

National Aeronautics and
Space Administration



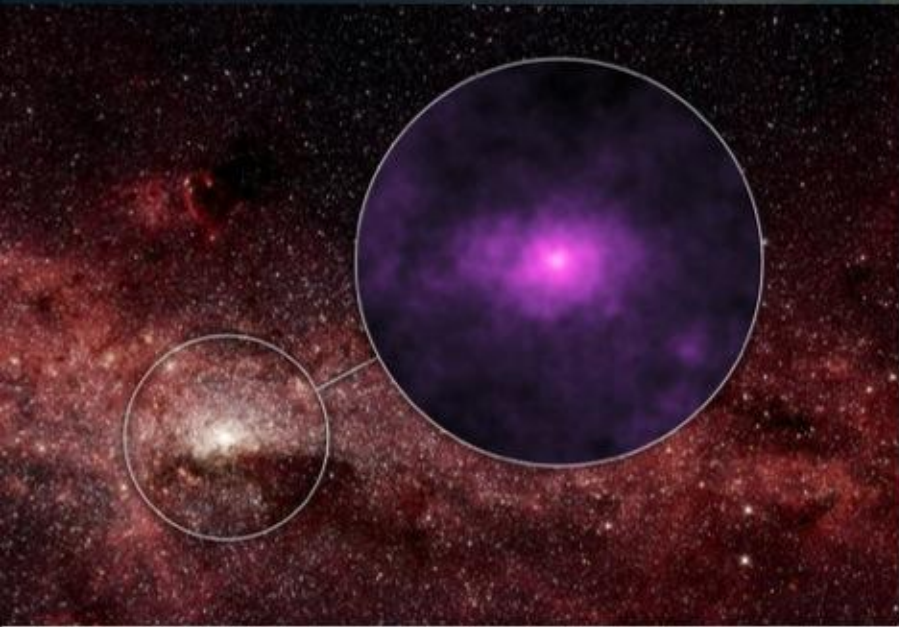
Science Mission Directorate

Weekly Highlights

May 8, 2015



Extra X-rays at the Hub of our Milky Way Galaxy



- NASA's Nuclear Spectroscopic Telescope Array (NuSTAR) has captured a new high-energy X-ray view (magenta) of the center of our Milky Way galaxy. The smaller circle shows the area where the NuSTAR image was taken.
- The center of our Milky Way galaxy is bustling with young and old stars, smaller black holes and other varieties of stellar corpses -- all swarming around a supermassive black hole called Sagittarius A*.
- Astronomers have four theories to explain the X-ray glow. When stars die, they don't always go quietly into the night. Collapsed dead stars that belong to stellar pairs, or binaries, can siphon matter from their companions. This "feeding" process differs depending on the nature of the normal star, but the result may be an eruption of X-rays.
- According to one theory, a pulsar could be at work. Pulsars are the collapsed remains of stars that exploded in supernova blasts. They can spin extremely fast and send out intense beams of radiation. As the pulsars spin, the beams sweep across the sky, sometimes intercepting Earth, like lighthouse beacons.
- Other possible culprits include white dwarfs, which are the collapsed, burned-out remains of stars not massive enough to explode in supernovae. Because these white dwarfs are much denser than they were in their youth, they have stronger gravity and can produce higher-energy X-rays than normal.
- Another theory points to small black holes that slowly feed off their companion stars, radiating X-rays as material plummets down into their bottomless pits.
- The source of the high-energy X-rays might not be stellar corpses at all, but rather a diffuse haze of charged particles called cosmic rays. The cosmic rays might originate from the supermassive black hole at the center of the galaxy as it devours material. When the cosmic rays interact with surrounding, dense gas, they emit X-rays.
- However, none of these theories match what is known from previous research, leaving the astronomers largely stumped.

