

Atoms and Stars

IST 2420

Class 7, February 26
Winter 2007

Instructor: David Bowen

Course web site: www.is.wayne.edu/drbowen/aasw07

Red: added after notes printed

Email problem...

- Jason Banks, your WSU email account is over quota and not receiving new messages. Delete some old messages to correct this.

Midterm Questions:

- **Questions 25 and 26 are back on.**

Agenda

- Assignments and passbacks
- Reminders: Online Grade Reports, Grade What-If, Essay grades
- Readings: “Watershed”
- Preview: Galileo
- Review: Boyle’s Law
- Upcoming assignments
- Review for Midterm

Handouts & Announcements

- Class 7 Notes
- Initial the sign in sheet

Due tonight

- Report for Lab 8 Part 2

Coming up...

- **Tonight: Review session for Midterm**
 - One hour, at the end of class (replaces lab)
- **Next week: Midterm**
 - One hour at the start of class
 - 3 to 5 questions from the list
 - Regular class, with lab, after Exam
 - Only assignment (except for studying): read Manual for Experiment 13

Grade What-If (repeat)

- What is your average now?
 - What grade are you headed for?
 - What do you have to improve to get a better grade?
- It's the Grade What-If (doing what-if with your Atoms and Stars grade)
 - On the course web site
 - Save to a disk drive if you want to save results
 - Early in semester to work on course grade

Essays back...

- Diskettes being passed back, grade on diskette
- Also a file with the details
 - YTI_2420_W07_Essay_1g.doc
 - “YTI” = “Your Three Initials”
 - “_” if no middle initial on file with WSU
 - G = “graded,” comments and grades in []
- These grades, like all here, can be discussed
- This assignment, like all here, can be redone

Lab 8 Pt 1 - Carts

- How did Aristotle explain coasting?
 - Air pushed out of way coming in at back
 - Difference between taped and untaped – a problem for Aristotle
- Cart hitting barrier with block on top
 - Block slid further on top of cart
 - Many noted analogy to seat belt in car
 - How would Aristotle explain body continuing in car?
 - But the windows prevent air from coming in behind
 - Huge problem for Aristotle – no explanation

Missing a Class...

- No excuses needed
- BUT you are still responsible for the material (standard for College level).
 - Syllabus: get the notes, read them (and other assignments), and get any questions cleared up before the next class.
- To make up the grade, write a two-page summary of the NOTES (see Syllabus for details).
 - Missing one or two classes lowers your grade by only a small amount.

