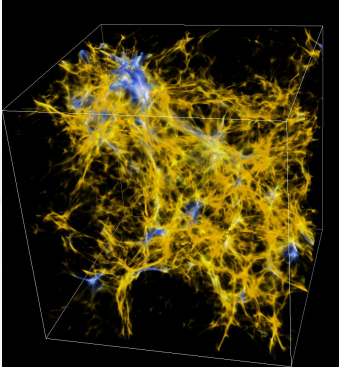


ASTR340: *The Origin of the Universe*

Prof. Massimo Ricotti
Room: PSC 1156 Phone: 301-405-5097
Email: ricotti@astro.umd.edu
Office hours: 11.00-noon Thurs
or by appointment
TA: Jongwon Park
Email: jwpark@umd.edu
Room: PSC 1238 Phone: NA
Office hours: 11am-12pm Mon




NO OPEN LAPTOPS DURING LECTURES



Welcome!

- ✦ What is this course about?
- ✦ Logistics
 - ✦ Textbook, web pages
 - ✦ Pre-requisites
 - ✦ Assignments, exams, grading
 - ✦ Academic integrity
 - ✦ Semester plan
- ✦ Discussion
 - ✦ Cosmogony : myth vs. science
 - ✦ Why is the sky dark at night?


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Cosmology

- ✦ The study of the Universe as a whole
 - ✦ What does the present-day Universe look like?
 - ✦ What was the history of the Universe?
 - ✦ What is the future of the Universe?
 - ✦ What makes the whole thing “tick” ?
- ✦ These are clearly **big questions!**

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Textbook & web pages

- ✦ Required text: *Foundations of Modern Cosmology* (2nd edition) by Hawley & Holcomb
- ✦ Course web page:
 - http://www.astro.umd.edu/~ricotti/NEWWEB/teaching/ASTR340_18.html
 - ✦ Information, syllabus, lecture schedule
 - ✦ Assignments
 - ✦ Past lectures
 - ✦ Each lecture is posted the day before
 - ✦ Interesting material (e.g., links to simulations, Nobel lectures)

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Pre-requisites

- ✦ Mathematics

- ✦ High-school algebra and geometry/trig

- ✦ Familiarity with astronomy at ASTR100 level

- ✦ Course will be fairly self-contained

- ✦ I will use basic astronomy terms freely (e.g. star, planet, galaxy), and will cover some topics quickly

- ✦ Consult chapters 4 and 5 of the textbook for review/refresher, as needed

- ✦ Please ask about anything when you are unsure!

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Assignments & Grading

- ✦ Assignments:

- ✦ Homework: 30%

- ✦ Midterm : 25%

- ✦ Final : 30%

- ✦ Participation/quizzes: 15%

- ✦ TOTAL : 100%

Grades and HW on ELMS, everything else on my webpage

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- ✦ **Note: No “extra-credit projects”**

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Letter grades

★ Grading by:

Letter grade	Percentage
A	85-100
B	70-84
C	60-69
D	40-59
F	0-39

- ★ I will curve final scores for a B median
- ★ This means that homework is important!

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Exams

- ★ One mid-term, in class October 18th
- ★ Final exam, 1:30-3:30 pm Dec 17th
- ★ Special arrangements? Let me know asap
- ★ In event of a REAL EMERGENCY which forces you to miss an exam
 - ★ Contact me prior to the exam if at all possible
 - ★ Document the emergency

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Homeworks

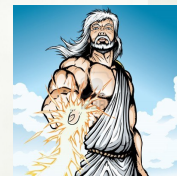
- ★ Homework assigned approx. once every 2/3 weeks (6 total)
- ★ HW is collected *at the start of class* on the due date (a week later)
 - ★ Please hand in on time, or document the valid reason why it is late.
 - ★ No credit after the day on which it is due.
 - ★ Missed because of emergency? Document it

