Active Learning Techniques for Astronomy Courses at All Levels

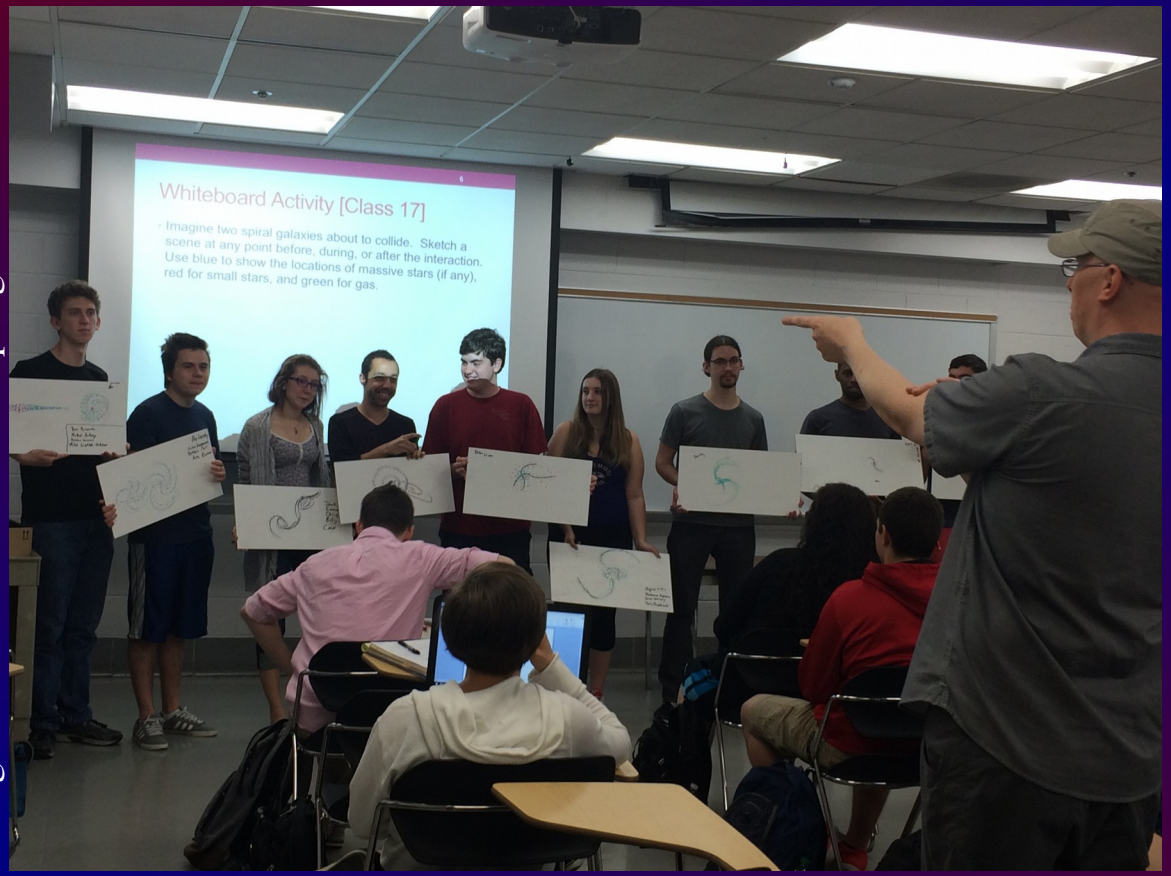

Image from UMD ASTR121 Spring 2016

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2016 GROWTH Education Workshop

Talk Outline

- What is the goal of active learning?
- Some Active Learning Activities
- Getting Student Buy-In
- Incorporating Active Learning Activities into Your Course
- Resources

What is the goal of active learning?

"Active learning is a process whereby students engage in activities, such as reading, writing, discussion, or problem-solving that promote analysis, synthesis, and evaluation of class content."

Description from Center for Research on Learning and Teaching at University of Michigan

What is the goal of active learning?

Traditional lecture promotes a culture of memorization and "stamp-collecting" among many students, even those that are interested in the subject.

When you test the conceptual understanding (for example, using concept inventories) of these students, their understanding is often quite superficial.

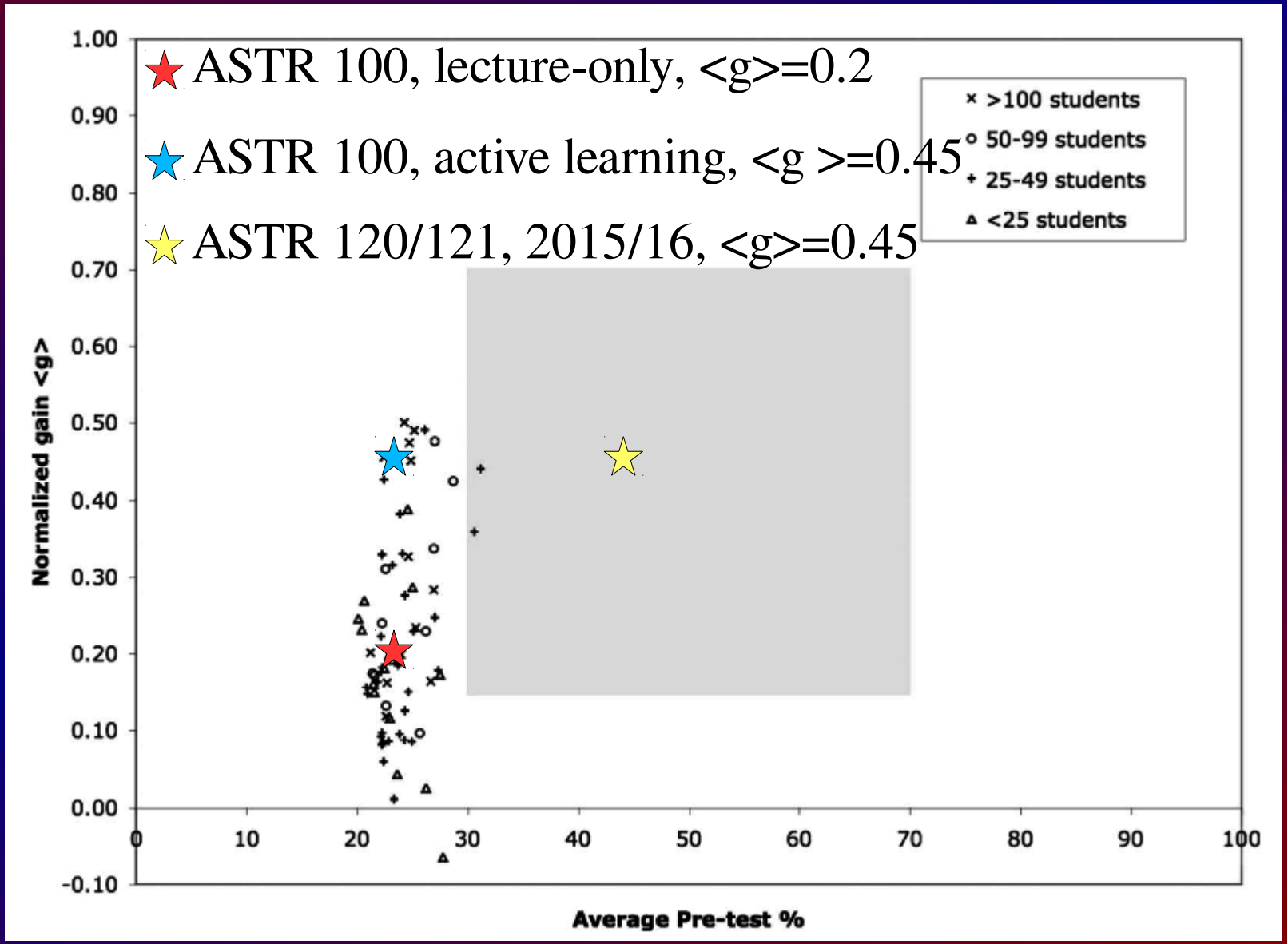
What is the goal of active learning?

