National Aeronautics and
Space Administration

# Science Mission Directorate

## Weekly Highlights

September 23, 2016

# Studies Find Echoes of Black Holes Eating Stars

*To be published in the Astrophysical Journal*

*Illustration credit: NASA/JPL-Caltech*

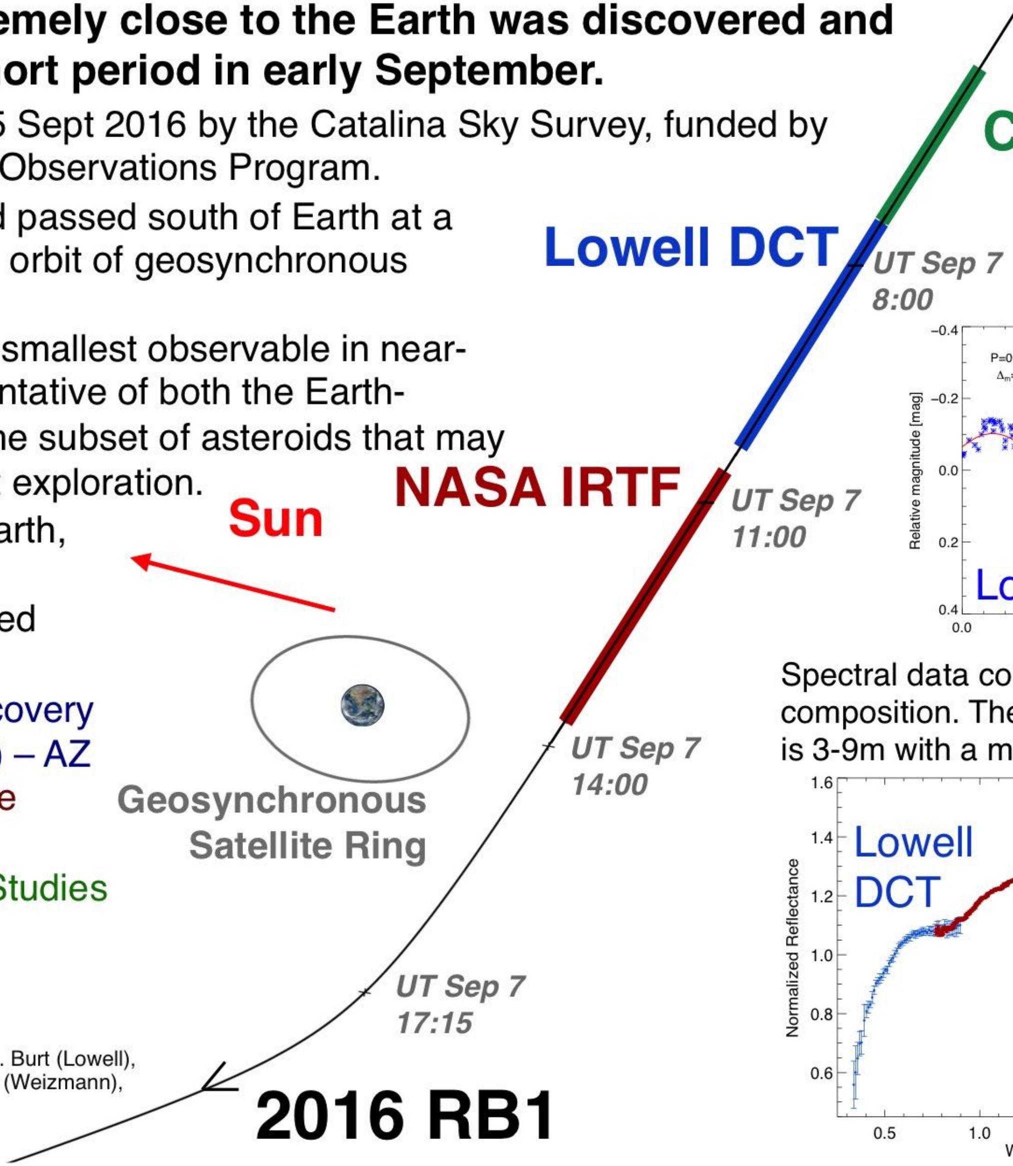
*This illustration shows a glowing stream of material from a star, disrupted as it was being devoured by a supermassive black hole. The feeding black hole is surrounded by a ring of dust. This dust was previously illuminated by flares of high-energy radiation from the feeding black hole, and is now shown re-radiating some of that energy as heat in the infrared part of the spectrum.*

