# The Argonne Experiments And The End Of Quarkery

Experimental results obtained over the past year at the Illinois Argonne Zero Gradient Synchrotron (ZGS), taken in the context of previous "anomalous" experiments elsewhere, have conclusively refuted the basic assumptions of the quantum mechanical approach to high energy physics, and of the fantastic "theory" of quarks which was the degenerate end-product of that approach. At the same time, by demonstrating the existence of dynamic geometric structures at subnuclear levels, these experiments point the way to a new theoretical framework for high energy and elementary particle physics, a framework premised on the same self-organizing processes which are fundamental in plasmas, and, for that matter, in biological and social evolution.

For the past 50 years physicists have attempted to use quantum mechanics to explain subnuclear particles (protons, electrons, etc.) and fields on the basis of two fundamental assumptions: 1) that all matter is composed of point particles, without structure or dimensions, and 2) that their interactions are controlled by potentials — fixed laws governing the forces they apply on each other. Any sort of geometrical structure on a scale smaller than that of a proton (about $10^{-13}$ cm) was excluded by the quantum mechanical "uncertainty principle." Just as the Ptolemaic astronomer piled epicycle onto epicycle to cover over the gap between their assumptions and observation, so, especially in the past 15 years, most particle physicists have stuffed a mixture of Buddhist metaphysics and pure humbug into the chasm which separates the Ultimate Particles — Quarks — from anything resembling reality. Galileo's telescopic observations of Jupiter's moons, flatly contradicting the Ptolemaic assumptions of an earth-centered universe, swept the field clear for Kepler's breakthroughs. Today, the unarguable observation of subnuclear geometric structure performs the same task in eliminating the old quantum structure, quarks and all.

### *The Argonne Proton Spin Experiments*

The Argonne experiments, like all experiments in high energy physics, consisted of accelerating subnuclear particles (in this case protons) to high energies and hurling them against similar targets, and observing the results. The aim of all such experiments is to obtain some notion of the nature of the particles by observing their interactions. The unique advantage of the Argonne experiments for the study of the internal geometry of particles is that it allowed the experimenter to fix precisely the alignment in space of the accelerated beam protons and those of the target protons.

Protons, like all other subnuclear particles possess a magnetic field, similar to that which would be created by a charged body spinning on its axis — the direction of the axis of the magnetic field is called the *spin* alignment of the proton. In a normal accelerator, protons of all different spin alignments collide with the target, thus blurring out any geometrically determined interactions. Even if the accelerated proton beam begins as a polarized beam, with the spins all aligned in one direction, either parallel or anti-parallel to the overall magnetic field in the accelerator, the rapidly changing magnetic fields in the accelerator tend to flip or depolarize the protons long before they have achieved very high energy. The Argonne ZGS accelerator, which has weaker focusing magnetic fields than any other accelerator of its size, can, with certain modifications, accelerate the protons without depolarizing them. Thus, beginning in 1973, the Argonne Lab in Illinois became the first high energy accelerator to collide spin aligned protons with spin aligned targets (liquid hydrogen). It remains at present the only accelerator capable of doing this.

Protons, accelerated to 12 billion electron volts energy (12 GeV or the equivalent of a temperature of 120 trillion degrees C), collide with hydrogen nuclei and are scattered into detectors arranged in a given plane and at definite angles. Since both the beam and target, or "recoil" proton, are observed, the dynamics of the interaction can be calculated. By moving the detectors, the entire scattering pattern can be determined.

The theoretical expectations for the spin aligned experiments were unexciting. Since spin is considered to be a very small magnetic effect, not really geometric, but just another minor field, the theorists expected that at high energies, spin effects would become very small, or even disappear entirely. The exact opposite occurred.