Providing students with appropriate, well-chosen, and challenging questions and activities can cause them to:

- think more deeply about the material
- consolidate their understanding of the material
- confront uncertainties, contradictions, or gaps in their understanding

What is the goal of active learning?

69 intro, non-major Astronomy courses with almost 4000 students evaluated using LSCI. (Prather et al., 2009, Am. J. Phys., 77, 4, 320.)



Some Active Learning Activities

There are many activities that can be used and adapted for nearly all levels of students:

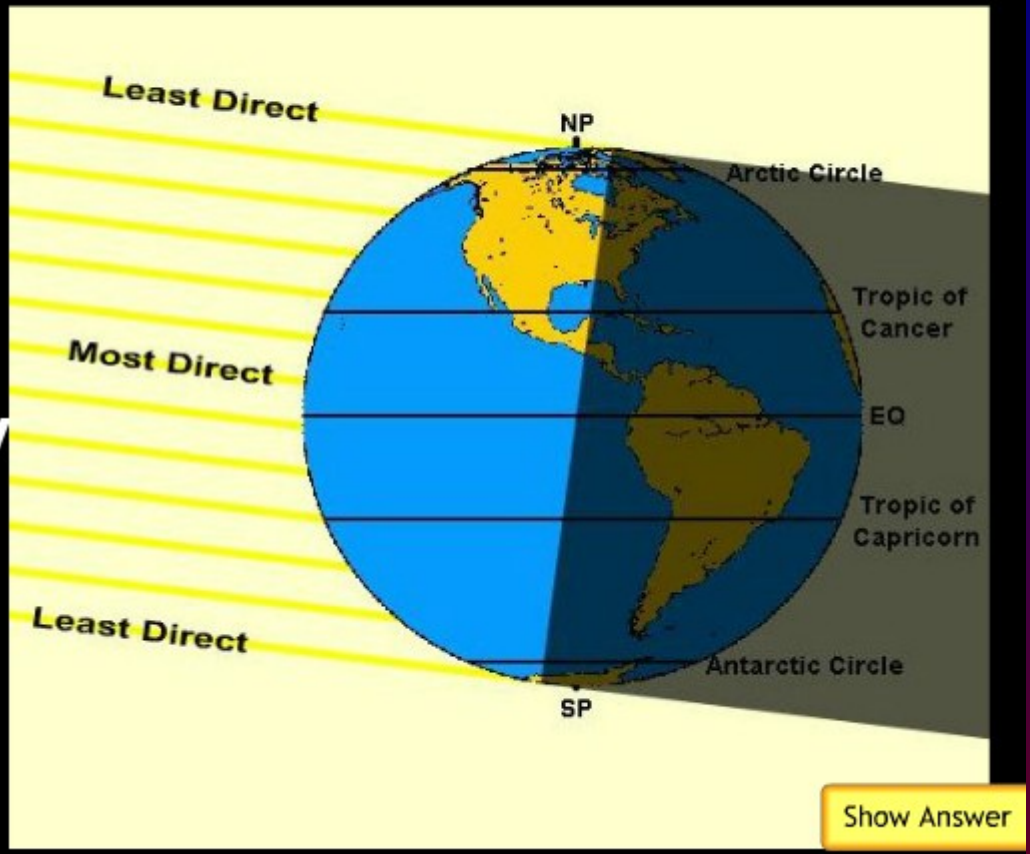
- Think-Pair-Share questions (i.e., “clicker” questions)
- Lecture-tutorials
- Ranking tasks
- Group activities
  - discussion questions
  - visual questions
  - targeted calculations
- Writing and critiquing

