CPS Plasma Page

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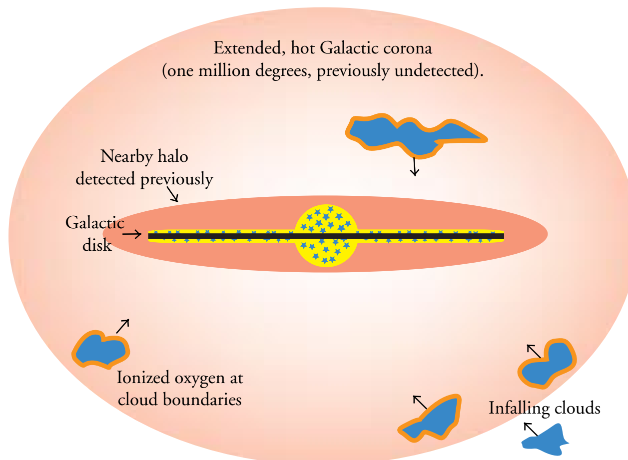
FUSE Satellite Reveals Vast Extent of Galactic Plasma Corona

NASA's Far Ultraviolet Spectroscopic Explorer (FUSE) satellite has provided evidence for a vast invisible corona of plasma, far larger than previously imagined, enveloping our Milky Way galaxy.

The surprising finding comes from observations of clouds of hydrogen gas raining onto our galaxy from outside. Though these clouds had been suspected before of falling into our galaxy like intergalactic comets, the FUSE observatory was needed to detect the previously unseen 100,000 to one million degree Fahrenheit surfaces of the clouds. This is a clear signature the clouds are barreling through the extensive, hot tenuous medium of the galactic corona at nearly one million miles per hour.

The FUSE observations are akin to knowing the Earth has a highly extended atmosphere by seeing the trails of meteors as they burn up from friction with the atmospheric gases. The infalling clouds may be fragments of smaller galaxies gravitationally torn apart by the Milky Way, or may be gas left over from the formation of our galaxy.

The hot glowing plasma outer surfaces of the clouds were discovered during a FUSE survey of quasars and other distant objects far from the Milky Way. Dr. Kenneth Sembach of the Space Telescope Science Institute (STSI) in Baltimore, Maryland and his collaborators detected the absorption of ultraviolet light produced by oxygen atoms that have had five of their eight electrons stripped off as the infalling clouds of gas pass through the hot galactic corona. Some of these clouds were detected previously by radio telescopes on Earth and by the Hubble Space Telescope, but FUSE for the first time picked up the hot outer edges of the clouds produced by interactions with the galactic corona.



Astronomers have known about a much smaller halo of plasma around the galactic disk for some time but were previously unaware of the extended corona just discovered. "This is an astonishing discovery," says Sembach. "The fact that we see the ionized clouds in so many directions means the galactic corona must be extensive. It may extend as far as the Milky Way's nearest neighboring galaxies, the Magellanic Clouds."

The vast region of hot plasma completely encapsulates the Milky Way and may be 100,000 light years or more in size. The corona could be left over from the formation of the Milky Way, or it may have been created by early episodes of star formation in which the hot gas was heated by supernovae and expelled from the galactic disk. The FUSE observations of clouds falling into the corona are important because they indicate that the Milky Way continues to accrete material even though the galaxy is billions of years old. Studying the accretion of the clouds and their interaction with the hot corona around the Milky Way will help astronomers understand better how galaxies formed and have evolved over time.

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Ultracold Plasmas are a Chilling Puzzle

Plasmas are usually hot. The plasma in a solar corona can have a temperature in the millions of degrees. Researchers at the National Institute of Standards and Technology's (NIST) Physics Laboratory, however, have created "ultracold" plasmas – with the electrons about one degree above absolute zero – by cooling neutral atoms to within a hundred-thousandth of a degree of absolute zero and then zapping them with just enough laser energy to separate the electrons and ions to achieve the plasma state.

One of the key measures of any plasma is the recombination rate – how fast the ions and electrons recombine to form neutral atoms. Theory says there are three main recombination processes, and their efficiency varies in a known way with temperature and density. However, NIST physicist Steven Rolston says that in practice, an expanding ultracold plasma recombines much faster than expected at very low densities – so much faster that no existing theory describes it.

Rolston and his group are continuing to refine their experiments to explain the behavior of ultracold plasmas, which, although they only exist in earthly labs, are thought to model the interior of white dwarf stars or gas giant planets like Jupiter. The research also may uncover a path to synthesizing "anti-hydrogen" atoms, the antimatter equivalent of hydrogen. Precise comparisons of the properties of such antimatter twins may probe the fundamental nature of the forces that bind matter and the universe together.