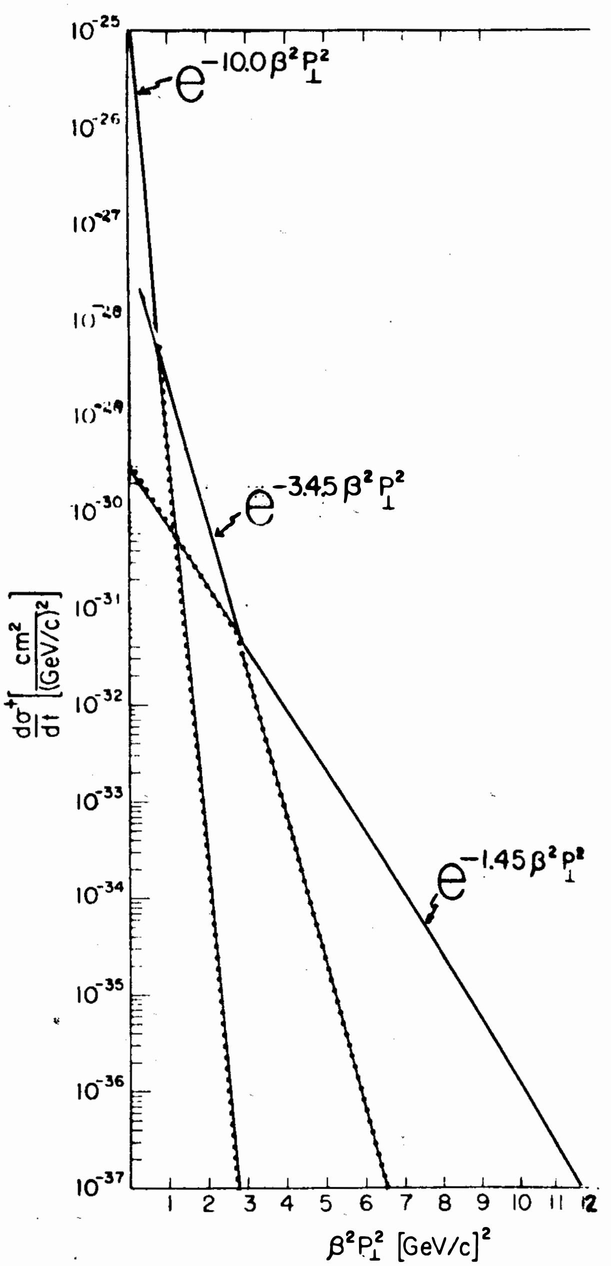
The experimenters at Argonne found that spin alignment effects were *thousands of times stronger than expected at high energies*, and were especially strong at large recoil angles, that is in more "head on" collisions where the interactions of the particles were the strongest. Specifically, they found that there was much greater scattering when the spins of the two protons were parallel than when opposed.

Secondly, when the spins were parallel and the spin direction is up, there was far more scattering to the left than to the right. This asymmetry, similar to the ability of optically active molecules to rotate the polarization of light, was concentrated in certain high angles of recoil, thus producing "jets" of protons in certain directions (Fig. 1).

Thirdly, the experimenters found that the apparent "shape" of the proton was very much non-spherical. When the proton spins were aligned along with the beam,

