Resolving X-ray astronomy with HEAO-2

The satellite is named for Albert Einstein. It is the second in a series of High Energy Astronomical Observatories, whose province is particularly the investigation of the sky in the X-ray and gamma-ray parts of the electromagnetic spectrum. It is coming on strong on the heels (or should one say the solar panels) of its predecessor, HEAO-1, discovering more and more new things in a branch of astronomy that Einstein in his lifetime probably never suspected existed.

Already the reports give a hint of controversy. As reported elsewhere in this issue (see p. 234) HEAO-1 discovered a bright diffuse background flux that dominates the X-ray sky. This flux has been generally attributed to a very hot gas that pervades the whole universe. HEAO-2 has been finding a large number of new quasars, and that has prompted a suggestion from astronomers at the Harvard-Smithsonian Center for Astrophysics that quasars may be contributing more to the diffuse X-ray background than had previously been counted on, and that may require some revision about how much gas, if any, is there.

This could turn out to be a serious controversy. It may also be just a flurry in a scintillation counter. A lot of back and forth is to be expected at this stage in such a wide open inquiry. Einstein sat and watched while de Sitter, Friedmann and LeMaitre argued over what general relativity meant for the shape and dynamics of the universe. 1920 was too early to tell. It was not until the 1930s that Einstein himself, after a trip up Mt. Wilson to talk to Edwin Hubble, gave up his old fashioned belief in a static universe. Even now it is probably too early to tell what general relativity means for the shape of the universe.

In X-ray astronomy NASA would hope for a quicker consensus, if only because budgets are made in two-year increments. Meanwhile, what the Einstein Observatory carries that others did not is an imaging telescope for X-rays. The pictures it makes by translating the X-ray image optoelectronically into something visible allow even people who don't come from the planet Krypton an opportunity to see what an X-ray source looks like. The instrument is the result of 20 years of development after a suggestion by Riccardo Giacconi of the Harvard-Smithsonian Center, who is principal investigator for HEAO-2 with overall scientific responsibility for the program. Other principal scientists are George Clark of MIT, Robert Novick of Columbia University, Stephen Holt of the Goddard Space Flight Center and Harvey Tananbaum of the Harvard-Smithsonian. Leon Van Speybroeck of the Harvard-Smithsonian designed the telescope optics.

The telescope has been seeing distant quasars, and among them some that have never been identified as such. When it identifies what its handlers think is a quasar, its handlers communicate the location of the object to the Anglo-Australian Observatory at Siding Spring, Australia. The 4-meter visible-light telescope at that observatory is used to investigate the spectrum of the object. The standard way of determining that a quasar is a quasar is by its spectrum in visible light.

Another early contribution is a possible new home for black holes in the globular clusters of stars. These are numerous gangs of very old stars that hang like globules in the space above and below the plane of our galaxy (and presumably other galaxies). They contain some of the oldest stars in the universe.

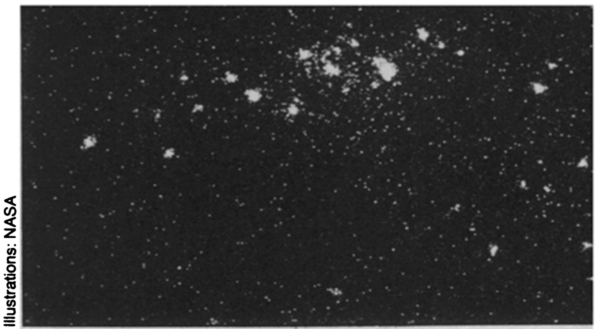
A number of globular clusters have been recorded as sources of X-rays, and there has been the customary attempt to figure out just what the mechanism of emission might be. In one such cluster HEAO-2's telescope pinpointed the X-ray source as being quite in the center of the bunch of stars. This would mean that it was associated with whatever was holding the cluster together. That has to be a mass about thirty times the sun's. That much mass implies a black hole. The observers are looking to see whether other globular clusters show similar circumstances.

Working astronomers are likely to be especially interested in the HEAO-2 telescope's ability to resolve X-ray sources within other galaxies. Previous astronomical X-ray detectors could tell that a given galaxy was a source of X-rays but they could not tell what parts of it were emitting how much. The HEAO-2 telescope can see sharply enough to do this, and a survey that it did of the galaxy M31, which is a spiral rather similar to our own Milky Way, indicates the presence of dozens of individual X-ray sources in the central bulge of the galaxy and others strung along the spiral arms. The sources in the central bulge appear to be oddly skewed with reference to the galaxy's axis of rotation. More observation of this and other galaxies is necessary to see what this curious behavior means in the continuing discussion of the physics of galactic centers.

Another important point for the astrophysicist is the discovery of several new spectral emission lines in studies of hot plasma (ionized gas) in various parts of the sky. The Einstein observatory did not make the first determinations of X-ray emission lines. Lines from silicon and iron have been identified previously. HEAO-2's studies of half a dozen supernova remnants have revealed lines from magnesium, sulfur, argon and calcium, in addition to iron. Theory holds that such heavy elements are made in the late stages of stellar evolution or in the supernova explosion itself, so the HEAO-2 observers argue that this is freshly synthesized material they are seeing. The abundances come out similar to those of those elements in the solar system, so the observers argue that this could support the notion that the solar system was formed out of debris from a supernova explosion.

X-ray emission lines of fluorescence lines from X-ray excitation of cool material have also been observed from several classes of objects ranging from the gas clouds that pervade clusters of galaxies to hot stars and binary systems containing white dwarfs or neutron stars. The ability to observe X-ray spectral lines from such a variety of objects could have an important effect on astrophysical theory making and could be the beginning of an X-ray cosmochemistry to go with the radio cosmochemistry that has been rolling along the last ten years.

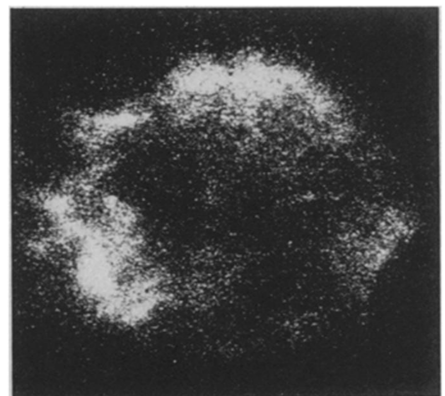
Of course these are only the earliest results from the X-ray telescope. Astronomers will eagerly await more while debating the significance of these. X-ray astronomers are somewhat breathless people. They come on much faster than contemplators of the shape of space and time such as Einstein or Friedmann. □



Illustrations: NASA

String of X-ray sources in core of M31.

X-ray of hot, young stars, Eta Carinae.



Gassy halo of supernova remnant, Cas A.