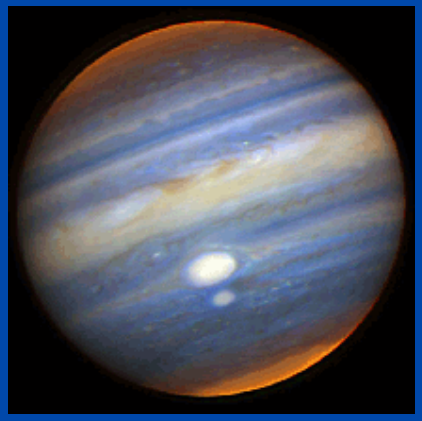
Astro 18: Planets and Planetary Systems
Lecture 1: Overview



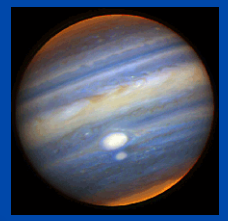
Claire Max

UC Santa Cruz

September 23, 2010

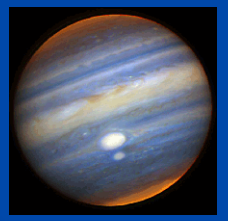
Class website:
http://www.ucolick.org/~max/Astro18_2010/Astro18.html

Who we are, office hours, sections

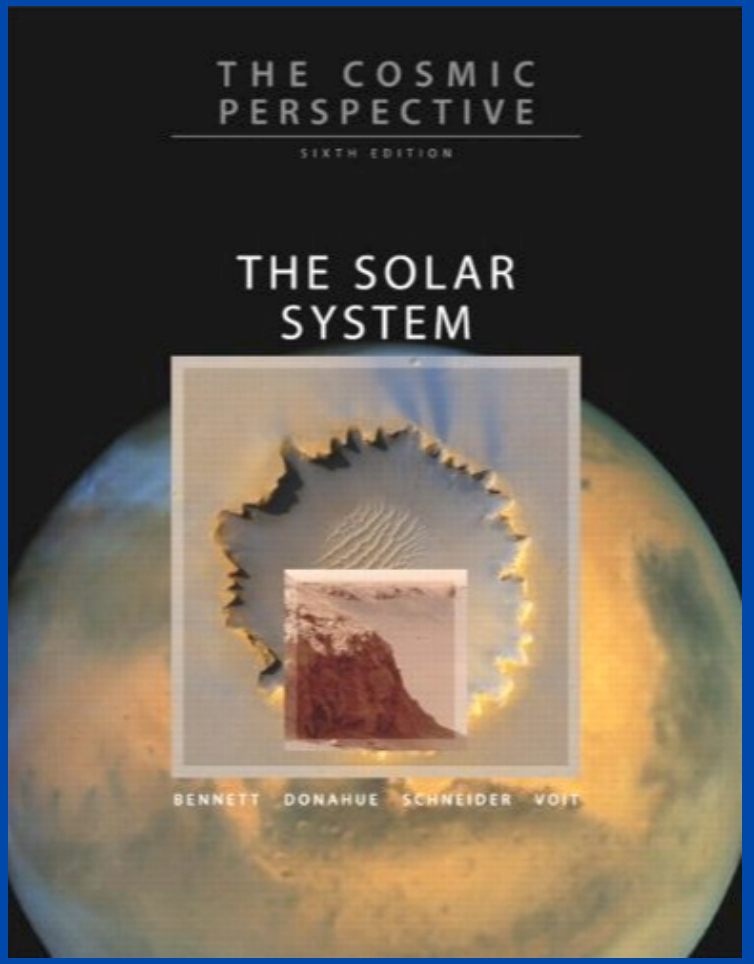


- **Claire Max, Professor**
  - **Office hours Thursdays 2:00 – 3:00 pm, Center for Adaptive Optics, room 205**
- **Jenn Burt, Teaching Assistant**
  - **Office hrs Mondays 11am – 12pm, Interdisciplinary Sciences 255**
- **Other meeting times can be arranged in person**
- **Sections will be in a room still to be determined**
  - **You must attend 1 section per week *and* 1 lab every other week**
  - **Times to be determined (poll on Tuesday)**
  - **We will discuss further toward end of this lecture**

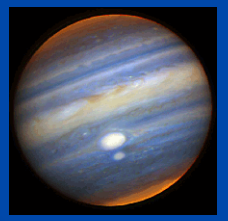
Textbook



- The Cosmic Perspective: The Solar System (6th Edition) with media update
- Authors: Bennett, Donahue, Schneider, Voit
- Publisher: Addison-Wesley / Pearson

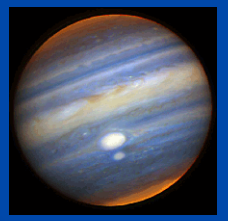


Two class websites



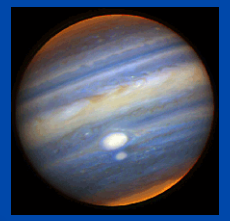
- http://www.ucolick.org/~max/Astro18_2010/Astro18.html
  - My own website for this class
  - All class lectures will be posted here
  - Class announcements, schedules, homework assignments and solutions, links to useful websites
- Mastering Astronomy: http://masteringastronomy.com/
  - Website related to the textbook – login info with text
  - Some of the homework problems, many self-help tutorials, PDF version of the textbook

Outline of this lecture



- Overview of our Solar System and of other planetary systems
- Five minute break
  - Please remind me to stop at 12:45 pm!
- Overview of Astro 18
  - What is the course about?
  - Goals of the course
  - How the course will work

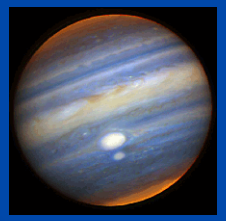
Overviews



- **Our Solar System**

- **Other planetary systems**

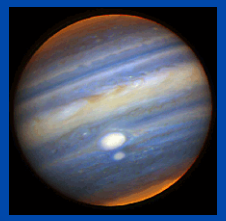
First…

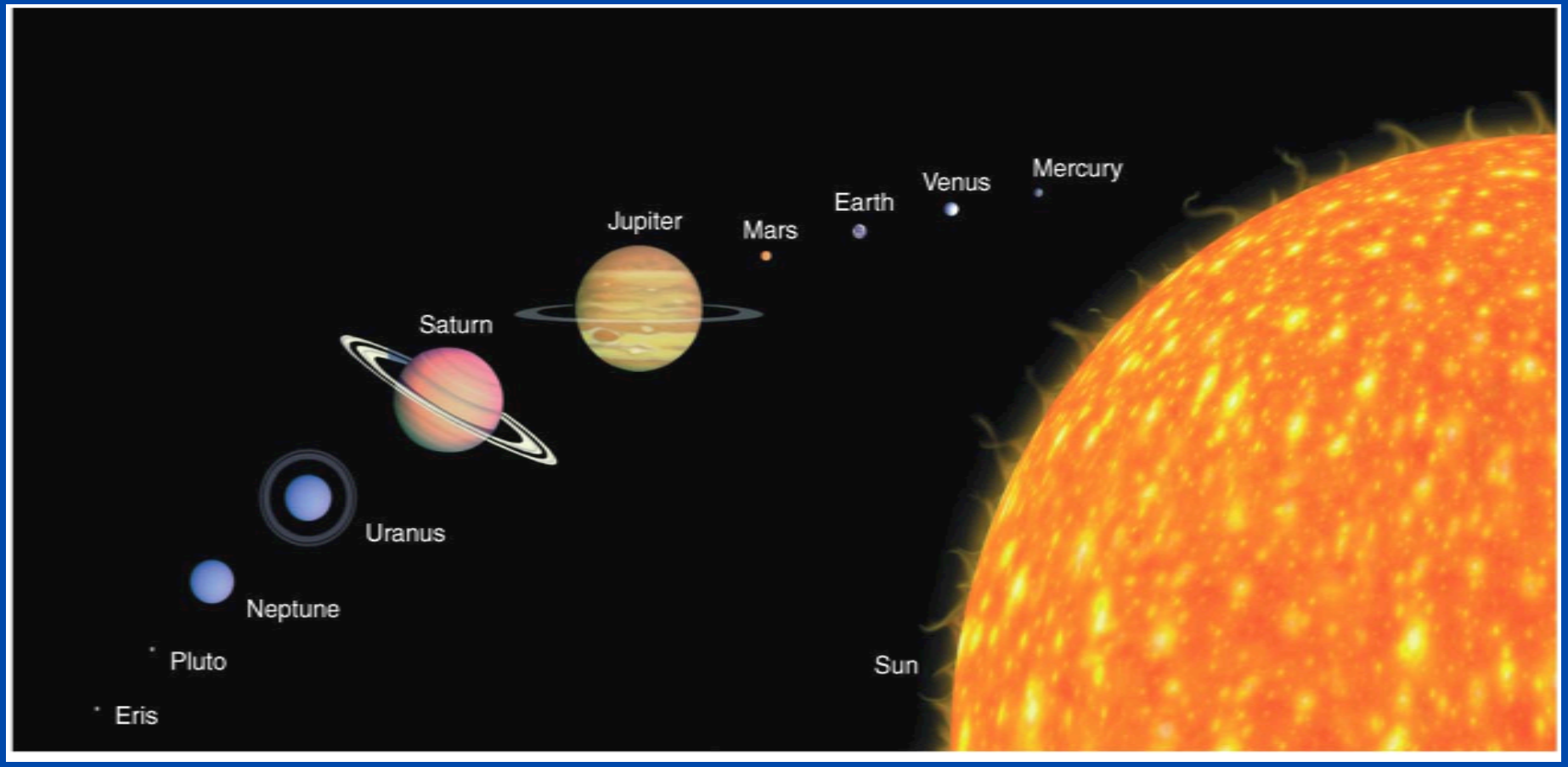


- **Who has seen a planet? What did it look like?**

- **Who has looked through a telescope? What did you see?**

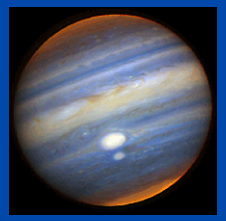
Our Own Solar System

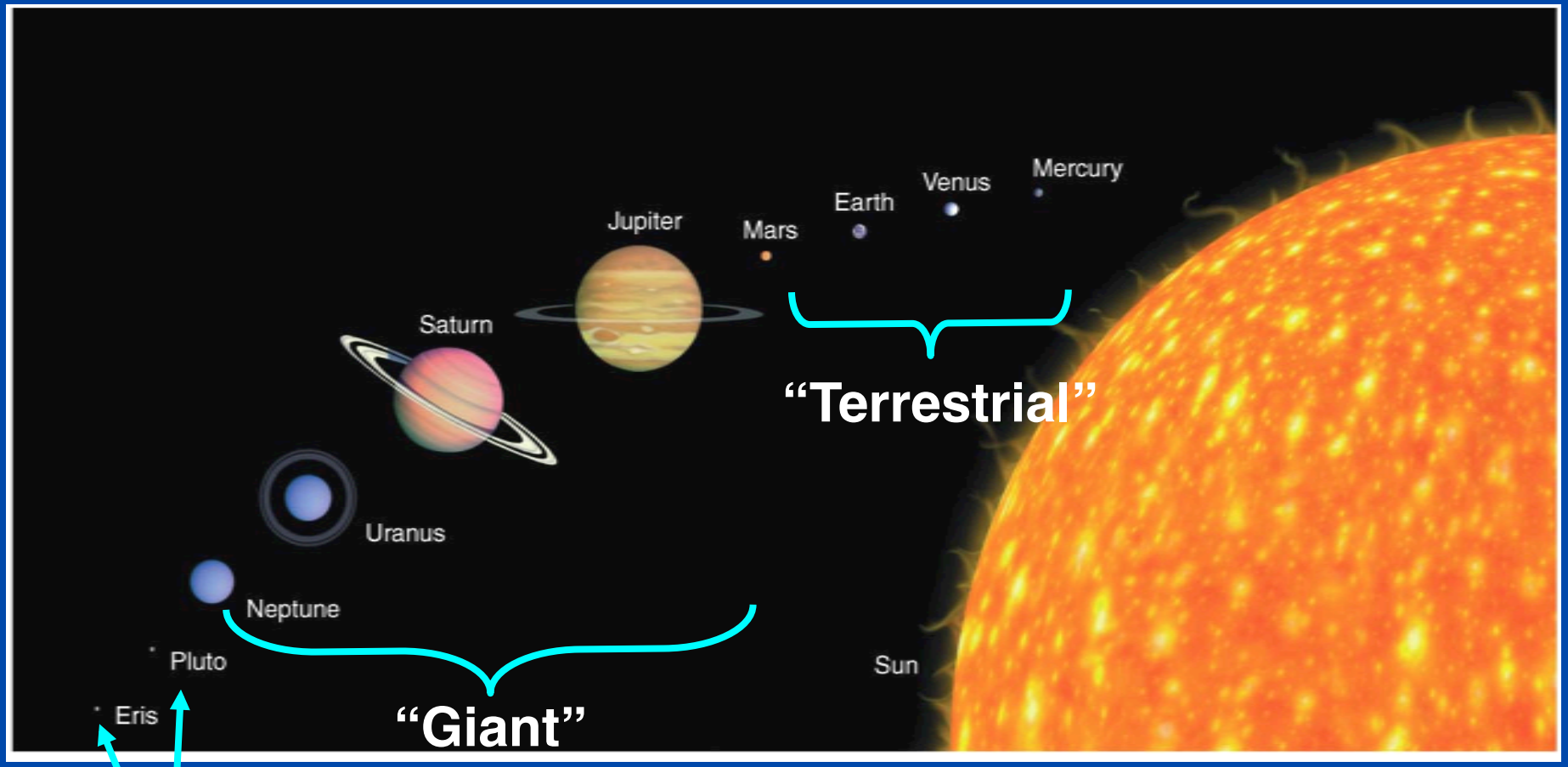




- Relative sizes are in correct proportions
- Relative distances are all wrong here

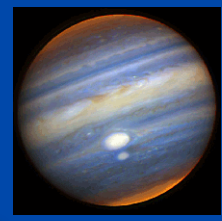
Sub-categories of planets





"Dwarf Planets"

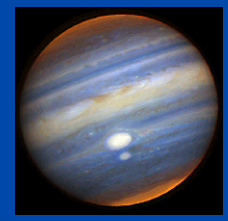
Status of (poor old) Pluto?



