Research in Astronomy

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Resources and Information for Students

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Questions we might try to address

(students should let us know what they're interested in discussing)

- What are the different topics or subfields that make up astronomy research?

- What are the big questions in astronomy today? What are some of the "smaller" questions?

- How are researchers trying to answer these questions?

- What kind of "tools" should a young astronomer have? How can you identify interesting research areas/questions/projects?

- How can you get and stay informed about astronomy research?

- How can you get involved in research?

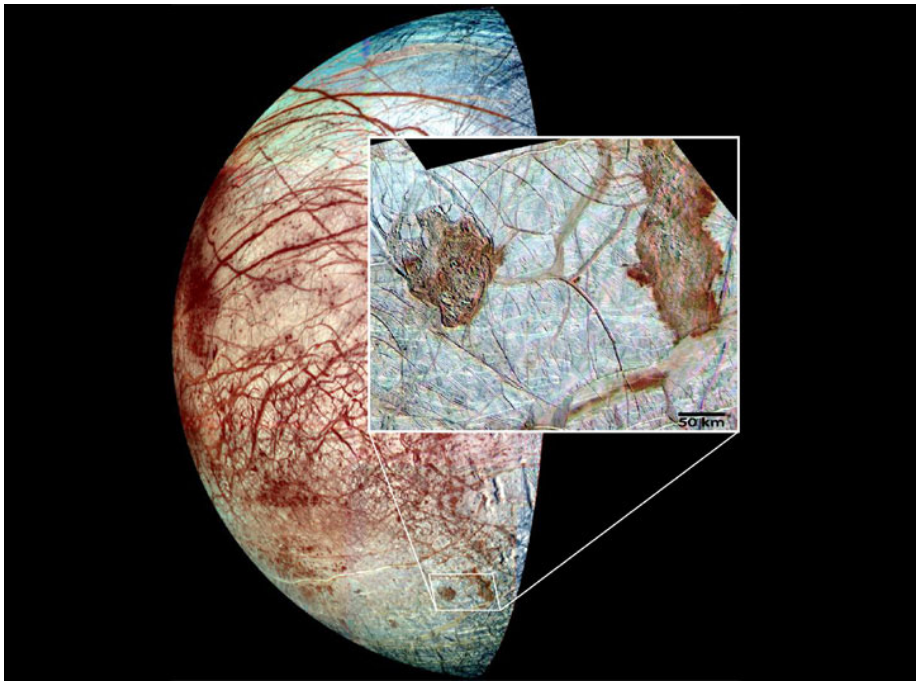
What are the different topics or subfields that make up astronomy research?

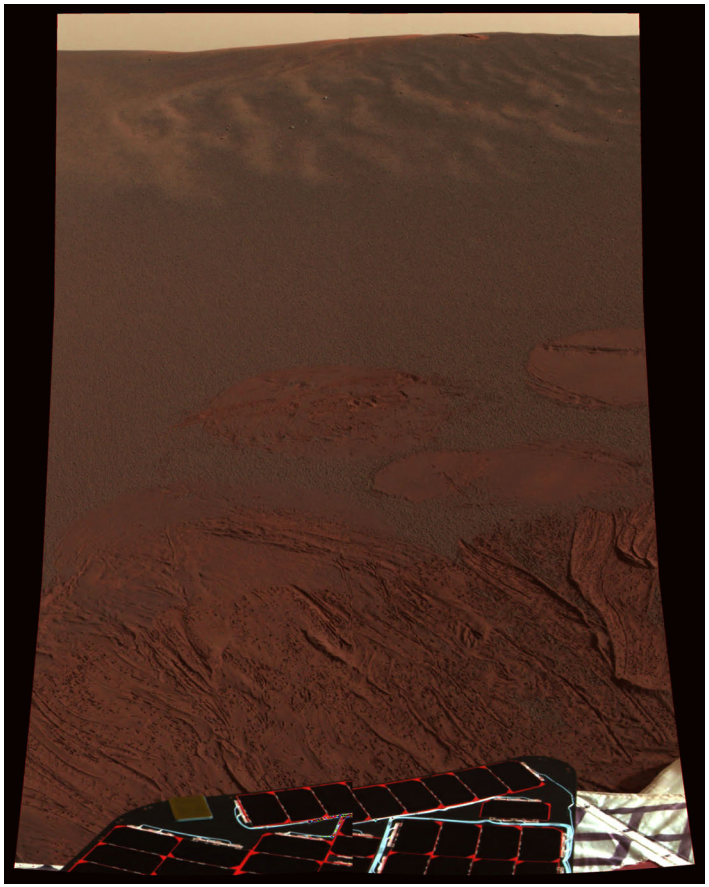
Planetary science and geology/geophysics