Credit NASA/JPL-Caltech

The NuSTAR image (larger circle) is one of the most detailed ever taken of the center of our galaxy in high-energy X-rays. The X-ray light has been assigned the color magenta. The brightest point of light near the center of the X-ray picture is coming from a spinning dead star, known as a pulsar, which is near the giant black hole. While the pulsar's X-ray emissions were known before, scientists were surprised to find more high-energy X-rays than predicted in the surrounding regions, seen here as the elliptical haze. The NuSTAR image has an X-ray energy range of 20 to 40 kiloelectron volts. The background image was captured in infrared light by NASA's Spitzer Space Telescope.

Cluster Data Reveals Source of Black Auroras



This dramatic panorama shows a colorful, shimmering auroral curtain reflected in a placid Icelandic lake. The image was taken on 18 March 2015 by C. Gauna, near Jökulsárlón Glacier Lagoon in southern Iceland.

- Most people have heard of auroras - more commonly known as the Northern and Southern Lights. Less familiar are phenomena known as black auroras, dark patches which often subdivide the glowing curtains of red and green light.
- For almost 15 years, the joint ESA and NASA's four Cluster satellites have been orbiting Earth, sending back data on electrical fields, magnetic fields and particle populations as they sweep above the region of space where these colorful curtains of light are created. By flying in close formation through Earth's magnetosphere, the quartet has gathered multi-point observations which help to cast light on how the dark "cavities" in the shimmering auroras are created.
- Auroras are generated by electrons that are accelerated along Earth's magnetic field lines. The fast-moving electrons collide with atoms in the ionosphere at altitudes of between 100 to 600 km. This interaction with oxygen atoms results in a green or, more rarely a red glow in the night sky, while nitrogen atoms yield blue and purple colors.

- Whereas bright auroras are created by electrons plunging downward into the ionosphere, neighboring black auroras are caused by electrons escaping from the ionosphere - like a kind of anti-aurora. Until now, scientists have been struggling to explain the relationship between the two auroral types.

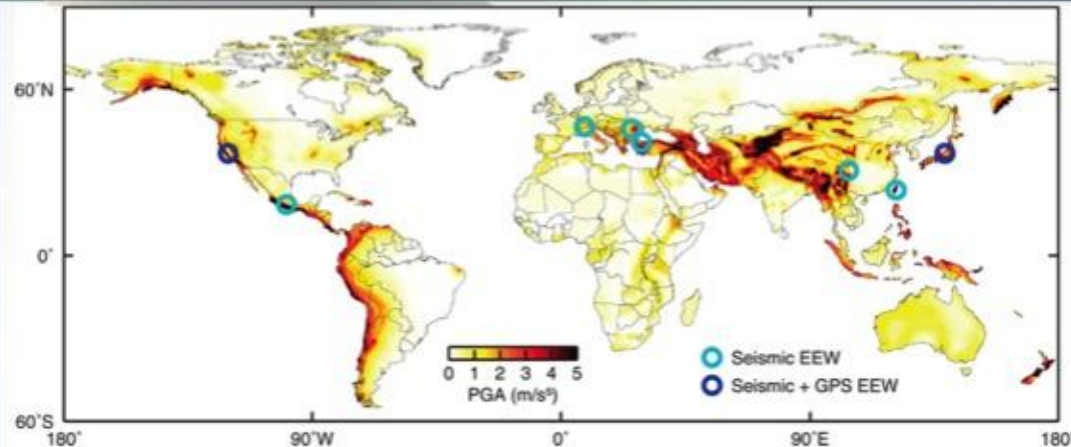
- Previous studies revealed that the electron population of the ionosphere becomes more and more depleted in these dark regions. Now scientists have used the archive of Cluster data to develop an accurate model of electric fields and currents at the heart of the black auroras. This new research accounts for the observed evacuation of electrons from the ionosphere to the magnetosphere and explains the dynamic behavior of the black aurora.

