SCIENCE NEWS of the week

Do Anomalons Exist? Yes—So Far

Anomalons are either atomic nuclei or nuclear fragments that show a much stronger propensity to interact with other matter than nuclei usually do. That is, they interact before their time or before they have proceeded through some piece of matter as far as is normal (SN: 10/30/82, p. 284). That is, provided anomalons exist. If they do, they may represent some exotic and interesting state of nuclear matter.

Throughout the sessions of last week's Sixth High-Energy Heavy Ion Study and Second Workshop on Anomalons, held at the Lawrence Berkeley Laboratory (LBL) in Berkeley, Calif., the question hanging over the assembly was whether anomalons really do exist. Physicists interested in the subject had not wanted to make much publicity over them, fearing that the phenomenon might be sensationalized and then, embarrassingly, turn out to have been a false alarm. By the end of the meeting, the consensus, at least as it was expressed in a summary talk by Ingvar K.N. Otterlund of the University of Lund in Sweden, is that they do exist. As he put it, "Anomalons are still provocative."

The question of existence is one of how you use statistics. The evidence for anomalons comes from the statistics of high-energy heavy nuclei in collision with solid targets (either blocks of photographic emulsion or stacks of plastic leaves). When a nucleus enters such a target, it is likely to collide with a nucleus in the target and break into fragments. Some of these fragments will proceed some distance and interact with another nucleus of the target, fragmenting again.

Gathering statistics on the distances travelled by all the different fragments, experimenters can determine a quantity known as the mean free path for a given nuclear isotope in a given kind of target, the mean distance such an isotope travels before interacting. Anomalons, for which evidence begins to appear when the impinging primary nucleus has rather high energy, are a group that proceed for very much less than the appropriate mean free path for their sort. But, in this context, what defines "very much less"? Few "normal" nuclei ever hit the mean free path exactly. How short does a path have to be to be anomalous? Since anomalons, if they exist, contribute to the statistics that determine the mean free path in a given experiment, how does one compare that with a "normal" situation in which there are no anomalons? Otterlund subjected the 9,658 interactions reported in experimental papers at both the first and second anomalon workshops to an analysis that, according to him, gets around these difficulties. He concludes that anomalons are real, but their incidence is more like three percent of all nuclear fragments rather than the six percent claimed by other investigators.

One of the outstanding questions has been whether anomalons occur in nuclear species of very low atomic number. (The first experiments dealt with fragments of fairly high atomic number.) That is, does being an anomalon depend on the amount of electric charge the fragment has? Evidence so far is mixed. Groups at Cairo University in Egypt (represented by Omar E. Badawy) and Phillips University in Marburg, West Germany (represented by Eberhard R. Ganssauge), find evidence for anomalons in particles of atomic number 2 and 3. A group from the State University of New York at Buffalo (P.L. Jain and colleagues) do not find such evidence for atomic numbers 2, 3 or 4. Pressed hard by questioners, Jain insisted, "Given my statistics, I do not see them." On the other hand Barbara Judek of the Canadian National Research Council in Ottawa reported evidence for anomalons even in nuclei of atomic number 1, including single protons. But, she says: "I'd better be careful. Jain doesn't see anything for charge 2 and 3, and I'm seeing things for charge 1."

The Egyptian experiment also showed another interesting result: The probability of producing anomalons is higher for peripheral collisions — glancing blows rather than head-on crashes. But as Otterlund points out, the Egyptians need more statistics; they have only 250 instances.

The targets for the Egyptian experiment were irradiated with nuclei at the Synchrophasotron at the Joint Institute for Nuclear Research at Dubna in the Soviet Union. All the others were irradiated at LBL's Bevalac. So for what it's worth, anomalons appear both East and West.

The most popular theoretical suggestion for what an anomalon is seems to be that it is a "quark-gluon plasma." That is, in the anomalous fragment, the identities of neutrons and protons are destroyed. What is left is the quarks that make up the neutrons and protons, and the anomalon is a bag of quarks plus gluons, the particles that embody the forces between quarks. This quark-gluon plasma would have laws of behavior all its own. It would be a fascinating new state of nuclear matter. Can it exist? Is that what an anomalon is? Right now, says Otterlund, "We don't know."

As "homework for the third anomalon workshop," Otterlund proposes close studies with several kinds of detector (emulsions, plastic and Cerenkov counters) of the first few centimeters after nucleus-nucleus collisions. That is where anomalons should appear, and good statistics and topological studies of their tracks may help penetrate the mystery.