Solar system, space plasma; Solar physics/astronomy ⇒ Stellar astronomy ⇒ Interstellar medium ⇒ The Milky Way and other galaxies ⇒ Large scale structure ⇒ Cosmology ⇒ Astroparticle physics

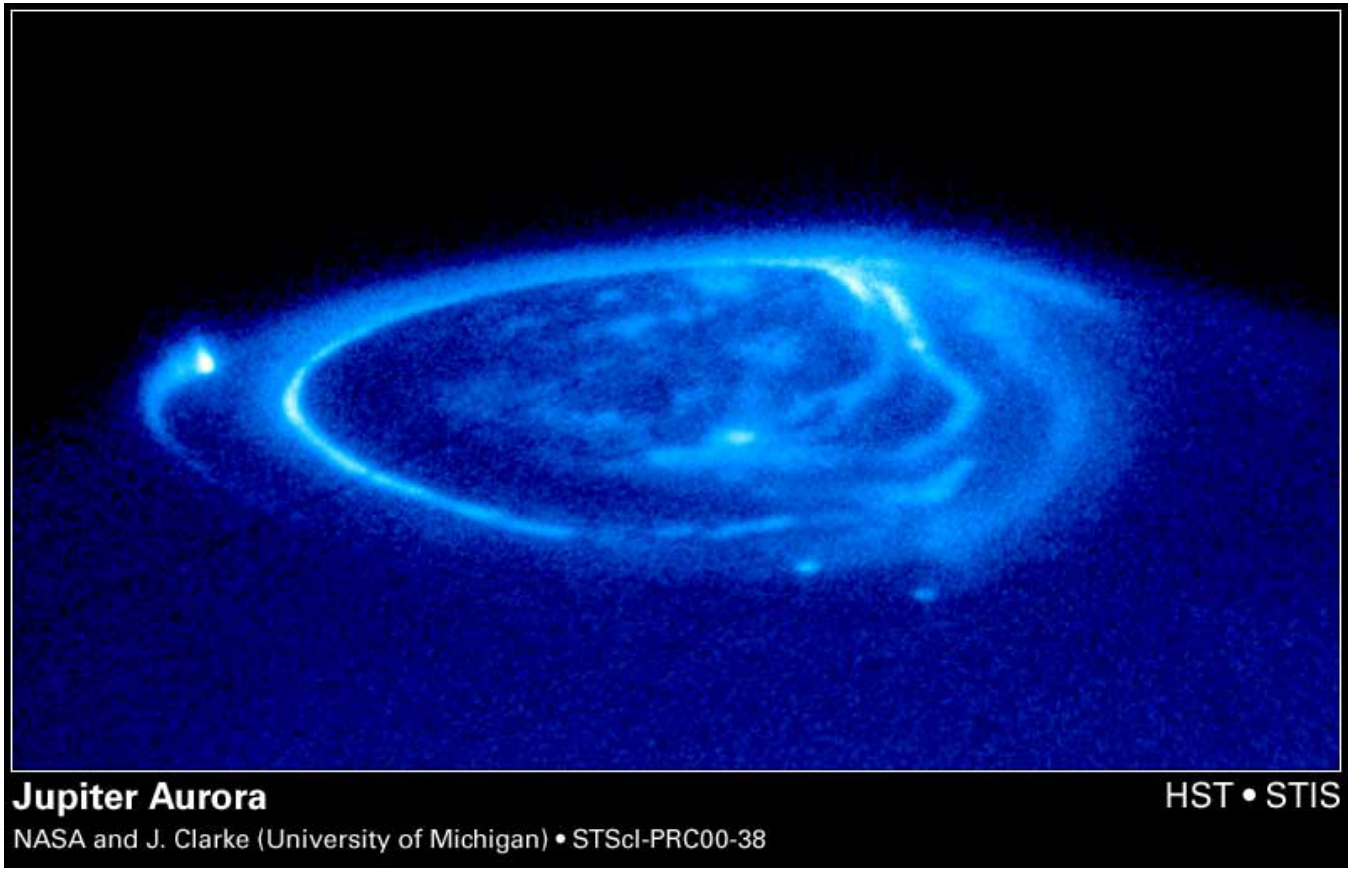
Most fields have observational sides and theoretical sides that are viewed as being relatively separate from each other.

