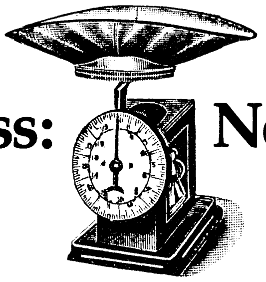
From Russia With Mass: Neutrinos



Neutrinos have always been a highly elusive part of physics. The existence of this variety of subatomic particle was postulated about the year 1930, but it was not demonstrated by experiment until 1956. In 1980 neutrinos are still elusive, but extremely interesting, to judge by the concentration exhibited by the 60-odd particle physicists, nuclear physicists and cosmologists who gathered for the Miniconference and Workshop on Neutrinos with Mass held at Cable, Wis., last week.

The first postulations of the properties of neutrinos gave them a rest mass of zero. That means that they do not exist at rest. If they ever should come to rest, they would vanish. They would exist only in motion, that is. Of all the particles known to physics only neutrinos and photons (the particles of light) were thought to have this zero-rest-mass peculiarity.

Now the question is whether neutrinos do in fact have rest mass after all. As the Miniconference showed, there is experimental evidence of a nature that cannot be easily talked away, which shows that neutrinos have rest mass. If the evidence holds up, basic ideas in particle physics, nuclear physics and cosmology will be affected.

The most direct piece of evidence for neutrino rest mass comes from experiments that study the form of radioactivity known as beta decay of nuclei. It was for the accommodation of this process that the existence of neutrinos was originally postulated. Momentum and energy seemed to be disappearing. The neutrino was invented, an almost undiscoverable particle with a zero rest mass that enabled it to carry off any amount of energy from almost zero on up. Now beta decay is being used to search for a neutrino rest mass, which, although very tiny and therefore undiscoverable with the accuracy limits of older beta-decay experiments, nevertheless may exist.

The experiment that offers the most definite measurement has been operating for several years in Russia at the Institute for Theoretical and Experimental Physics at Novosibirsk. It records the spectrum of electrons given off by the beta decay of tritium bound in molecules of the amino acid valine ($C_5H_{11}NO_2$). In the experiment, two of the hydrogen atoms in the valine are replaced by tritium atoms. (Tritium is the isotope hydrogen-3.) From time to time, a neutron in a tritium nucleus turns itself into a proton, emitting an electron (in olden days called a beta ray) and an antineutrino. The experimenters use detecting equipment to record the electrons' energy and momentum. With this information the researchers try to calculate a probable rest mass for the antineutrino.

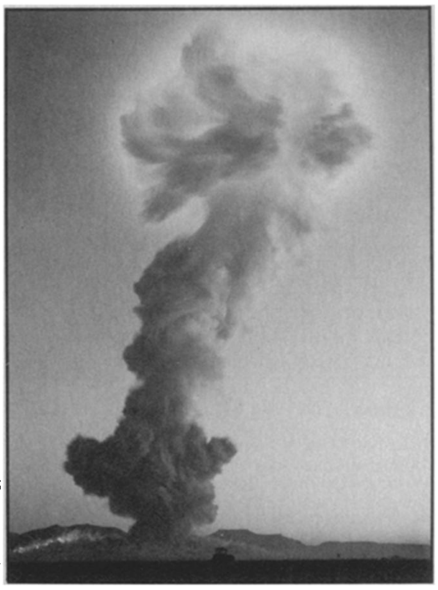
The general conclusion of the Novosibirsk experimenters, related to the Miniconference by Oleg Egorov, who represented them, is that "there is an indication that the electron antineutrino has a nonzero mass." (Whatever mass the antineutrino has, the corresponding neutrino will have.) Egorov gives the latest numbers. They are conditional on whether the energy-level structure of the helium-3 atom that is left in the valine molecule after the tritium atom decays affects the outcome of the antineutrino mass calculation. The antineutrino mass lies between 26 and 46 electron-volts if the energy-level structure of helium-3 affects the calculation or between 14 and 46 electron-volts if it does not.

Embedding the tritium in a silicon matrix is the method chosen for an experiment that has been running at the University of Guelph, Ontario, Canada. John Simpson of Guelph reported that the tritium is accelerated (in ionized form) in a Van de Graaff machine. It is then driven into a small block of silicon mounted in a notch in a piece of lithium. As Simpson puts it, "It buries itself inside this 10^{-6} ton detector." (A witticism at the expense of particle physicists, whose detectors usually go in the multiton range.) The tritium gets caught in the crystal matrix of the silicon, and the lithium is used to observe the electrons that come off in the beta decays. Simpson reports only very preliminary results for the moment, but he hopes to have completed the technical adjustments in about a year so as to be able to test with relatively high accuracy for a figure of 35 electron-volts. His study of the Russian experiment convinces him that that is really their best figure.