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Academic integrity

- ★ **Always:**
 - ★ Present your own thoughts in your own words
 - ★ Cite any references that you use
- ★ **Never:**
 - ★ Copy from another student
 - ★ Allow other students to copy from you.
 - ★ Directly quote any published article unless you also give full credit to that article.
- ★ Per campus policy, please write the honor pledge on each assignment



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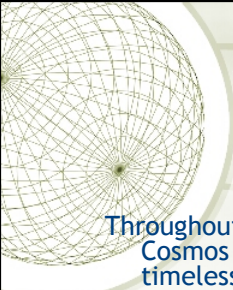
10



Topics to cover

- ✦ Early history of cosmology
- ✦ The laws that govern the Universe
 - ✦ Newton's laws of motion and gravitation
 - ✦ Einstein's Theory of Relativity
- ✦ Observations of the Universe
 - ✦ The universe is expanding!
 - ✦ What does the future hold?
- ✦ The Big Bang Theory
 - ✦ What is it...
 - ✦ ... and why do we think its right?
- ✦ Physics of the very early universe

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Discussion: myth and science in cosmogony

Throughout history, all cultures have sought to make the Cosmos intelligible, imposing order and addressing timeless questions:

- ✦ Have the heavens and Earth existed forever?
- ✦ Is the Universe unendingly large?
- ✦ If not, how did it all begin?
- ✦ Will the Universe come to an end?
- ✦ How did humans come about, and what is their role in the Universe?

- ✦ *What are your questions?*
- ✦ **Cosmogony** = an explanation of the origin and evolution of the Universe
- ✦ **Cosmology** = the **scientific** study of the formation, structure, and evolution of the Universe

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Creation myths

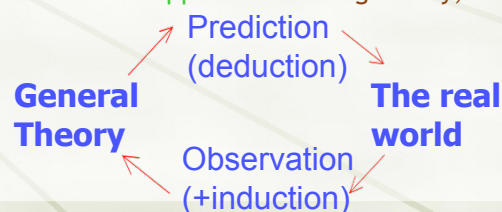
- ✦ Myths may be meant literally or figuratively
- ✦ Mythology reflects what is important to a culture, e.g.
 - ✦ revolve around seasons, planting & harvesting for agricultural societies
 - ✦ involve animals with human characteristics for hunter-gathering peoples
- ✦ Creation myths share common themes
 - ✦ Use similar imagery to describe origins/formation of the Universe: e.g creation from seed/egg; supreme craftsman; order from chaos
 - ✦ Use past events to explain aspects of the human condition
 - ✦ Involve catastrophes and supernatural occurrences
 - ✦ Establish relationships among animals, humans, gods
 - ✦ Assert the centrality of humans to the Cosmos

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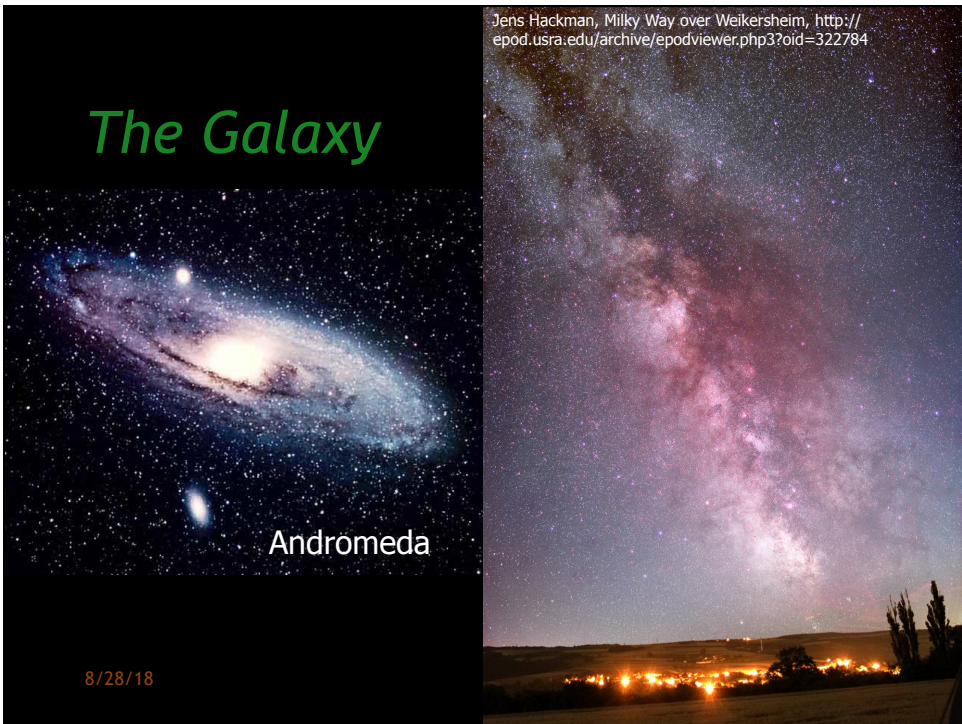
Scientific cosmology

