Opportunities and Challenges in Astronomy and Astrophysics:

Presentation to the Review of U.S. Human Space Flight Plans Committee

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and

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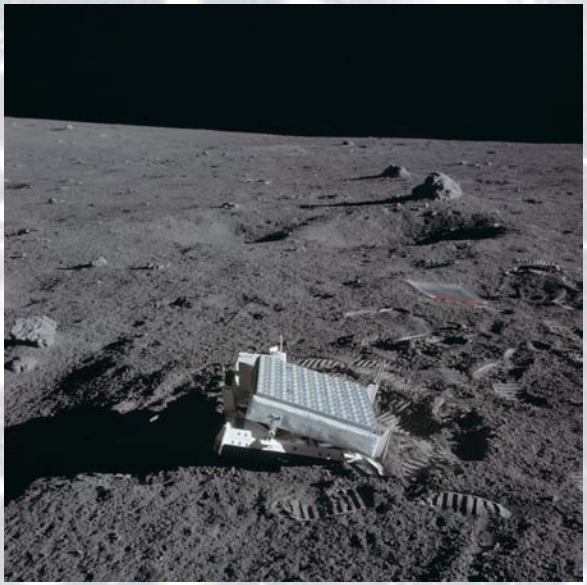
This presentation represents my personal views and not those of Astro2010.

Astronomy and Human Space Flight: A Productive Past

Astronaut Andrew Feustel helps to install the Wide Field Camera 3 during a May 14, 2009, spacewalk visit to Hubble.

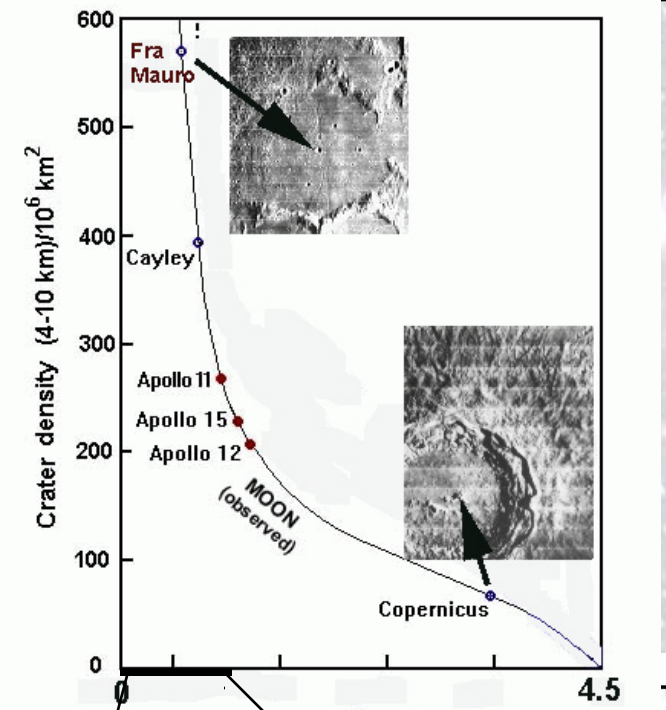
Astronomers are grateful that astronauts have been willing to risk their lives to improve HST!