It would be good to be able to use gaseous atomic tritium. As Tom Bowles of Los Alamos Scientific Laboratory puts it, there are concerns about the Russian experiment: the effect of the molecule on the decay reaction and the possibility that the electrons were scattered before they left the solid source. "There are a lot of questions on the Russian experiment, but we haven't found anything definitely wrong," Bowles says. That inspired a group led by R. G. H. Robertson of Michigan State University to propose an experiment to the LASL administration that would use a beam of atomic tritium. The technology of this is very difficult, but Bowles mentions a device known as an ion trap, in which such a beam might be confined. It will take a year to get the kind of tritium beam they want, says Bowles, and probably two or three years for a statement of results.

It may take longer than that to come to some definite answer to the basic question. There are indirect ways of looking for neutrino mass, especially the search for evidence of so-called neutrino oscillations (SN: 5/10/80, p. 292; 6/14/80, p. 377). These plans and other things discussed at the symposium, especially some of the effects of the existence of neutrino mass, will be the subject of future articles. □

Smoky and leukemia: High rate confirmed



Dept. of Energy

Brush blazes beneath Smoky's rising cloud.

A nearly threefold increase over the expected incidence rate for leukemia has been confirmed among participants in military maneuvers involving the 1957 nuclear-weapons test known as Smoky (SN: 2/11/78, p. 92). "If not a chance occurrence, the apparent excess of leukemia among Smoky participants suggests that such persons may have received more radiation than previously supposed or that low doses of radiation may be more carcinogenic than past estimates predicted," according to Glyn Caldwell and colleagues at the Center for Disease Control in Atlanta, Ga. An account of their study appears in the Oct. 3 JOURNAL OF THE AMERICAN MEDICAL ASSOCIATION.

Military records show that throughout the 1950s, an estimated 250,000 troops witnessed at relatively close range one or more nuclear-weapons blasts and practiced maneuvers afterward in regions where residual contamination may have existed. (A smaller number of unidentified civilian researchers and support personnel also took part in these tests.) Smoky, a 44-kiloton bomb, was detonated Aug. 31, 1957, atop a 210-meter tower near the Smoky foothills of Nevada. The 3,224 persons included in the CDC study have all been confirmed by Defense Department or Energy Department documents as having participated in Smoky exercises.

Comparing the general age- and sex-specific U.S. incidence rates for the four types of observed leukemias (acute myelocytic, chronic myelocytic, hairy-cell and acute lymphocytic) with the ages of identified Smoky participants, the CDC team predicted that only three individuals should have developed the cancer. In fact, bone marrow examination confirmed leukemia in nine Smoky test participants (all but one of whom are now dead).

Hairy-cell leukemia may be related to chronic lymphocytic leukemia, a type not associated with radiation exposures. However, seven of the nine leukemia cases —those involving myelocytic types—"are clearly" of the type that can be caused by radiation, the CDC team claims. Even if the hairy-cell case is excluded, the increase of observed leukemia over the incidence expected in the Smoky group "remains statistically significant," the CDC researchers conclude. □

Light on the pineal gland

Both artificial and natural light are known to affect animals by suppressing secretion of the hormone melatonin from the pineal gland in the brain. Now it has been shown that light also affects the human pineal gland, via the retina of the eye. Alfred Lewy conducted experiments with six volunteers at the National Institute of Mental Health and proved that humans respond to light with melatonin suppression, just as animals do.

There is a catch, however. Perhaps humans have adapted to artificial light over the years, so it no longer affects them, Lewy told the 12th Congress of the Collegium Neuro-Psychopharmacologicum in Gothenburg, Sweden. So what humans need now, for melatonin suppression, is light of an intensity equaling that of indirect sunlight, rather than ordinary room light.

