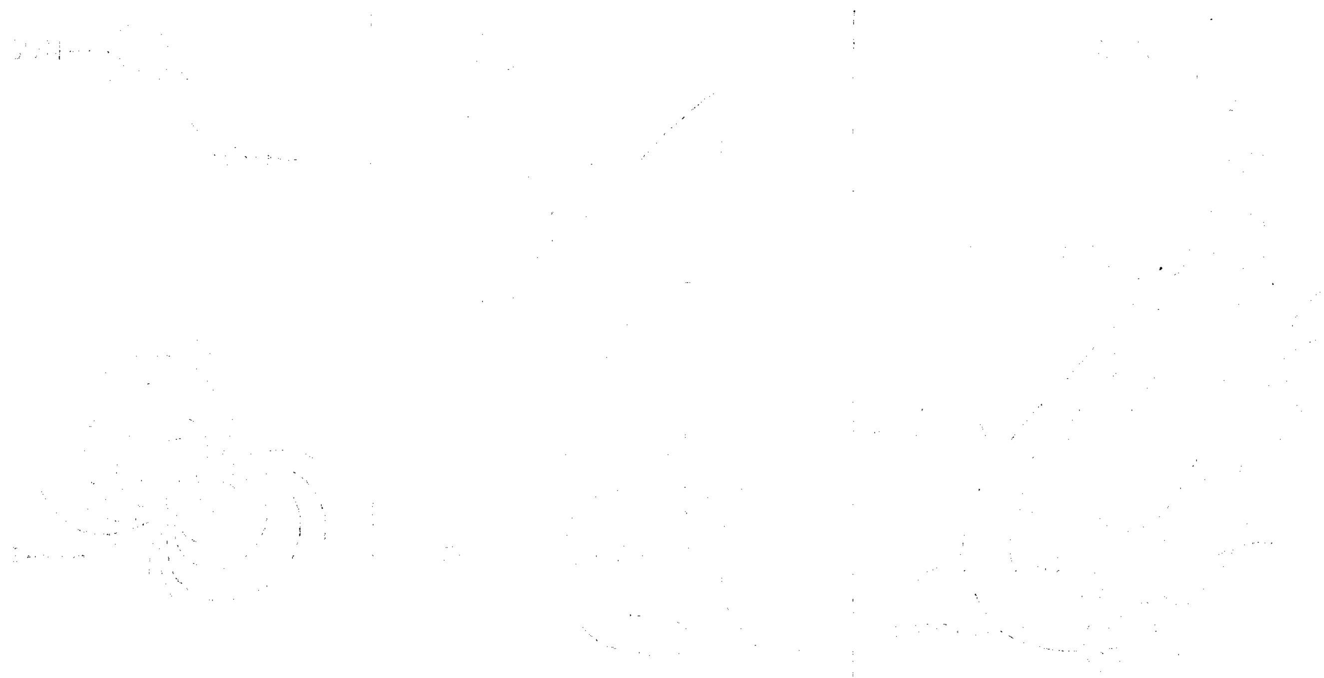
*The Magnetic Family*

# HOW FATHER SUN WOOS MOTHER EARTH

***A Most Energetic and Fruitful Relationship Is Beginning To Be Understood***



**The wherewithal of life and warmth are transferred in this fashion across 93,000,000 miles of space**

WE know that the surface of the sun boils and bubbles actively, from time to time ejecting huge clouds of charged particles and streams of X-rays into the space between the sun and the planets. These solar eruptions are known as flares. If the flares occur in the right position on the sun's surface, the clouds of charged particles travel across space to collide with our atmosphere.

Although the energy carried by these solar particles averages less than one millionth of the energy radiated by the sun in the form of visible light, and their effects are usually not noticed by the man in the street, they can, nonetheless, be very important. They produce communications blackouts, magnetic storms, and auroral displays; and they also produce violent changes in the intensity of the Van Allen belts, which are apparently related, in a manner not yet clearly understood, to other atmospheric effects.

The entire matter of sun-earth relationships, including the formation of the Van Allen Belts and their possible role in geophysical phenomena, is at the moment the most exciting and fruitful field of space research.

In the great flares of 1960 we obtained for the first time an understanding of the complete sequence of events during one of these eruptions. These were the flares of March, September, and November of that year. At various times during these events we had the Explorer VII satellite in orbit near the earth, the Pioneer V spacecraft out in interplanetary space, and a large number of experimenters simultaneously taking observations on the ground.

The combination of the space flight data and the ground observations revealed a fascinating picture. It appears that a tongue of plasma, i.e., of relatively slow-moving charged particles, erupted from the surface of the sun at the site of the flare, and moved out across interplanetary space at a speed of about 1,000 miles per second. At this rate it took the plasma cloud about one day to reach the earth. The cloud dragged with it lines of solar magnetic force, which were frozen into the cloud and forced to move with it by the laws of electro-magnetism. These lines of magnetic force had their roots on the surface of the sun in the vicinity of the flare, but as the plasma tongue moved across space the magnetic lines were drawn out with the plasma like loops of taffy.

