NASA's BITSE solar scope is ready for balloon flight over New Mexico

August 26 2019, by Lina Tran

Team member Nelson Reginald examines the BITSE instrument in the lab where it was built, at NASA's Goddard Space Flight Center in Greenbelt, Maryland. BITSE is a coronagraph, a kind of telescope that blocks the Sun's bright face in order to reveal its dimmer atmosphere. Credit: NASA's Goddard Space Flight Center/Joy Ng

NASA and the Korea Astronomy and Space Science Institute, or KASI, are getting ready to test a new way to see the Sun, high over the New Mexico desert.

A balloon—large enough to hug a football field—is scheduled to take flight no earlier than Aug. 26, 2019, carrying beneath it a solar scope called BITSE. BITSE is a coronagraph, a kind of telescope that blocks the Sun's bright face in order to reveal its dimmer atmosphere, called the corona. Short for Balloon-borne Investigation of Temperature and Speed of Electrons in the corona, BITSE seeks to explain how the Sun spits out the solar wind.

The solar wind is the stream of charged particles that constantly blows from the Sun's outer atmosphere, washing over the entire solar system. While scientists generally know where it forms, exactly how it does so remains a mystery. But unlocking the nature of the solar wind is key to predicting how solar eruptions travel. The solar wind is a bit like a water slide: Its flow determines how a solar storm barrels through space. Sometimes, the storms crash into Earth's magnetic field, sparking disturbances that can interfere with satellites and everyday communications systems like radio or GPS.

A collaboration between NASA and KASI, BITSE demonstrates a new way to study the solar wind. While standard coronagraphs capture the corona's density, BITSE also measures the temperature and speed of electrons in the solar wind to help understand the powerful forces that accelerate them to speeds of 1 million miles per hour. BITSE's balloon flight is a key step in the testing and development of this instrument, and will help the team of scientists and engineers fine-tune their technology for future spaceflight.

"This is a coronagraph capable of measuring these three properties, all of which you need to understand how the solar wind is formed and accelerated," said Nat Gopalswamy, BITSE principal investigator at NASA's Goddard Space Flight Center in Greenbelt, Maryland. By improving coronagraphs, BITSE furthers our understanding of the corona itself, the driving force behind the solar stuff that fills the space around Earth—ultimately improving our ability to forecast weather in space.

Flying to the edge of the atmosphere

Before launch, in the wee hours of morning, technicians from NASA's Columbia Scientific Balloon Facility's field site in Fort Sumner, New Mexico, will ready the balloon for flight, partially filling the large plastic envelope with helium. The balloon is made of polyethylene—the same material grocery bags are made of—and is about as thick as a plastic sandwich bag, but much stronger. As the balloon rises higher above the surface and atmosphere pressure drops, the gas in the balloon expands and it swells.

BITSE will meander upwards until it is some 22 miles above the ground. There, it will coast, taking pictures of the Sun's seething hot atmosphere. By the end of the day, it will have collected as much as 64 gigabytes—40 feature-length movies' worth—of data.

BITSE's journey to the sky began with an eclipse. Coronagraphs work by mimicking eclipses; like the Moon, a metal disk—called an occulter—blocks the Sun, bringing the corona into the spotlight. During the Aug. 21, 2017, total solar eclipse, Gopalswamy and his team tested key parts of the instrument in Madras, Oregon. In just two minutes of totality, they took 50 images—and demonstrated the challenges and advantages of utilizing their instrument's particular technique.

Now, the team is no longer limited to hurried research in the Moon's shadow. A balloon will take their instrument to the edge of the atmosphere, where it will fly for at least six hours. Balloons offer a low-cost way to access this region, allowing scientists to make measurements and perform tests they can't from the ground. There, BITSE can collect its images with much less background light than from the ground, which interferes with observations of the dim corona.

A new type of coronagraph

BITSE combines several important technologies. First, the instrument is constructed with a single occulting stage. Then, there's a special camera that captures polarized light—light waves that bob in certain directions. Scientists use these photos to map out electron density, or how many electrons are in the corona and where.

Typical coronagraphs use a wheel that cycles through polarizer filters—each oriented to different angles—and combine the images to get the polarized light. BITSE's polarization camera analyzes the observations pixel by pixel, making the process more reliable by reducing the number of moving parts.

"We glued the entire sheet of micro-polarizers on top of the camera detector, so we don't need the polarization wheel," said Qian Gong, BITSE lead optics engineer at Goddard.

BITSE also has a filter wheel, which blocks out all the corona's light except for four specific wavelengths. The ratios of these different wavelengths provide scientists with the temperature and speed of electrons in the corona—measurements they can't obtain from the ground, even during an eclipse. By focusing on a previously unstudied slice of the corona that is key to solar wind formation, the scientists hope to gather new clues to its origins. One day, a version of BITSE could make these measurements from space, extending their observation time from hours to months.

More than 22 miles above the surface, BITSE will drift high above the realm of birds, airplanes, weather, and the blue sky itself. The altitude presents unique challenges, Gong said. Certain design elements are specific to balloon flight, like BITSE's temperature-sensitive optics. An onboard thermal system will ensure BITSE doesn't get too cold during its ascent. Even the glue they used on the polarization filters was carefully selected both to provide good adhesive and withstand the expected temperatures. A shift of just a few microns—an average human hair is 75 microns across—in response to the chilly upper atmosphere could impact their data, she explained, since each pixel is 7.5 microns wide.

At such high altitudes, the sky is dimmer; where the atmosphere is thin, there are few air particles to scatter light. Compared to the ground, these are much better conditions for a coronagraph. Still, the edge of the atmosphere is brighter than space.

"The sky brightness fundamentally limits what we can see, and drives our need to go to the next step: observations from space," Goddard solar scientist Jeff Newmark said. Together, Gopalswamy and Newmark are leading the team sending BITSE to the sky, one step closer to space, where there's no interfering background light.

A true collaborative mission, BITSE features extensive contributions from both NASA and KASI. NASA provided the main optical, mechanical, pointing, communications, and gondola assemblies, as well as overall management and launch of the mission, while KASI provided the filter wheel, instrument computer and camera system, among other contributions.

Lofty goals

At the end of BITSE's flight, technicians at the Fort Sumner field site will send termination commands, kicking off a sequence that separates the instrument and balloon, deploys the instrument's parachute, and punctures the balloon. An airplane circling overhead will keep watch over the balloon's final moments, and relay BITSE's location. Hours later, far from where it started, the coronagraph will parachute to the ground. A crew will drive into the desert to recover both the balloon and BITSE at the end of the day.

Data from BITSE's flight will be useful for the models that scientists use to predict space weather. But the team will be looking to the flight to validate BITSE's design and performance in a near-space environment. From their field campaign observing the Aug. 2017 solar eclipse to this year's balloon flight and eventually, spaceflight, the team has continued to set their sights ever higher.

Provided by NASA's Goddard Space Flight Center

Citation: NASA's BITSE solar scope is ready for balloon flight over New Mexico (2019, August 26) retrieved 23 April 2024 from https://phys.org/news/2019-08-nasa-bitse-solar-scope-ready.html