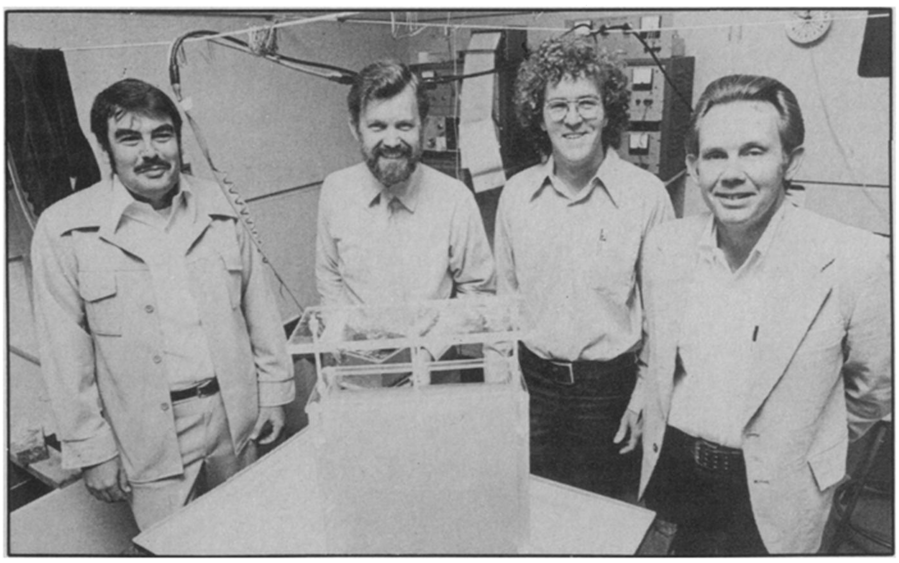
Apparent discovery of long-sought monopole:



Illustrations U. of Calif./Berkeley

Physicists Pinsky, Price, Shirk, and Osborne: A very strange track in the Lexan stack.

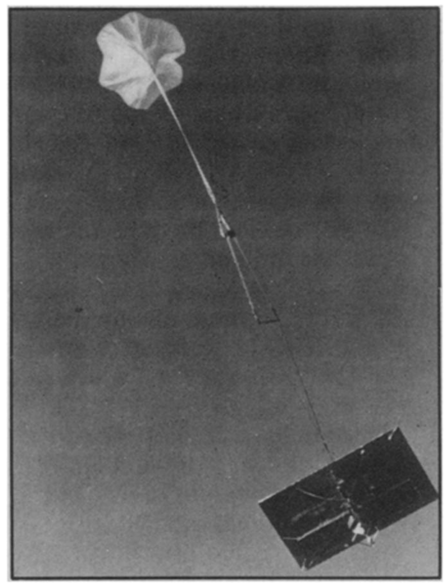
Symmetry and reciprocity are esthetically and philosophically important aspects of physical phenomena. Nature is often messy, and physicists don't always find symmetry and reciprocity so they are especially satisfied when they do. These qualities make natural phenomena particularly pleasing and tractable to theorists.

Electricity and magnetism are related phenomena—electricity tends to cause magnetism and vice versa—and in the 200 years that electricity and magnetism have been studied, physicists have found that every electrical effect has a magnetic analogue and every magnetic effect an electrical analogue save one. Electric charges are frequently found in monopoles, items with either positive or negative charge (example: electrons and protons). But magnetic poles, like book ends and foo dogs, always came in pairs. The most elementary magnet always had one north and one south pole. Cut it in half and you got two new magnets each a dipole and not separated north and south poles.

Now that defect has been remedied—assuming that a remarkable claim reported to the public two weeks ago by a group from the University of California at Berkeley and the University of Houston and published in the Aug. 25 PHYSICAL REVIEW LETTERS is true. The four physicists, P. Buford Price and Edward K. Shirk of Berkeley and Weymar Zack Osborne and Lawrence S. Pinsky of Houston, say they have found a magnetic monopole among the cosmic rays.

The word "revolutionary" is almost too hackneyed to use, but the discovery is certainly that. If confirmed—and confirmation is essential—it will rank among the most momentous achievements in the history of physics. It will bestow on Maxwell's equations, which are the summary statement of classical electromagnetic theory, a symmetry they did not have when they were formulated 110 years ago, open a new realm of particle physics, require a supplement to quantum electrodynamics, render impossible the discovery of a free quark, and, if monopoles can be manufactured in numbers, lead possibly to interesting technological developments, including new propulsion mechanisms and new therapy for tumors.