- In 2007 the Internationa
  Astronomical Union vo
  that Pluto and bodies li
  were "dwarf planets"
- Not "real planets"
- Very contentious!
- We'll discuss this in a later lecture

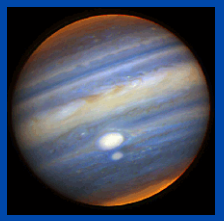
It turns out there are many Pluto-like objects in our Solar System

How to remember order of planets?



- Mercury Venus Earth Mars Jupiter Saturn Uranus Neptune (Pluto?)
- Mnemonic: a sentence with same first letters of words. Helps remember a list. Examples for the original nine planets:
  - My very eager mother just sent us nine pizzas
  - My very energetic monkey just swung under nine palmtrees
- Extra credit on mid-term exam:
  - Come up with a new mnemonic for the first eight planets. (Prepare ahead of time). I'll post them all on web, and we'll vote on the best.
  - Can start at either closest (Mercury) or farthest (Neptune) from Sun.

More Solar System inhabitants

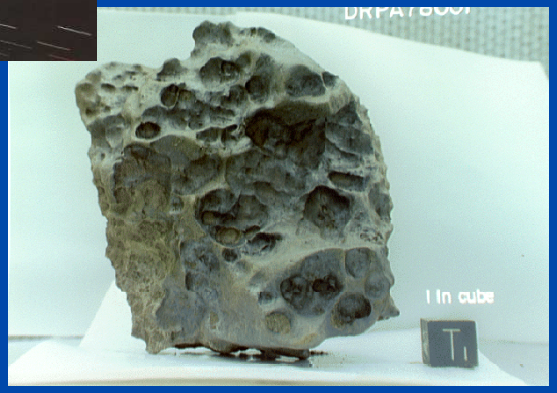


- Asteroids

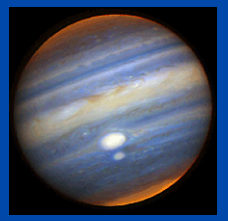
view from Galileo spacecraft

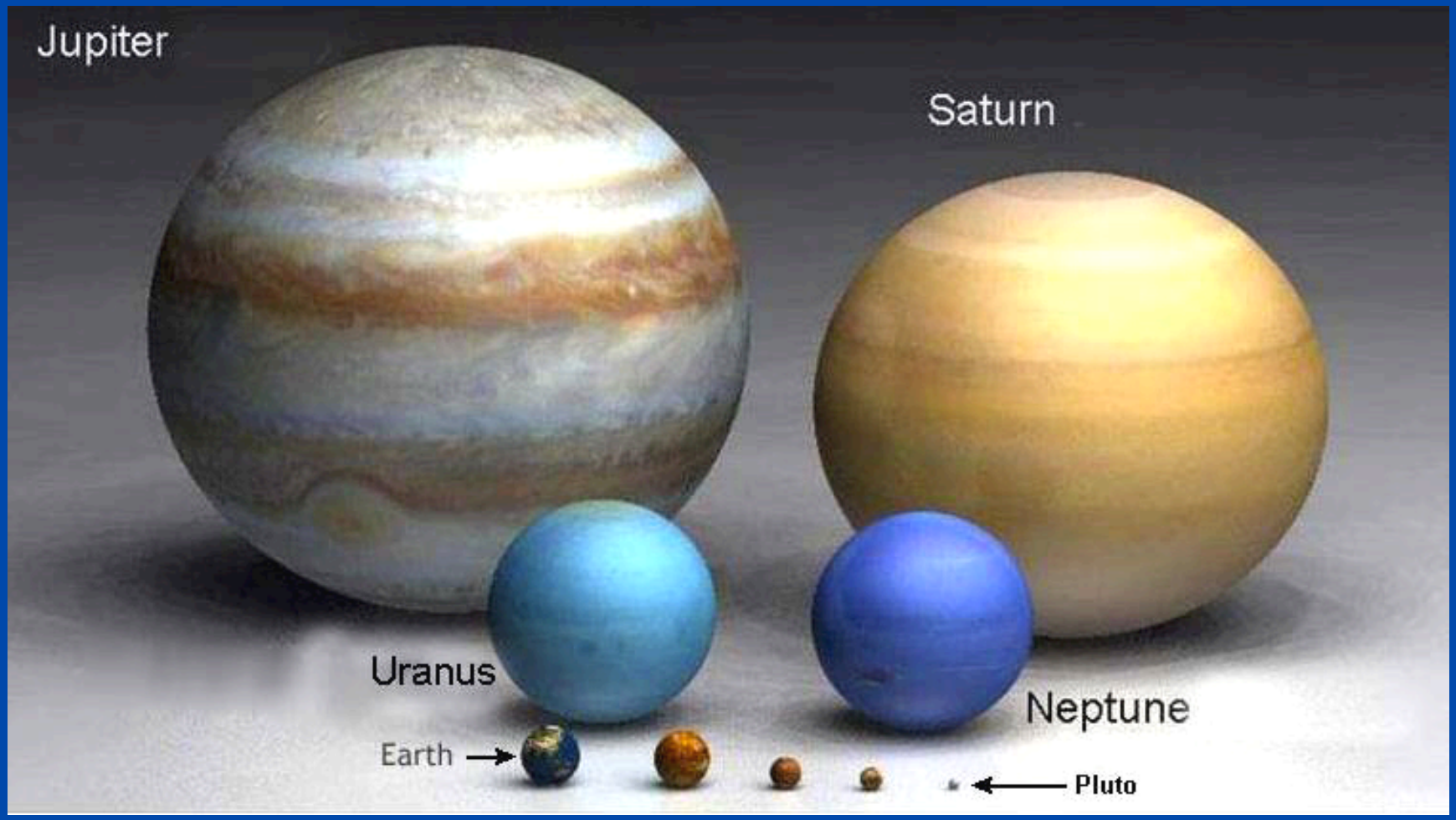
- Comets

- Meteorites
  - I'll bring in my collection

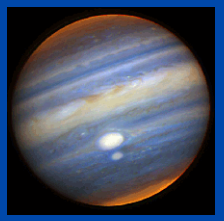


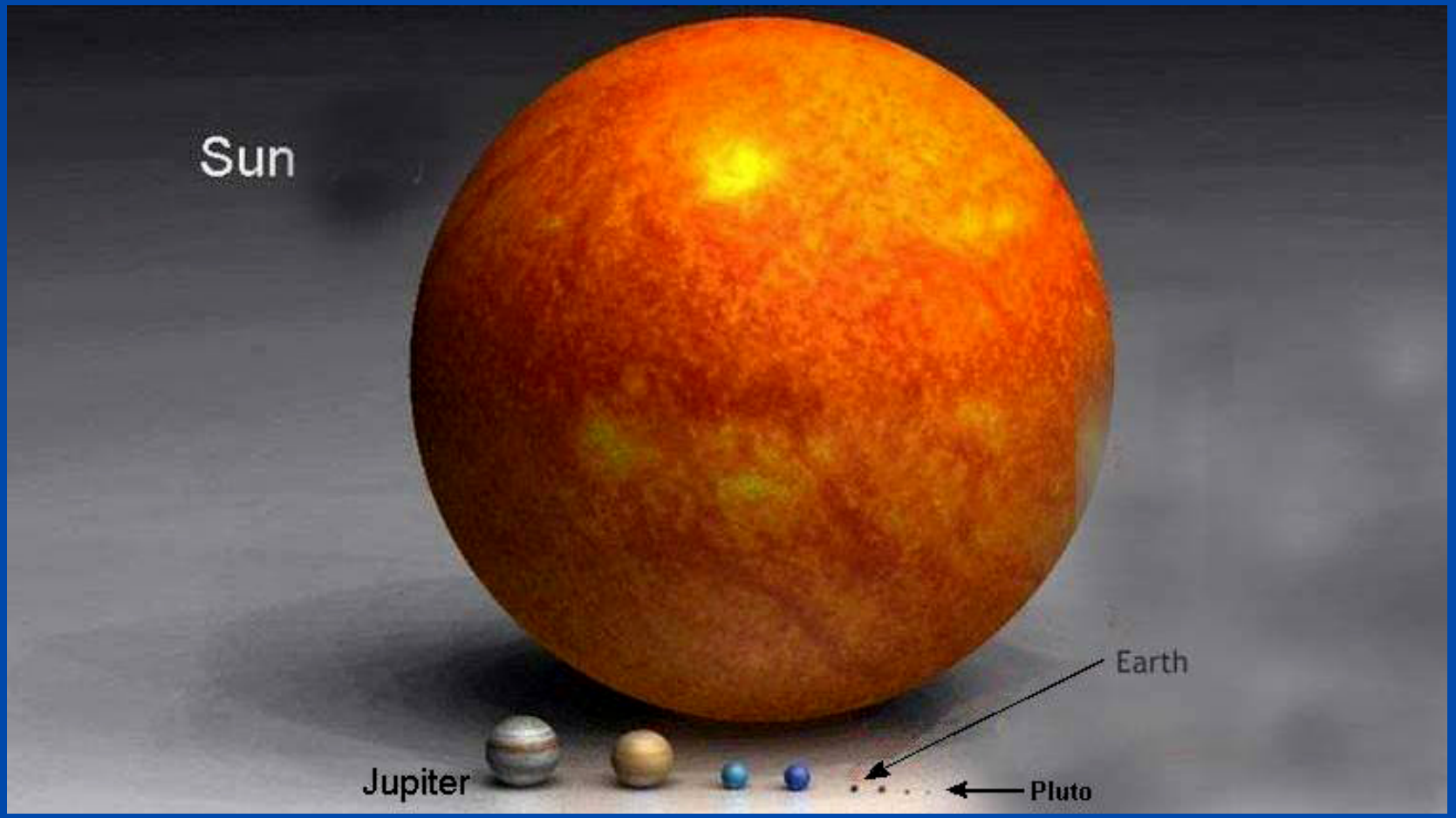
Relative sizes of the Planets



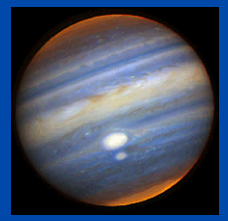


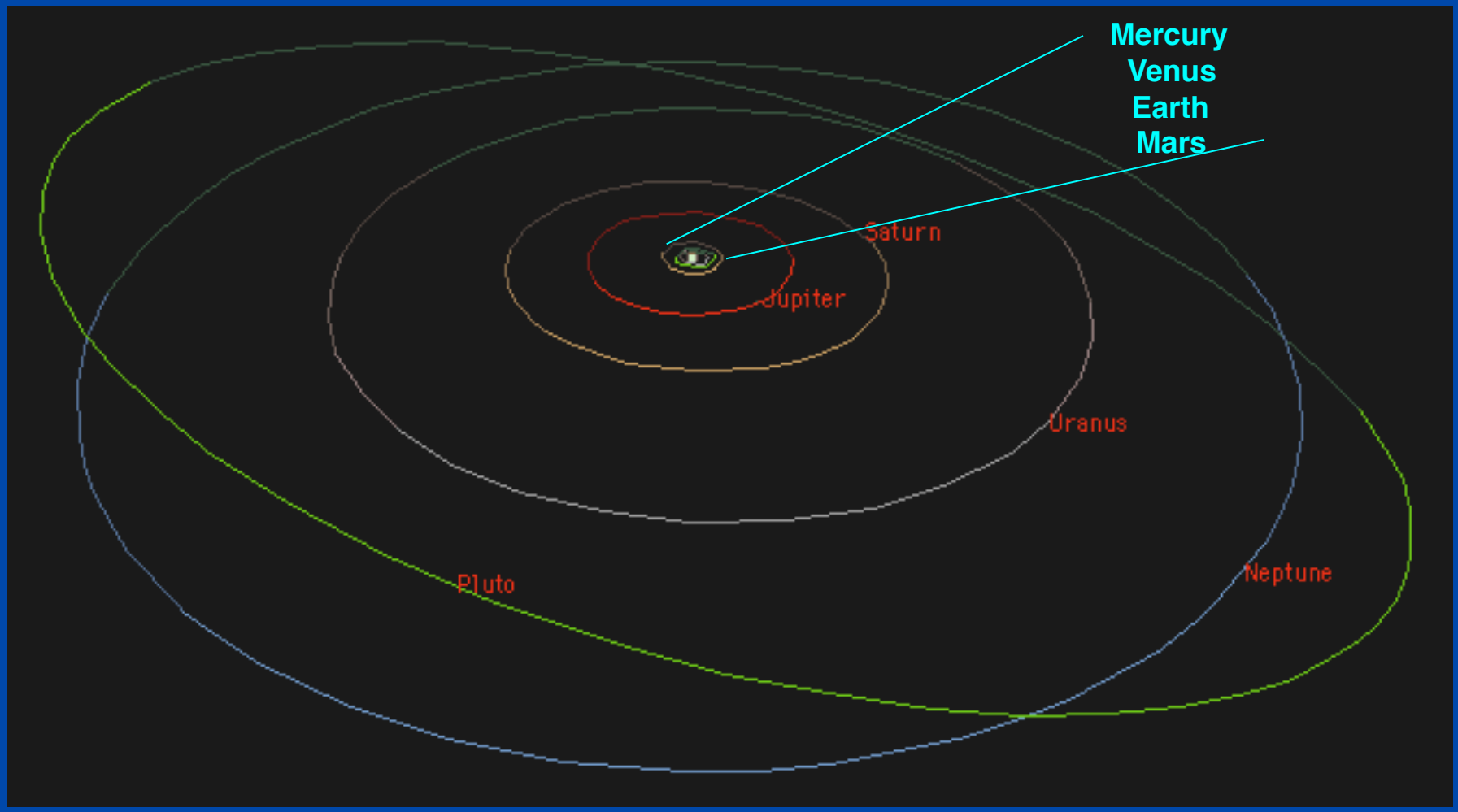
Sizes compared with the Sun (!)



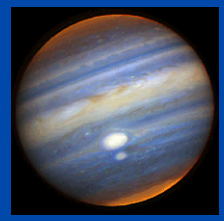


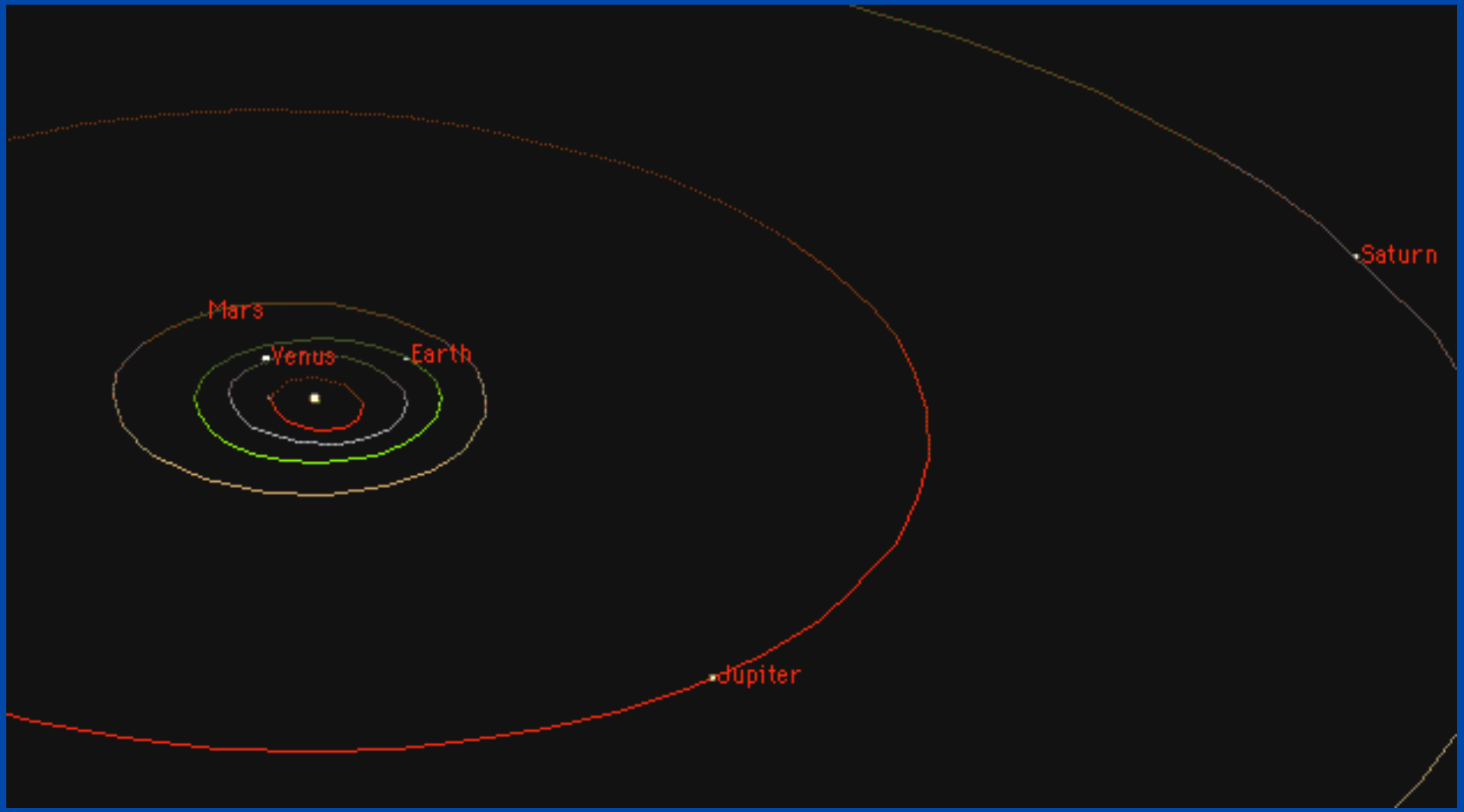
Distances in the Solar System take quite a bit of getting used to



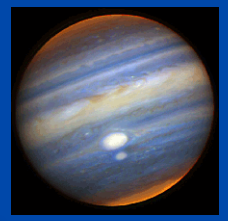


The “Inner Planet” orbits





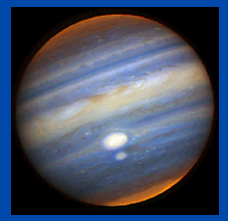
Scales within the Solar System: The Sun and the Earth



1. **If the Sun were 0.5 meters in diameter, roughly how big would the Earth be?**
   - a) baseball
   - c) ping-pong ball
   - d) pea

2. **How far from the center of the Sun would the Earth's orbit be?**
   - a) at the back of this classroom
