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)