- These new results will lead to a better understanding of the interaction between Earth's upper atmosphere and the space environment. Modeling the connected solar, magnetosphere, and ionosphere systems is important to our modern technological society. For example, GPS signals can be modified by changes in electron content in the ionosphere, so that their navigational and timing accuracy are significantly reduced. Accurate modeling of the ionosphere is necessary to make the necessary corrections.

Crowd-sourced Earthquake Early Warning

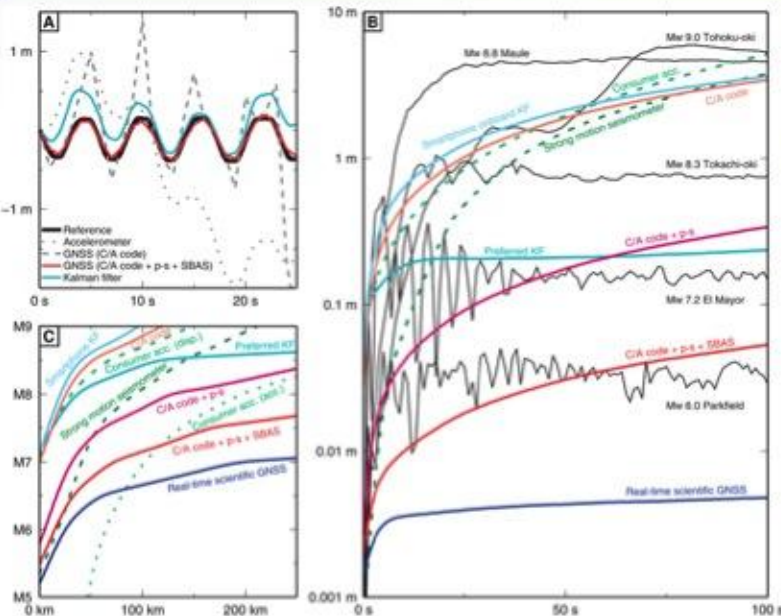
Sarah E. Minson, Benjamin A. Brooks, Craig L. Glennie, Jessica R. Murray, John O. Langbein, Susan E. Owen, Thomas H. Heaton, Robert A. Iannucci, and Darren L. Hauser | *Science Advances* | APRIL 2015 | doi: 10.1126/sciadv.1500036

NASA JPL scientists and USGS and University colleagues demonstrated that earthquake early warning (EEW) could be achieved via crowdsourcing. They utilized controlled tests of consumer devices, simulation of an M_w (moment magnitude) 7 earthquake on California's Hayward fault, and real data from the M_w 9 Tohoku-oki earthquake. Common consumer devices such as smartphones contain low-cost versions of the sensors used in EEW. Although less accurate than scientific-grade instruments, these sensors are globally ubiquitous. Earthquake early warning (EEW) can reduce harm to people and infrastructure from earthquakes and tsunamis, but it has not been implemented in most high earthquake-risk regions because of prohibitive cost.



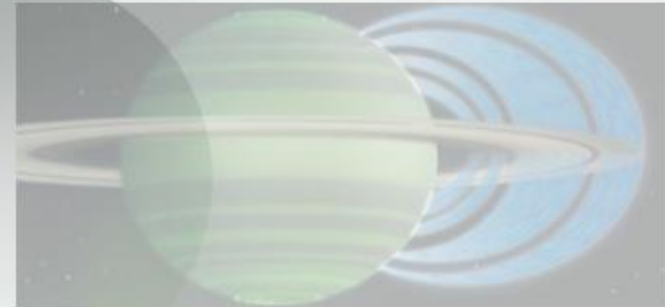
Above: Global seismic hazard and extent of EEW. Symbols show the few regions of the world where public citizens and organizations currently receive earthquake warnings and the types of data used to generate those warnings. Background color is peak ground acceleration with 10% probability of exceedance in 50 years from the Global Seismic Hazard Assessment Program.