   - b) half a football field away
   - c) at the entrance to campus

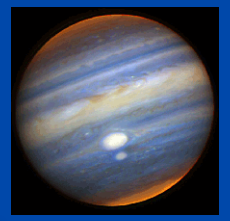
Scales within the Solar System: The Sun and the Earth



1. **If the Sun were 0.5 meters in diameter, roughly how big would the Earth be?**
   - a) baseball
   - c) ping-pong ball
   - d) pea

2. **How far from the center of the Sun would the Earth's orbit be?**
   - a) at the back of this classroom
   - b) half a football field away
   - c) at the entrance to campus

Scales within the Solar System: the Outer Planets

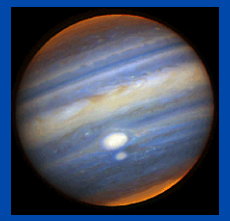


1. If the Sun were 0.5 meters in diameter, roughly how big would Jupiter be?
    a) basketball
    c) baseball
    d) ping-pong ball

2. How far from the center of the Sun would Jupiter's orbit be?
    a) half a football field away
    b) from here to the entrance to campus
    c) in downtown Santa Cruz

1. How far would the nearest star be?
    a) San Francisco
    b) New York
    c) Johannesburg South Africa

Scales within the Solar System: the Outer Planets

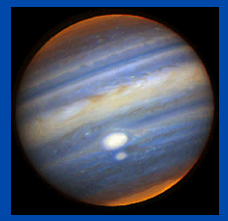


1. If the Sun were 0.5 meters in diameter, roughly how big would Jupiter be?
   - a) basketball
   - c) baseball
   - d) ping-pong ball

2. How far from the center of the Sun would Jupiter's orbit be?
   - a) half a football field away
   - b) from here to the entrance to campus
   - c) in downtown Santa Cruz

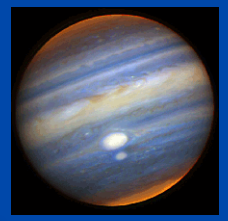
3. How far would the nearest star be?
   - a) San Francisco
   - b) New York
   - c) Johannesburg South Africa

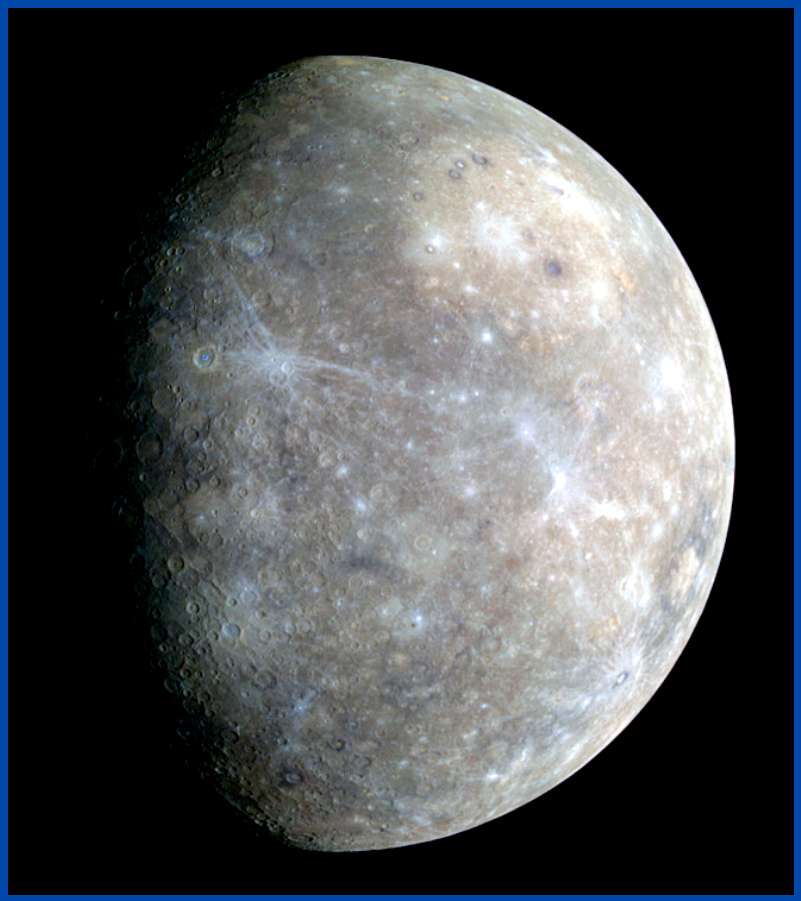
The Moral of the Tale



- **Space is VERY EMPTY!**

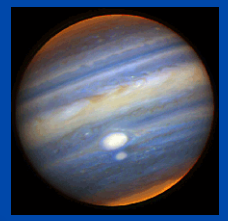
Mercury from Messenger spacecraft: lots of craters, major fault lines/cliffs

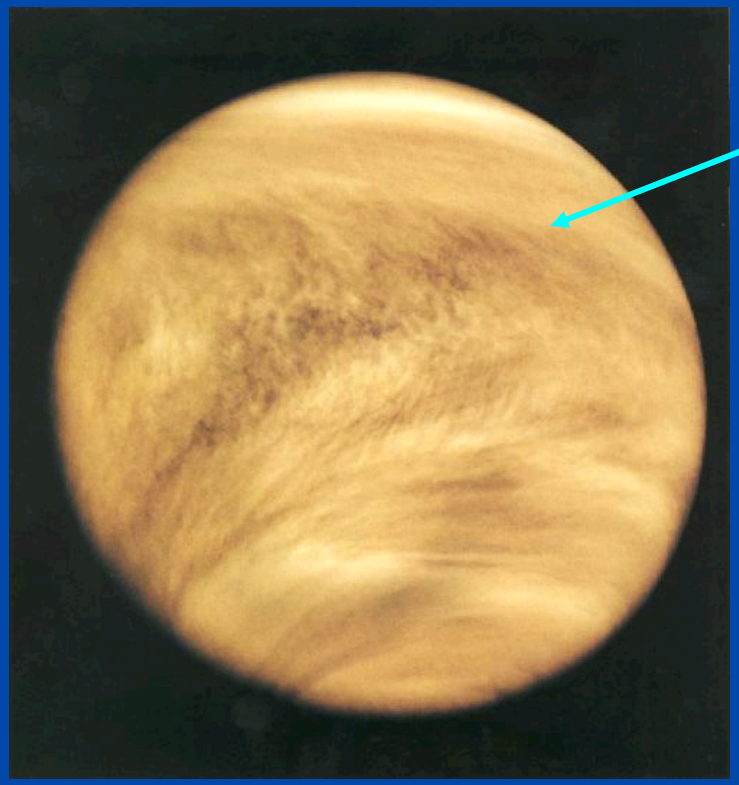




Enormous thrust fault line: evidence that Mercury shrank by 1 - 2 km after it solidified (!)

