

10/13/05: Corrections on slides 28 and 37

# Atoms and Stars IST 2420 and IST 1990

Class #6: October 12 and 17

Fall 2005 sections 001, 005, 010 and 981

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[www.is.wayne.edu/drbowen/aasf05](http://www.is.wayne.edu/drbowen/aasf05)

# Tonight

- Handouts
  - o Class 6 Notes
  - o Sources for Midterm
- Initial the sign-in sheet
- Review of names
- Due:
  - o Lab 3 Report
  - o Due last week: Essay 2 (on diskette for face-to-face)

# From Class #5:

1. Dates of Archimedes (Encyclopedia Britannica) between 290 & 280 BC, to 211 or 212 BC
  - Aristotle 384 – 322 BC
  - No implication here that Archimedes corrected Aristotle
2. Slide 26 “Rene Descarte ~1625 said if light speed *infinite*” – no, “finite”

# How Do We Know What Science Is?

- Who says what the scientific method is?
- We listen to what scientists say they do, and watch them doing it
  - For example, Copi. Exception: Frances Bacon ~ 1600, at the time of the origins of science
- Science is an open community – to be taken seriously, you must take its methods and concerns seriously
  - Galileo, Newton, Einstein and others were “mainstream” at first, revolutionary later

# Just Another Belief?

- Some people say that science is just another set of beliefs
- Scientists base their claims to truth on sensory evidence – experiments (direct experience)
- *Some* religious people say the senses are not reliable; that faith wins out over (trumps) the five senses
  - Most religions accept science, in its domain of the natural world

# Induction / Deduction

- Reader, “We Are All Scientists”
- Induction: drawing broad conclusions from a few cases, e.g. “green apples are sour”
- Deduction: drawing a specific conclusion from numerous observations, e.g. “someone broke in and stole the teapot and spoons”
  - Open window, teapot and spoons missing, palm-print on window, boot marks outside

# Nature is the final arbiter

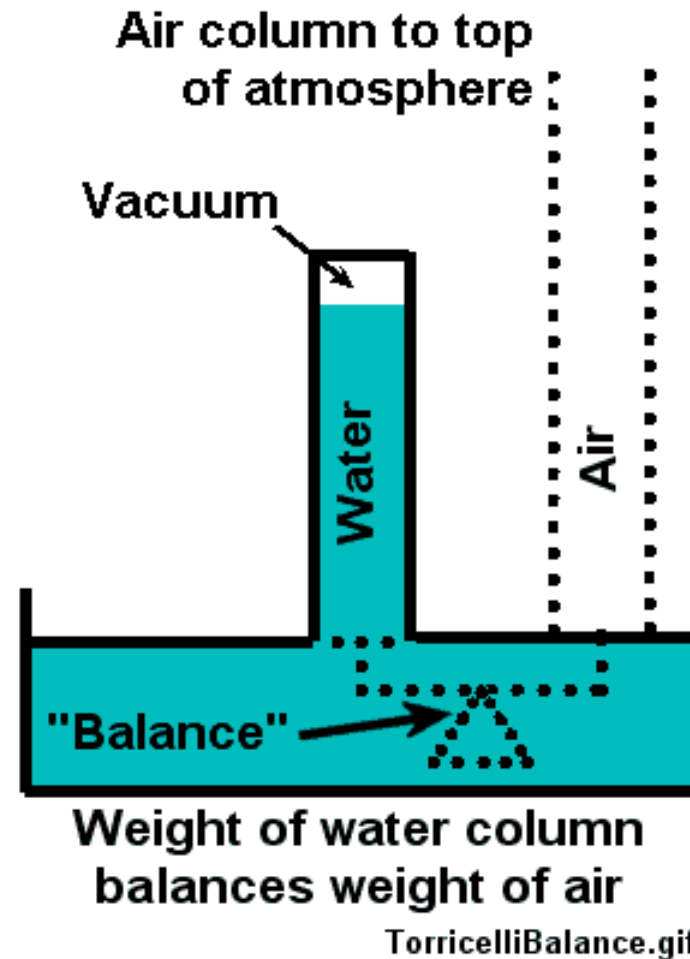
- “Nature is the final arbiter in the natural sciences”
  - o arbiter – judge, decision-maker
  - o If experiments do not agree with your theory, your theory is rejected