Left: Device tests. (A) Comparison of displacements obtained from consumer GNSS receivers with and without phase smoothing (p-s) and SBAS, by twice integrating smartphone acceleration and by Kalman filtering acceleration and GNSS data. Almost any smartphone or similar consumer device would generate the displacement and acceleration data shown with gray lines. (B) Drift of position obtained from various devices (GNSS, double-integrated accelerometers, and Kalman filtering thereof) compared to observed earthquake displacements. (C) Using the drift curves shown in (B) and the peak ground displacement expected as function of magnitude and distance from the source, we can calculate the minimum magnitude earthquake observable with a signal-to-noise ratio of 10. Dotted line shows sensitivity of acceleration recorded on a smartphone. Dashed lines show sensitivity of displacement data obtained by twice integrating consumer and scientific acceleration data. At very close distances, the highest-quality consumer devices can observe earthquakes as small as M_6 with a signal-to-noise ratio of at least 10.

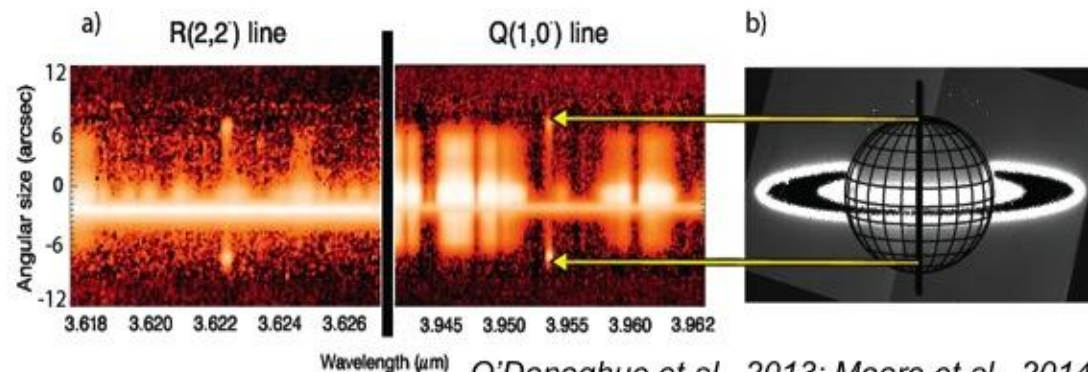


Saturn "Ring Rain"

- Charged oxygen ring particles flow along magnetic field lines and "rain" into Saturn's atmosphere, altering local chemistry.
- "Ring rain" represents a siphoning of ring material into Saturn's atmosphere; it may be responsible for the sharp boundary between the B and C rings, and it directly affects our current understanding of ring formation and evolution.



- Observations in 2011-2014 from the W. M. Keck Observatory of the ionized molecule H_3^+ in Saturn's ionosphere probe ring rain and mass loss from the rings. Variations in one hemisphere are mirrored in the opposite hemisphere.
- These are the first ever measurements of ions in Saturn's mid-latitude ionosphere by the only technique possible from the ground and are highly complementary to *Cassini*.
- Ring rain measurements significantly enhance the few remote diagnostics of Saturn's upper atmosphere.
- Measurements of the Enceladus "rain" footprint (not yet seen in infrared) would allow study of a host of magnetospheric and atmospheric phenomena resulting from this electrodynamic interaction.



O'Donoghue et al., 2013; Moore et al., 2014

05/06/2015

Five Stars Pathway Workshop & Website

- On April 30, 2015, the Five Stars Pathway presented a professional development workshop for 35 afterschool educators at the national Best Out-Of-School Time (BOOST) Conference in Palm Springs, CA
- The Five Stars Pathway project created a model in which five “generations” of females engage in science together in an afterschool setting, with each generation representing one stage in the pathway of pursuing a career in science, technology, engineering, or math (STEM)
- The workshop disseminated the electromagnetic spectrum curriculum via the project website:
<http://multiverse.ssl.berkeley.edu/FiveStars>
- The Five Stars project is funded by through a grant from NASA Science Mission Directorate, Heliophysics Division