The Watershed

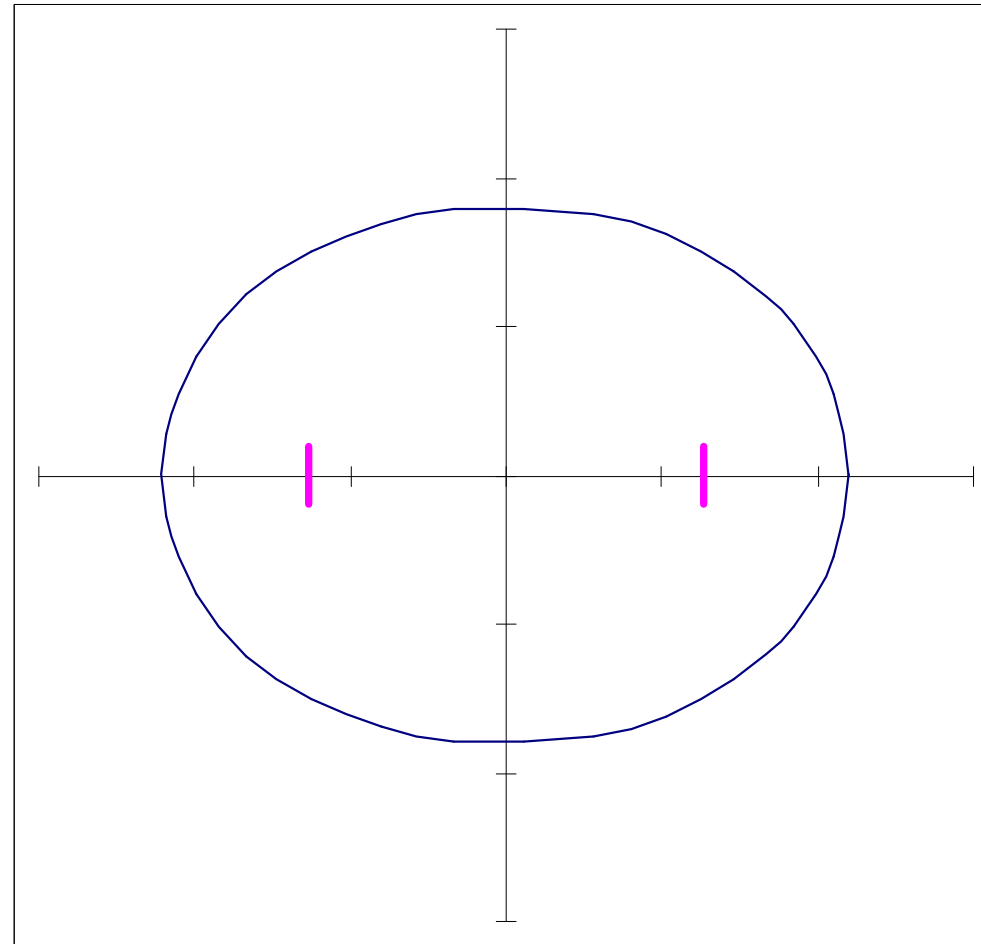
Chapter 6. The Giving of the Laws

- 1609 The New Astronomy with first two laws
 - o Precise verifiable mathematical laws, divorced from theology and spheres
 - o Solar system: free-floating bodies in space moved by forces between them

The Watershed

- Brahe “gave” Mars to Kepler – the most elliptical.
 - Brahe and others could not make it fit
- Copernican orbits centered on earth’s orbit, not sun, but sun supposed to cause orbits
- K saw balance between a force in sun (today, gravity) and a force in the planet (today, inertia or resistance to motion)

Ellipse



The Watershed

- Plane of Mars orbit passed through sun, angle between Mars plane and earth's fixed
- Initially kept circular orbits but threw out constant speed
 - reasoned that force varied with distance from sun, so speed could also
- Verified hypothesis with four of Brahe's positions, but added two – did not work

The Watershed

- Insisted on both the facts and the theory
 - A break with previous civilizations – Alfred North Whitehead
 - Even a break with K's Mysterium Cosmographicum
 - Koestler: Made necessary by change from fitting to geometrical theories towards physical causes

The Watershed

- Started over, threw out circular motion as well
- Did not assume shapes of orbits as his predecessors did
 - Only three points determine a circle
 - Calculated enough points to show the shape, had to start with earth since Mars seen from earth
 - Work on Second Law had many errors but still worked at the end

The Watershed

- Developed new methods, refined his skills
- Returned to shapes of orbits, showed Mars orbit not a circle
- Frightened by abandoning circular orbits
- Convinced himself by combining force of sun and force of planet that orbit was egg-shaped (bigger at one end)

The Watershed

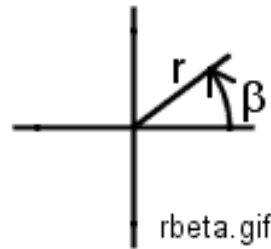
- Used ellipse as an aid to calculations for years while insisting orbit was egg-shaped
- Calculations were laying the foundation for calculus (invented by Newton later) – theory of area of irregular shapes
- Clued in by numerical relationship which seemed at first like a coincidence
- K: “The roads that lead man to knowledge are a wondrous as that knowledge itself.”

