Space and You: from Climate Change to the Big Bang

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Natural Sciences Week 2009

September 16, 2009

Overview of Astronomy

What it is: the study of the natural world beyond Earth, but also a means to understand Earth as a planet and host for life in that broader context.

Major Issues

The birth, evolution and fate of the Universe

Life cycles of stars

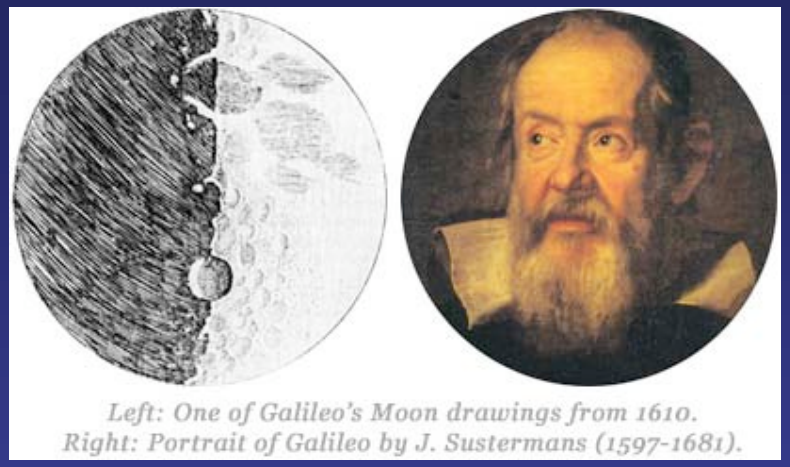
Life cycles of galaxies

Black holes

Exoplanets, Astrobiology - is there life elsewhere?

They are all interconnected - it’s all one Universe!

International Year of Astronomy - 2009



Left: One of Galileo's Moon drawings from 1610.
Right: Portrait of Galileo by J. Sustermans (1597-1681).

400th Anniversary of Galileo's telescope

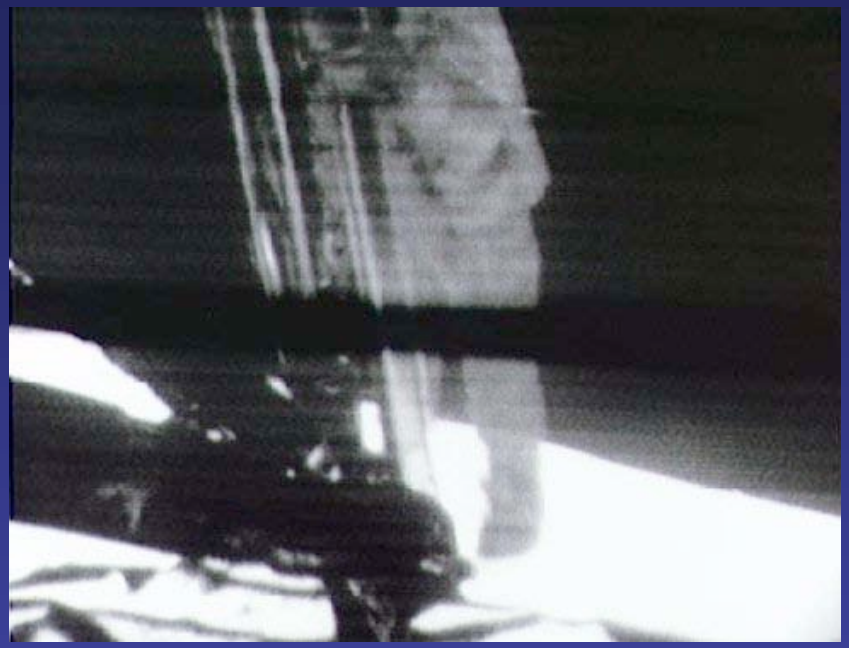
Approved by United Nations http://www.astronomy2009.org/

Galileo telescope kit: https://www.galileoscope.org/gs

Activities throughout the Fall on campus

http://mcdonaldobservatory.org/iya/

40th Anniversary of the First Landing of People on the Moon

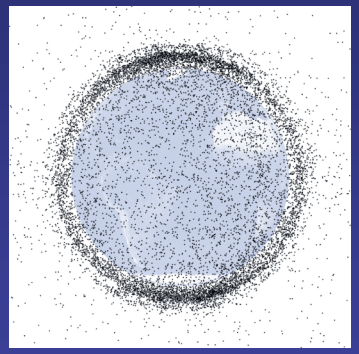


Learned that Neil Armstrong did not step from ladder onto the Moon, but onto a thin baseplate and from there took the famous “small step.”