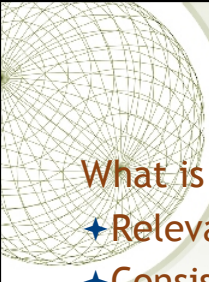
- ✦ Non-anthropocentric narrative
- ✦ Is based on concept of causality, but not purpose
- ✦ Derives from **data** = objective (reproducible), quantitative observations of the physical world
- ✦ For scientists, the word **theory** means something very serious
- ✦ Models/theories are continually re-evaluated based on the **scientific method**
- ✦ To be scientific, **a theory must be falsifiable** : whole or part may be rejected based on new data
- ✦ New data can **support** an existing theory, but **cannot prove it**



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The scientific method

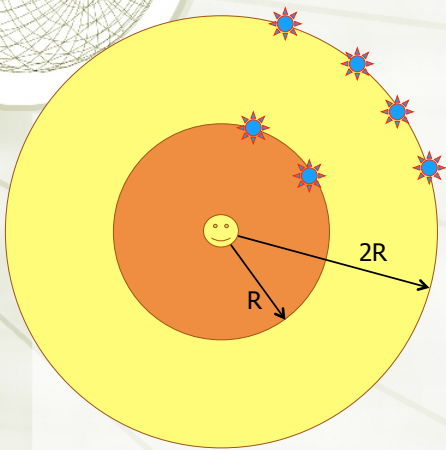
What is a “theory”? Let’s start with a hypothesis

- ★ Relevant (explanatory power)
- ★ Consistent (within and without)
- ★ Predictive (qualitative and quantitative)
- ★ Testable (falsifiable)
- ★ Simple (Occam’ s razor)

A hypothesis that survives significant tests of many of its predictions can become a *theory*, and perhaps even a *law*.

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Why is the night sky dark?

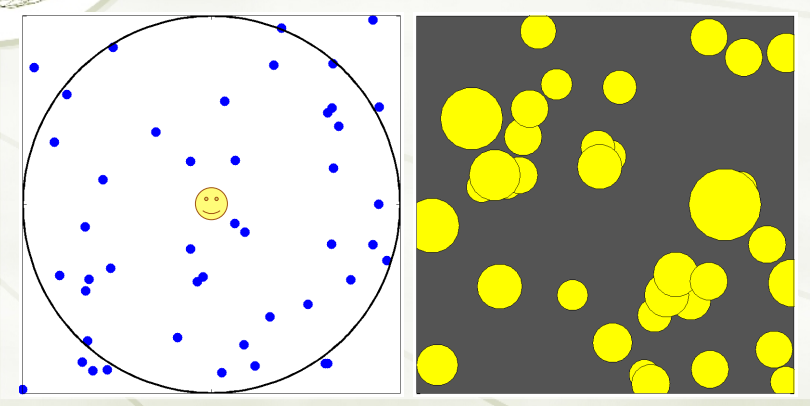


- $A \sim R^2$, so if there are N stars in the first shell, there will be $2^2=4N$ stars in the second shell
- Stars in the second shell are half the apparent size of stars in the first shell (they are 2x farther), so each one covers $\frac{1}{4}$ of the area
- Thus, each shell contributes $4N \times \frac{1}{4}A = NA$ **the same** to the brightness of the night sky independent of distance!