The Watershed

- Rejected an orbit because he had made a mistake in calculations and also didn't realize it was an ellipse, tried an ellipse and came back to that equation

- o $r = 1 + \varepsilon \cos \beta$

- o $\varepsilon =$ “eccentricity”



- o “Ah what a foolish bird I have been”

- But rest was mopping up

The Watershed

- Kepler saw no particular reason for these laws, or egg, did not make sense until Newton
 - Ashamed of abandoning circular orbits
- Prouder of orbits based on five regular solids
- Unique in devotion to both theory and observation, even switching back and forth
- Also deep immersion, knowing the numbers

The Watershed

- Removed astronomy from geometry to physics – motion and its causes – looked at it in a new frame
 - o Koestler: essence of creativity

The Watershed

Chapter 7. Kepler Depressed

- Publishing difficulties, difficulties getting Brahe's data, getting paid, etc. (Tengnagle)
- Broke with King, didn't give edition to King but sold it to publishers in lieu of salary
- Not a friendly reception: friends but no colleagues

The Watershed

- Germans did not recognize significance, but English did, most importantly, Newton
- Kepler getting known, somewhat happier but always complaining about health, money
- King Rudolph (patron) getting eccentric, isolated, brother grabbing kingdom
- Kepler saw a second exile coming

The Watershed

Chapter 9: Chaos and Harmony

- Galileo invented telescope, but Kepler explained how it worked – 1610: *Dioptrice*
 - Very straightforward and plain
- 1611 King Rudolph abdicated (died a year later), wife and child dead (K still kept title)
- Modest provincial mathematicus post in Linz, upper Austria, but he got the salary

The Watershed

- Religious problems – disagreed with doctrines the Lutherans later abandoned
 - o Mother accused of witchcraft in Leonburg, threatened with burning at the stake 1615 – 1621
 - o Accused of the evil eye, entering houses through locked doors and more
 - o K shot back as Imperial Mathematicus, demanded he receive all documents, etc.

The Watershed

- o Mother transferred to Wuerttemberg, led to torture chamber, refused to confess, failed “weeping test,” was released (Pg 220) a year later
- o Could not return to Leonburg – threatened with lynching
- 1618 Kepler discovered 3rd law ($t^2 \propto r^3$) more straightforwardly, with only one backtrack

