



# Advanced Composition Explorer



## Energetic Particles

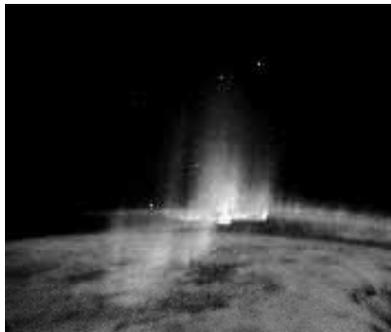
The acceleration of charged particles to extremely high energies takes place throughout the universe: on the Sun, in interplanetary space, at the edge of the solar system, at the blast waves of supernovae, and in other powerful systems, like neutron stars and black holes. The diagram on the back of this page helps to illustrate the origins of some of these particles, described below.

### From the Sun:

Solar wind is the stream of electrically-charged particles flowing outward from the Sun at an average 400 km/second (almost a million miles per hour!) although this speed can vary from 200 to 1000 km/second. The Sun's output in all forms (for example, light, solar wind, and energetic particles) varies with time and the position of the Sun. These changes are called solar activity and are probably reflections of changes below the Sun's surface. Sunspots and solar flares are some visible signs of solar activity. We can study the output of the Sun and how it varies to probe its inner workings. In addition to the solar wind, which is continually present, occasionally the Sun will emit particles (solar energetic particles, or SEPs) that are up to ten times more energetic than the solar wind, and which are associated with coronal mass ejections or solar flares.

The Sun's activity causes the "space weather" that affects Earth. Magnetic storms on Earth due to solar activity produce the beautiful Aurora borealis and Aurora australis (as seen at right), but can also cause a variety of highly undesirable consequences, such as electrical current surges in power lines, and interference in radio, television, telephone, and defense communication signals.

Safety and communications during space flight may be seriously impacted by major solar activity. The continuous broadcast of solar wind, magnetic field, and SEP data from ACE allows accurate forecasts of space weather up to one hour beforehand to help us prepare.

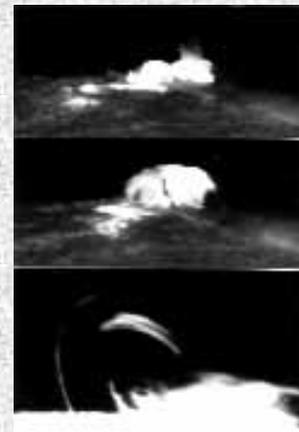


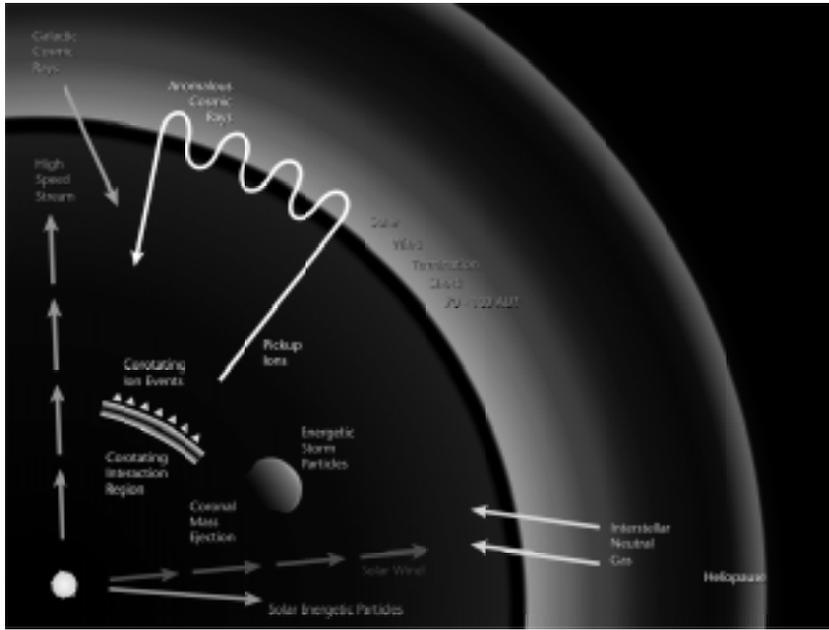
The solar wind near the Sun contains streams of high and low speed particles. The high-speed streams originate in coronal holes (cooler and less dense areas in the solar surface) and extend toward the solar poles. The low-speed streams come from near the Sun's equator. As the Sun rotates, alternating streams of high and low speed can come out in the same direction. The high-speed solar wind streams then overtake the slower plasma (plasma is gas made up of electrically-charged particles) as the particles move away from the Sun, producing corotation interaction regions (CIRs)

"Where did I come from?"

