

# Astronomy 330



This class (Lecture 21):  
Evolution of World View

Next Class:  
Lifetime

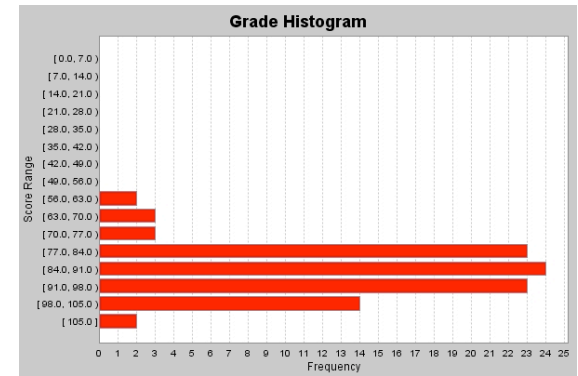
**HW #9 due on Sunday!**

Music: *Concerning the UFO Sighting near Highland, Illinois*  
– Sufjan Stevens  
Apr 14, 2009      Astronomy 330 Spring 2009

# Exam 2



- Good job again!
- Average was 88%!
- On final, I will replace grade of this exam with grade on Section 2 of Final, but only if it is higher.



# Paper Rough Draft



- Worth 1% of your grade, but really worth more!
- **Due on or before April 22nd! (Hard date!)**
- Should pretty much be the final paper.
- Will be looking for scope, ease-of-read, scientific reasoning, **proper citation**, and general style.
- 5 to 8 pages double-spaced 12-point font, not including references.
- *Mars is a planet without an overzealous monkey population (Holt et al. 2000; James & Mann 2006; Walker 20007).*  
– *I expect to see a few refs per page!*

# Question



How was Exam 2?

- a) About the appropriate or expected level.
- b) Too easy.
- c) Too hard.

## Question



Would you had have preferred that Exam 2 was

- a) the Thursday before Spring break.
- b) the Thursday after Spring Break
- c) as it was, 2<sup>nd</sup> Thursday after Spring Break.

## Question



I am trying to develop my new course astro 150. The book salespeople are trying to convince me that students like material online and not books. Do you really like discussion groups, online assignments (outside of Compass), etc?

- a) I like the setup of astro 330 (online lecture notes and good reviews), i.e. a required book that is not really required.
- b) I like the setup of astro 330 (online lecture notes and good reviews), and don't think a book is necessary to keep up with the topics.
- c) I sometimes get lost, and would like a book, if you followed it more closely.
- d) I like electronic books.
- e) I would prefer the idea of self-tests, online discussions, and better interaction on the web.

## Outline



- Worldview: do we think aliens may be out there?
- What is  $f_c$ ?

## Drake Equation



Frank Drake

That's 3.3 intelligent systems/century



$$N = R_* \times f_p \times n_e \times f_l \times f_i \times f_c \times L$$

# of advanced civilizations we can contact in our Galaxy today	Star formation rate	Fraction of stars with planets	# of Earthlike planets per system	Fraction on which life arises	Fraction that evolve intelligence	Fraction that communicate	Lifetime of advanced civilizations
	20 stars/yr	0.12 systems/star	1.25 x 0.12 = 0.15 planets/system	0.4 life/planet	0.23 intel./life	comm./intel.	yrs/comm.

## Next Step



- Besides needing technology, intelligent life must have a **want** to communicate with extraterrestrial life.
- That means that it **MUST** believe in the possibility of other life.
- Requires civilization to undergo three steps:
  1. A correct appreciation of the size and nature of the Universe
  2. A realization of their place in the Universe
  3. A belief that the odds for life are reasonable. The beings of Qearth must have taken their Qastro 330 class and came up with a good number of communicable civilizations in the Q'drake equation.



<http://www.bybeeweb.com/cats/amelia-step.jpg>

## Big Questions



- Our capacity for interstellar communication arose at the same time as our interest in it. Coincidence?
- Can a society have a highly developed technology with an incorrect astronomy?
- What if the skies were constantly cloudy?
- What if their solar system had no other planets?
- What if they lived in a molecular cloud?
- What if they lived in a huge cluster of galaxies?

## Copernican Revolutions



1. We are not the center of the Solar System.
2. We are not the center of the Galaxy.
3. We are not the center of the Universe.

## Our First View



- The first concepts of the Universe were Earth-centered.
- How did we come to this point– Astro 330?
- First recorded cosmology was from the Babylonians.
  - The Universe is a large oyster, and we are inside.
  - But other aspects of their astronomy was advanced.
  - Regularity of astronomy for crop planting, harvesting, and accurate calendars back to the 3800 BC.