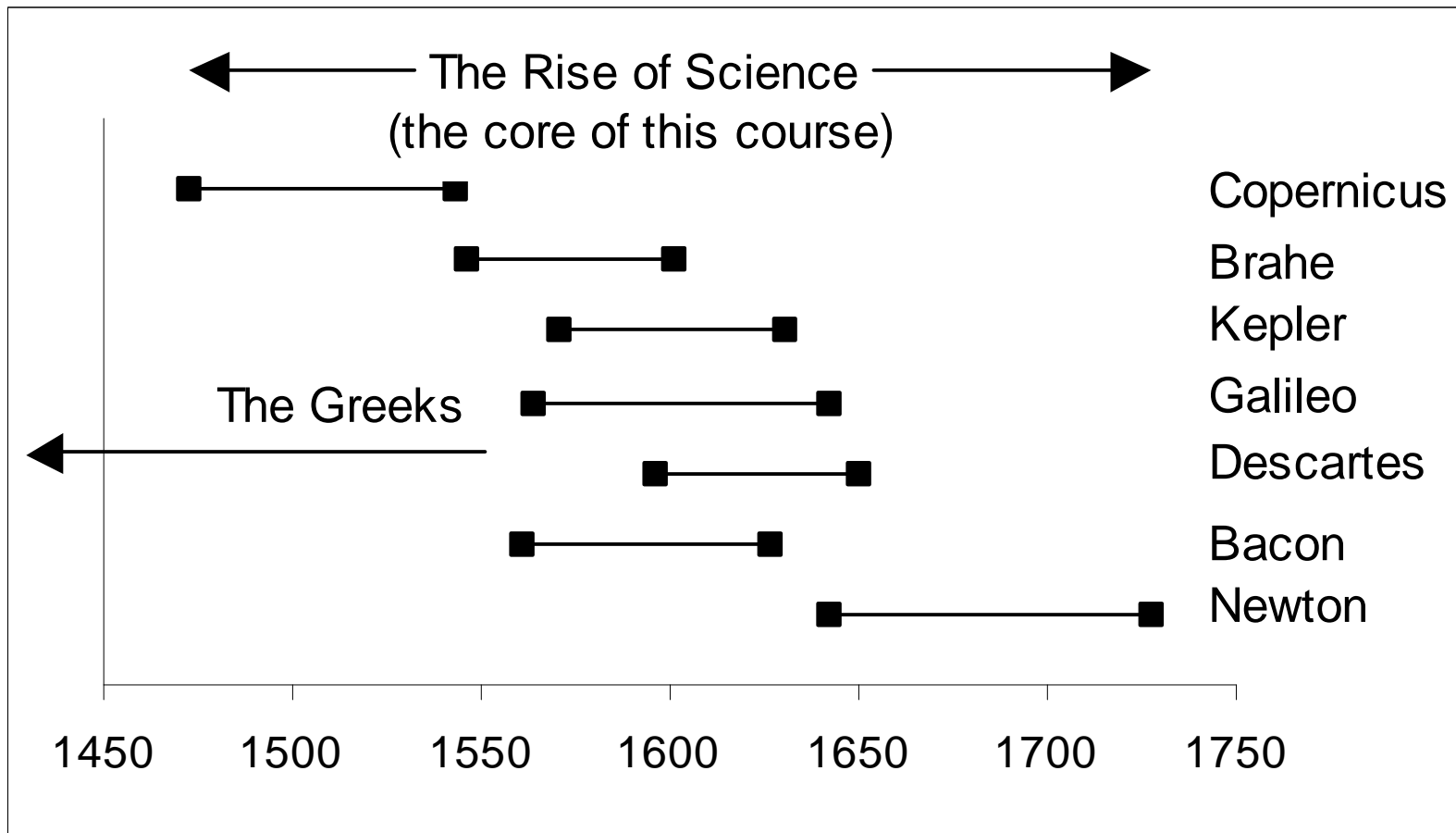
The Watershed

- Contribution of Kepler was methods; did not abandon mysticism
- Without calculus, Kepler could not see the connections between his three laws
- Koestler: “...Kepler set out to discover India and found America.”
- Quote from Heinrich Herz (discovered radio waves) Pg 225

The Watershed

- King Wallenstein wanted Kepler for astrological advice, but Kepler felt this was unethical, avoided it.
 - King got planetary positions from Kepler, gave them to his other astrologers
 - Kepler dismissed
- Wandered, looking for a position, trying to get money owed him
- Died in Ratisbon, Germany 1630

Readings – Galileo and Later



Galileo: Preview (Q25)

- Astronomical observations with telescope
 - Mountains on moon (not perfect)
 - Discovered Moons of Jupiter (Earth not unique)
 - Saw phases of Venus, argued (falsely) these were incompatible with geocentrism (Q26)
- Argued (falsely) that tides on Earth incompatible with geocentrism (Q26)
- Sensational book brought attention

Galileo (continued) (Q25)

- Publicly supported Copernicus, Church said he had to be evenhanded with Ptolemy
 - Put Pope's words in mouth of "Simplicius"
- Church (Inquisition) put him on trial, forced him to stop saying the Earth moved, put him under house arrest
 - He transformed his career
 - Apparently disagreed, privately

Boyle's Law (cont'd)

- Boyle's Law is an example of “the new Physics” Q12
 - Makes specific mathematical predictions
 - Exhibits mathematical regularities in nature
- (Modern changes:
 - Correct when atoms in gas are far apart
 - Pressures higher than this when atoms close)

Boyle's Law (cont'd)

- Mathematically: $P_1 \times V_1 = P_2 \times V_2$ Q13
 - o P: Pressure
 - o V: Volume
 - o ₁: “sub 1” means time 1 - before (a change – any change)
 - o ₂: “sub 2” means time 2 - after (the same change)
 - Assumes temperature the same at time 1 and time 2
 - Will always be the case in problems for this course
 - A more general law if temperature changes
 - o Ignore the pressure and volume units (no unit conversions here)

Boyle's Law (cont'd)

- Mathematically: $P_1 \times V_1 = P_2 \times V_2$
- Problem: given numbers for any three of P_1 , V_1 , P_2 , V_2 , find the fourth number
- Method Q13c:
 1. Identify what each of the three given numbers is
 2. Substitute numbers into Boyle's Law
 3. Multiply two numbers on same side
 4. Divide to yield answer (get unknown by itself)
- Check: multiply both sides afterwards
 - o *Know you are right*

Boyle's Law Examples

- Example 6: A gas with a volume of 20 quarts and a pressure of 1.5 atmospheres is compressed to a pressure of 6 atmospheres. Find its new volume.