The discovery confirms a prediction made in 1931 by P. A. M. Dirac, then of Cambridge University in England, now of Florida State University. From Benjamin Franklin's day to Dirac's, physicists had accepted the imbalance between electricity and magnetism on the ground that magnetism is a secondary or derivative effect. Electricity was primary, according to the general view, and electric charges, positive and negative, as Franklin named them to everybody's subsequent confusion, were physically real. Magnetism was a force field produced by moving electric charges, electric currents. By the topological nature of things, the magnetic field lines had to form closed loops around the electric currents or interlaced with them where the electric currents were circular. In consequence any physical magnet had to exhibit at least two poles, a north pole where the field lines exit and a south pole where they reenter, completing their loop inside the bar. You cannot have single magnetic poles on which the field lines simply end as they do on electric charges. In fact, while electric charges are physically real, magnetic poles tended to be regarded more as geometric artifacts, simply the places where the field lines left a solid piece.

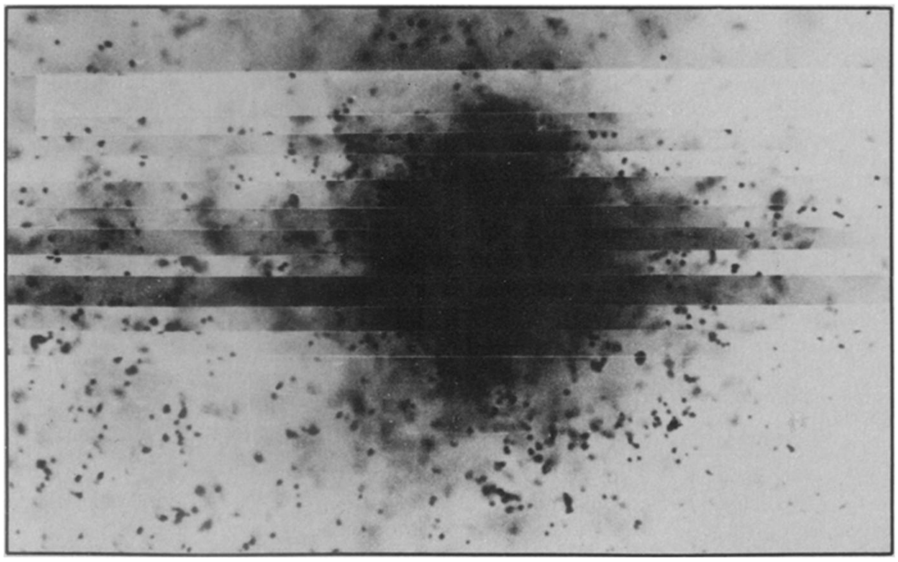


The detector floats aloft over Sioux City.

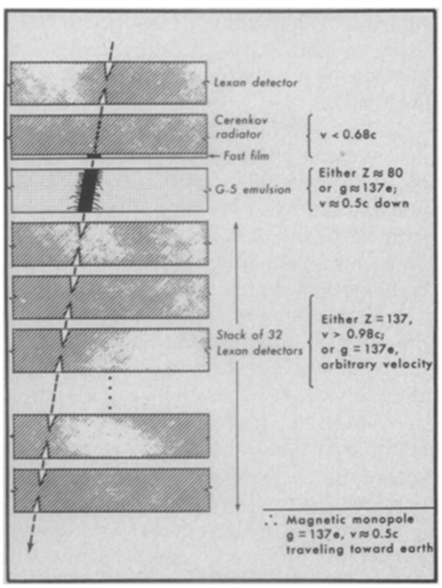
There were always people who wondered why magnetism wasn't also primary and equal in status to electricity, why there couldn't be magnetic charges that would form magnetic currents and generate secondary electrical effects. Dirac was led to espouse the reality of magnetic monopoles through one of the basic aspects of his thought that demanded that kind of a symmetry in the quantum mechanical realm. Dirac is a theorist's theorist, who has led physics into some unusual places—he is, for example, the original theorist of antimatter—and much of his work has been related to a thread that has run through his thinking for the half century of his activity, namely a desire to find relationships among the fundamental entities of physics, such as the basic unit of electric charge, and the fundamental constants (Planck's constant, Newton's universal gravitational constant, the fine-structure constant) that continually reappear in the basic equations of physics. Such relationships, Dirac has repeatedly said, are capable of profoundly illuminating physics and cosmology.

It was such a relation that led to the prediction of the magnetic monopole. If there existed a magnetic monopole, then he could set up a reciprocal relation between its magnetic charge, the basic electric charge unit (the charge on an electron), the velocity of light and Planck's constant. The relationship immediately shows why electric and magnetic monopoles have to be quantized. If only the electric monopole exists, there is no

‘Controlled excitement’



Lack of a halo around the track in the photographic emulsion indicated low speed.



Track, with deductions from each section.

apparent reason why it should be quantized, yet its quantization is an experimentally verified fact. If both monopoles exist there is no way for them not to be quantized. Needing the monopole, Dirac postulated its existence. From his figures he could predict that its magnetic charge would come in integral multiples of a basic unit, 68.5 times the electron's electric charge.