# Sea of Air (Torricelli)

- Aristotelian explanation: a single side of the container – vacuum does it all
- Torricellian – pressure *difference* between two sides
  - o 34' column of water – weight of water balances weight of air – see next slide

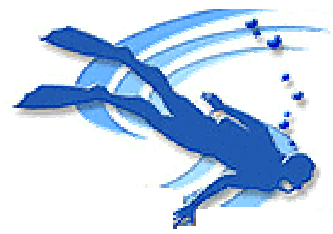
# Sea of Air (Torricelli) #2

- Figure illustrates the balance or equality of the weight of a water column (34') and an air column.
- Virtual balance, like →



# Why Are Scuba Tanks Thick? #1

- Scuba – diving with suit, flippers, air tank (not with a snorkel)



- Start our reasoning with human lungs
  - o Lung muscles for breathing are not strong
    - If inside-to-outside pressure difference more than about one foot of water, cannot breath
  - o 34' under water, atmospheric pressure, doubles
  - o 68', triples pressure difference, etc.

# Why Are Scuba Tanks Thick? #2

- To breathe, must match outside water pressure with air pressure from tank
- Tank does not need to be thick for depths
  - Crushing water pressure is fairly balanced with inside air pressure – more than balanced, actually
  - Needs to be thick to contain air pressure above water
    - Outside pressure is much less there

# Special Relativity

- Speed of light in a vacuum given symbol  $c$  ( $E = mc^2$ )
  - 186,000 mi/sec = 670 billion mi/hr = 6 trillion mi/yr
  - 6 trillion miles = one light year (distance)
- Einstein's Theory of Special Relativity (1905):
  - Speed of light is maximum speed for anything
  - Space travel would take a very long time. Outside of our solar system, distances are many light years, travel would take that long in years

# Big Bang & General Relativity

- Big Bang: Universe is expanding
  - Started from a tiny point ~ 15 billion years ago
- What is outside the Universe as it expands?
- General Relativity: nothing is outside!
  - The Universe creates the space as it expands
  - When space expanding (at edge of Universe), speed of light can be exceeded
  - “Space & time change from neutral ‘stage’ to ‘actors’”

# Natural Disasters #1

- Campus group interested in natural disasters last week
  - Hurricanes, tornadoes, earthquakes, tsunamis
- Hurricanes best understood
  - Rising air over warm ocean – spirals counterclockwise as seen from above in Northern Hemisphere due to earth's rotation
  - Picks up water vapor, condenses out higher up

