FIRST GAMMA-RAY SKY CATALOG

Thirteen sources, astronomers hope, is not an unlucky number to begin with

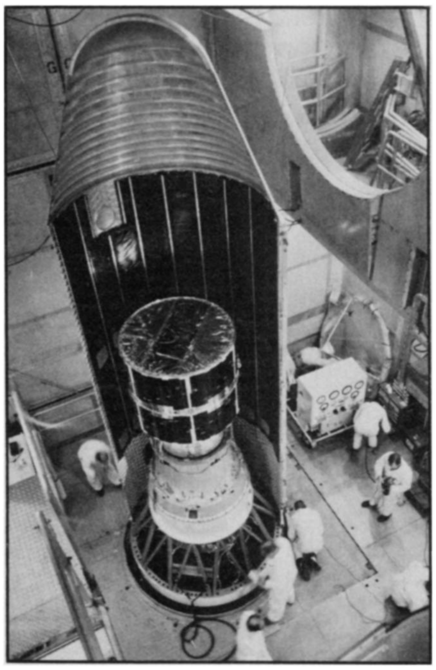
BY DIETRICK E. THOMSEN

Point sources of radiation are the staple study of astronomy. In fact, point sources of light, mostly stars, were the only things astronomers studied for millenia. So now, as astronomers extend their observing capability to one after another of the nonvisible parts of the electromagnetic spectrum, they reflexively look for point sources. So far they have always found them. Sometimes the point sources of nonvisible radiation coincide with familiar stars; sometimes they do not. Finding out just what the point sources are becomes one of the major observational questions.

The question is particularly interesting in the case of the latest spectral range to be invaded, that of high-energy gamma rays. Brightness in this part of the spectrum seems to bear something like an inverse ratio to brightness in light. "The brightest gamma ray source in the sky, the Vela pulsar, is also the weakest known visible source," says Kenneth Bennett of the European Space Agency.

Bennett came to the meeting of the American Astronomical Society in Atlanta to present the first catalog of high-energy gamma ray point sources, the Cos B catalog, named for the satellite that generated it. When Cos B was launched, almost two years ago (SN: 8/16/75, p. 102), two point sources of gamma rays above 100 million electron-volts energy (frequencies greater than 10^{21} hertz, wavelengths about a tenth of a milliangstrom or less) were known, the Crab pulsar and the Vela pulsar. Cos B, which was launched for ESA by NASA, has discovered 11 new ones. The 13 make up the catalog, each member of which is fitted with a number that begins with the letters CG and states the galactic longitude and latitude of its location. Thus, the Vela pulsar, located at galactic longitude 263.7° and galactic latitude −2.6°, becomes CG 263−2. (Galactic coordinates use the plane of the galaxy, essentially the line of the Milky Way, for their equator; the north and south poles are each 90° away. Galactic longitude zero is the direction of the galactic center in the constellation Sagittarius.)

Thirteen sources are not many compared to the millions of visible stars, but then photons of this high energy are rarities compared to the uncountable billions of photons of starlight that arrive every second. The arrival rate of 100-MeV photons is given by Bennett as 10^{-6} per square centimeter of detector per second, or putting it another way, one such photon arrives at a square centimeter of detector every million seconds (277.78 hours or 11.6 days). "I can show you our 100,000th gamma ray," says Bennett, exhibiting a slide of one of the latest pieces of the satellite's data.



NASA

Gamma-ray detector for Cos B satellite.

To collect these few and long-awaited bits of information, Cos B, which is a one-experiment satellite, carries a detector consisting of a 16-grid spark chamber, a Cerenkov counter and an energy calorimeter. The Cerenkov element gives the detector a directionality that many detectors for high-energy gamma rays lack. The Vela pulsar is such a strong source, and its position is so well known that it can be used to calibrate the resolving power of the detector. In the best case the detector can resolve the direction of a source to about a quarter of a degree. The detector has a sensitive area 50 centimeters square.

In 22 months of scanning, Cos B has looked mostly around the galactic plane. Some areas have been on the detector's axis for as long as 100 days. The Vela region was of course of special interest, and the constellation Virgo, the location of an important cluster of galaxies, was studied for possible extragalactic sources. All of the 13 now in the catalog are believed to belong to our galaxy. Ten of these have been recorded only by Cos B; the two pulsars were known before and one of the new sources has also been seen by the SAS-2 satellite. To find faint sources the data must be analyzed by hand. There is a good deal left in the bank to be analyzed, and the satellite keeps taking more, so the future is likely to see additions to the catalog. The scientists operating the experiment are an international collaboration that goes under the name Caravan and includes people from the Universities of Leyden, Milan and Palermo, the Max Planck Institute at Garching, West Germany, the Center for Nuclear Research at Saclay, France, and ESA's Space Science Department at Noordwijk in the Netherlands.

Of the 11 new sources in the catalog none is more than 7° from the galactic equator. None comes within a fraction of the Vela pulsar's intensity. The brightest of them is no more than a third of that pulsar's brightness and the weakest about a fifteenth of it. None of the 11 has so far been identified with an optical or radio source, nor has a comparison of their locations with those of X-ray sources found by the X-ray astronomy satellite Uhuru yielded any correspondences. Although one class of things one ought to be able to see in gamma rays is the spiral arms of the galaxy (because cosmic rays, which are abundant in the arms, should generate gamma rays when they strike interstellar matter), three sources in the southern hemisphere that have been called arms look like points to Cos B.

The spectra of the point sources are also unusual. The radiation can't come from thermal sources as the largest part of a star's radiation does, because then the observed brightnesses in gamma rays would imply even greater brightnesses in visible light, and the reverse seems to be true. The Caravan group hopes that optical and radio astronomers will look at the locations in the Cos B catalog to see if they can find anything. Bennett says the group would especially like to arrange correlated observations with the High Energy Astronomy Observatory satellite that is scheduled to be launched soon. If some of the gamma-ray sources can be identified by correlated observations with HEAO or ground-based observers, it may be possible to figure out what manner of object they are. "Please help us find out what they are," Bennett asked the astronomers. "Unless we have some idea of their time variability or spectra, we cannot find out with our instrument." □