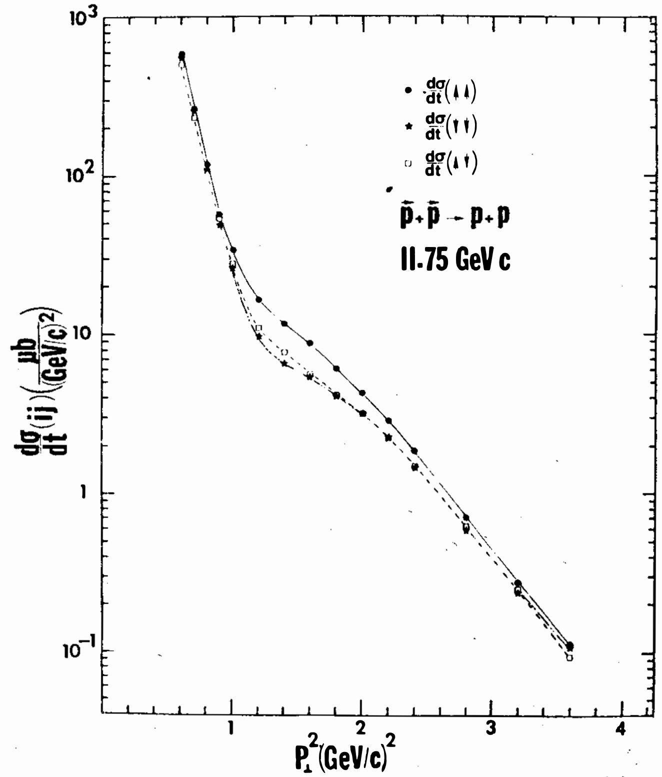
## Figure 1— Proton Cross Sections

### Figure 1a



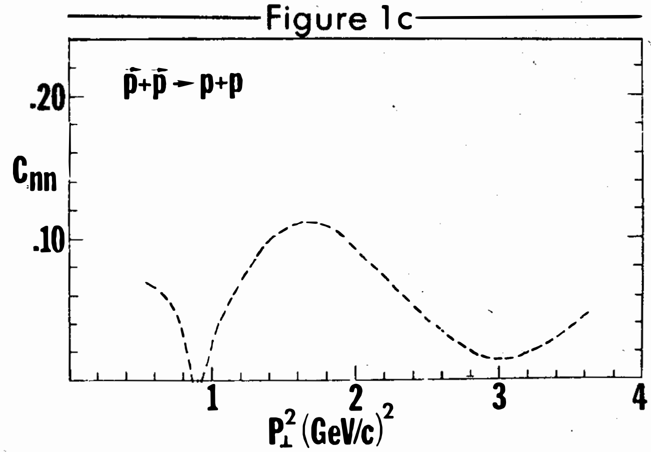

1A depicts the overall cross section scatter rate versus the perpendicular velocity. Note the two sharp breaks in the scattering curve.

### Figure 1b




1B shows scattering of spin parallel, right scattered (↑↑), left scattered (↓↓) and anti-parallel (↑↓) protons, showing an increase of spin effects at the first break in the cross section graph.

### Figure 1c




1C is the curve of spin effects. There is an increase in spin effect as the perpendicular velocity approaches the second break.

there was much more scattering (about twice as much) as when they were aligned at right angles to the beam.

These results in themselves were startling and disturbing enough. The existence of very strong spin effects at high energies and the fact that these effects were strongest for the most violent and penetrating collisions immediately strongly imply that spin is not some simple magnetic effect but is intrinsic to the geometric structure of the proton. If the proton as a whole poses an asymmetric (non-spherical) structure associated with its spin, then this has further implications for the famous parity experiments performed in the late 1950s and never since adequately explained.

These experiments showed that in the decay of certain radioactive elements, such as Cobalt, electrons were emitted with their spins aligned in the direction of their motion, while positrons, the anti-matter equivalent of electrons, were emitted with spins aligned opposite to their motion. What was perplexing was that this asymmetry implied that in some way positrons and electrons were mirror images of each other, but were not mirror images of themselves — they possessed left- and right-handedness. That is, a sphere when reflected in a mirror will be identical to itself, but a right- or left-handed glove will not be, nor will a particle whose spin is aligned with its motion.

The obvious implication was that this "parity violation" was a symptom of a geometric asymmetry in the structure of the electron similar to that of isomerism in organic molecules. The Soviet physicist Lev Landau suggested this at the time, but he was generally ignored. The Argonne results demonstrate that such geometric asymmetry in fact exists at the most fundamental structural level of the proton, at least, and quite possibly the electron as well.

However, while disturbing, this aspect of the results does not flatly contradict the quantum assumptions, since we are here dealing with the geometry of the proton as a whole and thus at scales (around $10^{-13}$ cm) which are still "allowable." The critical aspect of the Argonne experiments lies in the fine structure of the spin effects. For about 10 years, it has been known that the proton appears to possess some internal structure. If it were totally homogeneous, the number of protons scattered over other protons would decline exponentially with increasing angle of scatter. Instead, there is a "break" in the scattering curve (Fig.1). As in the case of the famous Rutherford experiments with the nucleus of the atom, the higher than expected scattering at high angles implies a "hard core" of scattering, smaller than the proton as a whole, in this case about three times smaller in cross section. The normal explanation for this phenomenon has been that the proton, although not itself a point particle, is composed of point particles called partons, or the notorious quark (a nonsense word from James Joyce's existentialist novel *Finnegans Wake*).