I was in graduate school at the time. It was inconceivable that 40 years later, no one would be on the Moon…

Our understanding, use, and exploration of space has exploded in these last 40 years

Hundreds of satellites in near Earth orbit, synchronous orbit, and elsewhere, and debris



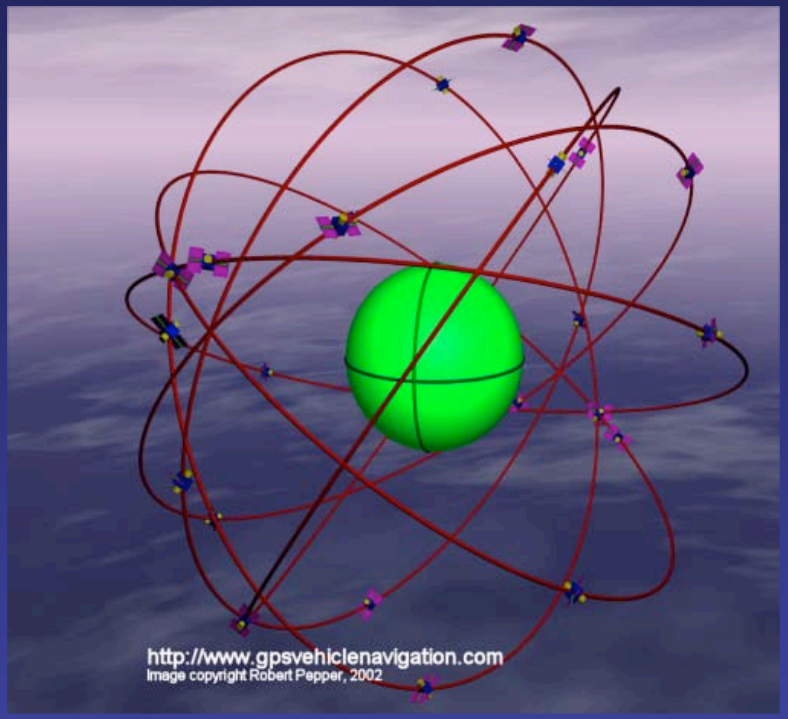
Check live orbit status:
http://science.nasa.gov/Realtime/jtrack/3d/JTrack3D.html

Check view from given satellite to Earth:

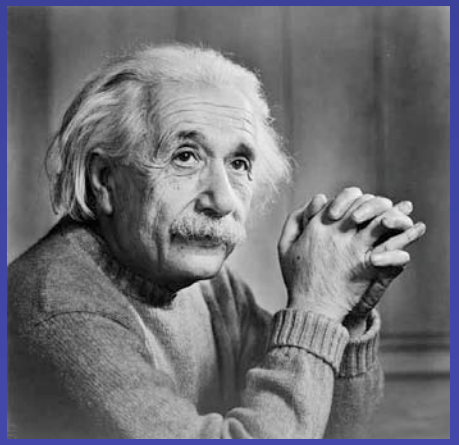
http://www.fourmilab.ch/earthview/satellite.html

Basis for much of our telecommunications industry: cell phones, television, the internet

One especially fascinating application: the Global Positioning System



GPS depends not only on an array of satellites in orbit, but must be programmed to understand Einstein's theory of warped space and time to function properly.



A precious, vanishing resource: our dark skies

"Darkness is as essential to our biological welfare, to our internal clockwork, as light itself." -Verlyn Klinkenborg, "Our Vanishing Night," National Geographic magazine, November 2008