—D.E. Thomsen

Inflationary model predicts little rotation

Inflationary cosmology, the relatively recent rival of the well-respected big bang theory for the early history of the universe, may be rewriting the first split second of that history. First proposed by Alan H. Guth of Massachusetts Institute of Technology in Cambridge, and based on the so-called Grand Unified Theories of particle interactions, the inflationary theory, with some modifications made by other scientists, has been used to solve many cosmological riddles (SN: 2/12/83, p. 108). Now, physicists John L. Ellis and Keith A. Olive report from the CERN laboratory in Geneva, Switzerland that the newcomer model has achieved still another victory.

The inflationary model incorporates the successful ideas of the big bang theory, but adds a period of extremely rapid spatial expansion, or inflation, which alters the course of early cosmological history and, remarkably, thereby influences many of the cosmological features observable today. One of those features is the lack of large-scale rotation in the universe, which may be explained only artificially in the big bang model, but which, according to Ellis and Olive, is naturally accounted for within the inflationary framework.

A rotating universe should not be thought of as a phonograph record revolving about a center, but rather as a fluid that exhibits a property that physicists call vorticity. The phenomenon is like a stream in which the water moves faster and faster as one crosses from one shore to the other. A small horizontal paddlewheel would indicate the vorticity of the stream by rotating, since the water rushing against the paddles on one side is swifter than that on the opposite side.

Evidence that might indicate a universal rotation of about 10^{-13} radians per year (a radian is about 57°) was reported last year by one astronomer studying the orientation of galaxies in different parts of the sky (SN: 8/7/82, p. 84). No confirmation of those results, however, has since been reported. George F. Smoot of the University of California at Berkeley has examined the background microwave radiation that bathes the cosmos to look for variations in it that would indicate vorticity on large scales. He found none and says, "I don't think there's any strong positive evidence for rotation." Ellis agrees and says that if the universe is rotating, its rate is at most 10^{-13} to 10^{-14} radians per year.

The rotation speed at the birth of the universe could have been almost anything. Many physicists agree, however, (though it's somewhat a matter of taste) that the unitless parameter that governs vorticity in cosmological equations probably had an initial value close to one. Conservation of angular momentum dictates that the rotation speed will decrease as the universe expands and ages, but the amount of expansion predicted by the big bang theory is not sufficient to account for the lack of presently detectable rotation assuming an initial rotation. The recent work of Ellis and Olive in the June 23 NATURE indicates that a short era of phenomenal expansion in the universe's youth could have diminished a relatively large rotation rate to a rate today that is consistent with the lack of observed rotation. The super-cooling stage, predicted by the inflationary model, is accompanied by just such an expansion, which could increase the radius of the early universe by as much as a factor of 10^{30} in just 10^{-32} seconds.

Although it is not known exactly how the short reheating period (caused by a phase transition similar to water freezing), which follows the inflationary expansion, would affect rotation. Ellis feels that Guth's model can explain present observations. This adds to the inflationary theory's list of successes, which include explaining the present rate of universal expansion, the isotropy (sameness in all directions) of the cosmological background radiation and the apparent scarcity of magnetic monopoles. *—P. D. Sackett*

The longest day

Even the earth can't escape the clutches of old age; it too is slowing down and showing signs of irregularity. As a result, time stations around the world cooperated late last month to give the aging earth and its inhabitants a break—a one-second break to be exact. The earth's rotation about its axis is continually slowing, but not at a steady rate. This irregularity has been observed with photographic instruments since about 1932, according to Laura Charron, an astronomer at the U.S. Naval Observatory in Washington, D.C. The insertion of "leap seconds" every year or so is required to keep world clocks — which use the "ticking" of the cesium atom as a standard—in step with the rotation of the earth.

The extra second was added this year on June 30; the minute beginning at 7:59 p.m., EDT, of that evening was 61 seconds long. It was the twelfth such second to be added since the adjustment process began in 1972, when two leap seconds were added. In that year, says Charron, the time for the earth to complete one turn on its axis was decreasing by four-thousandths of a second every day. This year, the rate is only about three-thousandths of a second per day. The variability of the rate of the earth's rotation is believed to be caused by a variety of factors, including friction in the earth's atmosphere, oceans and core. ☐

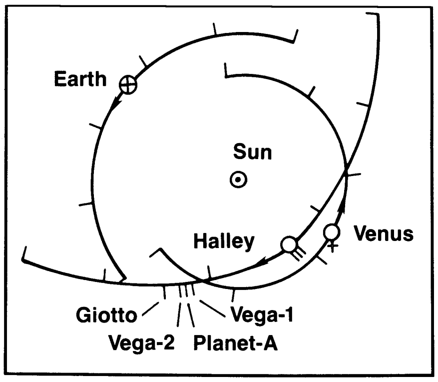
Pioneer Venus craft to study Halley

The Soviet Union, Europe and Japan all are at work on spacecraft to be launched toward comet Halley as the famed comet takes its first swing through the inner solar system in 76 years. The United States is not. Yet one U.S. probe not only will be well-placed to take a good look, but will be in a unique position to study one of the rare event's most scientifically significant phases: the final days as Halley approaches its perihelion, the most sunward point in its orbit, when the comet's most active outpourings will begin.

