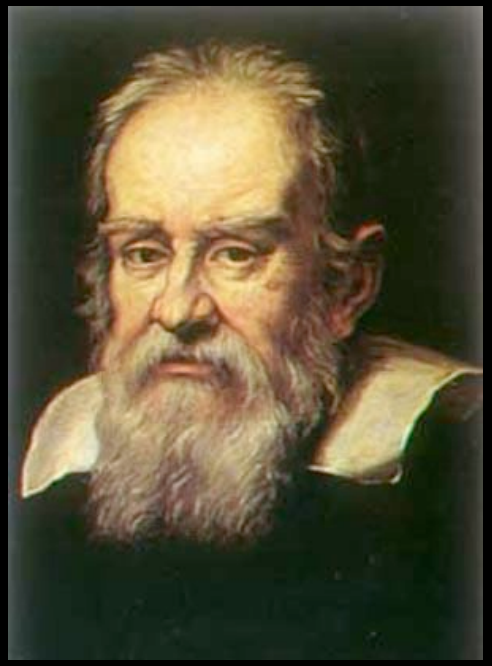
Astronomy

The Study of Stars, Galaxies, Planets, and More

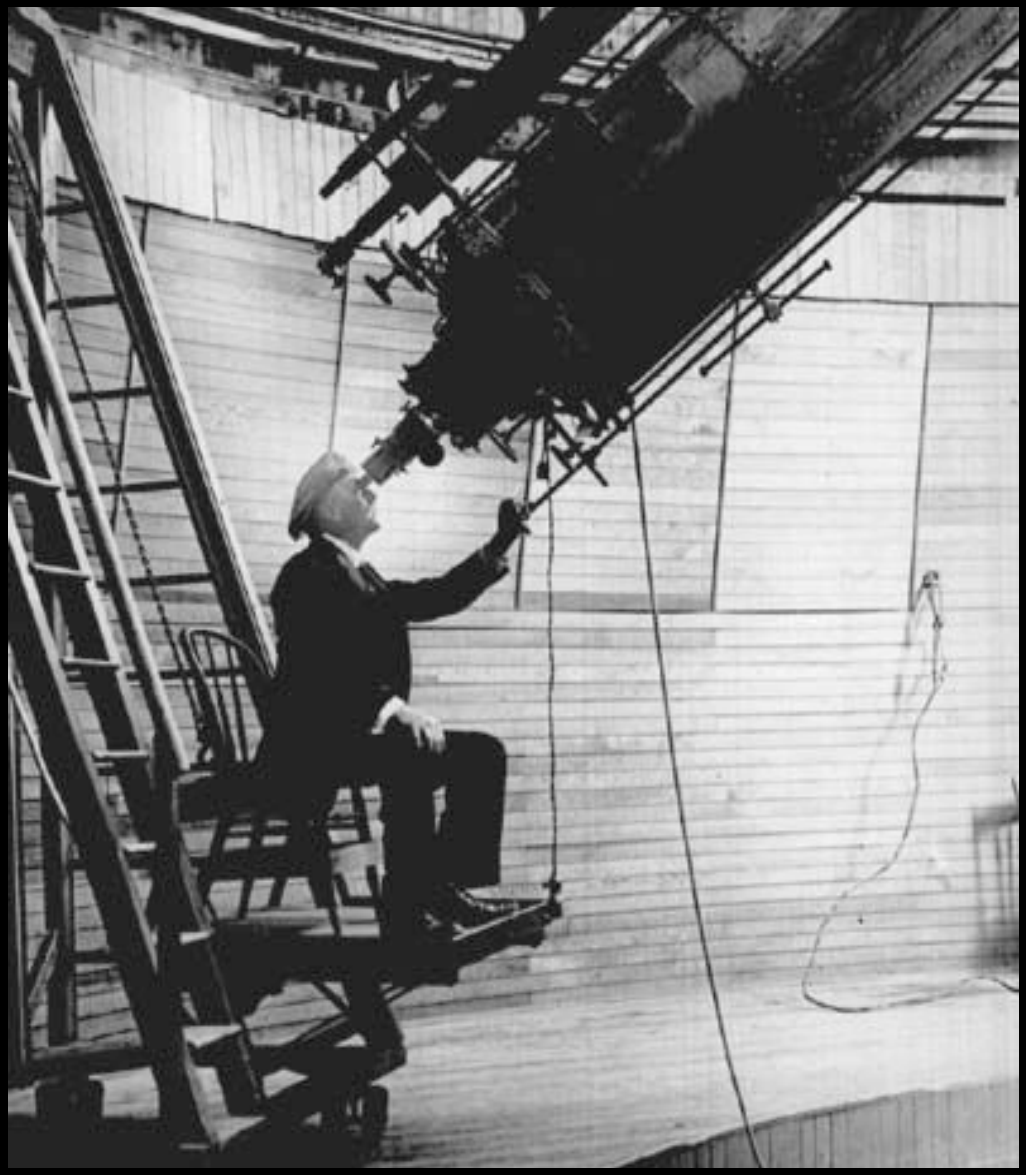
Who is an astronomer?

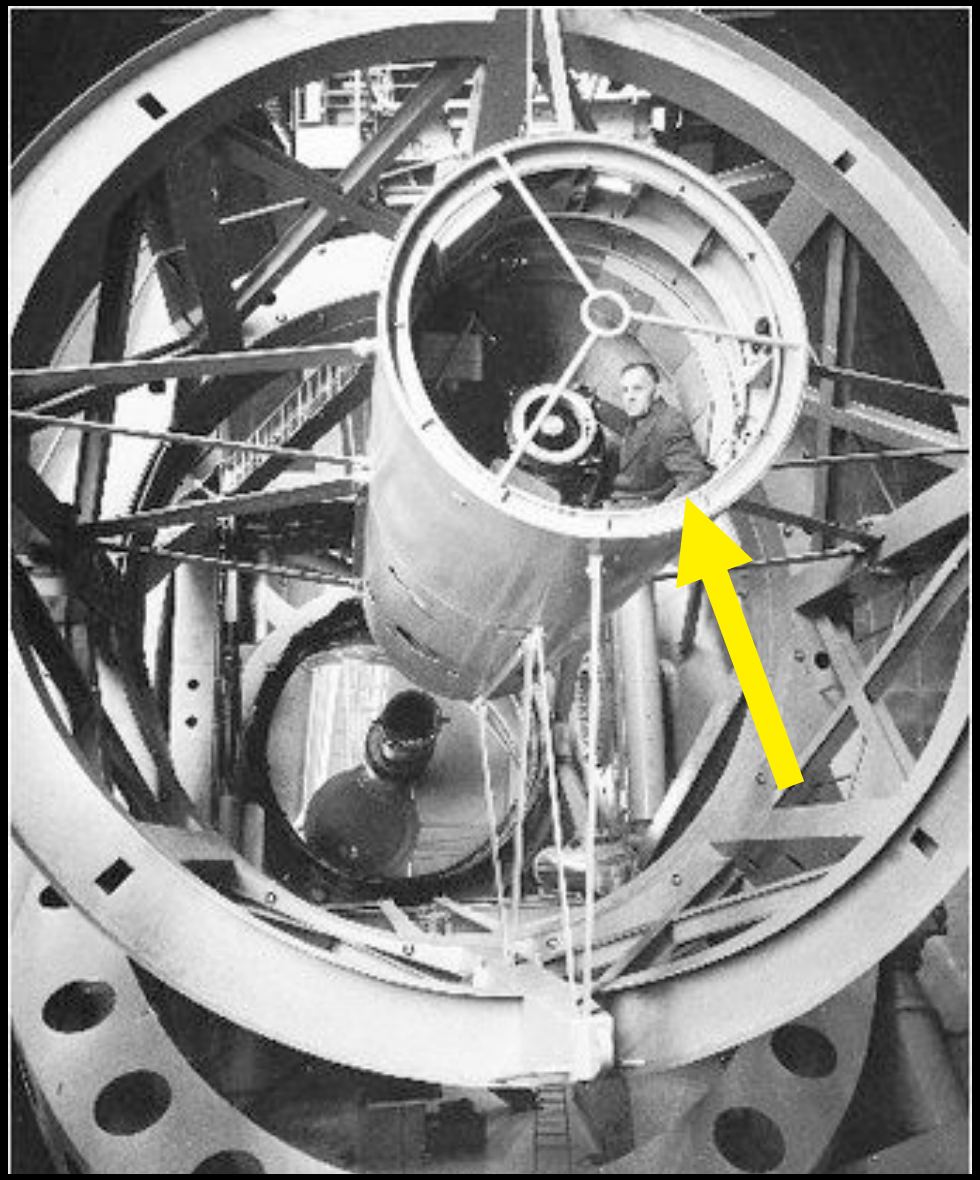
1500s - 1600s



Who is an astronomer?

1900s





Who is an astronomer?

Now

How to become an astronomer

Math and problem solving skills
Curiosity and determination
Writing, speaking, and teamwork skills
Creativity

4 years of college
= Bachelors
(astronomy, physics, math)

3~4 years of graduate school
= Masters
5~6 years of graduate school
= Doctorate

Where are astronomers?

~6,000 in N. America alone!

