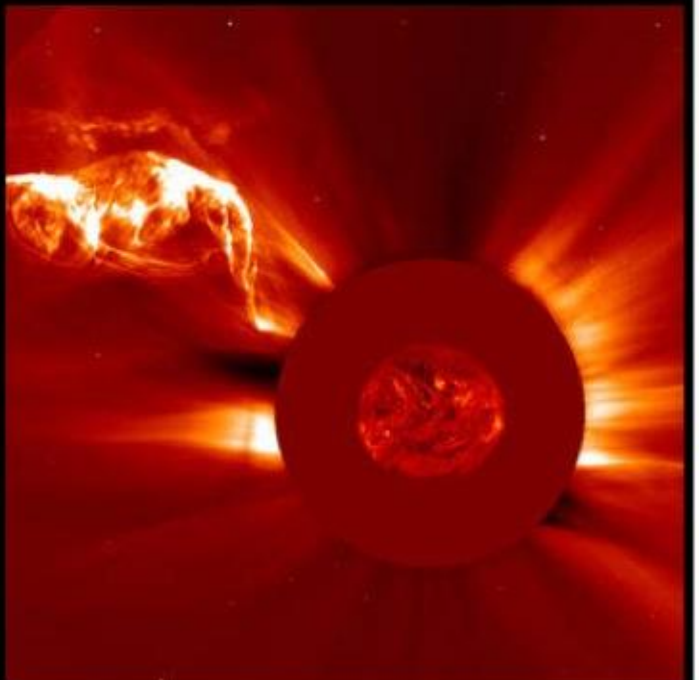
National Aeronautics and
Space Administration

Science Mission Directorate

Weekly Highlights

October 2, 2015

Understanding the Space Radiation Environment



A long solar filament erupted into space on April 28-29, 2015. CMEs are sometimes associated with a wave of high-energy particles that can be dangerous to astronauts and electronics outside the protection of Earth's magnetosphere. Credit: ESA , NASA, SOHO.

- On Aug. 7, 1972, during the heart of the Apollo era, a powerful solar flare exploded from the sun's atmosphere. This wash of quick-moving particles would have been dangerous to anyone outside Earth's protective magnetic field. Luckily, the Apollo 16 crew had returned to Earth just five months earlier.

- In the early days of human space flight, scientists were only just beginning to understand how events on the sun could affect space, and in turn how that radiation could affect humans and technology. Today, as a result of extensive Heliophysics and space radiation research, we have a much better understanding of our space environment, its effects, and the best ways to protect human and robotic explorers.

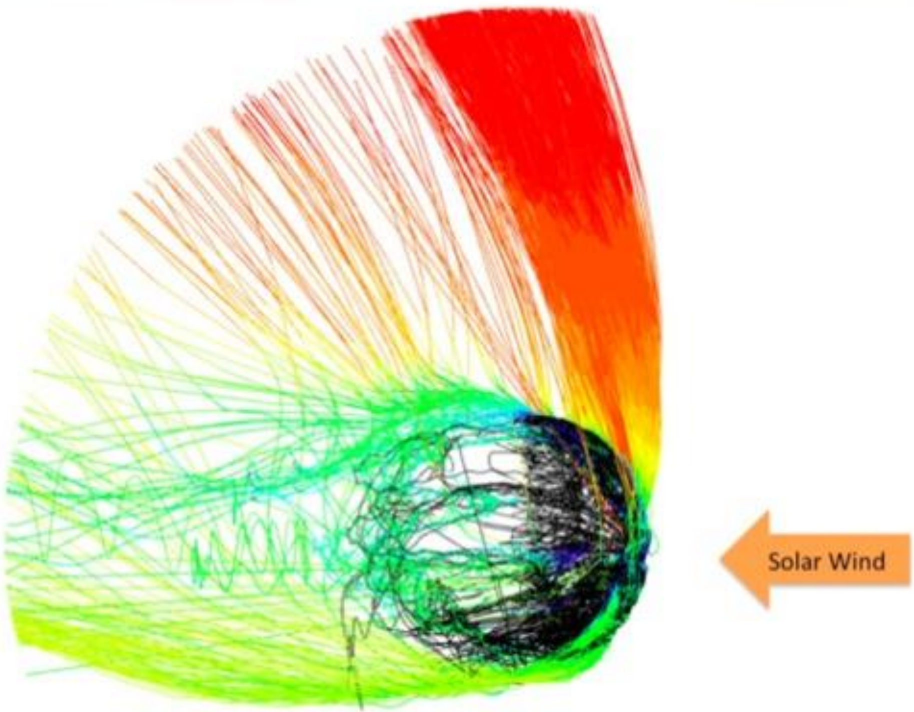
- NASA currently studies how to protect astronauts and electronics from radiation – efforts that will have to be incorporated into every aspect of future Mars mission planning. Radiation is basically waves or sub-atomic particles that transport energy to another entity – whether it is an astronaut or spacecraft component. Energetic particles can be dangerous to humans because they pass through the skin, depositing energy and damaging cells or DNA along the way.