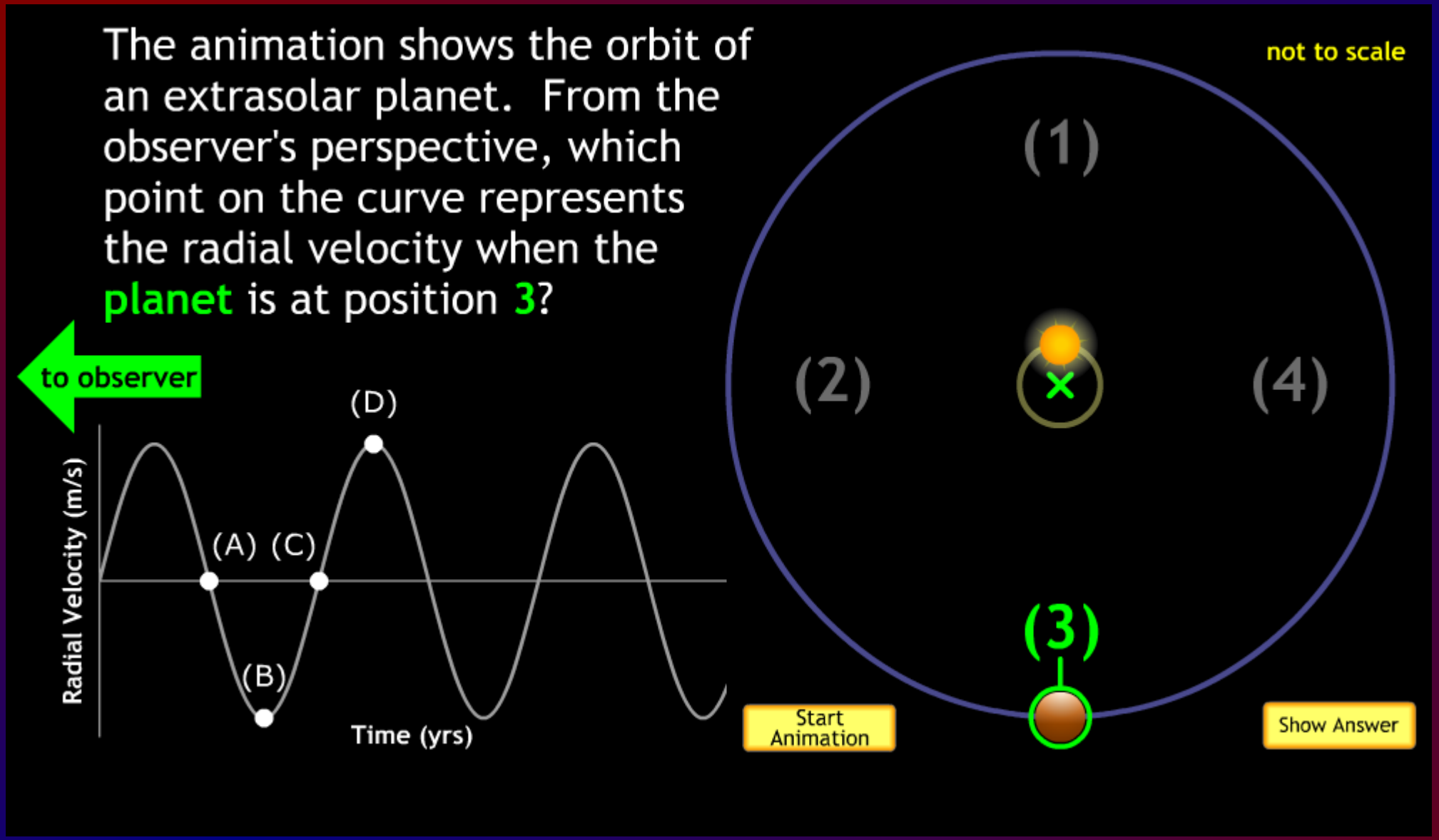
Think-Pair-Share Questions

- Present the students with a multiple choice question
- Students think on their own and submit an answer, either with a "voting card" or clicker (THINK)
- If most (>= 85%) answer correctly, go on.
- If not, students discuss their answer and reasoning with their neighbors (PAIR)
- Students re-vote (SHARE) – usually most answer correctly. If not – **teachable moment!**

The image shows the Earth being hit by the sun's rays on _____?

A) June 21
B) September 21
C) December 21
D) October 21 (or February 21)
E) April 21 (or August 21)





both planet and star are orbiting counterclockwise

Think-Pair-Share Questions: Why?

- When students discuss with their peers, they are practicing how to think through problems and articulate their reasoning.
- If other students point out flaws in reasoning, or explain something that isn't understood at all, it is remembered better.
- The activity forces students to think about the material instead of passively absorbing information.
- The instructor gets immediate feedback on student understanding.

Lecture-Tutorials

- Written by astronomy educators and field-tested to vet question order, effectiveness, and wording.
- Lead students through exploration of underlying concepts for typical topics such as seasons, phases of the Moon, Doppler shift, binary stars, Hubble Law, and more.
- Written for intro non-major students, but can be adapted/expanded for higher-level students.

Figure 1 shows Earth, the Sun, and five different possible positions for the Moon during one full orbit (dotted line). It is important to recall that one-half of the Moon's surface is illuminated by sunlight at all times. For each of the five positions of the Moon shown below, the Moon has been shaded on one side to indicate the half of the Moon's surface that is **not** being illuminated by sunlight. Note that this drawing is not to scale.

1) Which Moon position (A–E) best corresponds with the Moon phase shown in the upper-right corner of Figure 1? Make sure that the Moon position you choose correctly predicts a Moon phase in which only a small crescent of light on the left-hand side of the Moon is visible from Earth.

   Enter the letter of your choice: _____

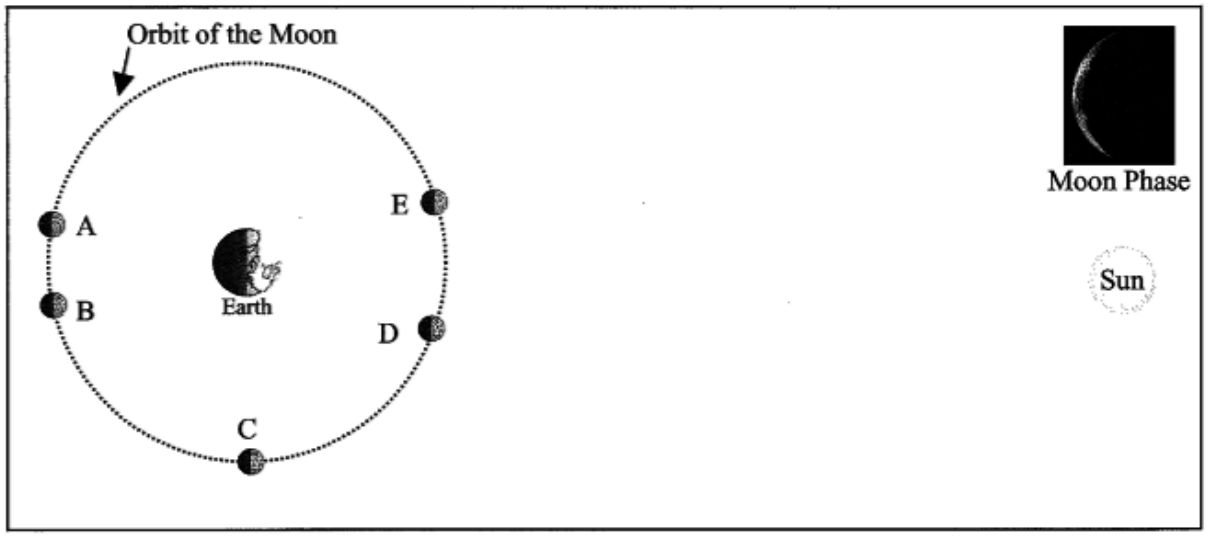


Figure 1

2) In the blank boxes below, sketch how the Moon would appear from Earth for the four Moon positions that you did **not** choose in Question 1. Be sure to label each sketch with the corresponding letter indicating the Moon's position from Figure 1.

