National Aeronautics and
Space Administration

Science Mission Directorate

Weekly Highlights

April 15, 2016

Behemoth Black Hole Found in an Unlikely Place

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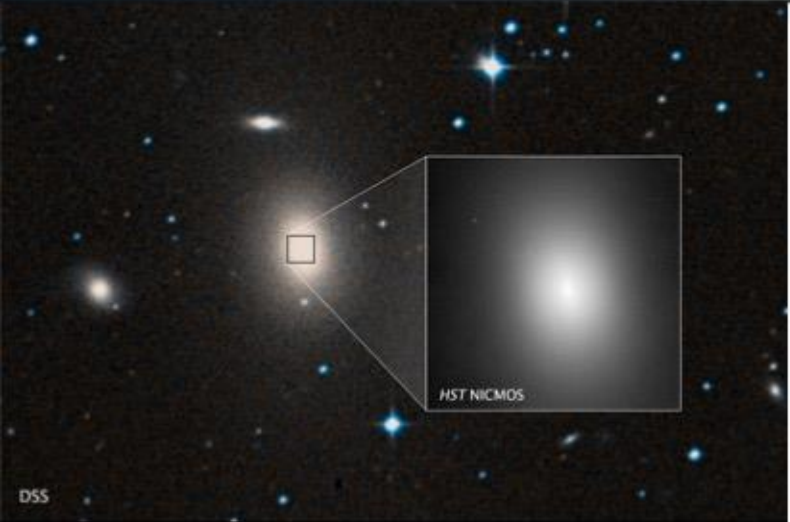


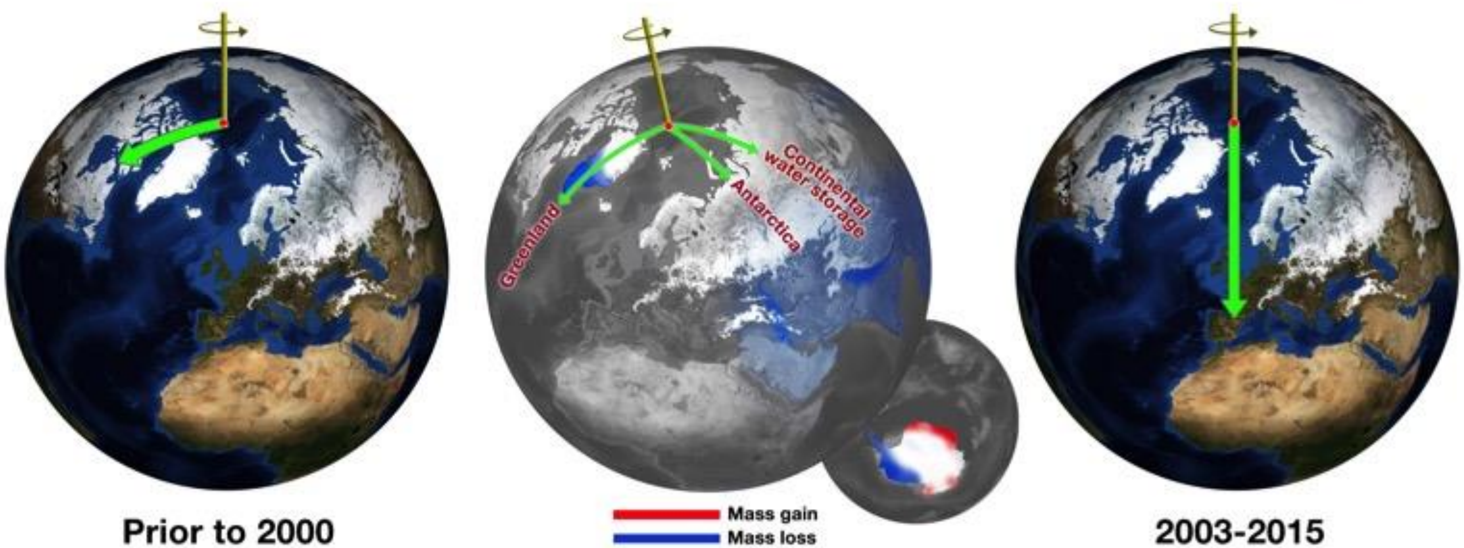
Credit: NASA, ESA, and C.-P. Ma (University of California, Berkeley) Acknowledgment: Digitized Sky Survey (DSS), STScI/AURA, Palomar/ Caltech, UKSTU/AAO, and A. Quillen (University of Rochester) Elliptical galaxy NGC 1600 taken by the Digitized Sky Survey, resides in an uncluttered region of space. A close-up view, is shown in the inset image, which was taken in near-infrared light by the HST's Near Infrared Camera and Multi-Object Spectrometer (NICMOS).