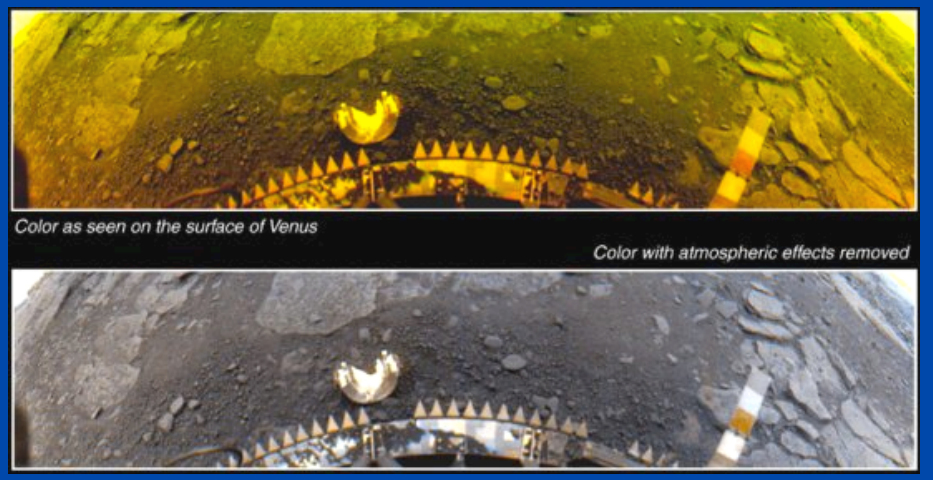
Venus: dense atmosphere, volcanoes, hot surface





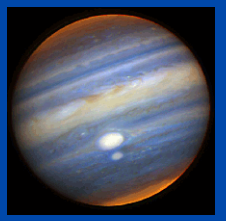
Ultra-Violet image showing thick cloud layer (from spacecraft)

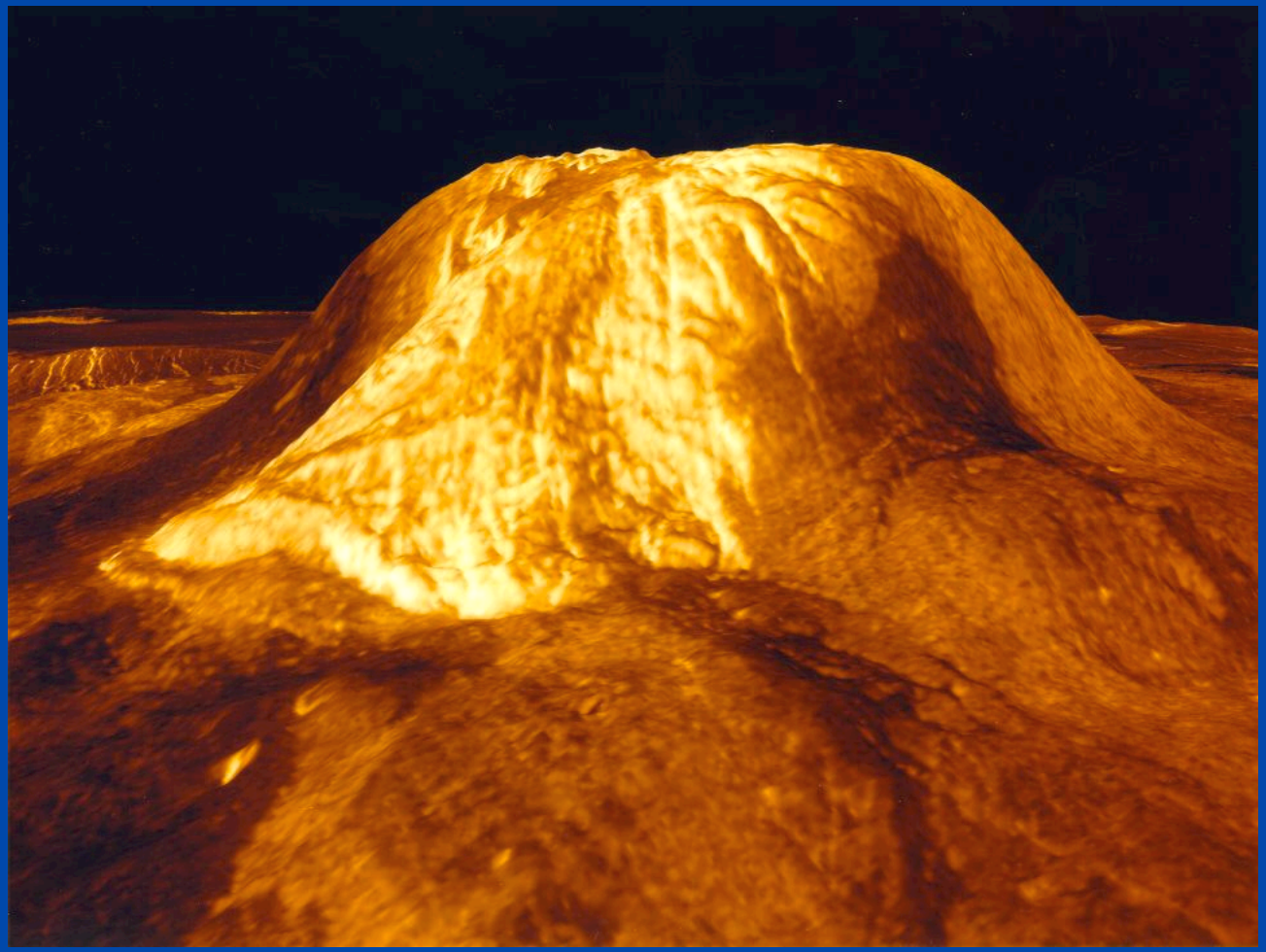
Venera 14 lander: hot rocks



Surface temperature > 700K (hotter than Mercury)
Surface pressure 90 x Earth

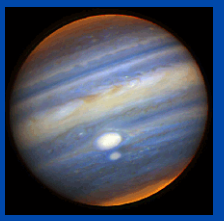
Huge volcanoes on Venus

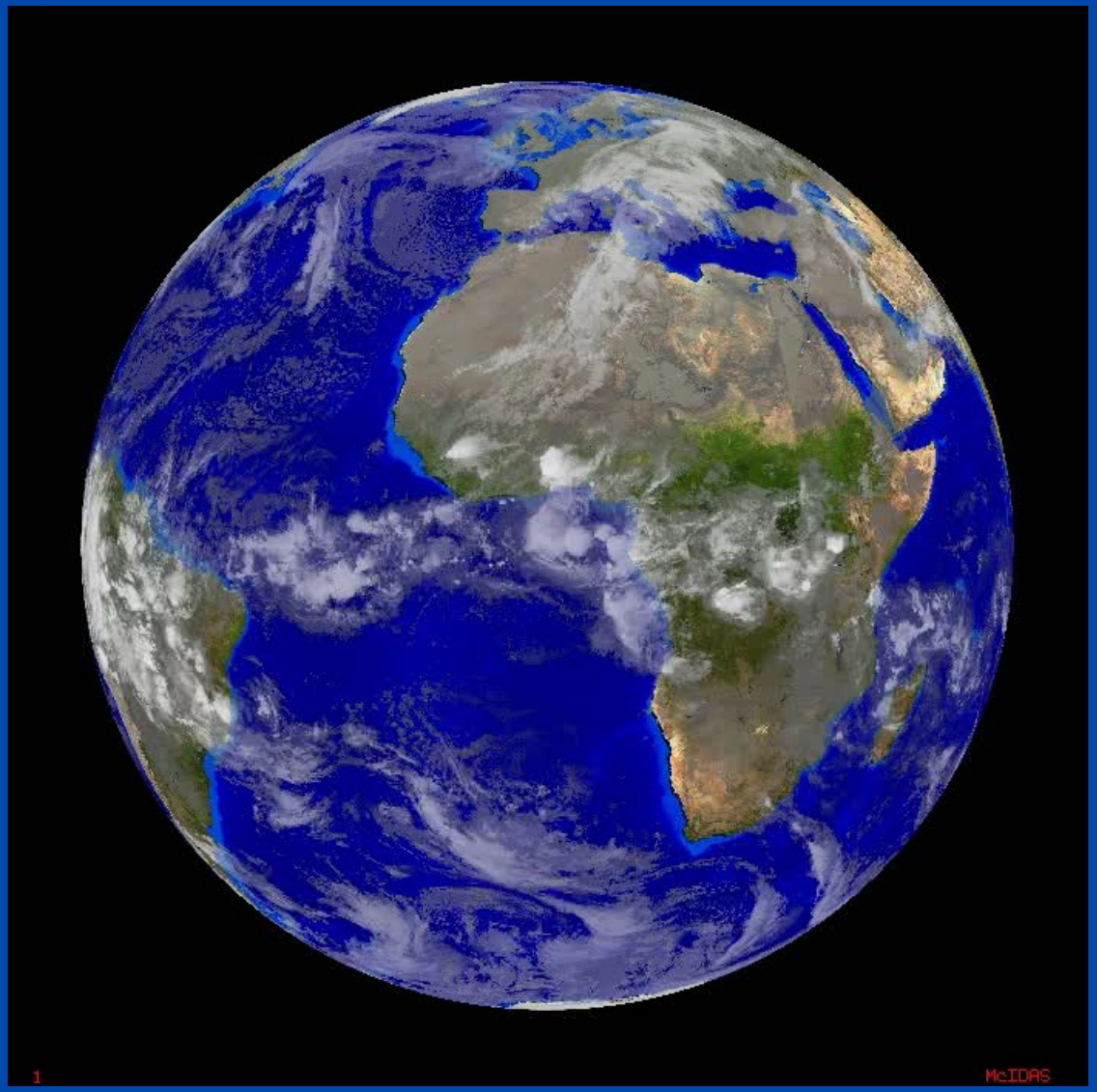




- **Topography from Magellan spacecraft (radar measurement)**
- **Gula Mons Volcano**

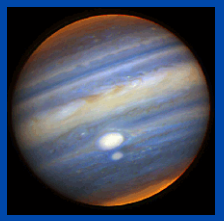
Earth: In the Habitable Zone

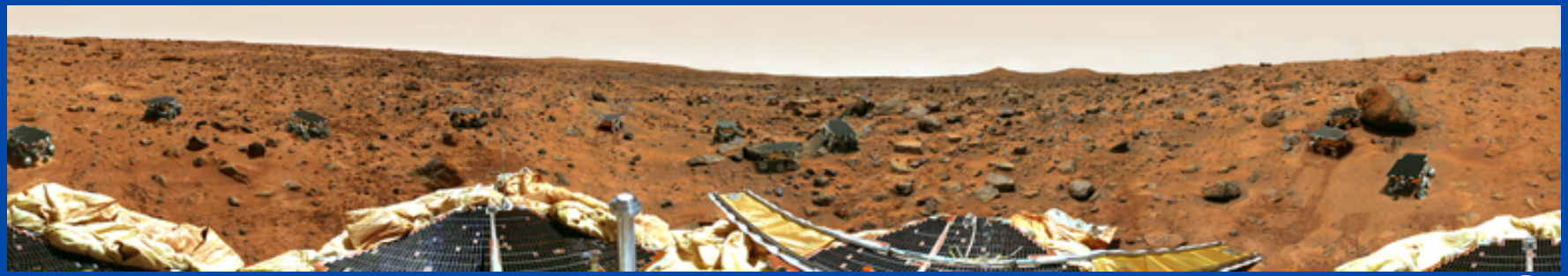




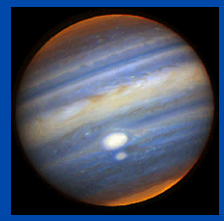
- What are the conditions for life?
  - Not too hot, not too cold – just right
- Is our climate changing? Why? How fast?