Planetary science and geology/geophysics

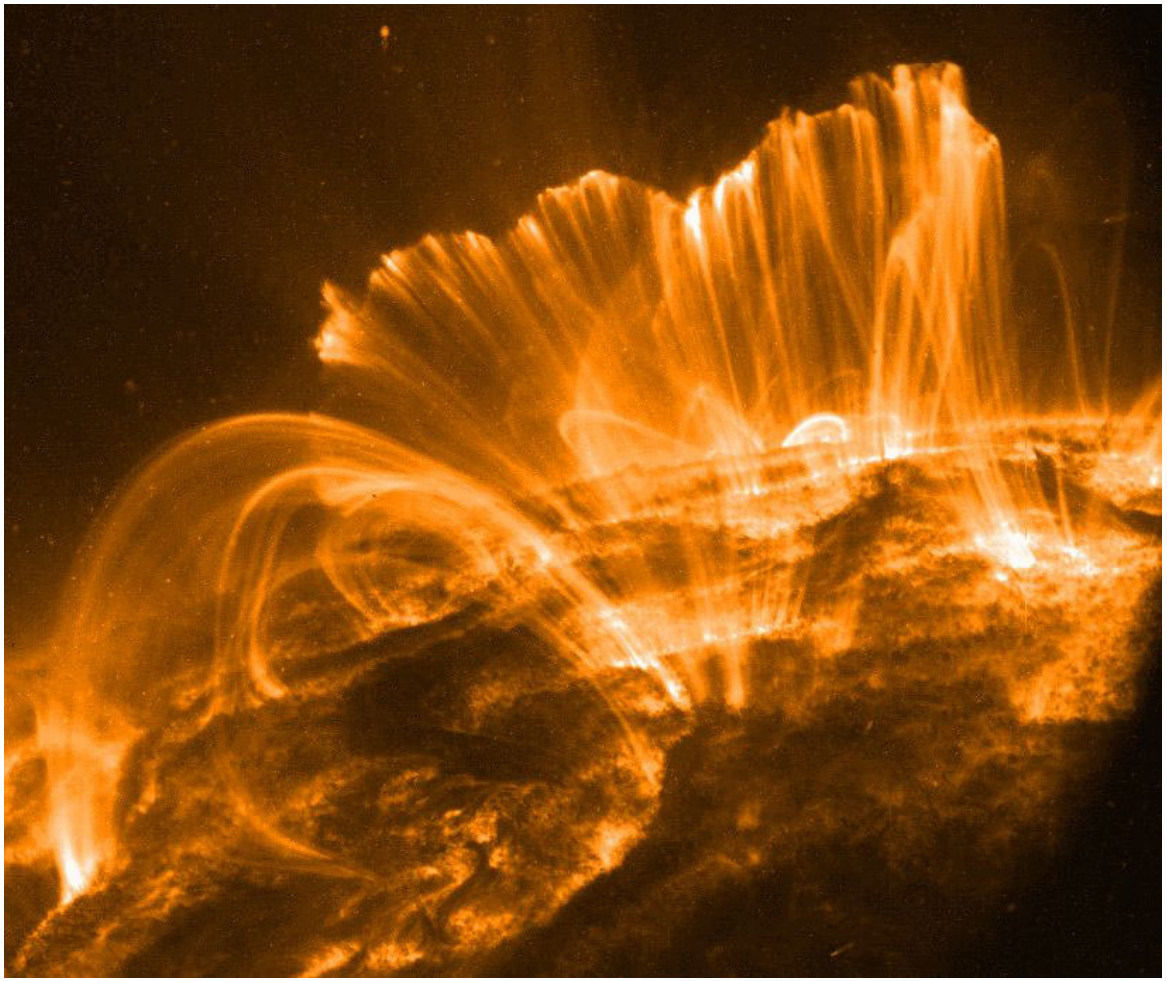




Solar system, space plasma



Solar physics/astronomy

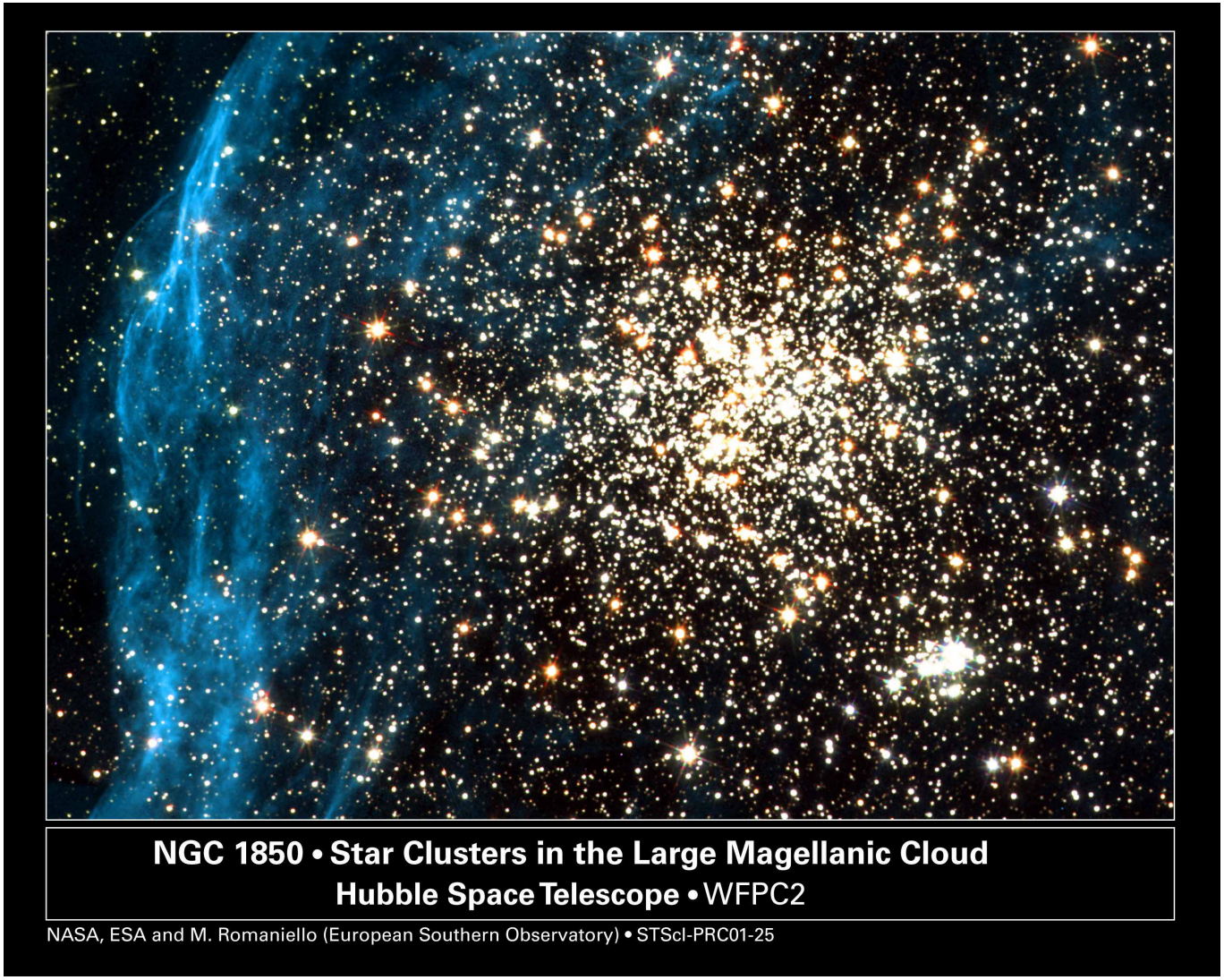


(Magneto-)fluid dynamics on the surface of the Sun. This far ultraviolet image reveals very hot plasma.