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CPS Outreach a Success at the IEEE ICOPS

On May 27, the Coalition for Plasma Science (CPS) hosted a wine and cheese reception at the Institute of Electrical and Electronics Engineers (IEEE) International Conference on Plasma Science (ICOPS) in Banff, Alberta, Canada. Attendance was estimated to exceed 200.

Gerald Rogoff (foreground) with IEEE Conference Chairman, Robert Fedosejevs

CPS Membership Chair Dr. Gerald Rogoff introduced the Coalition to those unfamiliar with it and updated the group on its activities. He observed that outside of those in the field, few people know anything about plasmas. They don't know what a plasma is; they don't know where plasmas are found, either in nature or in applications; and they don't know about the importance of plasmas in their lives. Among these people are many who are important to the plasma science community: government policy-makers in Washington, who determine research funding; the media, which feeds information to the general public (which in turn can influence research funding levels and priorities); and K-12 students and teachers, who will be providing the people for future work in the field.

For those attendees unfamiliar with the organization, he explained that CPS was formed to address this important problem for the broad range of plasma science perspectives and interests. He also noted the Coalition's broad audience (which includes government policy-makers, the media, and the education community), and outlined the organization's activities, its educational literature, and the nature of its membership. He pointed out that what CPS does depends greatly on the interests of the individuals involved, and that it is always open to suggestions for new activities.

In addition to Dr. Rogoff's presentation, brief remarks about the importance of CPS's work were presented by Dr. Robert Fedosejevs, the Conference Chairman, and by Dr. Robert Parker, Chairman of the Plasma Science and Applications Committee of the IEEE Nuclear and Plasma Sciences Society, which sponsors the conference.

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Mapping the Plasmasphere: Earth-based Tools Image Weather in Space

"Following scattered solar explosions, we're in for some severe space weather over most of North America."

It's not your typical forecast, but operators of hundreds of active satellites would be interested in hearing it. Using ground-based instruments, Massachusetts Institute of Technology (MIT) researchers can now provide real-time images of space weather – a new view of the same information NASA gets from space-based sensors looking back at the Earth. The work, by scientists at MIT's Haystack Observatory and Lincoln Laboratory, will appear in an upcoming edition of the American Geophysical Union's Geophysical Research Letters.

Unexpected disturbances in the plasmasphere - the cloud of charged particles extending 10,000-plus miles above Earth - affect satellite transmissions and result in damage to satellites and spacecraft. Satellite communications are used for everything from TV to military operations such as locating soldiers in Afghanistan or steering tanks during a sandstorm. The occasional severe storm can also disrupt long-distance electric power transmission lines.

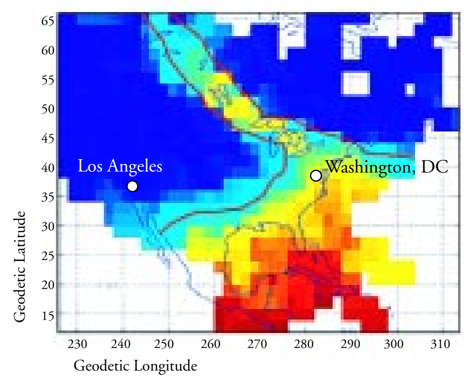
Pairing information gleaned from hundreds of special dual-frequency Global Position System (GPS) receivers with data from Haystack's ionospheric radar, researchers at MIT were able for the first time to map the changing plasmasphere from the ground.

The researchers say they have achieved a breakthrough in using new methods to study and map the Earth's atmosphere, with results directly applicable to the very young field of space weather prediction.

"The ionospheric radar measurements from Haystack show how space weather effects far out in the magnetosphere are directly connected to the upper atmosphere, where they can disrupt systems such as GPS," said James Burch of Southwest Research Institute, a principal investigator for NASA. "Phenomena known as plasmaspheric tails that develop during magnetic storms were thought to be relatively benign, but the Haystack observations have shown that in fact they have strong ionospheric effects."

Plasmaspheric tails are long plumes with increased electron concentrations. Radio waves originating on the ground can move through homogenous areas easily, but the edge of the tails, where low- and high-density areas of electrons collide, is like a brick wall to radio waves.

This disrupts satellite transmissions, but "knowing there is a problem (such as the location of a plasmaspheric tail) allows the user to change to another communications link," said Philip Erickson, research scientist in Haystack's Atmospheric Sciences Group.



Analysis of GPS navigation signals monitored at over 120 sites provides a snapshot of ionospheric total electron content (TEC) over North America during a major geomagnetic disturbance. The bold red outlines the low-altitude footprint of a TEC plume.

"What we see goes far beyond our wildest expectations," said John C. Foster, associate director of Haystack. "We are looking with new eyes, ground-based eyes, at the phenomena that give us space weather effects. We are just at the beginning of a very rich area for research."

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