When magnetic force lines become distended in this manner they lose their strength. By the time these lines reached the earth they were some 500 times weaker than they were at the surface of the sun. However, the magnetic field within the plasma tongue was still sufficiently strong to screen the earth partially from the cosmic rays which normally bombard the planet.

—ROBERT JASTROW,
in "NASA's Scientific
and Technical Programs,"
(U.S. Gov't Printing Office, $1.50).

EDITOR'S NOTE: *Dr. Robert Jastrow is chief of the theoretical science division of the National Aeronautics and Space Administration. He points out that whereas his report above was written after the facts were established, what is written below was written when only a few tentative observations were available. Consequently, it ranks as a brilliance of intuitive science.*

IF COSMIC rays can be excluded from a certain region, it follows that they can also be confined in that region if they are produced inside it. Particles



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*could* be generated at the sun and caught in orbits similar to the trapped orbits of the Van Allen layer.

In such a model it is possible to have particles moving through the vicinity of the earth on steep-pitched spiral orbits in which they may be stored for a long time.

There are a few occasions, perhaps five in all, on which particles of *cosmic-ray energy* are known to have come from a large solar flare. In at least one of the five, the flare of February 23, 1956, which was also the best documented, particles with a momentum of 30,000,000 electron volts arrived directly, followed by particles of somewhat lower energy, with momentum of 10,000,000 electron volts. The less energetic particles continued to arrive for some hours after the flare, and apparently from all directions in the solar system.

IT is beyond any reasonable doubt that particles of subcosmic-ray energies have come from large solar flares with time delays of the order of an hour and that they show storage for a matter of many days, certainly four and possibly seven or eight days on occasion. These particles, by showing the very long storage, make it possible to observe a propagation to the earth in two different ways.

The particles can propagate at their own speed on their spiral orbits from a disturbance on the sun to the earth, provided that the magnetic field configuration in the intervening space is suitable. They will have very small radii of gyration, so that unless the field is exactly suitable they will not hit the earth from a particular disturbed region on the sun.

At lower particle energies, the probability for reaching the earth directly from a particular disturbance on the sun diminishes. Another method of propagation then becomes possible: on or near the sun a certain storage region, [a magnetic bottle, like that sketched on page 42] of plasma and magnetic field is filled with these low-energy particles, and a part of that storage region expands with the motion of the gas so as eventually to include the earth.

THUS we have the possibility of an indirect method of propagation, in which the particles do not come to us at their own travel speed but rather at a speed dictated by the comparatively slow expansion of the gas moving and carrying the magnetic field with it. Such particles are merely stored and gain access to the earth later, depending on the travel time of the gas.

This indirect method of propagation will become more and more probable as we go to lower particle energies. On general grounds one would expect that the sun is more frequently able to make the lower-energy particles than the higher ones.

SINCE the discovery of the radiation zones by Van Allen, it is tempting to speculate that the low-energy particles are often fed into the storage region around the earth by the same processes that stir up the magnetic field of the earth and make a magnetic storm.

Perhaps we are observing the effects of a continuous spectrum of solar particle energies, and we are finding that the most energetic ones can come to us only by the direct channel, and the less energetic only indirectly. The particles of very low energies cannot enter the earth's field by any means, but we can see them get in when the field is disturbed by plasma motion, that is to say, by magnetic storm disturbances. Thus we span, possibly with the same intrinsic solar spectrum, all of the phenomena, from the cosmic-ray outbursts on the sun to the supply of the Van Allen layer by the particles producing the magnetic storms.

Such a point of view requires that the particles injected at the outer edge of the Van Allen zone be able to diffuse thoroughly through the zone. If the particles are supplied in an outer arc, they must later be able to appear on inner arcs. The lifetimes of these particles, once they are in captured orbits, may be very long, and therefore the rate at which they have to be diffused is not necessarily very high, but they must be able to get around.

THE region in the vicinity of the earth in which the earth's magnetic field dominates all dynamical processes might be called the "magnetosphere." The laws of motion of ionized material in the magnetosphere are greatly affected by the fact that the entire magnetospheric conducting region is separated from the conducting earth by the insulating sheath of the nonionized dense atmosphere.

Therefore we have no right to assume an intrinsic stability of the material on one particular tube of force or on one particular surface of revolution of a tube of force around the axis as we would if those lines of force were anchored in a conductor. Because of the intervention of the insulating atmosphere, however thin, the conducting material on one line of force can completely change places with material on another line of force.

—THOMAS GOLD,
in "The Exploration of Space,"
edited by Robert Jastrow
(Macmillan, $5.50).