Lecture-Tutorials: Why?

- Lead the student through conceptual understanding in multiple steps.
- Often connects to visuals and spatial thinking.
- Helps students check correctness of their thinking by providing “student conversations”.
- Since they are done in groups, they provide another opportunity for students to articulate their reasoning to others.

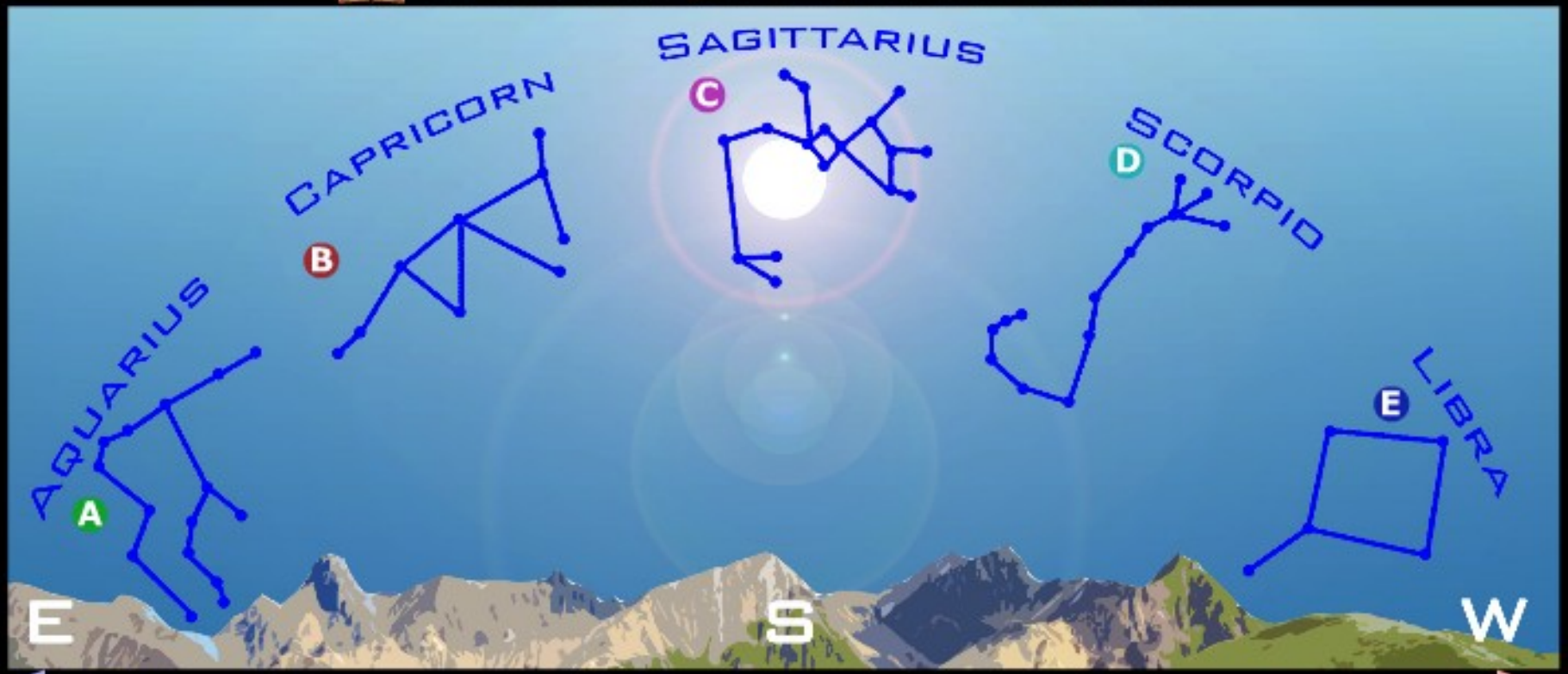
Ranking Tasks

- Ordering tasks that encourage students to think quantitatively without scaring them with math
- Developed for intro non-major students, but can be adapted for higher-level students

Directions: If you could see both the Sun and the other stars during the day, this is what the sky would look like looking south at noon on January 1 for an observer in the northern hemisphere. Rank the constellations in order that they would first appear to rise above the horizon on this day, from first to rise to last to rise.

NOTE: First place the objects in order, and then click the button between two objects if they are equal.

Click here for background information on this problem



first to rise ← last to rise

C < A < D < E < B

Group Activities: Discussion Questions

- Open-ended questions that encourage students to think about a concept in a way that you direct by your choice of question.

