A new puzzle in physics: The 'cosmion'

The latest cherished principle of subatomic physics to be threatened by experiment is the charge independence of the strong interaction. Observations that violate it are reported in the Dec. 30 PHYSICAL REVIEW LETTERS as a result of work done partly at Brookhaven National Laboratory in Upton, N.Y., and partly at the Nuclear Research Center Demokritos near Athens.

The strong interaction is the force that holds atomic nuclei together. It acts equally upon the electrically charged proton and the neutral neutron. This independence of charge was crucial in convincing physicists that in the binding of the nucleus they were dealing with a new kind of force and not a manifestation of electromagnetism as early thoughts on the subject had tended to suppose. Now the charge independence doesn't look as complete as it once did thanks to the present work. The work was done by T. E. Kalogeropoulos of Syracuse University and the Demokritos center and nine colleagues from the two institutions.

In the experiments, hydrogen and deuterium nuclei were bombarded with antiprotons to see what happened as the antiprotons met the protons in the nuclei and annihilated each other. Out of such annihilations certain debris is expected, including pi mesons and photons. The basic experimental finding is that there are too many photons, surprisingly too many, almost a whole extra photon per annihilation. The interpretation of this seemingly simple fact leads down a number of important paths in subatomic physics.

Photons are the particles that embody electromagnetic forces; they carry them from place to place, so to speak. The appearance of an extra one in these annihilations means that in some way the electromagnetic interaction is mixing into the nucleon-antinucleon annihilation reaction, quite contrary to the usual expectation. For that meddling to happen something has to slow up the annihilation process. The annihilation was expected to occur under the governance of the strong interaction solely and to proceed "instantly." As physicists define "instantly," this would be the time it takes light to cross a deuterium nucleus. Kalogeropoulos and his group figure that it takes 100 times as long as that. Something is slowing up the annihilation reaction and allowing electromagnetism to get into the act. "It is, of course, a great mystery at the present time why the strong forces, presumably responsible for [the annihilation] do not 'act' with expected typical . . . strong-interaction widths," remarks one of their papers.

The slowing of the annihilation process indicates the existence of a new quasi-atom or metastable bound state of matter and antimatter analogous to the long-studied positronium. Positronium is a state in which an electron and a positron (its antiparticle) become bound together on the way to annihilation and go through a series of atomlike energy transitions before they finally overlap and annihilate. Now such a state appears to occur between particles in the nucleus (nucleons) and their antiparticles, the first evidence for such a thing between particles subject to the strong interaction. One interpretation of the extra photon is as radiation given off during a change from one energy level to another in this quasi-atom. Kalogeropoulos and his group suggest calling the quasi-atom a "cosmion" from the Greek word for jewel, beautiful and cosmos. The cosmion's existence had been suggested by some recent theoretical work, especially that of the Soviet physicist I. S. Shapiro.

Further interpretation of the discovery leads to a suggestion of a microstructure in nucleons similar to that of the atom itself. As the atom consists of a nucleus surrounded by something else, so the nucleon would consist of a core surrounded by something else. Kalogeropoulos says it is as if this core were what you had to get at to make the annihilation happen, and it takes a fleeting bit of extra time to do it.

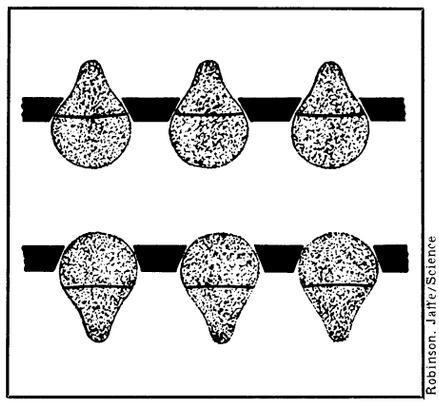
The unexpected time that the annihilation takes suggests a connection with another recently discovered unexpectedly long time interval, the lifetime of the psi or J particles (SN: 11/30/74, p. 340). These are newly discovered extremely massive particles that have lifetimes against radioactive decay that are unbelievably long for particles of that mass subject to the strong interaction. A possibility is that the same aspect of particle structure is responsible for both effects. Kalogeropoulos says theorists are working on ways to link the two discoveries.