55% at universities or colleges

teaching and research

NMSU, UTEP, NM Tech, UNM

30% working at national labs, government agencies

engineering at observatories, labs

Goddard, Ames, Jet Propulsion Lab, Los Alamos

Apache Point, Kitt Peak, Magdalena Ridge

also planetariums, science museums

Gene Roddenberry, Hayden, Adler

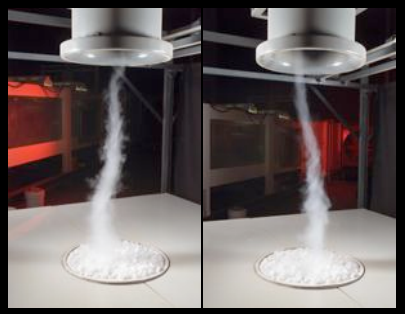
10% work in private industry

aerospace, instrument sensing, data analysis, programming

What do astronomers do?

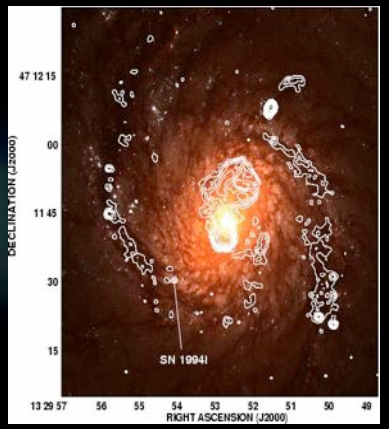
Theory

develop new physics, simulations to model reality



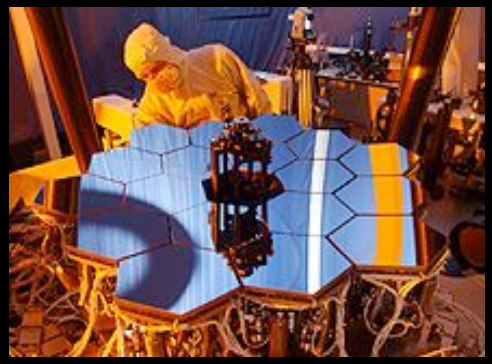
Observation

study objects with telescopes, test theory predictions, find new objects



Mission/Instrument

design/operate telescopes & space probes; large teams



Sometimes astronomers travel

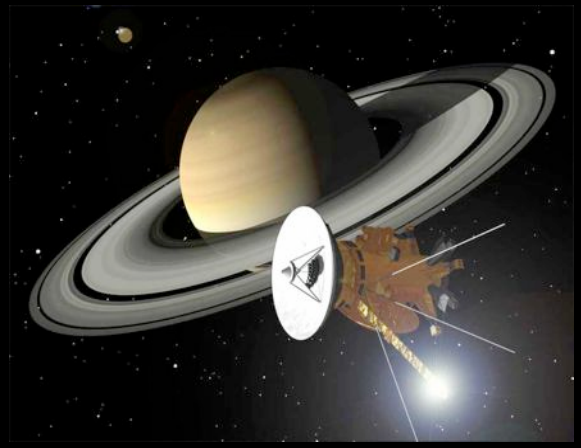
- Work with collaborators
- Attend/present at conferences
- Use telescopes

Astronomical Observatories

Top 100 Universities

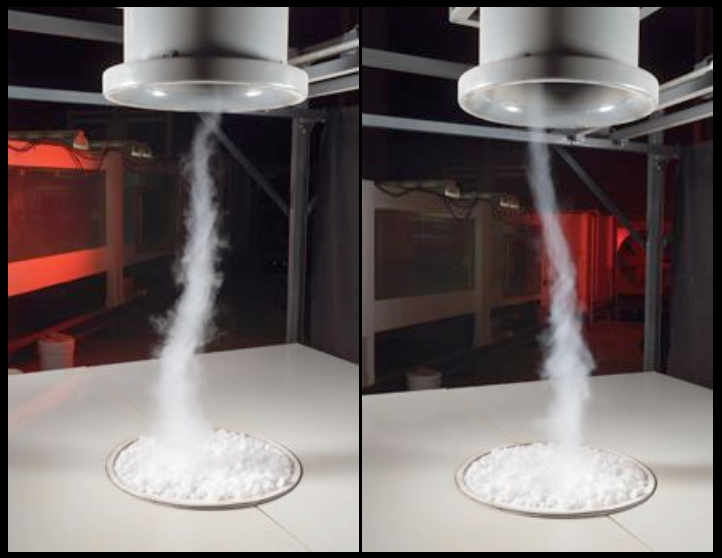
What tools do astronomers use?

Telescopes



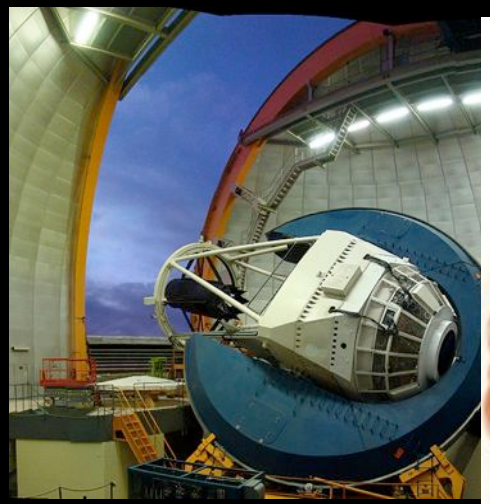
Probes

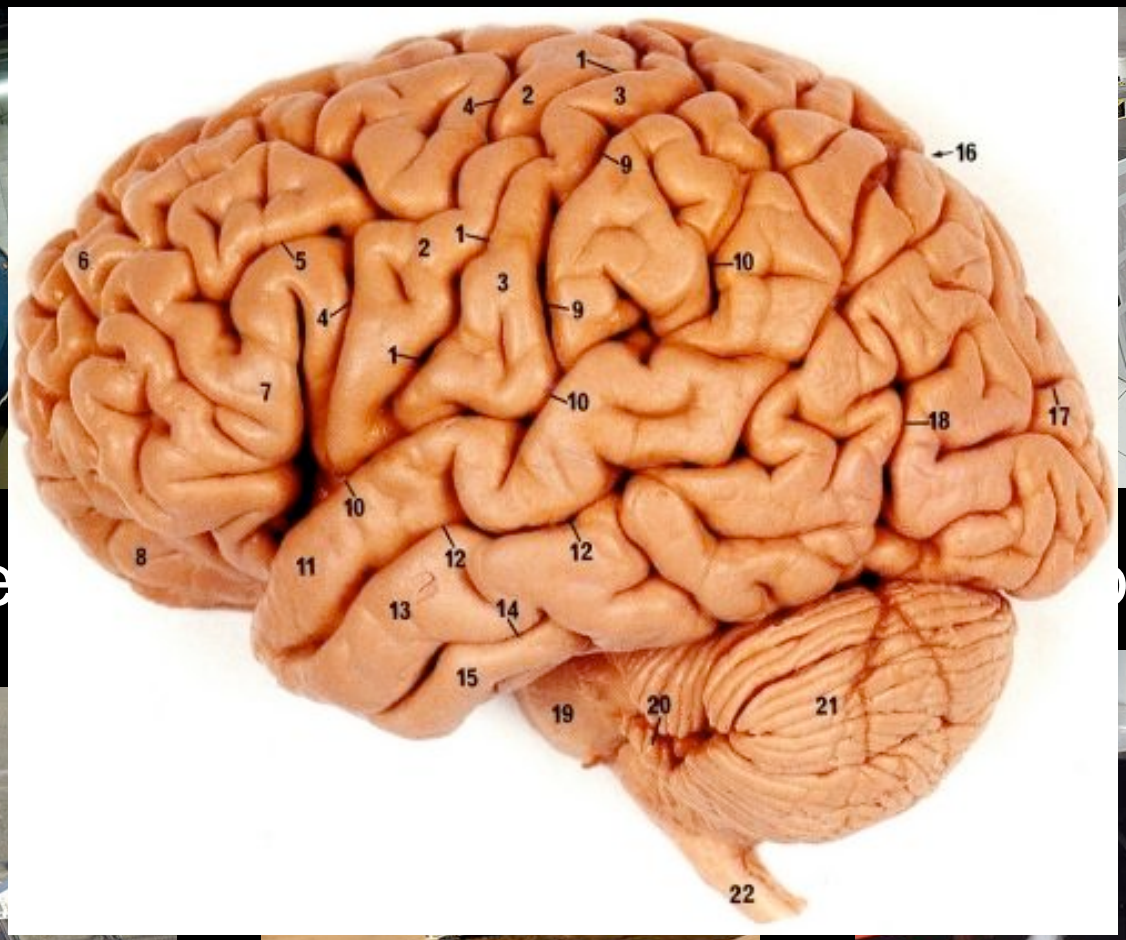
Experiments



What tools do astronomers use?

