United States Senate

WASHINGTON, D.C. 20510

April 15, 1985

Mr. Carlton Kammerer
Director
Office of Congressional Affairs
Nuclear Regulatory Commission
1717 H Street, N.W.
Washington, D.C. 20555

Dear Mr. Kammerer:

I am writing to bring to your attention the enclosed comments from my constituent, Ms. Phyllis Tyson.

I would appreciate your reviewing this correspondence and preparing a report on the stated problems. Please send your reply in duplicate to my state office:

Senator John W. Warner
1100 East Main Street
Richmond, Virginia 23219

My constituent and I appreciate your assistance in this matter. I am grateful for all you can do to resolve this matter within the existing laws, rules and regulations of the Nuclear Regulatory Commission.

Thank you for your time and courtesy.

With best wishes,

Sincerely,

John W. Warner

JWW/jah
Enclosure

85 Campbell, Apt. C-3
Harrisonburg, VA 22801

March 25, 1985

Senator John W. Warner
Russell Senate Office Building
Washington, D.C. 20510

Dear Senator Warner:

Yesterday (Sunday, March 24, 1985) I watched television for quite some time and at the end of day I realized it was no "ordinary" Sunday. I am very troubled over the report 60 Minutes gave to the U.S. citizens concerning the New York State nuclear plant - which took 15 years to "develop" at billions of dollars and is full of mistakes and errors in construction - thus causing EXTREME DANGER to the whole state and the HUMAN LIFE involved in that area. From what I gather, absolutely NO ONE can visit to inspect this "Government Nuclear Plant" - absolutely no one. Also, the Unions involved were full of drug addicts, corruption in using inferior metals to construct this nuclear plant, and even the contractors were "paid off". Also, whenever "anyone wanted to report this inferior construction - THEY WERE ELIMINATED or FIRED from the job. Thus, I would take it - the whole nuclear plant is like a dynamite keg waiting to explode when in use.

Whenever a person using DRUGS IS INVOLVED in any project whatsoever, you will know for positive that negative brain cells are at work: they are aimed and designed to DESTROY. It is senseless to bring this to the President's attention: he is so involved in "making friends with Unions, no matter what their 'inside motives' might be" he would simply by-pass this request as coming from "an anxious woman". There is just as much danger from such an attitude as there is in the actual partaking of construction using inferior materials.

I would like a full investigation made of this particular incident and a Bill passed concerning the NON-USE of Unions in any construction done by our Government. Also, I would like those fired from this job because they "used caring eyes" to see such mismanagement and gross negligence REHIRED WITH POSITIONS TO OPERATE THIS PLANT IF AND WHEN IT IS OPERABLE.

During one of Dr. Kennedy's sermons on Sunday he mentioned another such "incident" in construction work: I believe it was a school building where the construction of

faulty gas pipes (allowing leaks) were placed underground, and then when the building was full (this was somewhere out West in a recent accident) over 400 children and teachers, etc. LOST THEIR LIVES. One of the women afterward said to a reporter that she "knew this would happen since her husband had known about the faulty construction work" and KEPT SILENT ABOUT IT.

These people are MURDERERS - there are more silent murderers in this country and abroad than you would ever imagine. I would like laws initiated to reflect this - committees set up to inspect ANY AND ALL COMPLAINTS about faulty construction and full protection to those who do (with a Christian heart) complain about it.

Let me hear from you please, on these subjects. I am enclosing a copy of this letter to The Church. No doubt, they will "have a HAND in the rebuilding of character so that by the year 2000 we have no more of this "murder through negligence". I enclose an article which may be of benefit to you during your role as Senator for our country.

