

Celestial



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CCAS Officer Brian P. Cox took this photo of the Flame Nebula (center) and Horsehead Nebula (right) through his home telescope. Both nebulae are about 1,500 light years from Earth, and are located in the constellation Orion.

Next Star Gazing: ONLINE!

Saturday, May 15th at 7pm PT

CCAS Astronomer Kent Wallace and President Aurora Lipper will be taking you on a virtual tour of the night sky, so you can stargaze right from home!

Connect here:

CentralCoastAstronomy.org/stargaze

Total Lunar Eclipse!

Wednesday, May 26th

In the early morning of May 26th, a total Lunar eclipse will be visible from the Western United States.

To find out when and what will be visible in your area, visit:

<https://www.timeanddate.com/eclipse/map/2021-may-26>

Next Stargazing: ONLINE! Invite friends!!

Saturday, May 15th at 7pm PT

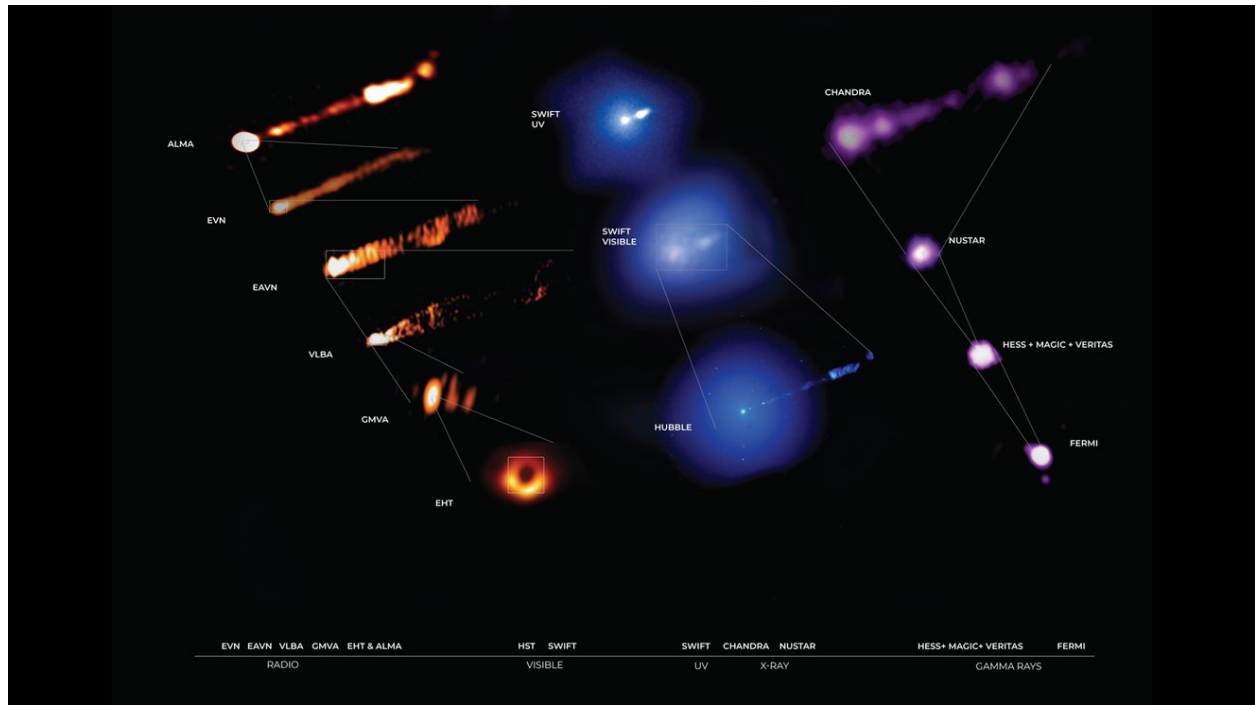
On May 15th, CCAS Astronomers Kent Wallace and Brian P. Cox will join President Aurora Lipper to take you on a virtual tour of the night sky. You'll be able to interact, ask questions, and gain insight on the best objects to view this time of year. Using the tools you've learned, you'll be able to stargaze from the comfort of your own home. You can download your handout to follow along, as well as a free sky chart on our website at the below link. Anyone can join, we'll be showing objects visible naked-eye, through binoculars, and through a telescope.



Invite all your friends! Anyone with the link can join our free online stargazing session. All that's needed is an internet connection. Join the stream using any tablet, personal computer, or YouTube enabled TV. Can't join us live? The video will be available on demand on our YouTube channel. Check our website for all the details:

CentralCoastAstronomy.org/stargaze

Telescopes Unite in Unprecedented Observations of Famous Black Hole by NASA / JPL



Different wavelengths of light can reveal unique features of the same cosmic object. A jet of material being spewed into space by a supermassive black hole in galaxy M87 is shown here in wavelengths ranging from radio waves to gamma rays. Credit: NASA/ESA/ESO/NAOJ/NRAO/CXC/EHT

In April 2019, scientists released the first image of a black hole in the galaxy M87 using the Event Horizon Telescope (EHT). However, that remarkable achievement was just the beginning of the science story to be told.

Data from 19 observatories are being released that promise to give unparalleled insight into this black hole and the system it powers, and to improve tests of Einstein's Theory of General Relativity.

"We knew that the first direct image of a black hole would be groundbreaking," said Kazuhiro Hada of the National Astronomical Observatory of Japan, a co-author of a new study being published in *The Astrophysical Journal Letters* to describe the large set of data. "But to get the most out of this remarkable image, we need to know everything we can about the black hole's behavior at that time by observing over the entire electromagnetic spectrum."

