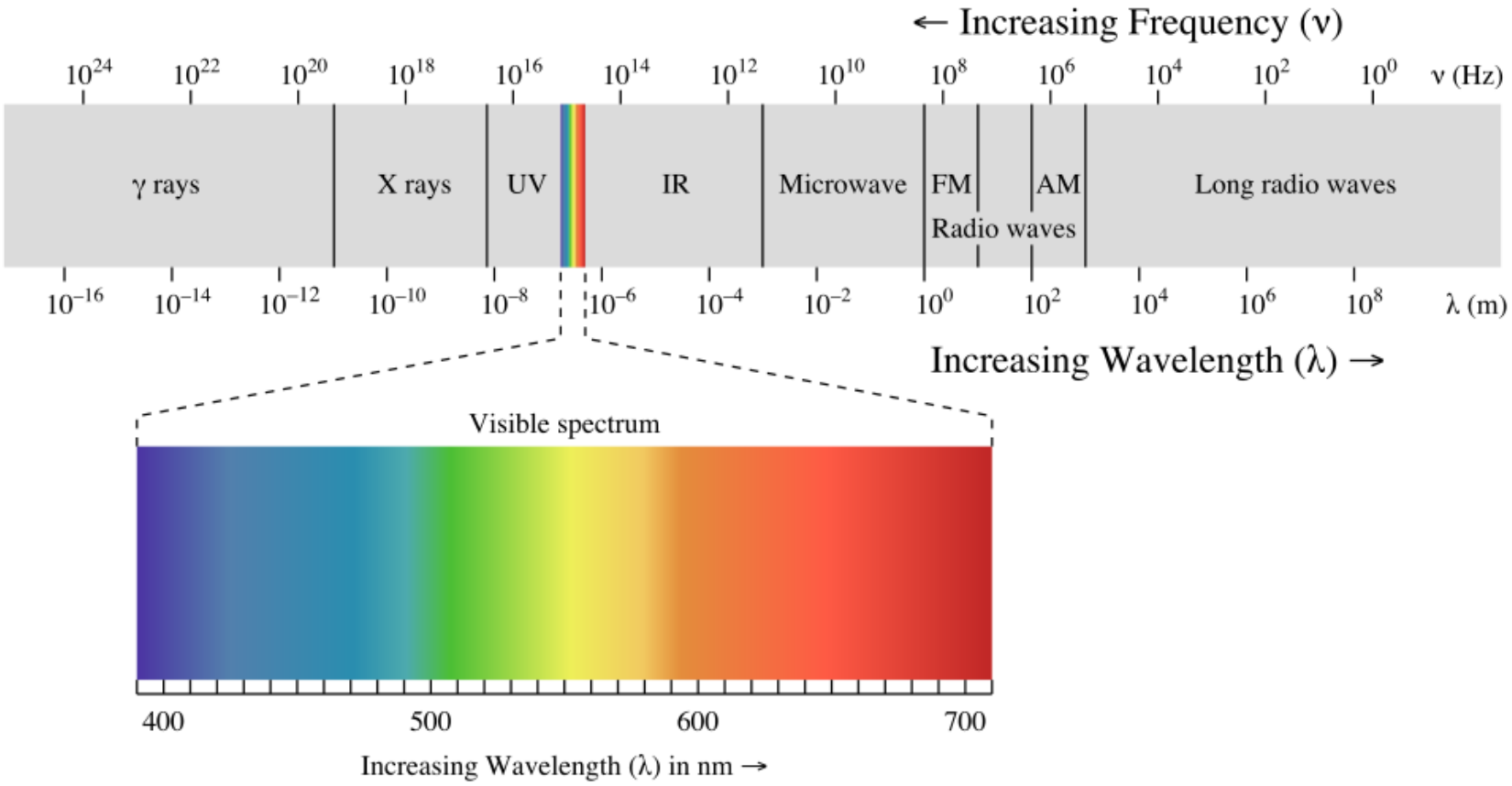
# What's the best first telescope?

- Binoculars!
- Easy to use
- Very portable
- Inexpensive
- Can build an inexpensive mount for it

# Care of your telescope

- NEVER touch lenses or mirrors with your fingers
- Keep covered when not in use
- Avoid moisture
- Never wipe moisture off, allow it to air dry
- May need to re-collimate it periodically
- If you must remove dust from lenses or mirrors, use a blower, soft brushes, or clean cloths

# Other wavelengths



# UV & Infrared telescopes

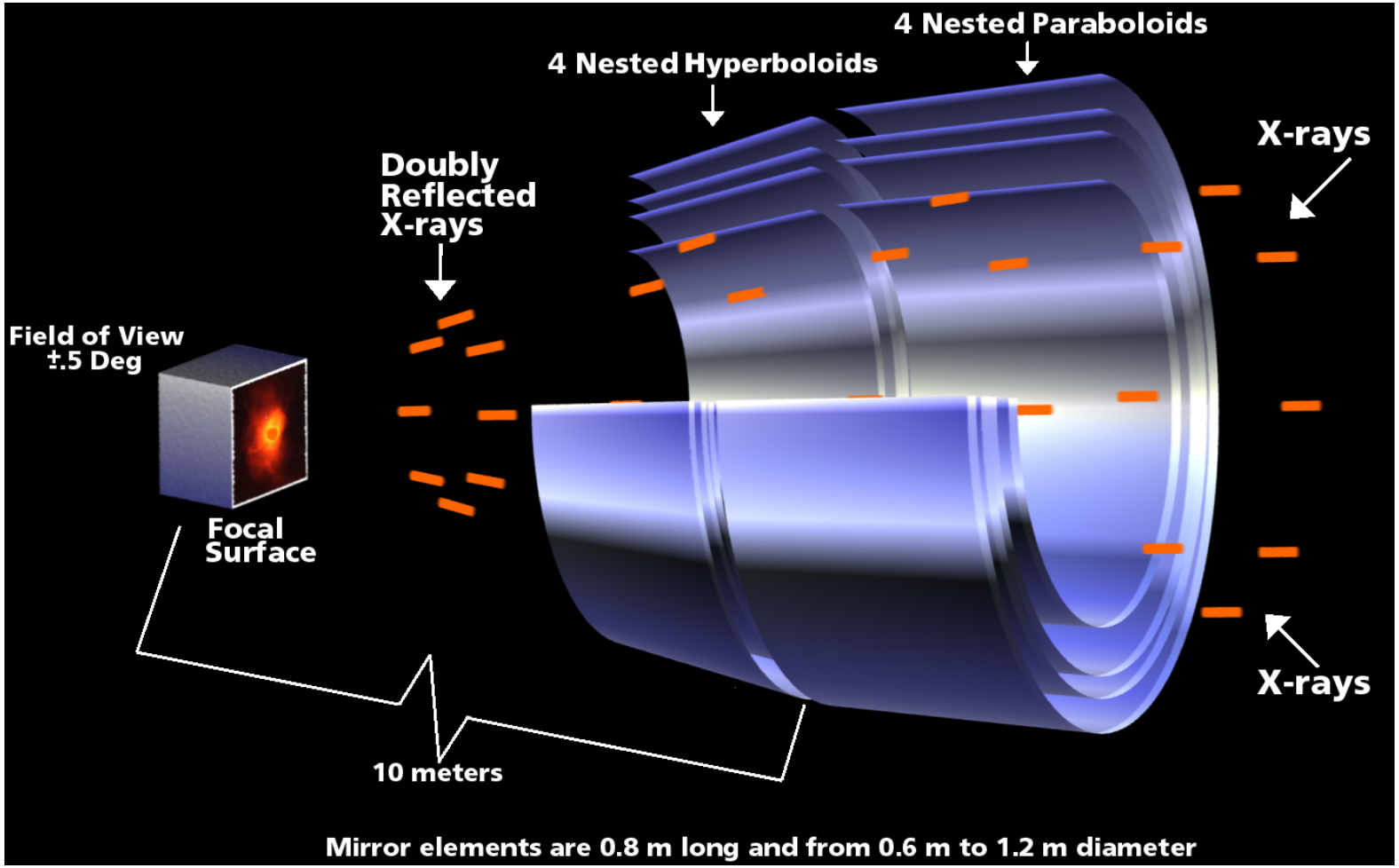
- Work similarly to optical telescopes
- Differences:
  - Lens/mirror material
  - Detector/camera
- UV and infrared telescopes work best in space, or at very high altitudes

