NSTA Web Seminar:
Discover the Universe from Galileo to Today

Presented by: Dr. Natalie Batalha

Tuesday, January 20, 2009
International Year of Astronomy: Advances in Technology & Discoveries of the Last 400 Years

Natalie Batalha
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Born: 15 Feb 1564
Pisa

Professor of Mathematics
University of Padua
1592-1610

1610: Chief Mathematician to Grand Duke of Tuscany
Cosimo II de Medici
Major Accomplishments

• Inventor

• Father of experimental physics

• Father of modern astronomy
Which of the following did Galileo do?

a) Proved that the Earth orbits the Sun  
b) Invented the telescope  
c) Discovered the brightest moons of Jupiter  
d) None of the above  
e) All of the above
Surface of the Moon is earth-like
Sun is blemished, changing, and rotating
The Universe contains more than is visible to the naked eye:

Pleiades Star Cluster

Galileo's observations on the Pleiades
New Planets: Medicean “stars”

Jupiter’s brightest satellites:
  Io, Ganymede, Callisto, Europa
Venus undergoes phases
Haec immatura a me jam leguntur oy

The mother of love emulates the shapes of Cynthia
What was significant about Galileo's discovery of Jupiter's four brightest satellites?

A. It showed that theories that a planet can only have one satellite are wrong.
B. It showed that there are some objects which do not orbit the Earth.
C. It showed that some satellites have atmospheres.
D. It showed that Jupiter is the most massive planet.
A. It showed that theories that a planet can only have one satellite are wrong.
B. It showed that there are some objects which do not orbit the Earth.
C. It showed that some satellites have atmospheres.
D. It showed that Jupiter is the most massive planet.
JOHANNES KEPLER

1571 to 1630

http://kepler.nasa.gov/johannes
Born: 27 Dec 1571
Weil der Stadt

1594-1600: Teacher of astronomy & mathematics at the Protestant School in Graz

1600: Meets Tycho Brahe; 1601: Imperial Mathematicus
Astronomy
Optics
Mathematics: logarithms, calculus
The last scientific astrologer
JOHANNES KEPLER

Kepler tried to fit planetary orbits into a nested system based upon the five perfect geometric solids.
Tycho in Denmark: Uraniburg
Do you teach Kepler’s Laws of Planetary Motion to your students?

a) Yes, with mathematics
b) Yes, without mathematics
c) No
1609: First 2 Laws of Planetary Motion
It’s the Law!
...so, you see, the orbit of a planet is elliptical.

What's an orbit?

What's a planet?

What's elliptical?
1618: 3rd Law of Planetary Motion
\( P^2 = a^3 \)

<table>
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<th>Sidereal period ( P ) (yr)</th>
<th>Semimajor axis ( a ) (AU)</th>
<th>( p^2 )</th>
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<td>Pluto</td>
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Q: Does life in any form, however simple or complex, carbon-based or other, exist elsewhere than on Earth? Are there Earth-like planets beyond our solar system?

Kepler’s Objective: are earth-like planets common or rare in our galaxy?
Your ideas: What makes a planet Earth-like?
“The habitable zone (HZ) is defined as the region around a star in which liquid water can exist on the surface of the planet.” - Kasting, 2001
Habitability: Atmosphere

Atmosphere important for life:
- temperature stability
- radiation shield
- water transport

Too small: Can’t hold onto a life sustaining atmosphere (Mercury, Mars)

Too big: Can hold onto the very abundant light gases (H\textsubscript{2} and He) and turn into a gas giant (Jupiter, Saturn, Uranus, Neptune)
How will Kepler Find Planets?
Transit Photometry

Transit Detection of Exoplanets

We only see the dip, not an image as shown here.
Transit Photometry

• The amount of dimming depends on size of planet (ratio of the area of the planet to its parent star)

Jupiter: 1% area of the Sun (1/100)
Earth or Venus: 0.01% area of the Sun (1/10,000)

• To measure 0.01% must get above the Earth’s atmosphere
Spacecraft will stare at same patch of sky for $\geq 3.5$ years
How big is this area on the sky?

a) As big as a dinner plate held at arms length.
b) As big as my open hand held at arms length
c) As big as a coin held at arms length
d) As big as a grain of sand held at arms length.
There are > 6 million stars in this area. We have to pick 150,000 to observe.
Largest Schmidt telescope ever built.

Largest telescope to be sent outside of earth orbit.

Primary Mirror
A really big digital camera!
Assembled and Tested at Ball Aerospace
Delta rocket is now being assembled on launch pad 17A at Cape Canaveral.
Spacecraft arrives in Florida via truck (phew...)
What do you think? Do you expect earth-like planets to be common or rare?

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<th>common</th>
<th>rare</th>
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“Well, this mission answers at least one big question: Are there other planets like ours in the universe?”
Special Thanks to NASA and our Presenter: Natalie Batalha
• **NSTA Learning Center – Focus on Teachers**
  January 21, 2009

• **Picture-Perfect Science Lessons: Using Children’s Books to Guide Inquiry, Grades K-4**
  January 22, 2009

• **Media Literacy in the 21st Century: WGBH Teachers’ Domain**
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