Sincerely,

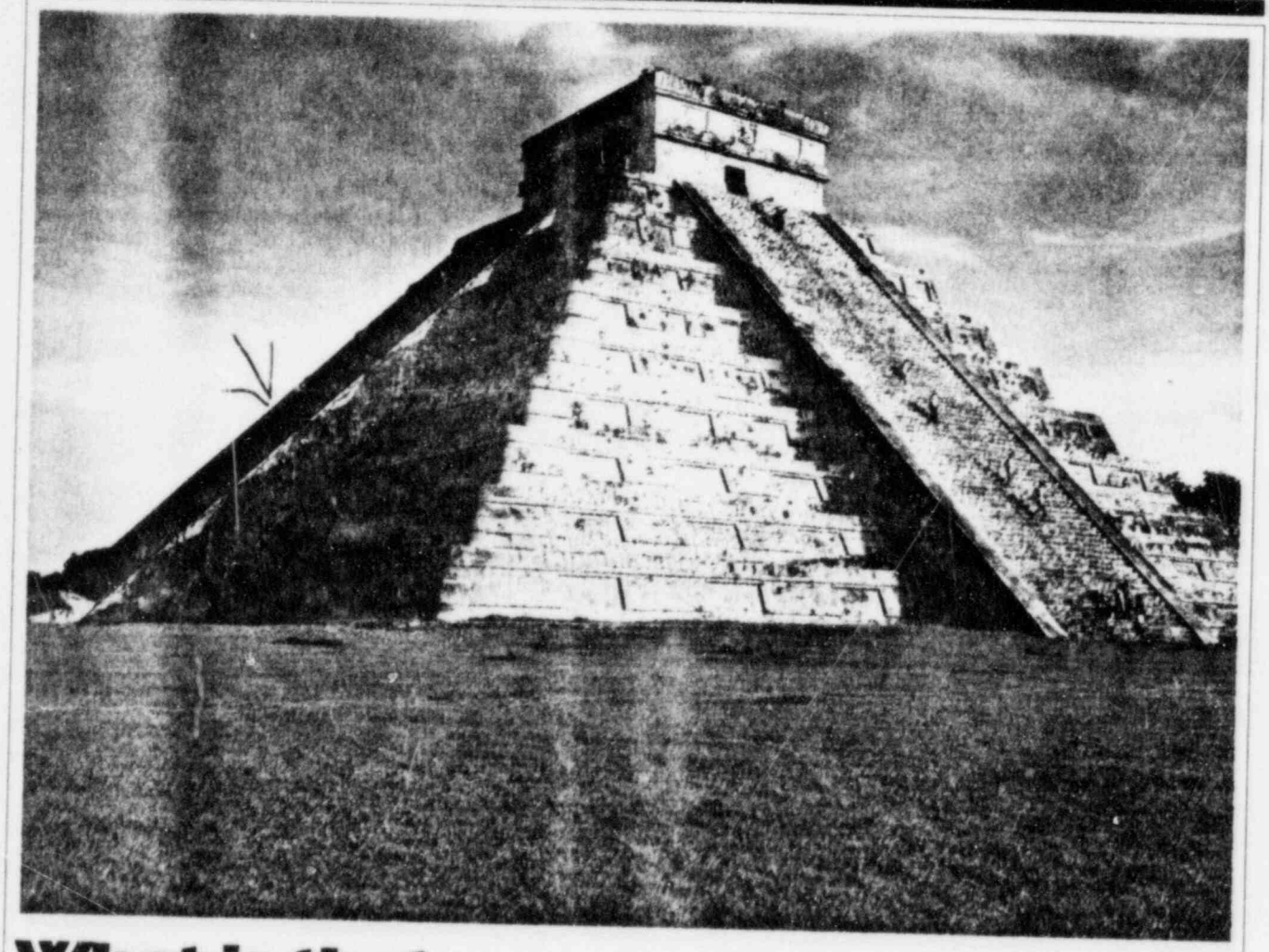
Phyllis Tyson

Phyllis Tyson

ENCLOSURE

cc: The Church

The Challenge



What is that serpent doing on that temple?

BY PIERCE G. FREDERICKS

In the color print, the snake is, indeed, perfectly outlined where indicated.

A challenge indeed!

It's his Kukulcán, aka Quetzalcóatl, the feathered serpent, was the hero-god of the Maya, and almost 1,000 years ago they built this temple dedicated to him at Chichén Itzá in Yucatán. It is so cunningly designed that twice a year—at the spring and autumnal equinoxes—the late afternoon sun picks up the edges of the terraces and turns the temple's north staircase into a vision of a writhing snake.

The calculations necessary to bring this about would be complex under any circumstances, but become astonishing when you learn that the Maya had to pinpoint the equinoxes with two calendars, neither of them accurate. The more modern had a 365-day year but no allowance for the extra quarter of a day we pick up with leap year. Over centuries, why didn't the appearance of the serpent drift away from the equinoxes? In fact, the Maya knew about the quarter day and built with it in mind, but they didn't want it in their calendars because it disrupted the way the two meshed for religious observances.

The Maya were obsessed with time, scarcely surprising among a people who believed the universe had been born and destroyed four times. To find out why our universe only has until the year 2011 and how to do addition Maya-style, turn to page 87.