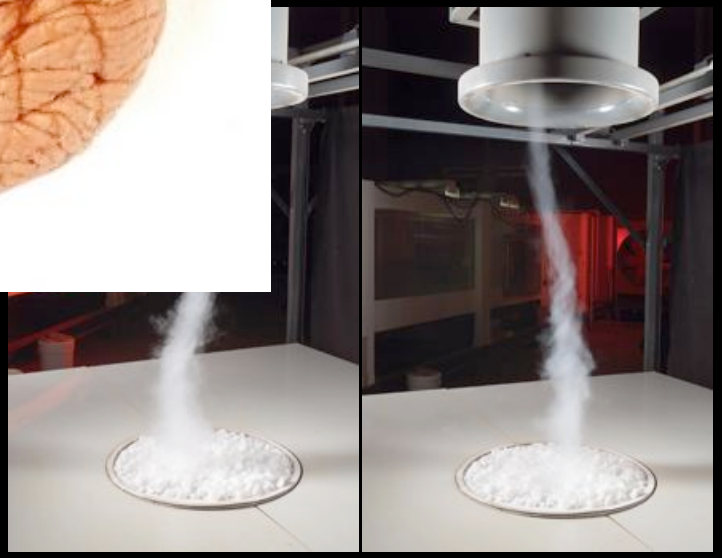
Our brains



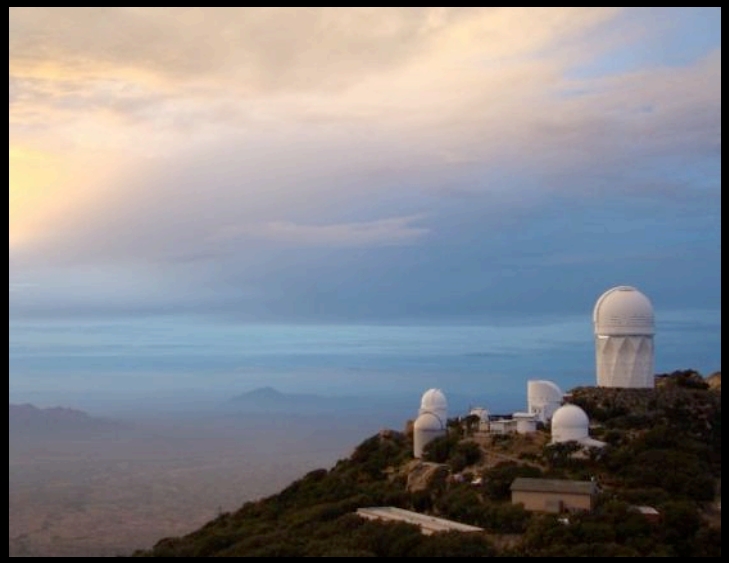


Telescope

eriments

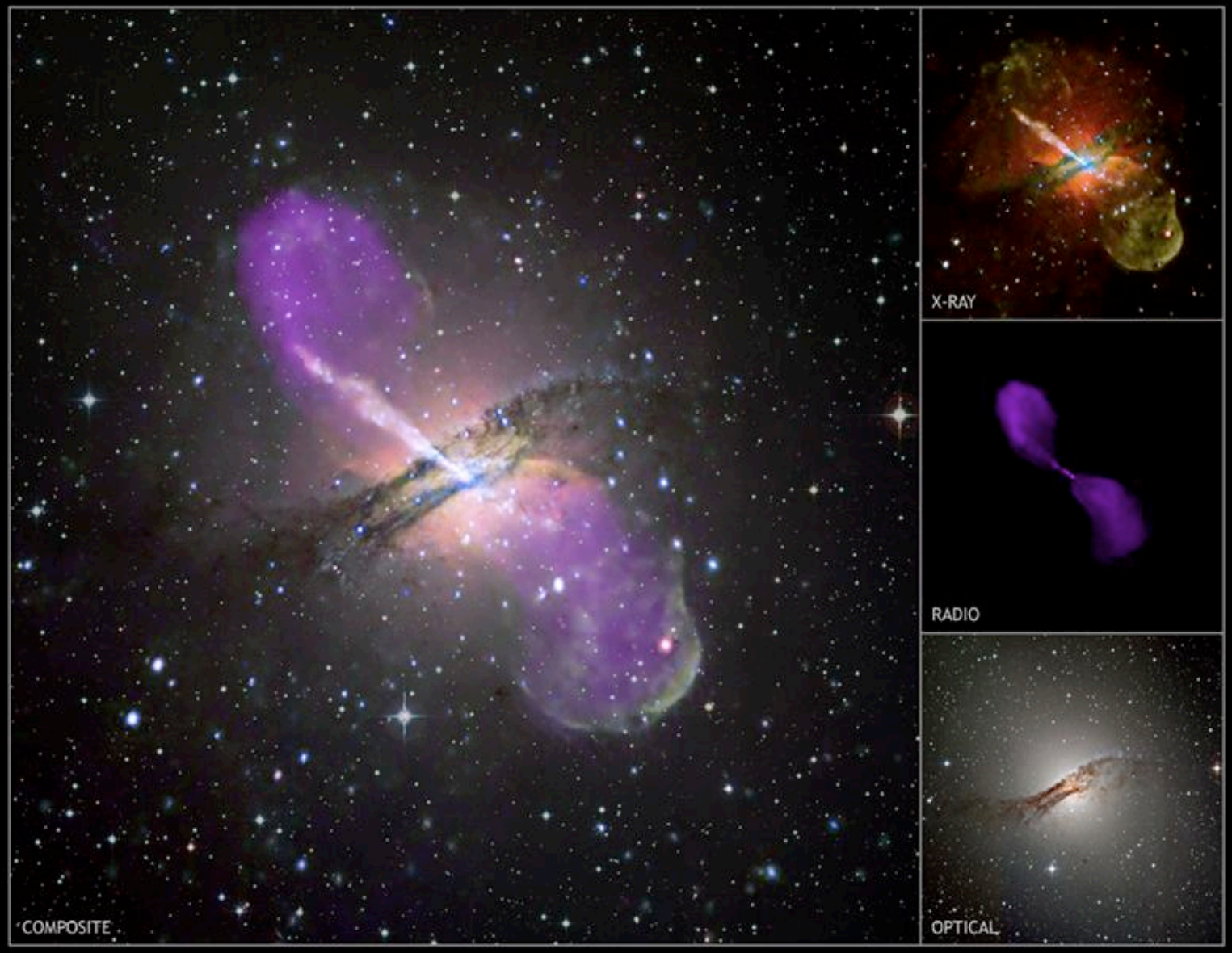


Telescopes can be on Earth ...

