Science Mission Directorate

Weekly Highlights

September 2, 2016

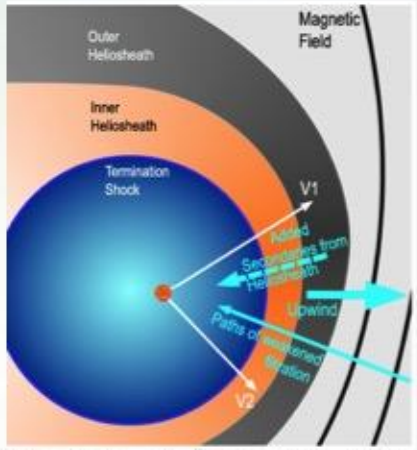
The NASA Heliophysics IBEX Mission Delivers Important Data on our Boundary with Interstellar Space to our Doorstep

Schwadron , et al. (2016). DETERMINATION OF INTERSTELLAR O PARAMETERS USING THE FIRST 2 YEARS OF DATA FROM THE INTERSTELLAR BOUNDARY EXPLORER. Astrophysical Journal (in press)

Where our solar system meets interstellar space, the heliopause, is an area of space we know little about. Yet, it's at this boundary that potentially harmful particles, like galactic cosmic rays, travel toward us into our solar system.

The NASA Heliophysics Interstellar Boundary Explorer (IBEX) mission, launched in 2008, measures particles at the heliopause to better understand this boundary and in which direction our solar system is traveling through space. The IBEX payload includes two Energetic Neutral Atoms (ENAs) sensors that help us in collecting this data. The IBEX-Lo sensor measures neutral atoms from ~10 eV to 2 keV, or at speeds below a few hundred km/s, while the IBEX-Hi sensor measures faster ENAs from ~300 eV to 6 keV.

The analysis of these particles is also being supported by the NASA Heliophysics Voyager Interstellar mission. Voyager 1 and 2 took more than 30 years to reach the interstellar boundary region. We're fortunate to already have 8 years of data from the interstellar boundary region with IBEX close to home, as it orbits Earth. IBEX ENA observations help us understand this dynamic interstellar boundary region as we move through interstellar space.



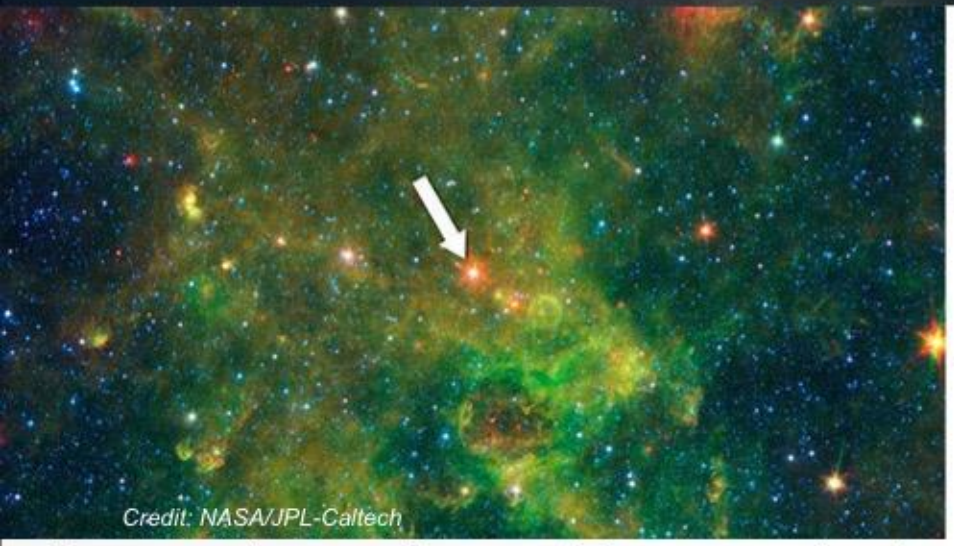
This figure shows magnetic fields compressing the nose region of the heliosphere in the south. This is where less plasma filtration occurs, and the direction from which O ENAs predominantly come from.

Asymmetries along the boundary, and the changing activity of the sun, affect the flow of galactic cosmic radiation into our solar system. Understanding more about these asymmetries is important as this radiation has the potential to impact Earth's atmospheric layers and pose hazards to human space exploration.

In a paper soon to be published in the *Astrophysical Journal,* Dr. Nathan Schwadron of the University of New Hampshire and an international team of co-authors confirm a suspected asymmetry at the nose of the heliosphere, which is the area containing our solar system, the solar wind and the entire solar magnetic field. For this asymmetry to form, interstellar plasma accumulated to the north of the nose, and interstellar magnetic field to the south. Interstellar oxygen (O) ENAs are more likely than helium (He) to exchange a charge, or trade an electron, in a collision with the charged particles of the interstellar plasma. As a result, interstellar O ENAs suffer higher loss rates in the north than in the south. This makes it appear as if they predominantly originate from the south. Helium, as a noble gas, has a much stronger force of attraction allowing it to hold on to its electrons, even in collisions. If we only analyze the ENA O data at the asymmetry, scientists could be "tricked" into thinking that the direction of motion of the heliosphere is more southward than it actually is. But, analyzing interstellar He with O data we see that is not the case.