Boyle's Law Examples (cont'd)

- Example 7: A gas with a volume of 3 quarts and a pressure of 4 atmospheres beforehand is expanded to a volume of 6 quarts. Find its pressure after the expansion.
- Example 8: A gas with an earlier pressure of 2 inches of Mercury and a volume of 6 cubic feet is compressed to a pressure of 3 inches of Mercury. Find its volume after the compression.

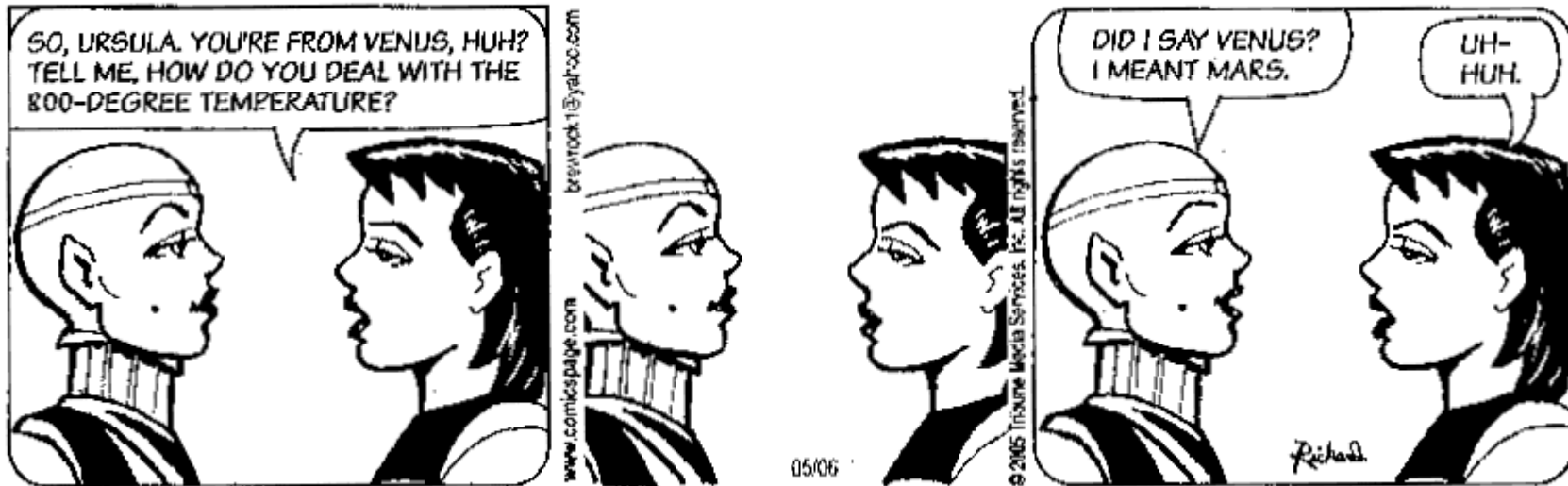
Life on Other Planets?

- Life like us?
 - May be alternate forms, but we haven't come up with any
- Deep space empty, cold, dark.
 - Life would need self-contained energy, light, materials
- Stars have energy, but temperatures are millions of degrees, much too hot

Life on Other Planets?

- So focus on planets
- In our solar system, no good candidates except Earth
 - Closer ones too hot