Stellar astronomy

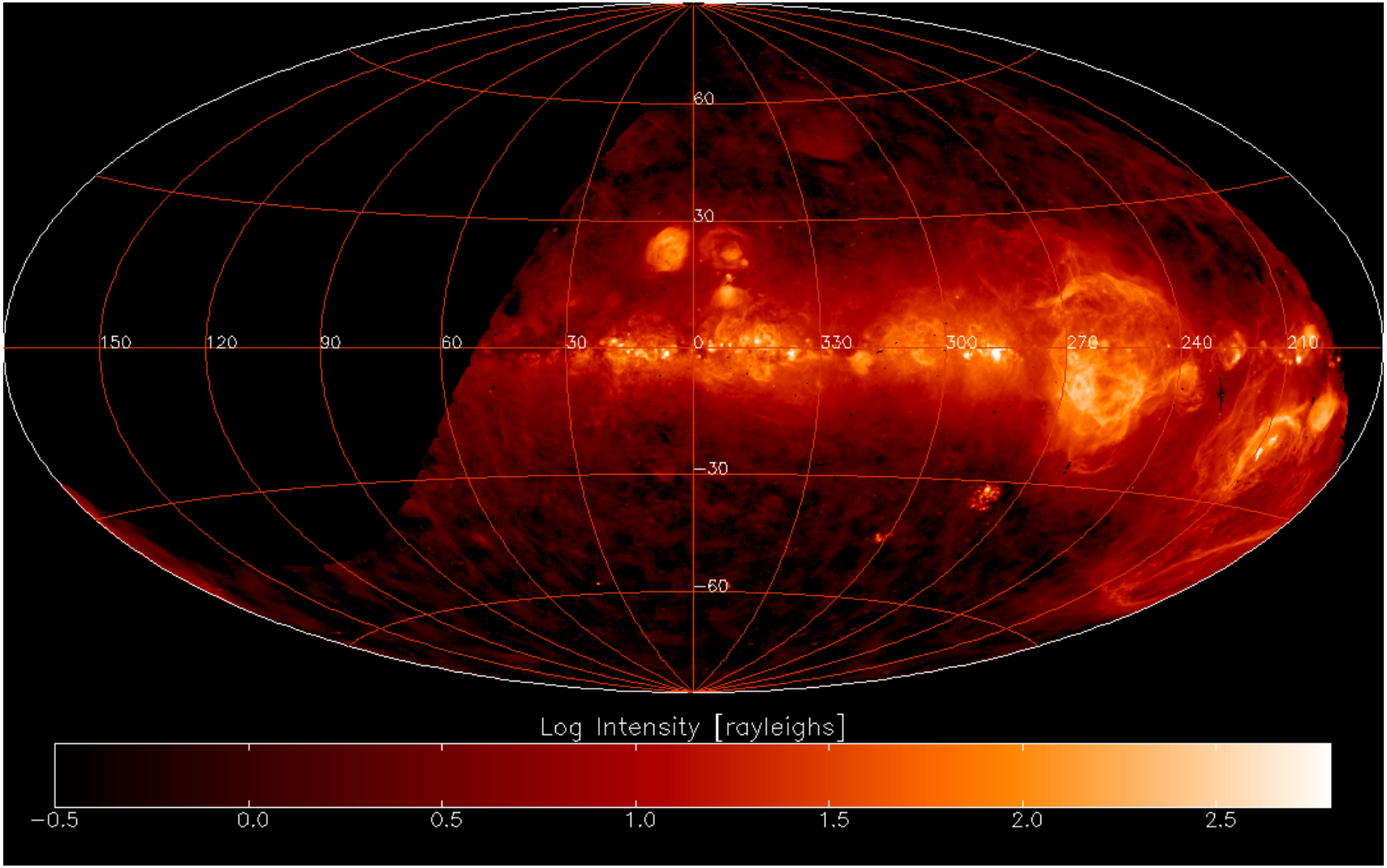
Star clusters are bound by gravity. The math that describes hot gases (stat mech) are also applicable to these systems. And the presence of blue stars seen in the image on the left is not currently understood. They should be long-gone from this cluster.

Interstellar medium



Supernovas that recently exploded in this star cluster formed the shock-compressed (blue) gas seen on the left.