- A human mission to Mars means sending astronauts into interplanetary space for a minimum of a year. Nearly all of that time, they will be exposed to the harsh radiation environment of space. Throughout the journey, astronauts must be protected from radiation that comes from the sun, which regularly releases a steady stream of solar particles, as well as occasional larger bursts in the wake of giant explosions, such as solar flares and coronal mass ejections.

- Since solar activity strongly contributes to the deep-space radiation environment, a better understanding of the sun's modulation of this radiation environment will allow mission planners to make more informed decisions for future Mars missions. NASA currently operates a fleet of spacecraft called the Heliophysics System Observatory that studies the sun and its interactions with Earth and the solar system. These Heliophysics observations and supporting research help us better understand the origin of solar eruptions and what effects these events have on the overall space radiation environment.

MAVEN Finds Escaping Ions Form "Mohawk" Pattern of Polar Plumes

NASA's Mars Atmosphere and Volatile Evolution (MAVEN) has found that Mars sports a "Mohawk" of escaping atmospheric particles at its poles which may be the major source of gas loss to space.

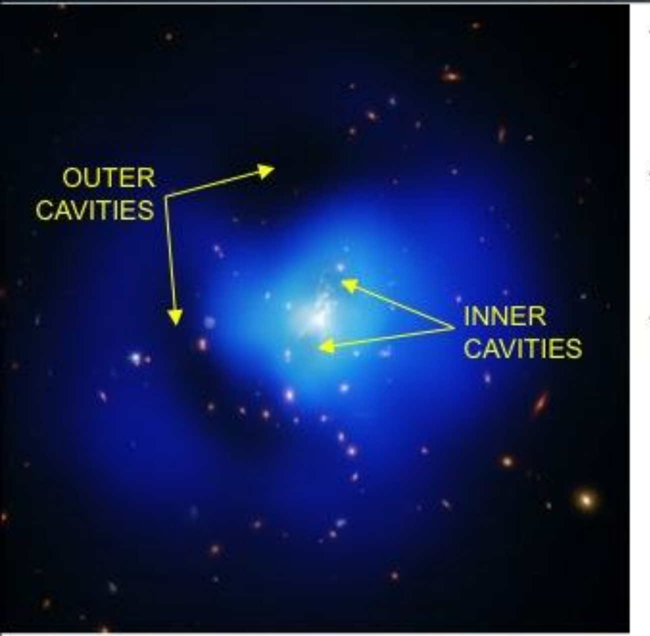


Computer simulation of the interaction of the solar wind with electrically charged particles (ions) in Mars' upper atmosphere. The lines represent the paths of individual ions and the colors represent their energy, and show that the polar plume (red) contains the most-energetic ions.

- MAVEN orbits at different altitudes above Mars' surface. As MAVEN dips down into the atmosphere, the satellite identifies the cold ionosphere at closest approach and, as MAVEN rises back up in altitude, measures the heating of this charged gas to escape velocities.
- Atoms in the Martian upper atmosphere become electrically charged ions after being energized by solar and space radiation. Theoretical models had predicted that the electric field generated by the incoming solar wind could drive ions in the direction of one pole or the other, creating a polar plume of escaping ions. When tracing particle trajectories in the models, the plume looks a bit like a Mohawk hairstyle.
- MAVEN's goal is to discover which mechanisms are most prominent for atmospheric loss, and to estimate the rate at which the Martian atmosphere is being eroded away.