Team Probes Peculiar Age-Defying Star

Published in the August 29, 2016 issue of the Astrophysical Journal.



Credit: NASA/JPL-Caltech

- For years, astronomers have puzzled over a massive star lodged deep in the Milky Way that shows conflicting signs of being extremely old and extremely young. Researchers initially classified the star as elderly, perhaps a red supergiant. But a new study by a NASA-led team of researchers suggests that the object, IRAS 19312+1950, might be something quite different -- a protostar, a star still in the making.
- Located more than 12,000 light-years from Earth, the object first stood out as peculiar when it was observed at particular radio frequencies. Several teams of astronomers studied it using ground-based telescopes and concluded that it is an oxygen-rich star about 10 times as massive as the sun.
- Some researchers favor the idea that the star is evolved -- past the peak of its life cycle and on the decline. Intense radio sources called masers suggested the star was old. In astronomy, masers occur when the molecules in certain kinds of gases get revved up and emit a lot of radiation over a very limited range of frequencies. The result is a powerful radio beacon -- the microwave equivalent of a laser. One maser observed with IRAS 19312+1950 is almost exclusively associated with late-stage stars.
- Even so, the object didn't entirely fit with evolved stars. Especially puzzling was the smorgasbord of chemicals found in the large cloud of material surrounding the star. A chemical-rich cloud like this is typical of the regions where new stars are born, but no such stellar nursery had been identified near this star.
- Scientists proposed that the object was an old star surrounded by a cloud typical of the kind that usually accompanies young stars. Another idea was that the observations might somehow be capturing two objects: a very old star and an embryonic cloud of star-making material in the same field.
- Researchers began to reconsider the object, conducting observations using ESA's Herschel Space Observatory and analyzing data gathered earlier with NASA's Spitzer Space Telescope. Both telescopes operate at infrared wavelengths, which gave the team new insight into the gases, dust and ices in the cloud surrounding the star.
- The additional information leads scientists to think the star is in a very early stage of formation. The object is much brighter than it first appeared, emitting ~20,000 times the energy of our sun. Large quantities of ices made from water and carbon dioxide were found in the cloud around the object. These ices are located on dust grains relatively close to the star, and all this dust and ice blocks out starlight making the star seem dimmer than it really is.
- The dense cloud around the object appears to be collapsing, which happens when a growing star pulls in material. In contrast, the material around an evolved star is expanding and is in the process of escaping to the interstellar medium. The envelope of material has an estimated mass of 500 to 700 suns, which is much more than could have been produced by an elderly or dying star.
- Researchers think the star is probably in an embryonic stage, getting near the end of its accretion stage -- the period when it pulls in new materials to fuel its growth. Still, the researchers acknowledge that the object is not a typical protostar. For reasons they can't yet explain, the star has spectacular features of both a very young and a very old star.

Sulfurous Ceres

Hubble Space Telescope was used to observe dwarf planet Ceres at ultraviolet-visible (UV-vis) wavelengths to study surface composition and complement Infrared measurements made by Dawn. Two new major types of species were detected:

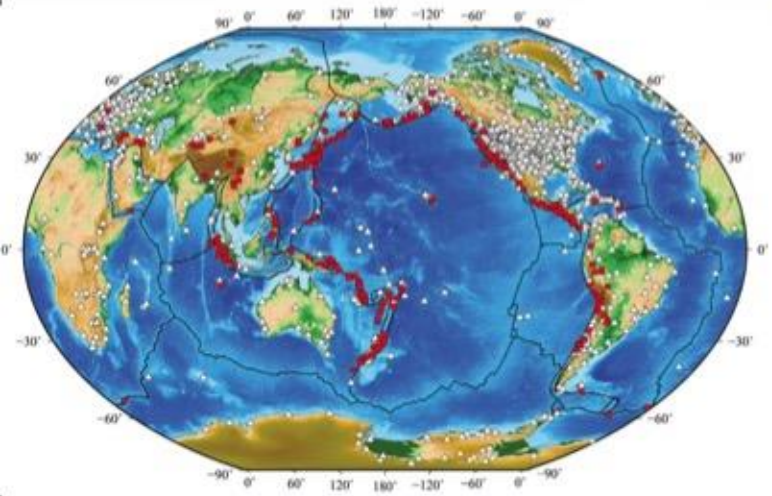
- **Sulfur and SO_2** – likely responsible for UV-vis spectral variations seen across the surface of Ceres. These species may be linked to recent geothermal activity on Ceres, hinted at by Dawn and Herschel observations.
- **Graphitized carbon** is a natural weathering product, the result of charged particle bombardment and thermal processing of carbonaceous species. This is the first time it has been detected on the surface of another object in the solar system. It is expected that other dark asteroids could have graphitized carbon on their surfaces as well.

