NSTA Web Seminar:
Discover the Universe – From Galileo to Today

Tuesday, December 16, 2008
Discover the Universe – From Galileo to Today

Image courtesy of *The Cosmic Perspective* by Bennett, Donahue, Schneider, & Voit; Addison Wesley, 2002

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Galileo Galilei (1564 - 1642)

Despite the notable efforts of his contemporaries, the Italian Galileo Galilei is widely regarded as one of the founders of modern astronomy. His concise observations of a range of astronomical objects laid the foundations for centuries of research.

Galileo built his telescope in the summer of 1609.

On 25 August 1609, Galileo demonstrated his first telescope to Venetian lawmakers. This was the first astronomical outreach activity with a telescope, and the first thoroughly documented use of the telescope for astronomy.
Galileo Galilei (1564 - 1642)

By October 1609 Galileo had developed a telescope that gave him 20x magnification.

With his new 20x telescope he observed the Moon and discovered the four largest moons of Jupiter.

He would go on to use his telescopes to study sunspots and the phases of Venus.

Galileo’s observations revolutionized astronomy and changed our worldview profoundly.
Telescopes
Astronomers learn about the Universe by observing light.

- Telescopes gather more light than our eyes can, and provide greater clarity.
- Use instruments attached to the telescopes to record and analyze the light.
Types of Telescopes

How many basic types of telescopes are there?

Use the poll buttons to answer:

A. 1  
B. 2  
C. 3  
D. 4  
E. 5

Use the Chat Window to list the types of telescopes you know.
Types of Telescopes

There are 2 basic types of telescopes:

**Refractors:** Use lenses to refract (bend) light into a focus to form an image.

Largest in the world is the 40-inch at Yerkes Observatory in WI, USA

Difficult and expensive to manufacture at larger sizes. No modern professional telescopes use this design.
Types of Telescopes

There are 2 basic types of telescopes:

**Reflectors:** Use mirrors to reflect light into a focus to form an image.

Largest in the world are the twin 10-meter Keck telescopes on Mauna Kea, HI, USA.
The Spectrum of Light

- “Visible light” is a tiny fraction of the Electromagnetic Spectrum
- Gamma rays--billions of waves per inch
- Radio waves--up to miles-long wavelengths

Use Clip Art to mark which ends of the spectrum are low and high energy.
The Spectrum of Light

- “Visible light” is a tiny fraction of the Electromagnetic Spectrum
- Gamma rays--billions of waves per inch
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Low Energy Waves  
(Low Frequency)

High Energy Waves  
(High Frequency)
Telescopes at other wavelengths

At other wavelengths, you still want telescopes to bring light to a focus/make an image.

Making mirrors for X-rays is difficult since X-rays penetrate and pass through conventional optical mirrors.

XRT aboard the joint JAXA-NASA Hinode Solar Observatory

Radio telescopes use a dish to reflect radio waves to a focus where an antenna collects them.

Green Bank Telescope is a 100-meter radio telescope in West Virginia, USA
Constellation Orion

Visible Light

Infrared Light
Space Telescopes

Why put telescopes in Space? ...To get above the atmosphere

Advantages of having a telescope in space:

- No atmospheric blurring.
- The sky is darker.
- To see light blocked by the atmosphere.
- Mirrors do not flex under their own weight as they do on the ground.
Mark which image you think is the one taken from space.
Detectors

Originally, astronomers’ only detector were their own eyes. They recorded what they saw in drawings.

Beginning in the 1800s, photographic plates were used at the focus of telescopes to collect light over long exposure times.
Today, astronomers use digital detectors, such as CCDs (Charged-Coupled Devices): Solid-state semi-conductor chips that use the photoelectric effect.

Photons knock electrons loose when they collide with certain elements. Loose electrons create a charge that we measure.
Detectors

CCDs are used in video and digital cameras.

- Linear response: double the exposure time or star brightness, double the charge
- Extremely sensitive: up to 80% of photons are detected
- Digital Output: analyze with computers
- Wide dynamic range: very faint or bright stars are measured accurately.
An Online Activity for Students about Telescopes

http://amazing-space.stsci.edu/resources/explorations/groundup/
Let’s Pause for Two Questions from the Audience
What Have We Learned about Earth’s Place in the Universe 400 years after Galileo?
The Solar System

8 planets, dozens of moons, 100s of dwarf planets, 100,000s of asteroids, trillions of comets and meteoroids, …?

Mostly distributed in a disk about the Sun

Sun blows a wind of charged gas into space: the Solar Wind

Boundary between Solar Wind and interstellar space 100 AU from the Sun
The Milky Way Galaxy

A giant disk of more than 100 billion stars 160,000 light-years across and 1,000 light-years thick.

The Sun is 30,000 light-years from the center.

It takes 250 Million years for the Sun to complete one orbit.