- Astronomers have uncovered a near-record-breaking supermassive black hole, weighing 17 billion suns, in an unlikely place: in the center of a galaxy in a sparsely populated area of the universe. Until now, the biggest supermassive black holes — those roughly 10 billion times the mass of our sun — have been found at the cores of very large galaxies in regions of the universe packed with other large galaxies.
- The newly discovered supersized black hole resides in the center of a massive elliptical galaxy, NGC 1600, located about 200 million light-years from Earth in the direction of the constellation Eridanus.
- The researchers were surprised to discover that the black hole is 10 times more massive than they had predicted for a galaxy of this mass. Based on previous Hubble surveys of black holes, astronomers had developed a correlation between a black hole's mass and the mass of its host galaxy's central bulge of stars — the larger the galaxy bulge, the proportionally more massive the black hole. But for galaxy NGC 1600, the giant black hole's mass far overshadows the mass of its relatively sparse bulge.
- One idea to explain the black hole's monster size is that it merged with another black hole long ago when galaxy interactions were more frequent. When two galaxies merge, their central black holes settle into the core of the new galaxy and orbit each other. Stars falling near the binary black hole, depending on their speed and trajectory, can actually rob momentum from the whirling pair and pick up enough velocity to escape from the galaxy's core. This gravitational interaction causes the black holes to slowly move closer together, eventually merging to form an even larger black hole. The supermassive black hole then continues to grow by gobbling up gas funneled to the core by galaxy collisions.
- The frequent meals consumed by NGC 1600 may also be the reason why the galaxy resides in a small town, with few galactic neighbors. NGC 1600 is the most dominant galaxy in its galactic group, at least three times brighter than its neighbors. Most of the galaxy's gas was consumed long ago when the black hole blazed as a brilliant quasar from material streaming into it that was heated into a glowing plasma.
- Velocity measurements were made by the Gemini Multi-Object Spectrograph (GMOS) on the Gemini North 8-meter telescope on Mauna Kea in Hawaii. GMOS spectroscopically dissected the light from the galaxy's center, revealing stars within 3,000 light-years of the core. Some of these stars are circling around the black hole and avoiding close encounters. However, stars moving on a straighter path away from the core suggest that they had ventured closer to the center and had been slung away, most likely by the twin black holes.
- Archival Hubble images, taken by the Near Infrared Camera and Multi-Object Spectrometer (NICMOS), support the idea of twin black holes pushing stars away. The NICMOS images revealed that the galaxy's core was unusually faint, indicating a lack of stars close to the galactic center. A star-depleted core distinguishes massive galaxies from standard elliptical galaxies, which are much brighter in their centers. Scientists estimated that the amount of stars tossed out of the central region equals 40 billion suns, comparable to ejecting the entire disk of our Milky Way galaxy.

Climate-driven Polar Motion: 2003–2015

Adhikari, S., & Ivins, E. R. | Science Advances | April 2016 | doi: 10.1126/sciadv.1501693

NASA JPL scientists analyzed space geodetic and satellite gravimetric data from NASA's Gravity Recovery and Climate Experiment (GRACE) mission for the period 2003–2015 to show that all of the main features of polar motion are explained by global-scale continent-ocean mass transport. The changes in terrestrial water storage (TWS) and global cryosphere together explain nearly the entire magnitude (83 mas ± 23%)* and mean directional shift (within 5.9° ± 7.6°) of the observed motion. Additionally, the study found that the TWS variability fully explains the decadal-like changes in polar motion observed during the study period, offering, thus, a clue to resolving the long-standing quest for determining the origins of decadal oscillations. Earth's spin axis has been wandering along the Greenwich meridian since about 2000, representing a 75° eastward shift from its long-term drift direction. Earth's spin axis has been wandering along the Greenwich meridian since about 2000, representing a 75° eastward shift from its long-term drift direction. The past 115 years have seen unequivocal evidence for a quasi-decadal periodicity, and these motions persist throughout the recent record of pole position, in spite of the new drift direction.



