National Aeronautics and
Space Administration

Science Mission Directorate

Weekly Highlights

October 30, 2015

Black Hole Markarian 335 Has Major Flare

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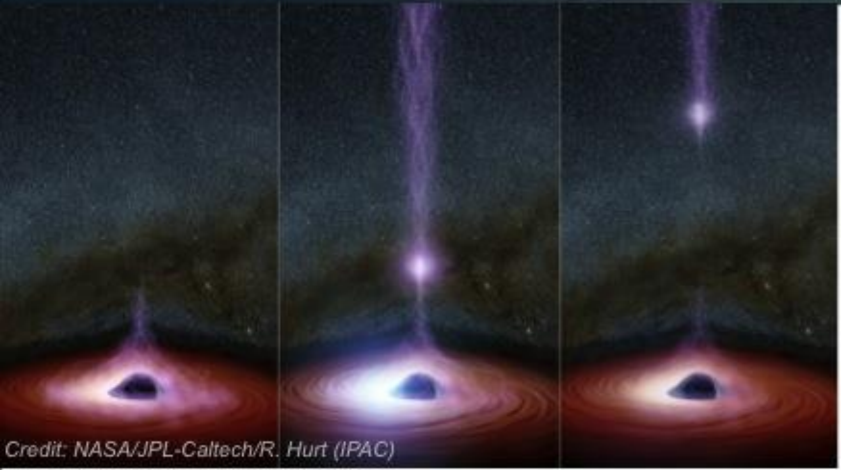


Credit: NASA/JPL-Caltech/R. Hurt (IPAC)

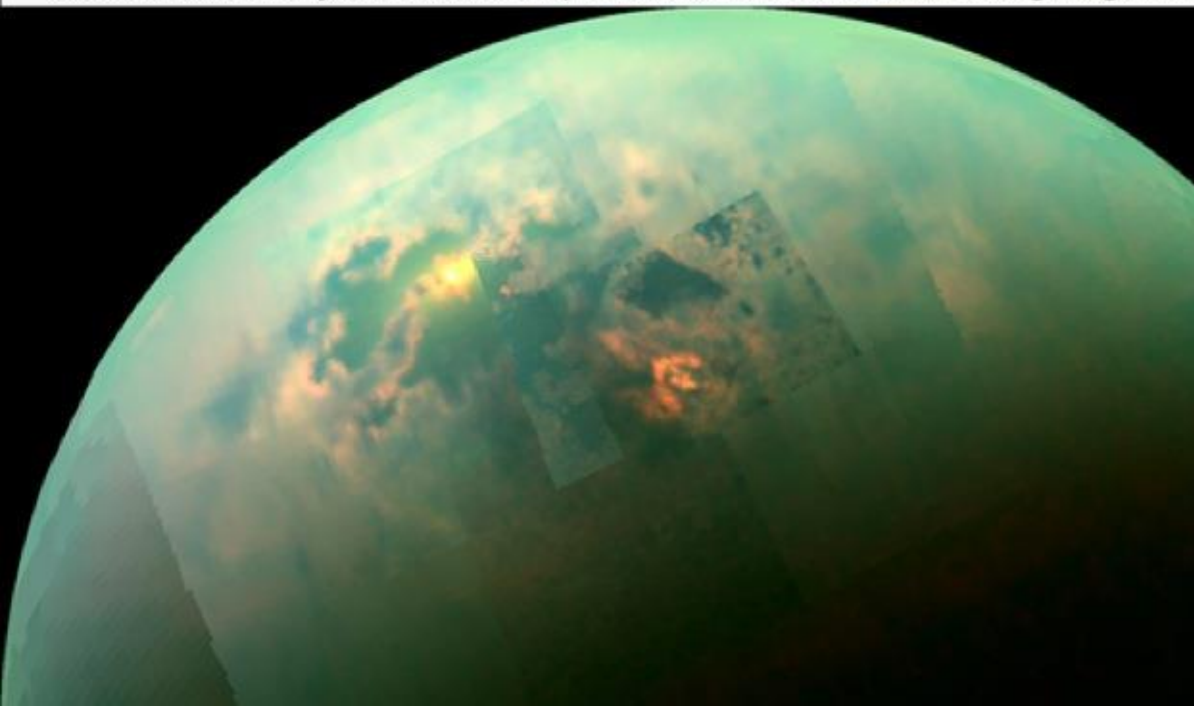
The diagram shows how a corona, can create a flare of X-rays around a black hole. The corona (feature represented in purplish colors) gathers inward (left), becoming brighter, before shooting away from the black hole (middle and right). The immense gravity of the black hole warps the appearance of the disk and stars behind it.