The immediate problem with this explanation, even for the proton scattering results, is that there is a second break in the curve, implying a doubly compound structure. This problem cannot be avoided simply by postulating that the quarks have sub-quarks of their own, and so on, because this would still imply some real extended substructure within the proton on the scale of the first break, even if these are considered only as local clumpings of smaller point particles. But of course, since only scattering is being measured and not geometric structure, these results can, and were, dismissed as "merely interesting."

The Argonne spin experiments explode this little cover-up. Dr. Alan Krisch, one of the main Argonne experimenters (and not coincidentally, one of those involved in the earlier scattering cross-section experiments) discovered that the maximum spin effects occur at precisely the same angles of scattering as the breaks in the overall cross-section curve (Fig. 1). This is a critical experiment of the highest importance, since it demonstrates beyond a doubt that the *geometrical properties of the proton, its ability to asymmetrically deflect other particles is itself distinctly inhomogeneous on a scale of at least an order of magnitude smaller than that forbidden by quantum mechanics.*

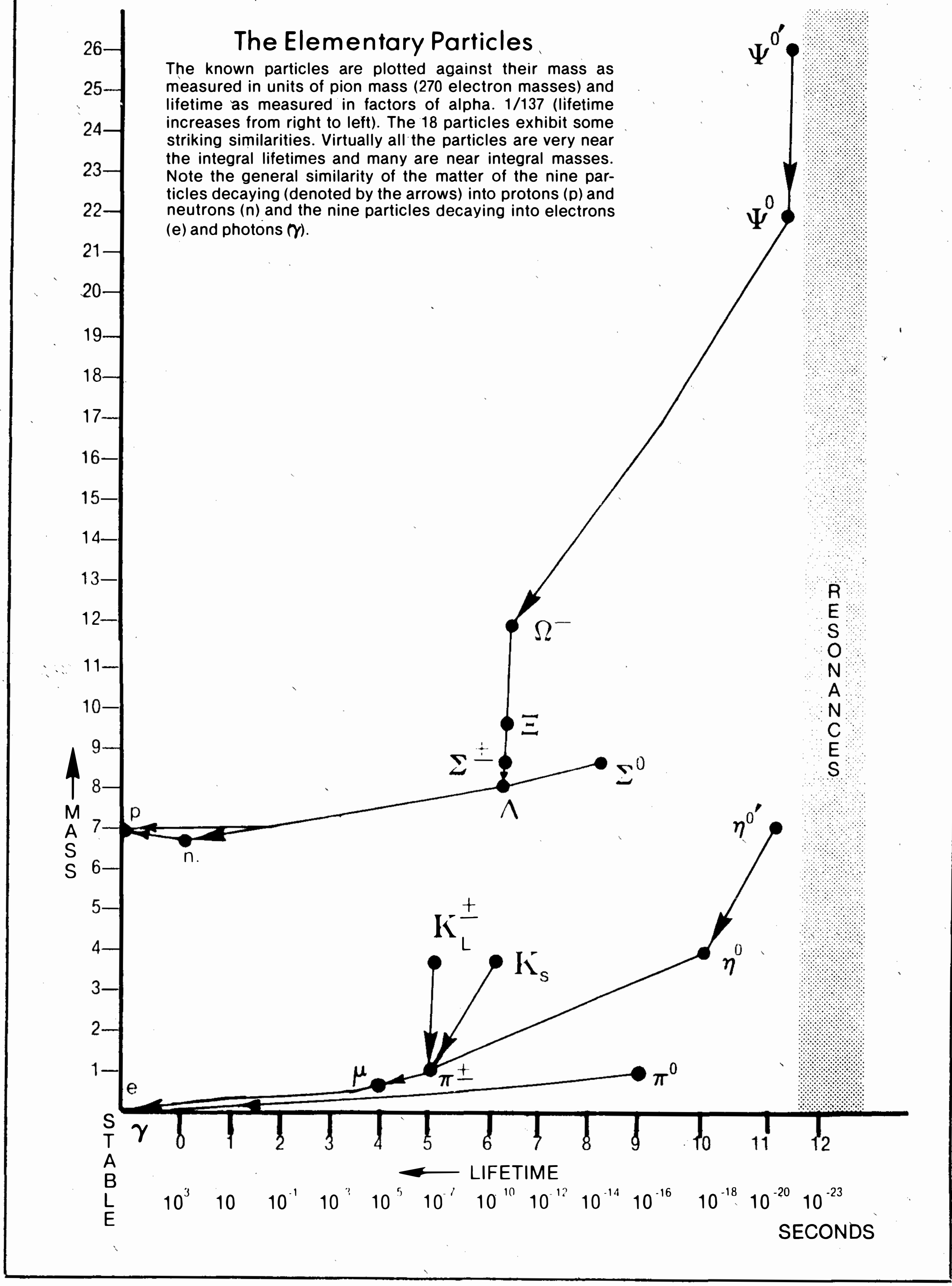
This is the crucial point to the experiments and therefore deserves elaboration. The combination of quantum mechanics and relativity theory implies that for any particle of mass M, there is a distance, $D = h/Mc$, called the Compton wavelength of the particle, where h is Planck's constant and c is the speed of light. There can be no concentrations of matter within the particle that are smaller than this wavelength, excepting the special case of point particles. Thus, the experimentally verified existence of structures within the proton at least five times smaller than the proton's Compton wavelength implies either than quantum mechanics does not hold in the interior of protons, or that Planck's constant is at least five times smaller in that region, or that the speed of light is about five times larger, or some combination of all three!