## Our First View



- The Mayans computed the length of year to within a few seconds (0.001%).
- So early humans had a weird mixture of precise calendar astronomy with primitive concept of the Universe and mythological systems incorporating magic.



<http://www.mayasites.com/equinox.html>

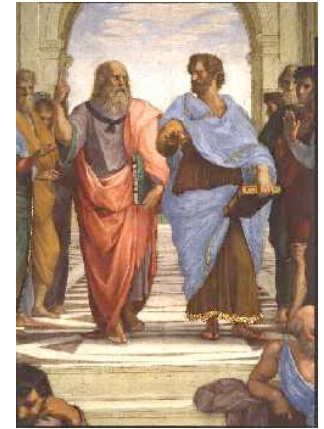


<http://ephemeris.com/history/mayan-calendar.jpg>

## Greek Astronomy



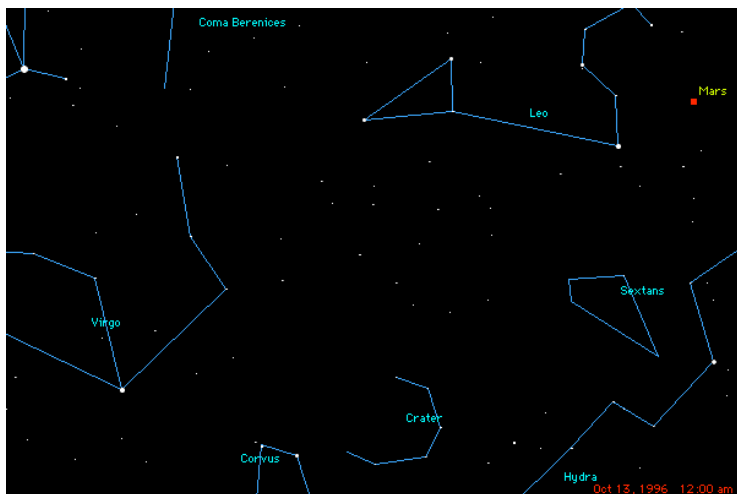
- Greeks were excellent Astronomers
  - Cataloged star positions & brightness.
  - Systematic, quantitative observations.
  - Natural philosophers.
- They observed that the stars, Sun, and planets revolved around the Earth.
- So Earth is center of Universe-**geocentric cosmology** (mostly from Plato and Aristotle).
- Even though other philosophers (Aristarchus) argued for a heliocentric cosmology.
- Perfect Spheres of motion?



## Mars Moves WRT the Stars!



E  
A  
S  
T



W  
E  
S  
T

## Motions of Planets



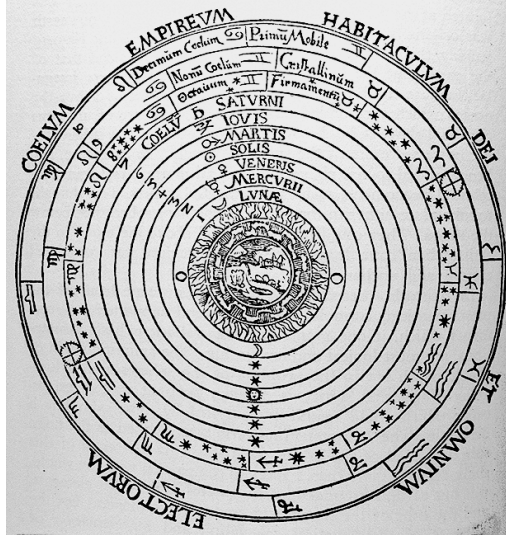
- So, over time the planets seem to move along the ecliptic from west to east over long time periods.
  - This is called **prograde** motion
  - Note that they still rise in the East and set in the West each day. We are referring to their relative motion wrt the stars.
- But once in a while, a planet appears to stop and reverses direction
  - Reverse direction is called **retrograde** motion (east to west).
- Planets move counter-clockwise (looking down at the north pole)

## How can we explain the Planet motion?



But with a **geocentric cosmology** you can't easily explain the retrograde motion of the planets.