…interstellar medium in the galaxy



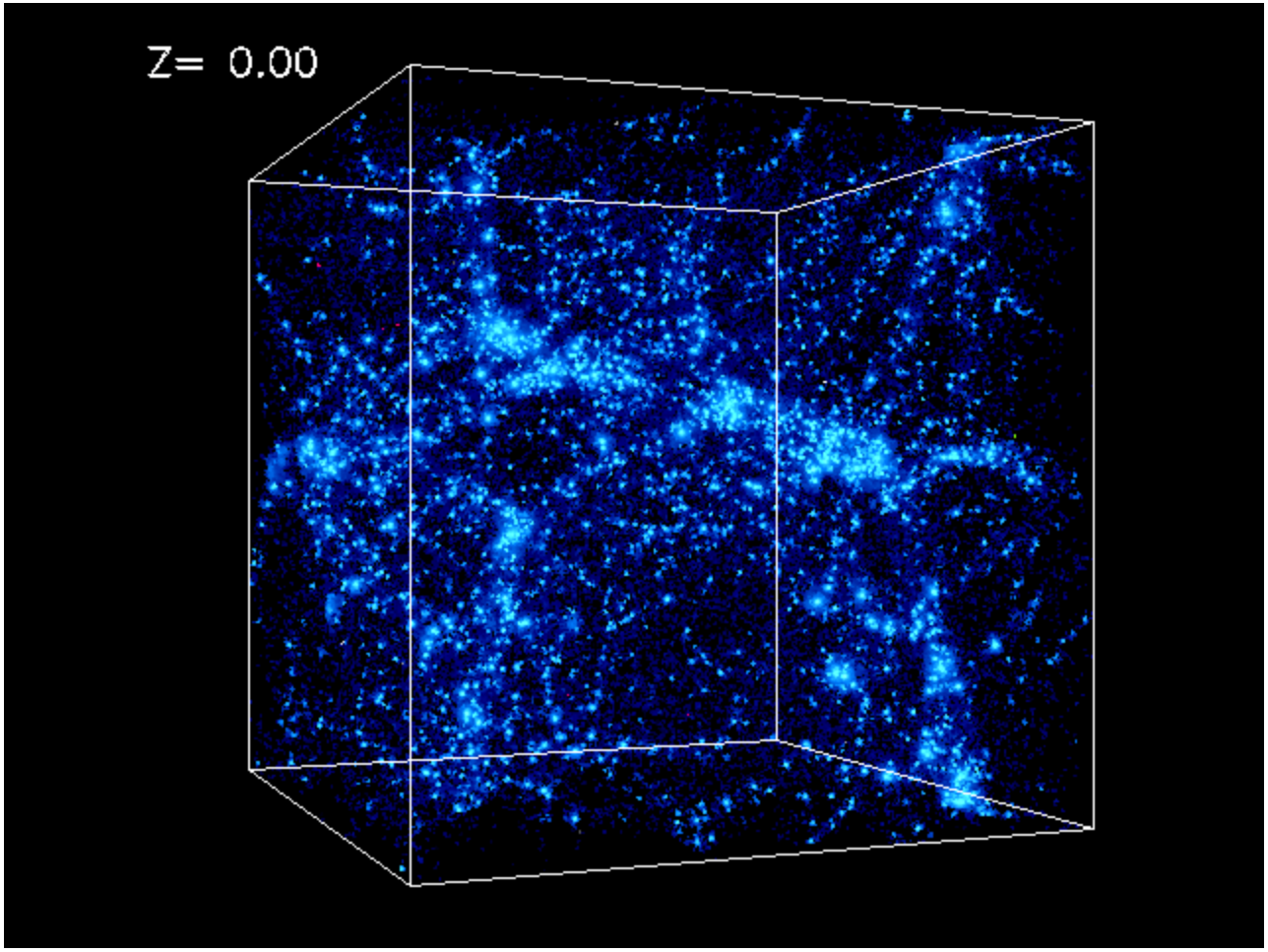
Map of warm hydrogen gas in the Milky Way made by Prof. John Gaustad, with the help of many Swarthmore students of the years.