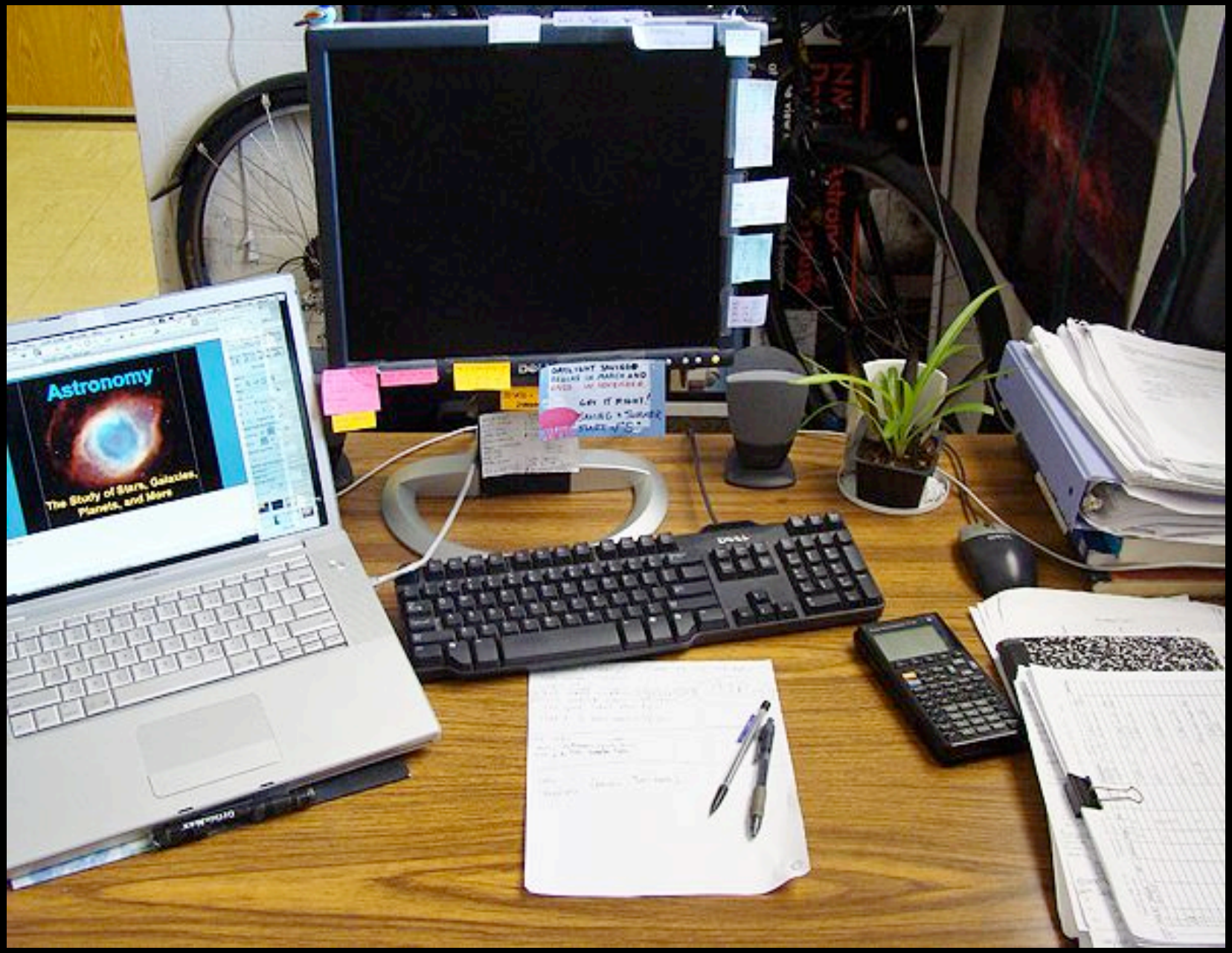


... or in space

Different telescopes look at different kinds of light

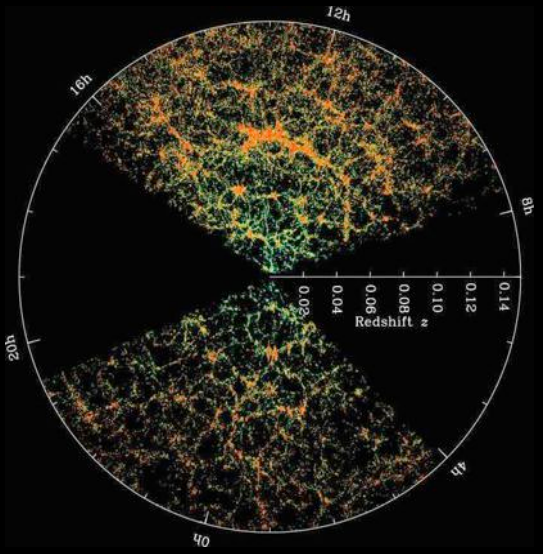


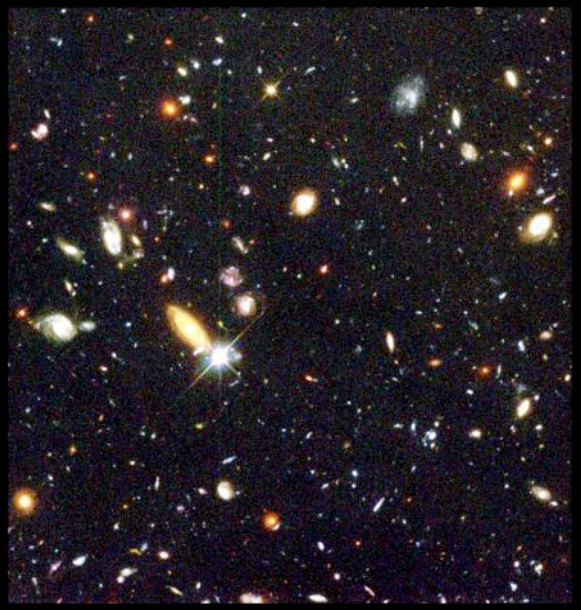
A typical day

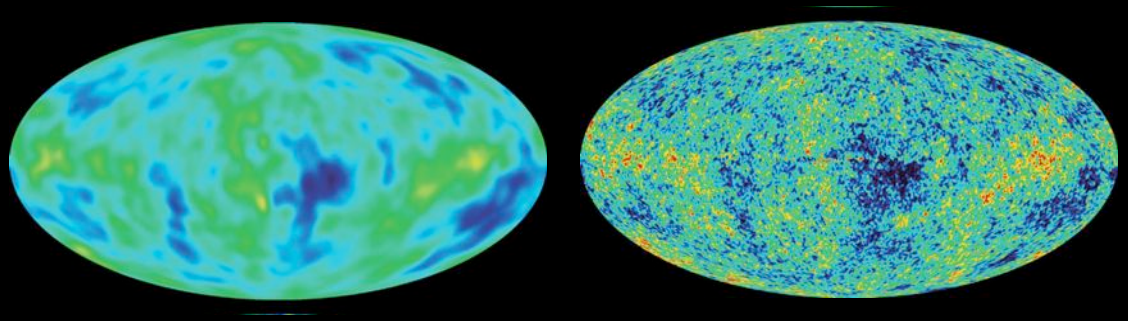


We also work together to create large sky surveys

- Sloan Digital Sky Survey
  - Milky way stars, other galaxies
- Hubble Deep Field galaxy survey
  - distant galaxies
- COBE and WMAP
  - the early universe







What do astronomers study?

acceleration of particles accretion, accretion disks astrobiology astrochemistry atomic data atomic processes black hole physics conduction convection dense matter diffusion elementary particles equation of state gravitation gravitational lensing gravitational waves hydrodynamics instabilities line: formation line: identification line: profiles magnetic fields (magnetohydrodynamics:) MHD masers molecular data molecular processes neutrinos nuclear reactions, nucleosynthesis, abundances plasmas polarization radiation mechanisms: general radiation mechanisms: nonthermal radiation mechanisms: thermal radiative transfer relativity scattering shock waves stellar dynamics turbulence waves atmospheric effects balloons celestial mechanics instrumentation: adaptive optics instrumentation: detectors instrumentation: high angular resolution instrumentation: interferometers instrumentation: miscellaneous instrumentation: photometers instrumentation: polarimeters instrumentation: spectrographs methods: analytical methods: data analysis methods: laboratory methods: miscellaneous methods: N-body simulations methods: numerical methods: statistical site testing space vehicles space vehicles: instruments techniques: high angular resolution techniques: image processing techniques: interferometric techniques: miscellaneous techniques: photometric techniques: polarimetric techniques: radar astronomy techniques: radial velocities techniques: spectroscopic telescopes astrometry eclipses ephemerides occultations reference systems time Sun: abundances Sun: activity Sun: atmosphere Sun: atmospheric motions Sun: chromosphere Sun: corona Sun: coronal mass ejections Sun: evolution Sun: faculae, plages Sun: filaments Sun: flares Sun: fundamental parameters Sun: general Sun: granulation Sun: helioseismology Sun: infrared Sun: interior Sun: magnetic fields Sun: oscillations Sun: particle emission Sun: photosphere Sun: prominences Sun: radio radiation Sun: rotation (Sun:) solar-terrestrial relations (Sun:) solar wind (Sun:) sunspots Sun: transition region Sun: UV radiation Sun: X-rays, gamma rays comets: general comets: individual (... , ...) Earth interplanetary medium Kuiper belt meteors, meteoroids minor planets, asteroids Moon Oort cloud planets: rings planets and satellites: formation planets and satellites: general planets and satellites: individual (alphabetical order) solar system: formation solar system: general stars: abundances stars: activity stars: AGB and post-AGB stars: atmospheres (stars:) binaries (including multiple): close (stars:) binaries: eclipsing (stars:) binaries: general (stars:) binaries: spectroscopic (stars:) binaries: symbiotic (stars:) binaries: visual (stars:) blue stragglers stars: carbon stars: chemically peculiar stars: chromospheres (stars:) circumstellar matter stars: coronae stars: distances stars: dwarf novae stars: early-type stars: emission-line, Be stars: evolution stars: flare stars: formation stars: fundamental parameters (classification, colors, luminosities, masses, radii, temperatures, etc.) stars: general (stars:) Hertzsprung-Russell diagram stars: horizontal-branch stars: imaging stars: individual (... , ...) stars: interiors stars: kinematics stars: late-type stars: low-mass, brown dwarfs stars: luminosity function, mass function stars: magnetic fields stars: mass loss stars: neutron (stars:) novae, cataclysmic variables stars: oscillations (including pulsations) (stars:) planetary systems (stars:) planetary systems: formation (stars:) planetary systems: protoplanetary disks stars: Population II stars: premain-sequence (stars:) pulsars: general (stars:) pulsars: individual (... , ...) stars: rotation stars: spots stars: statistics (stars:) subdwarfs (stars:) supergiants (stars:) supernovae: general (stars:) supernovae: individual (... , ...) (stars: variables:) Cepheids (stars: variables:) Î´ Scuti stars: variables: other (stars:) white dwarfs stars: winds, outflows stars: Wolf-Rayet ISM: abundances ISM: atoms ISM: bubbles ISM: clouds (ISM:) cosmic rays (ISM:) dust, extinction ISM: evolution ISM: general ISM: globules ISM: Herbig-Haro objects (ISM:) H II regions ISM: individual (... , ...) (except planetary nebulae) ISM: jets and outflows ISM: kinematics and dynamics ISM: lines and bands ISM: magnetic fields ISM: molecules (ISM:) planetary nebulae: general (ISM:) planetary nebulae: individual (... , ...) (ISM:) reflection nebulae ISM: structure (ISM:) supernova remnants Galaxy: abundances Galaxy: bulge Galaxy: center Galaxy: disk Galaxy: evolution Galaxy: formation Galaxy: fundamental parameters Galaxy: general (Galaxy:) globular clusters: general (Galaxy:) globular clusters: individual (... , ...) Galaxy: halo Galaxy: kinematics and dynamics Galaxy: nucleus (Galaxy:) open clusters and associations: general (Galaxy:) open clusters and associations: individual (..., ...) (Galaxy:) solar neighborhood Galaxy: stellar content Galaxy: structure galaxies: abundances galaxies: active (galaxies:) BL Lacertae objects: general (galaxies:) BL Lacertae objects: individual (... , ...) galaxies: bulges galaxies: clusters: general galaxies: clusters: individual (... , ...) (galaxies:) cooling flows galaxies: distances and redshifts galaxies: dwarf galaxies: elliptical and lenticular, cD galaxies: evolution galaxies: formation galaxies: fundamental parameters (classification, colors, luminosities, masses, radii, etc.) galaxies: general galaxies: halos galaxies: high-redshift galaxies: individual (... , ...) galaxies: interactions (galaxies:) intergalactic medium galaxies: ISM galaxies: irregular galaxies: jets galaxies: kinematics and dynamics (galaxies:) Local Group galaxies: luminosity function, mass function (galaxies:) Magellanic Clouds galaxies: magnetic fields galaxies: nuclei galaxies: peculiar galaxies: photometry (galaxies:) quasars: absorption lines (galaxies:) quasars: emission lines (galaxies:) quasars: general (galaxies:) quasars: individual (... , ...) galaxies: Seyfert galaxies: spiral galaxies: starburst galaxies: star clusters galaxies: statistics galaxies: stellar content galaxies: structure (cosmology:) cosmic microwave background (cosmology:) cosmological parameters (cosmology:) dark matter (cosmology:) diffuse radiation (cosmology:) distance scale (cosmology:) early universe (cosmology:) large-scale structure of universe cosmology: miscellaneous cosmology: observations cosmology: theory gamma rays: bursts gamma rays: observations gamma rays: theory infrared: galaxies infrared: general infrared: ISM infrared: solar system infrared: stars radio continuum: galaxies radio continuum: general radio continuum: ISM radio continuum: solar system radio continuum: stars radio lines: galaxies radio lines: general radio lines: ISM radio lines: solar system radio lines: stars submillimeter ultraviolet: galaxies ultraviolet: general ultraviolet: ISM ultraviolet: solar system ultraviolet: stars X-rays: binaries X-rays: bursts X-rays: diffuse background X-rays: galaxies X-rays: galaxies: clusters X-rays: general X-rays: individual (... , ...) X-rays: ISM X-rays: stars