BREWSTER ROCKIT: SPACE GUY! By Tim Rickard



2/26/07

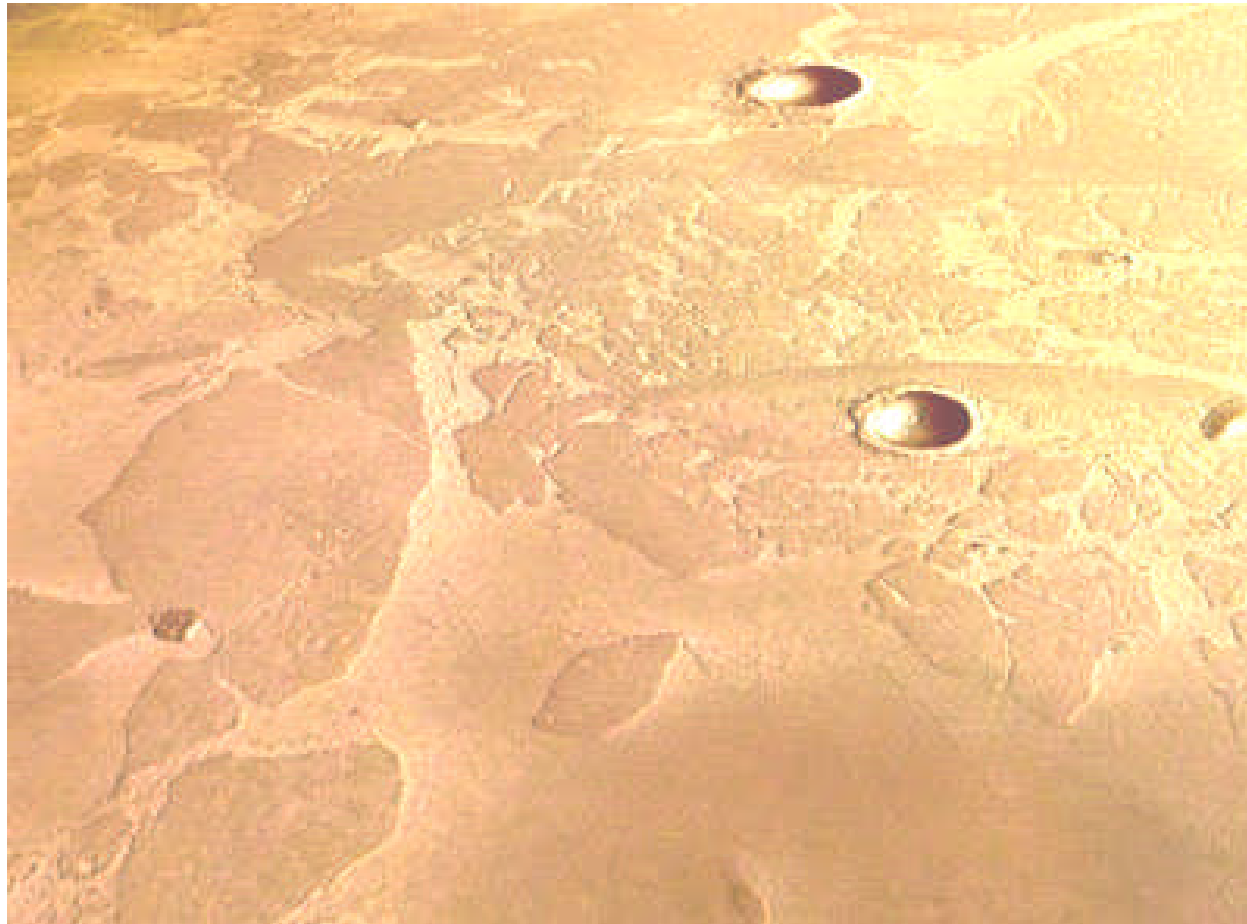
Atoms and Stars, Class 7

37

Life on Other Planets?

- So focus on planets
- In our solar system, no good candidates except Earth
 - Further ones too cold
 - Mars the best other possibility
 - Current search is for water on Mars
 - We may find microscopic life, or its remains
 - Moons too small to have atmospheres

Life on Other Planets?



Mars picture: a dust-covered frozen sea?

2/26/07

Atoms and Stars, Class 7

39

Life on Other Planets?

- Planets around other stars?
- We are finding other stars with planets
 - Present techniques best for planets close to star
 - So far, too close to star, too hot
 - If planets around other stars are common, maybe there will be some planets with the right conditions, and maybe some of them will have life

Life on Other Planets?

- Our other approach is to look for radio signals
 - SETI: Search for Extraterrestrial Intelligence
 - Distances mean powerful signals, imply a much more advanced civilization than ours
 - Long distances imply radio waves started long ago if they reach us now, would be even more advanced
- Aliens visiting earth not supported in mainstream science

For next week

- IST 2420
 - Review for Midterm
 - Read the manual, Experiment 13

Review Session

Passbacks

Question and Answer