Dirac's postulation was taken seriously enough to provoke searches from time to time. Monopoles were expected to be long-lasting particles. Their nature would make it difficult or impossible for them to decay into other elementary particles (which are mostly electrical in nature—if there is independent magnetic charge in nature, it ought to be as well conserved as electric charge), and so if monopoles attached themselves to something magnetic, they ought to last for eons. It was reasoned that they might attach themselves to minerals in the earth or on the bottom of the sea or on the moon. In the air they might stick to oxygen molecules, which are slightly magnetic. Monopoles might be created in accelerator experiments if their mass happened to be less than the energy the accelerator disposed of. They might also be created in the interactions of cosmic rays. They have been looked for in all those places.

The monopole searchers have always been a tiny minority of physicists. Many prominent physicists have considered the whole idea extremely farfetched, and it would be easy to embarrass several of them by assembling disparaging quotes from years past. Except that it might not embarrass them—at least not yet. This discovery needs confirmation, abundant confirmation, before it will overcome the ingrained skepticism of many of the certified pundits.

The jackpot—if it is a jackpot and not three lemons—came in a cosmic-ray experiment. A balloon carried into the upper atmosphere a detector composed of a special photographic film, a photographic emulsion and a stack of 33 sheets of a special Lexan plastic. Cosmic-ray particles passing through the Lexan cause damage and dislocations, and the tracks of this damage can be brought out by an etching process. From the developed tracks the physicists can determine the electric and magnetic characteristics and the masses of the particles that made them.

The particular flight was made in September 1973 over Sioux City, Iowa. For two years the many tracks in the detector were examined one by one. The unusual one was spotted on July 21 of this year. Julie Teague is credited with finding the event in the emulsion and Walter Wagner first saw the etched cones in the Lexan and measured their length.

The film indicated that the particle had a speed no greater than 68 percent that of light. The emulsion track could have been made by a nucleus of atomic number 80 or a particle of magnetic charge 137 with a velocity half that of light. From the tracks in the Lexan it could be determined that either the particle had a speed very nearly that of light and an atomic number of 125 (far beyond the heaviest of the heavy elements anybody is looking for), or it was a magnetic monopole with a magnetic charge of 137 and an unknown velocity.

On the whole, the low velocity seemed the better option, and that leads to a high mass estimate. Any ordinary particle with a velocity half that of light would have been stopped in the plastic, but this one went through all 33 sheets. That means its mass has to be more than 200 times the proton's (or about 200 billion electron-volts or more).

"These facts," the team members conclude, "strongly favor identification of the particle as a magnetic monopole with a charge of 137 and a mass greater than 200 times that of a proton, traveling at a velocity roughly half that of light."

"From any piece of evidence," Price says, "you might conclude a different particle passed through our detector. But all the findings put together force the conclusion that it was a monopole. There is no other known explanation."

Confirming experiments will require extensive balloon flights and considerable money, so they are likely to proceed slowly. Steve Ahlen, one of the graduate students involved, rates the response of other scientists as "from very skeptical to sort of hopeful. It's not like anybody's rushing around saying: 'Aha! They've found a monopole.' " All alternatives must be checked out.

Ahlen points out that though his group believes they have found a monopole, Luis Alvarez, also of Berkeley, has done several careful experiments of a different kind (trying to pull monopoles out of mineral samples) and not found any. There must be a reason why, and if the present group's claim is true, the explanation most likely will involve a reassessment of some of the properties scientists thought monopoles should have. Many problems have to be sorted out, Ahlen says, but still there's a "controlled excitement."

The magnetic charge of the supposed monopole fits neatly with Dirac's prediction, being twice his basic unit. The mass is more than he would have expected, but mass estimates are always the weakest links in theoretical predictions of new particles.

The mass is, in fact, somewhat fantastic for a single particle. Only the heaviest atomic nuclei surpass it, and they contain hundreds of particles. The heaviest particles that accelerator experiments have so far found are around four billion electron-volts.

The mass, of course, explains why accelerator experiments have never found monopoles. No existing accelerator can apply that much energy to the creation of new objects. However, if the mass is not much over 200 billion electron-volts, then, when and if colliding-beam facilities are built to take the fully accelerated protons of the world's two biggest accelerators (400 or maybe 500 billion electron-volts), there may be a capability of producing monopoles in them. Provided other factors don't supervene.

And other factors may. One of the questions Price raises is why other searchers with greater collecting power but different techniques failed to find monoples. Is there something about them that prevents them from being trapped in ferromagnetic solids? Do they interact with matter in such a way as to create other, more elusive particles? There may be more to their nature that makes them hard to produce and keep than the energy requirement.