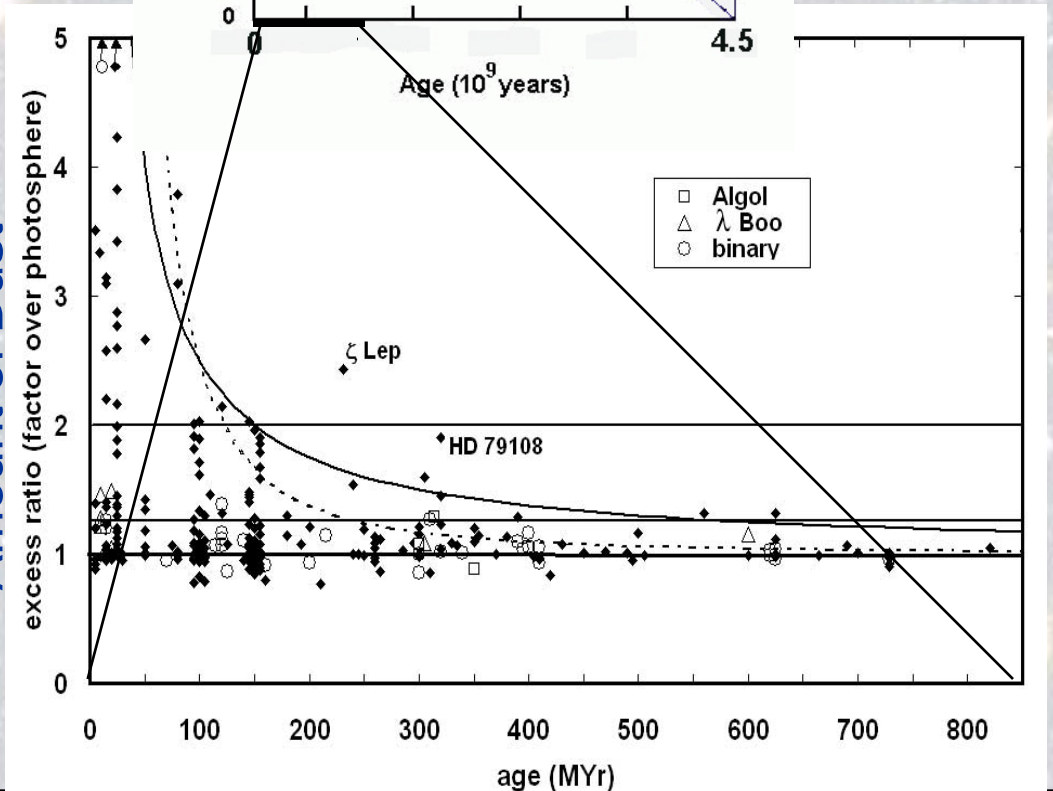
Apollo 14 laser ranging retro-reflector



Lunar retro-reflectors have provided the means for fundamental tests of gravitational theory using data gathered since 1971.

Unanticipated Returns: Time Scales in Planetary Systems





- Radioactive age dating of lunar rocks established a time scale for cratering in the Solar System
- Recent Spitzer Space Telescope data show evidence for clearing of material around other stars that would create similar impact records
- Connection between our own Solar System and distant ones possible because of the lunar sample return

Data showing the existence dust and particles like meteors around other stars from Spitzer Space Telescope.

Your First Question

Please give examples of important science objectives that could be addressed by NASA's human space flight program in the next and coming decades.

Astro2010 has received over four hundred inputs from the broad astronomical community. Only a few of these mention a connection with the human space flight program:

-- placement of new retro-reflectors on the Moon

-- deployment of radio telescopes on the back side of the Moon

-- use of newly developed launch vehicles for astronomical missions

but Astro2010 did not request papers on science objectives specifically related to human space flight.

Engineering connections could include servicing facilities at L2, and building large telescopes in space.

Your Second Question

How, and in what areas, can exploration and science be mutually supportive?

Astronomy is an exploration of places that we cannot visit easily in person, and there are many connections between what we can visit and what we can only study remotely.

