Power Line Radiation in the Magnetosphere

New experimental evidence confirms that radiation leaked from electric power lines can reach the magnetosphere—the cocoon provided by the earth's magnetic field that isolates us from the solar wind and protects us from bombardment by cosmic rays. Yet the new data do not resolve the controversy about how significantly the magnetosphere is influenced by man-made signals. It is possible, according to a group at Stanford University, that certain features of the earth's space environment are controlled by electromagnetic pollution.

The Stanford radio scientists envision that waves radiated from power lines travel to the magnetosphere. There they could interact with charged particles, primarily electrons, in much the same way that naturally occurring waves do. The interaction is quite complicated, and may "turn on" the magnetosphere by amplifying the original waves or by spawning new emissions. If this happens, the electrons' trajectories would be perturbed, and some of the particles would even be lost from the magnetosphere by dropping into the ionosphere. The type of magnetospheric emission possibly linked with power line radiation (PLR) is called chorus, because tape recordings sound like a chorus of birds chirping. To date, however, only a very small fraction of chorus has been linked indisputably with PLR.

Fascination with the role of PLR in the magnetosphere derives less from concern about environmental damage—PLR has been prevalent for half a century and has had no apparent devastating impact on life on earth—than from curiosity about "the fundamental magnetospheric instability that grows waves and precipitates particles [into the ionsphere]," says Chung Park of Stanford. If PLR catalyzes this instability, Park would like to understand the "very subtle mechanism" by which it does so.

According to Park, Stanford's strongest evidence that PLR can trigger chorus comes from a recent experiment in which a transmitter at Siple, Antarctica, broadcast a signal that simulated the radiation from power lines. The receiver, near Roberval, Quebec, at the other end of the magnetic field line that reaches the earth at Siple, monitored the magnetospheric emissions. Even broadcast signals as weak as 0.5 watt were amplified by the magnetosphere, and chorus-like emissions—chirps whose frequency increases rapidly with time—started at some of the transmitted frequencies. Although, in some cases the starting frequency of the magnetospheric vocalizations was shifted as much as 25 hertz from the transmitted frequency, Park and co-workers knew that even these emissions were triggered, because their frequency changed whenever the transmitted frequency did.

Richard Thorne of the University of California at Los Angeles and Bruce Tsurutani of the Jet Propulsion Laboratory, however, do not believe that the results of the Siple experiment can be extrapolated to the entire magnetosphere. That experiment only probed phenomena occurring along the magnetic field line connecting Siple and Roberval—a very special field line, they say. Above the equator, the field line is four earth radii (25,000 kilometers) from the center of the earth, in a region where the density of charged particles is very high but decreases rapidly with altitude. Thus, says Thorne, there is an excellent wave guide between Siple and Roberval. He and Tsurutani suspect that considerably less magnetospheric activity would be induced by an experiment done at a higher latitude. There the magnetic field lines penetrate into the deep magnetosphere where most chorus activity occurs, and where such wave guides are rare.

Thorne believes that virtually "all waves seen in space can be explained as naturally occurring"—not triggered by man-made sources. However, he and Tsurutani would be convinced that PLR plays a major role in inducing those waves if there is direct evidence from satellites that PLR is found deep in the magnetosphere. Better yet, they would like to see PLR caught in the act of triggering chorus there.

This order is hard to fill, say the Stanford researchers, but Paul Luette of Sandia Laboratory, who was recently a graduate student at Stanford, came up with an appetizer. In June he found a record from the ISEE-1 satellite clearly showing that signals, whose frequencies were constant in time and were multiples of the power system frequency, can be detected in the magnetosphere. Independently, Francois Lefeuvre of the Centre de Recherches en Physique de l'Environnement terrestre et planétaire in Orléans, France, observed similar evidence in a record from the European satellite GEOS-2. Although PLR is seen, it is not specifically associated with any magnetospheric emissions.

Thus, direct satellite evidence that PLR triggers chorus remains elusive. Moreover, new data from the Voyager mission to Jupiter "prove that chorus exists without PLR," says Donald Gurnett of the University of Iowa. Like the earth, Jupiter has a magnetosphere, but Jupiter does not have electric power lines. Nonetheless, Jupiter's magnetosphere is not quiet. While Stanford's transmitter experiment indicated that PLR could trigger chorus, the Voyager records prove that chorus can occur naturally.

Other evidence for a strong power line effect is equivocal. The Stanford group and Kenneth Bullough and Thomas Kaiser of the University of Sheffield cite statistical evidence that chorus occurs preferentially above longitudes where electric power is consumed heavily and at times when electricity use is high. Their data seem to confirm the idea that chorus is linked to PLR, but not very convincingly. Tsurutani says that "the peaks [of chorus occurrence] are insignificant statistical fluctuations" as they are less than 1 to 2 standard deviations from the background. Furthermore, Tsurutani and Thorne obtained data with the OGO-5 satellite that disagree with the Stanford and Sheffield data.

Although armed with more and better data than they had 4 years ago, when Stanford's Robert Helliwell first discovered that PLR might affect the magnetosphere, the physicists are still arguing about how much magnetospheric activity is natural and how much is induced by PLR. Ironically, the controversy could be resolved in a single day if a short, simple experiment were done. But no one has had the audacity to suggest turning off all the electric power plants in the world, even briefly. To get a better idea about interaction between PLR and the magnetosphere, a Canadian power company currently is measuring the radiation from some of its transmission lines, and some Japanese researchers have proposed sending balloons, rockets, and satellites into the magnetosphere for the expressed purpose of monitoring the effects of PLR.

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