- NASA's Explorer missions Swift and NuSTAR (Nuclear Spectroscopic Telescope Array) caught a supermassive black hole in the midst of a giant eruption of X-ray light, helping astronomers address an ongoing puzzle: How do supermassive black holes flare?
- The results suggest that supermassive black holes send out beams of X-rays when their surrounding coronas -- sources of extremely energetic particles -- shoot, or launch, away from the black holes.
- Supermassive black holes don't give off any light themselves, but they are often encircled by disks of hot, glowing material. The gravity of a black hole pulls swirling gas into it, heating this material and causing it to shine with different types of light. Another source of radiation near a black hole is the corona. Coronas are made up of highly energetic particles that generate X-ray light, but details about their appearance, and how they form, are unclear.
- Astronomers think coronas have one of two likely configurations. The "lamppost" model says they are compact sources of light, similar to light bulbs, that sit above and below the black hole, along its rotation axis. The other model proposes that the coronas are spread out more diffusely, either as a larger cloud around the black hole, or as a “sandwich” that envelops the surrounding disk of material like slices of bread. In fact, it's possible that coronas switch between both the lamppost and sandwich configurations.
- The new data support the "lamppost" model -- and demonstrate how the light-bulb-like coronas move. The observations began in September 2014 when Swift, which monitors the sky for cosmic outbursts of X-rays and gamma rays, caught a large flare coming from the supermassive black hole called Markarian 335, or Mrk 335, located 324 million light-years away in the direction of the constellation Pegasus. Eight days later, NuSTAR set its X-ray eyes on the target, witnessing the final half of the flare event.
- After careful scrutiny of the data, the astronomers realized they were seeing the ejection, and eventual collapse of the black hole's corona.
- How could the researchers tell the corona moved? The corona gives off X-ray light that has a slightly different spectrum -- X-ray “colors" -- than the light coming from the disk around the black hole. By analyzing a spectrum of X-ray light from Mrk 335 across a range of wavelengths observed by both Swift and NuSTAR, the researchers could tell that the corona X-ray light had brightened -- and that this brightening was due to the motion of the corona.
- Coronas can move very fast. The corona associated with Mrk 335 was traveling at about 20 percent the speed of light. When this happens, and the corona launches in our direction, its light is brightened in an effect called relativistic Doppler boosting.
- Putting this all together, the results show that the X-ray flare from this black hole was caused by the ejected corona.

A Surprising Twist to Titan's Origin Story

Measurements of two nitrogen isotopes indicate that Titan's chemical heritage traces straight to the original material in the protoplanetary nebula – the cold disk of gas and dust from which the Sun formed – and not to gas and dust local to Saturn.

- Saturn's moon Titan has an atmosphere that is rich in nitrogen compounds, and is thought to be composed of ammonia ice. Measurements of the heavy and light nitrogen isotopes (^{15}N and ^{14}N) by the gas chromatograph on the Cassini-Huygens probe indicated that the ratio of these two was very similar to those measured just recently in cometary materials.
- Comets retain tracers of some of the primordial ingredients – the protosolar nebula – from which the solar system formed. This protosolar nebula would have been much cooler than the subnebula around Saturn and would had a very different composition of the different Nitrogen gasses and ices.



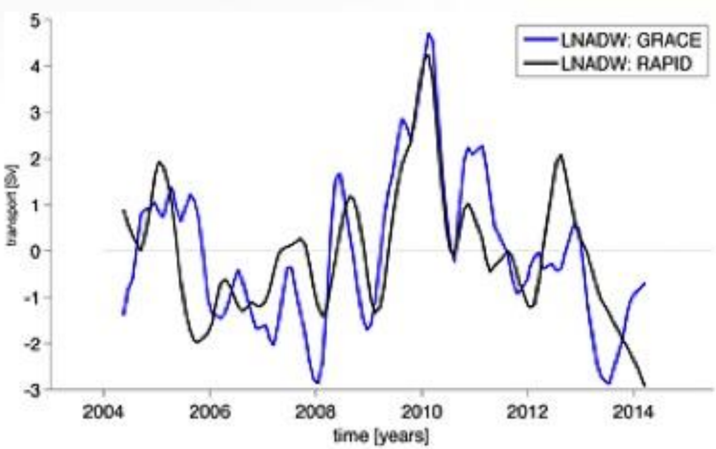
- After considering many options for atmospheric escape processes that might affect this ratio, none were sufficient to account for an original value that would be indicative of Titan's formation close to Saturn.
- This finding may help answer fundamental questions about the original building blocks of the planets and as well as address whether meteorites and comets brought nitrogen to Earth or whether nitrogen was part of our planet's original makeup.