For example:

Exosolar planetary systems

-- planet discoveries are accumulating rapidly

-- Kepler mission will quantify number of Earth-like planets

-- transit studies are yielding data on atmospheres and surface temperatures of exosolar planets

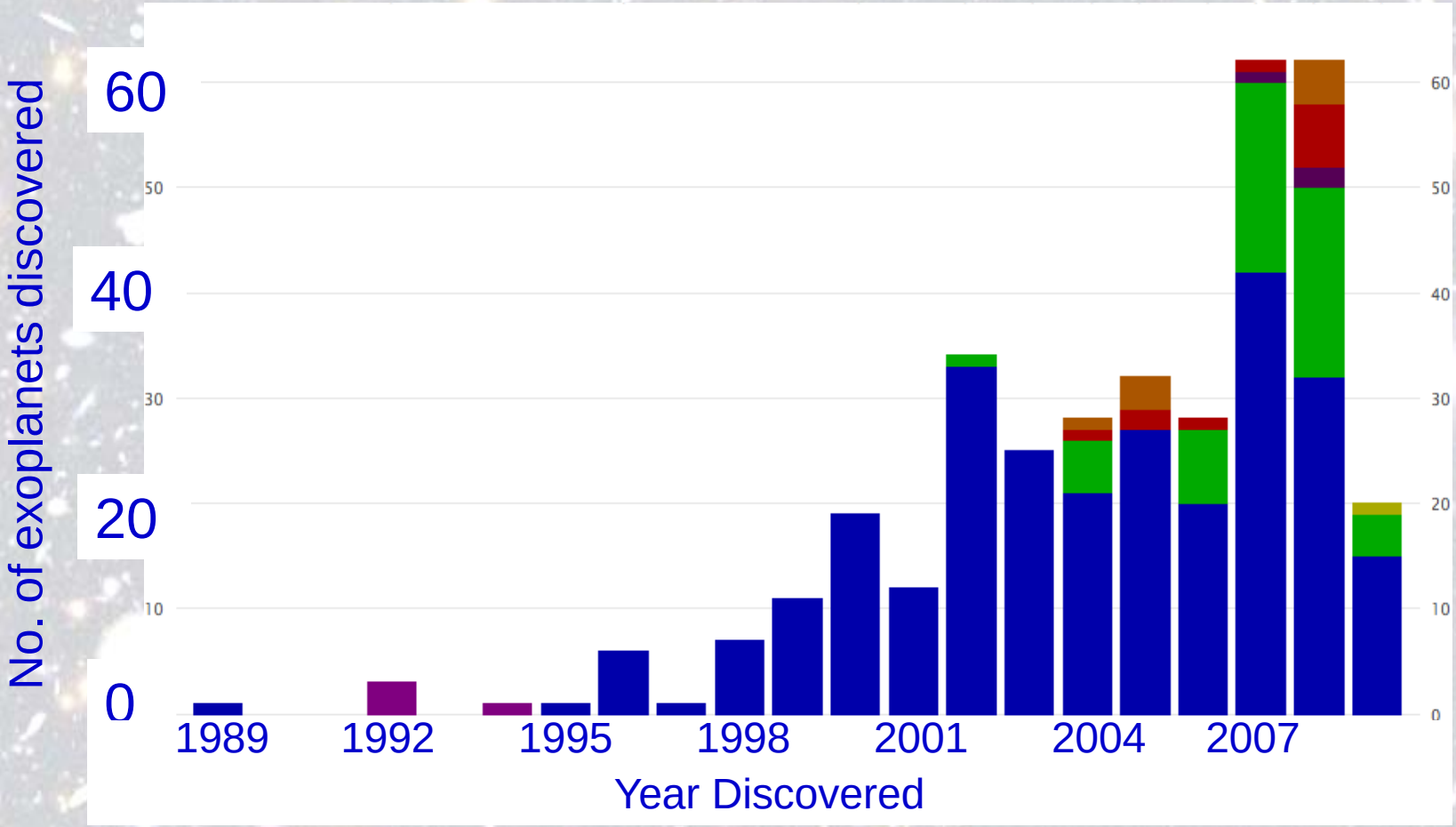
Violent events

-- studies of the Sun are driving towards more predictability of flares

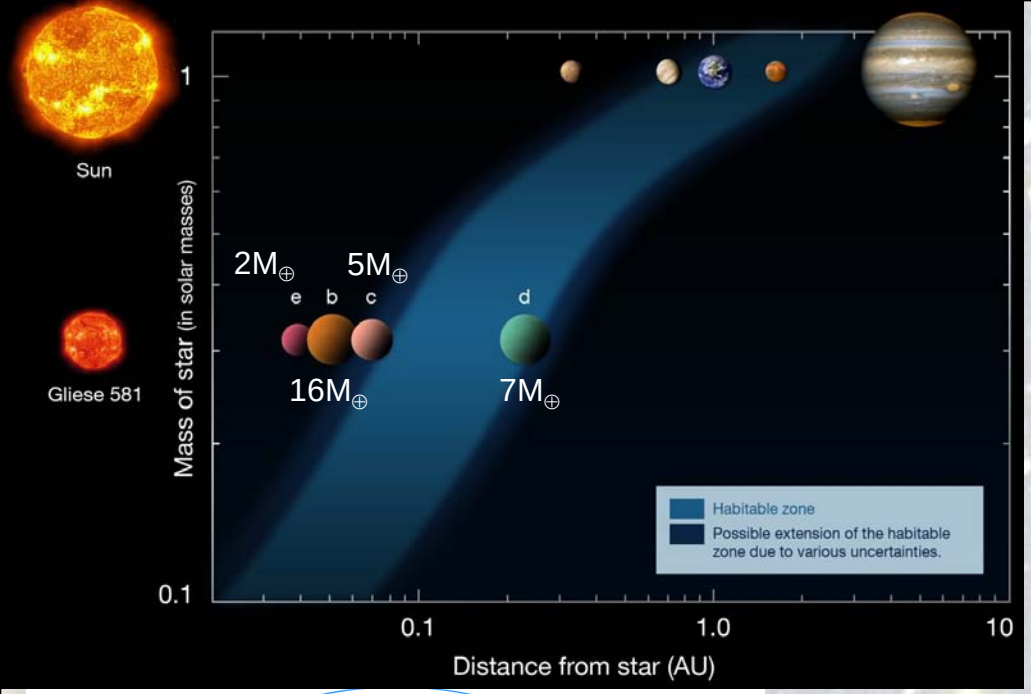