- Supermassive black holes, with their immense gravitational pull, are notoriously good at clearing out their immediate surroundings by eating nearby objects. When a star passes within a certain distance of a black hole, the stellar material gets stretched and compressed as the black hole swallows it.
- A black hole destroying a star, an event astronomers call "stellar tidal disruption," releases an enormous amount of energy, brightening the surroundings in an event called a flare. In recent years, a few dozen such flares have been discovered, but they are not well understood.
- Astronomers now have new insights into tidal disruption flares, thanks to data from NASA's Wide-field Infrared Survey Explorer (WISE). Two new studies characterize tidal disruption flares by studying how surrounding dust absorbs and re-emits their light, like echoes. This approach allowed scientists to measure the energy of flares from stellar tidal disruption events more precisely than ever before.
- Flares from black holes eating stars contain high-energy radiation, including ultraviolet and X-ray light. Such flares destroy any dust that hangs out around a black hole. But at a certain distance from a black hole, dust can survive because the flare's radiation that reaches it is not as intense.
- After the surviving dust is heated by a flare, it gives off infrared radiation. WISE measures this infrared emission from the dust near a black hole, which gives clues about tidal disruption flares and the nature of the dust itself. Infrared wavelengths of light are longer than visible light and cannot be seen with the naked eye. The WISE spacecraft allowed the variation in infrared emission from the dust to be measured.
- Astronomers used a technique called "photo-reverberation" or "light echoes" to characterize the dust. This method relies on measuring the delay between the original optical light flare and the subsequent infrared light variation, when the flare reaches the dust surrounding the black hole. This time delay is then used to determine the distance between the black hole and the dust.
- Measuring the infrared glow of dust heated by these flares allows astronomers to make estimates of the location of dust that encircles the black hole at the center of a galaxy.
- Researchers found that the infrared emission from dust heated by a flare causes an infrared signal that can be detected for up to a year after the flare is at its most luminous. The results are consistent with the black hole having a patchy, spherical web of dust located a few trillion miles (half a light-year) from the black hole itself.

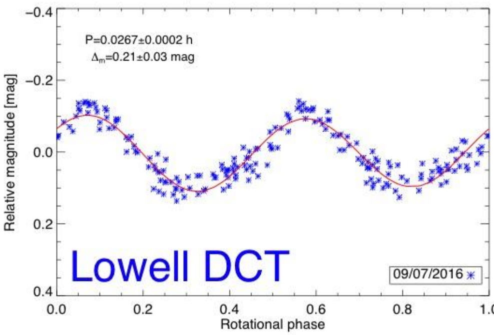
# Multi-facility study of asteroid 2016 $RB_1$ during its near-Earth encounter

**A asteroid passing extremely close to the Earth was discovered and observed within very short period in early September.**

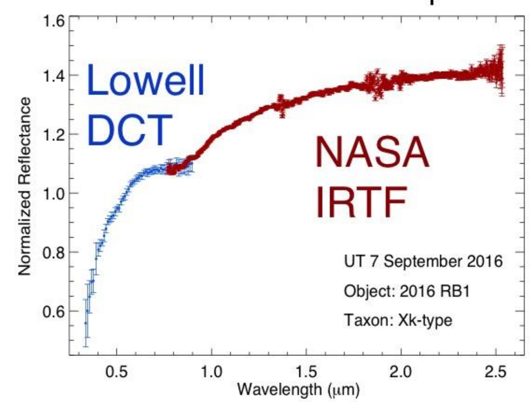
- 2016RB1 was discovered 5 Sept 2016 by the Catalina Sky Survey, funded by NASA's Near-Earth Object Observations Program.
- Two days later, the asteroid passed south of Earth at a distance comparable to the orbit of geosynchronous satellites.
- This asteroid is among the smallest observable in near-Earth space and is representative of both the Earth-impacting population and the subset of asteroids that may be accessible to spacecraft exploration.
- As it passed close to the Earth, "Target-of-opportunity" observations were conducted from:
  - Lowell Observatory's Discovery Channel Telescope (DCT) – AZ
  - NASA's Infrared Telescope Facility (IRTF) – HI
  - Center for Solar System Studies (CSSS) - CA




Lightcurves suggest a rapid rotation period of 96.1 sec.