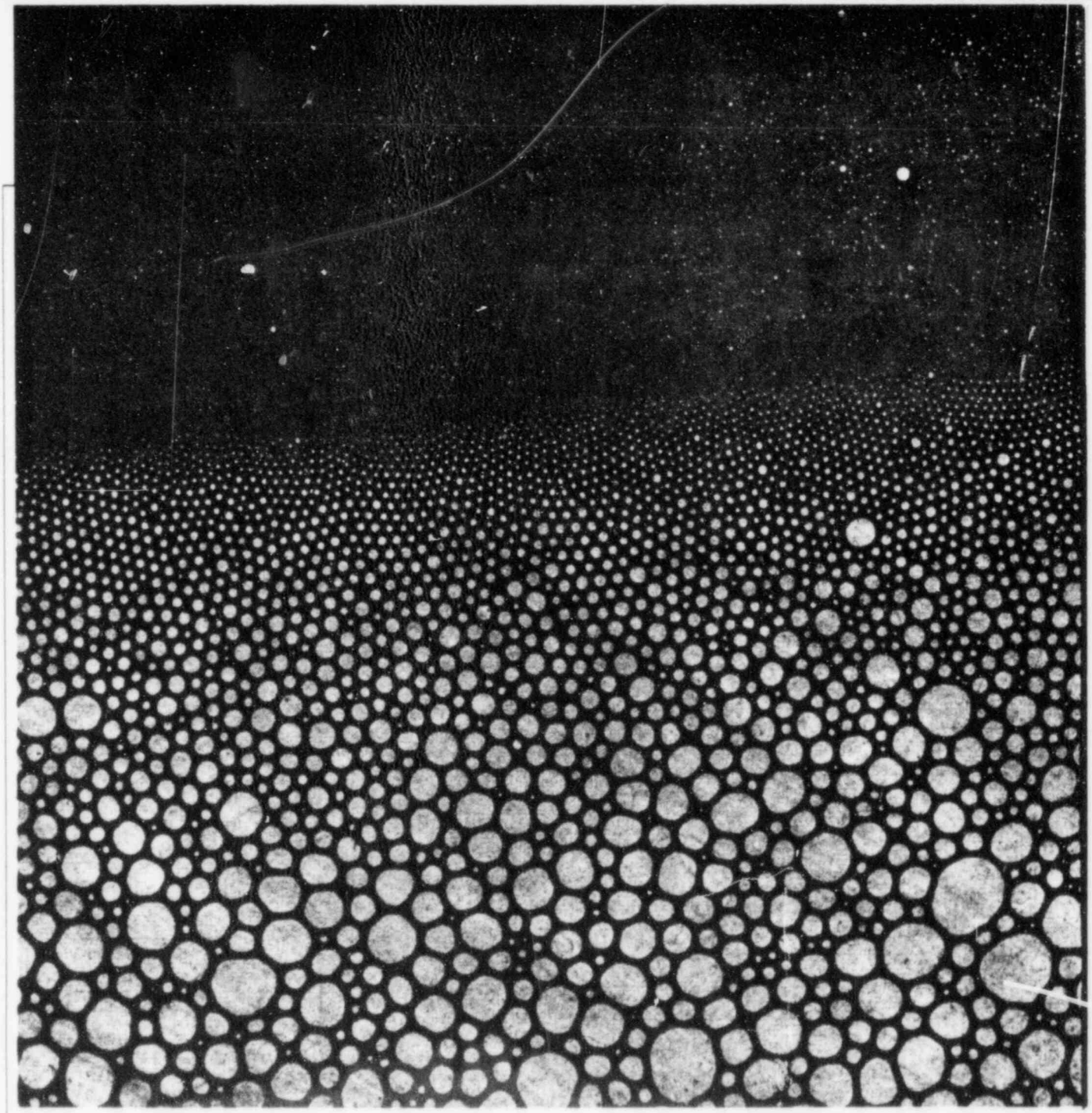
Tales of Dis

Guillen: He has long had an interest in the asymmetrical aspects of the universe.

The universe began in chaos. Then the tug of gravity arranged galaxies into highly ordered geometric patterns. Figuring out how it happened is a thorny mathematical problem; to tackle it, mathematical physicist **Michael Guillen** adapted kinetic theory, usually used to describe the motion of molecules. "I treated galaxies as if they were molecules," he says, "and the universe as a vessel." The results, he was surprised to note, turned out to be in very close agreement with the observational data.

But research is only one part of Guillen's life. He teaches physics and math at Harvard, and he successfully popularizes mathematics in as many ways as he can, seeing it as an extension of his teaching commitment. His recent book, *Bridges to Infinity*, was excerpted in our August 1984 issue. He regularly appears on television as science contributing editor for *CBS Morning News*. And he's at work on his second book, which will accompany a PBS series on mathematics this spring. If that's not enough, he's a member of a National Academy of Sciences panel on math and science education, which is due to release recommendations this spring on the direction education should take over the next 10 years.

In this issue, Guillen takes on the perpetually intriguing subject of antimatter. His article begins on page 32.