-- high energy missions are discovering and quantifying the numbers of energetic objects elsewhere in our galaxy that emit high levels of γ–rays

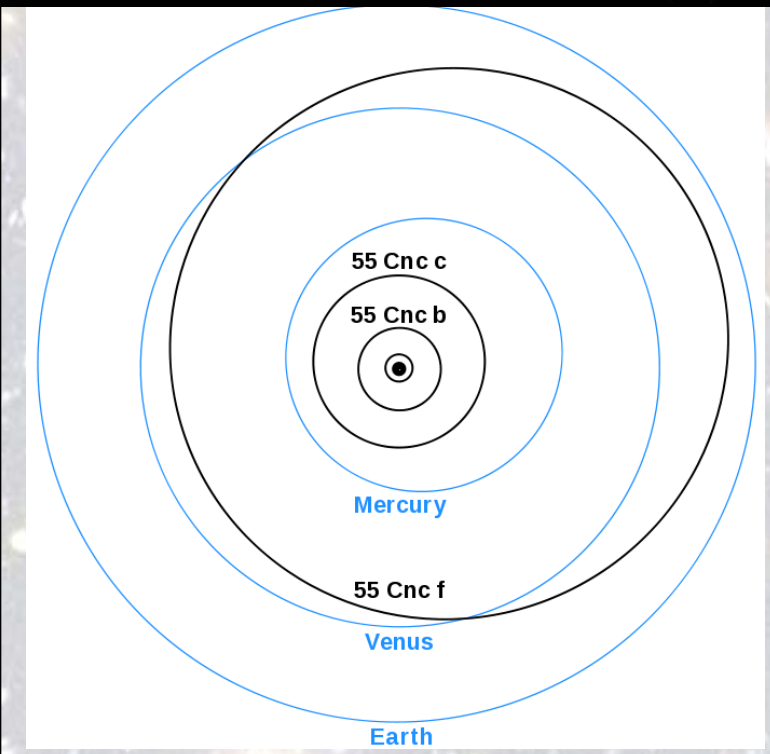
Exosolar Planets

- Pace of discovering exosolar planets is accelerating
- Neptune and Uranus-size planets now being found
- Transit observations are providing data on atmospheric characteristics



