Does the Earth's Magnetosphere Protect Us From the Sun's Solar Wind?

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Emissions from the Sun create conditions in our solar system that are very hostile to life. Earth's magnetosphere protects the planet's surface from charged particles of the solar wind. Without this protection, life as we know it would probably not exist on Earth.

Interaction Between the Magnetosphere and the Solar Wind

Liquids circulating inside part of Earth's iron core generate the planet's geomagnetic field. When combined with the interplanetary magnetic field (IMF) generated by the sun, it produces the magnetosphere, which extends thousands of miles from Earth into space. The solar wind -- protons and electrons emitted by the sun -- travels through the solar system. When the solar wind encounters Earth, the magnetosphere deflects most of the charged particles and shields our planet's surface. But when the IMF field lines and the geomagnetic field lines are not parallel, they tend to interact, creating a path for the solar wind particles to leak into the upper atmosphere, the most spectacular consequence of which are the auroral displays (aurora borealis and aurora australis) over the higher latitudes.

Biological Shielding

If not for the magnetosphere pushing away electrons and protons of the solar wind, the charged particles would inflict doses of harmful radiation to life on Earth. Astronauts traveling outside the magnetosphere have to be protected from solar radiation. And, high-altitude air travel over the poles, where the shielding effect of the magnetosphere is weakest, is considered risky for certain groups such as pregnant women.

Transmission Lines, Pipelines and Telecommunications

The magnetosphere also protects us from disruptions to power lines and telecommunication systems. However, this protection is not absolute. As scientists at the European Space Agency put it, the Earth's magnetosphere sometimes behaves like a sieve. It does protect us from the solar wind, but not always.
Fluctuations in the magnetosphere caused by the solar wind can build up high voltage differences (as high as 10 volts per mile) across very long electrical conductors such as power transmission lines and pipelines. These buildups can severely disrupt system controls. In 1989 in the province of Quebec in Canada, the solar wind caused a massive province-wide outage of electricity.
Radio communications are also at the mercy of the solar wind. Disruptions occur only occasionally, when the solar wind is intense enough to penetrate the magnetosphere. However, these events give us an idea of what the situation would be if Earth were not protected.

Conserving Earth's Atmosphere

Earth's magnetosphere is also vital in preventing our atmosphere from being pushed out into space by the pressure of the solar wind. For example, in 2008, Earth, Mars and the sun were aligned so that the same blast of solar wind hit the two planets, one after the other. European Space Agency spacecraft observed that Mars, because of its weaker magnetosphere, lost about ten times the oxygen that the Earth did during this encounter. This event shows that the magnetosphere plays an active role in limiting depletion of the atmosphere.

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Northern Lights

WHAT ARE NORTHERN LIGHTS?

The bright dancing lights of the aurora are actually collisions between electrically charged particles from the sun that enter the earth's atmosphere. The lights are seen above the magnetic poles of the northern and southern hemispheres. They are known as 'Aurora borealis' in the north and 'Aurora australis' in the south..
Auroral displays appear in many colours although pale green and pink are the most common. Shades of red, yellow, green, blue, and violet have been reported. The lights appear in many forms from patches or scattered clouds of light to streamers, arcs, rippling curtains or shooting rays that light up the sky with an eerie glow.

WHAT CAUSES THE NORTHERN LIGHTS?

The Northern Lights are actually the result of collisions between gaseous particles in the Earth's atmosphere with charged particles released from the sun's atmosphere. Variations in colour are due to the type of gas particles that are colliding. The most common auroral color, a pale yellowish-green, is produced by oxygen molecules located about 60 miles above the earth. Rare, all-red auroras are produced by high-altitude oxygen, at heights of up to 200 miles. Nitrogen produces blue or purplish-red aurora.

