Astronomy

Death in the ultraviolet

After years of physical decline and several attempts to cut its funding, the venerable International Ultraviolet Explorer (IUE) spacecraft has finally fallen under the budget ax. On Sept. 30, the European Space Agency and NASA shut down all operations of the 18-year-old craft. Launched in 1978 and expected to last just 3 years, the IUE endured, taking ultraviolet spectra of more than 100,000 celestial targets, from comets to quasars.

Although it made ultraviolet observations until the very end, the aging craft had suffered a series of mishaps in recent years. A gyroscope failure last March left it with just one working gyro out of the original six, and engineers had to scramble to keep the craft from rotating haphazardly. Unwanted light scattering into the IUE's fine-error sensor, a device that keeps targets in the field of view by tracking nearby guide stars, had made it more difficult to conduct observations. Solar panels, which power the craft, had degraded, and the damage wrought by 18 years of exposure to ultraviolet radiation in space had steadily heated the IUE's spectrograph, posing problems for electronic devices.

"We've been hanging by our fingernails at times," says Andrew G. Michalitsianos, former deputy project scientist at NASA's Goddard Space Flight Center in Greenbelt, Md. Even if funding hadn't been cut, "I think from a technical point of view, IUE would not have lasted beyond a year."

Veteran ultraviolet astronomer Jeffrey Linsky of the University of Colorado at Boulder acknowledges such handicaps. Nonetheless, he says, "the craft produces very useful data despite the fact that it's 18 years old.

"The science per dollar coming out of IUE is very high. If it suffered a death from natural causes—fine. But I would call this murder. NASA should have continued the mission," he adds.

Astronomers mourn IUE's passing on several counts. The craft was placed in a geosynchronous orbit so it would always reside above the same spot on Earth. This enabled ground controllers to monitor IUE continuously and to point it at short notice toward newly discovered celestial phenomena. In addition, the altitude of its orbit, which varied between 42,000 and 26,000 kilometers above Earth, gave the craft a nearly unobstructed view of the heavens and allowed it to examine an object for hours at a time.

In contrast, the Hubble Space Telescope has a low orbit. Earth looms large and blocks observations for about half of each 90-minute pass completed by the telescope. Hubble's primary mirror has four times the diameter of the mirror on IUE, and the telescope's two ultraviolet spectrographs have higher sensitivity and spectral resolution than the single IUE spectrograph. Yet IUE's ability to conduct long-term observations made it better for extended studies, such as tracking comets and monitoring the periodic flare-ups of variable and binary stars, Michalitsianos says.

Among its triumphs, IUE played a key role in monitoring the stellar explosion supernova 1987A, was the first spacecraft to detect molecular sulfur in a comet, and just last March examined the bright comet Hyakutake. "Many ultraviolet astronomers cut their teeth" on the IUE, notes project scientist Yoji Kondo of Goddard.

Astronomers are now compiling an archive of IUE spectra, which should be available late next year. Meanwhile, for the next few centuries at least, IUE will remain mute in its current orbit.


NASA

Artist's rendition of the International Ultraviolet Explorer.

Hubble measures deuterium on Jupiter

According to the Big Bang theory of cosmology, only the three lightest elements—hydrogen (along with its much rarer isotope, deuterium), helium, and lithium—were forged in the first few seconds after the birth of the cosmos.

Deuterium plays a special role because the amount generated in the Big Bang traces a key quantity in cosmology—the density of ordinary matter, such as protons and neutrons, present when the universe began.

Because stars burn deuterium into helium, the abundance of this isotope dwindles over time. To measure the original allotment, astronomers must use their telescopes like time machines, peering back to the era when the universe was only about 1 billion years old. Determining exactly how much deuterium has been depleted since then is also useful: It indicates the rate at which stars lived and died in different parts of the cosmos.

Several teams of astronomers have measured the abundance of deuterium early in the universe, but their numbers don't agree (SN: 5/18/96, p. 309). In contrast, a newly reported determination of deuterium abundance on Jupiter matches the value measured by a probe that parachuted into the planet late last year.

Lotfi Ben Jaffel and Alfred Vidal-Madjar of the Institute of Astrophysics of Paris and their colleagues used the Hubble Space Telescope's Goddard high-resolution spectrograph to measure the ratio of deuterium to hydrogen in Jupiter's atmosphere. Although hydrogen atoms far outnumber deuterium, Jaffel and his collaborators succeeded in detecting the faint deuterium emission by directing the spectrograph to look along the limb of the planet. From this vantage, the instrument looks through a greater depth of atmosphere, maximizing the number of deuterium atoms it sees.

Last month, at a conference on the spectrograph held at NASA's Goddard Space Flight Center in Greenbelt, Md., the group reported that Jupiter has about 6 deuterium atoms for every 10,000 hydrogen atoms. This number agrees with the value measured by a device, carried on the Galileo spacecraft, that plunged into Jupiter on Dec. 7.

Jupiter and the rest of the solar system became isolated from the surrounding interstellar gas and dust about 4.5 billion years ago, when the sun was born. Although stars have continued to burn deuterium since then, no such depletion should have occurred on Jupiter. In addition, Jupiter's gravity prevents hydrogen and deuterium from escaping. For these reasons, the planet's current abundance should represent the amount the planet had at the birth of the solar system.

"This is a good example of what I like to call cosmic archaeology," says Tobias C. Owen of the University of Hawaii in Honolulu. "The deuterium-to-hydrogen ratio is like an ancient artifact that we have unearthed by investigating a tomb—Jupiter—that has been undisturbed for 4.5 billion years."

Although Jupiter's deuterium abundance now seems secure, measurements of the isotope elsewhere in the universe remain inconclusive. In the Milky Way, astronomers have measured deuterium abundance only in nearby stars, those within about 160 light-years of Earth, notes George Sonneborn of NASA's Goddard Space Flight Center in Greenbelt.

Most spectrographs now in operation record only near- and mid-ultraviolet light, and they can't detect the weak deuterium emission from distant stars. A spectrograph now scheduled for launch in late 1998 can scan the sky in the far ultraviolet, where deuterium emission is stronger. The instrument, known as FUSE (Far Ultraviolet Spectroscopic Explorer), should enable astronomers to measure deuterium in some of the oldest and most distant reaches of the galaxy, Sonneborn says.