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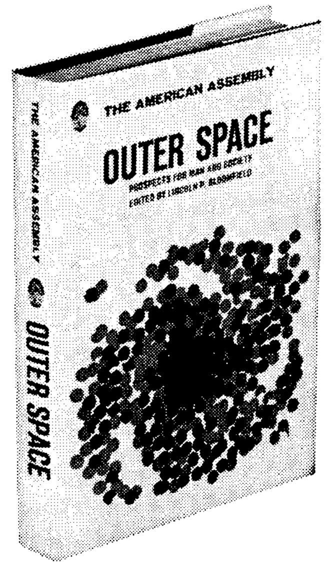


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# THE RESEARCH FRONTIER

**WHERE IS SCIENCE TAKING US?** *In the realm of magnetism, one direction is clearly pointed by Nobel laureate Albert Szent-Gyorgyi in his elegant little book, "Introduction to a Submolecular Biology." He tells how he started his own researches in histology, found cells too complicated, took up physiology, found physiology too complex, turned to bacteriology, found bacteria too complicated, and turned to muscle. After twenty years of studying muscle, he still couldn't understand the fundamental workings of muscle without first understanding the processes through which the energy of electrons is transferred. He is now engaged in meticulous examination of the relationship between electron charge transfer and growth. Recently he published, in* Proceedings of the National Academy of Sciences, *what time may prove to be the beginning of a table of elements for cancer. The table correlates the strength of positive and negative charges of specific chemicals with the known relative abilities of those chemicals to trigger malignant growth.*

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THE literature of bioclimatology is replete with attempts to relate psycho-physiological disturbances in the human population to various physical parameters of the environment. Recently, considerable interest is being expressed in the possible effect of air ionization in this regard. Relatively few papers of note have been published on the possible relationship of magnetic fields to these parameters. Two major objections have been raised to all of these studies. First, the mechanism of action is completely unknown since no known physiological system exists to be influenced by such physical parameters. Second, the naturally occurring magnitude of change in the physical parameter is generally much less than that noted to result from common, manmade disturbances (e.g, the magnetic and electrical fields produced by sixty cycle alternating current electric power).

Within the past few years, however, evidence has been presented which has a direct bearing on the validity of these objections regarding particularly geomagnetic force fields. The presence of free radicals, semi-conductors, and conduction bands has been demonstrated in a variety of physiologically important systems. Some evidence has been presented for an organized neural control system in vertebrates based upon similar solid state direct current flow in elements of the central nervous system. This system has furthermore been observed to correlate with certain behavioral changes in the human.

The presence of such charge-transfer based systems would provide a mechanism whereby environmental force fields could exert an influence upon the organism. If the system influenced by such physical force fields was itself responsible for any aspect of behavior, then some behavioral effect would be noticeable. Some observations have recently been reported indicating that organisms do respond to such fields.

Certain marine fish demonstrate a remarkable sensitivity to magnetic and electrostatic fields, apparently by a system sensing the presence of low direct current potentials. Humans have been shown to sense the presence of low density UHF (radar) fields, and protozoa demonstrate orienting responses to low frequency electromagnetic fields. Many organisms demonstrate biological cycles of activity linked to the cyclic variation in environmental force field patterns and influenced by local application of low magnetic fields.

In the physical sciences knowledge has also increased leading to the concept of much more complex force field interrelations, both planetary and solar-terrestrial in scope [such as those described in the preceding contributions to this issue of *SR*/Research]. Short period fluctuations in the magnetic field have theoretically the greatest probability of being the physiologically active portion of the geomagnetic environment. While the exact origins are in doubt, the presence of diurnal variations, magnetic storms, and high frequency fluctuations have been demonstrated. The resultant electrical currents occasionally reach magnitudes amply high enough to produce disturbances in delicately balanced biological charge transport systems.

A statistical study, relating a simple index of geomagnetic activity to a gross index of psychological disturbances over a long period of time, appeared to be a logical method of preliminary investigations. In view of the widespread nature of geomagnetic disturbances, data gathered at two geographically distant points offered the possibility of obviating local effects such as air ionization, etc.

As a pilot study, the daily magnetic intensity (K-Sum) determined at Fredricksburg, Va., was correlated against the daily rate of psychiatric admissions to two hospitals in Syracuse, N. Y., for a period of approximately four years. It was realized that the data used had several inadequacies. The K-sum is a gross index of geomagnetic activity that is only loosely related to short period fluctuations. In addition, the K-sum is probably related to other nonmagnetic geophysical parameters such as cosmic ray flux and electrostatic fields. The rate of patient admissions is governed by such factors as the availability of beds and the disposition of the examining physician. Nevertheless, a statistical analysis of the data produced interesting results.

The daily data was tabulated on IBM punch cards and subjected to various correlations. Correlations on a day-to-day basis, and a small number of various phase-shift combinations thereof, showed very low levels of agreement, although all were positive and statistically significant. However, when the K-sums for thirty consecutive days and the admissions for the same thirty day period were handled as blocks of data, higher order correlations were obtained.

A sliding scale of one day, giving 1391 consecutive data points, was utilized. The coefficients of correlation, etc., for non-linear relationships proved to be 0.27 and 0.26. The probability of obtaining such a relationship by chance alone is less than one in a thousand.

These results would suggest that a relationship does exist between the incidence of psychiatric disturbances in the human population and some geophysical parameter coupled with the magnetic field. It appears likely that a more ambitious program based upon broader data gathering procedures, both clinical and physical, would reveal the identity of the responsible geophysical parameters and make possible controlled laboratory studies.

* * * *

We recognize that we are working far out on the boundaries of present knowledge. To avoid suspicions



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