Spectral data constrain albedo and composition. The inferred size of object is 3-9m with a metal-rich composition.

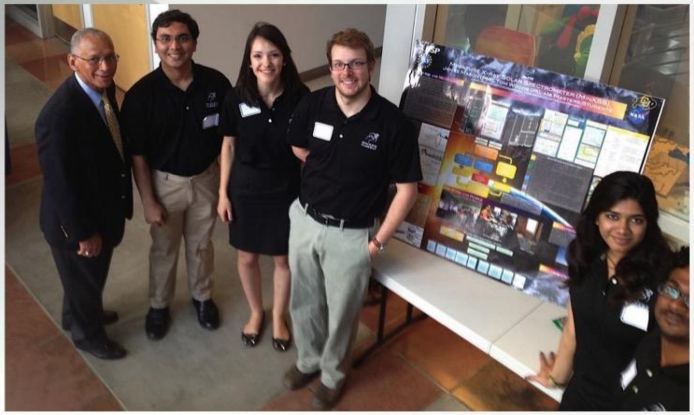



*Observations & analysis:* N. Moskovitz (Lowell), B. Burt (Lowell), T. Burt (Lowell), A. Thirouin (Lowell), D. Polishook (Weizmann), B. Warner (CSSS), V. Reddy (LPL)

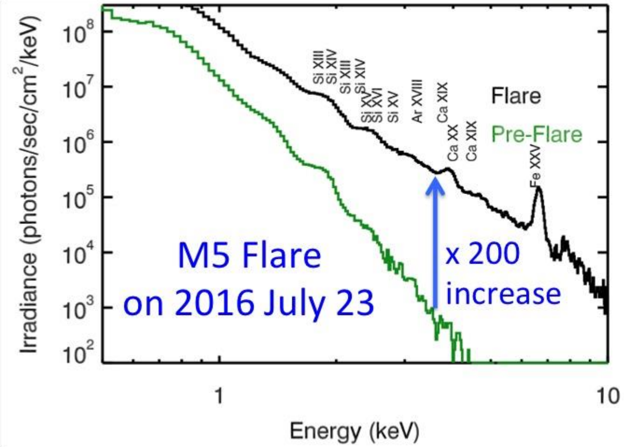
# Heliophysics MinXSS CubeSat Fills Critical Gap in Solar Spectral Irradiance Data

MinXSS CubeSat data fill an important spectral gap in solar irradiance measurements, collecting soft X-ray (SXR) data at spectral resolutions we have not obtained before. The SXR region has mostly been measured by broadband photometers in 3-7 nanometer wide bands on missions like GOES, SDO, SNOE, SORCE and TIMED. MinXSS will not only provide up to 100 times more spectral information than the data we have from other missions, but will also calibrate the broadband photometer measurements spanning decades from those missions.

Studying SXR data from the sun can tell us important things about its corona or atmosphere; such as its temperature, density and chemical composition. Many scientists are interested in research and data that will help connect coronal events, like solar flares, to processes that will help us better understand one of the biggest mysteries we have about the sun and its processes, called the coronal heating problem. The sun's corona is very hot compared to its surface and we do not fully know why. Analyzing MinXSS data will help scientists search for answers to this mystery.