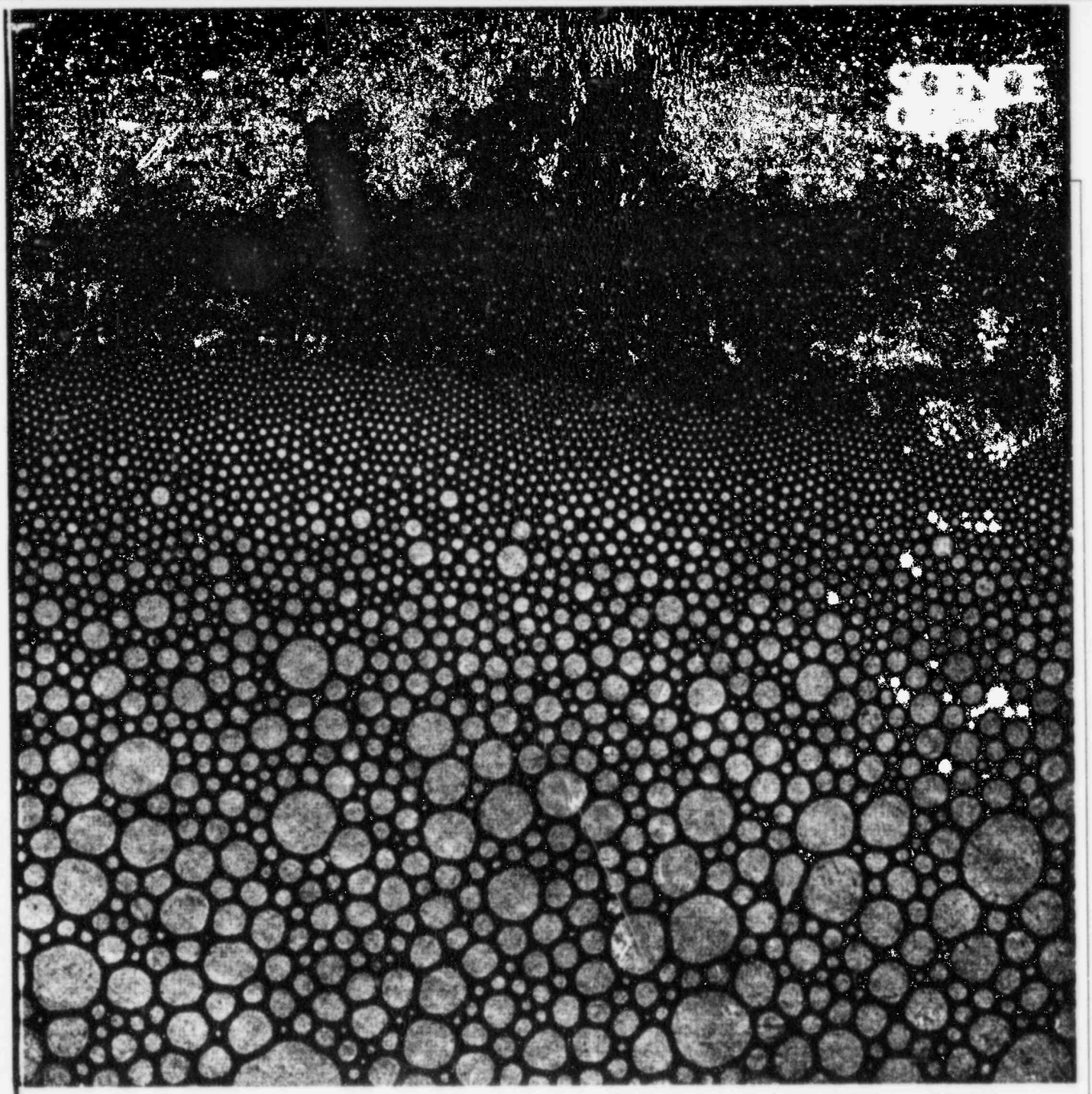


Note to Senator:
Acf drug users
begin attacking to
the Antimatter system =
body cells, brain cells
and finally personality
and spirit!

THE PARADOX OF ANTIMATTER

BY MICHAEL GUILLEN

Seeking universal symmetry, physicists are trying to find as much antimatter as matter. But they haven't. Could this mean the cosmos had an Original Flaw?



Immediately after the Big Bang, says one theory, there were 10 billion and one protons for every 10 billion antiprotons.

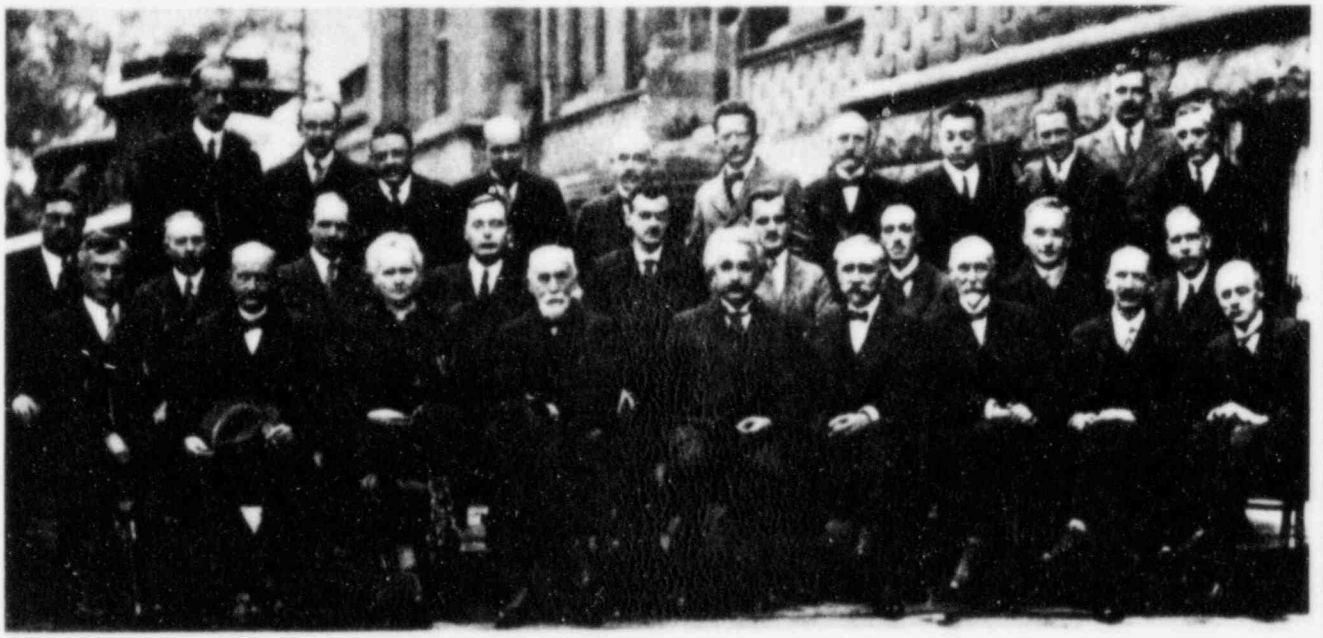
Whoever thinks a
faultless piece to see,
Thinks what ne'er was, nor
is, nor e'er shall be.
–Alexander Pope