What do astronomers study?

The Sun, planets (formation and history, composition, atmosphere), moons, asteroids and comets, searching for water, solar system formation, interactions in solar system (Sun and planets, planets and moons and rings), planets around other stars, forming stars, stars young/old and large/small, binary stars, clusters of stars, exploding stars, dead stars, dust and gas, how stars change dust and gas, galaxies, galaxies orbiting other galaxies, galaxies colliding, clusters of galaxies, dark matter, shape of the universe, the early universe, etc.

What do astronomers study?

Astronomy-related careers

Computer Science

Pattern recognition software to track features on the Sun's surface

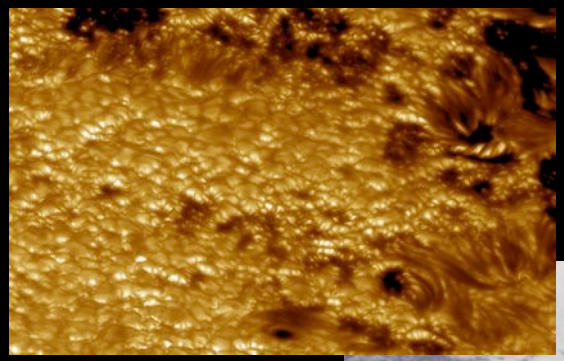
Spaceflight Industry

Engineers hired by companies like SpaceX and Blue Origin

Science Visualization

Create scientifically accurate artwork and animations for researchers and educators

… and also …



Credit: SpaceX/Chris Thompson

Astronomy education

Formal Teaching
- All grades and ages

Astronomy Education Research

Informal Teaching
- Planetariums
- Museums
- Science Centers
- NASA Education/Public Outreach (EPO) Offices

Citizen Science

Help scientists analyze real data!

Galaxy Zoo

classify galaxies, hunt for supernovae

Ice Hunters

search for icy worlds beyond Pluto

Planet Hunters

search for planets around other stars

Solar StormWatch

track storms on surface of the Sun

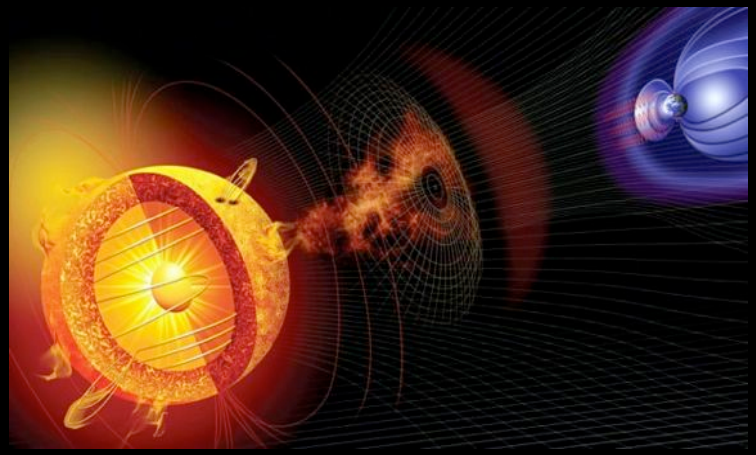
What are interesting things astronomers are researching right now?

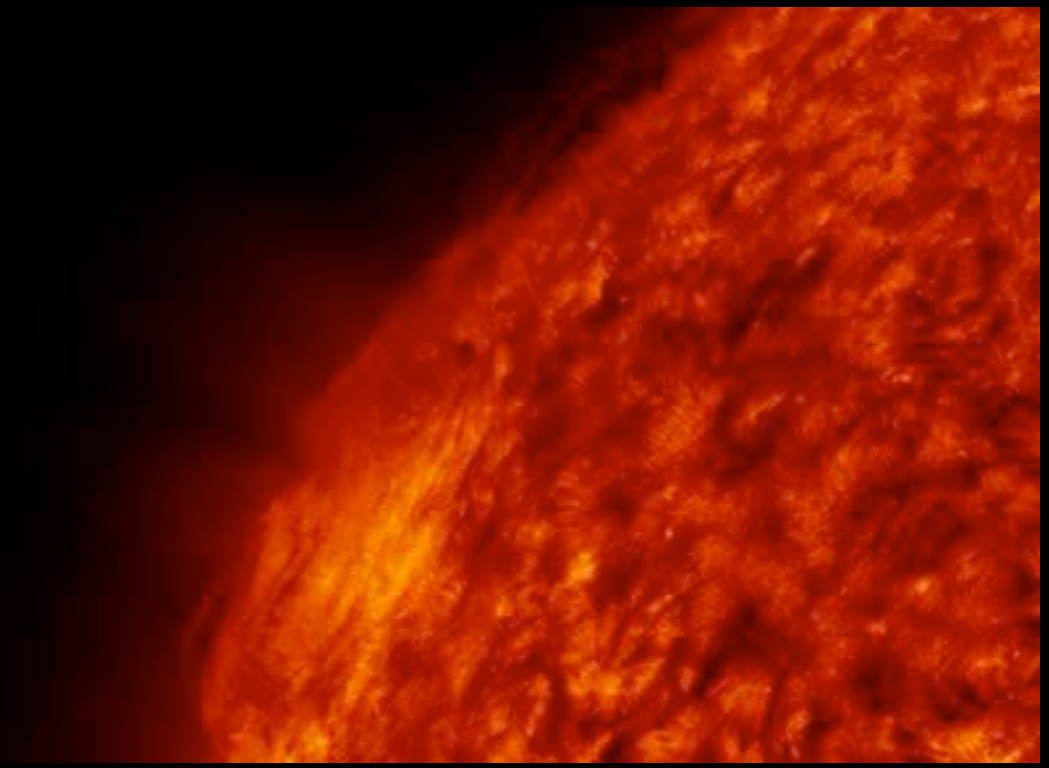
Living With a Star (LWS): SDO

Solar Dynamics Observatory studies Sun's variability

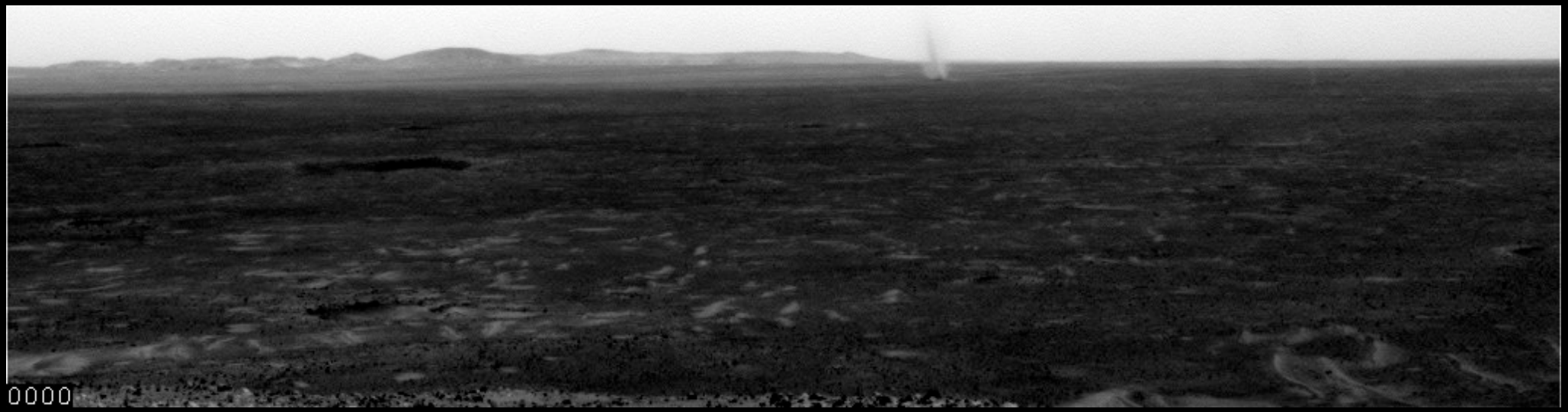
Connection to spaceweather: flares!

