nerve-conduction time remains at about 4 milliseconds until the animal is 5 centimeters long (the increase in diameter of the nerve axon compensates for the increased length of the nerve). However, the time required for the signal to reach the abdomen increases steeply for larger animals, reaching more than 16 milliseconds for a 20-centimeter lobster. As the animals age, the weight and length of the abdomen decrease relative to their total size, making the abdomen less able to propel the animal away from danger, the investigators report in the Aug. 12 SCIENCE.

The growing ferocity of the claws makes up for a less effective flight mechanism in old lobsters. Claw weight and length increase with age relative to the lobster's total dimensions. Furthermore, each claw specializes to act as either a crusher or cutter.

The behavioral changes are appropriate to these physical differences. Juveniles, 3 to 5 millimeters long, respond to a wooden rod with a tail flip 98 percent of the time. Adults, 17 to 25 centimeters long, tail flip only 18 percent of the time. The adult lobsters usually respond aggressively with raised, open claws.

Recent experiments, Lang says, indicate the change in defense strategy is gradual and reaches a minimum of about 10 percent tail-flip responses when the lobster is 90 centimeters long. The fraction of escape responses may still decrease, but more slowly, after that length.

The explanation for the switch is not that older animals are unable to flip their tails. When an adult loses its claws, it reverts to the tail flip as an escape mechanism. "Thus while the neural circuit for the reflex is intact and functional, it is simply not an efficacious response for a large, clawed animal," the researchers say.

Now the researchers are trying to determine the mechanism for the strategy change. Lang hypothesizes that nerve signals from the claws inhibit the tail-flip response. As the claws grow, they probably develop more sensory receptors and thus transmit more signals. Experiments in which sensory nerves are cut should shed light on this conjecture.

Crayfish, which have smaller claws than lobsters, have a somewhat different behavioral strategy. Like young lobsters, they are easily alarmed and use the tail-flip escape often. The nerve axons that carry signals to the muscle responsible for the tail flip take up a greater portion of the nerve cord than in lobsters, suggesting the greater importance of the tail flip.

The researchers propose that since different structures in animal bodies grow at different rates, growth rates can provide insight into behavioral strategies. "These results demonstrate that physical factors place constraints on particular behaviors," Lang and colleagues conclude. □

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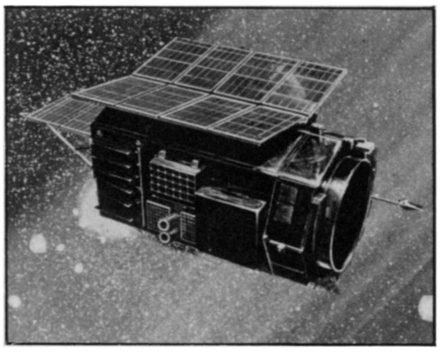
# HEAO: One up and two to go


NASA

*HEAO-A will see with an unclouded eye.*

Anyone ever caught in dense fog will readily recall the profound revelations accompanying its dissipation: one suddenly sees the previously invisible detail and obtains a clearer impression of the terrain. To date, astronomers have largely labored within analogously obscured conditions. Earth's atmosphere—although it allows free passage to much of the electromagnetic spectrum—insidiously absorbs X-rays and gamma rays, and thereby renders astronomers blind to a great deal of incoming celestial information.

A promise of "clearer skies" rode with the successful launch last week of the first of three High Energy Astronomy Observatories—HEAO-A. Orbiting 240 miles above the ground and well-removed from the atmosphere's murky umbrella, the 3-ton satellite successfully began using its keen electronic eyes in a search for high-energy phenomena. If all continued to go as scheduled, it became fully operational on Aug. 18.

Many common astronomical bodies like stars radiate much of their energy as visible light. Studying this with conventional optical telescopes for several hundred years, astronomers have deduced an impressive corpus of knowledge.

There are, however, exotic objects like X-ray busters, quasars and black holes, which emit tell-tale information about themselves via high-frequency radiation. Up until now, astronomers have garnered only a few peeks at the unobscured cosmos, using small sounding rockets, balloons and the Uhuru satellite, launched in 1972. Uhuru particularly distinguished itself by sighting some 339 X-ray-emitting objects, including a possible black hole in Cygnus X-1.

Uhuru's capabilities, however, pale by comparison with those of HEAO-A, which houses four separate experiments and will ultimately detect several times as many sources as did Uhuru.

The first experiment is designed to search the entire sky for any objects that discharge low-energy (150 electron-volts) to high-energy (20,000 eV) X-rays (wavelengths, 10 to 0.1 angstroms). The Large-Area X-ray Survey experiment is so sensitive, it will even detect an object that is only five ten-thousandth as intense as the Crab nebula.

The faceted, cylindrical satellite will be kept "looking" roughly along directions perpendicular to the earth-sun line. About this axis, it will rotate once every 30 minutes, enabling the experiment to scan the entire sky in just six months. (HEAO-A, however, is designed to live for a year.) The detector has a total viewing surface, arranged in seven proportional-counter modules of about 14,000 square centimeters—several times greater than Uhuru's.

A second experiment will survey the heavens for objects—both pointlike and diffuse—that emit anything from 10,000-eV X-rays to 10-MeV gamma rays (wavelengths, 0.1 to 0.0001 angstroms). The instrument is an array of scintillation counters—devices that produce detectable light whenever penetrated by a high-energy particle or electromagnetic radiation. With these, it will be possible to measure whether the incredible uniformity of the universal background radiation persists at gamma-ray energies. Also, the detector's electronic reflexes can respond to fluctuations in an object's emission that occur as frequently as once every 50 microseconds.

A third experiment will record the gross structure of the sky's X-radiation from 200 to 60,000 eV (wavelength, 10 to 0.01 angstroms). The experiment's proportional counters will define the celestial "topography" in X-rays, much as a terrestrial map indicates relief with isometric contours. And, importantly, the Cosmic X-ray experiment will also decipher what portions of this background radiation are actually due to the cumulative emissions of discrete sources—as opposed to those due to ubiquitous gas and dust.

The fourth experiment will provide accurate location measurements of X-ray sources whose radiation is between 1,000 and 15,000 eV (wavelength, 1.0 to 0.1 angstroms). It will not only determine positions of selected objects to within five arc-seconds, it will measure their angular sizes to within twice that accuracy—about one five-hundredth the apparent size of the moon. The experiment, as well as the entire satellite, orients itself using two star cameras that recognize key landmarks: well-known stars, visible to the naked eye.

The subsequent satellites, HEAO-B and HEAO-C, are scheduled to be launched in 1978 and 1979 respectively. The HEAO-B will carry a focusing X-ray telescope that will scrutinize the most interesting objects seen by its predecessor. The HEAO-C will do experiments involving virgin cosmic rays—that is, before they're altered as a result of charging through earth's atmosphere—and more extensive gamma-ray observations. □