The Italian Renaissance master Leonardo da Vinci, like most great painters, did not strive to incorporate perfect symmetry into his work, believing that to do so was unimaginative and liable to produce a dull, static-looking painting. The British Nobel laureate Paul A. M. Dirac, like most great scientists, however, sought all along to preserve the perfect symmetry of his theories and on one occasion, in 1928, was led thereby to predict the existence of an entirely novel species of matter. It has come to be called antimatter, because in some sense it is the mirror image, the photographer's negative—in short, the perfectly symmetrical counterpart—of ordinary matter. Particles of antimatter have been observed and studied extensively in atom smashers worldwide, but antimatter in bulk form has yet to be discovered anywhere in the cosmos. It would appear as though the universe is not perfectly symmetrical in the way scientists had been led to anticipate by Dirac's prediction: It looks to be made up mostly of matter, with just a sprinkling of antimatter. For the artist, this reality might make the universe all the more a perfect masterpiece, but for the scientist, it merely means the universe is all the more flawed.

For the scientist, symmetry makes for perfection, because for every way in which the universe is symmetrical, there is a fundamental law that is obeyed, and the collection of such laws is what accounts for the rational

Michael Guillen is featured in Contributors.

THE CASE OF MIND OVER ANTIMATTER



Paul Dirac (row 2, fifth from left) attended an international conference on physics in 1927, along with Max Planck (row 1, second from left, Madame Curie (row 1, third from left), Albert Einstein (row 1, fifth from left) and Niels Bohr (row 2, far right).

Although they had known since the late 1600s what basic rules nature follows on a human scale, physicists in the year 1900 had yet to sort things out at the atomic level. Becoming increasingly impatient, even desperate, some of them, including Germany's Max Planck, sought a breakthrough at any cost. "By nature I am peacefully inclined and reject all doubtful adventures," he recalled later on, but at the time "I was ready to sacrifice every one of my previous convictions about physical laws."

The decades that followed were revolutionary, giving birth not only to the theories that constitute modern physics but also to a generation of physicists whose minds cultivated ideas that in more settled times would surely have been disparaged as nothing more than wild-eyed speculation.

Preeminent among those "children of the revolution" was the late British Nobel laureate in physics Paul Adrien Maurice Dirac. Born in 1902, Dirac grew up during the very years that Planck, Einstein and others were fashioning the theories of relativity and quantum mechanics. By the time Dirac finished graduate school, the revolution was nearly complete, but not quite: It remained for Dirac to provide the finale with a revelation so bizarre that to this day it remains the stuff of science fiction.

Dirac entered the picture as a young physicist in the mid-1920s, when increasing attention was being given to the fact that the various newly wrought theories did not fully square with one another. In particular, quantum mechanics was putatively a theory about how atoms behave, and yet it was based on laws of motion that had recently been superseded by Einstein's theory of special relativity.

Dirac applied himself single-mindedly to this problem and after several years, in 1928, was the first to bring quantum mechanics into conformity with relativity theory. His achievement not only founded the subject of relativistic quantum mechanics, the basis of today's science of atomic behavior, but it also implied that, contrary to common sense, it was possible for subatomic particles to have less than no energy at all.

Throughout the history of science, it had been taken for granted that energy, like chronological age, was in the main a *positive* quantity. It had seemed as unscientific to suppose that an object could exist that had negative energy as it would have been to claim that the universe existed before it came into existence.

Given this, Dirac could simply have excluded as unrealistic the negative-energy possibility raised by his theory. To have done so would not have discredited his relativistic quantum mechanics any more than Webster discredits its dictionary by excluding nonsense words. If anything, such an expurgation would probably have *enhanced*, in some people's estimation, the credibility of Dirac's handiwork.

In fact, Dirac decided to retain the concept of negative energy and to figure out how it might manifest itself in the real world. Remarkably, his main reason for the decision was one we would normally associate with an artist rather than a scientist. "The whole beauty of the mathematics would have been spoiled [otherwise]," he told me at his eightieth birthday celebration. Besides, he recalled, "it wasn't very difficult to give these negative energy states physical meaning once you faced the problem."

A subatomic particle with negative energy, he demonstrated mathematically, could be thought of as being a kind of "anti-subatomic" particle with positive energy. It was a little like observing that an ordinary black-and-white photograph with its shading reversed would look the same as an ordinary photographic negative with its shading left alone.

It took only four years for experiments to confirm Dirac's brazen prediction and to retire a question that a colleague—another child of the revolution—is said to have posed one afternoon after listening to the radical idea. "We are agreed that your idea is crazy," he told Dirac. "What divides us is whether it is crazy enough to be true." ■

-M.A.G.

Every second, millions of high-speed protons arrive on Earth from thousands of trillions of miles away. For 20 years, scientists have monitored these cosmic rays, and the evidence is that not one started its journey as an antiparticle.

order in nature. For instance, the universe is spatially symmetrical; on the whole, it appears to look the same no matter in which direction you turn your gaze.

This means that natural processes, such as the gravitational interaction between two masses, proceed without regard to their orientation in space. Were the universe not spatially symmetrical, the Earth's orbit around the sun, for instance, would keep changing shape as the solar system rotates around the Milky Way; this would disrupt the regular succession of seasons here on Earth and perhaps even lead to extreme weather conditions inhospitable to human life. It follows that a universe that is asymmetrical in every way is an irregular, rather chaotic universe, but one that is *symmetrical* in every way is highly ordered, predictable and, for physicists at least, the picture of perfection—paradise.