Note: perfect circles



## Ptolemy (140 AD: 'p' is silent)



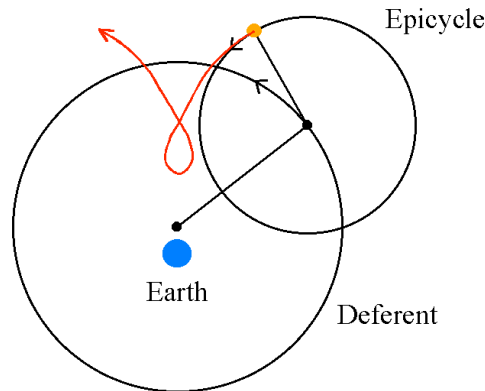
Took **geocentric** model with uniform circular motion to introduce the Ptolemaic system, or model, of the Solar System that explained **retrograde** motion



## Ptolemaic system



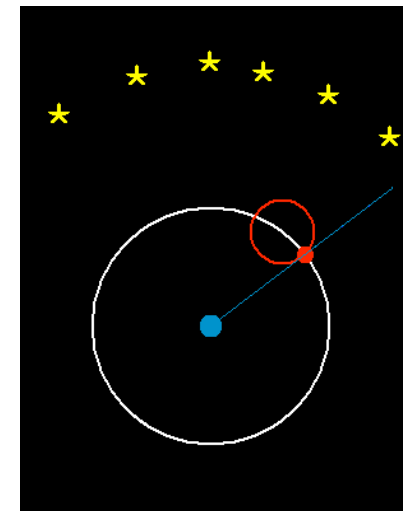
- Geocentric
- Nice circular motion



## Ptolemaic system



**Yes, it can explain retrograde motions**

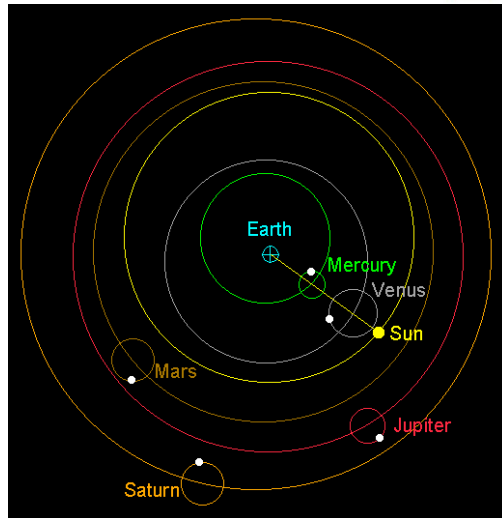




## Ptolemaic system



Overall system of the Solar System.

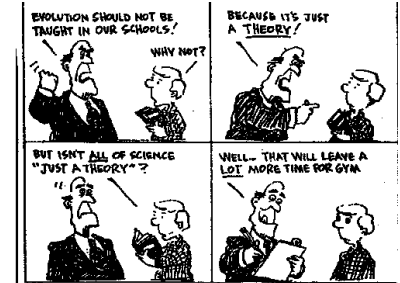


## Ptolemy's Geocentric Cosmology: Is it a Scientific Theory?



*Yes!* ...and an accurate one too

- Data: Sun/moon/star motions
- Tentative Model: circular orbits
- Prediction: uniform motion on sky
- New data: retrograde motion
- Refined model: epicycles  
– explains data!



<http://home.comcast.net/~fsteiger/theory.htm>

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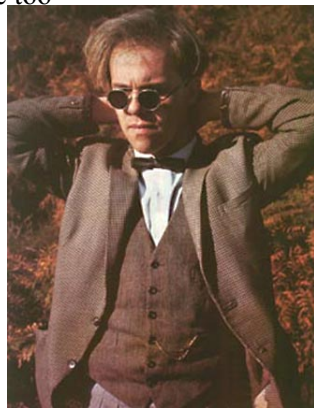


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**Result:** Ptolemaic system (theory)

- *Strength:* accurate fit of data
- *Weakness:* predictions for new data?

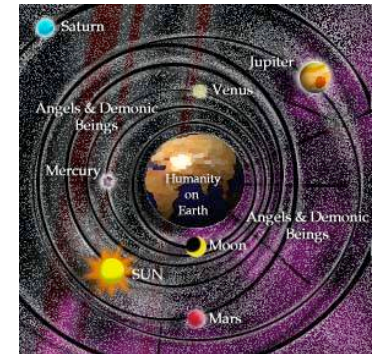


<http://www.tmdrfan.com/rthurlow/ThomasDolby1982.htm>

## Ptolemaic Problems



- Each planet acted independently of others
- There was no universal rule governing the planets motions.
- Nonetheless, for a 1000 years this model ruled western thought
- However, by the late middle-ages astronomers felt that it was too complex, and a search began for a system with simple underlying principles