Another big question is theoretical. Quantum electrodynamics is the theory that describes electromagnetic phenomena in the subatomic microcosm. But its technique works for objects that have a fairly weak interaction to other matter. Monopoles would interact very strongly with other matter, so new theoretical developments would be necessary to deal with their interactions.

Assuming that theory can be patched up and monopoles made and kept in copious numbers—very big ifs—a number of practical results might follow. There might be a whole family of magnetically charged particles for particle physicists to become interested in and from which they could learn very fundamental things about nature. Monopole accelerators could be made using magnetic fields to energize them at much smaller size and cost for the same energy than electric-particle accelerators, and monopoles could then be used as probes in particle physics.

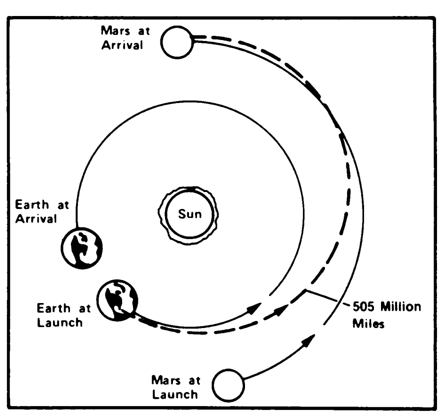
Monopole currents could be used in practical devices, especially motors and propulsive devices, and monopoles guided by magnetic fields might deliver energy for the destruction of tumors more efficiently and with less damage to healthy tissue than other options. All this is beginning to sound like science fiction come true, and someday it may. But if it is in the future, it's a long way down the pipe. Readers would be ill advised to rush out and buy stock in magnetic monopole manufacturing and mining companies. □

Viking off to Mars for historic landing

Mars ho! Viking is on its way. The dual-purpose spacecraft—one section will orbit the planet while the other lands on the surface—was launched from Florida's Kennedy Space Center on Aug. 20, nine days past its original Aug. 11 departure date. The National Aeronautics and Space Administration described the launch as "very clean," auguring well for a mission that will really begin when the spacecraft goes into orbit around Mars next June 19, one to three days later than its first-planned arrival. The remaining Viking, similarly delayed because it must use the same launch pad, was reset to take off on Sept. 1 (instead of Aug. 21), but it should still arrive on the originally scheduled Aug. 7, 1976.

The first of the problems that caused the delay, discovered barely three hours before the scheduled launch time, could have been disposed of in 24 to 48 hours. With that work underway, however, one of the batteries on the orbiter was found to be undercharged due to a faulty switch, leading NASA to decide to take the whole spacecraft down from its rocket and replace it with the Viking that would have been launched second. To save time, because a few more days' delay in launching would have meant an even longer delay in reaching Mars, the space agency bent one of its fundamental rules by allowing the spacecraft to be interchanged without first removing the half million pounds of fuel from the rocket on the pad. Time was doubly critical because early in November 1976, the movements of earth and Mars in their orbits will put the sun between them, cutting off communications for about a month, and Viking officials want the main part of the mission out of the way before then.

A minor question was whether the first launched lander would still be able to touch down on the Martian surface on July 4, 1976, as a bit of bicentennial bravado. Mission scientists have estimated that it will take 18 days for the orbiter to reveal whether the landing site, at the region



Martin-Marietta

Viking's 10-month flightpath to Mars.


NASA

Titan-Centaur booster lofts Viking.

called Chryse, is both safe enough and scientifically acceptable, but a shorter period may turn out to suffice. "I don't consider the Fourth of July all that sacred," says project manager James Martin. "We're going to land when we're ready to land." But, he adds, "I personally would not like to wait in orbit if we are ready."

Unlike several other NASA interplanetary missions, Viking does not have a list of extra scientific tasks such as astronomical observations to perform en route, so most of the direct concerns during the 10-month, half-billion-mile journey will be matters of engineering and navigation. The huge Viking scientific team, however, has been building up steam for years, and many of the specially built offices and laboratories at Jet Propulsion Laboratory in California, from which the flight is being controlled, will be occupied well before the two spacecraft reach their destination.

One of their major concerns, of course, is Viking's upcoming search for life—the first such on any planetary probe to date. But even without the quest for Martians, the mission still represents an unprecedentedly wide-ranging study of another world. At Kennedy Space Center a few days before the launch, about 150 scientists gathered for the third in a series of annual Mars symposia, and the overall topic was not biology, but the Martian atmosphere. (Biology was the star of the first meeting in the series, followed last year by discussions of Martian geology.)

But even at an atmosphere-oriented symposium, the intriguing possibility of life crept in. There are enough favorable and unfavorable data to keep even blasé scientists eager with anticipation. "It's not as though I don't have plenty to do," says a member of Viking's army of biologists, "but 10 months is a long time in some ways." □