Difficult to see the night sky from Austin

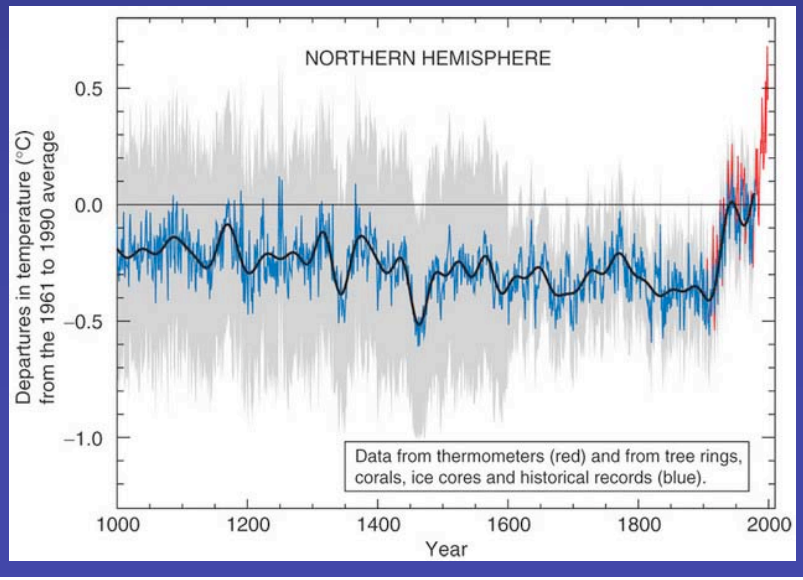
One of the offenders, the bright lights of the UT intramural fields

The Space Connection: Global Climate Change

The Sun irradiates the Earth and its atmosphere and drives weather and climate.

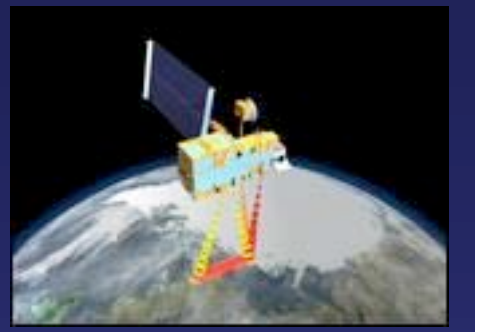
When I first began to read about global climate change a decade or more ago, I was a little skeptical; I knew the Sun had cycles, and the Earth has had ice ages. There are natural cycles.

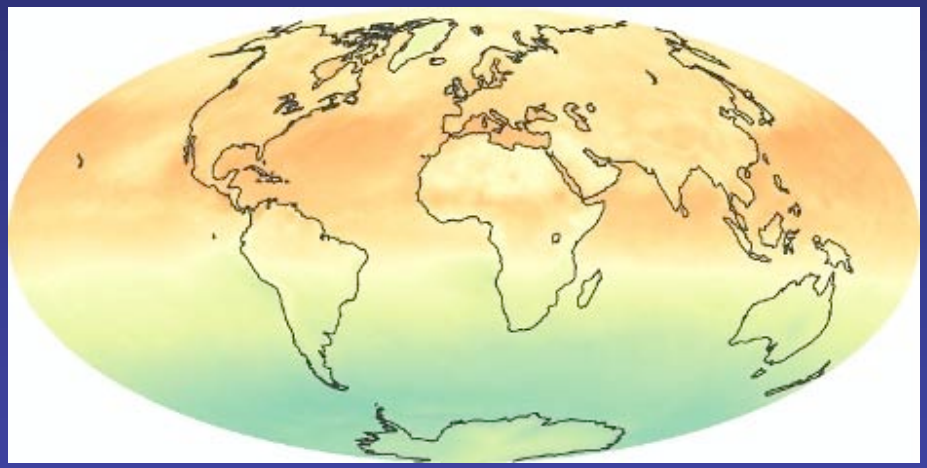
As an average, informed citizen, I have become convinced by the hockey stick diagram: human kind is contributing to global warming.



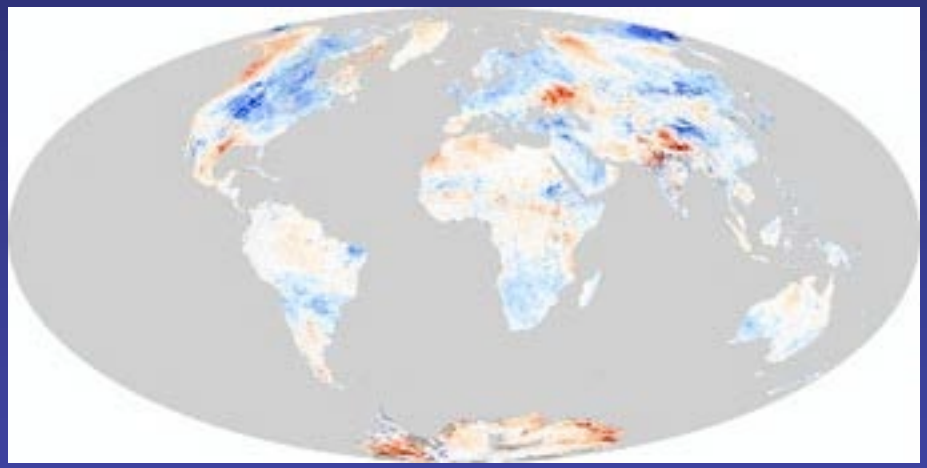
Inuit kids playing golf where snow and glaciers used to be.