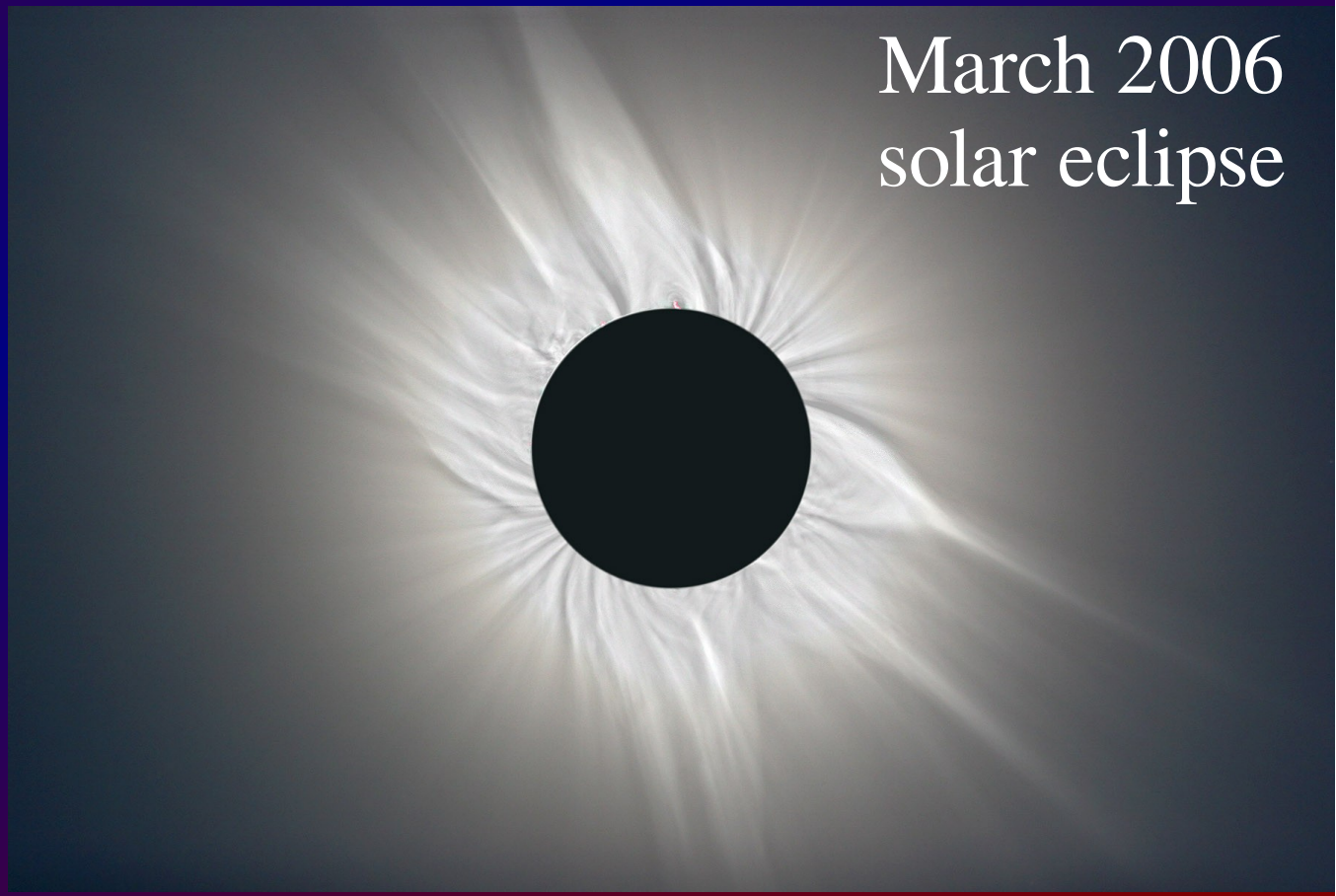
- Students discuss in a small group. Gives them time to think through the problem. Allows them to practice articulating their thinking. Less intimidating to answer for a group than as an individual.

Example discussion question: intro level

Discuss with your group:

During a solar eclipse, you can see part of the Sun's atmosphere that is about as hot as the Sun's core. When there's no eclipse, we usually just look right through this part of the Sun's atmosphere.

Why isn't fusion happening in this part of the Sun's atmosphere?



March 2006 solar eclipse

Example discussion question: higher intro level

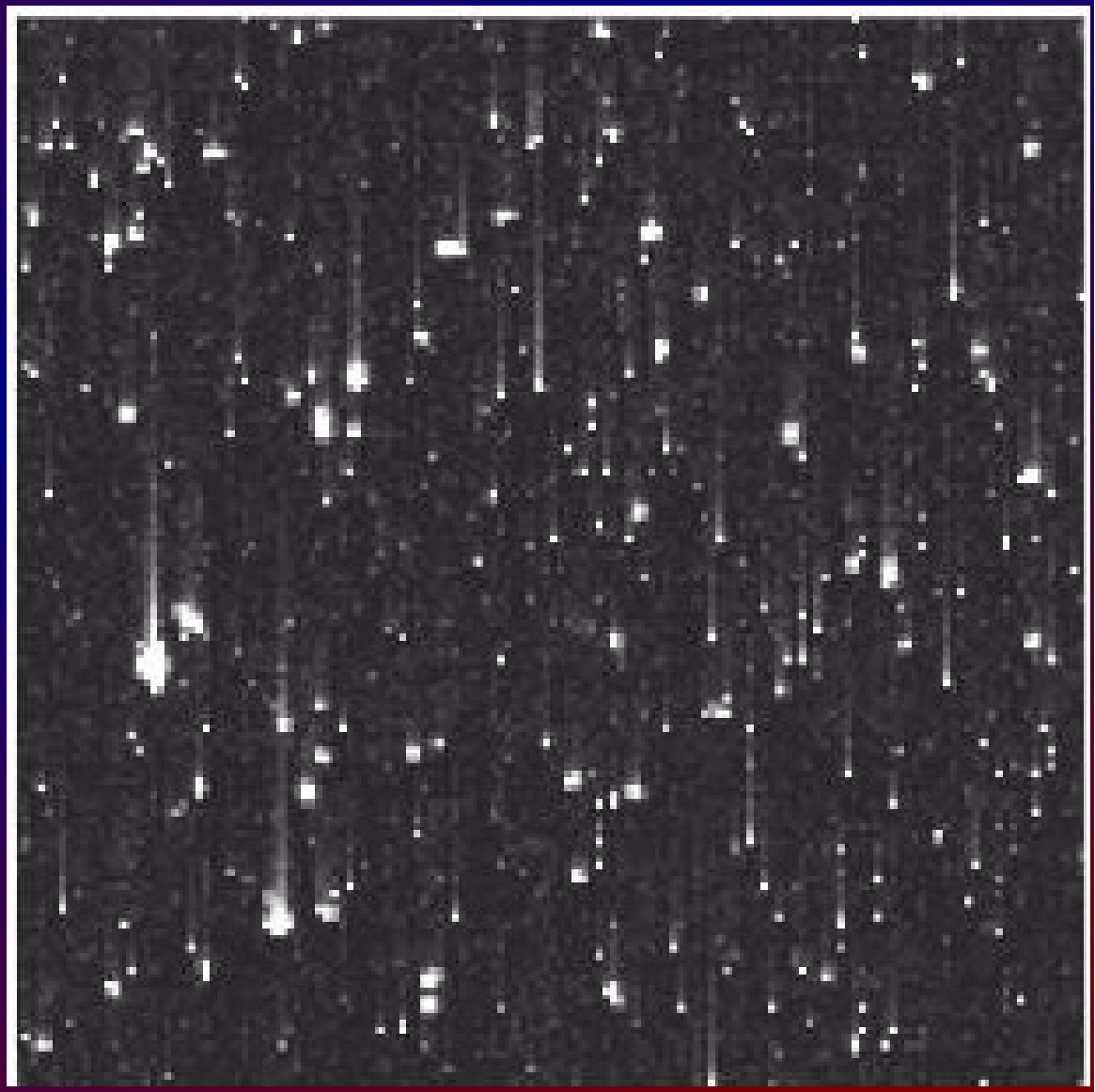
Discuss with your group: Suppose you're out watching the sky. You're facing directly south, and you see the view in the picture below, with the tall tree directly south of you.

As the night goes on, different stars will pass by the top of the tree. What will the RA and DEC of these stars be like compared to the RA and DEC of the star that's there right now?