# X-ray telescopes

- High energy photons (short wavelength, high frequency)
- Hard to focus

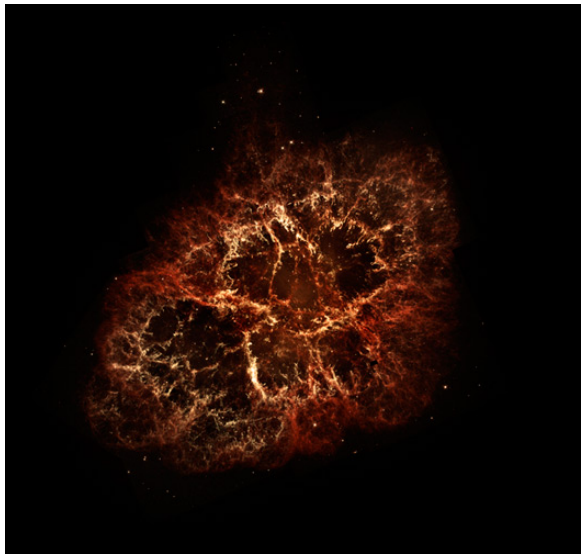
# X-ray telescopes

Chandra X-ray Observatory

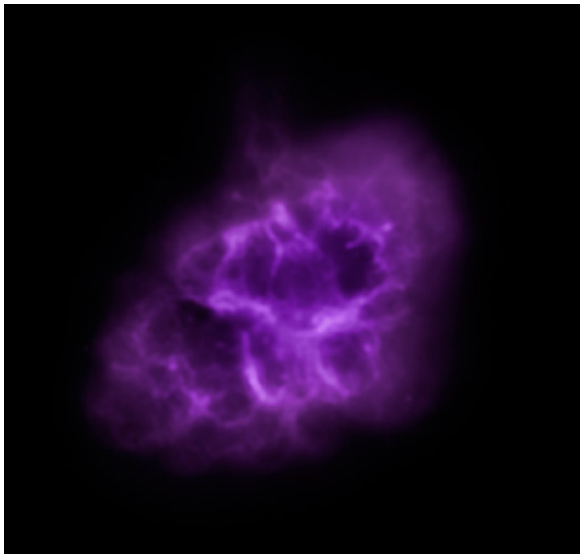


# Crab nebula

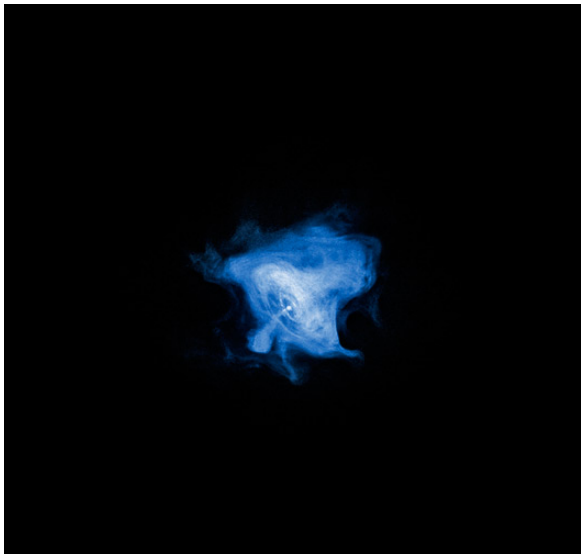
- Supernova observed in 1054



Optical



Infrared



X-ray

# Crab Nebula

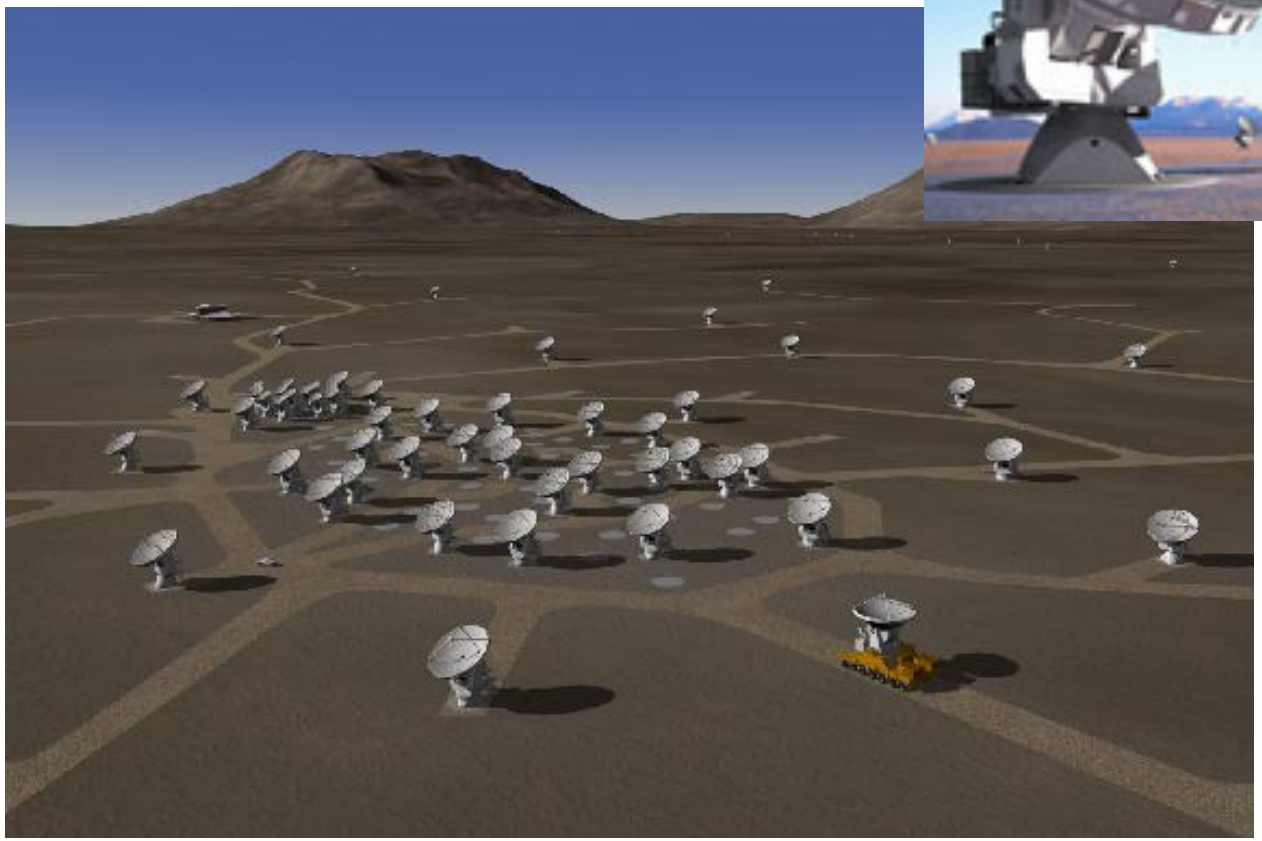
# Radio telescopes

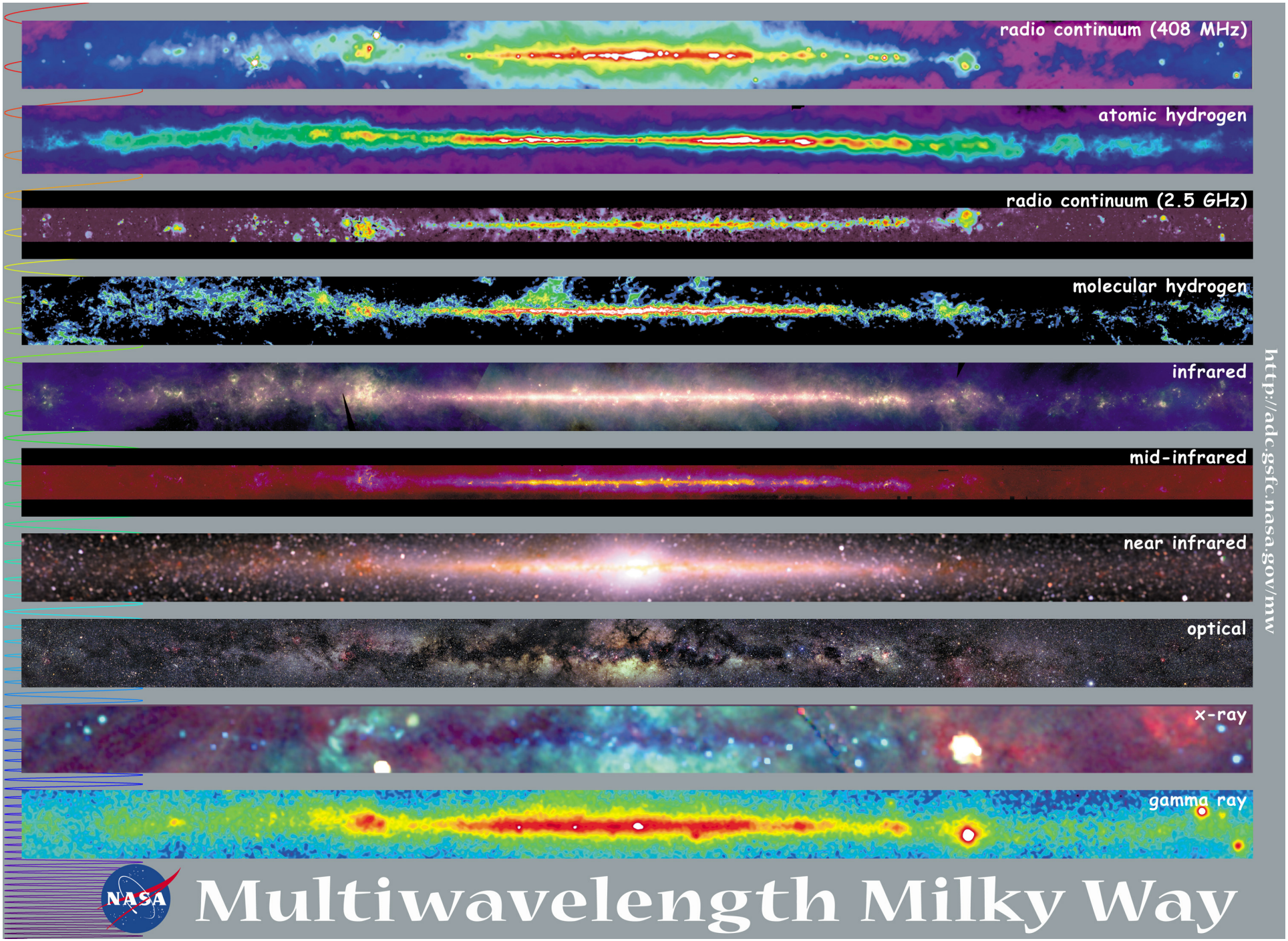
- Use antennas instead of lenses and mirrors