By themselves, these experiments still leave open the possibility that some strange combination of point particles and potential fields, even if organized on a finer scale than that allowed by quantum theory, could somehow account for the structure observed. However, other recent experiments have ruled out this escape hatch. If any sort of point particle potential combination is responsible for particle scattering in collisions, then it is only to be expected that at very high energies, as the beam particle spends less and less time in the other particles' potential field, that scattering cross sections (the number of particles scattered a given amount) will decrease. In fact, even at very high energies, the scattering cross section is continuing to increase — and this occurs not only for the presumably complex proton, but for the electron as well, supposedly the particle best understood quantum mechanically. Taken together, the recent results in high energy experiments totally undercut the foundations of not only current theories of elementary particles, but quantum mechanics in its present form. Of course, the implications of these results are by no means generally recognized, not even by the experimenters themselves. However, it should come as no surprise that such results have been obtained; the real wonder is that the present theories have lasted so long.

### *The Paradoxes of Quantum Mechanics*

Since its consolidation in the late 1920s, quantum mechanics has been bedeviled by epistemological

## Figure 2




### The Elementary Particles

The known particles are plotted against their mass as measured in units of pion mass (270 electron masses) and lifetime as measured in factors of alpha. 1/137 (lifetime increases from right to left). The 18 particles exhibit some striking similarities. Virtually all the particles are very near the integral lifetimes and many are near integral masses. Note the general similarity of the matter of the nine particles decaying (denoted by the arrows) into protons (p) and neutrons (n) and the nine particles decaying into electrons (e) and photons (γ).

blunders which it inherited from Newtonian mechanics, especially the notions of point particles and fixed interacting potentials. As demonstrated by Immanuel Kant in 1781, such point particles introduce inherent contradictions into any theory. For example, an infinitesimal electron will have an infinite electric field and thus infinite energy and mass. That the dominant formulations of quantum mechanics continued to insist on the Newtonian point particles is all the more remarkable when it is considered that the most striking successes of quantum mechanics are based on the recognition of a continuous or wave character to matter, the opposite of the ultimately discrete point particle.

