Galactic Center: A Matter of Antimatter

The center of our galaxy, like the centers of galaxies generally, is a place where highly energetic and somewhat mysterious processes take place. The center of our galaxy happens to be a bit more mysterious to us than many galactic centers, because it is obscured from our view by clouds of dust. Nevertheless, radio and infrared observations indicate well enough that our galactic center is the location of high-energy activities.

Now there is an observation in a new part of the spectrum. At the recent meeting in Washington of the American Physical Society, Marvin Leventhal of Bell Laboratories at Murray Hill, N.J., and C.J. MacCallum and P.D. Stang of Sandia Laboratories in Albuquerque reported observations of the gamma-ray spectrum of the galactic center. The most striking discovery from this spectrum is that antimatter, specifically anti-electrons or positrons, is present at the center. The discoverers say that the finding could be taken as evidence for the proposition that there is bulk antimatter in the universe, but that it is more likely further evidence for highly energetic processes by ordinary matter.

The laboratory discovery of antimatter began in the 1930s. Before then and concurrently, theoretical physicists were working out principles that state that for every particle there is an antiparticle, not only in the definitional sense that to every kind of particle there is a corresponding kind of antiparticle (antiproton for proton, antineutron for neutron, etc.), but also in the bulk sense: The amount of matter present should equal the amount of antimatter.

This principle causes a problem for cosmology. In laboratory experiments with subatomic particles the balance between matter and antimatter seems always to be respected, but in the ordinary world we inhabit there is an overwhelming preponderance of ordinary matter. Our section of the universe seems to be naturally all ordinary matter. The only antimatter we see appears to be made by energetic processes that start with ordinary matter. This macroscopic imbalance has led some cosmologists to propose that somewhere in the universe is bulk antimatter (antistars, antiplanets, etc.) to correspond to the matter we see in our neighborhood.

Rather than being evidence of the long-sought bulk antimatter, Leventhal, MacCallum and Stang suggest that the galactic center positrons are likely to be the result of processes of a nature already familiar — and possibly one not so familiar. The three more familiar mechanisms include the collision of high-energy cosmic ray particles with cold interstellar matter, the decay of radioactive debris produced in nova or supernova explosions and positrons generated in pulsars. The more unusual possible source is the evaporation of primordial black holes. This rests on a recent theoretical suggestion that the big bang that started the universe produced tiny black holes that are capable of "evaporating," that is, gradually disappearing while emitting streams of particles and antiparticles, of which positrons should be one variety.

Positrons make their presence known when they meet electrons. The annihilation of matter and antimatter that results from the meeting produces a pair of gamma rays of very precise energy, 511 kilo-electron-volts. It is the appearance of a sharp spike at this point in the galactic center's gamma-ray spectrum (with an uncertainty of plus or minus 1 kilo-electron-volt) that leads to the conclusion that positrons are there — and quite a lot of them: The observed intensity requires about 7.2×10^{42} annihilations per second.

The observations were made on a balloon flight from Alice Springs, Australia, on November 11 and 12, 1977, which observed the galactic center for 17.5 hours with a gamma-ray telescope that had an energy resolution of about 3 kilo-electron-volts (capable of determining energies to within 3 kilo-electron-volts). Earlier evidence for galactic center positrons had been deduced from work of R.C. Haymes of Rice University and collaborators, who used a telescope of much poorer energy resolution (70 kilo-electron-volts). This gave evidence of two possible lines within 70 kilo-electron-volts of 511. Leventhal and co-workers write that "the present work taken in conjunctio with this earlier work unambiguously establishes the existence of the 511 kilovolt positron annihilation line from the galactic center direction." □

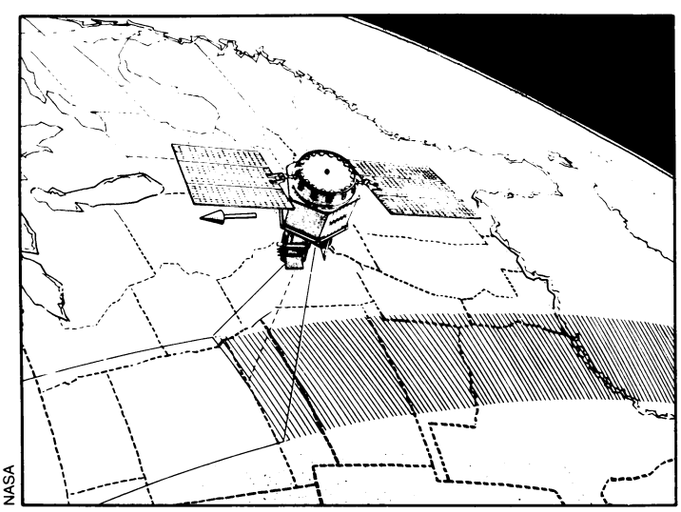
Satellite to take earth's temperature

A satellite that will serve as essentially an orbiting thermometer was launched on April 26 to measure temperatures on the earth below. But though the simple, relatively low-cost probe carries only a single instrument — an infrared radiometer — it will be used to study phenomena ranging from dust in Switzerland to eddies in the Tasman Sea, from crop freeze-damage in Texas to geologic faults in Italy.

The Heat Capacity Mapping Mission satellite, or HCMM (program officials call it "hickum"), will scan the earth in two wavebands: a visible and near-infrared channel from 0.5 to 1.1 microns and an infrared channel from 10.5 to 12.5 microns. Its orbit has been calculated so that it will cross over the same point on the earth's surface twice a day, in the early afternoon when the sun's heat is greatest and a few hours after midnight when the surface has radiated most of the heat away. The speed with which the surface cools varies greatly with different materials, and can be used to distinguish different types of land, water, vegetation and other characteristics.

There is thus a lot more to be learned from the HCMM measurements than the temperature alone. A dozen U.S. experiments and as many more in other countries are scheduled for the mission, some of them so diverse that it is remarkable that all are working from essentially the same measurements:

- Urban heat islands: The concentrations of structures, machines and even



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