The Milky Way and other galaxies

…and galaxy clusters

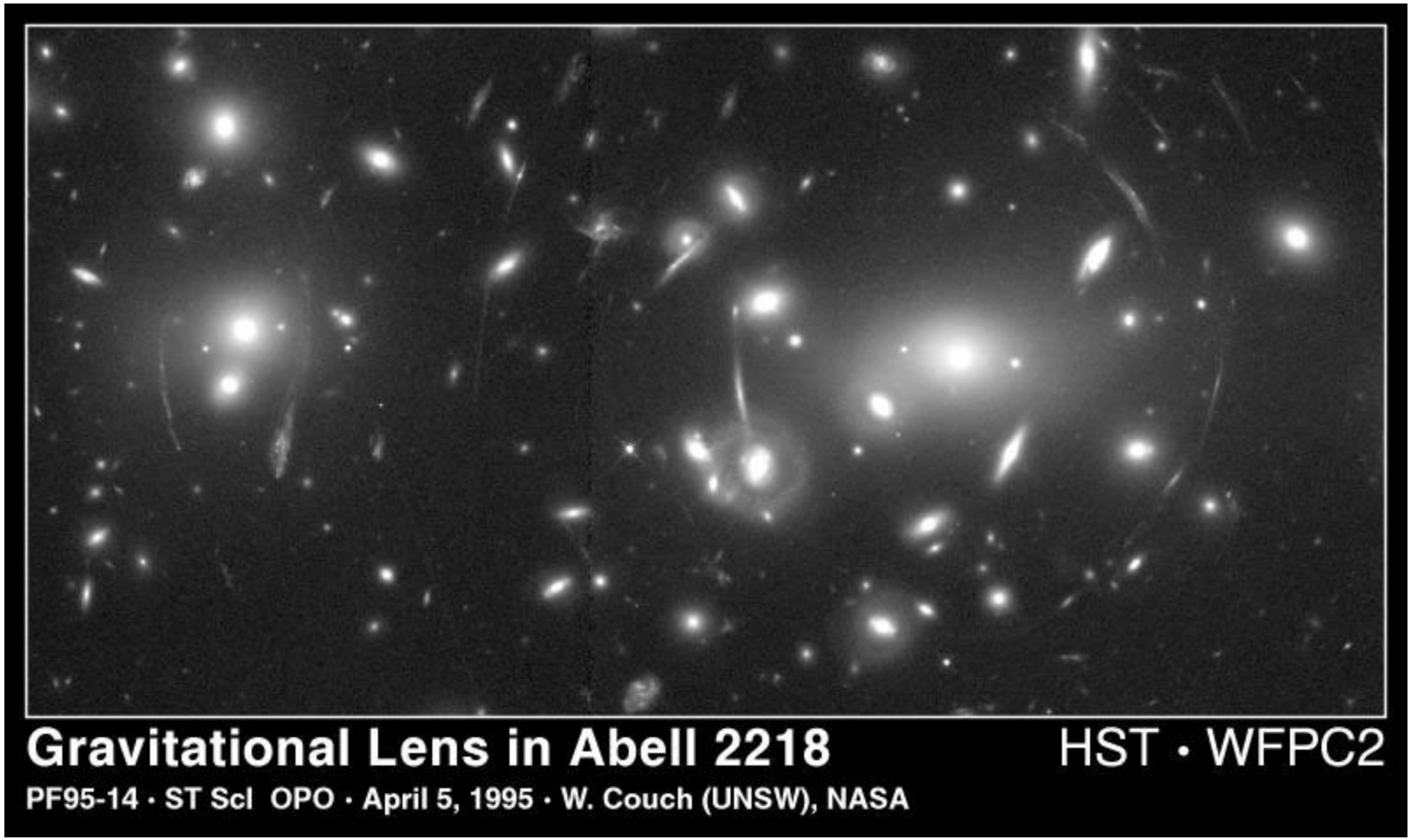
Gas, dust, and stars in the Milky Way (left); Numerous individual galaxies in the cluster shown on the right.