Finally the observation of the gamma-ray spectrum from nucleon-antinucleon annihilation offers a way of searching for antimatter in the astronomical cosmos. Many cosmologists would like to find as much antimatter as their is matter. If this gamma spectrum can be observed coming from many locations in the sky, it would indicate that a lot of annihilations are going on, and then cosmologists could conclude that there was a lot of antimatter in the cosmos. □

Egg cells and the electric connection

Egg cells are pretty amazing when you think about it. One tiny cell blossoms into an embryo and eventually into an adult with billions of cells that have differentiated into many tissue types. In most egg cells, a pattern has already been etched before fertilization that will determine which end of the cell will become an animal's head or a plant's shoot and which end will become an animal's tail or a plant's root. How these initial patterns are laid down in the egg is not known, but some Purdue University biologists have completed an interesting experiment that gives them a better idea.

Kenneth R. Robinson and Lionel F. Jaffe report their work in the Jan. 10 SCIENCE. They employed three basic assumptions in the design of their experiment. First, they knew that the eggs of some common brown algae (*Fucus*



Robinson, Jaffe/Science

Brown algae eggs: Rounded ends become leaves, pointed ends develop into roots.

and *Pelvetia*) are not polarized (do not have a pattern laid down) until after fertilization. This enables the

mechanisms at work during polarization to be studied more easily. Second, they knew that the algae eggs drive an electrical current of charged particles through themselves, and suspected that this might have something to do with the polarization. And third, they wondered whether a current of calcium ions might be involved since these can bind strongly to cell components and produce an electrical field inside the cell.

To test whether calcium ions were involved in the egg's electrical current during polarization, they rigged up a system of chambers and nickel screens with tiny holes. They plugged thousands of holes with fertilized *Pelvetia* eggs and passed radioactively labeled calcium ions into the system. *Pelvetia* eggs have the characteristic of polarizing themselves when exposed to light so that the illuminated side becomes the leafy part of the plant and the unilluminated side becomes the root. The team was therefore able to predetermine the sides and measure the flow of ions from the future root end to the future leafy end. The diagram shows the orientations after the eggs have begun to grow: The light shines on the rounded portions, the future leaves, and the pointed root ends are shaded.

The team found that six hours after fertilization, five times more calcium entered the future root end of the egg and three times more left the future leafy end of the eggs. This establishes that there is a flow of charged calcium particles across the polarizing egg. Whether or not this electric current is responsible for the laying down of the pattern is still unproven, but the team has a hypothesis. For the egg to polarize, there must be movement, Robinson says. "Since initially all parts of the cell appear the same, one way to become differentiated is for the 'stuff' inside the cell to move to one end." One possible force for moving the components of the cell, such as vesicles and large molecules, would be a moving field of current that would interact with the charge on the cell components. "The electric field would then cause the various charged entities in the cell to move toward one end," Robinson says.

An interesting project, Robinson says, would be to test already polarized eggs such as sea urchin eggs. These show an influx of calcium ions after fertilization (SN: 11/23/74, p. 327), but the ions' role in differentiation is unknown.