But insist on it they did, and as a result, in a fundamental way, the resulting theory of quantum electrodynamics was inherently contradictory. Results consistent with observation in the realm of atomic physics were only obtained by the use of various explicit and implicit approximation and "renormalization" techniques, all of which relied on the convenient fact that the electromagnetic coupling constant, which is about 1 /137, got much smaller very rapidly, leading to a rapid convergence of approximations. In contrast, the "strong" or nuclear interaction has a coupling constant considerably greater than 1 (about 13) and therefore similar series of terms in powers of the coupling constant *do not converge at all.* Thus from the start, quantum mechanics' internal contradictions prevented a rigorous treatment of nuclear interactions.

Nor was such a treatment seriously attempted. Beginning in the late 1930s, and with increasing speed after World War II, physicists fled from the problems of theory to the latter-day Holy Grail — the Search for the Ultimate Particle. By the late 1930s, in addition to the electron and proton, three other subnuclear particles had been observed, the neutron and two so-called mesons, of mass intermediate between the electron and proton. These particles were observed as a result of radioactive decay of the collisions of high energy cosmic ray particles with nuclei. With the development after World War II of increasingly powerful particle accelerators, more and more "elementary particles" both heavier and lighter than the proton were observed. These particles were detected by their tracks through cloud chambers and photographic emulsions. All had very short lifespans, less than a millionth of a second, decaying into other short-lived particles and eventually into protons, electrons, and energy.

Each particle had a corresponding antiparticle, identical except for charge. Particle-antiparticle pairs could be produced from sufficiently strong electromagnetic fields, and the collision of particle and antiparticle led to mutual annihilation.

By the early 1960s, 16 such particles (and their antiparticles) had been discovered and two more have been discovered in the past 15 years (Fig. 2). However, this already complex picture was further complicated by the epistemological blunders of the investigators. As accelerators grew more powerful, it became obvious that there were certain particular energies at which the interaction of two particles suddenly became stronger. These "resonances" could be interpreted as evidence of short-lived excited states of the particles involved, transient dynamic phenomena hardly outlasting the time of the collision itself, which were thus hundreds of times shorter lived than the fastest decaying "stable" particle. Unfortunately, the particle physicists decided to imbue these phenomena with greater dignity, and called them particles too. They thereby increased the number of "elementary particles" to well over 200, a number which grew with practically every new experiment.

The early 1960s was the logical period for physicists to step back and begin a fundamental reevaluation of their theories in light of the accumulated evidence. Unfortunately, this did not occur. Instead, high energy physics was submerged in a wave of numerology and Buddhist mysticism, as various groups attempted to induce from the mass of data regularities which would allow classification of the data into numerical groupings of various religious significances. With several hundred "particles," there was indeed quite a field for induction! Various symmetries and magic numbers — octets, nonets, dectets, sextets, etc., were rapidly found and given appropriate names — like Nobel laureate Gellmann's Eight Fold Way. After a while, the quest for doctrinal simplicity led to the theory that all of the 200 particles and resonances were made up of a single Ultimate Particle — a Quark.

Quarks, once invented, seemed to have the capability, as mere mental constructs, to multiply faster than rabbits. First of all, to account for all the different particles, it was immediately necessary to theorize more than one type of quark, which could combine together to make up the particles. Gellmann therefore created three quarks, distinguished by an imaginary quality he called "up," "down" and "strange" — Quark flavor. After a good deal more theorizing, without particular reference to any experimental results, it was decided to add a fourth flavor — "charm."

This however was insufficient, since if several identical quarks came together in one bigger particle, a fundamental dogma of quantum theory would be violated — the exclusion principle, which prohibits the cohabitation of identical particles. Thus to distinguish the similarly flavored quarks, a new property was invented — "quark color." Each flavor now had three colors — red, green and blue, as well as colored anti-quarks — cyan, magenta and yellow. (If the reader's credulity is now somewhat strained, he is referred to the January 1977 issue of Scientific American, where the quark theory, in living color, is described by its own proponents.)