Image from rcstalon.wordpress.com

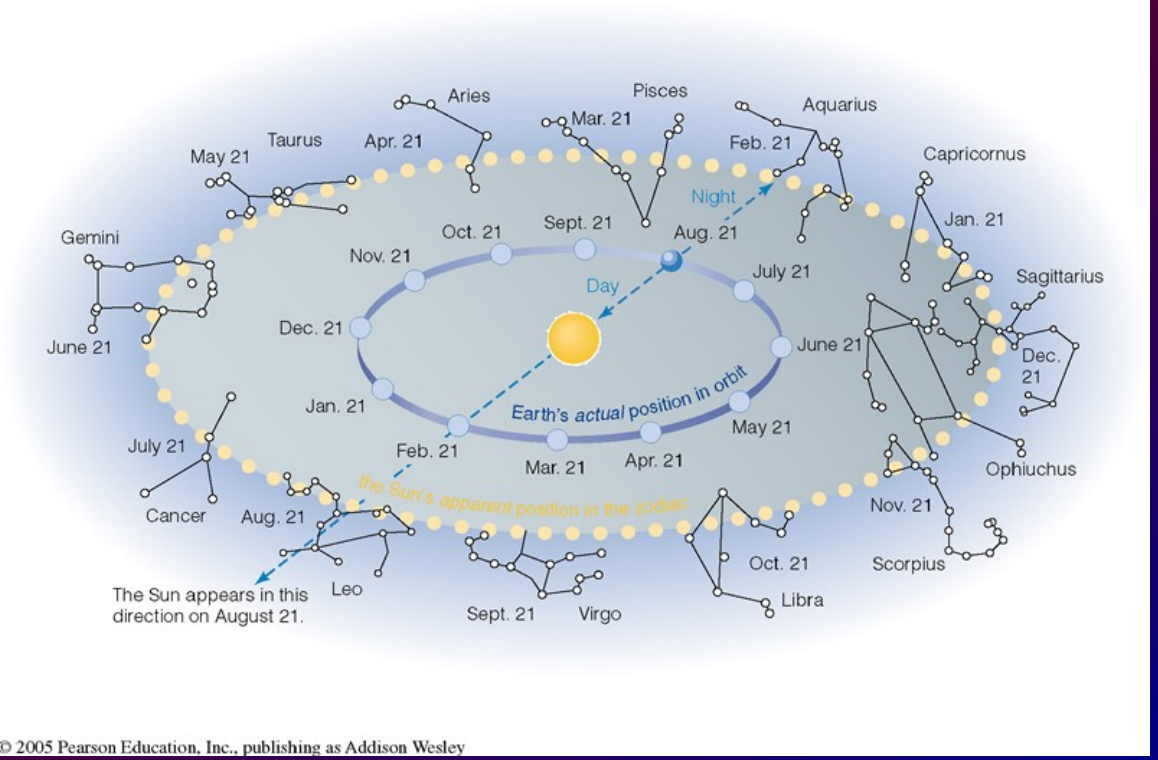
Example discussion question: major level

With your team: What is odd-looking about this CCD image? What do you think caused it?



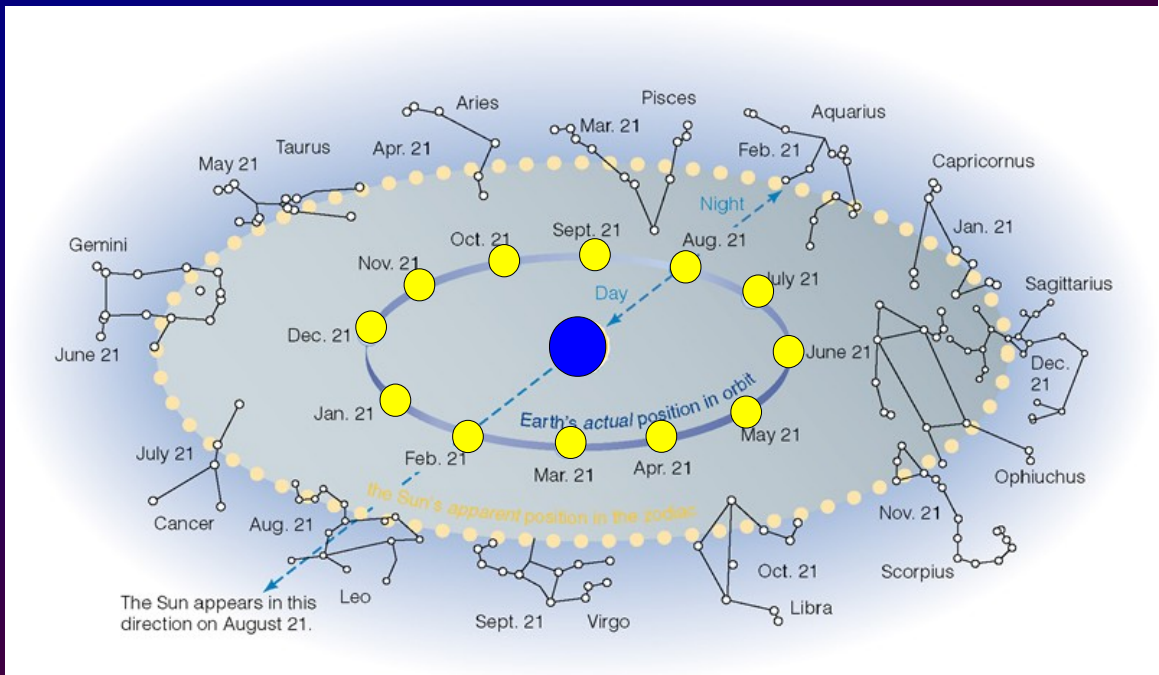
Group Activity: Visual Questions

- Discussion questions that encourage students to interpret, label, or draw a figure/graph.
- Many students don't understand which parts of a figure/graph are most important, so they get fixated on unimportant details.
- Questions also facilitate conceptual understanding by requiring students to think about important details, like the slope of a curve.



