

# FUSE Space Telescope Reaches the End; Astronomers Say Farewell

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The intrepid never-say-die space telescope known as FUSE has finally reached its mission's end and will be turned off after more than eight years of discoveries on everything from planets and nearby stars to galaxies and quasars billions of light-years away.

The satellite's control room on the Johns Hopkins Homewood campus will go dark on Oct. 18, leaving the satellite itself — its pointing system so often pulled from the brink of inoperability by enterprising engineers and scientists in that control room — to continue circling the Earth. Eventually, decades from now, its orbit will decay and the satellite will burn up in the atmosphere.

"It has been a great run. Who would have believed that a mission

designed for three years would have gone on producing great science for eight," said Warren Moos, Gerhard H. Dieke Professor of Physics and Astronomy at Johns Hopkins and FUSE principal investigator. "What a testament to the ingenuity and hard work of the FUSE team."

FUSE, short for Far Ultraviolet Spectroscopic Explorer, was a Johns Hopkins-managed NASA mission that complemented the Hubble Space Telescope with observations at short ultraviolet light wavelengths below the range in which Hubble operates. Its original, three-year science mission was extended by NASA three times.

Astronomers from around the world have published more than 1,200 papers based on data from the satellite, which was launched atop a Delta-II rocket in June 1999 from Cape Canaveral. FUSE produced not pictures of distant objects but spectrographs, which are digital "charts" that break down the light emitted by those objects. By analyzing FUSE data, astronomers were able to measure temperatures, densities and chemical compositions of objects near and far, helping to place them in context in the history of the universe.

Groundbreaking science done during FUSE's eight years include a rare glimpse into molecular hydrogen in Mars' atmosphere, confirmation of a hot gas halo surrounding the Milky Way galaxy and a first-ever observation of molecular nitrogen outside our solar system, among others.

George Sonneborn, FUSE project scientist at NASA Goddard Space Flight Center in Greenbelt, Md., said, "JHU has done a fantastic job delivering a top-quality science mission for NASA."

FUSE is the largest astrophysics mission that NASA has ever handed off to a university to develop and then operate. The 18-foot-tall, 3,000-pound satellite has been run by a group of about 25 scientists,

engineers and support staff from a basement-level control room in the Bloomberg Center for Physics and Astronomy.

Though FUSE's mission has been astoundingly successful from a scientific point of view, it faced a number of "death-defying" adventures dating back to late 2001. That's when, during a two-week period, two of the four "momentum wheels" that helped researchers aim the satellite at its targets stopped working. At least three wheels were needed to point FUSE with the precision needed for accurate astronomical observations.

Left with no other choices, the operations team conceived of and created a modified control system that used other devices onboard the satellite—electromagnets called magnetic torquer bars—to stabilize the satellite's pointing by periodically pushing or pulling the satellite against Earth's magnetic field. In just eight weeks, FUSE was back in business.

"It was a tenuous control at first, but it was certainly better than nothing," recounted Bill Blair, a research professor in the Henry A. Rowland Department of Physics and Astronomy and FUSE's chief of operations. "But with time, tweaks and experience, we got back into a very respectable science operations mode."

The satellite remained stable until Dec. 27, 2004, when yet another momentum wheel stopped operating, leaving the satellite with just one.

"True to form, we figured out how to use the magnetic trick to work with the single remaining wheel. But it was a lot harder than it sounds," Blair said.

It took most of 2005 to coax the satellite back into an effective operational mode, but from November 2005 into the spring of this year, FUSE was again gathering data. On May 8, however, the last momentum wheel malfunctioned. Researchers and engineers believe that some

source of excess friction slowed the wheel. After studying the problem, the operations team was able to restart the wheel and put the telescope back into service.

"From June 12 to July 12, the wheel performed again almost flawlessly," Blair said. "But then the 'wheels came off,' so to speak. The wheel operated perfectly right up to the end, and then it just stopped dead, probably indicating a catastrophic failure of some kind."

After a month of creative troubleshooting, the FUSE team had to face the sad fact that the satellite's science mission was, at last, at its end.

"The magnetic system just doesn't have enough muscle by itself to point and hold the satellite for astronomical observations," Blair said. "We contacted NASA and told them the science mission was over."

Now the team has less than a year to close out the mission, including reprocessing and archiving some 131 million seconds of science data, writing final reports and providing final documentation of the mission. FUSE's scientific data will remain available to astronomers for years, however, through a data archive at the Space Telescope Science Institute, which is located on the Homewood campus.

One part of the closeout process is concluding on-orbit operations and turning off the satellite. Until now, FUSE has continued to take end-of-mission calibration data and perform engineering tests of various kinds. But Oct. 18, FUSE gets "put to sleep" for good. After 30 years or so, its orbit will decay and FUSE will burn up in the atmosphere.

"After that Thursday, FUSE will be just another piece of space junk, orbiting the earth every 100 minutes or so. It is a sad and ignominious end to such an outstandingly successful mission," Blair said. "But a tremendous scientific legacy is left behind. I commend the team of

scientists and engineers who have worked so hard over the years to wring every last bit of science we could out of this amazing satellite."

Source: Johns Hopkins University

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