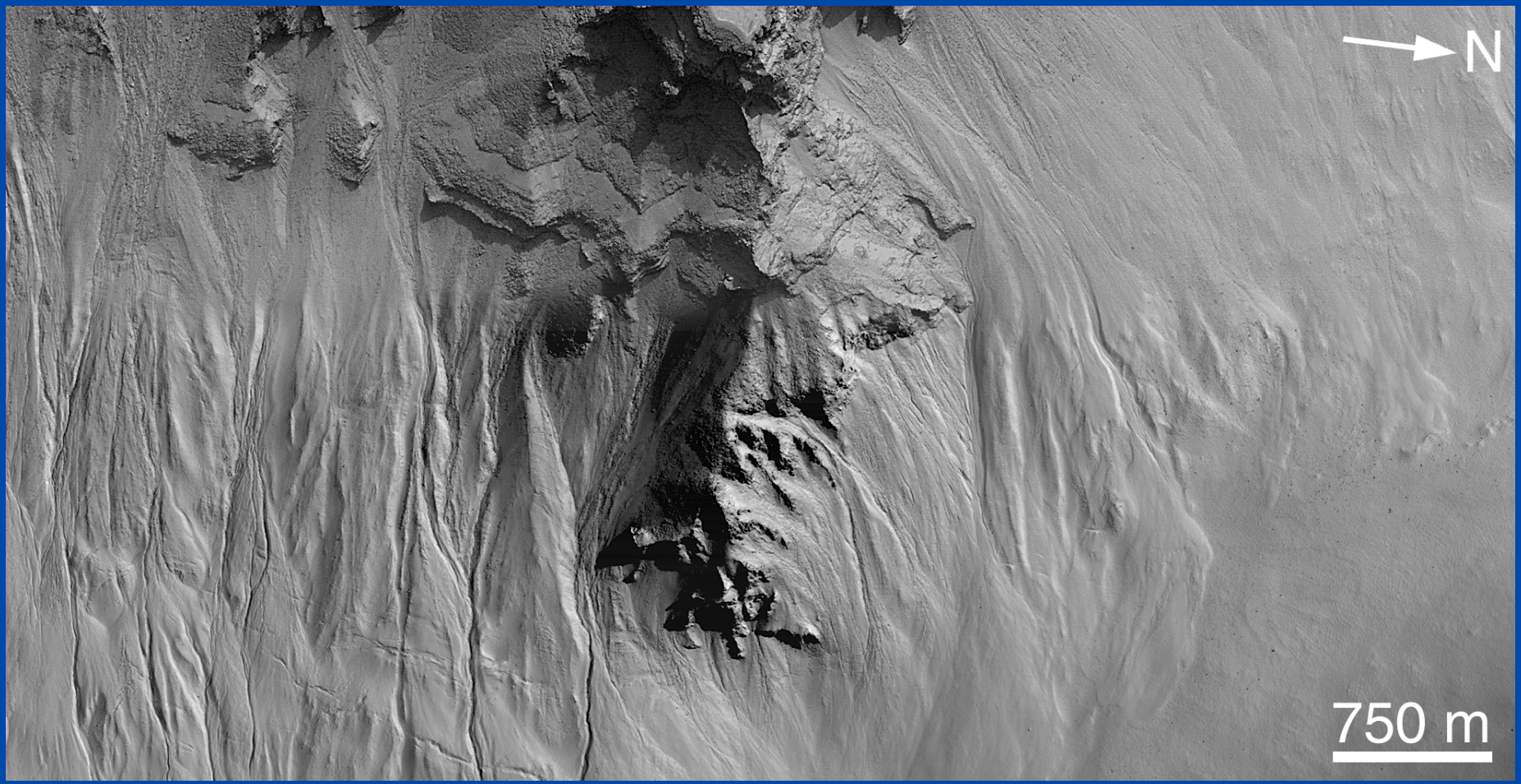
Mars: Not very hospitable right now





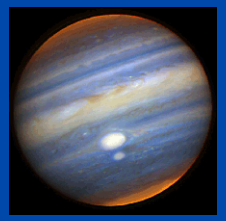
Mars: Stronger and stronger evidence for liquid water

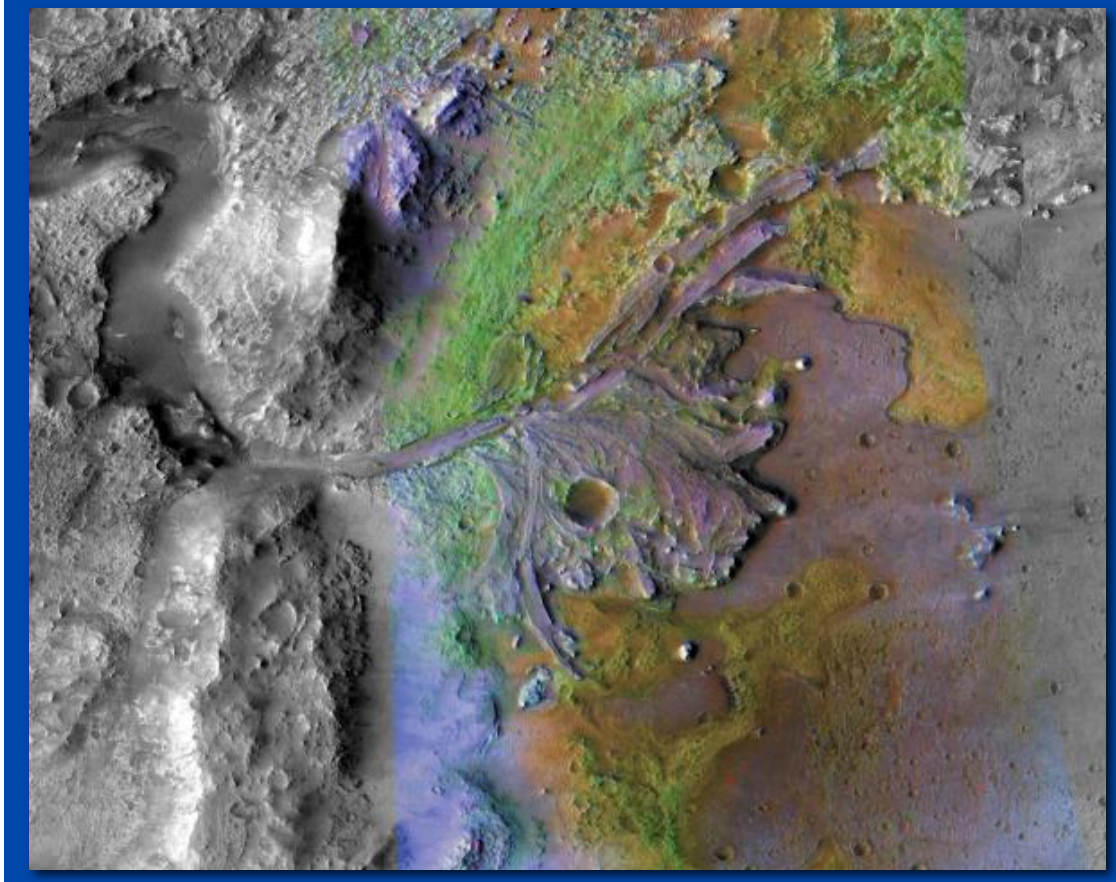




- **One line of evidence: gullies running down a slope**

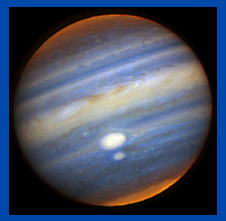
Mars: more evidence for liquid water

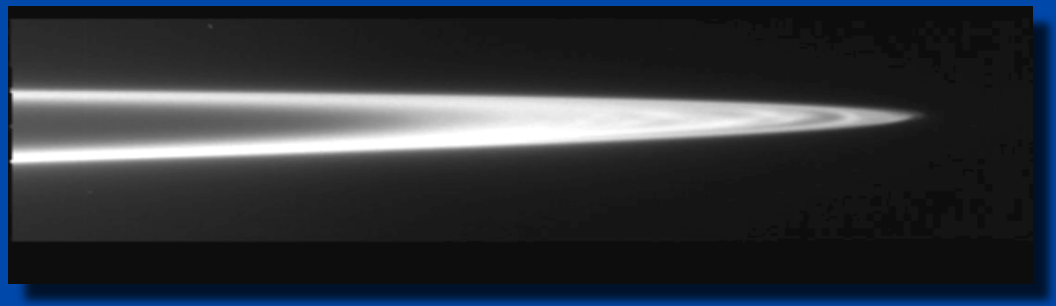




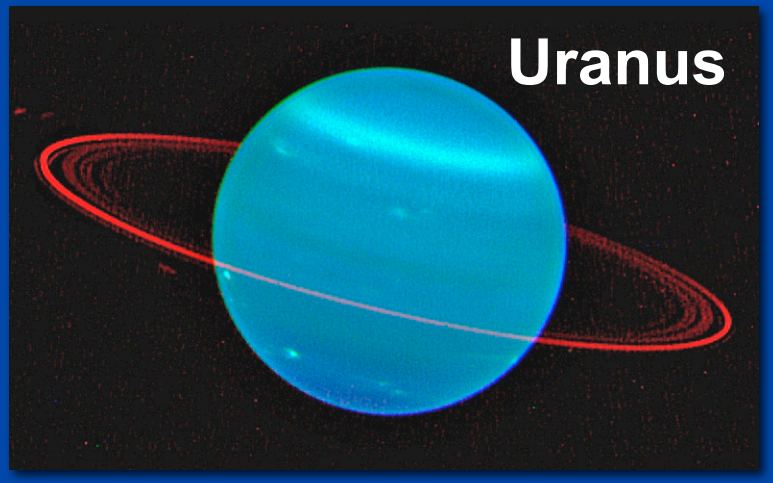
- **Ancient riverbeds?**
- **Did Mars have liquid water in past?**
- **What happened to it?**

All four Giant Planets have rings! Where did rings come from?