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Why is the night sky dark?

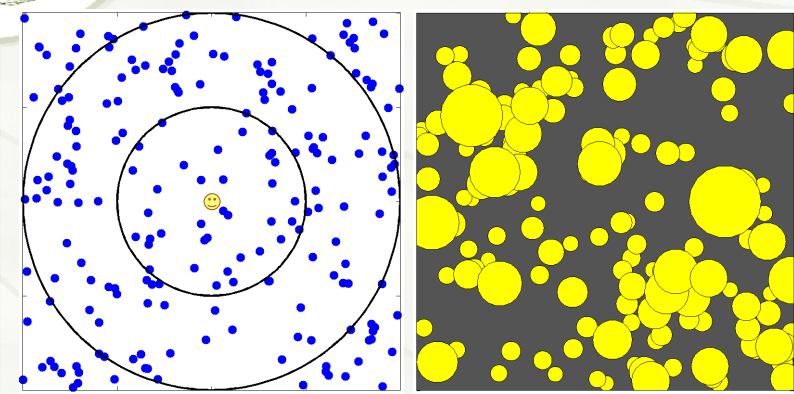
Olber's Paradox



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Why is the night sky dark?

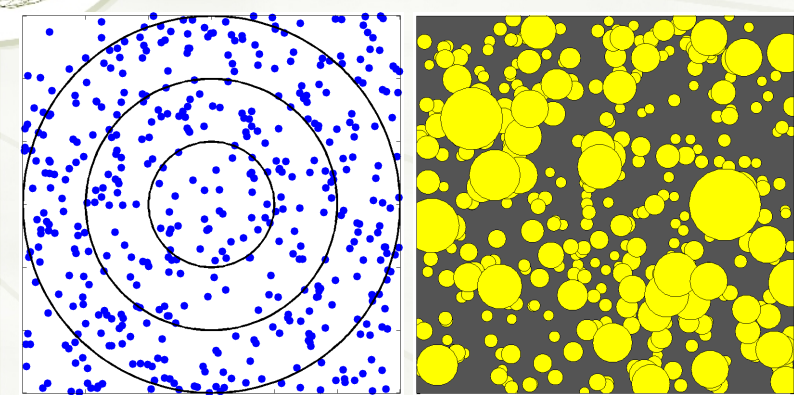
Olber's Paradox



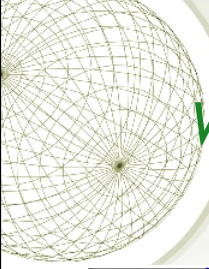
8/28/18 21

Why is the night sky dark?

Olber's Paradox

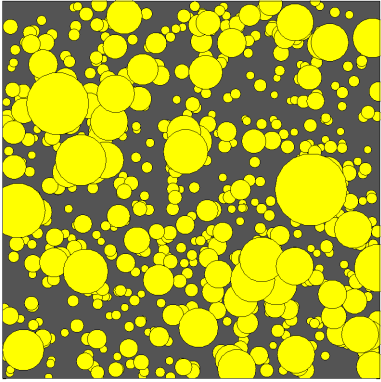
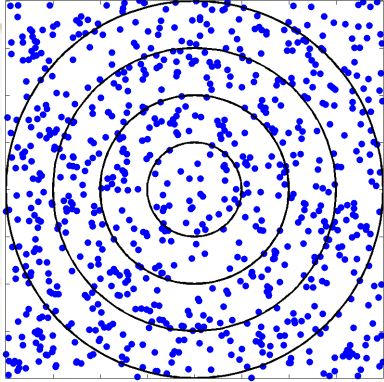


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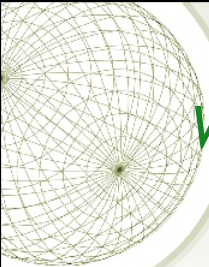
Why is the night sky dark?