One important approach is to gather data from orbit





Map of irradiance



Map of temperature anomalies

Global warming, and the human contributions to it are a tricky issue to analyze: strong, non-linear feedback processes.

Doubling the amount of greenhouse gas like CO in the atmosphere does not simply double the amount of warming.

One example: thawing of permafrost (Inuit golf) may lead to the release of vast stores of CO previously sequestered.

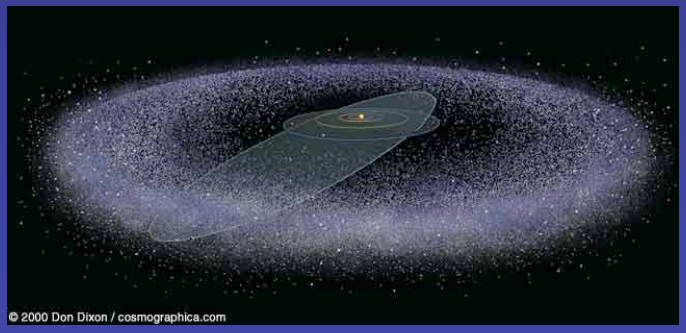
My recent concern has been that the political backlash against the idea of a human contribution to global warming has been so severe that scientists may have been overly conservative in their predictions; things may get worse faster than recent models have suggested.

The Earth is not in peril from human activity. The Earth will spin on for 5 billion years and do just fine. It is humans that are imperiled.

Pluto: a teaching moment

Many people, including astronomers, were upset when Pluto was demoted from being a planet.

Since the discovery of Pluto in 1930, the context has changed, specifically the discovery of the Kuiper Belt of small icy bodies in the 1990s.



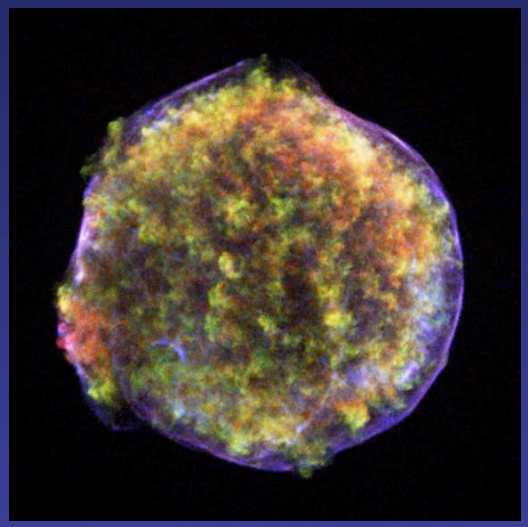
Pluto was not the last of the planets, but the first of the new class of Kuiper Belt objects.

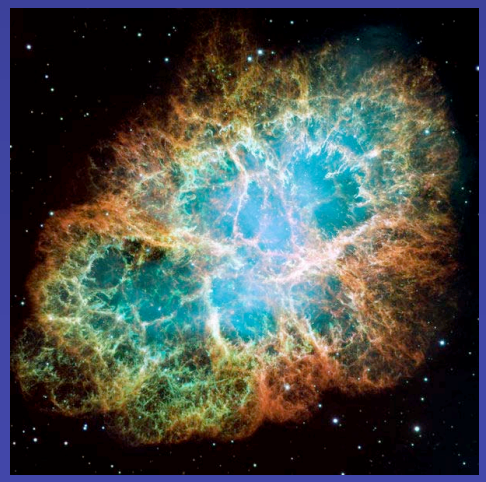
Life Cycles of Stars

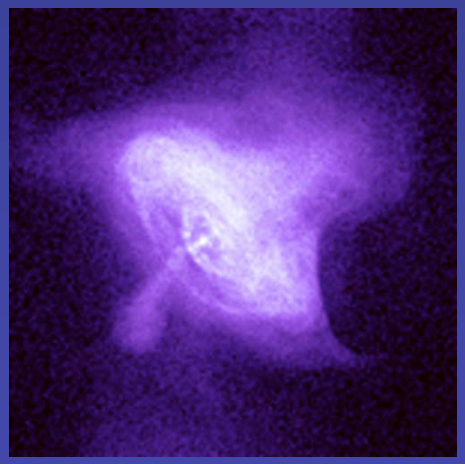
Birth from dilute interstellar gas - the pillars of creation