Color indicates discovery technique: radial velocity = dark blue, transit = dark green, timing = dark purple, astrometry = dark yellow, direct imaging = dark red, microlensing = dark orange, pulsar timing = purple





What are the goals?

Can we find other planetary systems that look like the Solar System?

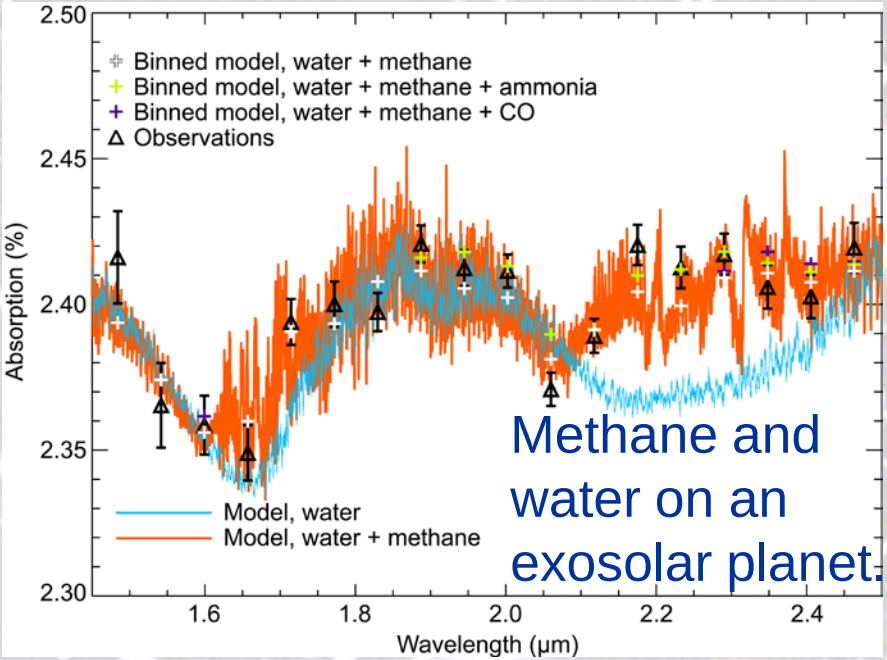
Can we find Earth-like planets in another's star's habitable zone?

How do planetary systems form and evolve?