<http://gbgm-umc.org/umw/bible/images/ptolmai2.jpg>

## Question



The main problem with an Earth centered Solar System are the retrograde motions of planets. It was solved by

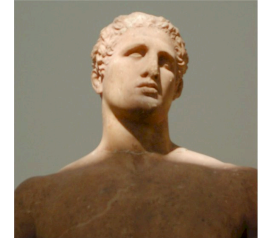
- Allowing the planets to move on orbits on orbits.
- Moving the Earth off the center a little bit.
- Perfectly circular orbits.
- Elliptical orbits.
- Superman making the Earth turn backwards.

## Lessons: Were the Greeks Stupid?



- Not at all!  
Developed sophisticated, successful model
- But built in prejudices about the world  
not just geocentric but egocentric

What about scientists today?  
Still can fool ourselves! (And have!)  
But: *scientific method* is tool:  
• To keep from fooling yourself  
• To correct yourself when you have



[http://www.farhorizon.com/europe/images/images-greece/head\\_of\\_Greek\\_god.jpg](http://www.farhorizon.com/europe/images/images-greece/head_of_Greek_god.jpg)

## Lessons: Were the Greeks Stupid?



### My guess:

70% of the material in this course will stand the test of time

- Compare baseball: 70% success is very good
- But also: 30% of course is wrong/incomplete!
  - Which 30%? Don't know!  
Would fix it if we knew! So...
  - You have to learn all of it!

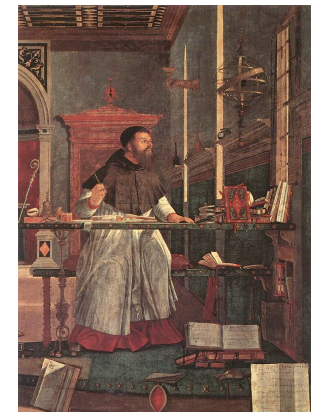


[http://sportsillustrated.cnn.com/baseball/mlb/specials/spring\\_training/2007/previews/cubs.html](http://sportsillustrated.cnn.com/baseball/mlb/specials/spring_training/2007/previews/cubs.html)

## Power of Ignorance



- Geocentric model was absorbed by Christianity.
- If Geocentric, then of course no ET life.
- St. Augustine (420 AD) incorporated Neo-Platonism. He listed science as a temptation to avoid: “a mere itch to experience and find out”
- Also said, “Nor do I care to know the course of the stars.”



[http://www.fholocaustmuseum.org/history\\_wing/assets/room1/St\\_Augustine.jpg](http://www.fholocaustmuseum.org/history_wing/assets/room1/St_Augustine.jpg)

## Power of Ignorance



- The European worldview degenerated for years.
- No one in Europe mentioned the supernova of 1054 (Crab Nebula), unlike China or Americas. People were afraid to notice it and be described as a heretic.
- Could an ET civilization reach technology with that sort of attitude?

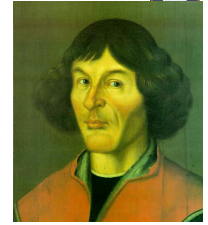
<http://www.pbs.org/deepspace/timeline/t114.html>



<http://www.godandscience.org/images/crabnebula.jpg>

<http://www.tulane.edu/~danny/southwest.html>

## Copernicus (1540) resurrected the heliocentric model



- If Earth moves, then stars have to be very far away.
- Was rejected on theological and philosophical grounds.
- 1616, the Catholic Church listed it as heresy.



## Giordano Bruno

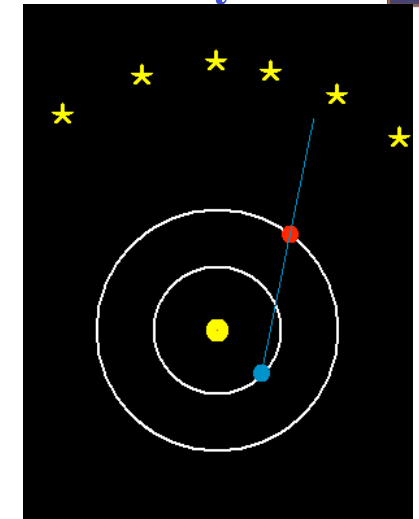


- Seems to have taken it one step further.
- Thought that the stars were all little Suns.
- Possibly with planets of their own.
- Maybe life on those other planets.
- Maybe more advanced than those on Earth.
- These are some of the reasons why he was burned at the stake around 1600.