# Arecibo Observatory (Puerto Rico)

# Very Large Array (New Mexico)

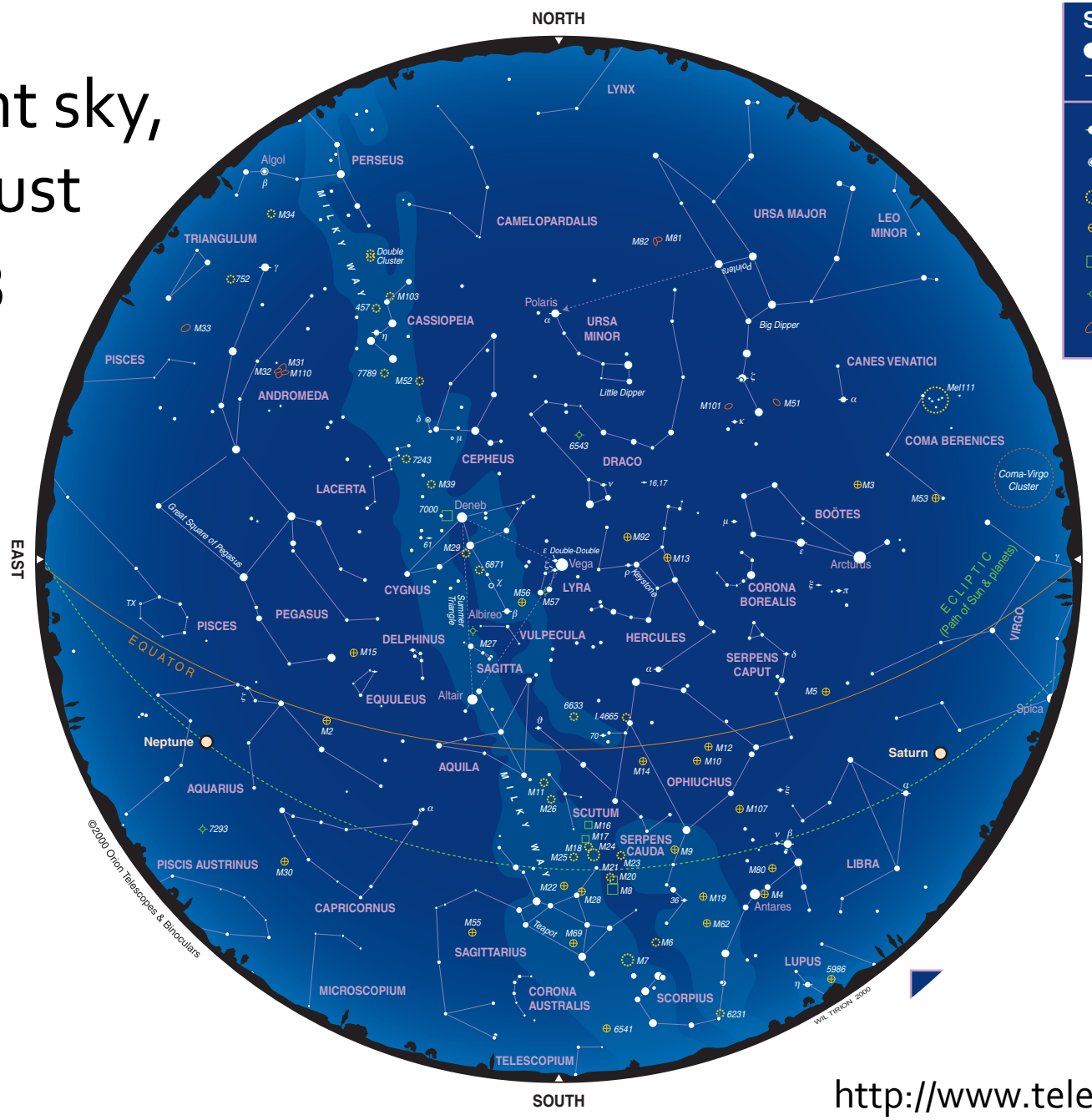
# Atacama Large Millimeter/ Submillimeter Array (Chile)




radio continuum (408 MHz)
atomic hydrogen
radio continuum (2.5 GHz)
molecular hydrogen
infrared
mid-infrared
near infrared
optical
x-ray
gamma ray
NASA
Multiwavelength Milky Way
http://adc.gsfc.nasa.gov/mw

# How to read a star chart

# Night sky, August 2013




## Star magnitudes

–1 0 1 2 3 4 5

- Double star
- Variable star
- Open cluster
- Globular cluster
- Diffuse nebula
- Planetary nebula
- Galaxy