The Spiral arms are the locations of new star formation.
If the Milky Way were the size of the continental United States (San Francisco to New York: 4,200 km), how large would the Solar System Be?

Use the poll buttons to answer:

A. Los Angeles (36 km)
B. A cookie (8 cm)
C. Texas (520 km)
D. Grain of sand (1 mm)
E. Central Park in New York City (5 km)
The Local Group

- Contains 3 large spiral galaxies—Milky Way, Andromeda, and Triangulum—plus a few dozen dwarf galaxies with elliptical or irregular shapes.
- Gravitationally bound together—orbiting about a common center of mass
- About 6.5 million light-years in diameter
The Local Supercluster

- A cluster of many groups and clusters of galaxies
- Clusters and groups spread away from each other as the Universe expands: The Local Supercluster gets bigger with time
- It has a flattened shape

- The Local Group is on the edge of the majority of galaxies
- The Local Supercluster is about 130 Million light-years across
If the Local Supercluster were the size of the continental United States (San Francisco to New York: 4,200 km), how large would the Milky Way be?

Use the poll buttons to answer:

A. Los Angeles (36 km)
B. A cookie (8 cm)
C. Texas (520 km)
D. Grain of sand (1 mm)
E. Central Park in New York City (5 km)
The Universe

- Surveys of galaxies reveal a web-like or honeycomb structure to the Universe
- Great walls and filaments of matter surrounding voids containing no galaxies
- ~100 Billion galaxies in the Universe

The Milky Way Galaxy obscures our view of what lies beyond it. This creates the gaps in all-sky galaxy surveys such as those shown above.
400 years after Galileo: New Telescopes and New Discoveries
WISE will map the sky in infrared light, searching for the nearest and coolest stars, the origins of stellar and planetary systems, and the most luminous galaxies in the Universe.

Launches November 2009!

WISE will deliver to the scientific community:

- Over 1 million images covering the whole sky in 4 infrared wavelengths
- Catalogs of $\approx 500$ million objects seen in these 4 wavelengths

wise.astro.ucla.edu
WISE Mission: Spacecraft

A cold, 40 cm telescope in Earth orbit
Enabled by new megapixel infrared detector arrays

By being in space, the 40 cm WISE telescope is as powerful as 6,000 8-meter telescopes on the ground!
Two decades ago IRAS gave us what is still our best view of the mid-infrared sky. WISE will map the entire sky with the resolution comparable to the view shown here.
Let’s Pause for Two Questions from the Audience
400 years after Galileo: Celebrating His Legacy

The Universe Yours to Discover

International Year of Astronomy 2009

NSTA Web Seminars
The International Year of Astronomy

Vision
To help the citizens of the world rediscover their place in the Universe through the day and night time sky, and thereby engage a personal sense of wonder and discovery.

Celebration
A global celebration of astronomy and its contributions to society and culture, highlighted by the 400th anniversary of the first use of an astronomical telescope by Galileo. The aim of the Year is to stimulate worldwide interest, especially among young people, in astronomy and science under the central theme
“The Universe, Yours to Discover “
Goals & Objectives

Increase **scientific awareness**.

Promote widespread access to new knowledge and **observing experiences**.

Empower astronomical communities in **developing countries**.

Support and improve formal and informal **science education**.

Provide a **modern image of science** and scientists.

Facilitate new **networks** and strengthen existing ones.

Improve the **gender-balanced** representation of scientists at all levels and promote greater involvement by **underrepresented minorities** in scientific and engineering careers.

Facilitate the preservation and protection of the **world’s cultural and natural heritage** of dark skies and historical astronomical sites.
World Wide Celebration

e.g.:
- Sidewalk Astronomy
- Astronomy Olympiads
- Open Doors
- Star parties
- Public Talks
- Exhibitions
- Stamps
- Science Cafés
- Websites
- Documentaries
- Etc…

Sidewalk Astronomy
Exhibits
Science Fairs
Planetarium Shows
NASA is celebrating IYA:
astronomy2009.nasa.gov
List of IYA Education Resources

1. International Year of Astronomy 2009
   http://astronomy2009.nasa.gov/

2. Amazing Space
   http://amazing-space.stsci.edu/

3. Kepler
   http://kepler.nasa.gov/ed/activities/

4. Modeling the Universe
   http://www.cfa.harvard.edu/seuforum/mtu/
Thank you!

Let’s Pause for Two Questions from the Audience
Thanks to our presenter, Dr. Bryan Mendez, and to NASA for sponsoring this program.
http://learningcenter.nsta.org
• NSTA Press: Picture-Perfect Science Lessons
  December 17, 2008

• FDA: Teach Science Concepts and Inquiry with Food
  December 18, 2008

• Sally Ride Science: Igniting Students’ Interests in Science Careers
  January 8, 2009

http://learningcenter.nsta.org
National Science Teachers Association
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