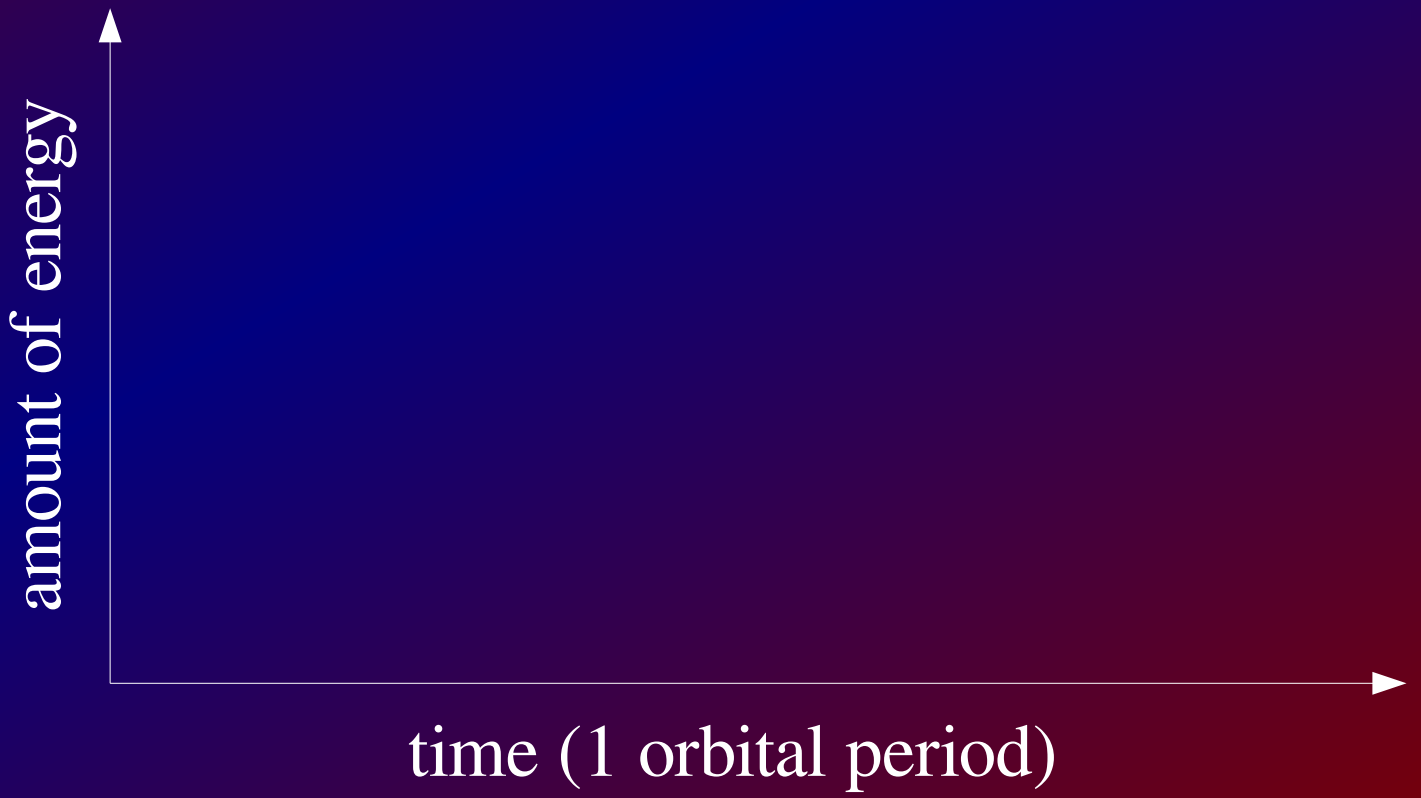
Where are the Earth and Sun on the diagram when you can see Gemini at night?

Is it possible to see Gemini at night if the Sun orbits Earth?



On transparency with team (put on team name):

1. Think about a planet orbiting the Sun on a **circular orbit.**
2. **Sketch and label** the planet's orbital energy, kinetic energy of its orbital motion, and gravitational potential energy on the graph.



Group Activity: Targeted Calculations

- Give students experience with relevant calculations by assigning individuals or groups different versions of the same type of calculation – the different versions illuminate patterns or exceptions.

- Adapt this to different levels by changing what initial info is given, what units are used/given, and how many steps are involved.

With your team: Calculate the theoretical angular resolution (in arcsec) for your telescope.

Team	Telescope	Diam (m)	λ (Angstroms)
	Subaru	8.2	5500
	Keck	10	5500
	Arecibo	300	5×10^9
	Spitzer	0.85	50,000
	GALEX	0.5	2000
	Chandra	1.2	12
	Planck	1.5	3×10^4
	IRTF	3	10,000

Writing and Critiquing

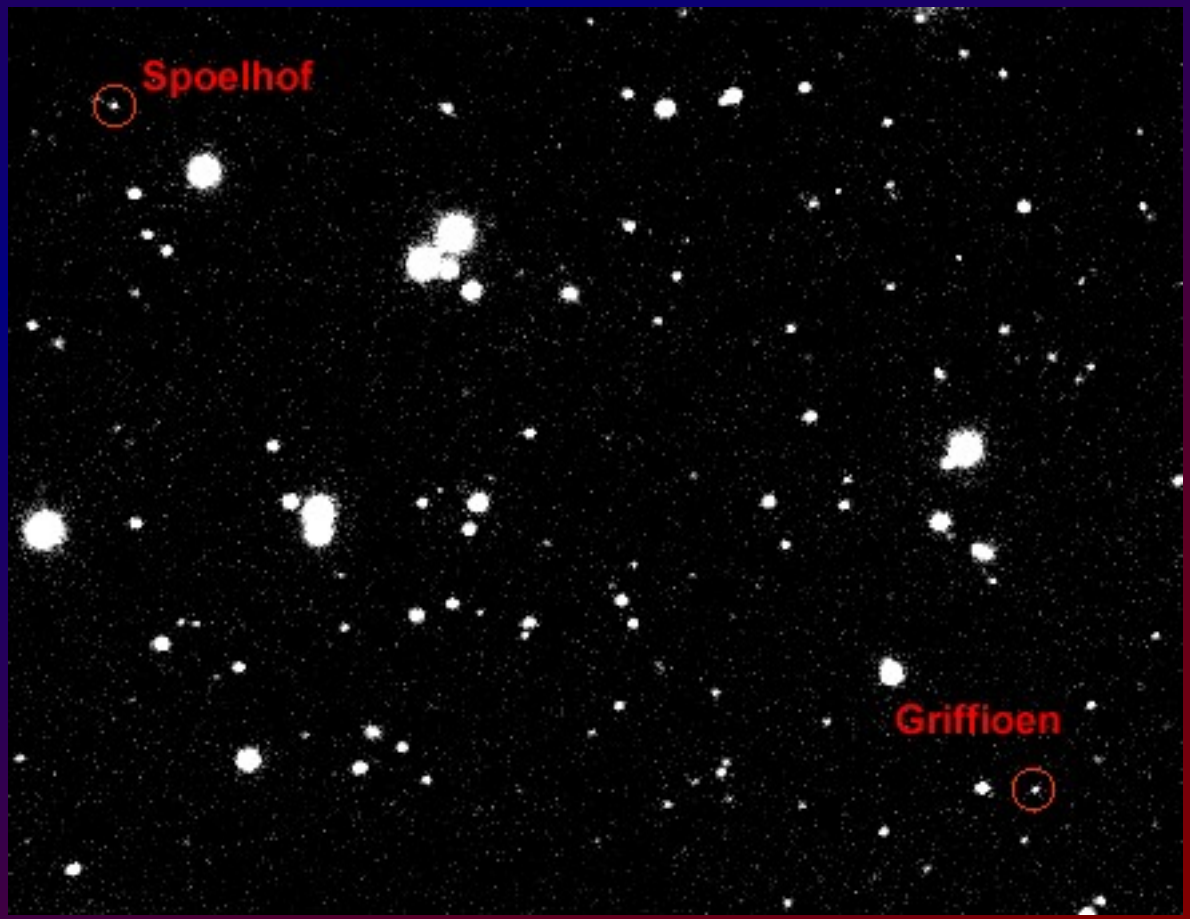
- Students write a short (~1 paragraph) answer to an open-ended question. Students exchange a draft of their answer with another student, and read and critique the other student's answer. They discuss their critiques, and then re-write their answers.

