bursts would have about one percent of the sun's power, would take a tenth of a second and be mostly gamma rays. This is what the general relativists suggest that gamma-ray astronomers look for. How many there ought to be no one can say, but there might be enough for a pop a month.

Observable or not, as the black holes dissipate themselves, they leave behind certain problems for theory. In the center of each black hole is a singularity, and the evaporation or explosion of the black hole leaves the singularity naked and exposed. This is bad because theory is unequipped for singularities.

One can describe a singularity in several ways. It is a point where the mathematics becomes intractable or where the laws of physics fail. It is the place where spacetime disappears. Several physicists at the meeting were ready to refer to it as "the edge of the universe."

According to Hawking, the black-hole radiation process results in an extra degree of randomness or unpredictability in what is going on. In classical mechanics one can definitely predict both the position and velocity of an object. In ordinary quantum mechanics one can definitely predict one of those values at the expense of an uncertainty in knowing the other. In the physics around a naked singularity, one can predict neither. It is as if some of the necessary information has fallen off the edge of the universe, or alternately, that through the singularity a certain amount of random information has been introduced to our universe from elsewhere.

Information is not the only thing that falls off the edge. One of the longstanding rules of particle physics goes too, the rule of conservation of baryons. Particle physicists have always observed that in any kind of particle behavior the net number of baryons—particles belonging to the same class as the neutron and proton—is always conserved. But look what happens in a black hole. At black hole densities, what goes in is mostly neutrons. What comes out is a random distribution that includes antineutrons and other antibaryons. Since antibaryons count as minus, the net baryon number coming out is less than what went in, and it seems that somehow baryons have fallen off the edge of the universe. Of course as Bryce De Witt of the University of Texas points out, not all theorists agree with the edge-of-the-universe definition of a singularity. There is a belief that if a theory of general relativity completely compatible with quantum field theory is achieved—there is still a long and difficult road to go—it will show us how to deal with a singularity.

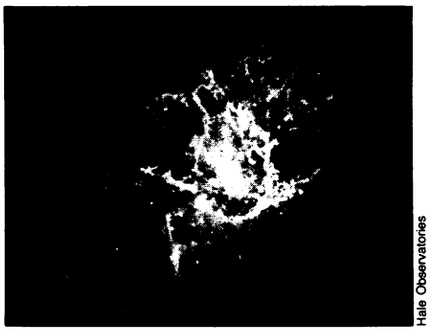
However that may be, if the gamma-ray astronomers should see what Hawking says they ought to see, we may have to conclude that out there in some direction or other are one or more putative edges of the universe, lurking nakedly, challenging us to deal with them. □

Gamma-ray laser in the sky

Physicists in terrestrial laboratories would love to be able to make X-ray or gamma-ray lasers. There is so much that could be done both in scientific experiments and practical procedures with coherent radiation in those parts of the spectrum. If a group at Bell Telephone Laboratories is correctly interpreting its data, the first gamma-ray laser may have been found—in the sky. It is everybody's favorite neutron star, the Crab nebula pulsar.

Martin Leventhal of Bell Labs told the Eighth Texas Symposium on Relativistic Astrophysics that gamma-ray spectra of the Crab turned up a line emission at 400 kilo-electron-volts energy. The line does not appear in the nebular background, so it must come from the pulsar.

Such a line is indicative of electron-positron annihilation on the surface of the neutron star. The strength of this line requires 10^{41} positrons per second to fall on the surface of the pulsar. Theory says that if as many as 10^{40} positrons per second fall on its surface, the Crab pulsar must have a surface coated with a kind of electron-positron fluid that forms real macroscopic drops. This fluid would produce induced annihilation radiation, or says Leventhal, "a gamma-ray laser in the sky—pretty fantastic." □



Hale Observatories

Crab nebula: Site of a natural laser.

A preview of the science budget for '78

Basic research is scheduled to receive a 3 percent increase in funds over and above an allowance for inflation in the federal budget to be submitted to Congress early in 1977. This word comes from presidential science adviser H. Guyford Stever, who offered a brief pre-Christmas preview of the science budget in a press briefing at the White House on Dec. 16. The briefing came after a meeting of Stever and 19 leaders in science and engineering with President Ford. The budget in question is for fiscal 1978, starting Oct. 1, 1977.

The final figures will, of course, have to be reviewed by incoming President Carter, but the press of time will limit the number of detailed changes that can be made. Also, it is to be remembered that all budget announcements are only proposals; Congress can, and usually does, reshape them considerably.

Detailed figures had not been finally determined, but Stever listed certain programs that do receive special emphasis in the proposed science budget.

- The National Aeronautics and Space Administration would receive money to begin development of the on-again, off-again orbiting space telescope, to be launched and tended by the space shuttle. NASA would also receive funds to begin work on a Jupiter Orbiter and Probe, scheduled for launch in 1981, and on LANDSAT D, the fourth in a series of earth resources satellites. No money will apparently be provided for a follow-up Viking Mars probe, which some scientists had hoped to launch in 1981. Also, no mention was made of a Lunar Polar Orbiter, which NASA has been pushing.
- The earthquake research program would receive roughly a doubling of its present $25 million budget. Stever said President Ford has personally taken a "growing interest in the earthquake problem" and that there will be "strong acceleration" of efforts to predict and mitigate the effects of earthquakes. The renewed interest will include an increase in the number of monitoring devices that measure uplift around faults, and more speculative precursors of earthquakes—such as excitement among animals—will also gain attention.
- A competitive grant program will be set up to encourage scientists from a wide range of disciplines to perform agriculture-related research. The program will be administered by the Agriculture Department in much the same manner as research projects funded by the National Science Foundation, rather than relying so heavily on scientists working for the department. Some $25 to $35 million will be available for the grants.
- Defense R&D is scheduled to increase 15 percent. Some new initiatives can be expected in the general health science area, but no particulars were yet available.

Stever said the Soviet Union had requested LANDSAT data to confirm its estimates of its bumper wheat crop this year, and the data did confirm that. NASA has been making wheat estimates under a project called LACIE (Large Area Crop Inventory Experiment). Stever said that National Academy of Sciences president Philip Handler announced at the budget meeting that the Academy will soon be releasing a report on how such satellite programs as LANDSAT can be used to help developing countries. □