*Administrator Bolden visited the MinXSS students in 2014, providing insight and advice in developing the mission. Over 45 students have worked on MinXSS.*




*This is a MinXSS measurement of the M5.0 flare taken on July 23, 2016, and indicates a factor of 200 increase in the brightness of soft X-ray (SXR) emissions. The pre-flare spectrum is the green line, and the flare spectrum is the black line. Some of the brighter coronal emissions lines are also labeled.*

MinXSS, the first CubeSat ever launched for the Science Mission Directorate, has been collecting data since its deployment from the International Space Station on May 16, 2016. MinXSS collects data on the energetics of solar flare emissions and how this energy impacts our atmosphere and ionosphere. By July, it had already met its minimum mission science criteria for science data and observations, seeing over 7 M-class solar flares and over 40 C-class flares. The minimum mission science criteria for MinXSS is to collect measurements of solar full-disk irradiance in SXR with a spectral resolution better than 1 nanometer, to sustain 30% accuracy for a minimum of one month, and to observe at least 6 medium-sized flares. MinXSS also won the 2016 AIAA Small Satellite Mission of the Year Award in August.

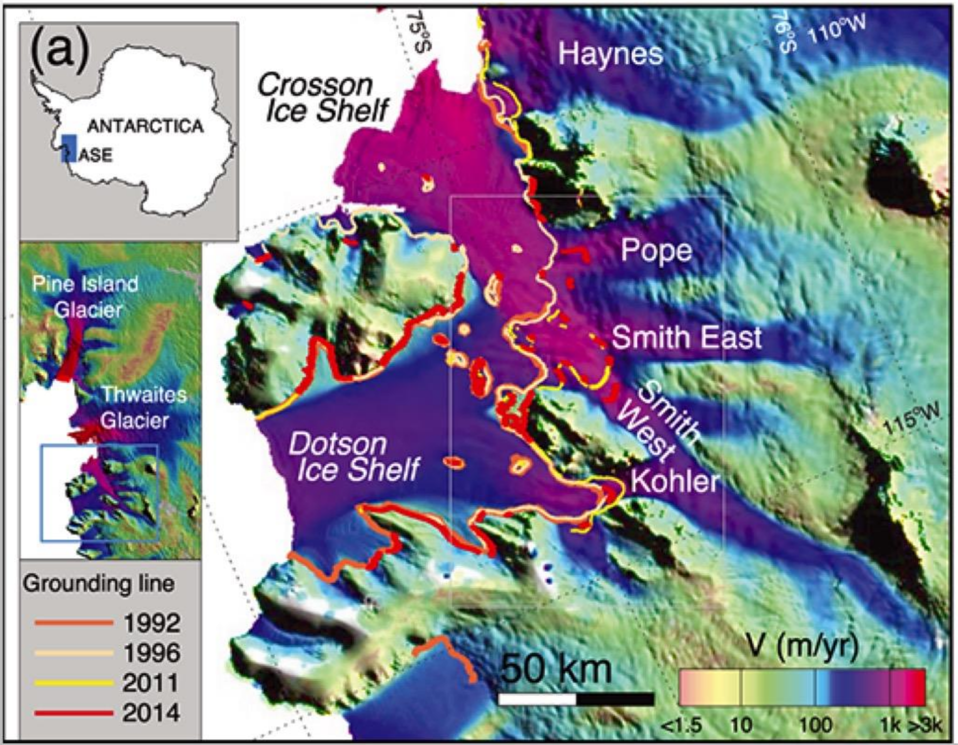
MinXSS itself is not much larger than a loaf of bread, yet can take narrowly-targeted scientific observations that fill a critical gap in existing solar irradiance measurements. This new and important MinXSS data is publically available and easily accessible online. A paper on what scientists are beginning to learn from MinXSS is in draft. The authors hope to see it published within the next few months.

MinXSS is a 3-Unit (3U) CubeSat built and operated by University of Colorado Boulder students and faculty at the Laboratory for Atmospheric and Space Physics (LASP) and the Aerospace Engineering Sciences Department (AES); the MinXSS team also includes scientists from NASA GSFC, SwRI, and NCAR. The NASA HQ Heliophysics Division manages CubeSat activities for the Science Mission Directorate.

