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." □

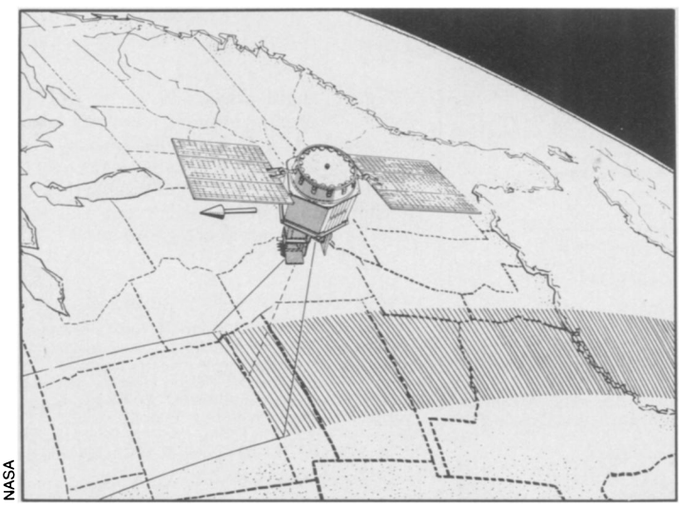
Satellite to take earth's temperature

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



NASA

HCMM satellite: Taking earth's temperature.

just rooftops and pavement in metropolitan areas can have significant effects on local weather, and some researchers wonder whether there may also be longer-lasting regional climatic changes. Target cities for the HCMM include seven in the United States (Los Angeles, St. Louis, Houston, Washington, Buffalo, Rochester and Syracuse) as well as others in Switzerland, France, Germany, Austria and Italy.

- Crops and other vegetation: Healthy plants take in water more efficiently than some diseased or otherwise water-starved ones, causing them to "run cooler." Studies of soil moisture, transpiration rates, general "plant stress" and thermal "signature" differences are being conducted with the HCMM in the United States, Italy, Sardinia, Australia, Canada, Spain and other countries.
- Water: These are perhaps the most wide-ranging of the HCMM projects, including water quality in the Great Lakes, a search for fresh-water springs in West Germany, measurements of ocean upwelling along the French coast, and a study in South Dakota to see if it is possible to identify areas whose groundwater supplies are particularly susceptible to contamination.
- Geology: Besides identifying soil and rock types from orbit, HCMM researchers will seek geologic faults, magma concentrations, signs of subsurface morphologies and other results, including studies in the United States, England, Morocco and elsewhere. Geothermal energy deposits will be sought in several countries.
- Snow: A special category, since its IR signature is different from that of liquid water, but it represents potential irrigation or flooding. One study will attempt to characterize the signature of snow seen through forest cover, including the effects of different kinds of trees.

The HCMM is the first of a series of Applications Explorer Missions using certain shared components to build small, low-cost satellites for specific types of measurements. The next in line will be SAGE, to be launched early next year for aerosol and gas studies in the stratosphere. SAGE and HCMM use roughly the same "base module" — attitude control, data-handling, communications and power systems. The HCMM module cost about $6.9 million (of a total $9.3 million for the satellite), says AEM program manager Dick S. Diller, while SAGE's similar module, ordered at the same time, cost only about $2.3 million. After SAGE is scheduled MAGSAT, for late 1979, to map gravitational and geomagnetic variations, possibly followed by ERBS, designed to measure earth's balance between incoming sunlight and reflected heat.

If ERBS is not built in the the AEM series, it may instead become a part of the larger Modular Multimission Spacecraft series, designed with interchangeable components that can be individually replaced in orbit via the space shuttle. □

Mental health report cites chronically ill

"He didn't give us very much time," Rosalynn Carter said as she cast a sidelong glance at the President. "He didn't give us very much money. But he did give us the opportunity to develop a plan and strategy for the direction of mental health services for the next decade." With that, Mrs. Carter —honorary chairperson of the President's Commission on Mental Health — presented her husband with the final form of one year's and $800,000 worth of work.

On accepting the document, Carter indicated with rather wry optimism that it promised to have a somewhat greater impact — at least in the near future — than that of his proposed energy plan. Some observers have said that if U.S. World War II strategists had been as adept as Carter's administration is in energy, the President related, "the people in Plains [Ga.] would now be speaking Japanese."

Carter did pledge to push most of the commission's 117 recommendations with Congress "next year." "I think [the report] will have a profound beneficial effect on our country in years to come," he said.

Rather than propose massive, across-the-board funding increases, the report calls for a steamlining of mental health delivery systems with a heavy emphasis on services for "the underserved": the poor, minorities, women, the elderly and, perhaps most significantly, the chronically ill. "We're calling for a new national priority to meet the needs of the chronically mentally ill," says Commission Chairman Thomas E. Bryant. "These people go from park bench to park bench... and boarding house to boarding house."

The report calls for $50 million a year in federal funds for five years to continue the phase-down of large state hospitals, to upgrade care in smaller hospitals and to develop "community based services." The latter aspect would replace the community mental health center (CMHC) concept, started under President Kennedy, with more flexible community centers. For lack of manpower, money or other factors, many areas of the United States have been unable to meet the stringent qualifications of a CMHC, and consequently have no or little outpatient treatment available, say the commissioners.

The report also advocates inclusion of mental health care in any plan for national health insurance. "Medicaid and Medicare ... frankly discriminate against mental illness right now," says Bryant. It also calls for substantial increases in research on the causes and treatment of mental illness, mental retardation, drug abuse and alcoholism.

New National Institute of Mental Health statistics indicate that close to 15 percent of Americans — rather than the previously believed 10 percent — are in need of mental health services at any one time. Overall, the report asks for $500 million in federal monies over the next three years, $600 million over the next five years. "It will not be a costly program," said the President. "In fact, it can save enormous amounts of public funds." □

NAS decries human rights violations

Following a trip to Argentina and Uruguay in mid March, a National Academy of Sciences delegation reported last week on what it feels are clear indications of human rights violations in both countries. The trip was sponsored by the Academy's committee on human rights and resulted from invitations by ambassadors of both countries following inquiries about scientists who were allegedly abducted or imprisoned without trial.

Certain "positive signs" during the trip foster hope "that Uruguay intends to move toward greater individual freedom and respect for human rights," the delegates said. Among those signs were: substantial official cooperation in discussing the problem of imprisoned scientists, opportunity to talk with imprisoned mathematician José Luis Massera, and an interview with the chief judge of the military tribunal prosecuting Massera's case. The judge said that "the plea and presence of the NAS could be viewed in a positive manner" when the case is decided.

The NAS visitors found the Argentine situation worse. "The true tragedy of Argentina is the large number of persons who have 'disappeared' over the past two years," they said. Even during their visit a prominent hematologist was abducted from her home at 3 a.m. by armed men who said they were "from the police"; she was "missing" six days. The government denies involvement. It does not deny incarcerating thousands of scientists — many for years and without trial — for political associations or action.

Many scientists have threatened to boycott a cancer meeting in Buenos Aires this year to protest the human rights situation. The NAS committee feels that Argentine scientists would be better served, however, by the attendance of foreign colleagues who may, while attending, elect to "express their ... concerns."

Meanwhile, NAS is asking Uruguay to speed Massera's trial and permit him to emigrate, and Argentina to release physicist Elena Sevilla and psychiatrist Claudio Santiago Berman, both imprisoned without trial. Limited resources restrict NAS action to individuals whose situation is "grave and well documented." □