Olber's Paradox



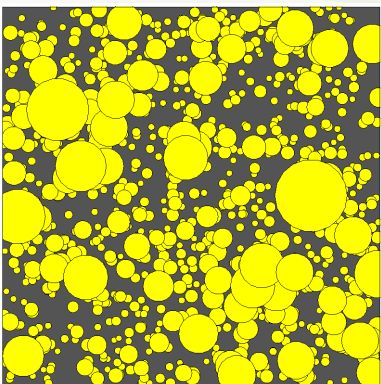
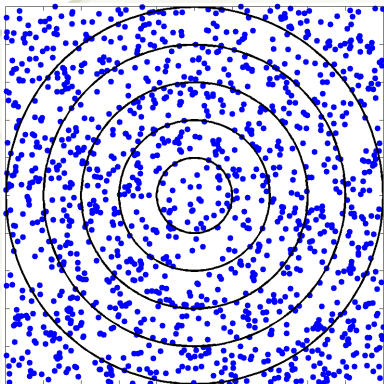
8/28/18 23

This slide illustrates Olber's Paradox. It features a wireframe sphere in the top left corner. The main title is "Why is the night sky dark?" in green, and the subtitle is "Olber's Paradox" in brown. Below the text are two square diagrams. The left diagram shows a central point with four concentric circles. The space between these circles is filled with small blue dots, representing stars. The right diagram shows a dark background filled with numerous yellow circles of varying diameters, representing stars of different sizes and brightnesses. At the bottom left of the slide is the date "8/28/18" and at the bottom right is the number "23".



Why is the night sky dark?

Olber's Paradox



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This slide is identical to the one above, illustrating Olber's Paradox. It features a wireframe sphere in the top left corner. The main title is "Why is the night sky dark?" in green, and the subtitle is "Olber's Paradox" in brown. Below the text are two square diagrams. The left diagram shows a central point with four concentric circles. The space between these circles is filled with small blue dots, representing stars. The right diagram shows a dark background filled with numerous yellow circles of varying diameters, representing stars of different sizes and brightnesses. At the bottom left of the slide is the date "8/28/18" and at the bottom right is the number "24".



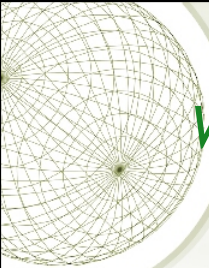
Why is the night sky dark?

Olber' s Paradox



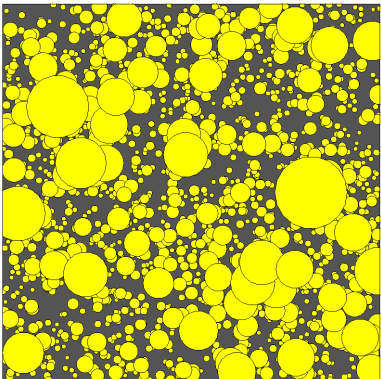
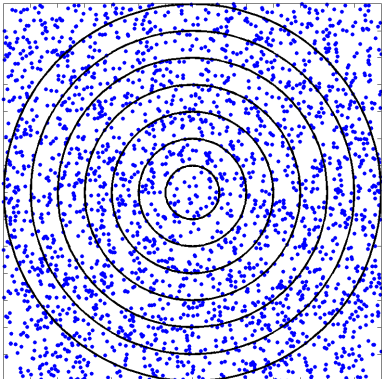
8/28/18 25

This slide illustrates Olber's Paradox. It features a wireframe sphere in the top left corner. The main text asks "Why is the night sky dark?" and identifies the concept as "Olber' s Paradox". Below the text are two square diagrams. The left diagram shows a central point with several concentric circles. The space between these circles is filled with small blue dots, representing stars. The right diagram shows a field of yellow circles of various sizes, representing stars of different apparent magnitudes. At the bottom left is the date "8/28/18" and at the bottom right is the number "25".