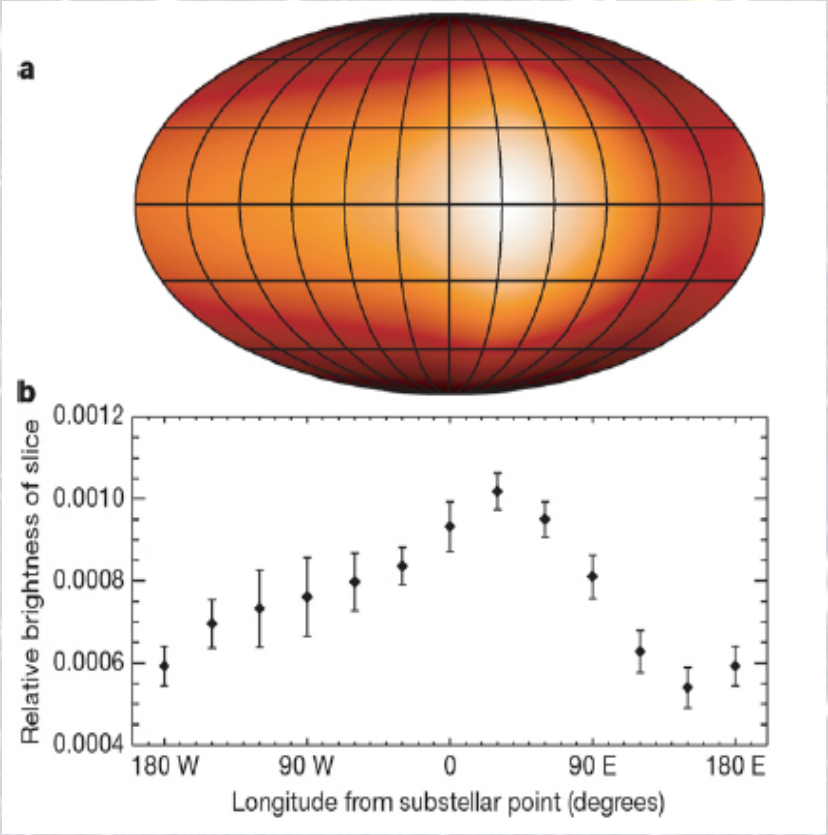
Can we find evidence for life elsewhere?

Understanding our own planetary system is essential!

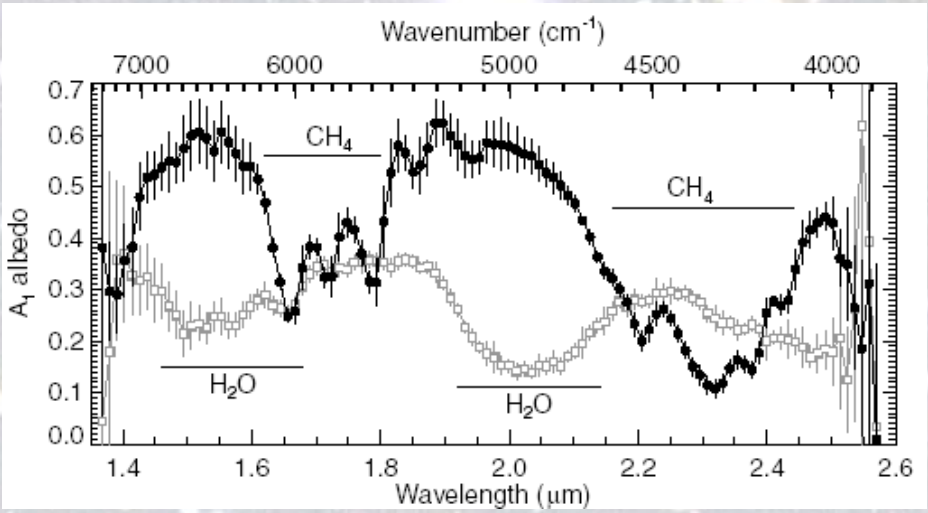
Transits Yield a Detailed View



Methane and water on an exosolar planet.



Surface temperatures on an exosolar planet.



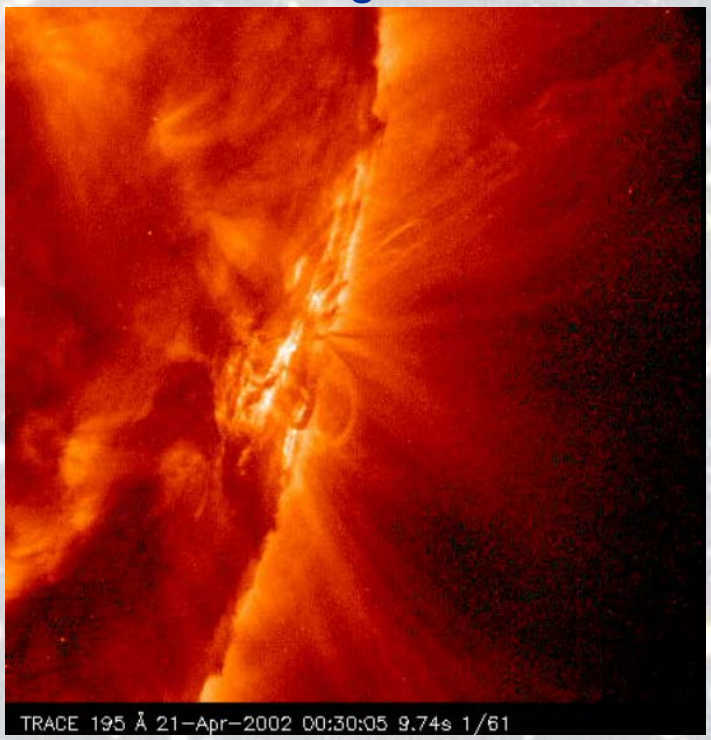
Methane on Pluto and Water on Charon.