The actual universe, it turns out, is anything but a scientist's paradise. The realization that it is materially asymmetrical is but the latest in a recent succession of similar realizations about the universe's other, numerous flaws. Just 40 years ago, for instance, it was known that many nuclear particles—including the proton, neutron and electron—spin like rifle bullets in flight. For years, physicists' theories predicted that within the total cosmic population of each such particle, there is an equal number of right-handed (clockwise) and left-handed (counterclockwise) spinners and that both behave identically in nuclear reactions. Then, in 1957, it was discovered that the universe is not even-handed: The radioactive decays of polarized cobalt-60 nuclei release more left-handed-spinning electrons than right-handed-spinning ones. By now, we are aware of many other instances of the universe's right-left asymmetry; the helical molecules of most life forms, for instance, are largely right-handed corkscrews.

Of course, it has long been realized that the universe is asymmetrical when it comes to time: Certain natural processes, such as human life, always evolve from the present to the future and never from the present to the past. But physicists always maintained a belief that this particular flaw in the universe's symmetry was confined to macroscopic processes and not evident in the microscopic processes of the subnuclear realm. In that realm, physicists believed, things were safely removed from the asymmetrical effects of aging and evolution. Of that belief, too, they were disabused, however, when in 1964 it was discovered that certain nuclear reactions involving a particle called the K-meson proceed preferentially in one direction of time.

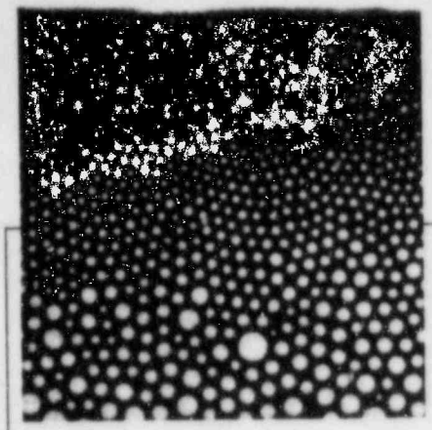
By contrast, the thesis that the universe is materially asymmetrical—preferentially composed of matter—has yet to be confirmed by any single piece of evidence that is as clear-cut and decisive as a cobalt-60 or K-meson experiment. And it is true, moreover, that in the 53 years following the first successful observation in 1932 of Dirac's predicted antielectron, or positron, physicists have observed in the debris of countless high-energy subnuclear collisions that each and every known kind of elementary particle has a corresponding antiparticle. The proton has its antiproton, the neutron its antineutron, and so forth. Nonetheless, many far-ranging field experiments—encompassing the Earth, the solar system, the galaxy and beyond—have invariably ended with the same conclusion: The universe is flagrantly anti-antimaterial.

For starters, the Earth is rather conspicuously anti-antimaterial, there being every indication that it is made purely of ordinary matter. It is known from laboratory experiments that a particle of ordinary matter and its corresponding antiparticle will completely annihilate each other upon contact, creating a sunburst of pure energy in the process. (This remarkable 100-percent conversion of mass to energy compares with the 25 percent that is accomplished in a conventional nuclear explosion and to the mere 7 percent that occurs in chemical combustion, such as the burning of coal, oil, wood or other ordinary fuels. For this reason, rocket ships in science fiction, such as the U.S.S. *Enterprise* in *Star Trek*, are often described as being powered by a mixture of matter and antimatter.) If there *were* any antimatter mixed into the Earth, therefore, its presence would be clearly signaled by the bright light caused by annihilation with matter.

Within the solar system, our various space probes have demonstrated that at least the moon, Mars and Venus are not made of antimatter; if they were, the probes would have disappeared in a blinding explosion when they touched down. In fact, though we could never tell by just looking (matter and antimatter appear the same from a distance), we can be quite certain that neither the sun nor any of the planets in the solar system is made of antimatter. The sun showers all nine planets, from Mercury to Pluto, with a perpetual solar wind of ionized matter; were the sun made of antimatter, its wind would be annihilated with a conspicuous glow when it encountered the Earth. This not being the case, the sun must be, like the Earth, made of ordinary matter. And likewise, since none of the planets is awash with the glow of matter-antimatter annihilations either, it follows that the whole solar system is made of ordinary matter.