Mandt et al. (2014), Astrophysical Journal Letters

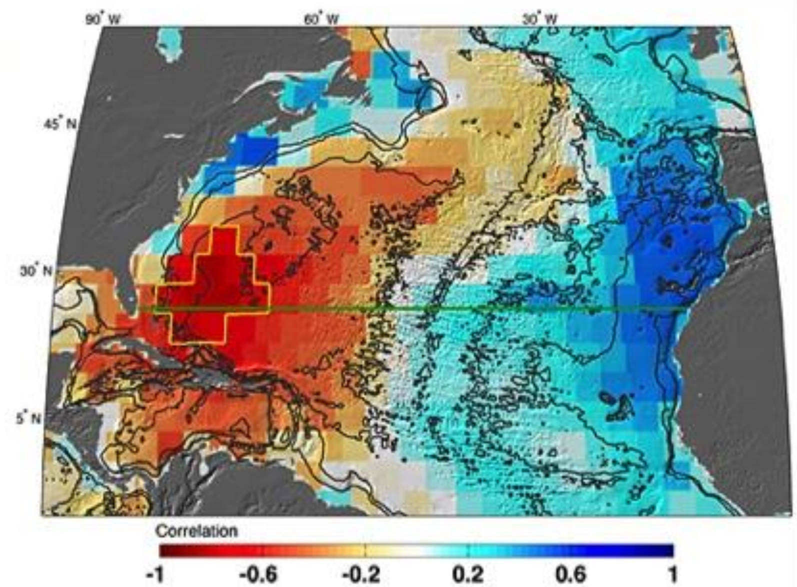
North Atlantic Meridional Overturning Circulation Variations From GRACE

Landerer, Felix W., David N. Wiese, Katrin Bentel, Carmen Boening, and Michael M. Watkins | Geophysical Research Letters| OCTOBER 2015 | doi:10.1002/2015GL065730

A NASA-JPL study presented the first measurements of Lower North Atlantic Deep Water (LNADW) transport changes using only time-variable gravity observations from Gravity Recovery and Climate Experiment (GRACE) satellites from 2003 until now. Improved monthly gravity field retrievals allow the detection of North Atlantic interannual bottom pressure anomalies and LNADW transport estimates that are in good agreement with those from the Rapid Climate Change-Meridional Overturning Circulation and Heatflux Array (RAPID/MOCHA). Concurrent with the observed AMOC transport anomalies from late 2009 through early 2010, GRACE measured ocean bottom pressures changes in the 3000–5000m deep western North Atlantic. These measurements agreed well with estimates from a network of ocean buoys that span the Atlantic Ocean near 26 degrees north latitude, giving the researchers confidence that the technique can be expanded to provide estimates throughout the Atlantic. In fact, the GRACE measurements showed that a significant weakening in the overturning circulation, which the buoys recorded in the winter of 2009-10, extended several thousand miles north and south of the buoys' latitude. These results highlight the efficacy of space gravimetry for observing Atlantic Meridional Overturning Circulation (AMOC) variations to evaluate latitudinal coherency and long-term variability. The AMOC plays a key role in the poleward transport of heat. Changes in this transport can influence climate at higher latitudes significantly, with potentially significant impacts for the Northern Hemisphere, in particular northwest Europe's climate.



Left: Meridional transport estimates from GRACE ocean bottom pressure (OBP) anomalies on the eastern and western margin integrated over the 3000–5000m depth layer at 26.5N, compared to the RAPID-MOCHA estimate of LNADW



Right: Correlation between GRACE OBP and the GRACE estimate LNADW transport at 26.5N. The yellow contour line highlights areas where the correlation |R| ≥ 0.7. Also shown is the location of the hydrographic in situ RAPID MOCHA section (green line).

Voyager 1 Helps Solve an Interstellar Medium Mystery

This artist's concept shows NASA's Voyager spacecraft against a backdrop of stars. Credits: NASA/JPL-Caltech

NASA's Voyager 1 spacecraft made history in 2012 by entering interstellar space, leaving the planets and the solar wind behind. But observations from the pioneering probe were puzzling with regard to the magnetic field around it, as they differed from what scientists derived from observations by other spacecraft.