Large scale structure



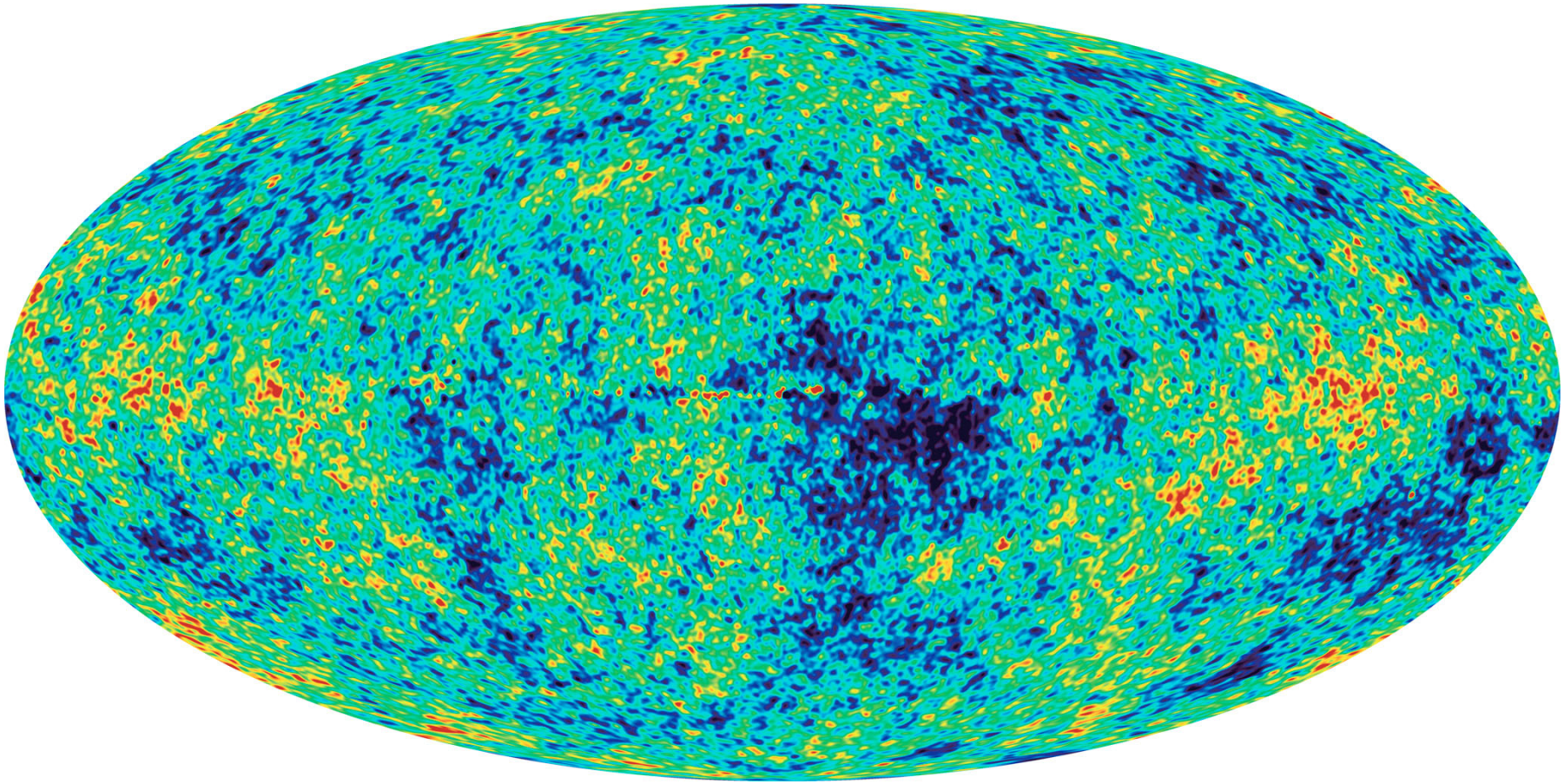
Numerical simulation of galaxy clusters and superclusters