# Grounding line retreat of Pope, Smith, and Kohler Glaciers, West Antarctica, measured with Sentinel-1a radar interferometry data

*Scheuchl, B., Mouginot, J., Rignot, E., Morlighem, M., & Khazendar, A.| Geophysical Research Letters| September 2016 | doi:10.1002/2016GL069287*

**NASA funded scientists employed Sentinel-1a C band satellite radar interferometry data to map the position of the grounding line (*) and ice velocity of Pope, Smith, and Kohler neighboring glaciers in West Antarctica for the years 2014–2016. The Sentinel-1a-derived ice velocities were combined with results from Landsat-8 and with an existing time series of ice surface velocity assembled from a suite of other Synthetic Aperture Radar (SAR) and optical satellites. They compared the results with those obtained using Earth Remote Sensing Satellites (ERS-1/2) for 1992, 1996, and 2011. They observed an ongoing, rapid grounding line retreat of Smith at 2 km/yr (40 km since 1996), an 11 km retreat of Pope (0.5 km/yr), and a 2 km readvance of Kohler since 2011. The variability in glacier retreat is consistent with the distribution of basal slopes, i.e., fast along retrograde beds and slow along prograde beds. Additionally, the results indicate that since 1996, Dotson and Crosson ice shelves have lost a number of pinning points that have held them together, due to ice shelf thinning, signaling the ongoing weakening of these ice shelves. Overall, the results indicate that ice shelf and glacier retreat continue unabated in this sector of Antarctica.**




***The Amundsen Sea Embayment (ASE) sector of West Antarctica has been undergoing significant changes over the past few decades and is the largest contributor to sea level rise from Antarctica at present. Spaceborne remote sensing is crucial to assess the state, and temporal and spatial changes in mass balance, and provide ice sheet numerical models with suitable observations and boundary conditions to model the evolution of ice in this sector.***

***Left:*** Grounding line mapping spanning from 1992 to 2014, along with ice velocity mapping combining various data sets overlaid on a Moderate Resolution Imaging Spectroradiometer (MODIS) mosaic of Antarctica. The 2014 grounding line is a result of this study and based on Sentinel-1 data.

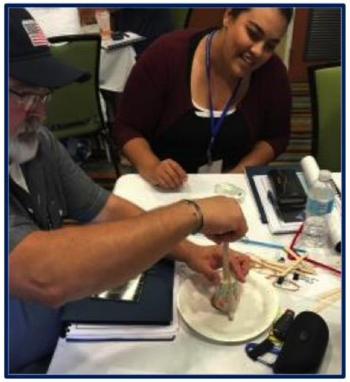
(*) grounding line is the boundary where a glacier loses contact with bedrock and begins to float on the ocean.

# Educators *Exploring the Solar System*, OSIRIS-REx Mission to Bennu

- On September 6-7, 2016, in Titusville, Florida, The *Exploring the Solar System* professional development training provided out-of-school time education professionals with tools to engage their audiences in NASA's solar system science and exploration
- The experience included a tour of NASA Kennedy Space Center and culminated in the viewing of the launch of the OSIRIS-REx spacecraft
- 31 participants representing the American Camp Association, State & National Parks, and the YMCA
- Hands-on activities and conversations with scientists focused on solar system formation and evolution, asteroids, meteorites, and robotic exploration of the solar system
- Participants will conduct and submit summaries of solar system/OSIRIS-REx programs at their home institutions between now and 2018
- Annual follow-up webinars will preced the arrival of OSIRIS-REx at asteroid Bennu (2018)
- Presented by educators and scientists from the Lunar and Planetary Institute (LPI), the Planetary Science Institute, the Southwest Research Institute, NASA's Johnson Space Center, the University of Arizona, and the University of Central Florida

*>87% of participants feel "confident" or "very confident" in implementing all presented activities*

*>75% of participants "probably" or "definitely" will implement nearly all the presented activities in their programs*




Participants designed and built core sample retrieval devices (above left), and learned about OSIRIS-REx from team member Dolores Hill (U of AZ, above right).

Participants pose during the tour of Kennedy Space Center.

*LPI is funded through the NASA Science Mission Directorate's cooperative agreement notice with USRA.*

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