## Moon Phases

- NEW — Aug. 6
- FIRST — Aug. 14
- FULL — Aug. 21
- LAST — Aug. 28

http://www.telescope.com

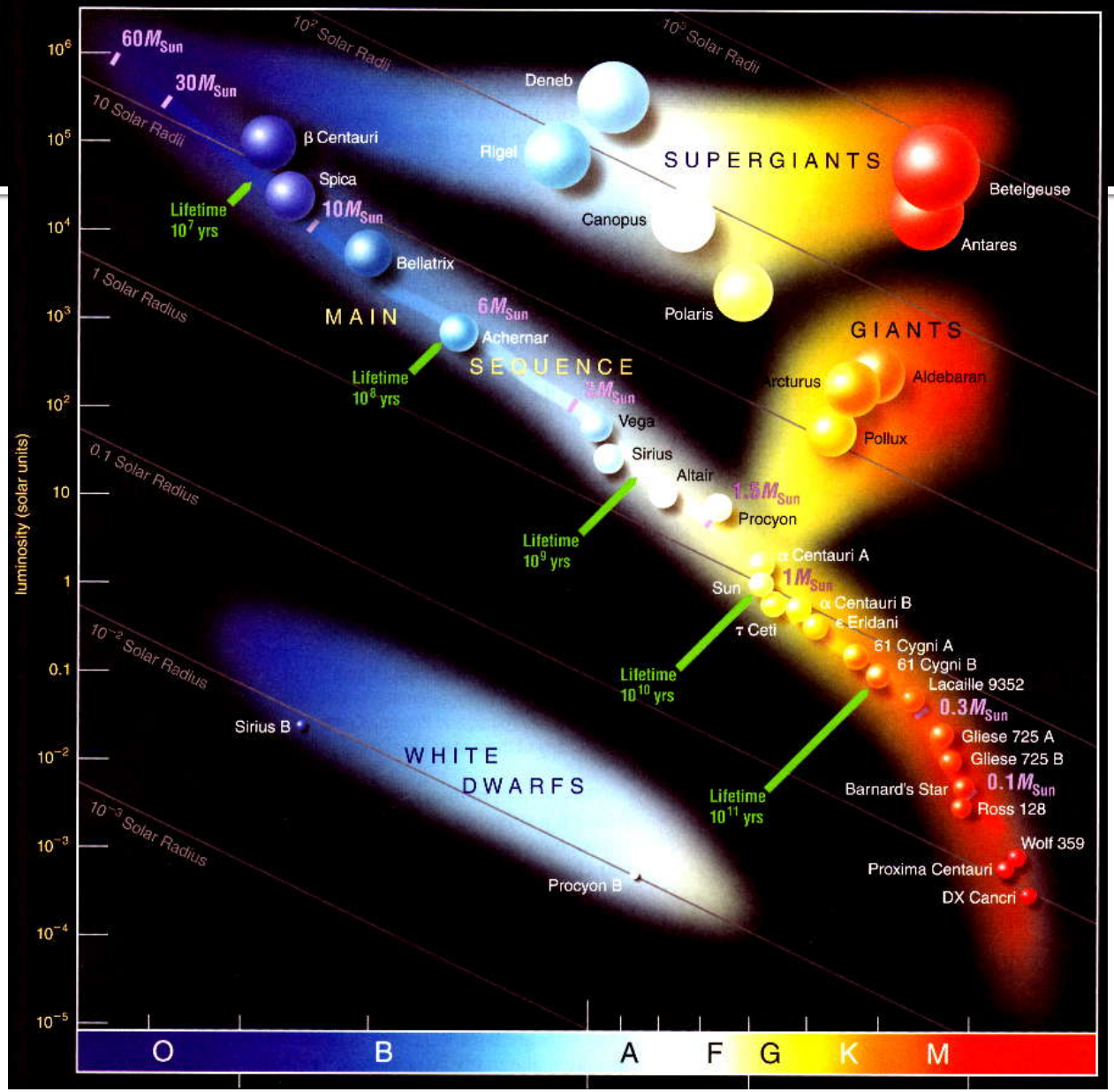
# Magnitudes

- What affects the brightness of stars?
  - Distance
  - Size
  - Temperature
- Magnitude = measure of brightness
  - $0^{th}$ magnitude = brightest stars
  - $5^{th}$ magnitude = faintest naked-eye stars
  - Logarithmic scale
    - 2.5 magnitude is 10 times dimmer than $0^{th}$ magnitude
    - 5 magnitude is 100 times dimmer than $0^{th}$ magnitude

# Temperature-Luminosity Diagram

The temperature of the star sets its color

hotter = bluer
cooler = redder



# The Brightest Stars in the Northern Hemisphere

| Name | When | Distance (light years) | Magnitude |
|---|---|---|---|
| Sirius | Winter | 8.6 | -1 |
| Arcturus | Spring/Summer | 37 | 0 |
| Vega | Summer/Fall | 25 | 0 |
| Capella | Winter/Spring | 42 | 0 |
| Rigel | Winter | 770 | 0 |
| Procyon | Winter/Spring | 11.5 | 0 |
| Betelgeuse | Winter | 640 | 0 |
| Altair | Summer/Fall | 17 | 1 |
| Aldebaran | Winter | 65 | 1 |
| Antares | Summer | 620 | 1 |

# The Zodiac

- Where is the Zodiac?
- The Ecliptic (the path the sun makes across the sky)
- Horoscopes are based on what constellation the sun is in on your birthday

| Constellation | Dates |
|---|---|
| Sagittarius | Dec 18 - Jan 18 |
| Capricornus | Jan 19 - Feb 15 |
| Aquarius | Feb 16 - Mar 11 |
| Pisces | Mar 12 - Apr 18 |
| Aries | Apr 19 - May 13 |
| Taurus | May 14 - Jun 19 |
| Gemini | Jun 20 - Jul 20 |
| Cancer | Jul 21 - Aug 9 |
| Leo | Aug 10 - Sep 15 |
| Virgo | Sep 16 - Oct 30 |
| Libra | Oct 31 - Nov 22 |
| Scorpius | Nov 23 - Nov 29 |
| Ophiuchus | Nov 30 - Dec 17 |

# Things to bring

- Star charts
- Red flashlight
- Laser pointer
- Binoculars
- Camera and tripod
- Sketchbook or notebook

# Useful Links

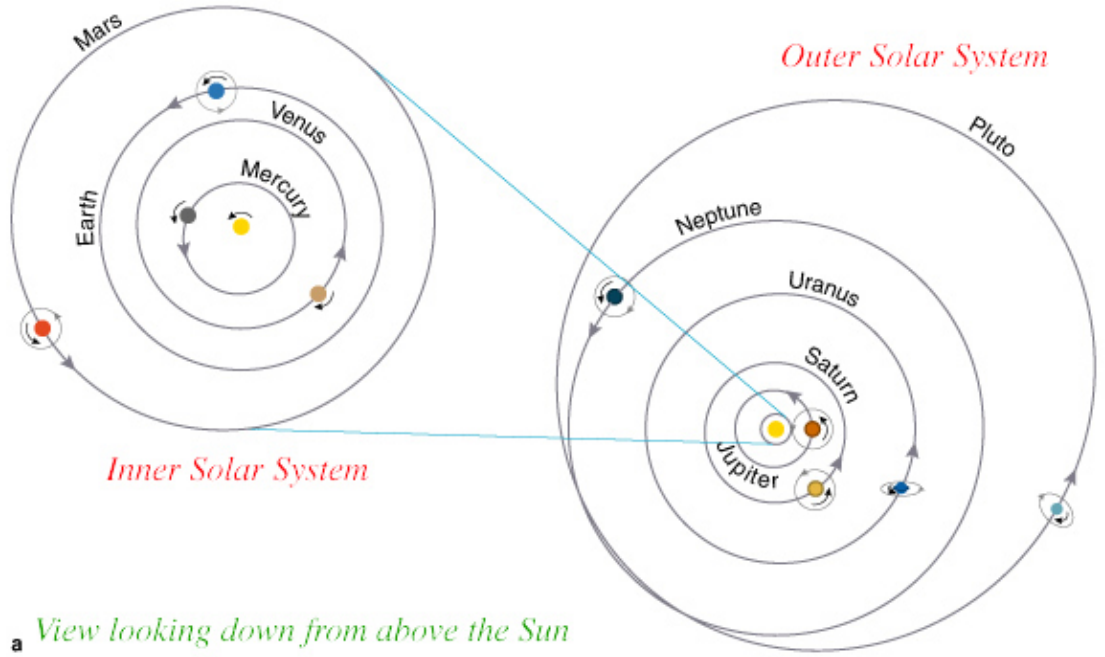
- http://www.astronomy.com
- http://www.skyandtelescope.com
- http://telescope.com
- http://physics.uwyo.edu/~chip/wiro/

