Astronomy

Ron Cowen reports early results from last month's shuttle-borne Astro Observatory mission

More on black holes

With all four of Astro's telescopes sometimes trained on the same star or galaxy, scientists had a unique opportunity to conduct collaborative research on the heavens. For example, both the Hopkins Ultraviolet Telescope and the Broad Band X-ray Telescope recorded spectra from the cores of several quasars and Seyfert galaxies. Tracing the intensity of X-ray and ultraviolet light and comparing the resulting curve to theoretical predictions may provide the best indication yet of whether a black hole powers the enormous energy output at the centers of these objects (SN: 12/15/90, p.372).

Simultaneous measurements from the Wisconsin Ultraviolet Photo-Polarimeter Experiment (WUPPE) indicated the shape of material that produces some of these intense emissions as well as the density of its immediate surroundings. Preliminary analysis of ultraviolet observations of the Seyfert galaxy NGC 1068, believed to harbor a black hole, shows that a significant amount of the light is polarized (waves aligned in one direction). The finding, says Christopher M. Anderson of the University of Wisconsin-Madison, agrees with a widely accepted model in which a disk of captured matter spews out a stream of intense energy as its mass disappears into the gravitational clutches of a black hole. A surrounding cloud of charged particles generated by the black hole polarizes the light. No net polarization could be detected if the mass fell in uniformly from all directions, rather than from an encircling disk, Anderson says.

Probing a dusty theory of star formation

WUPPE's observations of stars in the Milky Way helped to verify a theory about stellar dust and star formation proposed 25 years ago by Theodore P. Stecher, an astronomer at NASA's Goddard Space Flight Center in Greenbelt, Md., and principal investigator for Astro's Ultraviolet Imaging Telescope.

Using ultraviolet radiation from the supergiant star Alpha Camelopardalis like a flashlight from afar, WUPPE researchers found that certain wavelengths of ultraviolet light that pass through interstellar dust have little or no polarization — a strong indication that the dust absorbs light rather than scatters the radiation, says Arthur D. Code of the University of Wisconsin-Madison. Absorption leaves light unpolarized, while scattering creates polarization, he notes.

The finding, he adds, indicates that some interstellar dust may act as a vital cooling agent, absorbing ultraviolet energy released when massive gas and dust clouds collapse — a process believed to give birth to stars. If the interstellar dust could not absorb enough heat, the increase in temperature would halt the collapse before new stars formed, says Code, leader of the WUPPE team.

The WUPPE observations support Stecher's 1965 suggestion that interstellar dust contains graphite — a compound that absorbs ultraviolet light and could act as a cosmic coolant. Stecher had sought to explain the results of his sounding rocket experiments, which demonstrated that ultraviolet light below a certain wavelength became extinct as it traveled through the interstellar medium. Laboratory experiments showed that graphite in the interstellar dust could explain the missing ultraviolet wavelengths. But some researchers argued that the interstellar medium reflects ultraviolet light and could not contain much of the carbon compound.

WUPPE's results — some of the first data on polarization in the ultraviolet — provide evidence that the interstellar medium contains a significant amount of graphite, Stecher says.

Measuring dark matter

By analyzing the X-ray spectra of a halo of hot gas gravitationally bound by the elliptical galaxy NGC 1399, astronomers using the Broad Band X-ray Telescope inferred the galaxy's amount of dark matter — mass hidden from view because it does not radiate at any observed wavelength. The preliminary finding marks the first use of X-ray spectral data to estimate the amount of dark matter in an elliptical galaxy, says Goddard astronomer Richard F. Mushotzky.

Goddard researchers measured the width of characteristic spectral lines detected by the X-ray telescope and radioed to Earth. Those measurements enabled them to determine the temperature, and thus the average speed, of the gas particles surrounding NGC 1399.

The researchers then calculated the amount of mass the galaxy must contain in order to hold the speedy particles in orbit. They found that NGC 1399 should have six times as much mass as its light-emitting portions appear to hold. The missing mass, they assert, must be dark matter.

The early findings, notes Mushotzky, suggest that elliptical galaxies contain more than six times as much dark matter as visible mass — a ratio, he says, that agrees with previous estimates by other researchers of the amount of dark matter in spiral galaxies.

Measuring the footprints of violence

Astronomer Randy A. Kimble had to wait eight years, but he finally completed his gaseous quest — an elusive measurement of the helium between a hot white dwarf star and Earth, which may reveal the frequency and strength of supernova explosions and other violent outbursts in our corner of the universe.

Using a sounding rocket, Kimble had attempted in 1982 to measure the interstellar helium associated with the white dwarf G191B2B, but the experiment failed. His 25 minutes of observations in 1990, using the Hopkins Ultraviolet Telescope, exceeded by a factor of five the amount of observing time available on a sounding rocket, notes Kimble, of Johns Hopkins University in Baltimore.

The telescope data indicate the density of neutral helium between Earth and the star, notes Arthur F. Davidsen, chief researcher on the Hopkins telescope. But by relying on previous estimates of the *total* (both neutral and ionized) helium and hydrogen left over from the Big Bang, astronomers can now infer the amount of ionized helium in the local interstellar medium created by more recent violent events. Calculating the abundance of ionized helium may reveal the intensity and frequency of these energetic events.

A stream of galactic cosmic rays, leftover heat from supernova explosions, and intense radiation emitted by unseen neutron stars could all contribute to the ionization of helium in the nearby regions of the Milky Way, Davidsen says.

An outburst of stellar knowledge

Alerted by ground-based astronomers who viewed the outburst in visible light, researchers trained the Hopkins Ultraviolet Telescope on the binary star Z-Camelopardalis just as one of the star's two components — a red giant — erupted, hurling mass from its interior. The other member of this gravitational duo, a small white dwarf, sucks surface mass from the red giant in a manner resembling the theoretical model of matter falling into a black hole, says Hopkins astronomer Knox S. Long.

Because this system and similar binaries, known as cataclysmic variables, occur in our own galaxy, scientists have a better chance of deciphering how similar but larger-scale gravitational processes may occur in distant quasars and Seyfert galaxies, he adds. Long notes that a broadening of the normally sharp ultraviolet spectral lines offers clues to the nature of the violent outburst at Z-Cam.