## Copernican Theory



- Can explain retrograde motion
- Much simpler
- Still kept to circular motion
- Eventually changed the way we think of ourselves!





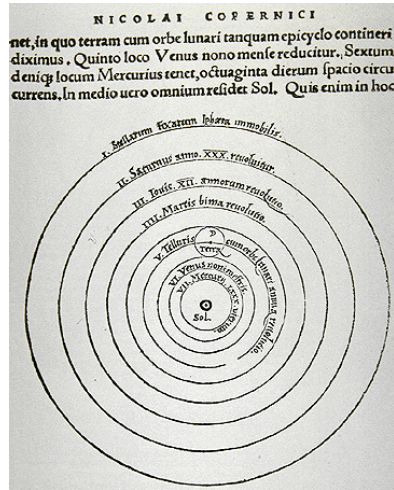
## Copernicus (1540) Heliocentric Model



BUT, keep in mind that the geocentric model was still valid. Both models explained the observed motion.

Heliocentric is NOT obvious!

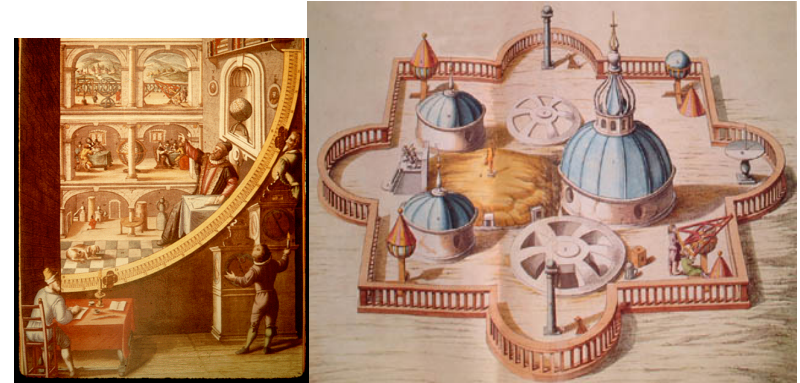
IT was determined a philosophical argument for 50 years! New observations were required to determine which is correct.



## Tycho Brahe (1580): Uraniborg



Accurate measurements to about 1 minute of arc (1/15 the diameter of the moon). No telescopes!



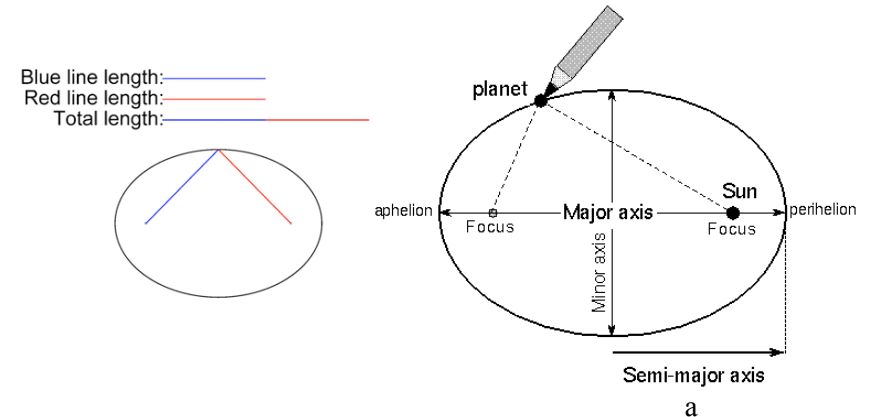
## Johannes Kepler (1600)



- Tycho's assistant in Prague
- After Tycho's death, succeeded Tycho's position and had access to the excellent data
- How to fit the Heliocentric model to accurate data of Mars?
- Circles didn't work.
- Ellipses!