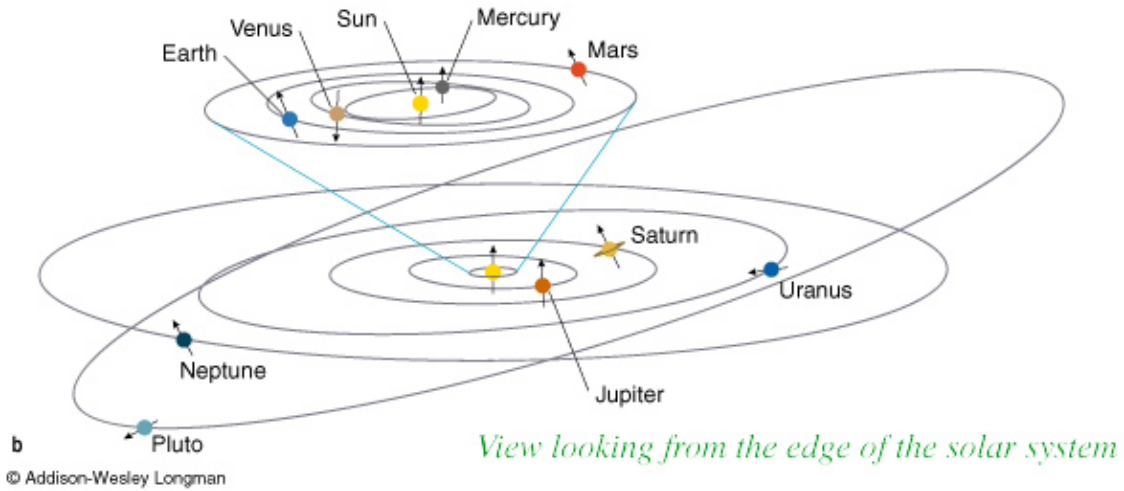
# Friday

Planets, The Moon, The Sun

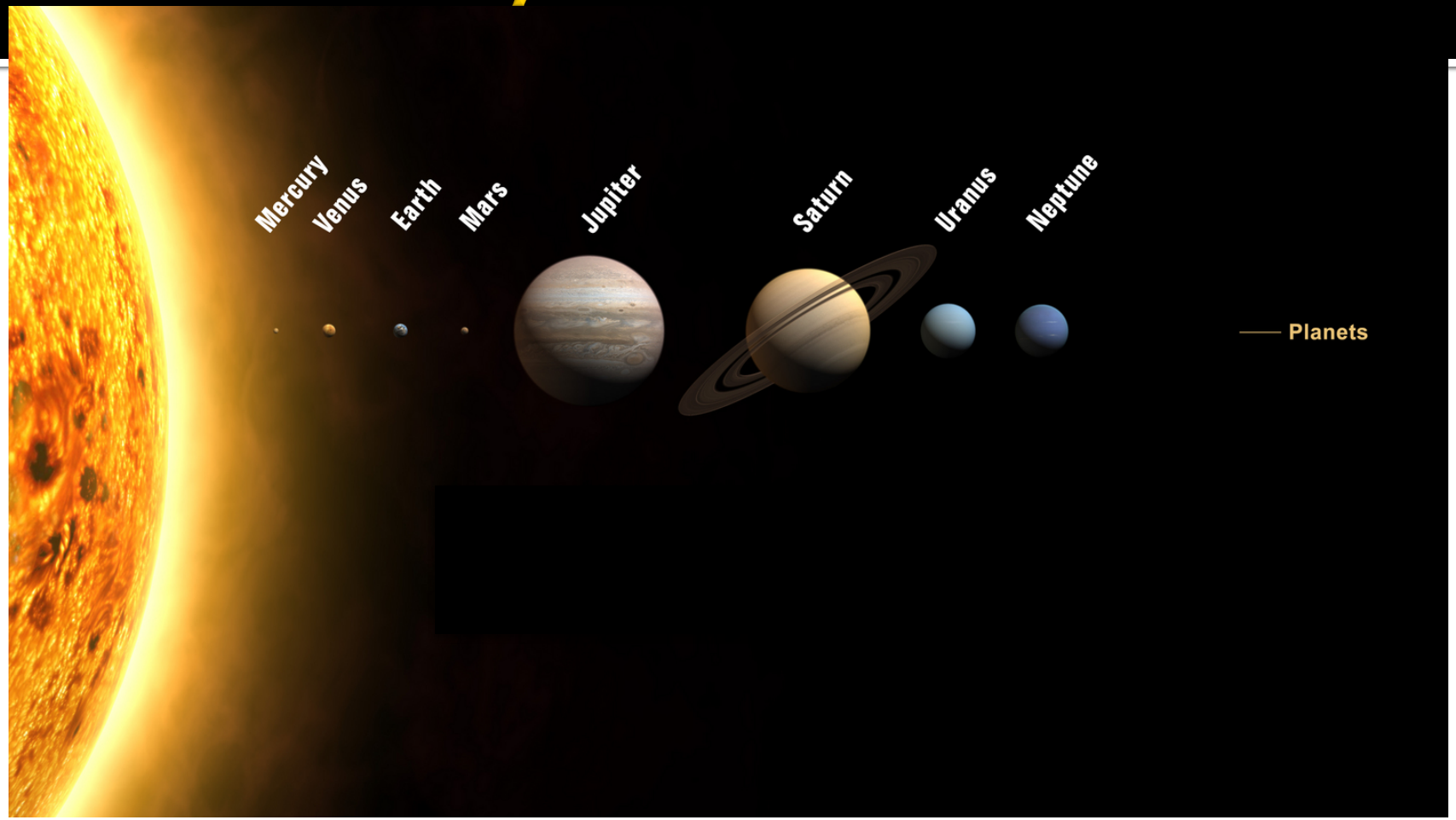
# Phases activity

# Planets



# The Solar System




Astronomy Picture of the Day, August 28, 2006
http://apod.nasa.gov/apod/ap060828.html4

# The five most visible planets

- Mercury
- Venus
- Mars
- Jupiter
- Saturn

# The Moon

# Draco Productions **Lunar Map**

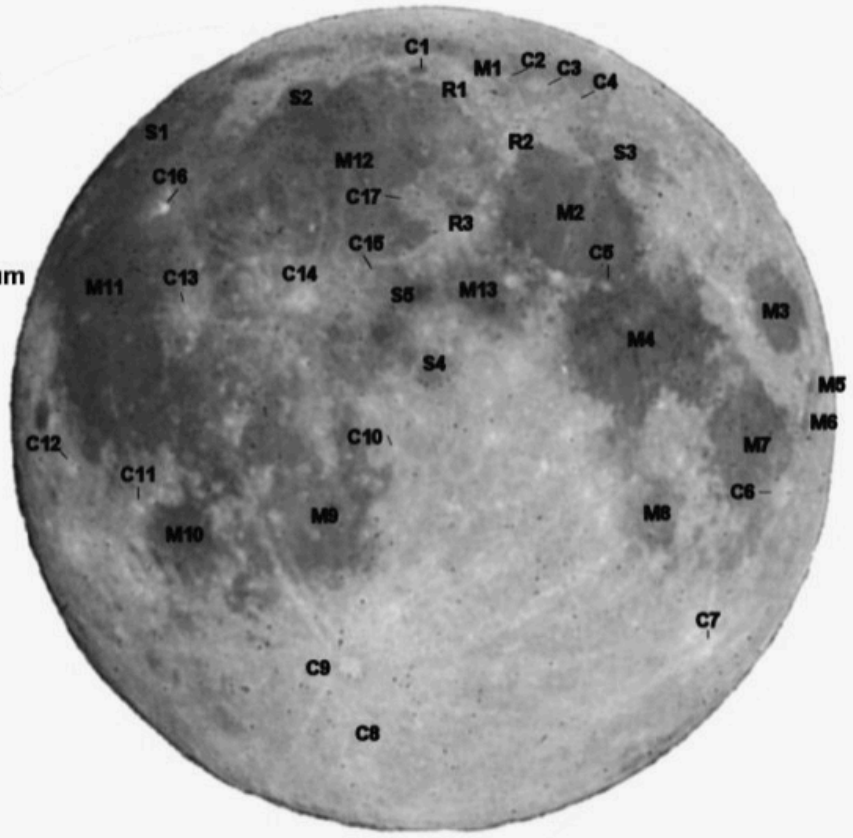
## MARIA - SEAS

M1 – Mare Frigoris
M2 – Mare Serenitatis
M3 – Mare Crisium
M4 – Mare Tranquillitatis
M5 – Mare Undarum
M6 – Mare Spumans
M7 – Mare Fecunditatis
M8 – Mare Nectaris
M9 – Mare Nubium
M10 – Mare Humorum
M11 – Oceanus Procellarum
M12 – Mare Imbrium
M13 – Mare Vaporum

## CRATERS

C1 – Plato
C2 – Aristoteles
C3 – Hercules
C4 – Atlas
C5 – Plinius
C6 – Langrenus
C7 – Petavius
C8 – Clavius
C9 – Tycho
C10 – Ptolemaeus
C11 – Gassendi
C12 – Grimaldi
C13 – Kepler
C14 – Copernicus
C15 – Eratothenes
C16 – Aristarchus
C17 – Archimedes