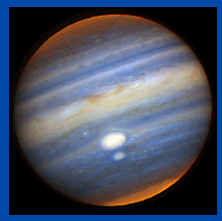




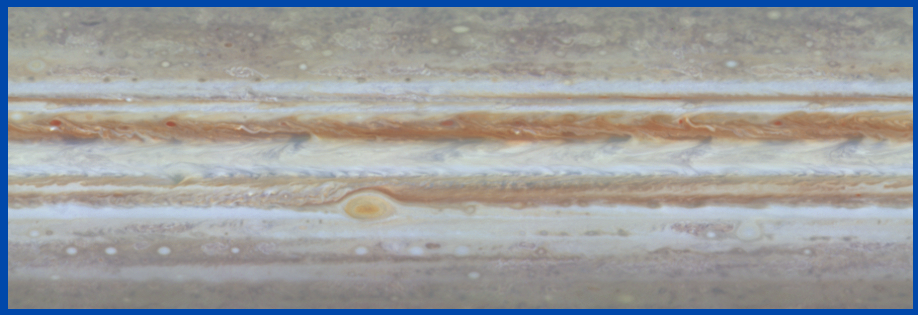
Jupiter



Jupiter

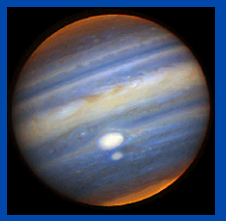


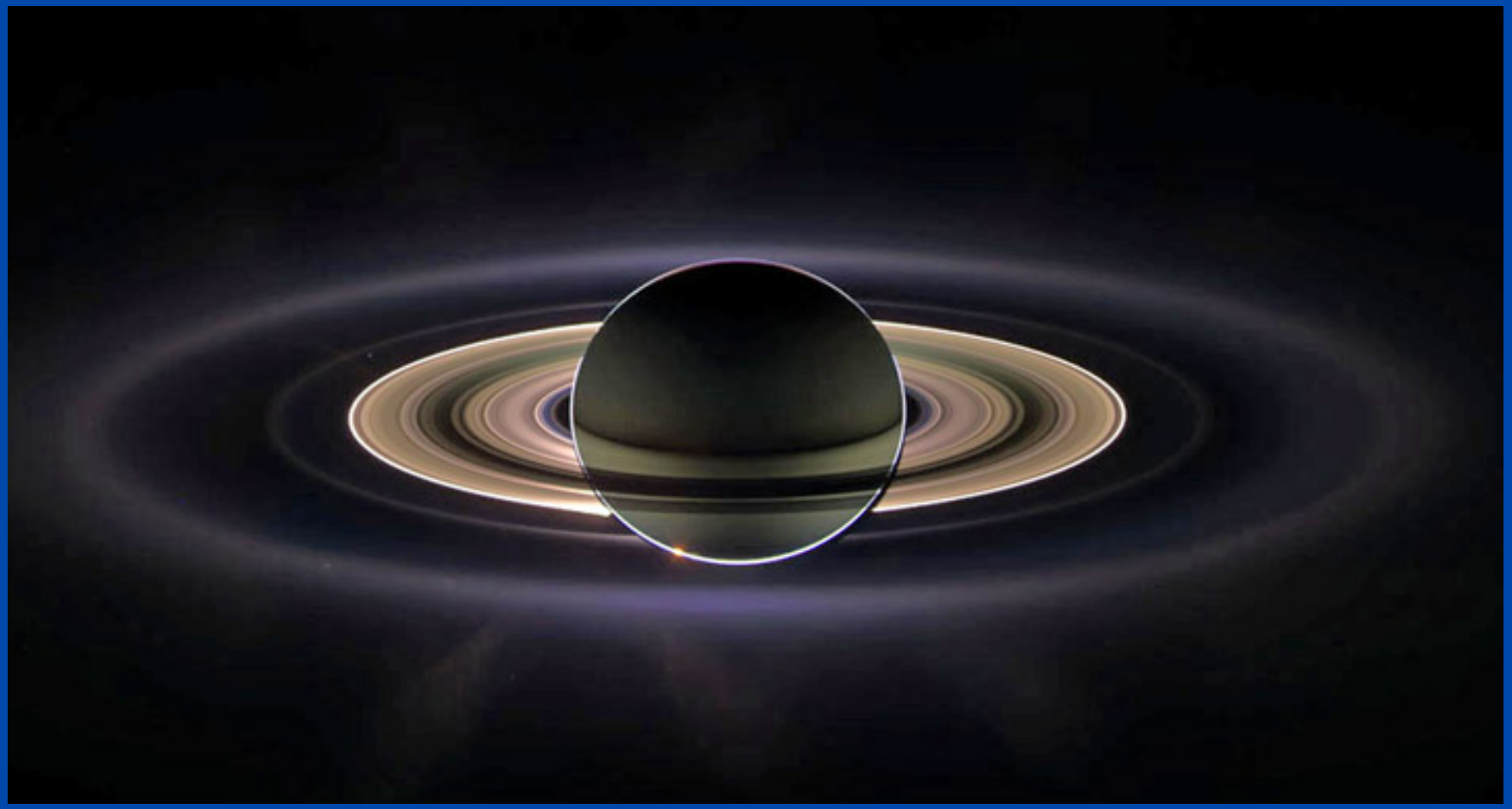
Great Red Spot



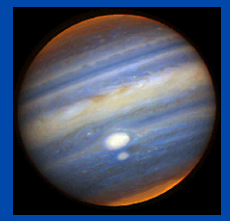
- **Jupiter emits more radiation (as infrared light) than it receives from the sun (in sunlight)**
- **Where does this energy come from?**

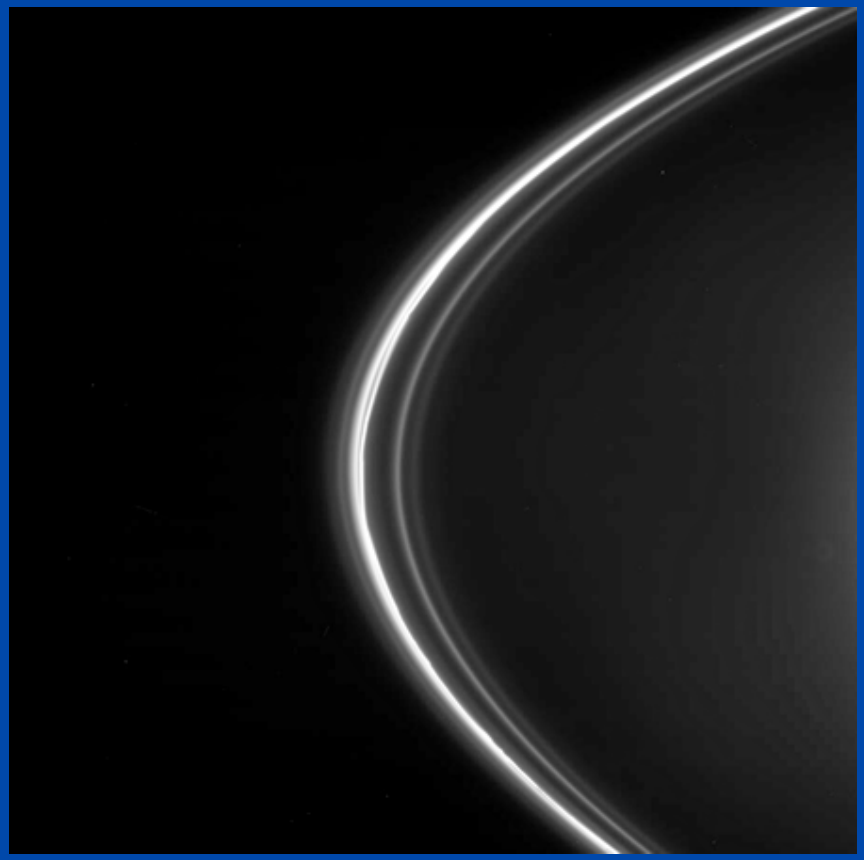
Saturn seen by the Cassini spacecraft





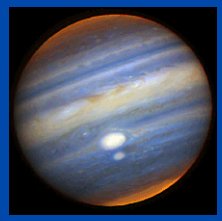
Saturn's rings from Cassini, cont'd



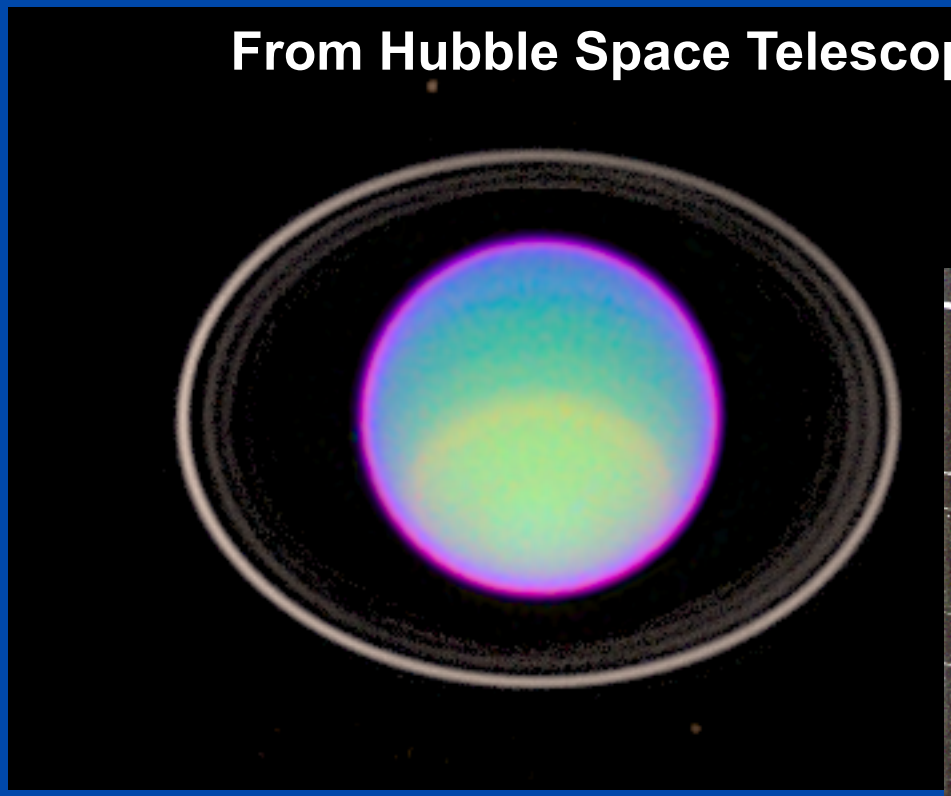


- **Moons act as shepherds for rings**
- **Rings are pieces of rock and ice - remnants of moons that broke up?**

Uranus and its rings

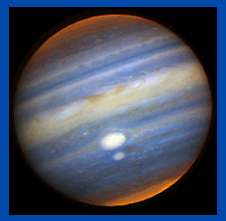


From Hubble Space Telescope

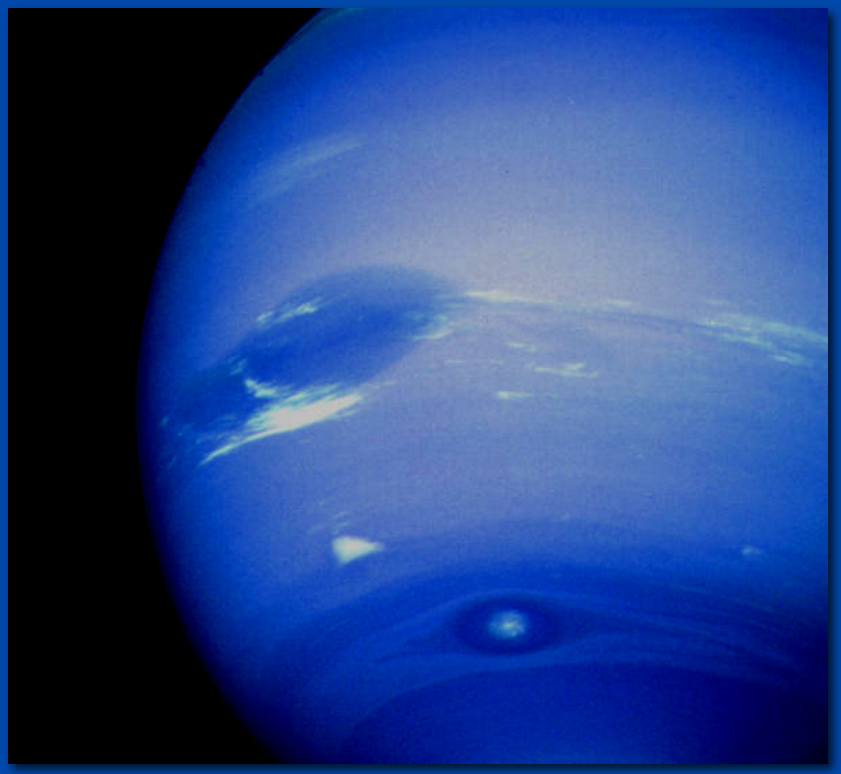


Closeup from Voyager spacecraft:

Neptune in visible light

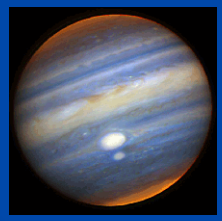


Visible: Voyager 2 spacecraft, 1989

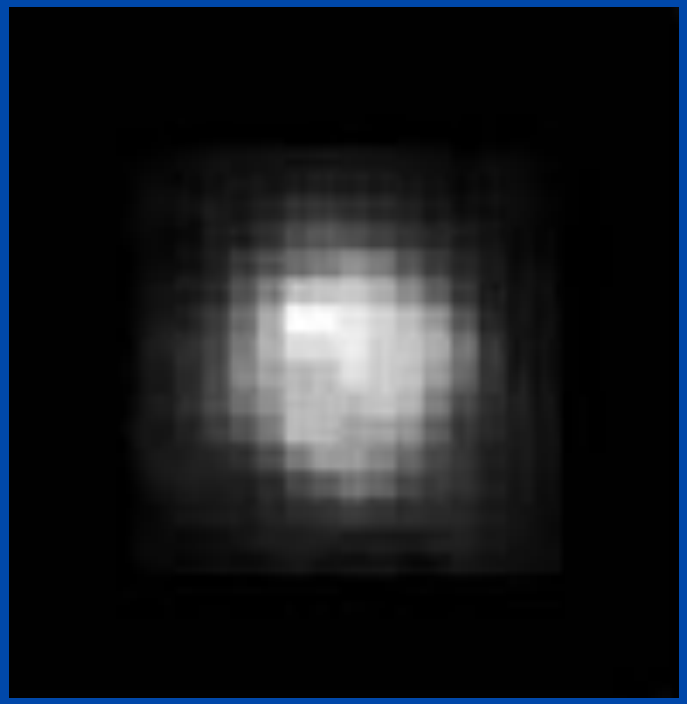


Compact features such as Great Dark Spot, smaller southern features: probably stable vortex structures