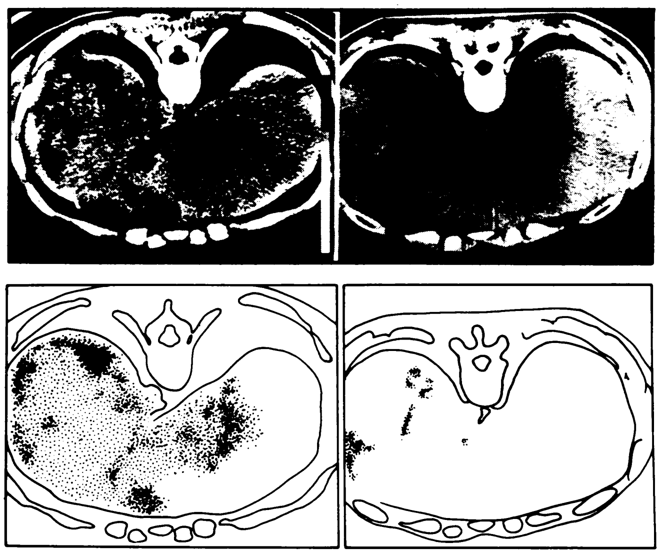
With his six normal volunteers, Lewy found that he needed to expose them to light of about 2,500 lux in intensity in order to completely halt melatonin output. That's about the same amount of light a person would experience sitting close to a window, looking out, on a sunny day. Lewy woke the volunteers at 2 a.m., and then kept them up for two hours, while exposing them to varying intensities of light. He found that with 500 lux, which is a bit brighter than ordinary room light, the melatonin secretion, which ordinarily goes on in the dark of night, did not change. As determined by blood samples during a two-hour period, however, he found that 2,500 lux suppressed melatonin completely, while 1,500 lux illumination cut it by 50 percent.

What does all this mean in humans? There are some interesting possibilities. One is that the pineal gland may affect human fertility as it does animal fertility. When bears hibernate in winter, for instance, their gonads actually shrink. And studies in Finland, the land of the midnight sun, suggest a similar light effect on human fertility, as demonstrated by a seasonal variation in births.

Another small bit of evidence is abnormality in melatonin secretion in some blind persons, along with anecdotal reports of excess infertility in the blind.

Melatonin secretion could also be related to mental illness. Preliminary data from four manic depressive patients indicate that they may be abnormally sensitive to light. An NIMH study showed that only 500 lux suppressed their melatonin secretion by 50 percent, although this amount of light had no effect at all in six normal volunteers. □

Treatment found for liver cancer



Johns Hopkins

CAT scans (top) show cancerous liver before treatment (left) and after immunoglobulin therapy. Black area is tumor. Schematic representations (below) show dramatic tumor reduction.

A treatment that significantly extends the life span of persons with inoperable liver cancer was announced earlier this week by researchers at the Johns Hopkins Medical Institutions in Baltimore, Md. The procedure, called immunoglobulin therapy, uses an antibody against a tumor-secreted protein to carry lethal radioactive iodine directly to the cancer cells. Survival rate has been stretched from three to four months following initial diagnosis and treatment to an average of 11½ months, according to Stanley Order, one of nine researchers who have been developing the treatment over the past 12 years.

Ferritin, a protein secreted by tumor cells as well as by normal cells, is injected into rabbits, and the antibodies against it are collected. The anti-ferritin is then linked to radioactive iodine and injected into the patient. For a reason Order doesn't yet understand, the radioactive complex concentrates in the tumor (but not in normal cells), delivering a high, continuous dose of radiation. The tumor remains radioactive for 20 to 25 days.

Of 11 patients treated thus far, eight have shown some benefit. One patient lived more than two years. A tumor that occupied 70 percent of one patient's liver shrank to 18 percent; another shrank from 50 percent to 5 percent. It is too early to tell with the other three, says Order. Patients are injected with a lead-lined syringe and remain behind inch-thick, six-foot-high lead walls for about a week so that they don't contaminate anyone. They're instructed to take their own temperatures and pulse rates, measure their own liquid intake and excretion, and flush the toilet twice.

Patients receive between 100 rads and 150 rads, but Order notes this dose is given over a long period of time, and no serious side effects have been seen. "There's no immediate danger from the radioactivity compared to what their life expectancies are," he says. "The main side effect the patients complain about is boredom."

The investigators are working to purify the antisera, to decrease the total amount of radiation to the body. They are also trying the same procedure in four patients with lung cancer, multiple myeloma and neuroblastoma, other cancers that synthesize and secrete ferritin.

"It will take us a number of years before we see how far we can go with this," says Order. "It will take a big effort to apply, but I do not believe the program will be restricted to this tumor." □