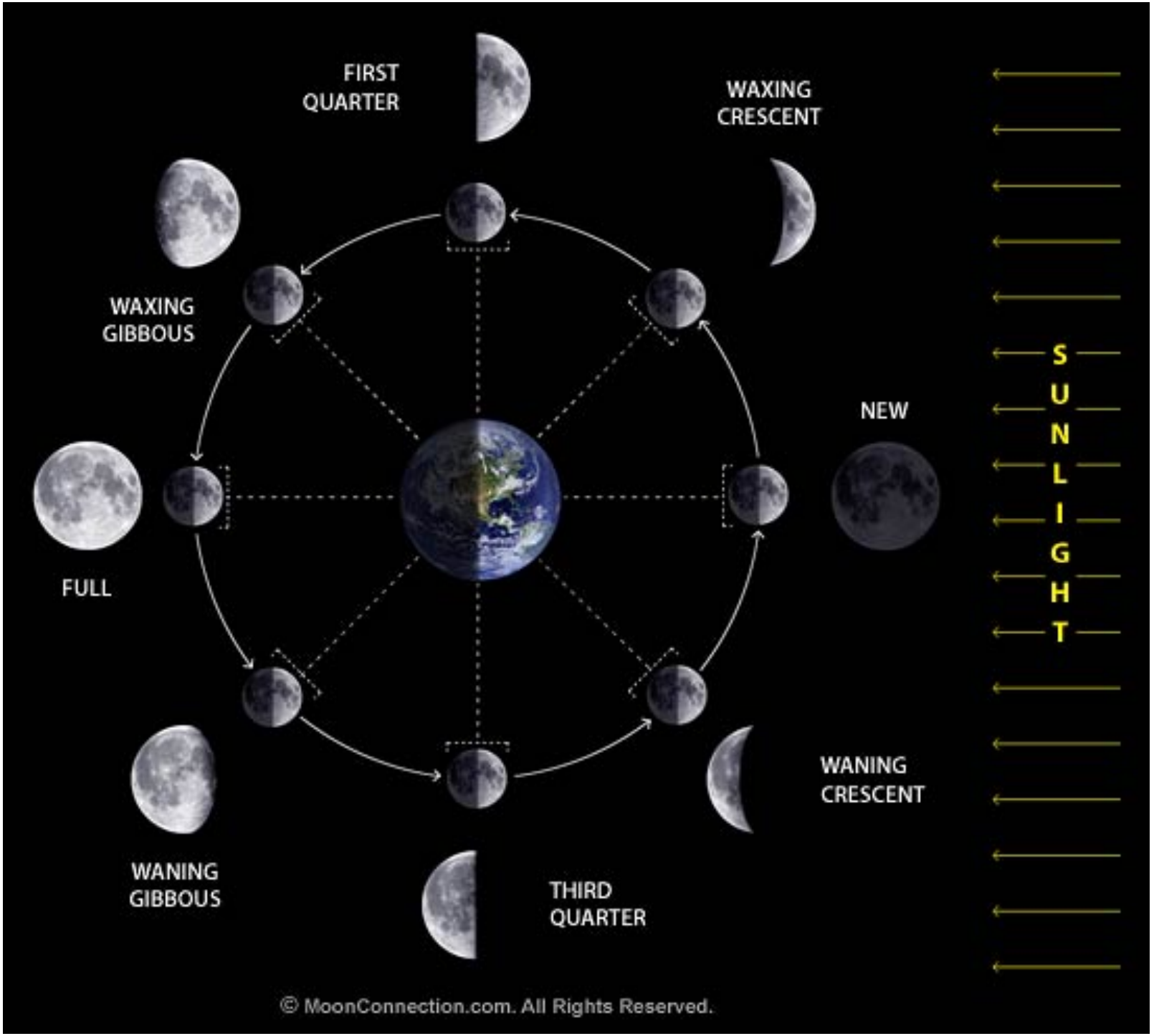

## SINUS (Bays) & LAKES

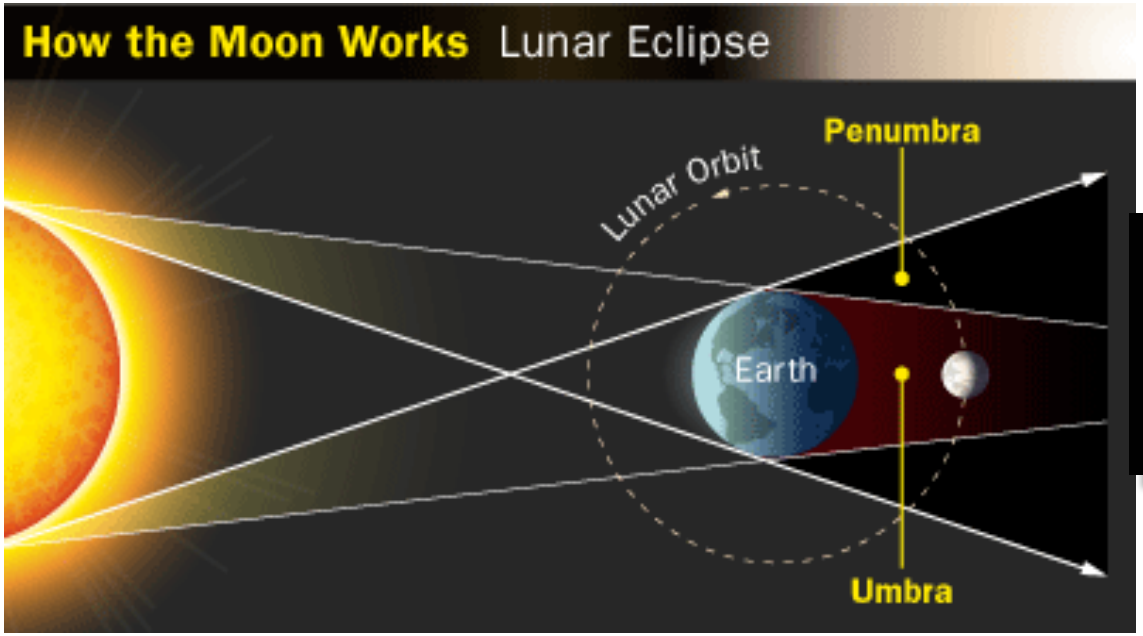
S1 – Sinus Roris
S2 – Sinus Iridum
S3 – Lacus Sominorum
S4 – Sinus Medii
S5 – Sinus Aestuum

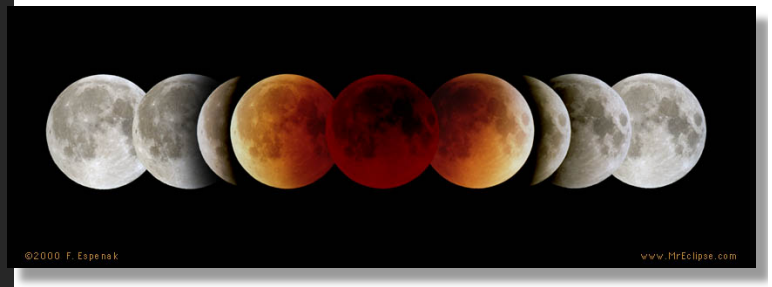
## MOUNTAIN RANGES

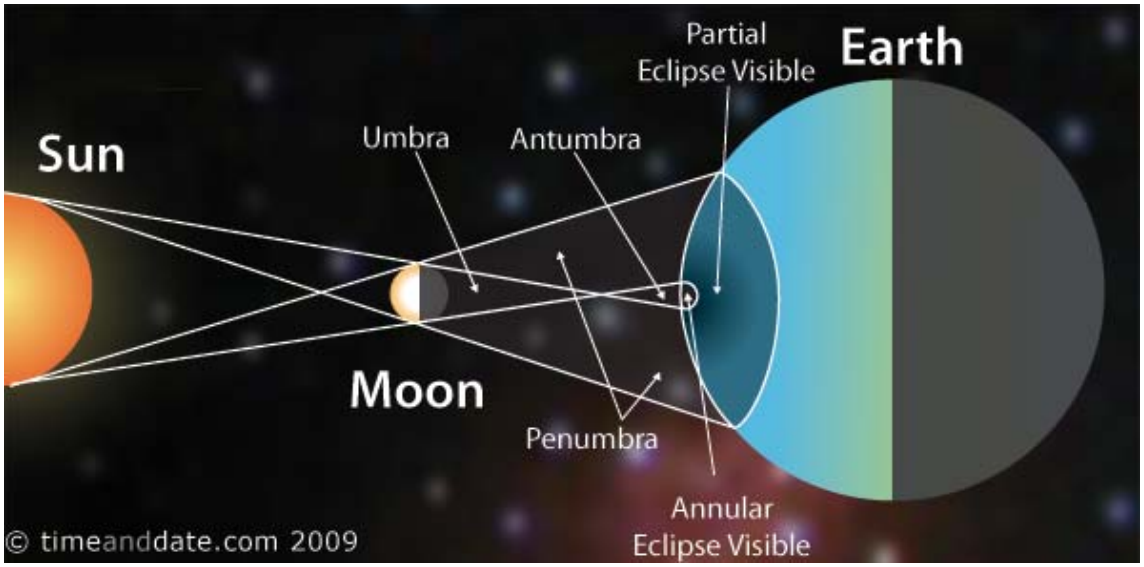
R1 – Alps
R2 – Caucasus
R3 – Apennines

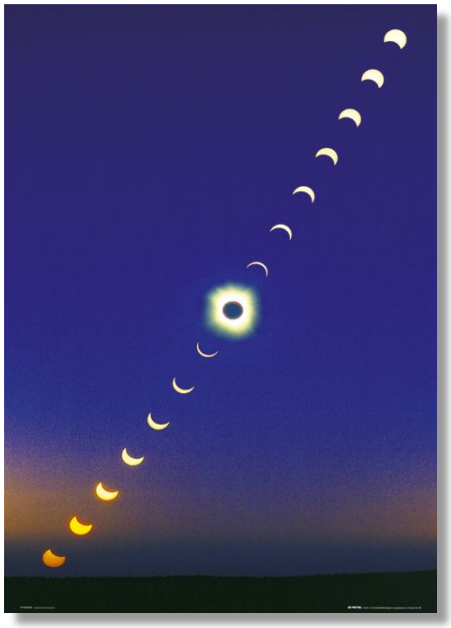
# PHASES OF THE MOON




How the Moon Works Lunar Eclipse
Penumbra
Lunar Orbit
Earth
Umbra


©2000 F. Espenak
www.MrEclipse.com


Partial
Eclipse Visible
Earth
Sun
Umbra
Antumbra
Moon
Penumbra
Annular
Eclipse Visible
© timeanddate.com 2009