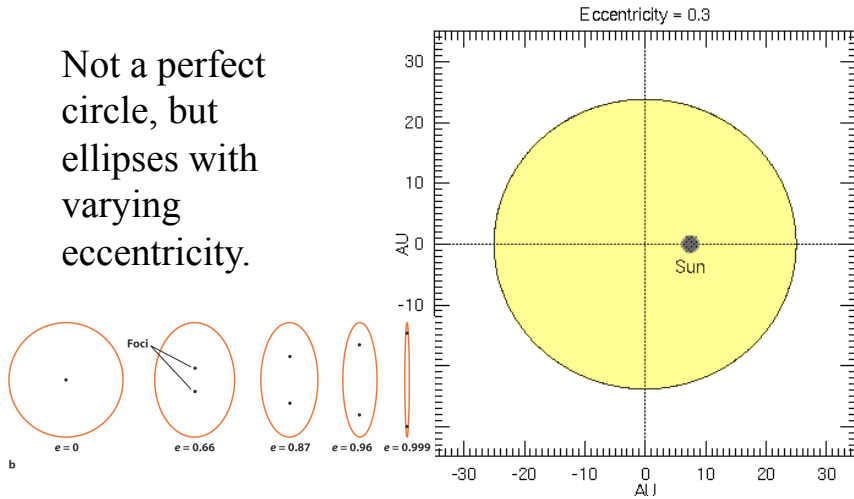
## Kepler's 1<sup>st</sup> Law: Orbits of planets are ellipses with the Sun at one focus



# Orbits of planets are ellipses with the Sun at one focus



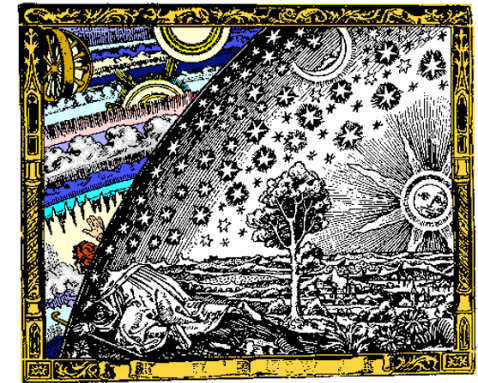
Not a perfect circle, but ellipses with varying eccentricity.



# Implications



New Twist— even the Sun isn't at the center of the solar system now. How does that change our view of the Universe and our place in it?



<http://antwrp.gsfc.nasa.gov/apod/ap010101.html>

# Galileo (1609) 400 Years!



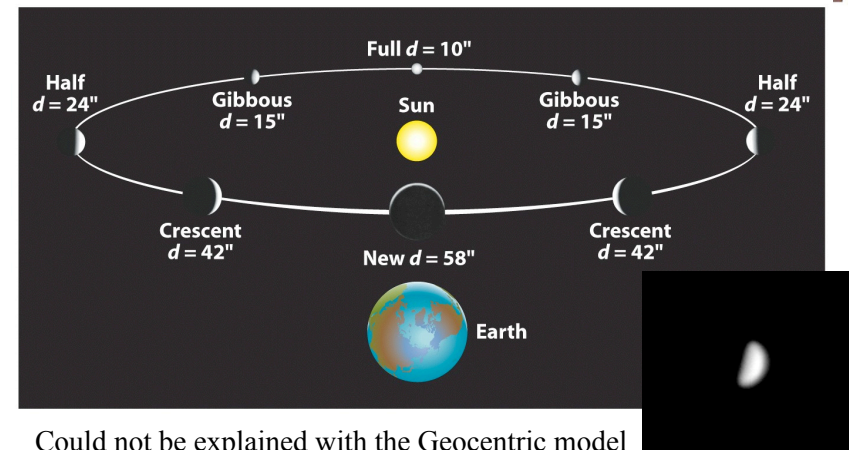
First to systematically use the telescope (but did not invent it).

- Moon has mountains and valleys
- Milky Way consists of faint stars
- Saturn is elongated
- Venus shows phases
- Jupiter has moons (now called Galilean moons)

Wow! Big stuff. The moons of Jupiter did not orbit the Earth!



# The Phases of Venus



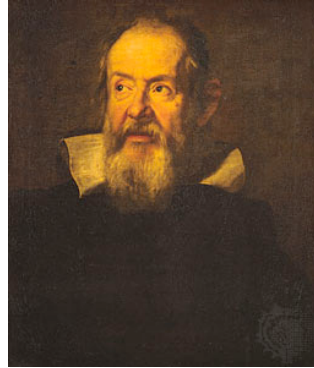
Could not be explained with the Geocentric model

<http://www.astro.ubc.ca/~scharein/a310/SolSysEx/phases/Phases.html>

## Galileo (1610)



- Disproved Ptolemaic system
- Rome bullied him into recanting (cleared in 1992)
- Now we understand the motions and the fact that the solar system **MUST** be Heliocentric, but now we need a reason why?
- Need something with predictive power.



## Isaac Newton



- Gave us a reason why--  
**GRAVITY.**
- Developed fundamental laws of nature.
- Now, we had a reason why the Solar System objects moved.
- And we could predict new objects!