By this time the number of elementary and unobserved particles had climbed to 24, not counting a few which, like the electron, were not included in the first place. But the quarkists were not through — they had to have a force to hold the quarks together, and thus a particle to carry that force. Eight of these "gluons" were deemed about right, bringing the total number of new particles to 32, considerably worse than when they started some 15 years previously.

(Not only have particles multiplied, but so have force fields. At last count theoretical justifications had been produced for at least three other forces besides the observed electromagnetic, gravitational, and nuclear forces.)

One serious problem remained. The quarks (charmed, colored, and flavored), have stubbornly refused to put in an appearance. Despite looking high and low for them with multibillion dollar accelerators, not one of these mythical beasties has yet been found. Unlike the Loch Ness monster, they have not even been glimpsed. Such an embarrassing lack of connection between theory and observation gives free play to the imagination, but also leads to nasty questions about the worthwhileness of the endeavor.

The quarkists have an explanation: "the law of quark confinement," which conveniently dictates that quarks can only exist inside other particles and thus can never be observed. This intriguing idea has led one devotee to ask rather plaintively, "If a particle cannot be isolated or observed even in theory, how will we ever know that it exists?"

We have thus arrived today at the Putrescence of the Elementary Particle. It is high time that physicists use the new results to sweep up the debris of quarkery. It is no coincidence that many of the most prominent particle physicists today reflect the same existentialism in their "life styles" as in their Buddhist physics. Einstein's violin and Mozart have been replaced by Feynman's bongos and rock music. One Nobel laureate recently made headlines by testifying in California against an ordinance prohibiting sex shows and nude bars, stating that after the long grueling hours of quark theory, he himself often frequented such scenes.

But it should not be thought that merely junking point particles for pure continuums will be all that is necessary. The problem is more fundamental. *It lies in the notion of fixed field laws, valid at all times and in all situations. Any such simple continua lead directly back to the conundrums of point particles.* Take, for example, the current confusion about Black Holes. General Relativity predicts that any sufficiently massive body will collapse under its own gravitational force without limit down to an absolute point — a point singularity, having infinite gravitational fields. Any object near such a singularity would get sucked in and disappear "over the edge of the universe."

Until recently, it had been thought that such singularities would be demurely covered up thus preventing physicists from every observing, and thus having to worry about one. Since light itself could not escape from the region around the singularity, a Black Hole of finite extent would be formed, within which nothing could be observed. The singularity would be out of sight, and presumably out of mind. Unfortunately physicists have been unable to separate the dilemmas at the opposite ends of the magnitude scale, and at a recent Astrophysics conference in Boston, quark met the Black Hole with disastrous effects. Calculations were revealed showing that pair formation would lead to energy and mass slowly leaking out of the Black Hole, eventually destroying it and leaving behind the "Naked Singularity." Morality and physics both trembled at the thought!

Thus the study of pure fields ends up in the same mess as the study of elementary particles. (Interestingly enough, the existence of gravitational singularities which is found so shocking on an astronomical scale is blithely ignored on the microscopic scale. Electrons, if they were point particles, would of course have gravitational singularities. To ignore these singularities because they are quite small is to imitate the famous young lady who was just a little bit pregnant.)

### *The Redirection of High Energy Physics*

The first step in redirecting subnuclear physics out of its present cul de sac is to throw overboard the fundamental assumptions which got it there in the first place — both point particles and unchanging fields. In place of these axioms, subnuclear or high energy physics must adopt those assumptions which are coherent with the directions already demonstrated in plasma physics, and, in an epistemological sense, in ecology and economics. The fundamental characteristic of the universe is *evolution* — this is obvious at the level of the biosphere or human society but must be coherently true of the physical universe as a whole. Thus it must be the case that the laws of the universe themselves evolve. In plasmas it is demonstrably the case that the evolution of a physical system is mediated through certain definite self-organizing geometric structures, such as the vortices common in energy-dense plasmas. Subnuclear physics, which is simply the extreme high energy extension of plasma physics, must be characterized by similar pheonomena.