# The Moon's Orbit

- Simulation
- Gravity
- Speed

# The Sun

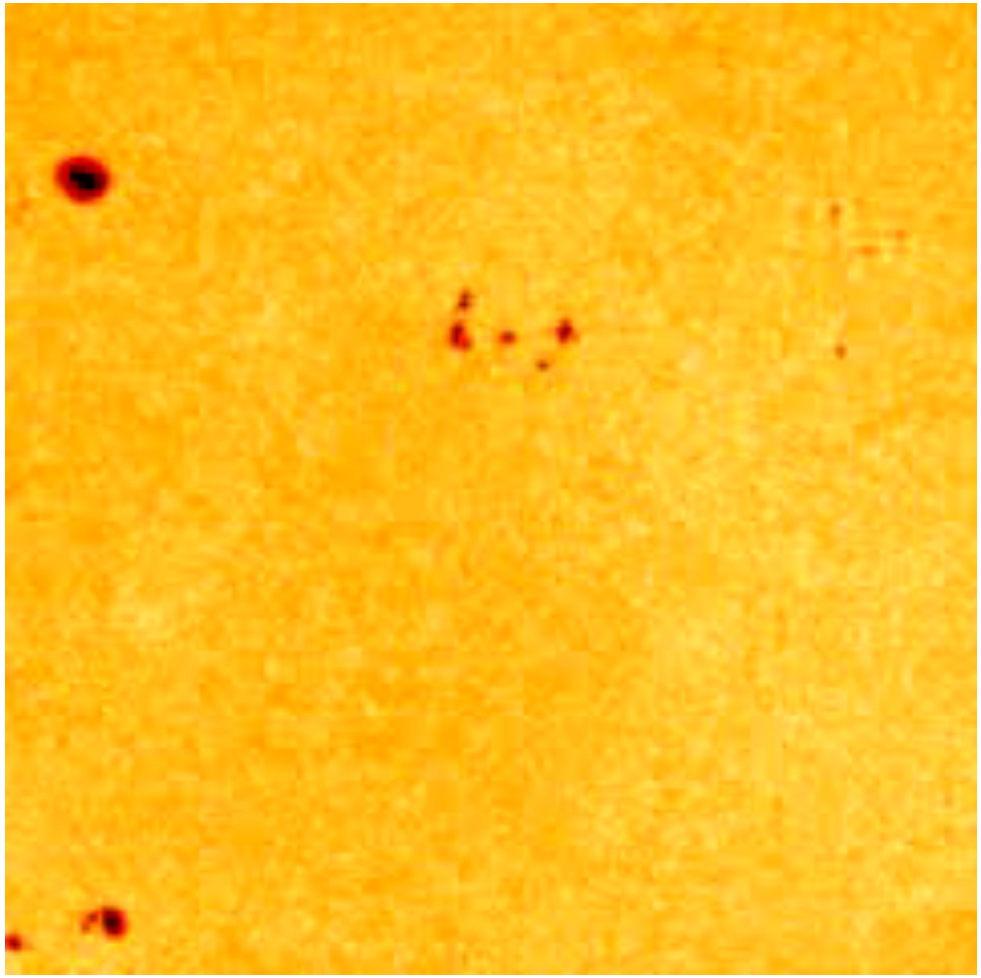
# Composition of the Sun

| Element | % of total number of atoms | % of total mass |
|---|---|---|
| Hydrogen | 91.2 | 71 |
| Helium | 8.7 | 27.1 |
| Oxygen | 0.078 | 0.97 |
| Carbon | 0.043 | 0.4 |
| Nitrogen | 0.0088 | 0.096 |
| Silicon | 0.0045 | 0.099 |
| Magnesium | 0.0038 | 0.076 |
| Neon | 0.0035 | 0.058 |
| Iron | 0.03 | 0.014 |
| Sulfur | 0.015 | 0.04 |