Phoenix Cluster: A Fresh Perspective on an Extraordinary Cluster of Galaxies

Published in the September 28, 2015 issue of The Astrophysical Journal



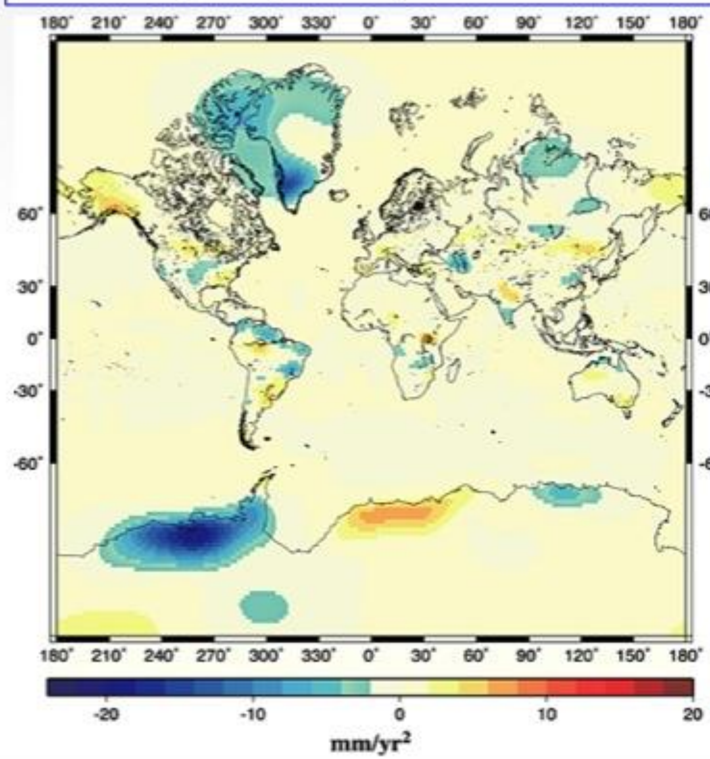
Credit: X-ray: NASA/CXC/MIT/M.McDonald

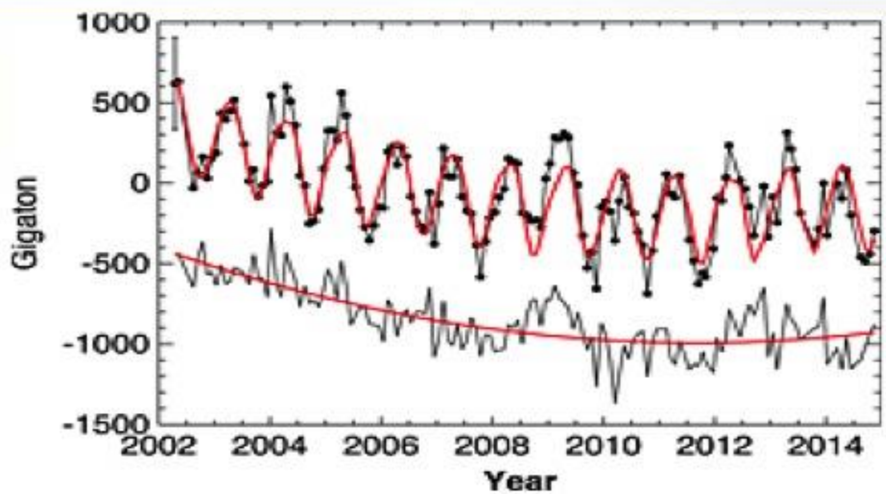
- New observations of the galaxy cluster SPT-CLJ2344-4243, nicknamed the Phoenix Cluster, at X-ray, ultraviolet, and optical wavelengths by NASA's Chandra X-ray Observatory, the Hubble Space Telescope, and the Clay-Magellan telescope located in Chile, are helping astronomers better understand this remarkable object.
- Clay-Magellan's optical data have now revealed narrow filaments from the center of the cluster. These massive cosmic threads of gas and dust extend for 160,000 to 330,000 lights years. This is longer than the entire breadth of the Milky Way galaxy, making them the most extensive filaments ever seen in a galaxy cluster.
- These filaments surround large cavities in the hot gas. The X-ray cavities can be seen in this image that shows the Chandra X-ray data in blue and optical data from the Hubble Space Telescope (red, green, and blue). Astronomers think that the X-ray cavities were carved out of the surrounding gas by powerful jets of high-energy particles emanating from near a supermassive black hole in the central galaxy of the cluster. As matter swirls toward a black hole, an enormous amount of gravitational energy is released. Combined radio and X-ray observations of supermassive black holes in other galaxy clusters have shown that a significant fraction of this energy is released as jets of outbursts that can last millions of years. The observed size of the X-ray cavities indicates that the outburst that produced the cavities in SPT-CLJ2344-4243 was one of the most energetic such events ever recorded.
- However, the central black hole in the Phoenix cluster is suffering from somewhat of an identity crisis, sharing properties with both "quasars", very bright objects powered by material falling onto a supermassive black hole, and "radio galaxies" containing jets of energetic particles that glow in radio waves, and are also powered by giant black holes. Half of the energy output from this black hole comes via jets mechanically pushing on the surrounding gas (radio-mode), and the other half from optical, UV and X-radiation originating in an accretion disk (quasar-mode). Astronomers suggest that the black hole may be in the process of flipping between these two states.
- X-ray cavities located farther away from the center of the cluster, labeled as "outer cavities", provide evidence for strong outbursts from the central black hole about a hundred million years ago (neglecting the light travel time to the cluster). This implies that the black hole may have been in a radio mode, with outbursts, about a hundred million years ago, then changed into a quasar mode, and then changed back into a radio mode.