The craft is the Pioneer Venus orbiter, which has been circling Venus since December of 1978. It was not designed with Halley in mind, and no one is planning to send it there. But as Venus circles the sun early in 1986, Halley will be coming around in the other direction, passing about 40 million kilometers from planet and orbiter on Feb. 4—just five days before the comet's perihelion.

The various probes being deliberately sent Halley-ward are expected to get much closer (the European Space Agency's Giotto is to be aimed within 1,000 km of the nucleus), but they will all do so in early March, about a month *after* perihelion. Pioneer Venus will have the immediately pre-perihelion scene all to itself. At 40 million km, the craft's "camera" (an imaging photopolarimeter, equipped with only a 3.7-cm telescope) and its radar mapping instrument will be too distant for meaningful results, but its ultraviolet spectrometer (UVS) says Ian Stewart of the University of Colorado in Boulder, definitely has a role to play. As Halley nears the sun, the growing heat will free more and more of the material that has been frozen in the icy nucleus, while the UVS looks on to measure the amounts and production rates of atomic hydrogen, oxygen, carbon, nitrogen and possibly other species such as sulfur. In addition, says Stewart, it will be in position to monitor any irregular outbursts, which could become more frequent as the heat approaches its maximum.

Various particles-and-fields sensors aboard Pioneer Venus will also be part of its Halley watch, observing the interaction between the comet and the solar wind. On Nov. 9, 1985, for example, while Halley is still on its way in, the spacecraft will fly through a region of the solar wind that came from the same part of the sun as solar-wind streams that were flowing past the comet only 10 days before. According to Devrie Intriligator of Carmel Research Center in Santa Barbara, Calif., this offers hope of providing a back-looking "calibration" of the solar wind's input to the comet. A similar alignment, she says, will exist on about March 11, 1986, when Halley is outbound.



I. Stewart

Venus closest approach 2/4/86
Perihelion 2/9/86
Vega-1 encounter (USSR) 3/5/86
Planet-A encounter (Japan) 3/7/86
Vega-2 encounter (USSR) 3/9/86
Giotto encounter (ESA) 3/13/86

Positions of Comet Halley, Venus (including PV orbiter) and earth are all shown as of Halley's perihelion. Orbit sections show 30-day intervals, beginning 12/1/85. Indicated along Halley's orbit are its positions during closest approaches by the four Halley-bound probes.

Data from other U.S. spacecraft will also be included as scientists try to improve their understanding of how the solar wind and Halley—or any comet, for that matter — affect each other. The Pioneer 7 probe, for example, has been doing solar-wind studies for 17 years from a huge, heliocentric orbit. Its position in 1986, Intriligator says, may possibly put it conveniently in the way as Halley's tail sweeps past, or at least in the way of solar-wind streams carrying traces of Halley-stuff along. Also taking part will be ISEE-3, a probe now on its way to fly through the tail of comet Giacobini-Zinner in September of 1985. Shortly after that event, says Frederick L. Scarf of TRW Inc., ISEE-3 will be "upstream" from Halley in the solar wind, enabling it to report on the solar wind's "raw state" so that researchers can get an idea of what sun-spawned material is showing up in downstream measurements of the comet. *—J. Eberhart*

Fermilab sets new record

In the wake of European rejoicing over the recent discovery of the long-awaited W and Z^0 particles at the CERN laboratory in Switzerland (SN: 2/5/83, p. 84, 6/18/83, p. 388), U.S. scientists at Fermi National Accelerator Laboratory in Batavia, Ill. have fired a shot of retaliation in the international physics technology competition.

On July 3, protons circling in the same underground tunnel used by an old Fermilab machine were pushed to unsurpassed speeds by new energy-efficient superconducting magnets. The $130-million dollar "Tevatron," which gave the protons the record-breaking energy of 512 billion electron volts, will be one-trillion electron volts (1 TeV=10^{12}eV) within a few months. At the higher energies provided by the Tevatron, physicists hope to explore the structure of the smallest particles of matter and begin to determine whether quarks represent the end of the subatomic lineage. ☐