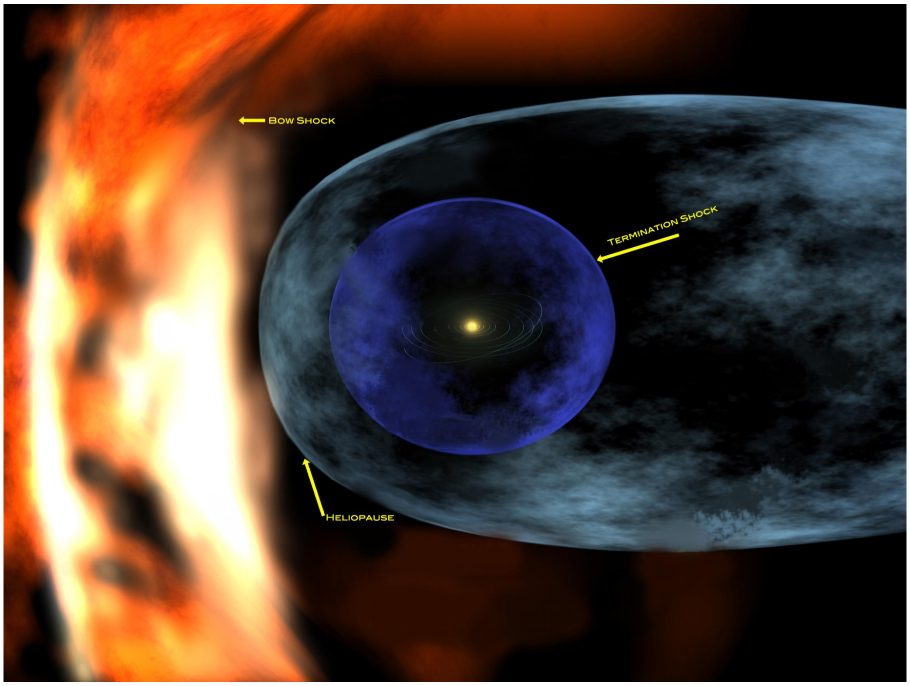
The connection between the Northern Lights and sunspot activity has been suspected since about 1880. Thanks to research conducted since the 1950's, we now know that electrons and protons from the sun are blown towards the earth on the 'solar wind'. (Note: 1957-58 was International Geophysical Year and the atmosphere was studied extensively with balloons, radar, rockets and satellites. Rocket research is still conducted by scientists at Poker Flats, a facility under the direction of the University of Alaska at Fairbanks - see web page http://www.gi.alaska.edu/

The temperature above the surface of the sun is millions of degrees Celsius. At this temperature, collisions between gas molecules are frequent and explosive. Free electrons and protons are thrown from the sun's atmosphere by the rotation of the sun and escape through holes in the magnetic field. Blown towards the earth by the solar wind, the charged particles are largely deflected by the earth's magnetic field. However, the earth's magnetic field is weaker at either pole and therefore some particles enter the earth's atmosphere and collide with gas particles. These collisions emit light that we perceive as the dancing lights of the north (and the south).

The lights of the Aurora generally extend from 80 kilometres (50 miles) to as high as 640 kilometres (400 miles) above the earth's surface.

Source: https://www.northernlightscentre.ca/northernlights.html

Heliosphere - from nasa.gov



The sun sends out a constant flow of charged particles called the solar wind, which ultimately travels past all the planets to some three times the distance to Pluto before being impeded by the interstellar medium. This forms a giant bubble around the sun and its planets, known as the heliosphere. NASA studies the heliosphere to better understand the fundamental physics of the space surrounding us - which, in turn, provides information regarding space throughout the rest of the universe, as well as regarding what makes planets habitable.

The solar wind is a gas of charged particles known as plasma, a state of matter governed by its own set physical laws just as the more common solids, liquids, and gases are. As the solar wind sweeps out into space, it creates a space environment filled with radiation as well as magnetic fields that trail all the way back to the sun. This space environment is augmented by interstellar cosmic rays and occasional concentrated clouds of solar material that burst off the sun, known as coronal mass ejections.

This complex environment surrounds the planets and ultimately has a crucial effect on the formation, evolution, and destiny of planetary systems. For one thing, our heliosphere acts as a giant shield, protecting the planets from galactic cosmic radiation. Earth is additionally shielded by its own magnetic field, the magnetosphere [link to 2e.Magnetosphere], which protects us not only from solar and cosmic particle radiation but also from erosion of the atmosphere by the solar wind. Planets without a shielding magnetic field, such as Mars and Venus, are exposed to such processes and have evolved differently.

NASA's studies of the heliosphere include research into: how the solar wind behaves near Earth; what causes and sustains magnetic and electric fields around other planets; how does the heliosphere interact with the interstellar medium; what do the boundaries of the heliosphere look like; what is the origin and evolution of the solar wind and the interstellar cosmic rays; and what contributes to the habitability of exoplanets.

The field is, therefore, intensely cross-disciplinary. Heliospheric research often works hand in hand with planetary scientists, astrophysicists, astrobiologists, and space weather researchers.
NASA heliophysics missions contributing to heliospheric research are: the Advanced Composition Explorer; NOAA's Deep Space Climate Observatory, the Interstellar Boundary Explorer, the Solar Terrestrial Relations Observatory; Voyager, and Wind.
Additionally, instruments on such NASA missions as Maven and Juno, observe the space around Mars and Jupiter respectively, and contribute to heliospheric research.

From: https://science.nasa.gov/heliophysics/focus-areas/heliosphere