# Natural Disasters #2

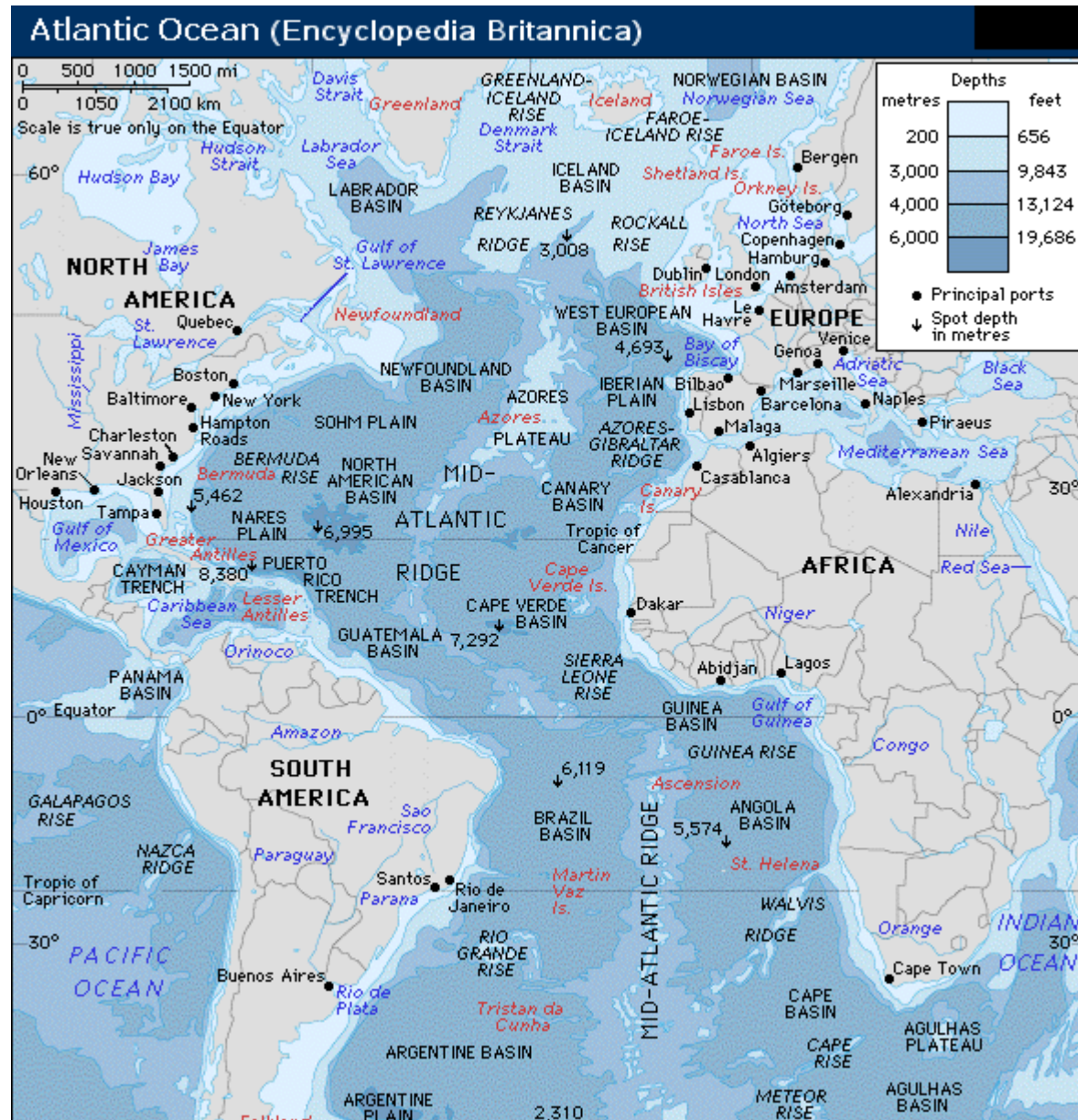
- Hurricanes best understood
  - When water condenses, air heats again – “fuel”
  - Strength: indicated by low pressure in the eye
    - No storm, 30” Mercury – if eye gets to 27”, get out of there!  
(Katrina)
  - Very large size, winds to about 200 mph
  - Called typhoons in Asia
- Tornadoes also circular, form over land, smaller but higher winds (about 300 mph)
  - Less well understood than hurricanes (“supercell”)

# Natural Disasters #3

- Earthquakes
  - o “Plate Tectonics gives general explanation
  - o Earth molten when formed ~ 4.5 BYA
  - o Cooled, surface condensed into continents (thin “plates”) floating on molten core (“magma”)
  - o Currents in core, like currents in boiling water, carry plates, like the skin on cooking pudding
  - o Plates crash into each other → earthquakes

Example:  
 North & South  
 America were  
 joined to  
 Europe and  
 Africa, magma  
 is boiling up at  
 Mid-Atlantic  
 Ridge, pushing  
 them apart.

Geography and  
 species from  
 before split  
 match across  
 Atlantic ocean



# Natural Disasters #5

- Earthquakes
  - As plates crash, tension in “crust” builds up
  - Longer time between quakes → larger quake
  - Cannot presently tell when quake will happen
- Tsunami – wave formed from underwater earthquake
  - Sensors, warning system, disaster network can move population out – Hawaii and Alaska monitoring centers
  - No such system in Asian 2004 tsunami, being built now

# Natural Disasters #6

- Natural Disasters
  - o At present, we cannot predict or control these
  - o We are learning a lot about them
    - Earthquake and hurricane construction codes
    - Modern buildings in California much better against quakes, in Florida against hurricanes
  - o Prediction will come first, control is a maybe

# Readings: “Motions in the Solar System”

- Motions in sky known to all civilizations
- Constellation: groups of stars, pattern invariant over human lifetime
  - 88 total constellations, Zodiac is 12 of these
- Angular measurement
  - Degrees:  $360^\circ = \text{circle (horizon)}$ ,  $90^\circ$  horizon to pole. Fist at arm's length  $\sim 10^\circ$ , finger  $\sim 1^\circ$
  - Minute ('):  $60' = 1^\circ$
  - Second ("):  $60'' = 60'$