The immense gravitational pull of a supermassive black hole can power

jets of particles that travel at almost the speed of light across vast distances. M87's jets produce light spanning the entire electromagnetic spectrum, from radio waves to visible light to gamma rays. The intensity of light across this spectrum gives a different pattern for each black hole. Identifying this pattern gives crucial insight into a black hole's properties (for example, its spin and energy output), but this is a challenge because the pattern changes with time.

Scientists compensated for this variability by coordinating observations with many of the world's most powerful telescopes on the ground and in space, collecting light from across the spectrum. This is the largest simultaneous observing campaign ever undertaken on a supermassive black hole with jets.

The NASA telescopes involved in this observing campaign included the Chandra X-ray Observatory, Hubble Space Telescope, Neil Gehrels Swift Observatory, the Nuclear Spectroscopic Telescope Array (NuSTAR), and the Fermi Gamma-ray Space Telescope.

Beginning with the EHT's now-iconic image of M87, a new video takes viewers on a journey through the data from each telescope. The video shows data across many factors of ten in scale, both of wavelengths of light and physical size. The sequence begins with the EHT image of the black hole in M87 released in April 2019 (the data was obtained in April 2017). It then moves through images from other

radio telescope arrays from around the globe, moving outward in the field of view during each step. (The scale for the width of squares is given in light-years in the bottom right hand corner). Next, the view changes to telescopes that detect visible light (Hubble and Swift), ultraviolet light (Swift), and X-rays (Chandra and NuSTAR). The screen splits to show how these images, which cover the same amount of the sky at the same time, compare to one another. The sequence finishes by showing what gamma ray telescopes on the ground, and Fermi in space, detect from this black hole and its jet.

Each telescope delivers different information about the behavior and impact of the 6.5-billion-solar-mass black hole at the center of M87, which is located about 55 million light-years from Earth.

"There are multiple groups revving up to see if their models are a match for these rich observations, and we're excited to see the whole community use this public data set to help us better understand the deep links between black holes and their jets," said co-author Daryl Haggard of McGill University in Montreal, Canada.

The data were collected by a team of 760 scientists and engineers from nearly 200 institutions in 32 countries or regions, using observatories funded by agencies and institutions around the globe. The observations were concentrated from the end of March to the middle of April 2017.

“This incredible set of observations includes many of the world’s best telescopes,” said co-author Juan Carlos Algaba of the University of Malaya in Kuala Lumpur, Malaysia. “This is a wonderful example of astronomers around the world working together in the pursuit of science.”

The first results show that the intensity of electromagnetic radiation produced by material around M87’s supermassive black hole was the lowest that had ever been seen. This produced ideal conditions for studying the black hole, from regions close to the event horizon out to tens of thousands of light-years.

The combination of data from these telescopes and current (and future) EHT observations will allow scientists to conduct important lines of investigation into some of astrophysics’ most significant and challenging fields of study. For example, scientists plan to use these data to improve tests of Einstein’s Theory of General Relativity. Currently, the main hurdles for these tests are uncertainties about the material rotating around the black hole and being blasted away in jets, in particular the properties that determine the emitted light.

A related question that is addressed by today’s study concerns the origin of energetic particles called “cosmic rays,” which continually bombard Earth from outer space. Their energies can be a million times higher than what can be produced in the most powerful accelerator on Earth, the Large Hadron Collider. The huge jets

launched from black holes, like the ones shown in today’s images, are thought to be the most likely source of the highest-energy cosmic rays, but there are many questions about the details, including the precise locations where the particles get accelerated. Because cosmic rays produce light via their collisions, the highest-energy gamma rays can pinpoint this location, and the new study indicates that these gamma rays are likely not produced near the event horizon – at least not in 2017. A key to settling this debate will be comparison to the observations from 2018 and the new data being collected this week.

“Understanding the particle acceleration is really central to our understanding of both the EHT image as well as the jets, in all their ‘colors,’” said co-author Sera Markoff, from the University of Amsterdam. “These jets manage to transport energy released by the black hole out to scales larger than the host galaxy, like a huge power cord. Our results will help us calculate the amount of power carried, and the effect the black hole’s jets have on its environment.”

The release of this new treasure trove of data coincides with the EHT’s 2021 observing run, which leverages a worldwide array of radio dishes, the first since 2018. Last year’s campaign was canceled because of the COVID-19 pandemic, and the previous year was suspended because of unforeseen technical problems. This very week, EHT astronomers are targeting the supermassive black hole in M87 again, the one in our galaxy (called Sagittarius A*), together with

several more distant black holes for six nights. Compared to 2017 the array has been improved by adding three more radio telescopes: the Greenland Telescope, the Kitt Peak 12-meter Telescope in Arizona, and the NOthern Extended Millimeter Array (NOEMA) in France.

“With the release of these data, combined with the resumption of observing and an improved EHT, we know many exciting new results are on the horizon,” said co-author Mislav Baloković of Yale University.

The Astrophysical Journal Letter describing these results is available here:

<https://iopscience.iop.org/article/10.3847/2041-8213/abef71>.

For more information about NuSTAR, visit:

https://www.nasa.gov/mission_pages/nustar/main/index.html

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CCAS Information

Founded in 1979, the Central Coast Astronomical Society (CCAS) is an association of people who share a common interest in astronomy and related sciences.

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CCAS Officer Brian P. Cox took this image of M81 (Bode's Galaxy, center), M82 (The Cigar Galaxy, left), and NGC 3077 (top right). These three objects are interacting galaxies in the constellation of Ursa Major (The Big Dipper)