Life Cycles of Stars

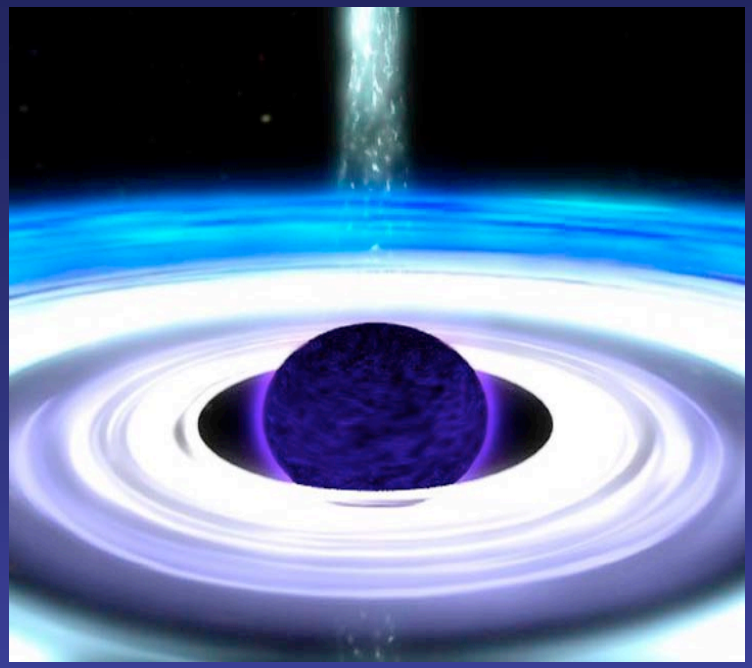
Death and Transfiguration - supernovae, neutron stars, black holes







