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Note on Hydromagnetic Propagation and Geomagnetic Field Stability

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In the adjoining letter, *Dessler* [1961] argues that the interface between the solar wind and the geomagnetic field is stable and cannot, therefore, generate hydromagnetic waves. According to our interpretation, his argument may be paraphrased as follows: He observes that, for many sudden commencement geomagnetic storms, surface magnetograms show no marked change in the level of disturbances from the period before the sudden commencement until well into the initial phase of the storm. He applies the attenuation factors calculated by *Francis and Karplus* [1960] to the measurements of the 1 cps component of the magnetic disturbances obtained at the surface. From this calculation, he concludes that, during the initial phase of these geomagnetic storms, the amplitudes of hydromagnetic disturbances above the ionosphere are less than 1 γ. Assuming that the sudden commencement indicates the presence of a solar wind, he further concludes that hydromagnetic disturbances are not generated in the region between the geomagnetic field and the solar wind and that this interface is, therefore, inherently stable. He subsequently accounts for the hydromagnetic disturbances which are frequently observed at the earth as having been produced by fluctuations in the energy density of the impinging solar wind.

It is not our purpose to question whether these solar wind fluctuations generate any or all of the hydromagnetic waves observed in the earth's field. Rather, we wish to point out that the method by which Dessler uses surface observations of magnetic activity to estimate the conditions at great distances above the surface is not valid in the light of available data.

The data include observations obtained from the space probe, Pioneer I [*Sonett, Smith, and Sims,* 1960; *Sonett, Judge, Sims, and Kelso,* 1960]. During the passage of the spacecraft through the distant geomagnetic field, field strength fluctuations of large amplitude ($\Delta B/B \leq 10$) were detected.[1] Measurements obtained simultaneously with a surface magnetometer in the Borrego Desert (Campbell, private communication) indicated almost no surface geomagnetic activity. This magnetometer had a threshold of about 0.1 γ in the frequency range of interest and is one of the instruments upon which Dessler relied for his data. Also, at the time that Pioneer I observed these disturbances, the A_p index was between 1 and 0. The predominant frequency component of these disturbances was about 0.1 cycle/sec. Frequencies of this value, according to the work of Francis and Karplus, should be less effectively attenuated than those at 1.0 cycle/sec. However, the observations indicate that even the lower frequency disturbances detected in the distant geomagnetic field were not measurable at the surface. Thus, Dessler's assumption that any large-amplitude hydromagnetic disturbances generated at the interface between the geomagnetic field and the solar wind would have been detected by the instruments which he mentions is not consistent with experiment.

Because of the apparent inconsistency of available data with Dessler's comments, we would like to consider briefly the problems that might be encountered in any treatment of hydromagnetic wave propagation in the exosphere. For example, the details of energy transport by such waves have not been established. The dispersionless character of very low frequency Alfvén waves suggests that, when the energy flux is constant, the amplitude of waves traveling inward through the geomagnetic field should decrease until the waves reach the region

[1] Large amplitude waves were observed also in the interface region on Pioneer V [*Coleman, Sonett, Judge, and Smith,* 1960].

in which the dependence of their velocity upon the ion density is of overriding importance compared with dependence on the field strength. However, the situation is probably complicated by the anisotropic behavior of the extraordinary mode and by the inhomogeneous nature of the medium to both the ordinary and extraordinary rays. Another problem arises when one attempts to ascertain the manner in which these disturbances, which, from a consideration of their amplitudes, structure, and velocities, appear to be shock-like phenomena in the distant field, are transformed into well-behaved waves as they enter the stronger fields nearer the surface. Further, we know of no treatment of the propagation of nonplanar hydromagnetic waves in the exosphere or of standing wave phenomena.

In summary, hydromagnetic disturbances as great as 100 γ have been observed in the distant geomagnetic field with no associated effects observed by instruments of the type discussed by Dessler. The complexity of the observed phenomena makes it difficult to establish whether the waves are generated by instabilities at the interface or by fluctuations in the intensity of the solar wind. However, the little empirical evidence at hand seems to indicate that it is dangerous to infer too much about disturbances of the type under discussion in the distant geomagnetic field on the basis of available ground observations.

References

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