In other work not yet published, Robinson, Jaffe and R. Nuccitelli found currents of sodium and chlorine ions moving across algae egg cells. The next step in their research will be to find out if the electric currents of calcium, sodium and chlorine particles are responsible for the polarization, Robinson says. That work, however, is still in the "thinking and talking stage." □

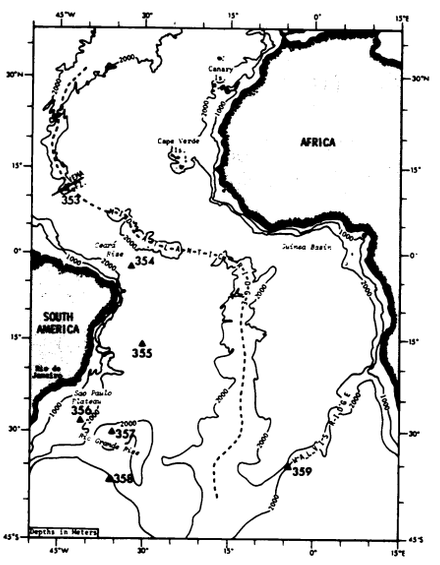
The mighty Amazon reveals her age

The ocean-wide ramblings of the deep-drilling ship Glomar Challenger seem hardly related to the steaming jungles of the Amazon River. Yet on the most recent leg of its years-long research odyssey, Challenger scientists have been able to discover the apparent time of the mighty river's birth—some 24 million years ago.

The mission of the Deep Sea Drilling Project's Leg 39 was to sample sediments from seven sites in the South Atlantic, seeking clues to its age and evolution. The second stop was the Ceara Rise, an undersea plateau about 300 miles northeast of Brazil's eastern tip. The upper levels of the core samples from the rise, dating back as far as the early Miocene Age about 24 million years ago, yielded traces of minerals and other land-derived materials similar to those carried into the Atlantic by the Amazon River today. The lower—and older—sediments, however, showed only the fossilized remains of microscopic creatures which lived and died in the ocean, with no signs of the river's contributions.

This corresponds approximately to the time when some researchers believe the Andes Mountains were formed, which leads to the possibility that the upthrusting of the Andes caused the general water drainage of South America to flow eastward, gradually accumulating into what is now the Amazon.

The seven Leg 39 sites also produced the beginnings of a history of the South Atlantic, most notably by revealing three periods, each millions of years long, when the depositing of sediments seems virtually to have stopped. About 65 million, 40 million and 12 million years ago, Leg 39



Aging the Amazon from DSDP site 354.

scientists theorize, drastic changes took place in the oceanic environment. One candidate, for example, is major shifts in deep current patterns such as that caused by the splitting of Australia from Antarctica about 50 million years ago. This particular schism led to the formation of the present West Wind Drift Current circling Antarctica, which would have affected the bottom currents of every major ocean and possibly led to the missing sediments of 40 million years ago.

The Leg 39 researchers, led by Katharina Perch-Nielsen of the Geologic Institute of Zurich, Switzerland, and DSDP chief scientific editor Peter Supko, will be further investigating such possibilities with data to be gathered from the southeastern South Atlantic over the next two months. □

A virus that switches off cancer

Viruses have been implicated long and heavily as cancer-causing agents in animals. So it comes as somewhat of a surprise that there is a cancer virus that is self-limiting. Even more intriguing, this virus increases the spontaneous regression of cancer caused by a related virus.

The virus and its actions have been discovered by Philip Furmanski, James Baldwin, Rodney Clymer and Marvin A. Rich of the Michigan Cancer Foundation in Detroit. They report their findings in the Jan. 10 SCIENCE.

A virus called the Friend virus is known to cause leukemia of the spleen in experimental animals. This leukemia almost inevitably leads to the rupture of the spleen and death. Rich isolated and characterized a virus that induces leukemia that is virtually indistinguishable from that induced by a Friend virus. But the leukemia caused by this virus eventually regresses, and the synthesis of the virus that accompanies the cancer also subsides. This singular virus prompted Rich and his colleagues to look into its action in greater detail.

They prepared ample quantities of the regressive Friend virus, as they call it. Then they inoculated groups of 10 mice each with 42 different doses of conventional Friend virus, regressive Friend virus or of a combination of the two.

The virus doses induced leukemia in most, but not all, instances. Among those instances where the viruses induced leukemia, spontaneous regression occurred in only two percent of