# “Motions in the Solar System”

- Stars circle around pole (Pg 93)
  - Really, earth is turning underneath stars
  - $360^\circ$  in 24 hrs =  $15^\circ/\text{hr}$
- Also move annually relative to sun
- Five visible planets Mercury, Venus, Mars, Jupiter, Saturn move with respect to stars
  - Uranus, Neptune, Pluto require telescope

# “Motions in the Solar System”

- Planets move through stars west to east like sun and moon, but periodically reverse or retrograde motion
  - o Mercury, Venus stay close to sun (morning & evening stars)
    - Retrograde when close to but farthest east of sun, reappear west of sun
  - o Mars, Jupiter, Saturn roam with respect to sun
    - Retrograde when opposite sun

# “Motions in the Solar System”

- Sun
  - Highest in sky at Summer Solstice (~June 21, most daylight)
  - Lowest at Winter Solstice (~December 21, longest night)
  - In between Spring and Vernal (Fall) Equinoxes – equal day and night
  - Reversed in Southern Hemisphere
  - Also moves east with respect to stars

# “Motions in the Solar System”

- Sun
  - As sun moves through stars, traces plane called “ecliptic”
  - Moves through 12 constellations of Zodiac

# “Motions in the Solar System”

- Moon
  - Rises in east, sets in west like sun
  - Also moves to the east with respect to stars
  - New moon – moon between earth and sun
  - Full moon – earth between sun and moon
- Eclipses
  - Moon eclipses sun, orbit tilted so rare
  - Lunar eclipse when earth’s shadow hides full moon

# Retrograde Motion #1

- Retrograde: moving or directed backwards
  - Backwards motions of planets – a problem for Aristotelian astronomy.
    - Celestial (heavenly) domain is perfect
    - Perfectly circular motion, but retrograde motion didn't fit in
    - Normally counter-clockwise from above north pole
    - All planets exhibited this sometimes
    - Plato's theory had extra spheres and features to handle retrograde motion

# Retrograde Motion #2

- Retrograde: moving or directed backwards
  - “Fixed” stars – most celestial objects (stars) rotate together, today called fixed
    - Now we see they really do move, just very slowly
  - Planet: Greek for “wanderer” – wandered among fixed stars
  - Motion actually very regular
  - Wander through astrological constellations

# Retrograde Motion #3

- Objects and orbits in solar system close to the same plane
  - Also close to the plane of our galaxy
  - Milky Way is looking out into the plane of our galaxy – we are in it so we see Milky Way 360°
- Computer demo: [Retrograde Motion](#)
  - Click “Model,” stop at “COPERNICUS”
  - Click on “Months,”
  - See “Notes” at bottom of screen to explain what you see
  - Top strip is view from earth to object (e.g. Sun)
    - Imagine strip wrapped around in back of your head
    - Background is astrological constellations (e.g. Pisces)
  - ~~Left to right~~ normal, reverse/pause is **retrograde**

# New “planets”

- Pluto discovered 1930, orbit radius  $\sim 30$  AU
- Quaoar discovered 2002,  $\sim 1/8$  size of Pluto
  - 42 AU from sun ( $42 \times$  radius of earth's orbit)
    - Radius of earth's orbit = 93 million miles
- 2003 VB12 (“Sedna”)  $\sim$  size of Pluto
  - Orbit radius  $\sim 39$  AU
- 2004 DW  $\sim 1/2$  size of Pluto
  - Orbit radius  $\sim 45$  AU
- 2005 “Xena” with moon “Gabrielle”
  - $\sim 20\%$  larger than Pluto, 39 to 97 AU (very flattened)
  - Plane  $\sim 43^\circ$  to ecliptic

# New “planets” (cont’d)

- Pluto discovered 1930, orbit radius ~30 AU
- Five new candidate planets since 2002 (see next slide)
- Definition of a planet is in dispute. Also casts doubt on whether or not Pluto is a planet
- Newest (Xena) may have the best claim – size, moon
- These are in or near the “Kuiper Belt” (asteroids)