Black Holes

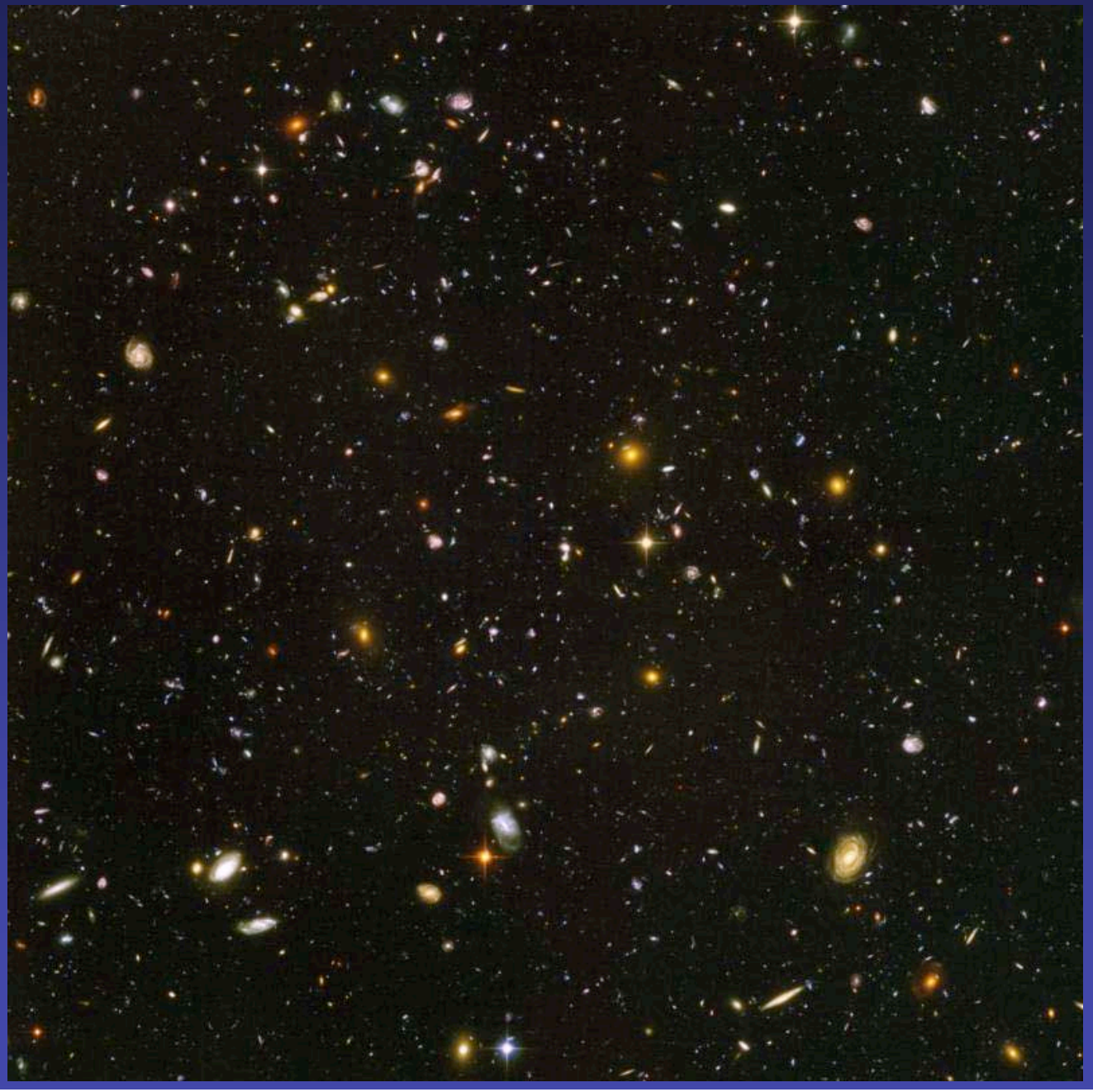


Stellar mass black holes orbiting companion stars

Supermassive black holes, millions to billions of solar masses, in the centers of our Milky Way and nearly all other galaxies, formed and grew with the galaxies.

Life Cycles of Galaxies

Hubble Ultra Deep Field



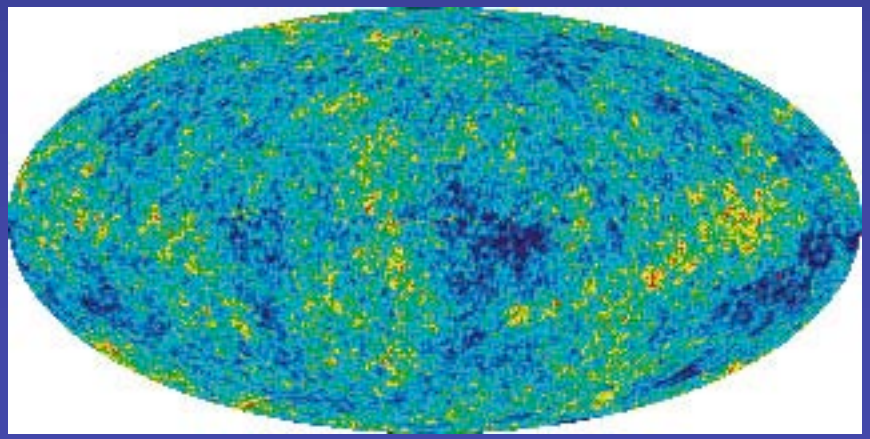
Every speck a Galaxy

The Birth, Evolution and Fate of the Universe

The golden age of quantitative cosmology

The birth of our Universe in a Big Bang 13.7 billion years ago

Tiny quantum fluctuations grow with dense regions becoming denser, hotter, rarefied regions more rare and cooler. The expanding Universe rings like a bell. We see this signal written in the cosmic background radiation, measured with incredible precision, one part in 100,000.