A new study offers fresh insights into this mystery. Researchers reanalyzed magnetic field data from Voyager 1 and found that the direction of the magnetic field has been slowly turning ever since the spacecraft crossed into interstellar space. They believe this is a result of the nearby boundary of the solar wind, a stream of charged particles that comes from the sun.

This study provides very strong evidence that Voyager 1 is in a region where the magnetic field is being deflected by the solar wind. Researchers predict that in 10 years Voyager 1 will reach a more "pristine" region of the interstellar medium where the solar wind does not significantly influence the magnetic field.

Previous Voyager 1 observations of the direction of the local interstellar magnetic field showed that was more than 40 degrees off from what other spacecraft have determined. The new study suggests this discrepancy exists because Voyager 1 is in a more distorted magnetic field just outside the heliopause, which is the boundary between the solar wind and the interstellar medium.

In 2009, NASA's Interstellar Boundary Explorer (IBEX) discovered a "ribbon" of energetic neutral atoms that is thought to hold clues to the direction of the pristine interstellar magnetic field. The new study uses multiple data sets to confirm that the magnetic field direction at the center of the IBEX ribbon is the same direction as the magnetic field in the pristine interstellar medium. Observations from the NASA/ESA Ulysses and SOHO spacecraft also support the new findings.

Over time, the study suggests that at increasing distances from the heliosphere, the magnetic field will be oriented more and more toward "true north," as defined by the IBEX ribbon. By 2025, if the field around Voyager 1 continues to steadily turn, Voyager 1 will observe the same magnetic field direction as IBEX. That would signal Voyager 1's arrival in a less distorted region of the interstellar medium. While Voyager 1 will continue delivering insights about interstellar space, its twin probe Voyager 2 is also expected to cross into the interstellar medium within the next few years.

Five Stars Pathway
Curriculum and Website Now Available to Use

http://multiverse.ssl.berkeley.edu/FiveStars

- The Five Stars Pathway program is a NASA-funded project which seeks to increase the representation of females in Heliophysics by engaging girls in relevant Science, Technology, Engineering and Math education (STEM) content and providing them with female role models
- The project is a partnership between Multiverse at University of California Berkeley's Space Sciences Laboratory and Girls Inc.
- The project created a multigenerational model in which five generations of females (elementary school girls, middle school girls, undergraduate students, graduate students and scientists) explore science together in an afterschool setting with each generation representing one stage in the pathway of pursuing a career in STEM
- The model and associated curriculum was tested at Girls Inc. of the Island City and Girls Inc. of Alameda County in California
- In Spring 2015, 10 additional Girls Inc. affiliates nationwide were trained on the model and curriculum

<u>Some NASA/ Institute for Global Environmental Strategies (IGES) reviewer comments:</u>

- "This is a very well thought-out project! It should serve as a model of all NASA after-school online educational content."
- "Very much liked the women in science focus -- this is an unmet need in science education."
- "Very nice collection of resources (videos, activities, background material) relating to the electromagnetic spectrum focusing on solar science."
- "This is a standout product that brings together several disparate lessons into a easy-to-use curriculum. The inclusion of the sequencing helps to provide flexibility to the end-user, which is very much needed with an informal audience."

Multiverse | girls inc.


Invisible Light: Ultraviolet

Age Range
Ages 10 +

Duration
20 minutes, indoors and outdoors

Participants

Special Notes
You will need a sunny day for this activity.

Overview
The Sun gives us light here on Earth in many different forms, some that we can see with our eyes and some that we cannot. One light form that we cannot see is ultraviolet light, or "UV" for short, but we sense it in different ways. Luckily, Earth's atmosphere protects us from most of the UV coming from the Sun, but some of it reaches us here on our planet. If we are exposed to too much UV light, it can give us a pretty bad sunburn and other skin problems. Lots of exposure to UV light is also not good for our vision, reducing the flexibility we have in the lenses in our eyes and eventually making it hard for us to see clearly. But UV light also has some benefits—it can contribute to our health. When we are exposed to the Sun, our skin is able to produce Vitamin D, which helps our bones stay healthy, among other things.

So, we need some UV light, but not too much. How do we find a good balance? How can we go outside and get enough UV light, but still protect our skin and eyes? With the help of some little UV beads, you are going to uncover some ways to be safe in the Sun!

Activity Goals
Participants will learn:
- That the Sun gives off different kinds of energy: visible light, and invisible light in the form of ultraviolet rays.
- That the Earth's atmosphere protects us from most of the harmful UV rays.
- That there are several ways that we can protect ourselves from the Sun's harmful rays.
- Why UV from the Sun is important to us.

Top: Lesson #4 cover. Bottom: an inside page.