Cosmology



"Arcs" of light from background galaxies bent by the gravitational mass of the galaxy cluster in the foreground. This is evidence for dark matter.

Cosmology and astroparticle physics



Map of structure in the cosmic microwave background - evidence for dark matter and dark energy, as well as the flat geometry of spacetime.

Just contemplating this list inspires some observations:

The different subfields relate to each other – there's a hierarchy of scale (e.g. the Milky Way is made up of stars and gas);

Many interesting questions that are currently being debated involve these interrelations (e.g. Is the Milky Way an isolated object or should we think of it as being physically connected to its neighbors – galaxy collisions and mergers, infalling gas?)

The Universe is dynamic – objects form, evolve, and sometimes disappear – but usually on very long timescales

What are the big questions in astronomy today?
What are some of the "smaller" questions?

1. What is the universe made of (what are 'dark matter' and 'dark energy')?
2. How did the diverse and structured universe we see today evolve from the homogeneous initial conditions?
3. How common are planets around other stars and what are they like? Can/do they harbor life?

How are researchers trying to answer these questions?

See handout for an example involving planet formation. But the key points are:

Make observations that are designed to *discriminate* among competing theories.

Make theories that involve basic physics; add physical effects that are simple at first and only more complicated as they are needed to match the data. Make quantitative predictions that can be tested.

Interactions (communication) between theorists and observers are key; they inform each other of the next productive steps to take.

What are some of the “smaller” questions?

(these are but a few arbitrary choices)

How does the Sun heat its corona?

How do rotation and mass-loss affect the evolution of stars, and how big does a star have to be in order to eventually explode as a supernova?

Why isn’t the supermassive black hole at the center of the Milky Way giving off lots of energy, like we see in quasars?

What are gamma ray bursts?

What is the history of star formation in the universe? When were the first stars formed?

What kind of "tools" should a young astronomer have? How can they identify interesting research areas/questions/projects?

The most important thing is to nurture your interest in the world – wanting to understand nature's workings is what will keep you asking the right questions and picking up the skills you'll need to be a good researcher.

Learn some computer languages and practical software packages, used, e.g., in data analysis (IRAF in optical astronomy); IDL…

Get involved in doing numerical (i.e. computer) simulations

Read about new research results, eventually begin scanning the literature.

Talk to the faculty!

How can you get and stay informed about astronomy research?

Astronomy Picture of the Day: http://antwrp.gsfc.nasa.gov/apod/astropix.html

Email lists: Sigma Xi's Science in the News: http://www.mediaresource.org/news.shtml; NASA's space science news: http://science.nasa.gov/

Physical Review Focus: http://focus.aps.org/

Read *Science*'s "News of the Week" each week

Scan tables of contents of ApJ, AJ, MNRAS, PASP (in Cornell Library or on-line) (Astro 61 webpage is a good source of specific information about the literature)

Annual Reviews of Astronomy and Astrophysics

How can you get involved in research?

Email to students we sent out a few weeks ago (posted at http://astro.swarthmore.edu/summer_research.html)

Research page on dept site (students page too)

REU programs

Keck astronomy consortium (summer exchange program and student research symposium)

Personal contacts

Dog-n-pony show (faculty presentations on actual summer research projects) at the end of February