- It is thought that rapid cooling may have occurred in between these outbursts, triggering star formation in clumps and filaments throughout the central galaxy at a rate of about 610 solar masses per year. By comparison, only a couple new stars form every year in our Milky Way galaxy. The extreme properties of the Phoenix cluster system are providing new insights into various astrophysical problems, including the formation of stars, the growth of galaxies and black holes, and the co-evolution of black holes and their environment.

A Global Assessment of Accelerations in Surface Mass Transport

Wu, X., & Heflin, M. B.| Geophysical Research Letters | AUGUST 2015 | doi: 10.1002/2015GL064941

Scientists at NASA/ JPL investigated the horizontal water mass transport in the Earth's dynamic surface layer of atmosphere, cryosphere, and hydrosphere, to determine global patterns and regional mean values of accelerations in surface mass variations during the Gravity Recovery and Climate Experiment (GRACE) mission's data span of nearly thirteen years. GRACE gravity data were supplemented by surface deformation from 607 Global Navigation Satellite System stations, an ocean bottom pressure model, satellite laser ranging, and loose a priori knowledge on mass variation regimes incorporating high-resolution geographic boundaries. While Greenland and West Antarctica were found to have strong negative accelerations, Alaska and the Arctic Ocean showed significant positive accelerations. In addition, the accelerations were not constant in time, with some regions showing considerable variability due to irregular interannual changes. No evidence of significant nonsteric mean sea level acceleration was found, but the uncertainty is quite large. Horizontal water mass transport in the Earth's dynamic surface fluid layer is an important part of various global change processes, and it is only since the launch of GRACE in 2002 that this phenomenon has been monitored globally with unprecedented resolution and accuracy.





Left: Global mass acceleration patterns using an optimal averaging filter around grid points on the Earth's surface. Bright colors with $|acc| \geq 2$ mm/yr^2 indicate statistically very significant features. ***Above:*** Mean mass change time series in Alaska/Yukon region west of 130°W (linked black dots). The solid red curve shows the nine-parameter fit model. The lower black curve and red curve show a similar time series and a fit model but with annual, semiannual, and 161 day cycles removed