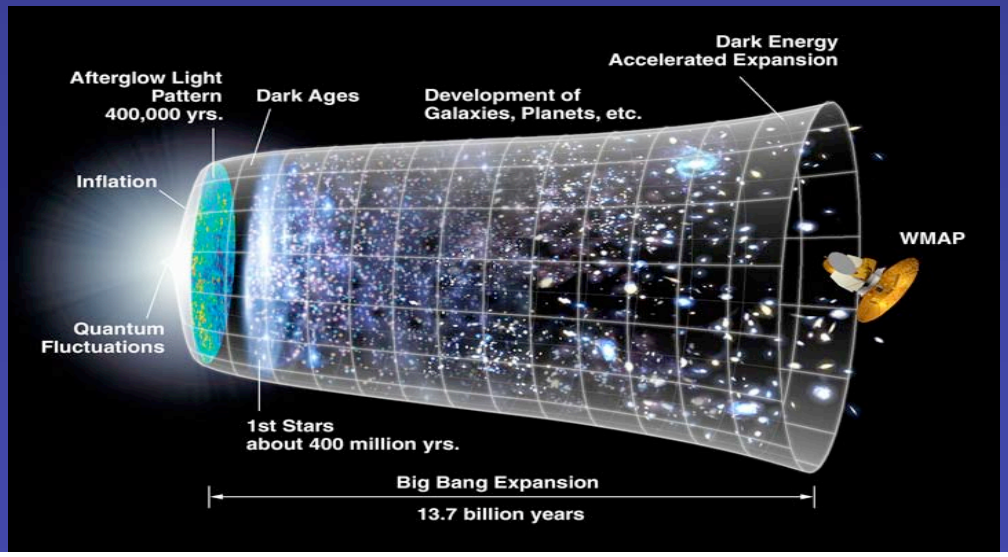
Fifth data release, Wilkinson Microwave Anisotropy Probe WMAP

The Growth of Structure

The Universe became cool and transparent when it was 376,000 years old.

The Universe was then dark for about 700,000 million years before the first stars formed: The Dark Ages

The originally tiny fluctuations eventually grew into all the structure we see, stars, galaxies, clusters of galaxies in an immense, expanding void.

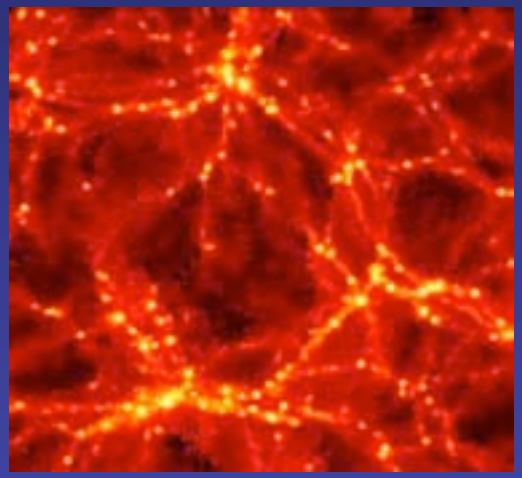


The Composition of the Universe

We are composed of protons, electrons, and neutrons

96% of the Universe is not like us

1/3 Dark Matter - gravitates, forms the structure in the Universe, the Cosmic Web



2/3 Dark Energy - anti-gravitates, causes the Universe to accelerate. Challenge to the roots of physics (or are we misinterpreting something?)

The Origin of the Universe

String theory

Multiple dimensions

Other Universes

Chaotic inflation

Landscape - a vast number of universes, only some hospitable for life?

The Fate of the Universe

Expansion into a dark void?

Exoplanets, Astrobiology - Is There Life Elsewhere?

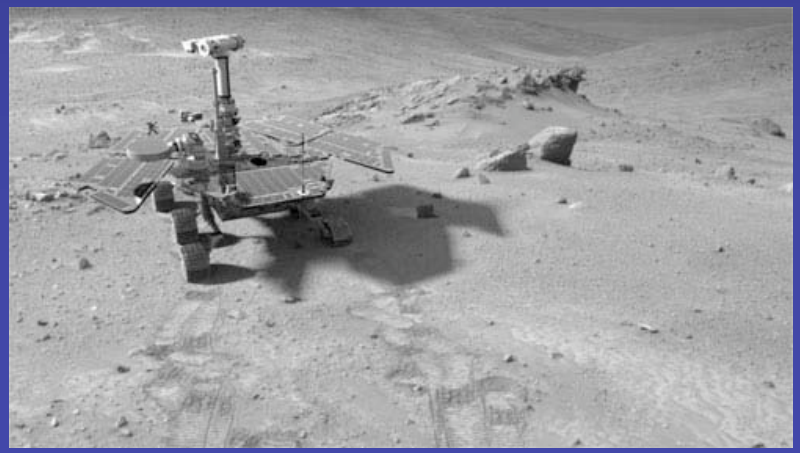
Nearly 300 planets found around other stars

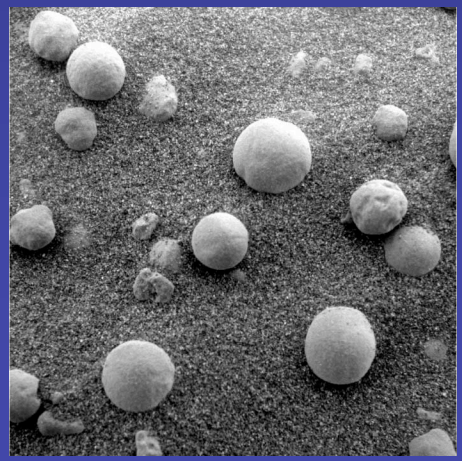
Solar systems unlike our own, Jupiter in the place of Mercury

Quest for “Earth-like planets”

Search for biomarkers - indirect evidence for life, as the oxygen in our atmosphere

Mars - follow the water, Rovers, orbiters, landers.





