CC/NUMBER 51
DECEMBER 21, 1981

This Week's Citation Classic

Farley D T, Jr. A plasma instability resulting in field-aligned irregularities in the ionosphere.
J. Geophys. Res. **68**:6083-97, 1963.
[Jicamarca Radar Observatory, Lima, Peru]

Strong currents flowing in the equatorial ionosphere can cause the plasma to become unstable and generate acoustic-like waves whose phase fronts are aligned with the geomagnetic field. The theory explains many features of a class of radar echoes from the ionosphere above Peru. [The *SCI®* indicates that this paper has been cited over 265 times since 1963.]

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August 31, 1981

"This paper has been cited often and resulted in a US Department of Commerce Distinguished Authorship award in 1964 because it gave the first clear demonstration that I know of that the ionosphere is subject to the same instabilities that occur in laboratory 'fusion' plasmas. The trail that led me to Peru began at Cornell University, where a radar technique, called incoherent scatter, was first proposed in 1958 as I was finishing my graduate work. During two postdoctoral years at Cambridge University and at Chalmers University in Sweden, I collaborated with John Dougherty on two theoretical papers on this subject. Because of this work and my own and my wife's wanderlust, I then joined the staff of the Jicamarca Radar Observatory, which was built by the US Department of Commerce near Lima, Peru, to study the equatorial ionosphere using the new incoherent scatter technique.

"I arrived in Peru late in 1961 and soon learned of other radar echoes that were not incoherent scatter. One variety comes from an altitude of about 105 km, where a strong current is known to flow, and these echoes have a spectrum with a sharp peak at a Doppler shift corresponding to the acoustic velocity, surely an important clue to their cause.

"Now in those days the modern development of plasma physics was just beginning. Ionospheric researchers, including me, knew little about it. I had attended a short plasma course at Cambridge, though, and Dougherty and I had taught ourselves some plasma kinetic theory while working on our incoherent scatter papers. I knew that currents in a plasma could produce the so-called two-stream instability, which generates waves moving at the acoustic velocity–just what the radar observed. Aha, I thought. But there were problems; the ionospheric current was apparently far too weak. But the two-stream theory neglected the important, in this case, effects of the geomagnetic field and collisions. The magnetic field was easy to include, but collisions were not. My first attempt indicated that no instability was possible, but I still thought I was on the right track. Fortunately, at about that time Dougherty[1] figured out how to apply a more appropriate collision model to incoherent scatter theory, and so I modified the two-stream theory in the same way, this time with success.

"To work out the details required computer calculations, which had to be done in Colorado. Anyone who feels frustrated by slow computer turnaround time should try debugging a program by proxy over a noisy 4,000 mile shortwave radio link. It all worked, though, and the results have withstood the test of time. The nonlinear aspects of this instability are still being investigated. The ionosphere is a very convenient laboratory for studying plasma turbulence. The subject of ionospheric plasma instabilities has been reviewed recently by Fejer and Kelley.[2] I enjoyed my six-year stay in Peru and still manage to visit the Observatory, now operated by the Geophysical Institute of Peru, about once a year."

1. **Dougherty J P.** The conductivity of a partially ionized gas in alternating electric fields. *J. Fluid Mech.* **16**:126-37, 1963.
2. **Fejer B G & Kelley M C.** Ionospheric irregularities. *Rev. Geophys. Space Phys.* **18**:401-54, 1980.