Above: Before about 2000, Earth's spin axis was drifting toward Canada (green arrow, left globe). JPL scientists calculated the effect of changes in water mass in different regions (center globe) in pulling the direction of drift eastward and speeding the rate (right globe).

**** Polar motion is the movement of Earth's spin axis as it wanders through the crust. Observations have tracked this motion for more than 100 years. Astrometric data, when combined with space methods, form a continuous time series since 1899 and have sufficient signal-to-noise ratio to accurately determine the pole position to a level much less than 1 millisecond of arc (mas; 1 mas ≈ 3.09 cm)***

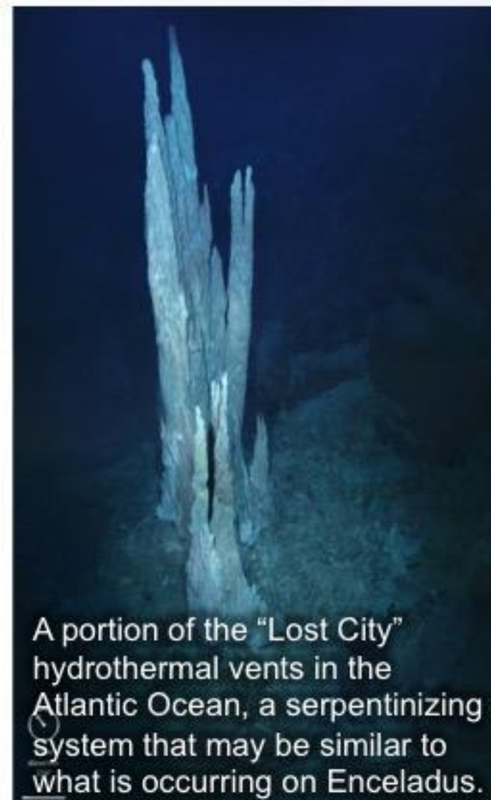
How Friendly Is Enceladus' Ocean to Life?

Tufa towers in Mono Lake, CA.

New data from the Cassini spacecraft have been used to model the ocean water on Enceladus to estimate the pH of its ocean, answering a fundamental question in determining whether Saturn's icy moon Enceladus could support life.

- Mass spectra observations of the plume gas made from the Cosmic Dust Analyzer (CDA) onboard the Cassini spacecraft indicate that the ocean is a sodium-chloride-carbonate solution with an alkaline pH of ~11-12.
- The dominance of NaCl is similar to oceans on the Earth, but the dissolved Na_2CO_3 concentrations mean that the ocean composition is similar to that of soda lakes on Earth (e.g., Mono Lake in California).
- The alkaline pH results from serpentinization, a geochemical process in which iron- and/or magnesium-rich rocks interact with water to produce hydrogen, a geochemical fuel that can support both abiotic and biological synthesis of organic molecules such as those that have been detected in Enceladus' plume from Cassini.
- Serpentinization has happened in many places throughout the solar system, but it is not known whether serpentinization is taking place on Enceladus today, or whether Enceladus' rocky core has been completely altered by past hydrothermal activity.
- The detection of native hydrogen gas in the plume today would indicate current serpentinization, and thus a source of energy for possible life.

Glein, et al. 2016.Geochimica et Cosmochimica Acta



A portion of the "Lost City" hydrothermal vents in the Atlantic Ocean, a serpentinizing system that may be similar to what is occurring on Enceladus.

Validating Solar Wind Predictions at Earth

Jian, L. K., et al. (2015), Validation for solar wind prediction at Earth: Comparison of coronal and heliospheric models installed at the CCMC, Space Weather, 13, 316–338 doi:10.1002/2015SW001174.