*The working assumption which must replace the current axiomatic system is that subnuclear particles are self-organizing geometric structures comparable with plasma vortices. Such structures mediate through their concentration (capture) of energy the development of new field-interactions, which in turn lead to new levels of self-organized structure.*

The postulate that subnuclear particles bear a resemblance to self-organizing entities in plasma physics is not at all speculative. It is indisputable that such particles do in fact concentrate immensely the field energy in coming into being in pair production — the field in fact organizes itself into the particle. The Argonne experiments prove beyond a doubt that we are indeed dealing with geometric structures, and thus, taken together with the phenomenon of pair formation, self organizing structures. In addition, the characteristic asymmetries of the Argonne experiments and the much earlier parity experiments are exactly what one would expect from specifically *vortical* structures.

Nor is it speculative to postulate fields which change their laws with time and space. As we have seen, non-constant values of c and h are in fact necessary to account for known experimental results, and without such changes "in the small," there is no way of avoiding the production of point singularities. Since geometric vortex-like structures can have greatly different interactions at short and long range, such changes of interaction law are coherent with their existence.

Such a working assumption enables us to begin to answer the question of why such a variety of short-lived particles — the 18 "stable" particles — should exist in the first place. That is, what role do they play in mediating the capture of energy? For example, in an extremely high energy plasma of electrons or electrons and positrons, direct energy capture through positron electron pair production is extremely slow. However, energy capture is mediated far more rapidly through the production of the short-lived particles which in turn decay into the stable, captured energy forms — the proton and electron.

It is striking that, as was first pointed out last year by the physicist MacGregor, the lifetimes of the particles are nearly evenly spaced from each other by factors of alpha — the electromagnetic coupling constant, 1 137. If very different forces, electromagnetic, strong, weak, are supposedly at work in these decay times, as is generally supposed, such a regularity of lifetimes must be considered a remarkable coincidence. However, if it is assumed that the particles are related to each other as various "compoundings" of vortex-like structures, then the regular relation of their energy throughput rates, and thus their lifetimes, is completely expected.

*A Program for High Energy Physics*

The adoption of the proposed working hypothesis immediately implies a theoretical and experimental program for the development of high energy physics. Theoretically, the examination of the interaction of compounded vortical-type geometries requires a considerable extension of current mathematical techniques. One method of attacking this problem is using three dimensional hydrodynamic computer simulation of collision of vortices, multiple vortice geometry, and so forth. The second is the development of techniques to deal with hyperspaces in which the rate of energy capture is the primary metric, defining the evolution of the system as a geodesic in such a space (a line of maximum rate of energy capture.)

Experimentally, a number of lines of investigation are immediately suggested. First, the repetition of the Argonne experiments with spin aligned electrons and positrons, and their extension to higher energy regimes using colliding beam techniques. Second, the study of the dynamic evolution of particles by attempting to find changes in interaction behavior with increasing "age" of individual particles or particle beams. Third, the development of techniques for examinging possible collective modes of interaction at high energies through increasing the densities of both accelerated particle beams, and of thermonuclear plasmas to extremely high values.

It is ironical, but not surprising, that ERDA's current budgetary plans call for the closing of the unique Argonne accelerator at the end of this year. Such an action would be the equivalent to destroying Galileo's first telescope. The requirement is quite the opposite — to subsume the investigation of self-organizing phenomena in the high energy realm within the broader context of the theoretical plasma physics program we have already proposed as the core of a fusion power development plan, and to give it the full financial support required.

The benefits of such a research program will inevitably be very great. For the fusion program itself, there will be a vast increase in the sort of useful cross-fertilization of research on high energy and thermonuclear plasma phenomena which has characterized the Soviet electron beam work. But beyond this, the understanding of the nature of the subnuclear realm will be, over the long run, essential to man's conquest of the universe, to the development of interstellar flight. Above all, it will give coherence to a new scientific view of the universe, in which the same self-developing creative tendency which characterizes human thought itself will be empirically demonstrated to be an immanent quality of matter at its most primitive level.

And, of course, the quarks can be quietly returned to their original home in some bottle of old Irish whisky.

*— Eric Lerner*