From just beyond the Milky Way galaxy, cosmic rays have brought us a

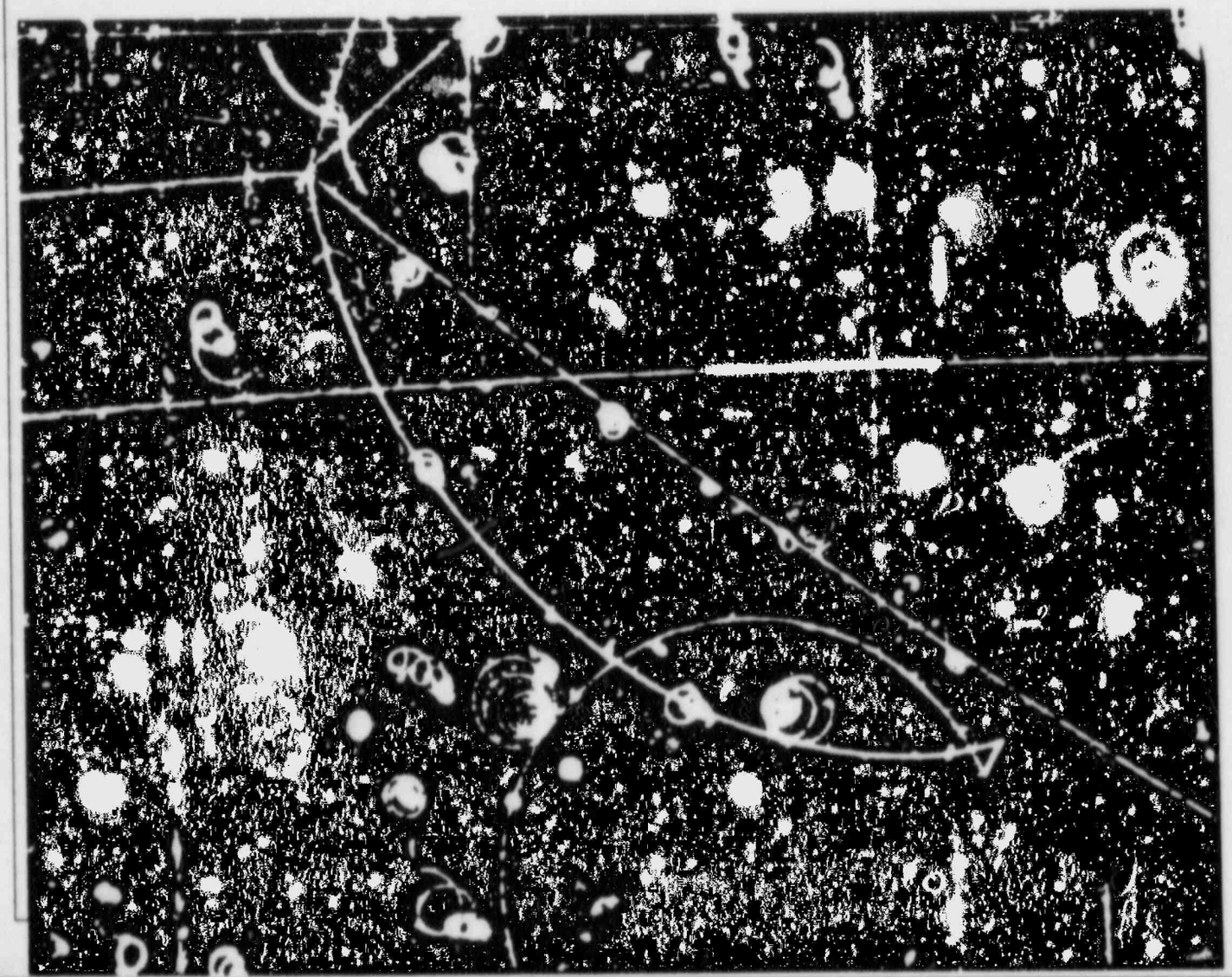
PHOTOGRAPH BY BILL LONGCOR/SCIENCE SOURCE/PHOTO RESEARCHERS



Today, pretty much all that is left of the enormous original population of protons and antiprotons is the excess number of protons. Literally, it seems, the universe is made up of leftovers!

similar message about the interstellar universe. Every second, millions of high-speed particles—mostly protons—arrive on Earth from thousands of trillions of miles away. For over 20 years now, physicists have been monitoring these transient samples of the galactic and extragalactic environment, and the evidence is that not one of these cosmic rays started its journey as an antiparticle. The one in 10,000 that do arrive at the Earth's upper atmosphere as antiprotons are thought to have been created, en route, from high-energy collisions of protons with the tenuous fog of gas and dust that fills interstellar space. Regrettably, we cannot be certain exactly what region of the interstellar environment we are sampling with these cosmic rays, because we cannot extrapolate these paths backward in any simple fashion to discover their points of origin: Most cosmic rays wend their way to Earth along twisting and turning paths, following a cosmos-wide network of magnetic-field lines like so many high-speed trolleys. But since cosmic rays come to us from all directions, whatever we *are* sampling with them must be ubiquitous and very anti-antimatter.

For regions of space well beyond the scale of our galaxy, the most compelling evidence for the universe's material asymmetry is embodied in the light emitted by clusters of galaxies. These gargantuan collections of galaxies are to astronomy what molecules (collections of atoms) are to chemistry; one of them can encompass upward of 100 trillion trillion trillion trillion trillion cubic miles of space and over 15 trillion trillion trillion tons of material. However, less than 0.1 percent of that material is



antimatter, judging from the small quantity of annihilation-associated light that such clusters emit.

All in all, this implies that no more than one in 1,000 or one in 10,000 stars in the universe may be made of antimatter. Considering that normal stars are separated by an average of 30 trillion miles, it works out that the nearest antistar would lie no closer than 600 trillion miles away. Now, while it has not been in their hearts to fully acknowledge the cosmic flaw revealed by these astrophysical observations, physicists for some years have had little choice but to incorporate it into their most preferred model of the universe, the so-called standard Big Bang model. According to this model, the universe we see today is the aftermath of a seminal explosion that happened 10 billion years ago. Galaxies are moving away from one another—like shrapnel immediately following an explosion—even as the physical boundary of the universe itself is receding, thereby creating ever more space into which the galaxies can expand.

