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Letters to the Editors

Comment on

Hydromagnetic Waves in a Non-Uniform Plasma by E. Kupfer

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In a recently published paper Kupfer (1975) reconsiders the problem of geomagnetic pulsations with periods systematically depending on geomagnetic latitude. The existence of simultaneous pulsations showing this characteristic was first demonstrated by Voelker (1962, 1963, 1965). Subsequently other authors have described observations where the dominant pulsation period increases with increasing latitude (see e.g. Stuart and Usher, 1966; Münch, 1968; Miletits, 1971; Orr and Matthew, 1971; Rostoker and Samson, 1972; Zelwer and Morrison, 1972). The effect can be seen from a special class of pc 3–5 events and most distinctly from a pi 2-type of pulsations having the shape of a damped oscillation and appearing only in the daytime with an occurrence maximum about noon (Voelker, 1966, 1967). These comparatively rare events which, moreover, are found almost exclusively in the H-component, were named pulsation single effects (pse's). In my opinion their characteristic features are most typical for the effect under consideration.

In spite of the extreme simplifications of Kupfer's model I agree with the conclusion that a small δ-shaped spatial deviation of the undisturbed plasma density from an otherwise smooth distribution cannot explain the observed latitude dependence in terms of poloidal hydromagnetic oscillations. The reason for publishing this comment is that Kupfer's result is inconclusive without detailed discussion. At least the following annotations should be added:

1. Much of the difficulty of interpretation arises from the restriction to poloidal oscillation modes that are required by the predominant H-polarization of pulsations with latitude-dependent periods, unless very complex propagation conditions in the ionosphere are involved. It is this observed H-polarization that makes it impossible to apply the well known theory of magnetospheric oscillations by Dungey (1954) having predicted an equal effect, but for D-polarized pulsations only.

2. Insisting on the general conception that these pulsations are caused by poloidal field-aligned hydromagnetic oscillations, I was led to the idea of a partly lamellar structure of the magnetospheric plasma (Siebert, 1964, 1965). As a crude model this means that the plasma distribution is continuous along the field lines and

discontinuous in direction of their principal normals, i.e. between adjacent L-shells. The azimuthal behaviour of the plasma is of less importance here. This lamellar structure hinders the plasma of a region from oscillating as a whole with a uniform period; instead, eigenoscillations of non-interacting lamellae are possible and lead to an easy interpretation of the observational facts. When the rigorous assumption of lamellar discontinuities is replaced by that of small δ-shaped changes in the plasma density, the effect under consideration can no longer be explained. Thus, the result obtained by Kupfer supports the idea of separately oscillating lamellae.

3. There is no question that the model described above and used in this crude form because of its mathematical practicability, is not realistic. Actually, the term "discontinuity" must not be understood in a severe mathematical sense but rather as the appearance of steep gradients in the plasma density. While estimations yielded already ten years ago that such a magnetospheric structure is sufficiently stable when it comes to exist, there remained the open question whether it will exist at all. Since then, Chappell *et al.* (1971) and Bewersdorff and Sagalyn (1972) discovered a phenomenon which might correspond to the predicted lamellar structure. By analysing satellite data of the magnetospheric plasma density they found large spatial density fluctuations over very narrow L-ranges at or near the plasmapause. Especially Bewersdorff and Sagalyn report cases of multiple splitting of the plasmapause. The phenomenon is most pronounced when this outer boundary of the plasmasphere is situated in $2 < L < 3$ or about $L = 3$. Then, there are density changes of over an order of magnitude in less than 0.1 L. According to these results it can be taken for proved that the lamellar structure is an idealized but reasonable and physically admissible model to study the effect in a first approximation. Unfortunately, no observations of this kind are available as yet which could allow a direct comparison between satellite and ground-based records belonging together.

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