Detailed comparisons to Solar System objects are becoming feasible!

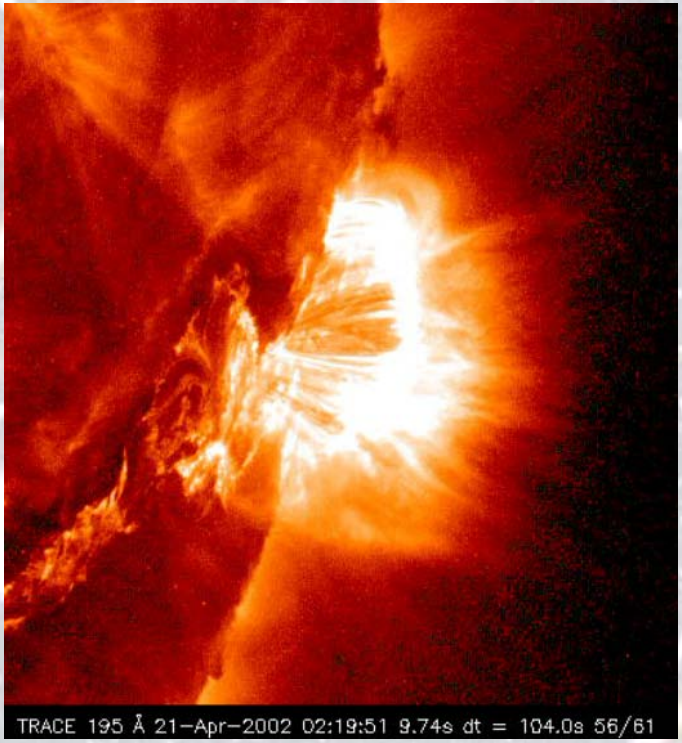
The Violent Sun

Astronomers have long tried to understand how the Sun's magnetic field causes the solar cycle and its attendant dangers. Study of other solar-type stars may shed light on the long-term nature of the solar cycle.

The goal is to understand the underlying physical mechanism which could lead to predictions of when activity might reach hazardous levels. Advances in numerical simulations and detailed data sets are moving us towards this goal.

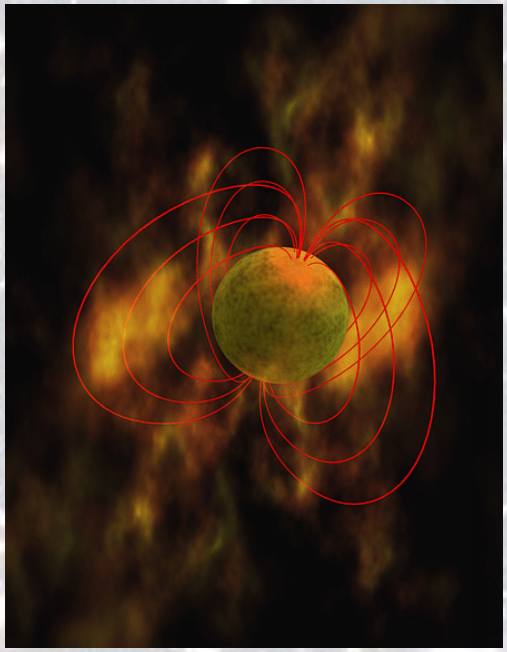


How and why do some solar active regions produces huge flares?