The model stipulates that before the Big Bang sent it flying in all directions, the material of the universe existed all in one place, a quivering point-mass of infinitely high density and temperature, just waiting to explode. Under these stressful conditions, the material existed in its most elementary, indivisible forms. With our present understanding of subnuclear physics, it is impossible to predict what forms these were, but it has usually been supposed that they included light of various frequencies and some half a dozen kinds of elementary particles, along with their corresponding antiparticles.

Corresponding kinds of antiparticles, that is, *not* corresponding numbers. To account for the material asymmetry of today's universe, it has been necessary to presume that the universe was materially asymmetrical, flawed, from the very beginning. According to the standard Big Bang model, the Original Flaw, as it were, was rather subtle. Immediately following the Big Bang, it amounted to there being 10 billion and one protons for every 10 billion antiprotons.

Subsequently, however, the flaw grew to its present obviousness as protons and antiprotons annihilated

Continued on page 81

In a bubble chamber, a proton collided with a pi-minus particle (bottom right), producing an electron, which spiraled clockwise, and its antimatter counterpart, a positron, which sped counterclockwise.

ANTIMATTER

Continued from page 37

one another. Today, pretty much all that's left of the original population of protons and antiprotons is the excess number of protons—literally, the universe we now see is made up of leftovers!

Although the standard Big Bang model is able to account this easily for the universe's material asymmetry, it has never been able to explain with similar ease the cause of the Original Flaw. What manner of imperfection or imbalance in the embryonic universe could possibly have been instrumental in bringing into existence one extra proton for every 10 billion perfectly matched proton-antiproton twins?

Possible answers to this puzzling question have been forthcoming throughout the past 15 years, but one of the most elegant of them has only recently turned up in the widely publicized Grand Unification Theories (GUTs) of particle physicists. For decades, physicists have noticed that only four kinds of forces do all the pulling and pushing in nature. Two of them—the gravitational and electrical—call the shots in most processes that range from the atomic on up to the astronomical realm. The other two—the weak and the strong forces—hold sway over most processes from the subnuclear realm on down. Having learned on other occasions that things can behave very differently and, nonetheless, be fundamentally the same (the chemical elements, for example, which are all one thing—atoms), physicists have wondered whether the four forces are but four varieties of a single force.

> The universe acquired its Original Flaw, calculations indicate, within the first 10^{-36} second of time.

The GUTs are an important theoretical development in this matter, in that they depict the electrical, weak and strong forces as members of a single family (for reasons ill understood, the gravitational force does not fit the family mold). Under normal conditions, like those that prevail in today's universe, the member forces act individualistically and are perceivable as three distinct forces. However, under conditions as severe as those imputed to the embryonic universe by the standard Big Bang model, the family members pull together, as it were, and behave as a single, unified unit. Under these conditions, the electrical, weak and strong forces become one and the same force—one so exceedingly formidable that it is able to convert matter into antimatter and vice versa, yet one whose overall effect, it so happens, is slightly different on matter than it is on antimatter.

This asymmetry, this imperfection in the nature of the unified force, many astrophysicists now believe, engineered the Original Flaw, the original one part in 10 billion excess of matter over antimatter. In the beginning, they imagine, the universe had precisely equal quantities of matter and antimatter; it was, in this respect, a physicist's paradise. Under the symmetry-corrupting influence of the unified force, however, slightly more of the antimatter was converted into matter than was converted back again into antimatter. In this fashion the universe acquired its Original Flaw, calculations indicate, within the first 0.000000000000000000000000000000000000000000001 second. So short a time is this in which paradise was lost that, by comparison, biting into an apple, say, lasts an eternity.

For many astrophysicists, this particular explanation of the Original Flaw is appealing insofar as it satisfies their preference for a universe that was initially perfectly symmetrical, even if only fleetingly and somewhat ambiguously so (given the asymmetrical nature of the unified force). However, if and when this explanation ever does become a permanent feature of the standard Big Bang model of the universe, it will only be after the Grand Unification Theories themselves are substantiated by considerably more evidence.

In the meantime, scientists desirous of a universe that is perfectly symmetrical might do well to consider the centuries-old gate that stands in the Japanese city of Neiko. It is perfectly symmetrical except for one almost insignificant detail: A small figure on the gate's left pillar is carved upside down on its corresponding right pillar. With this asymmetry, the gate's artisans believed, their work would not evoke the jealousy of the gods.

Artistry of Asymmetry

Apparently, in all the years it has stood, the gate has not attracted the envy of anyone except, perhaps, other artists. By many, it is regarded as the most beautiful gate in Japan. For if the asymmetry has detracted from the gate's scientific perfection, it has not detracted, and has even enhanced in some ways, its stature as a work of art. And so it is with the cosmos. If God designed the universe, then more than His humility is represented in its material asymmetry—so is His artistry. ■

For Further Reading

The Moment of Creation,
by James S. Trefil. Scribner's, 1983.
The Forces of Nature, by P.C.W. Davies. Cambridge University Press, 1979.
The First Three Minutes,
by Steven Weinberg. Basic Books, 1977.