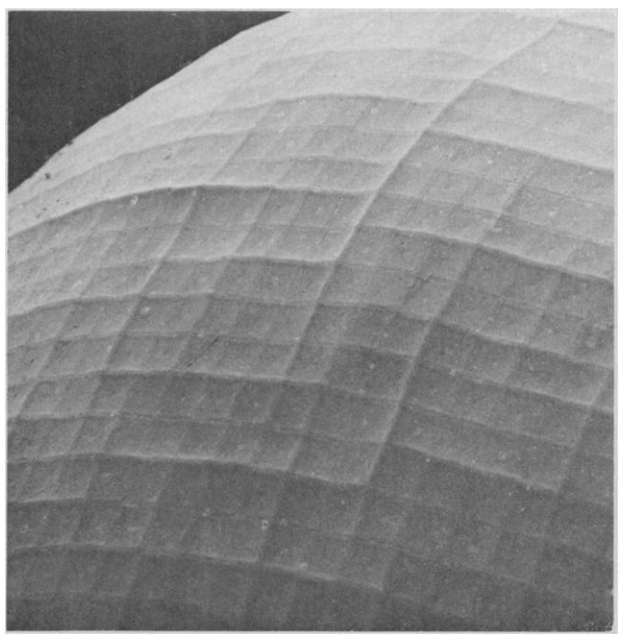
Lobster-Eye X-ray Telescope Envisioned

Lobsters do not have x-ray vision. Yet the design of their eyes could serve as a prototype for a new type of x-ray telescope—only the third design ever proposed. A lobster-eye telescope could have an extremely large field of view—the lobster eye, for instance, has a field of view greater than 180°—with moderately good spatial resolution. Furthermore, higher energy x-rays could be imaged than can be collected by current x-ray telescopes, such as the one on board the Einstein Observatory (the second High Energy Astronomy Observatory; *Science*, 6 July 1979).

Flying home from England last Christmas, Roger Angel of the Steward Observatory in Tucson was inspired by an article about animal vision* he read in *Scientific American*. The surface of a lobster eye, the article explains, is a hemisphere covered with radially oriented, square tubes. Light



"The lobster is the most unrectangular animal I've ever seen. But under the microscope [and in the micrograph reprinted here from Scientific American*] a lobster's eye looks like perfect graph paper," says Angel. [Source: David Scharf, Los Angeles]*

entering a tube may bounce from one or more of its reflecting sides and be focused onto a smaller hemispherical layer of photoreceptors inside the eye—the lobster's equivalent of a retina. Says Angel, "It struck me that the same principle could be applied to an x-ray reflector. I had my article† half written by the time we landed in Chicago."

Angel envisions a telescope "lens" made of part of a spherical surface covered by tiny square tubes with reflecting interiors. Each tube on a 2-meter section of sphere might be 0.1 to 1.0 millimeter on a side. This configuration would solve the problem faced by designers of x-ray telescopes—focusing the x-rays. The trouble with x-rays is that they are not refracted by passing through a material, and they will reflect from a mirrorlike surface only when they strike it at a grazing angle.

With the lobster-eye design, numerous tiny tubes are aimed nearly at each x-ray source. X-rays from the source entering those tubes will hit the reflecting walls at grazing angles and be focused onto one point on the detector—a section of sphere with half the radius of the lens. The surface of this sphere would be covered with x-ray-sensitive modules, perhaps similar in design to one of the x-ray detectors on Einstein.

A telescope of the new design would be ideal for mapping the entire x-ray sky, says Angel, because the field of view could be extremely large—180° if a hemispherical surface is covered with the tiny tubes. At the same time, it could monitor fluctuations in the x-ray output of the sources. This ability would complement the skills of Einstein.

However, Paul Gorenstein, a member of the Einstein telescope design team at the Harvard-Smithsonian Center for Astrophysics, says that a whole-sky survey is not the prime need of x-ray astronomy today. Gorenstein's view is that "the mainstream of x-ray astronomy is to make the best possible studies of individual objects." Thus, the limited funds earmarked for x-ray astronomy probably will be spent on a precisely pointed telescope with high resolution.

Angel has calculated that the best resolution possible with a lobster-eye telescope would be on a par with the highest resolution possible for Einstein. He finds that a telescope the size of the Space Telescope (a 2- to 3-meter telescope designed to be carried aloft by the Space Shuttle), with x-ray collecting tubes covering only a fraction of a spherical surface, say 10°, should be able to monitor a 10° patch of sky with 2-arc-second resolution.

Furthermore, it would be extremely easy, once the technology is developed, to extend the sensitivity of the telescope to higher energies than can be observed by Einstein. With the lobster-eye design, doubling the maximum energy is merely a matter of doubling the length of the tiny square tubes, according to Angel. The advantage of this feature is unclear now, as Gorenstein and Angel concur that doubling the maximum energy could be achieved, at considerable expense, even with current designs.

"I consider the lobster-eye telescope a very clever instrument," says Gorenstein. "But the technology for building it is not available at the present." Angel agrees, but says that since he wrote his article, he has become aware that the technology may not be as far off as he thought initially. "The square tubes of some microchannel plates [devices for intensifying beams of electrons] go a long way toward doing the job." Furthermore, once the technology for building one internally reflecting tube has been perfected, building enough of them for a telescope could be achieved by mass production. Gorenstein concludes that "once the technology is available, Roger Angel's way may, in fact, be the best way of building x-ray telescopes."—BEVERLY KARPLUS HARTLINE

*Michael F. Land, "Animal eyes with mirror optics," *Sci. Am.* **239**, 126 (December 1978).
†J. R. P. Angel, *Astrophys. J.* **233**, 364 (1979).

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