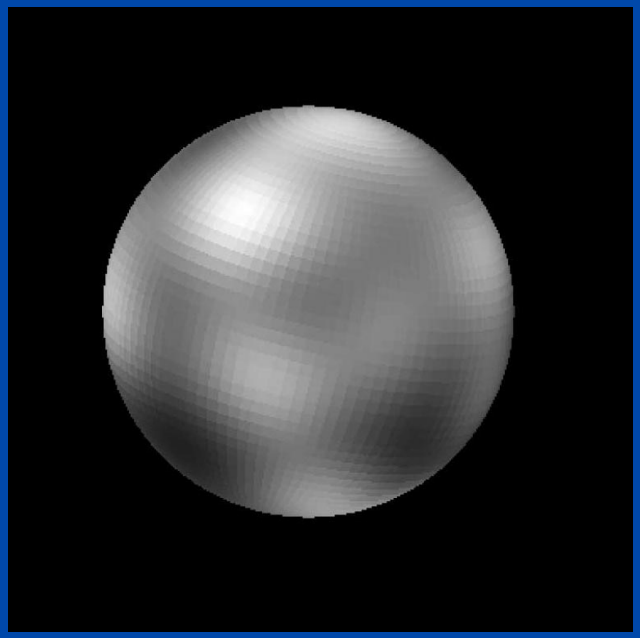
Pluto



Hubble Space Telescope Data

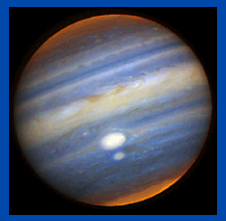


Computer model of data

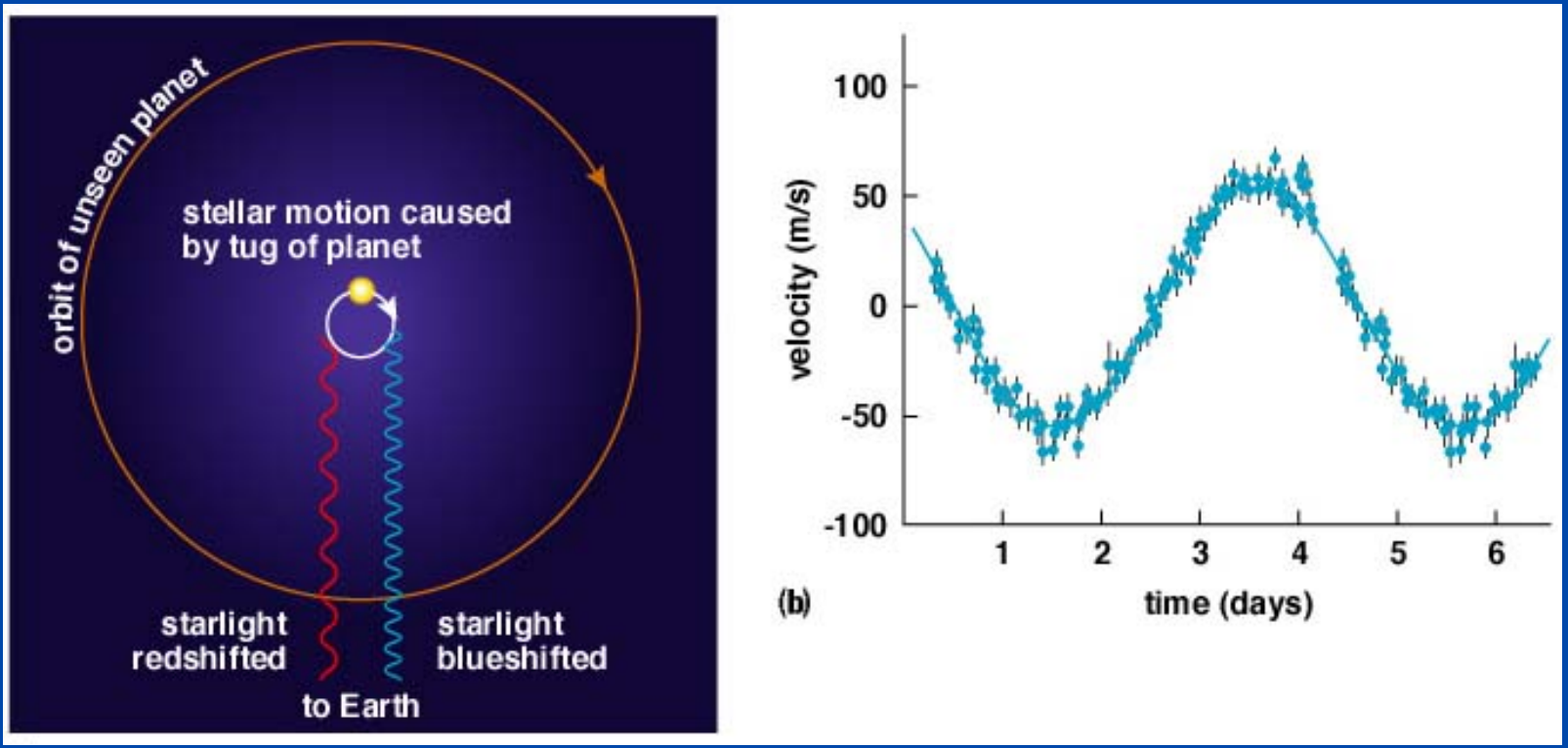


Why did astronomers decide it should be a “dwarf planet” ?

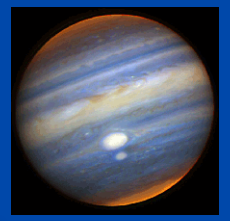
Extrasolar Planetary Systems

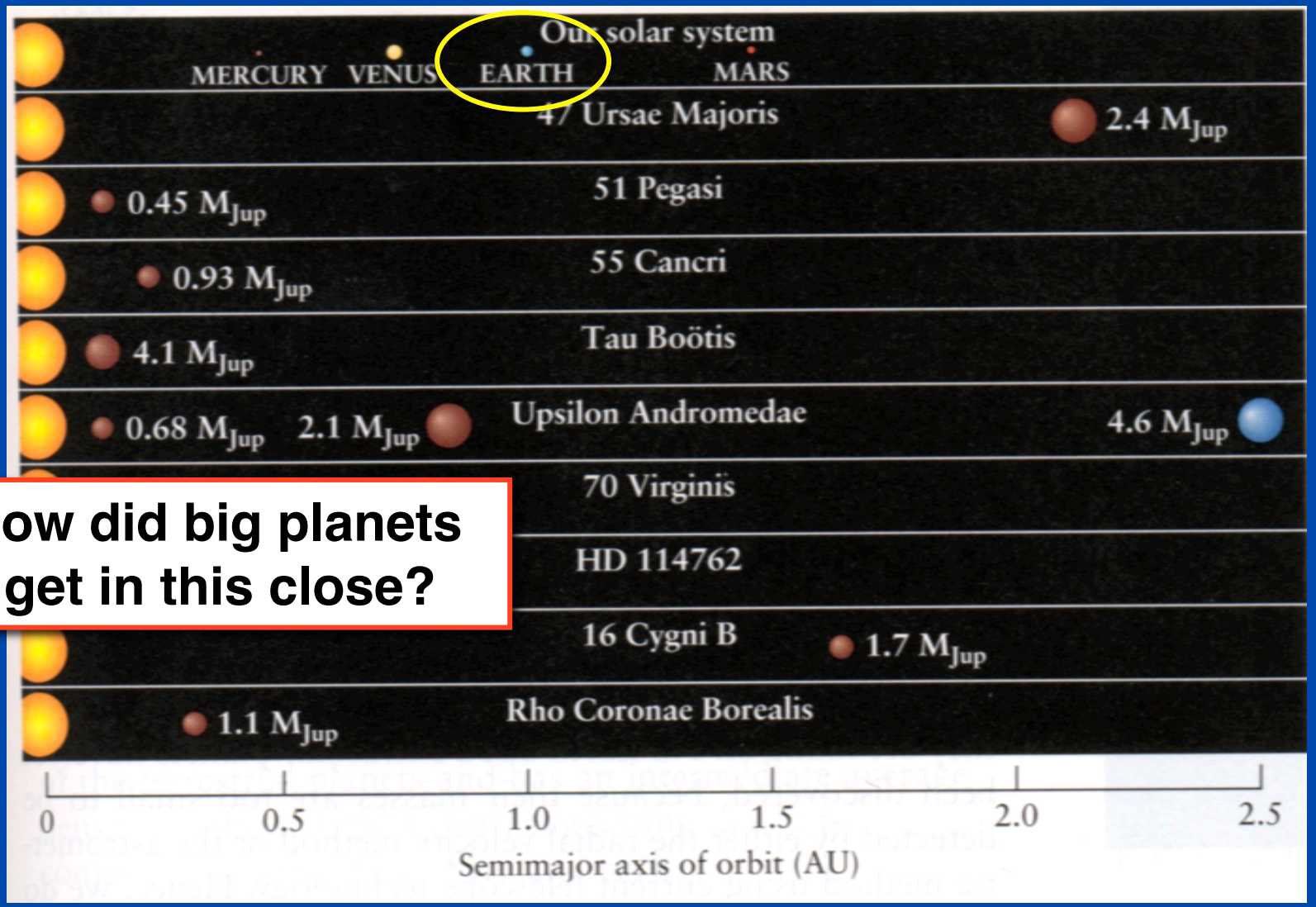


- Almost 500 planets have been discovered to date, in > 100 other solar systems!
- The majority of detections rely on stellar wobble



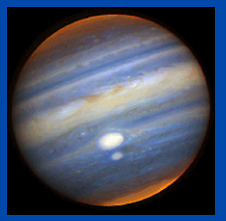
Planets discovered so far are very massive, very close to star

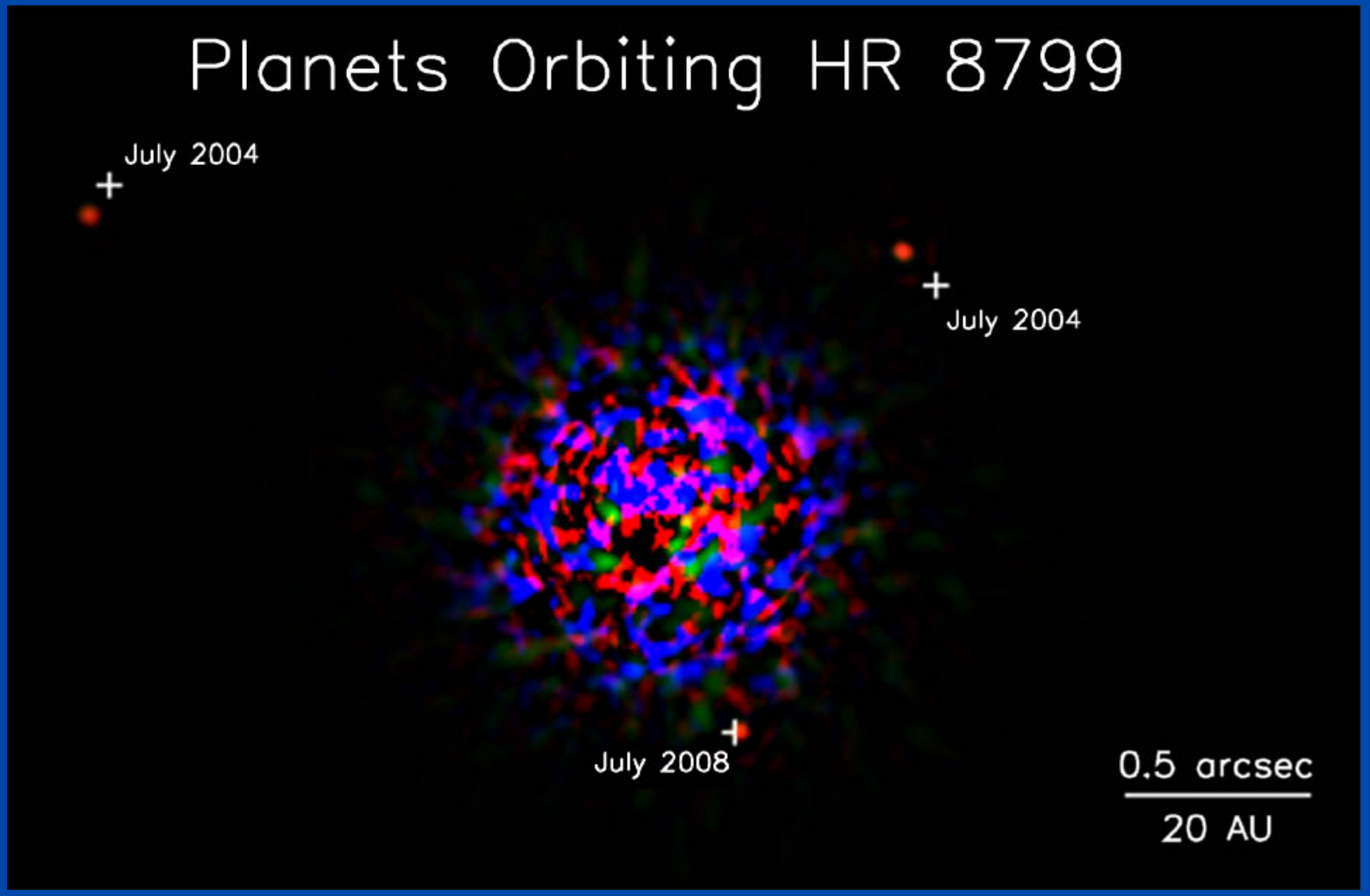


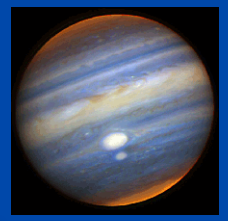


How did big planets get in this close?