- Give students experience in articulating their reasoning in writing and with the discipline's jargon.

- Give students experience in evaluating another's reasoning.

Topic Brief 8: Feb. 18, 2016

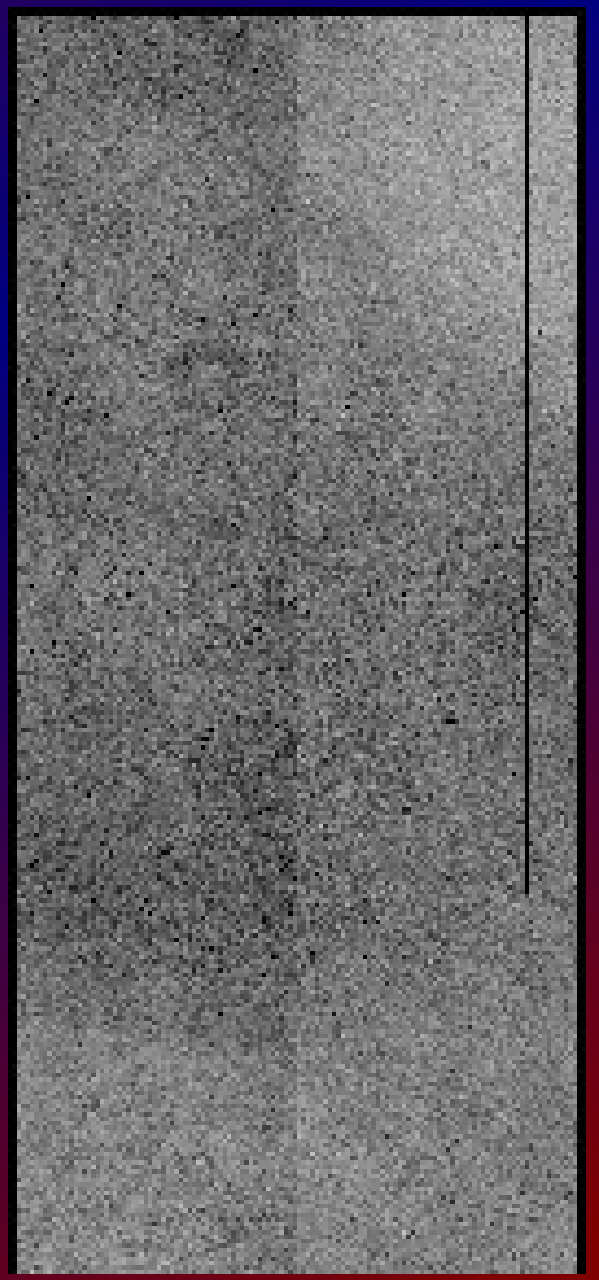
Imagine that you show the senator the image of two asteroids. You tell him that Griffioen is about 2 km across, and Spoelhof is about 4 km across. The senator asks, "Why do they appear the same size in the image?" Explain what is happening.
(Hint: remember that all you know about the asteroids when you are talking to the senator are their diameters and what this image looks like.)



Write a draft BY YOURSELF on paper.

In-Class Activity

What could be causing the image artifact that appears as the thin, vertical black line toward the right edge of the image? Explain your reasoning. (Hint: think about how CCDs read out.)



One of CCDs from CFHT's MegaCam

Getting Student Buy-In

- In order for active learning activities to be effective, the students must participate earnestly.
- Some students may be upset or feel cheated if they don't receive a lecture for the whole class time - they feel like you are not “teaching”.
- You need to make sure you have student “buy-in”.

Getting Student Buy-In

- Be sure to let your students know on the first day of class that you will be incorporating active learning activities, and how much time will be spent on them.

- Explain WHY you are incorporating these activities - education research shows that they are **more effective** than lecture in helping students learn.

- You should choose active learning activities that are related to the learning goals of the course, and on homeworks and exams, be sure to give problems that relate to the same learning goals.

Incorporating Active Learning Activities into Your Course: Learning How to Use Them

- It takes some practice to be comfortable using many of these activities.
- If you're new to active learning, try only 1 or 2 types of activities at first.
- Education researchers have put effort into developing best practices for many of the activities.
- You can make adapt the activities for your particular course and students, but try to preserve the pedagogical value.

Incorporating Active Learning Activities into Your Course: Learning How to Use Them

- Learn best practices by attending professional development workshops such as the Center for Astronomy's Tier I Workshop at AAS and the New Faculty Workshop by APS.

- Many schools have a teaching excellence center that should be knowledgeable in these activities and be able to help you implement them.

- If at all possible, ask another knowledgeable person to view a class and give you feedback on how activities are going.

Incorporating Active Learning Activities into Your Course: Realities

- Adding active learning activities to your courses will take development time outside of class and will take time in class – you will have to decide what material to focus on.

- You will have to experiment to see which activities work best for you and your students – they won't all go right the first time. That's OK!

Incorporating Active Learning Activities into Your Course: Realities

- You will also get to know your students better via the activities – you and they will be more invested in the course.
- Including active learning activities makes a course so much more interesting to teach – it is never the same!
- You will discover misunderstandings and ideas that you never would have realized the students have.