This question is usually one about life, but behind it are scientific questions about the material of which we are made, the atoms and molecules of our bodies. The answer to the question "Where did the matter we are made of come from?" is not so easy to find. The Earth and the solar system are made of material that has been changed and rearranged during the billions of years since its creation, so measuring its complete makeup, or composition, is important to understanding our origins.

Scientists have tried to answer these questions in many ways. Early in this century, we learned that matter from space is bombarding the Earth all the time. With the beginning of space missions, we learned that it comes not only from the sun, but also from the far distant reaches of the galaxy. The Advanced Composition Explorer, or ACE for short, studies the many different types of speeding, energetic particles in the heliosphere, the immense magnetic bubble containing our solar system and the Sun's magnetic field. ACE provides crucial information for understanding the sources, acceleration and movement of these high-energy particles.





Out in interplanetary space, CIRs produce shocks with high density, pressure, and magnetic field strength. CIRs very effectively accelerate particles, which then travel back toward us on Earth. Particles accelerated by interplanetary shocks are also observed and reveal information about matter in interplanetary space.

**From the local interstellar medium:**

Most of the matter in the universe heavier than hydrogen and helium was created in stars, where lighter elements are heated to very high temperatures and fused into heavier ones. This process is called nucleosynthesis. Supernova explosions result when the cores of massive stars have exhausted their fuel supplies and burned everything into iron and nickel. Such explosions eject products of nucleosynthesis back into the interstellar gas. This means, for example, that the iron in our blood was produced in massive stars that went supernova billions of years ago!

While the electrically-charged particles of the interstellar gas are kept outside the heliosphere by the interplanetary magnetic field, interstellar neutral gas flows through out solar system, at a speed of about 26 km/second. Collisions with solar ultraviolet light or particles can cause these atoms to lose an electron.

Now no longer neutral, the charged particles can be picked up by the Sun's magnetic field and carried outward to the solar wind termination shock, a region outside the planets of our solar system, but still inside the heliosphere. Some of these pickup ions undergo repeated collisions with the shock, gaining energy in the process. A fraction of these escape from the shock and scatter back toward the inner heliosphere. These accelerated particles are then known as anomalous cosmic rays (ACRs).

**From the galaxy:**

Galactic cosmic rays (GCRs) are the particles that flow into our solar system from far away in the galaxy. GCRs are atomic nuclei from which all the surrounding electrons have been stripped during their high-speed passage through the galaxy. They have been accelerated to nearly the speed of light, possibly by supernova shocks, and may have traveled many times across the galaxy, trapped by the galactic magnetic field. When we measure these heavier particles coming from space, we can learn what their likely history is based on their composition. Included in these cosmic rays are a number of radioactive particles. Their decay allows us to determine the age of that matter, as in the carbon-14 technique used to date archaeological artifacts.

ACE's instruments provide coordinated measurements of all these different samples of matter.

The ACE spacecraft was launched on a Delta II launch vehicle on August 25, 1997 from the Cape Canaveral Air Station in Florida. ACE is part of the Explorer Program, the longest continuing program at NASA, and so is also known as Explorer 71. Its mission lasts a minimum of two years, with a goal of five.

The spacecraft is about 1.5 million km (about a million miles) from Earth toward the Sun. It orbits a point, the L1 libration point, where gravity helps keep it at an ideal location to measure solar particles and plasma 24 hours a day, without being affected by the Earth's magnetic field. Its nine instruments sample the matter in the heliosphere that comes near the Earth, covering an unprecedented range of particle types and energies. Simultaneous measurements from ACE's instruments are coordinated and then compared to information from other missions, past and present, to create a comprehensive picture of the energetic particles near us.

By identifying the particles coming from the Sun, the local interstellar medium, and the galaxy, ACE provides us with a better understanding of the composition and evolution of the universe.



- ACE Lead Scientific Institution: California Inst. of Tech.  
<http://www.srl.caltech.edu/ACE>
- ACE Project Management: NASA Goddard Space Flight Center  
<http://www.gsfc.nasa.gov/ace/ace.html>
- ACE Real Time Solar Wind: NOAA  
[http://sec.noaa.gov/ace/ACERtsw\\_home.html](http://sec.noaa.gov/ace/ACERtsw_home.html)
- Cosmic and Heliospheric Learning Center  
<http://helios.gsfc.nasa.gov>