A few extrasolar planets have been imaged directly

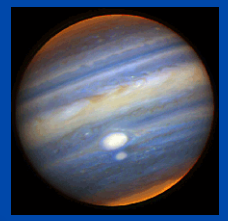






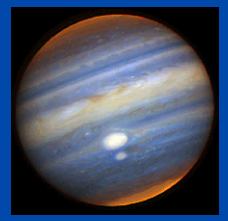
- It’s time for a break!

Goals of course



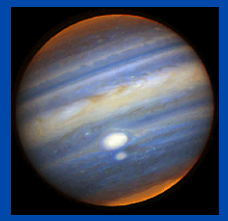
- Understand the unifying physical concepts underlying planetary formation and evolution
- Become familiar with the Solar System - it's our home in the universe!
- Other solar systems besides our own: Join in the excitement of discovery
- Gain an appreciation of how science works
- Improve your skills in quantitative reasoning

Tools we will use



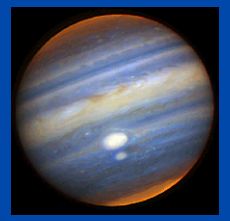
- **Physical concepts**
  - Gravity, energy, light
  - Three powerful unifying principles
  - Taught in this course
- **Math tools**
  - You should be somewhat comfortable with exponential notation, logarithms, algebra
  - We will review these in section meetings
  - We will make opportunities for those who know calculus to use it, if they are interested
  - Other needed tools will be taught in this course

How people learn



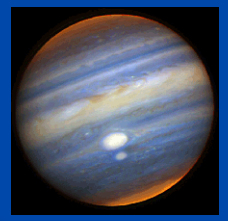
- The traditional lecture is far from the ideal teaching tool
  - Researchers on education study these things rigorously!
- I can't "pour knowledge into you"
- Learning is making meaning for oneself.
- It is you who must actively engage in the subject matter and assimilate it in a manner that makes it meaningful
- This course will emphasize active learning and an understanding of the unifying concepts of planetary science

Concepts vs. plugging in numbers



- **Lectures will emphasize concepts, challenge you to become critical thinkers**
  - **It is important to know how to calculate things, but concepts are important too**
  - **Difference between learning to plug numbers into equations and learning to analyze unfamiliar situations**
- **Exams will include conceptual problems as well as traditional computational problems**
- **Example: Explain how we can estimate the geological age of a planet's surface from studying its impact craters.**

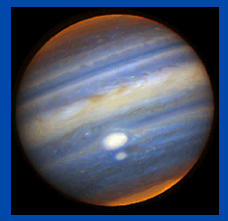
Elements of the course



- Reading
- Lectures
- Homeworks
- Sections, Lab exercises, and Stargazing
- Class Projects
- Exams
- You should expect to spend 8 to 10 hours a week working on this course outside of class

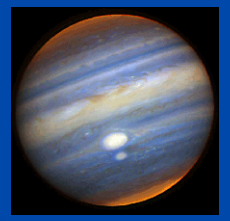
Plus: trip to Lick Observatory on Mt. Hamilton for those who can make it

Textbooks and Reading Handouts



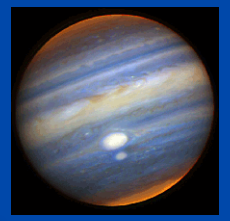
- "The Solar System: The Cosmic Perspective, 6th Edition with Media Update", by Bennett, Donahue, Schneider, and Voit
- At Bay Tree Bookstore
- Class website: http://www.ucolick.org/~max/Astro18_2010/Astro18.html
- We will also use the "Mastering Astronomy" website associated with the textbook: http://masteringastronomy.com
- Handouts:
  - Distributed in class (usually at the break)
  - Also on class websites

Reading assignments will be more important than in most science courses



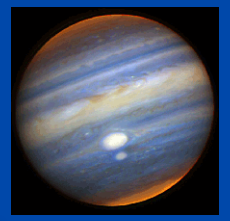
- Key for detailed, specific knowledge of planetary science and for understanding physical principles
- Assignments given at Tuesday lectures, and on web.
- I will assume that you have done the reading before each lecture
- To provide incentive for you to do the reading before each lecture, there will be a reading quiz at each class
  - You will be able to earn bonus points toward your final grade (up to 10 percentage points out of 100 total)

Lectures will discuss underlying concepts, key points, difficult areas



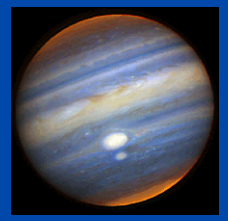
- **My lectures will be only partly from the textbook**
  - **Nitty gritty details will come from your reading assignments**
- **In-class ConcepTests will provide me with feedback on whether concepts are clear**
  - **I will pose a short conceptual question (no calculations)**
  - **I will ask you to first formulate your own answer, then discuss your answer with two other students, finally to report your consensus answer to me**
- **ConcepTests will not count toward your final grade.**
  - **They are to give me feedback on whether my teaching is clear**

Homeworks due each week



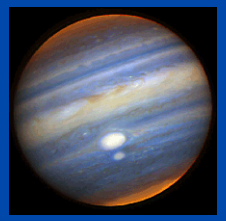
- Emphasis on developing calculation skills
- Also conceptual questions
- Somewhat shorter than the problem-sets usually done in physics classes, because you will also need time to work on Projects
- Homework due at start of class on Thursdays; handed out 1 week in advance (also on web)

Sections, Labs, Stargazing



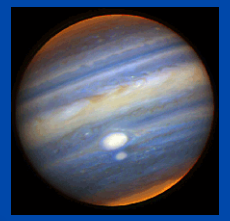
- **You must attend a section every week, *and* a lab every other week**
- **Sections: review and additional material**
- **Lab Exercises: group work, explore new concepts, hands-on activities (including telescope oberving)**
- **Stargazing: You must attend at least one evening. I will announce in class where and when. Also see**
  - **http://www.astro.ucsc.edu/astronomy_club**

We will take a field trip to Lick Observatory on Mt. Hamilton



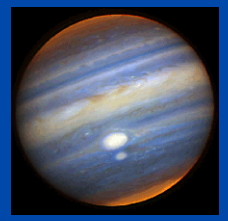
- **Mt. Hamilton is a 4200-ft mountain just east of San Jose**
- **About an hour and a half from here**
- **The first mountain-top observatory in the world**
- **Lots to see: telescopes, labs, lovely views, gift shop**

Class Projects will play an important role



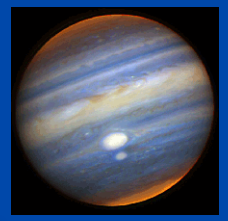
- **Reading, homework, lectures: "content"**
  - **What we know about our Solar System and others, and the scientific tools used to discover this knowledge**
- **Class Projects: "enterprise of science"**
  - **The way we *really* do science – starting with hunches, making guesses, making many mistakes, going off on blind roads before hitting on one that seems to be going in the right direction**
- **You will choose a general topic. Then you will formulate your own specific questions about the topic, and figure out a strategy for answering them**
- **I will provide structure via "milestones" along the way, so you won't get lost**

Grading and exams



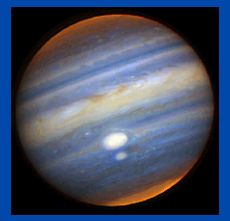
- **Homework** — 30% of final grade
  - Homework turned in one class late will be graded with a grade reduction of 1/2. Homework more than one class period late will not be accepted. Your one lowest-graded homework assignment will not count toward your grade.
- **Projects** — 30% of final grade
  - Includes both final presentation and written report.
- **Participation in sections, labs** — 10% of final grade
- **Exams** — 30% of final grade
  - One mid-term, one final exam.
- **Extra credit** — Reading quizzes up to 10%

Classroom Etiquette



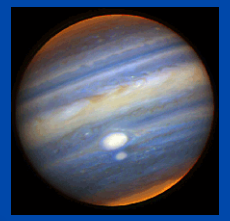
- We have a lot to learn, so each class meeting is important
- Conversation, reading newspapers, eating crunchy snacks, and other disturbances will not be tolerated
- Cell phones must be off, laptops closed. No email or text messaging.
- If you must leave class early, please clear it with me prior to class and find a seat near the exit.
- I will do my best to keep the presentation and discussion lively and interesting!
- In return, I expect your attention and participation. This will make your learning experience a gratifying one.

Guidelines for Assignments



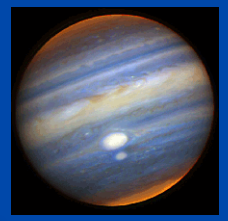
- **Your work should be clearly understandable**
  - If a friend of yours were to read your work, would he/she be able to understand exactly what you are trying to say?
  - Use proper grammar, syntax, spelling
- **Homeworks:**
  - Show your reasoning clearly (don't just give the final answer)
    - » We will give partial credit for clear, logical reasoning even if the "bottom line" is wrong
  - Include diagrams and sketches whenever they might add insight
  - Answer word problems with complete sentences
  - Always show what units you are using!
    - » Meters/sec versus miles/hour versus furlongs/fortnight

Academic Integrity



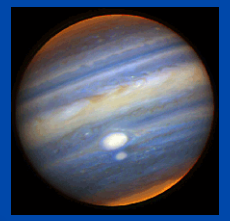
- **What is cheating? Presenting someone else's work as your own.**
- **Examples:**
  - **Copying another student's written homework**
  - **Allowing your own work to be copied**
  - **Although you may discuss problems with fellow students, your collaboration must be at the level of ideas and concepts only**
- **Your homework, project reports, exams, etc. must be written in your own words**
- **Legitimate collaboration ends when you "lend", "borrow", or "trade" written solutions to problems**
- **Talk, discuss, argue with your classmates till you understand. THEN write your OWN text or problem-set in your OWN words.**

To enroll in the course if you are not already enrolled



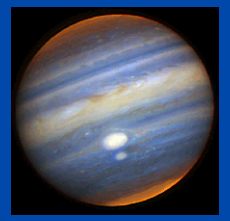
- **See Maria Sliwinski in the Astronomy Department Office (within the Physics Office)**
- **Interdisciplinary Sciences Bldg rm 211**
- **Phone number: 459-2844**
- ***PLEASE*: if you decide to drop the class, do so promptly so that others can enroll – there are people waiting to join the class**

Reading: Due Tuesday

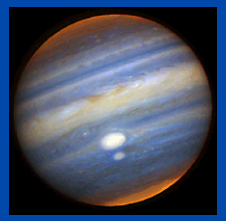


- Read Syllabus (on the web), buy textbook
- Reading:
  - The Cosmic Perspective: The Solar System
    - » Pages xxii - xxvii and
    - » Chapter 1: Our Place in the Universe
- Tuesday's class will be taught by Prof. Jonathan Fortney
- There will be a Reading Quiz at start of class

Homework due next Tuesday



- **Homework 1 (see handout): tell me a bit about yourself.**
  - **Email homeork to me from the email address you use the most. I will log this as the email address to use for the class.**
- **Stellarium: Activity 1**
  - **See handout (also on class website)**



- Most important: Give yourself room to have fun
- Go outside at night and look at the planets
  - We will learn how to find them using Stellarium
- The Solar System is an amazing place!