Hematite “blueberries”

The Fermi Paradox

Enrico Fermi famously asked: “Where are they?”

Other stars that could host life preceded the Sun by billions of years. Other civilizations should be hugely advanced, if they exist.

Basic, self-replicating probes traveling at Apollo speeds could fill the Galaxy in only hundreds of millions of years.

With all its tools and techniques, modern astronomy sees not a hint of life elsewhere, but it’s hard!

Simplest answer may be that there are few other civilizations, but why?

Roots of the Issue

The origin of life: how did natural systems make the transition from chemistry to biochemistry? Is self-replication and the opportunity for exponential growth, natural selection, adaptation, growth of complexity, common in the Universe?

The origin of consciousness: what is required to make a life-form self-aware? Another issue of complexity.

The Rare Earth hypothesis (Ward & Brownlee 2003) - conditions have to be "just right" in a Galactic and Solar System "habitable zone." The fact that Earth satisfies the conditions to host life is a very rare circumstance.

Possible counterargument - Earth in a disturbed Galactic ecology is not a bad thing, perturbations lead to complexity, a necessary ingredient for life, consciousness.

The Search for Extraterrestrial Intelligence

What resources should be devoted to SETI, given that the evidence seems to be that advanced life is rare?

My answer - some, because we are not sure. The risk is high, but the payoff would be tremendous.

Directed SETI - now we are “listening” and “watching.” Should we be actively sending signals, for instance directed, coded laser messages to announce our presence?

Future Perspectives

What is the future of the human race, Homo Sapiens?

100 years from now?

10, 000 years from now?

1,000,000 years from now?

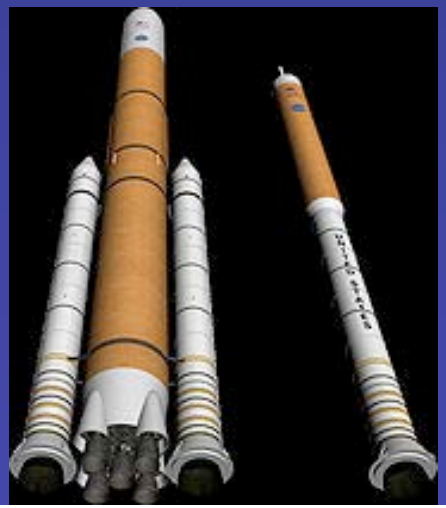
Are Homo Sapiens still evolving? How?

The Human Space Flight Program

An issue with which you will have to deal, as educated, tax-paying citizens.

The Columbia disaster illuminated the fact that NASA had been spending resources to send humans into low Earth orbit, with no long-range goal.

In 2004, President Bush presented his "Vision for the Exploration of Space:" retire the Space Shuttle by 2010, build new launch vehicles that could more safely send people into orbit and beyond. Return to the Moon by 2020.



2009 Augustine Committee

Charged by President Obama to review the status of NASA and the human space flight program.

http://www.nasa.gov/offices/hsf/home/index.html

Summary just released: NASA cannot do the job with its current budget.

"The nation is facing important decisions on the future of human spaceflight. Will we leave the close proximity of low-Earth orbit, where astronauts have circled since 1972, and explore the solar system, charting a path for the eventual expansion of human civilization into space? If so, how will we ensure that our exploration delivers the greatest benefit to the nation? Can we explore with reasonable assurances of human safety? And, can the nation marshal the resources to embark on the mission?."

$3 billion more per year (by 2014 on top of the current $18.7 billion) is required to go to the Moon, or asteroids, and Mars in the long run.

The Future of Humans in Space

The role of NASA

Scientific research versus human exploration

The role of international partners

The role of private industry

How will President Obama move forward?

How would you?

Space and You

The challenges and opportunities of exploring space around the Earth and out through the Universe will be a factor in your life.

Make the best of it!