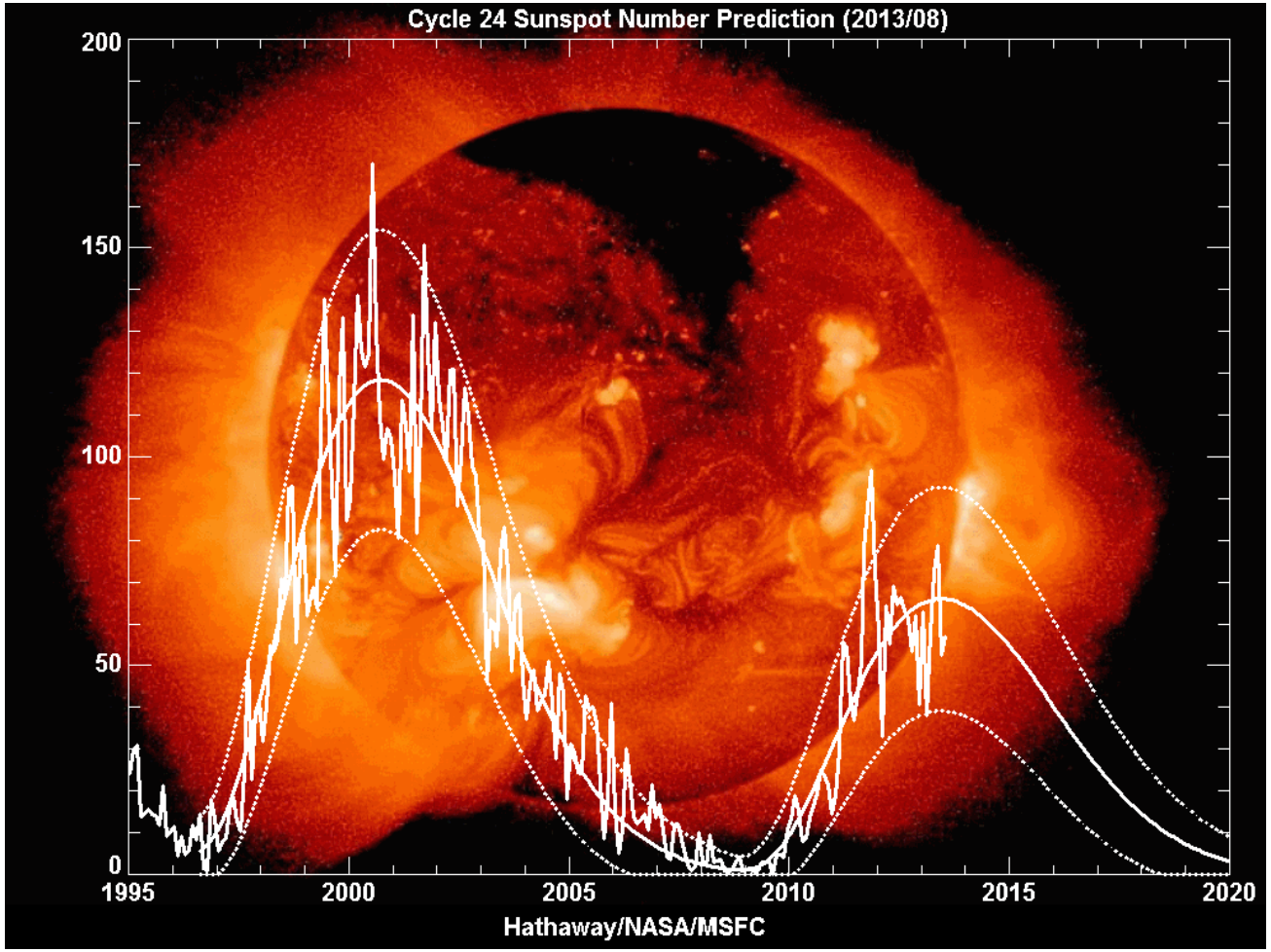
# Sunspots

http://sohowww.nascom.nasa.gov/

- Caused by magnetic fields on the sun

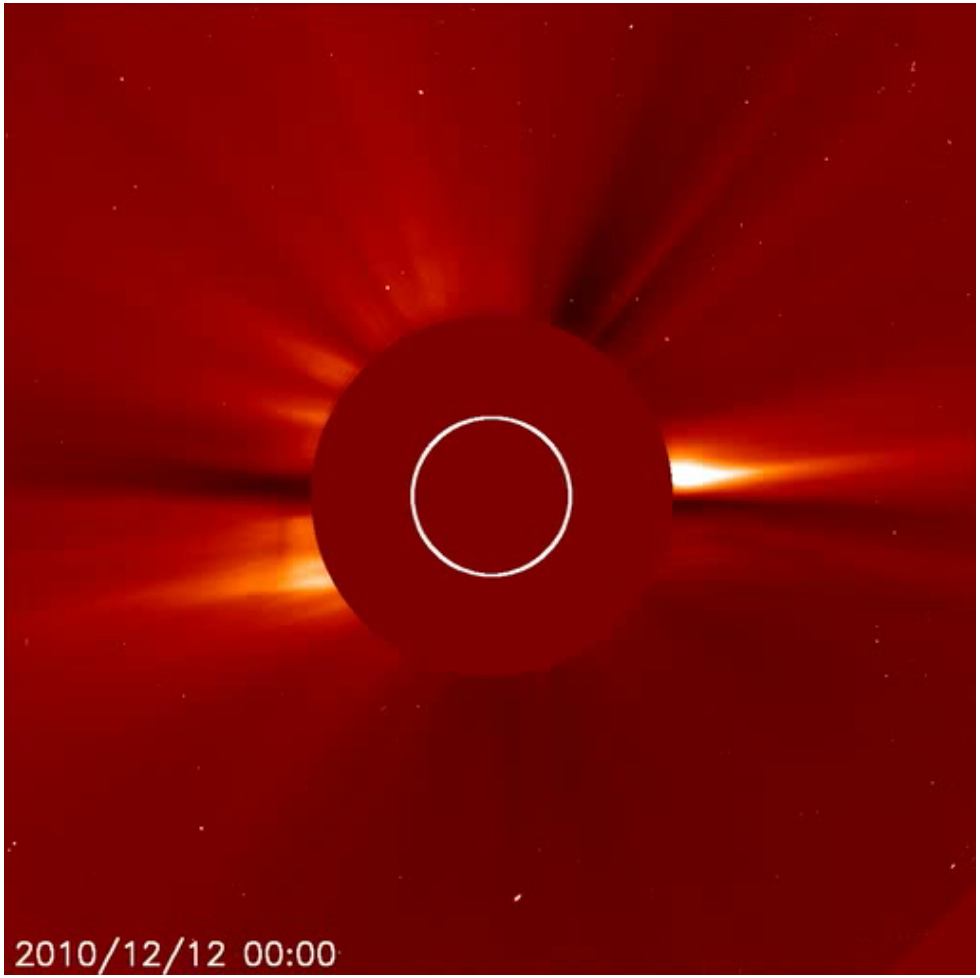


# Sunspot cycle, 11-years



# Coronal Mass Ejections

http://sohowww.nascom.nasa.gov/



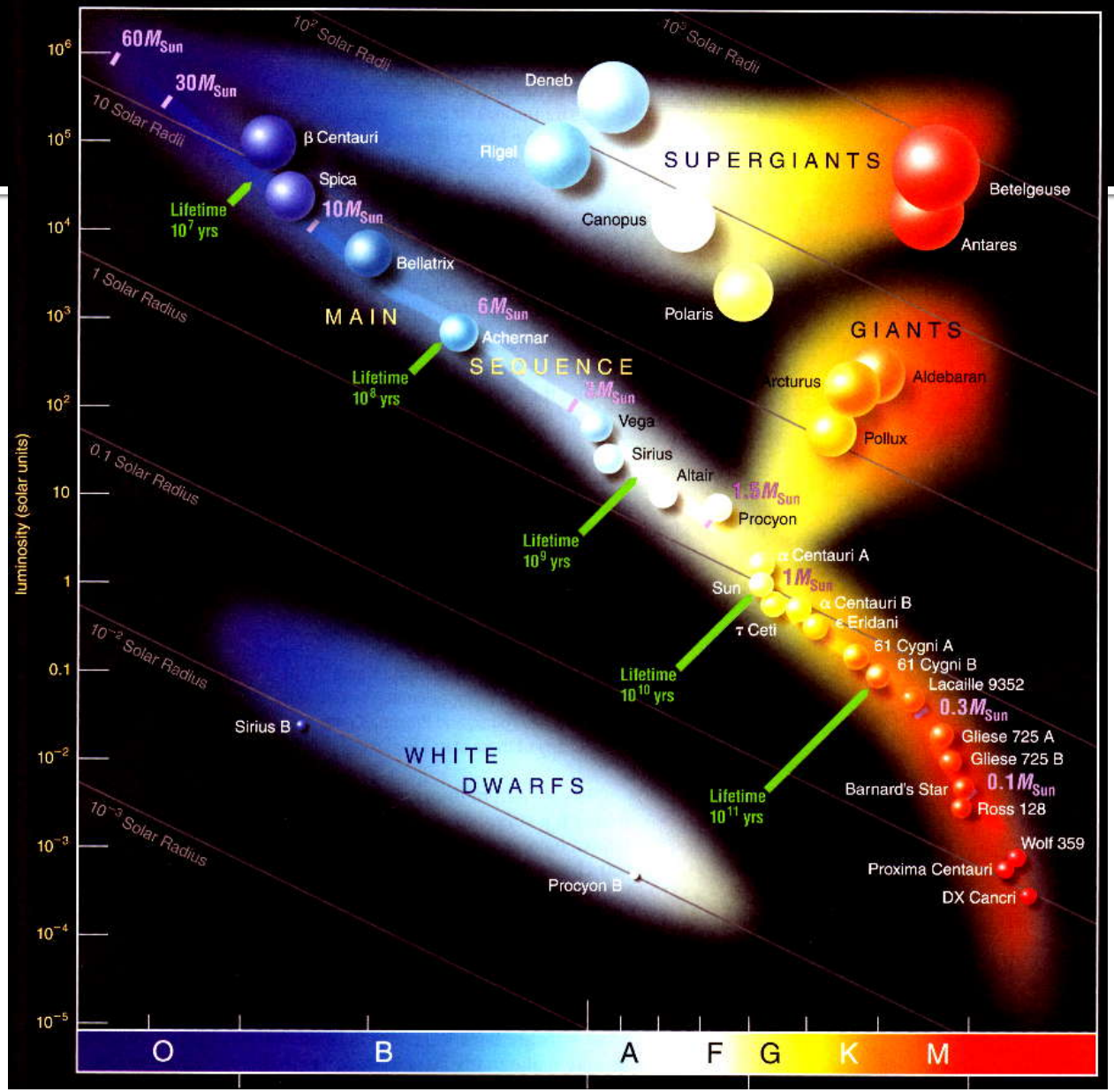
# Space Weather

- Material blown off the sun interacts with the Earth's magnetic field
- Can interfere with radio/television/phone signals
- Can damage satellites and spacecraft
- Aurora Borealis
- **Does not** affect Earth weather

# Temperature-Luminosity Diagram

The temperature of the star sets its color

hotter = bluer
cooler = redder



# Star Sizes

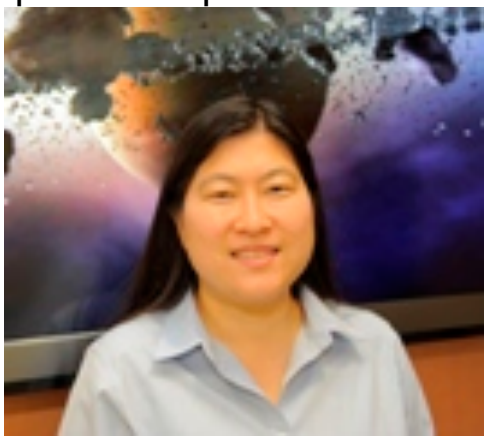
# UW Astronomy & Astrophysics Major

# UW Astronomy Faculty

Mike Brotherton
quasars

Danny Dale
extragalactic astronomy

Hannah Jang-Condell
exoplanets &planet formation



Chip Kobulnicky
massive stars

Adam Myers
cosmology & galaxy evolution

Mike Pierce
cosmology, instrumentation

# B.S. in Astronomy

- 12 semesters of physics
  - (mechanics, electricity & magnetism, quantum, optics, physic lab, research, etc.)
- 5 semesters of math
  - (calculus, linear algebra, differential equations)
- 3 semesters of astronomy
- 1 semester of computer science
- +USP credits