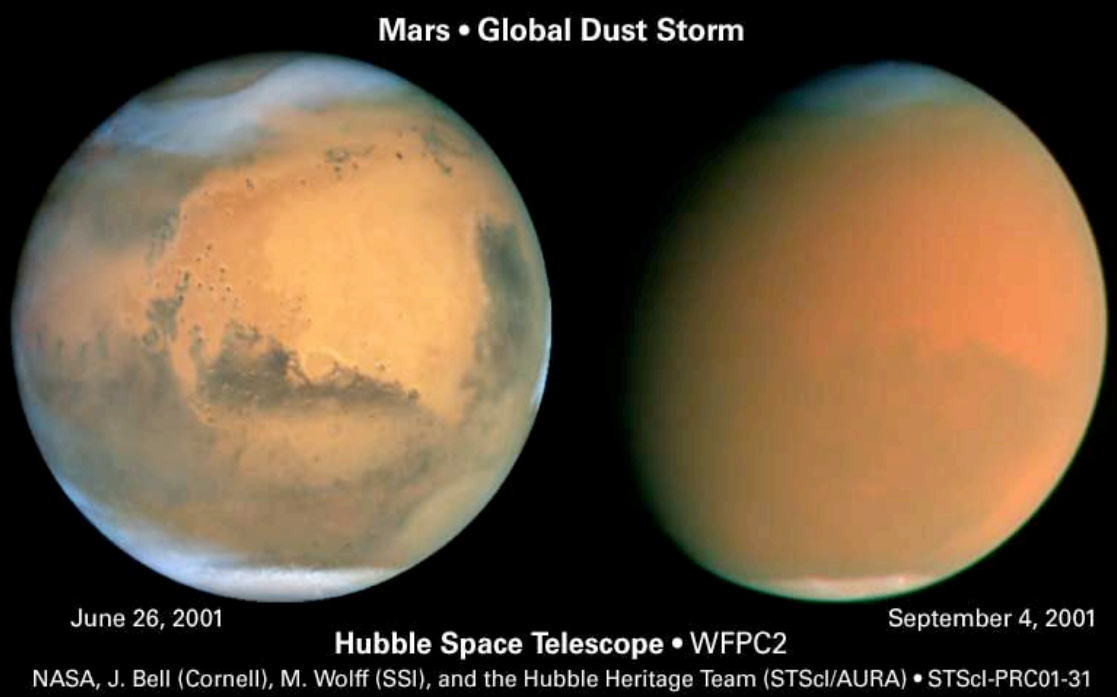
- Damage satellites (GPS and communications)
- Power grid failures

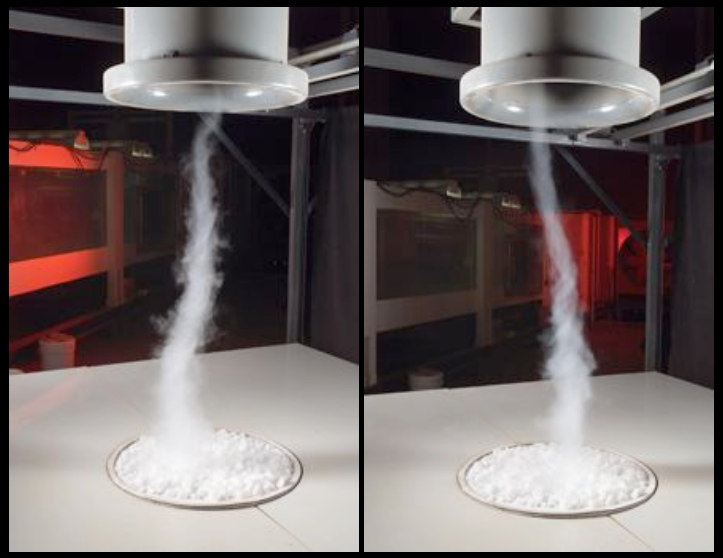




Dust devils on Mars







LCROSS/LRO

Lunar Crater and Object Sensing Satellite/Lunar Reconnaissance Orbiter

Search for water on the Moon

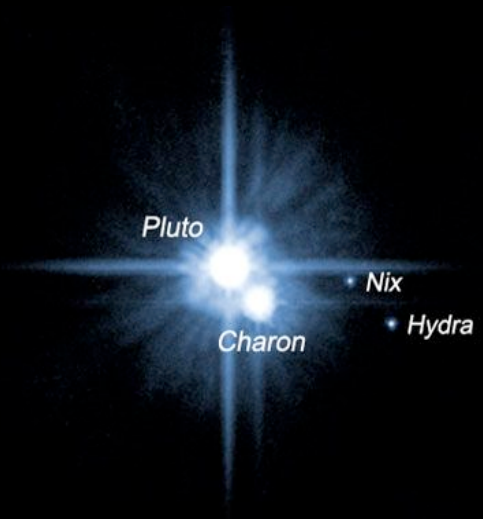
Cratering experiments with the NASA Ames Vertical Gun Range

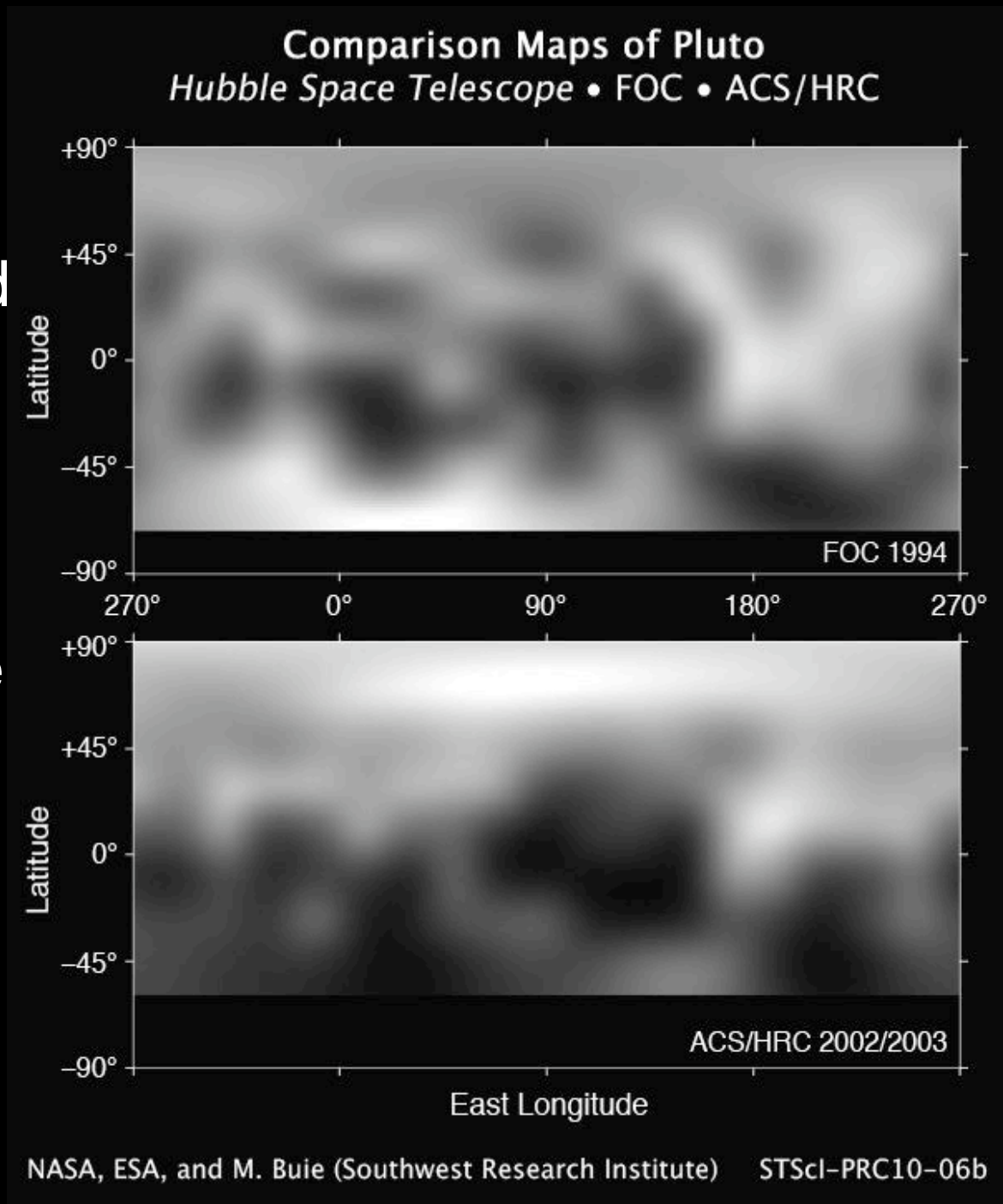
New Horizons and Pluto

2/3 size of Earth's Moon

"Frozen world", rock and ice (nitrogen)