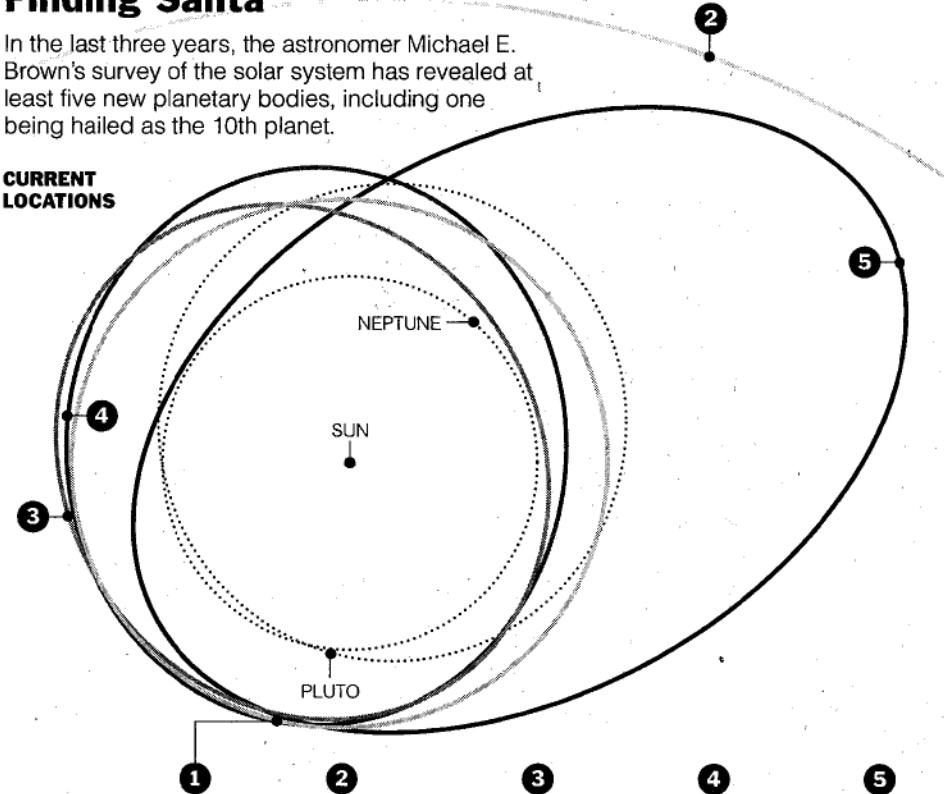
# New “planets” (cont’d)






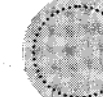
- Neptune outermost “real” planet
- “Reals” formed from dust cloud, forced orbits to circular
- Term “planet” may be abandoned

## Finding Santa

In the last three years, the astronomer Michael E. Brown’s survey of the solar system has revealed at least five new planetary bodies, including one being hailed as the 10th planet.

### CURRENT LOCATIONS



	1 QUAOAR	2 SEDNA	3 2003 EL61 (Santa)	4 2005 FY9 (Easter bunny)	5 2003 UB313 (Xena)	
<b>Discovered</b>	June 4, 2002	Nov. 14, 2003	Dec. 28, 2004	April 1, 2005	Jan. 5, 2005	
<b>Announced</b>	Oct. 7, 2002	March 15, 2004	July 28, 2005	July 29, 2005	July 29, 2005	
<b>Orbits Sun</b>	285 years	10,500 years	297 years	308 years	560 years	
<b>Distance from Sun</b>	42 A.U.	76 to 1,000	36 to 53	39 to 53	38 to 97	
<small>In astronomical units. One A.U. is about 93 million miles, the distance from the Earth to the Sun.</small>						
<b>Diameter</b>	 PLUTO 1,400 miles	 800 miles	 800-1,100 miles	 930 miles	 930 miles	 Greater than 1,400 miles*