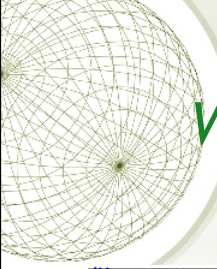
Why is the night sky dark?

Olber' s Paradox



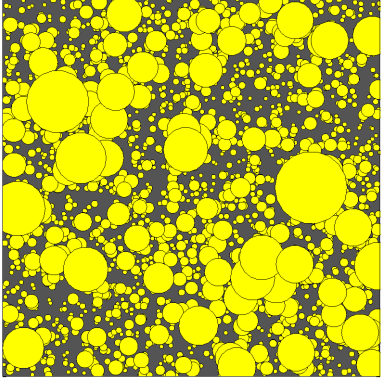
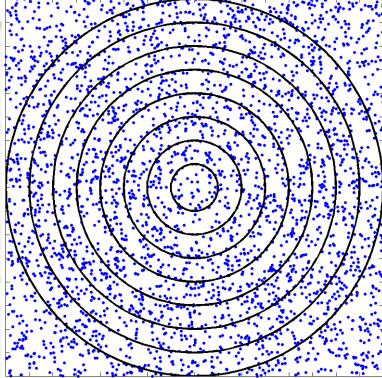
8/28/18 26

This slide is identical to the one above, illustrating Olber's Paradox. It features a wireframe sphere in the top left corner. The main text asks "Why is the night sky dark?" and identifies the concept as "Olber' s Paradox". Below the text are two square diagrams. The left diagram shows a central point with several concentric circles. The space between these circles is filled with small blue dots, representing stars. The right diagram shows a field of yellow circles of various sizes, representing stars of different apparent magnitudes. At the bottom left is the date "8/28/18" and at the bottom right is the number "26".



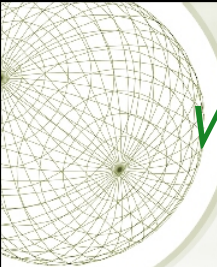
Why is the night sky dark?

Olber's Paradox



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This slide illustrates Olber's Paradox. It features a wireframe sphere in the top-left corner. The main content consists of two side-by-side diagrams. The left diagram shows a central point with several concentric black circles. The space between these circles is filled with a uniform distribution of small blue dots, representing stars. The right diagram shows a field of yellow circles of various sizes, representing stars of different apparent magnitudes. The text 'Why is the night sky dark?' is written in green, and 'Olber's Paradox' is in brown. The date '8/28/18' and the number '27' are at the bottom.



Why is the night sky dark?

Olber's Paradox



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This slide is identical to the one above, illustrating Olber's Paradox. It features a wireframe sphere in the top-left corner. The main content consists of two side-by-side diagrams. The left diagram shows a central point with several concentric black circles. The space between these circles is filled with a uniform distribution of small blue dots, representing stars. The right diagram shows a field of yellow circles of various sizes, representing stars of different apparent magnitudes. The text 'Why is the night sky dark?' is written in green, and 'Olber's Paradox' is in brown. The date '8/28/18' and the number '28' are at the bottom.



Why is the night sky dark?

Olber's Paradox



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The diagram illustrates Olber's Paradox. On the left, a square field of blue dots is overlaid with concentric circles centered on a point. The number of dots increases as the radius of the circles increases, representing the increasing number of stars in a uniform, infinite universe. On the right, a square field of yellow circles of varying sizes is shown, representing the cumulative brightness of stars in such a universe, which would result in a bright, featureless sky.



An online demo

★ <http://carma.astro.umd.edu/AWE/>

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The slide provides information about an online demo related to Olber's Paradox. The demo is located at the URL <http://carma.astro.umd.edu/AWE/>.



Next Time...

- ★ Will discuss
 - ★ classical (geocentric) model of the Universe
 - ★ observations and ideas of the Renaissance
- ★ *Please read Chapter 1 of the book*
- ★ *Read Chapter 2 next week*
- ★ First HW assigned Thursday next week

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