Seasonal changes?
- Entire atmosphere "snows" onto surface

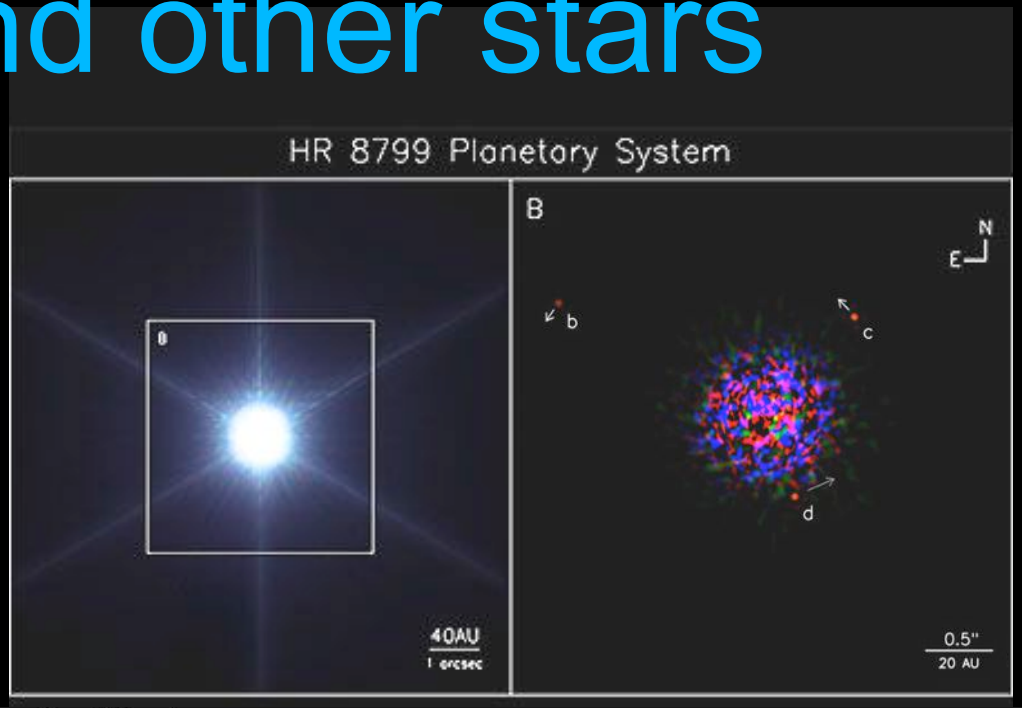


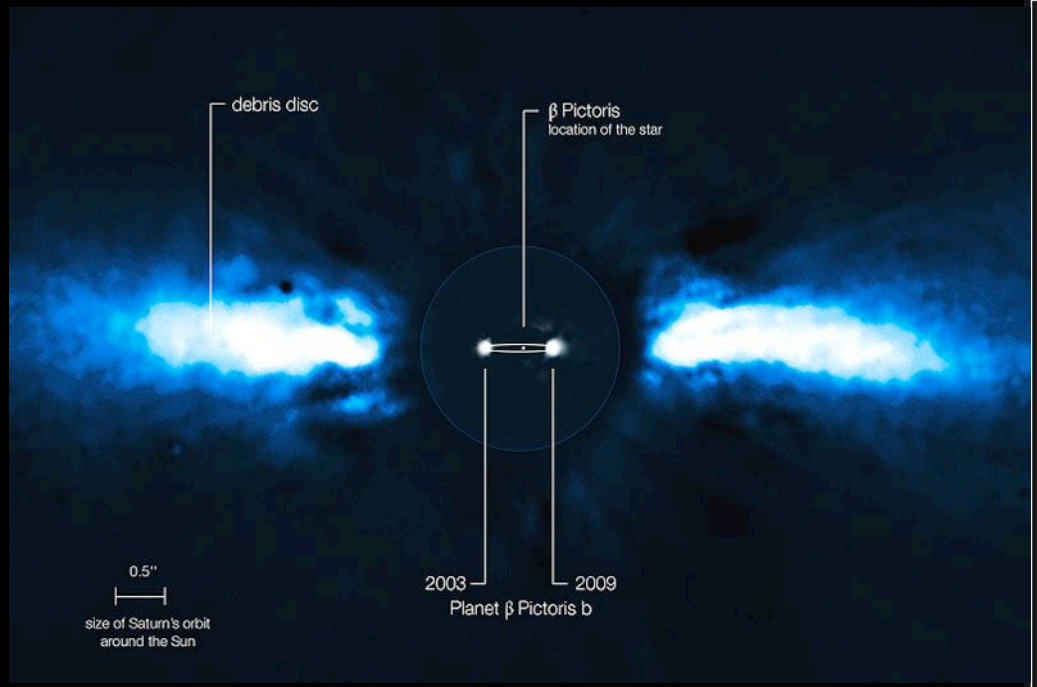


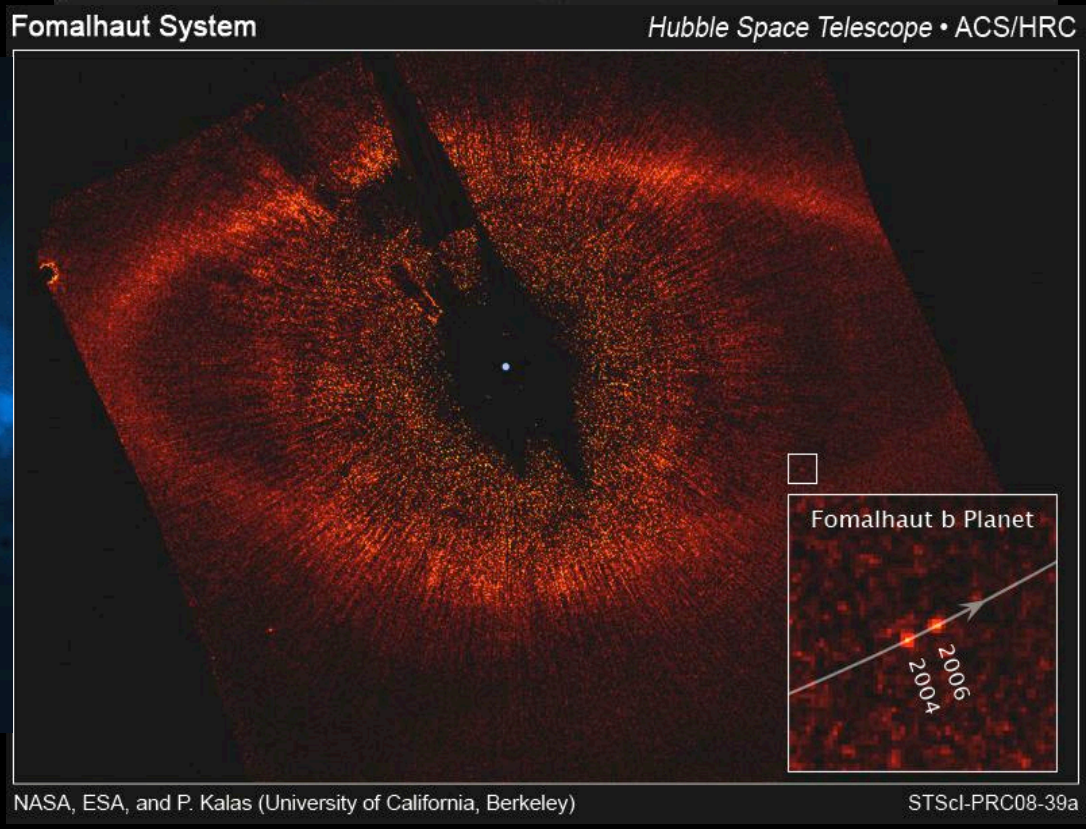
Planets around other stars

Previously, ~500 planets detected over 15 years

We managed pictures of 3

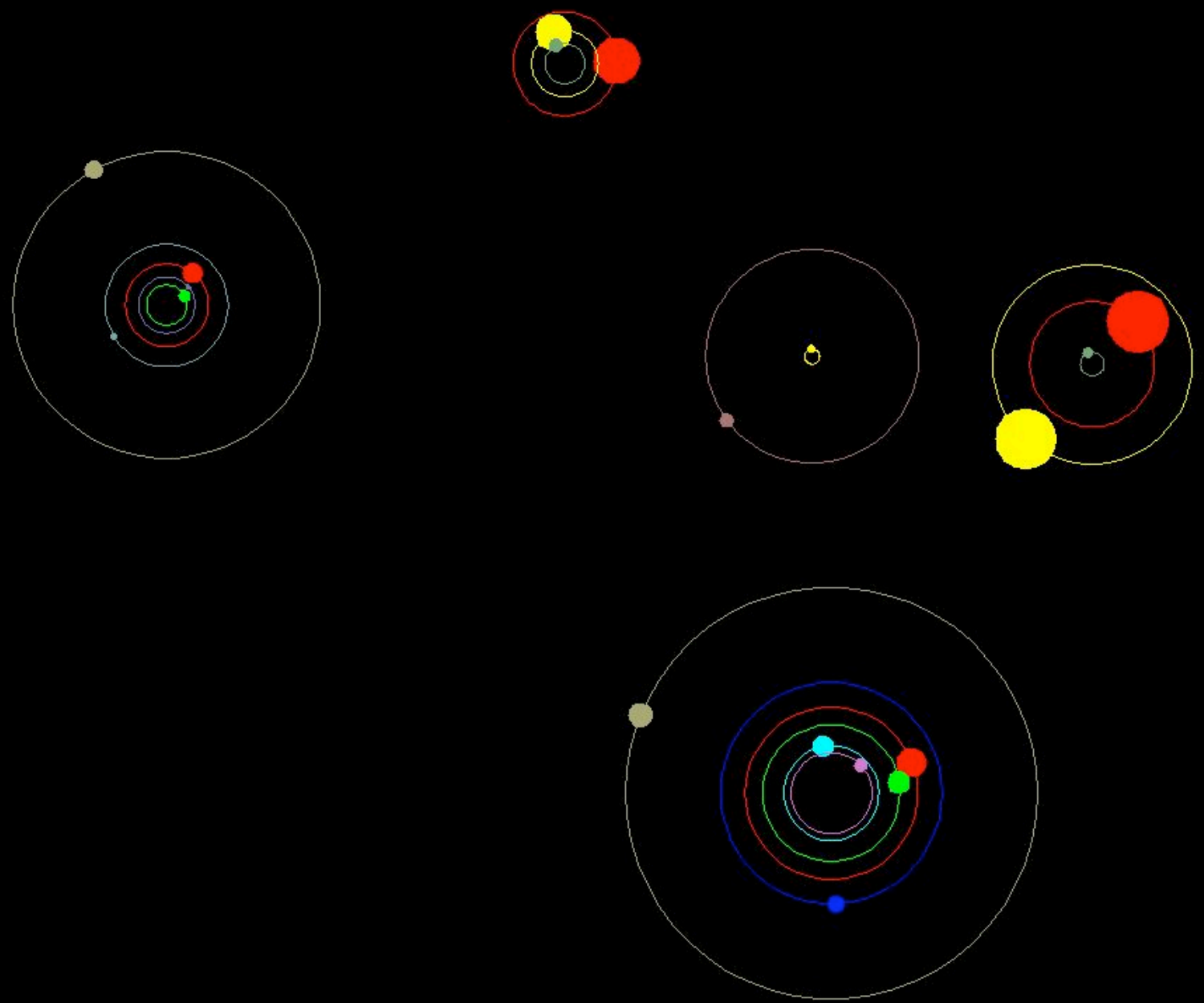






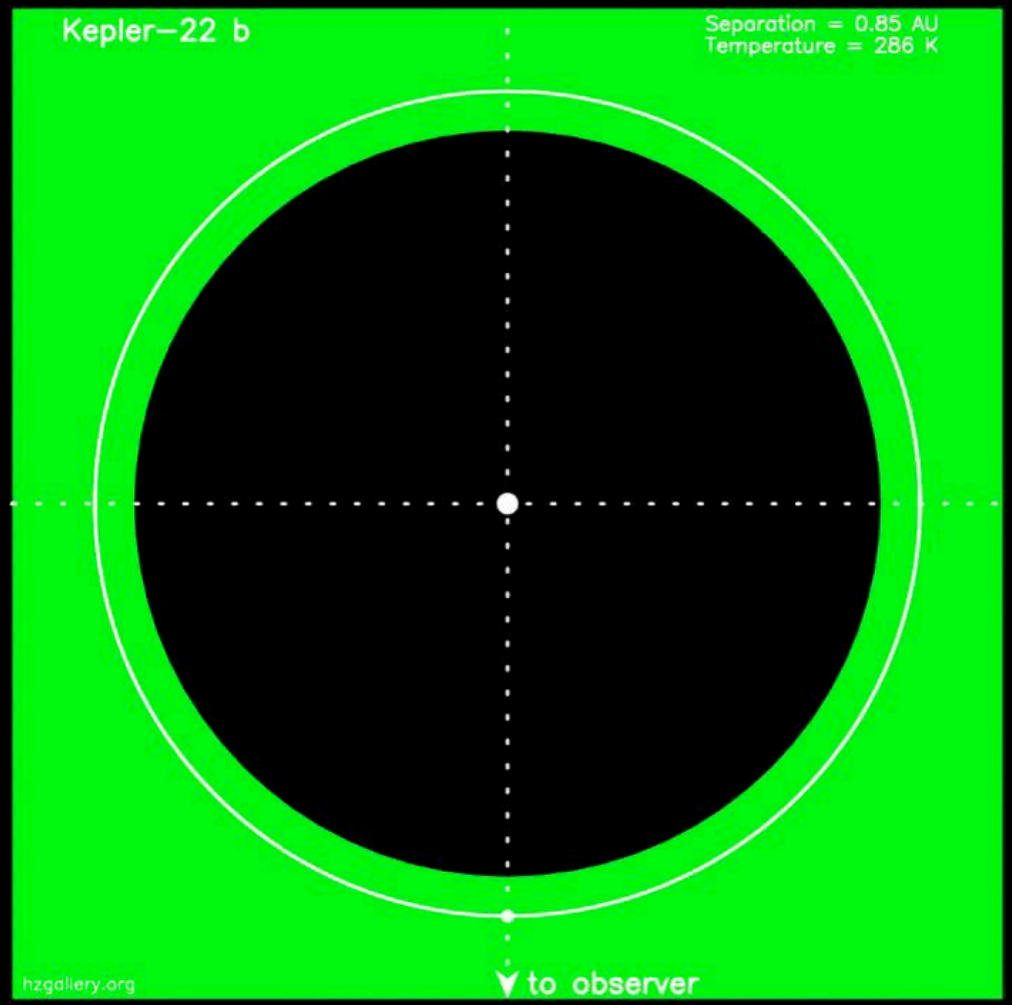
Planets around other stars

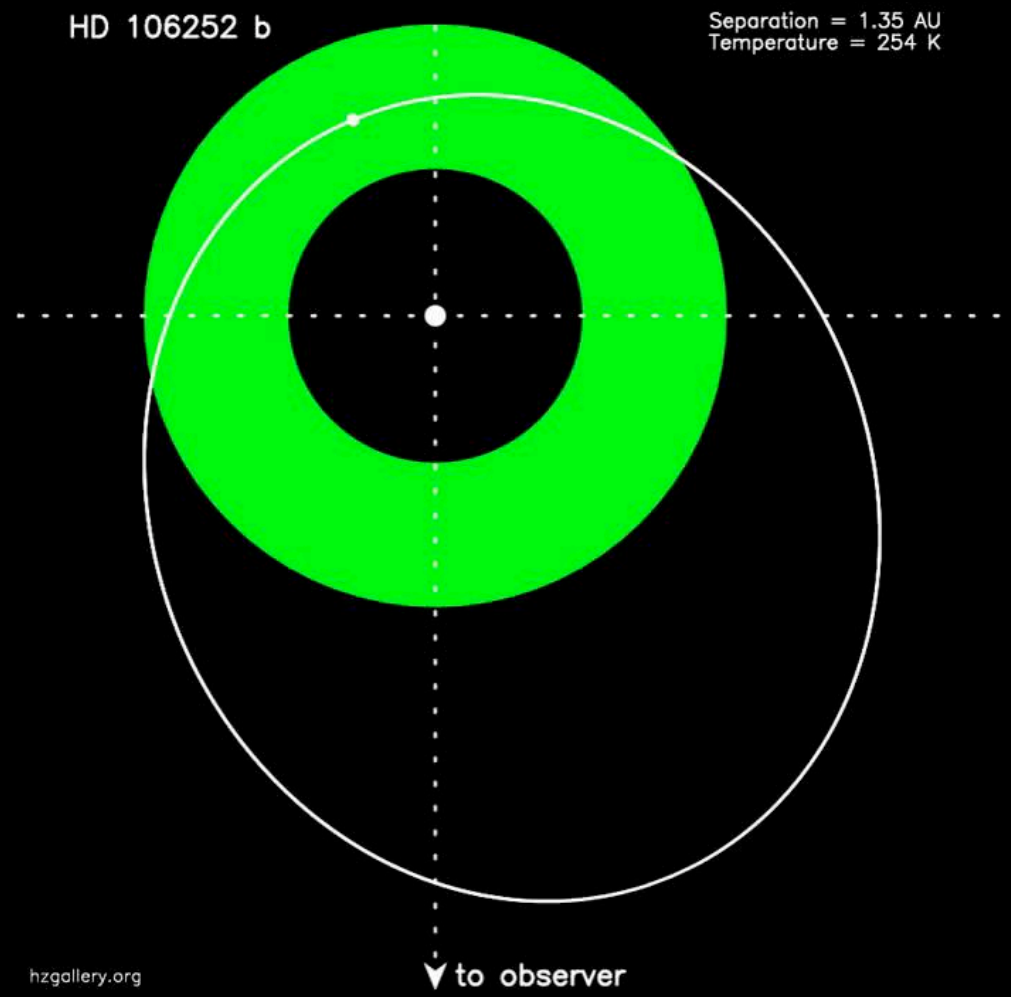
Since 2009, Kepler looked at 150,000 stars and found 1200 new planet candidates & 61 confirmed planets!



Planets around other stars

We're hoping to find other planets in the "habitable zone"





Galaxy formation

Simulating the formation of a galaxy like the Milky Way

Bolshoi: universe in a box

- Make a box 250 million light years wide
- Fill with dark matter from CMB
- Use physics to describe particle interactions
- Run on a supercomputer for 18 days
- Compare to observations of galaxies

Where can you learn more?

Organizations and telescopes:

- NASA (www.nasa.gov)
- Hubble telescope (hubblesite.org)
- Chandra telescope (chandra.nasa.gov)
- American Astronomical Society (aas.org)
- ESO (www.eso.org)
- Astronomical Society of the Pacific (www.astrosociety.org)

Citizen Science: (www.zooniverse.org)

News websites:

- www.space.com
- www.universetoday.com
- www.badastronomy.com

Your local astronomers:

- Astronomy Dept. at NMSU (astronomy.nmsu.edu)
- Amateur Astro. Society of Las Cruces (aslc-nm.org)