Modern society is increasingly reliant on a variety of technologies susceptible to the extremes of space weather. Severe space weather events have the potential to interfere with high-frequency radio communications and Global Positioning System (GPS) navigation, and disrupt electric power grids. Solar wind predictions are an important part of space weather forecasting as the different parameters of solar wind, such as velocity, density and magnetic field, can affect how impactful space weather events are here at Earth. Jian et. al, 2015, validated the coronal and heliospheric models for certain types of solar wind activity, called stream interaction regions (SIRs) which form when fast solar wind streams overtake and interact with the proceeding slow wind. These slow-to-fast stream interactions can trigger geomagnetic storms, disturb the thermosphere, and affect satellite orbital decay.

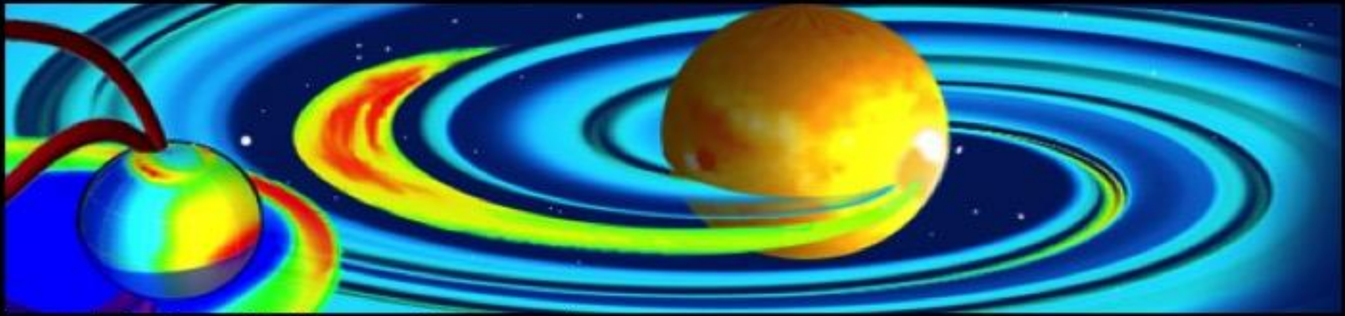


Image taken from http://ccmc.gsfc.nasa.gov/

Jian et al., 2015, looked at this aspect of space weather research by studying the accuracy of solar wind predictions using ten different models hosted at the Community Coordinated Modeling Center (CCMC).

These models used input from the ESA-NASA Heliophysics SOlar and Heliospheric Observatory (SOHO) mission as well as a network of ground-based solar-observing sites including the Global Oscillation Network Group and National Solar Observatory SOLIS at Kitt Peak, AZ, and Mount Wilson Observatory. The model output, associated with the near-Earth environment, was compared to Operating Missions as a Node on the Internet (OMNI) solar wind data, which integrates in situ observations from the ACE, WIND and Geotail missions. Jian et al.'s paper, published in the journal, *Space Weather,* outlines the strengths and weakness of each model's capabilities in predicting different solar wind parameters near Earth. Previous studies found that the empirically based solutions tended to match with in situ observations better. This study has demonstrated that the current suite of self-consistently derived models can sometimes perform better in many aspects than the empirical models.

Updates to this paper were presented at the biennial CCMC Workshop this past week in Annapolis, MD, to an audience composed of space scientists coming from institutions all over the world, as well as representatives from various government agencies. The CCMC is a multi-agency activity, housed at NASA GSFC, with a goal of bridging the gap between science and operations while enhancing space weather research. The discussion following the presentation noted that even with the progress made in the model predictions, the comparisons still highlight the need for future research.

"Destination:Mars" First Public Preview at the Microsoft "Build" Developers Conference

- On March 30-April 1, 2016, "Destination:Mars" had its first public preview at the Microsoft "Build" Developers Conference
- Attendees previewed the exhibit that will be installed at the Kennedy Space Center Visitors Complex in Summer 2016
- This was the first showing of the public version of the "OnSight" software tool that NASA developed for the Curiosity rover operations
- OnSight uses the HoloLens to creates an immersive representation of Mars, based on actual images gathered by Curiosity
- The system allows rover science team members to virtually walk around and explore regions near the rover; "Destination:Mars" uses a subset of OnSight's capability to create a guided tour of Mars' surface
- After being highlighted during the conference keynote, the demand to view the virtual reality experience was overwhelming
- On the first day, 1000 available slots to a virtual tour of Mars was booked up in 15 minutes; by the second day, the entire daily schedule was booked in about half of that time…People want to experience Mars!