Hendrix et al. GRL 2016

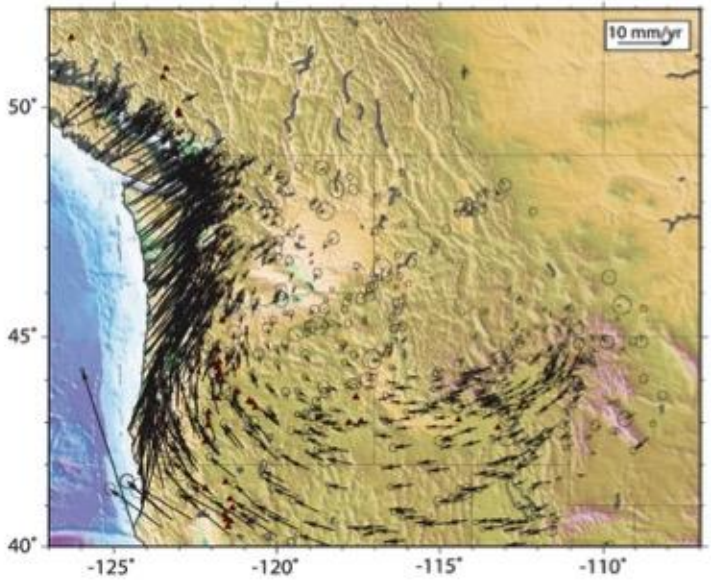
Physical Applications of GPS geodesy: A Review

Bock, Y., & Melgar, D. | Reports on Progress in Physics| August 2016 | doi: http://dx.doi.org/10.1088/0034-4885/79/10/106801

A recently published review paper of GPS applications presented a comprehensive review of the relevant concepts of geodetic theory, data analysis, and physical modeling for many processes at multiple spatial and temporal scales, and discussed the extensive global infrastructure that has been built to support GPS geodesy consisting of thousands of continuously operating stations. The paper is dedicated to Ivan I. Mueller, professor emeritus at The Ohio State University, recipient of the AGU Waldo E. Smith medal. The review emphasizes the stringent positioning accuracy requirements of GPS geodesy, millimeter to centimeter-level precision, that differentiates it from the ubiquitous use of GPS in everyday life (e.g. smart phone mapping applications, vehicle navigation) and reports on research co-funded by NASA, NSF and NOAA. The ability of GPS geodesy to estimate 3D positions with millimeter-level precision with respect to a global terrestrial reference frame has contributed to significant advances in geophysics, seismology, atmospheric science, hydrology, and natural hazard science. Monitoring the changes in the positions or trajectories of GPS instruments on the Earth's land and water surfaces, in the atmosphere, or in space, is important for both theory and applications, from an improved understanding of tectonic and magmatic processes to developing systems for mitigating the impact of natural hazards on society and the environment. Besides accurate positioning, all disturbances in the propagation of the transmitted GPS radio signals from satellite to receiver are mined for information, from troposphere and ionosphere delays for weather, climate, and natural hazard applications, to disturbances in the signals due to multipath reflections from the solid ground, water, and ice for environmental applications.



Left: Thousands of GPS stations (white triangles) established for global and regional geodetic applications. Earthquakes greater than magnitude 5 (red squares) since 1990, and major tectonic plate boundaries (black lines).



Left: The 1993–2011 GPS velocity field for the western US relative to the North America plate.

NASA Offers New Citizen Science Opportunity with GLOBE Observer on August 30, 2016

http://observer.globe.gov

NASA launched a new citizen science program, GLOBE Observer, on August 30, 2016, inviting the public to use a smart phone app to observe clouds in support of NASA and the GLOBE students and schools. The rollout included a web feature, video, and social media (left). The team is conducting a two-week cloud challenge to get as many observations as possible before Sept. 14.

Results:

- Nearly 4,500 individuals downloaded the app and registered within the first two days.
- Global distribution as shown in the map on the left where each circle represents a citizen science cloud observation for August 31.
- Exponential growth in social media audience with 1,400 Facebook followers and 92,000 reached through the Facebook event for the cloud challenge by Sept. 1
- More than 1,000 observations submitted in two days

NASA Earth Science Education Collaborative Team:
GSFC: Holli Riebeek Kohl, Kristen Weaver, Brian Campbell, Dorian Janney, Tassia Owen, Jeannie Allen
LaRC: Lin Chambers, Sarah McCrea, Jessica Taylor, Ann Martin
JPL: Peter Falcon, Erika Podest, Narendra Das, Susan Bell
IGES: Theresa Schwerin, Rusty Low
GLOBE Implementation Office: Tony Murphy
GLOBE Data & Information System Team: David Overoye, Cornell Lewis, Dixon Butler, and many others from GSFC/SSAI
NASA Earth Right Now Communication Campaign Team