10/5/05

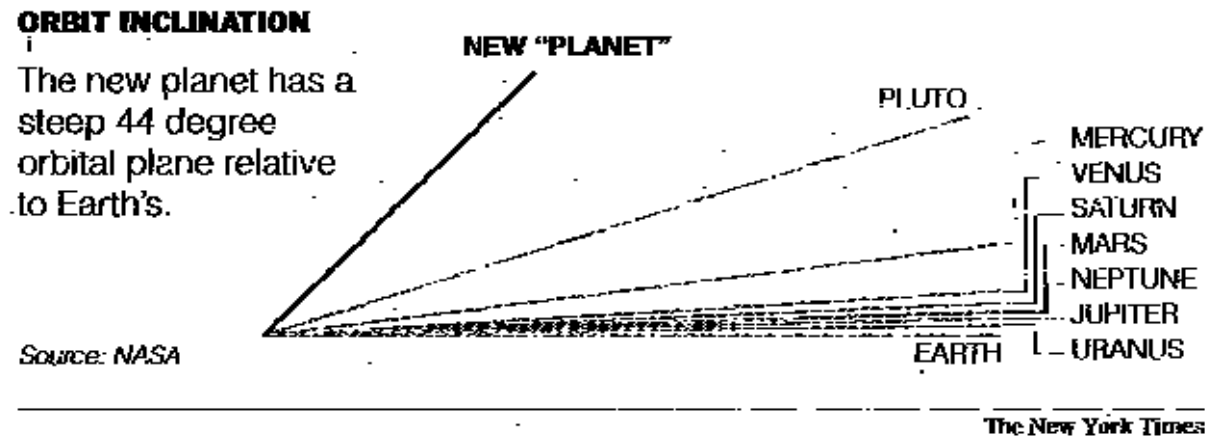
Atoms & St

\*The failure of NASA's Spitzer Space Telescope to see infrared heat indicated a diameter of less than 2,000 miles. But the telescope was mistakenly pointed in the wrong direction.

Source: Michael E. Brown, California Institute of Technology

The New York Times

# New “planets” (cont’d)



- “Classification” - what is a planet?
  - o Follows “description” in development of science
  - o What are the real differences?
  - o Interesting to see it going on here

# What are these things? (modern)

- Star – source of light (gravity has crushed atoms to start nuclear reactions)
- Planet – large, opaque, nonluminous, circles a star (Pluto is on the smallish side)
- Moon – a natural satellite of a planet
- Asteroid – Small planet, size from 1 km (.6 mi) to 1,000 km (620 mi)
- Comet – Few km, frozen ice & rock, elongated orbit, vaporizes when near sun, makes tail

# “Science is Progressive”

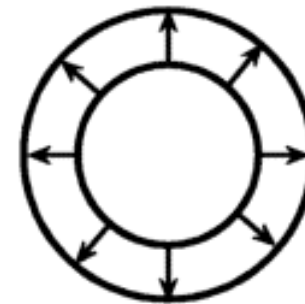
- Science always has a boundary
- Science makes progress beyond boundary
  - Past discoveries become new tools (barometer)
  - Extend theories beyond current experiments
    - Important in science, but can be misleading
    - Some scientists say that any religion is incompatible with science, but actually, that is an extension
- Old questions still important; new answers

# “Science is Progressive”

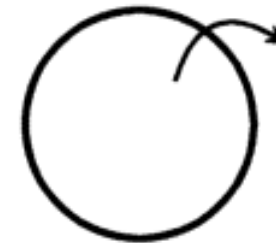
- After origin of science, most revolutionary scientific advances (late 19<sup>th</sup> and 20<sup>th</sup> centuries) extend scope, leave core valid (at least numerically – watch for Quantum Mechanics later)
  1. Newton (our common idea)
  2. Special relativity (max speed, energy = mass)
  3. General relativity (creation of space)

# “Science is Progressive”

- “Expanding circles of knowledge” (DB)
  - o Exact shape (circle) unimportant – “blob”
  - o Science moves boundary out
  - o Progresses (expands) by extending known into new territory
    - Theory and experiment



ExpandingCircle.gif



ACircleExpands.gif

# Assignments 2420

- Next week:
  - Report on Experiment 8
  - Reader:
    - Copernicus Incites a Revolution
    - The Planet Mars and Kepler's Three Laws of Planetary Motion
    - ~~What is Gravity?~~ (“deassigned” – read later)
    - Case History in Astronomy: Johannes Kepler
    - The Watershed to the start of Chapter 6 (“The Giving of the Laws” on Pg 189)
      - What is Creativity really like?

# Assignments 2420 (cont'd)

- Next week (cont'd):
  - Be ready for Q & A Review for Midterm at end of class
- Two weeks – POL will join us again
  - Midterm (one hour) plus labs afterwards
  - Watch for change in labs to be done
    - Lab III Part II (probably new equipment, new write-up)
    - Lab VIII Part II (omit II.B)

# Moodlers (POL & 1990)

- See “SUCCESS” on course web site

## 2420 POL

- Summaries
- Average two postings per week
  - Try answering the Exam questions!!!
    - Get me on record in writing
    - Rehearsal – the best way to study

# IST 1990

- Essay 1 due next week
- Reading – see Syllabus
- On the course web site:
  - Essay topics for all three essays
  - Notes on IST 1990 books
- Postings every week
  - Two credits: average one per week
  - Four credits: average two per week
- Four credit: extra readings online: PW = “apple”