nova remnants, such as Cassiopeia A, the Crab Nebula, Tycho's supernova, and others can be compared with the radio and optical pictures to obtain better information about the dynamics of the expanding gas and the mixing of heavy elements into the interstellar medium. Steven Holt, one of the HEAO-2 investigators at Goddard, and his colleagues, using the cooled silicon spectrometer on the satellite, have seen emission lines from many heavy elements in addition to those of iron and silicon that had been seen before.

A large number of supernova remnants seen in the Magellanic Clouds will provide a very useful "laboratory" for testing models of stellar and galactic evolution. Because they are at a known distance from the Earth their absolute luminosities and other data can be computed. David Helfand of Columbia, another of the investigators, told us that these remnants are anomalously bright, perhaps because the interstellar medium in the Magellanic clouds contains less material of heavy elements than our own galaxy. One puzzling phenomenon is an intense gamma-ray burst on 5 March (reported in an IAU telegram, number 3356) from a known supernova remnant in the Magellanic cloud. The burst put out a vast amount of energy in an extremely short time—at power levels up to 10^{37} watt, in the range of quasar emissions—however, x-ray observations made soon after the burst show no change from before, Novick told us.

There are also x-ray emissions from globular clusters and from stars of nearly every spectral class, from young stars not yet on the main sequence that had previously only been seen in the infrared, to main-sequence and old stars. Some of these sources are surprisingly bright. Leon Van Speybroeck (of the Harvard–Smithsonian Center for Astrophysics), who designed the telescope optics, has been able to resolve a number of x-ray sources in the Andromeda galaxy, which will, again, provide an interesting comparison with objects found in our own. Previously x rays had been expected only from stars with well-developed coronas; the observation of x rays from stars not expected to have coronas will challenge theorists to come up with models of stellar evolution that produce coronas or other mechanisms for generating x rays in more types of stars, Helfand said.

The observation of x rays from globular clusters produced further evidence that Jonathan Grindlay, a young astrophysicist at Harvard, has a charmed life for seeing x-ray bursts. In November, 1975, Grindlay was the first to find an x-ray burst (PHYSICS TODAY, April 1976, page 17), and he was at the telescope in Cerro Tololo when an optical burst occurred that correlated with an x-ray burst. Grindlay has suggested that some x-ray burst sources may be associated with collapsed remnants or centers of globular clusters (PHYSICS TODAY, January 1979, page 17). While he was on duty at the receiving station at the Goddard Space Flight Center, the Einstein satellite observed an x-ray burst from a globular cluster.

Extragalactic sources. Earlier x-ray observations with rockets and satellites such as Uhuru and HEAO-1 suggested that there is a diffuse background of x rays of cosmological origin. Some astrophysicists have interpreted these results to mean that there is a hot intergalactic gas, which could support the hope that there is enough mass in the universe to close it under gravitation. The earlier results were far from conclusive, and the observed radiation could as well have been due to many faint and unresolved point sources. The deep-sky survey by HEAO-2 appears to strongly favor the latter interpretation. Looking at regions of the sky with no known sources and outside the galactic plane, the telescope found large numbers of faint point-like sources, many of them quasars. Harvey Tananbaum of Harvard–Smithsonian, who is one of the investigators in the project, told us that the current data indicate that at least a third of the "background" actually comes from discrete sources and that the minimum figure is probably more like two-thirds. At this point, he said, one could almost ask if there is any appreciable diffuse background at all.

The deep-sky survey has also identified a number of quasars, a few of them previously unknown. The observatory has seen known quasars with red shifts up to about 3.1, among the largest known. Tananbaum said that the sensitivity of the detectors is sufficiently great that one should be able to see quasars with red shifts up to about 4, if there are any. The x-ray emission from quasars has a continuous spectrum, however, so that measurement of red shifts must await identification of optical counterparts to the x-ray sources.

The telescope also looked at emissions from clusters of galaxies. The analysis of these observations is a long-term project, but some interesting trends are already beginning to emerge. In addition to a diffuse emission, some clusters have concentrated sources, mostly associated with a few larger galaxies; other clusters exhibit a concentrated x-ray core, often associated with a large elliptical galaxy. Tananbaum said that it appears as if the former are clusters in the process of formation while the latter are more developed clusters in which much of the intergalactic gas has concentrated around a heavy central galaxy.

With the Einstein satellite, Giacconi said, x-ray astronomy has joined the mainstream. The sources being investigated are no longer those that are "special" or "intrinsic" x-ray sources, but the general objects of astronomy and cosmology, from stars to clusters of galaxies. One perhaps surprising aspect of this latest jump in resolution and sensitivity is that no inexplicable class of new cosmological objects has appeared, Lamb said; each previous new class of instruments seems to have found, very quickly, a new class of objects. But, he added, the observatory is still young and many of its data are still unanalyzed. It is unlikely that the Universe has come to the bottom of its bag of tricks for this—or any other—field. —TVF□

Oak Ridge Heavy Ions

The column structure shown in the photograph was tested during the week of 7 May, prior to installation of the acceleration tubes in the 25-MV Pelletron tandem accelerator. On 10 May, physicists from the National Electrostatics Corp produced a maximum potential of 32 MV, suggesting that the basic column structure will operate well at its design potential of 25 MV. Oak Ridge spokesmen believe this 32 MV is a record for a laboratory-produced potential difference.

The heavy-ion facility consists of the Oak Ridge Isochronous Cyclotron and the Pelletron; the combination will allow acceleration of heavy ions with masses as high as 150 with sufficient energy to overcome the Coulomb barrier. The facility is scheduled to be completed in the latter part of this year and to be ready for users early next year.

in brief

Brookhaven National Laboratory has awarded a $39-million contract to Ammann & Whitney Safeguard Construction Management Corp for managing the construction of tunnels, experimental halls and support buildings for Isabelle. □