NRC Report "Managing Space Radiation Risk in the New Era of Space Exploration" recommends further study of solar activity and its predictability.

Dangers from Outside the Solar System

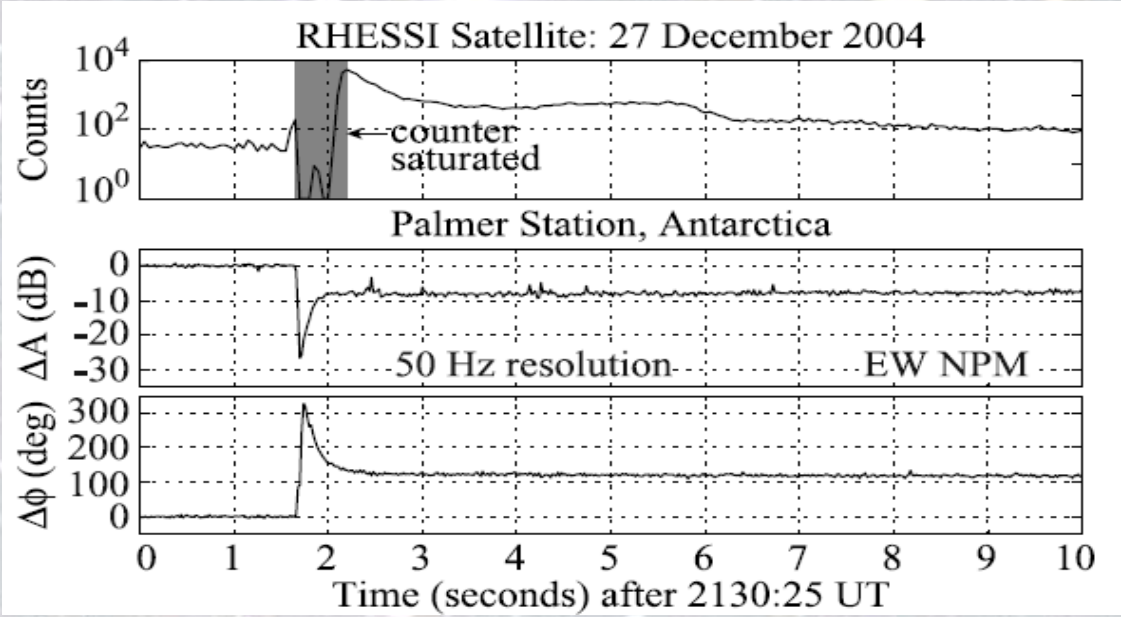


Artist's concept of a magnetar.

Spinning, magnetized neutron stars can emit copious quantities of gamma-rays.

A flare from SGR1806-20 (located half across the Milky Way from us) perturbed our atmosphere.

We don't have a complete census of such objects.



If such a flare were produced closer to the Solar System, it could be dangerous.

The γ-ray pulse from 1806-20 disturbed the Earth's ionosphere to a depth of ~20 km.

Summary

Astronomers have welcomed past opportunities to advance our understanding of the physical universe that were enabled by the human presence in space, and will no doubt do so in the future. We likely cannot predict today what the most significant result from future human space activities would be.

Searching for Earth-like planets and life outside the Solar System is a realistic goal for astronomers, and this goal must have a strong base of understanding in our own Solar System's planets and life.

Astronomy also shares a mutual interest with the human space flight enterprise in wanting to understand violent phenomena.

Visit http://sites.nationalacademies.org/bpa/BPA_049810 to find more about the astronomy and astrophysics decadal survey.