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INTERNATIONAL CONFERENCE ON COSMIC RAYS AND THE EARTH STORM Part I

I-3-P1. Theory of Magenetic Storms*

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We review here the main features of the theory of the main phase of magnetic storms based on the idea of drift of trapped particles[1]. Injection of solar protons (of 10-20 kev) may occur through perturbation of the geomagnetic field or through acceleration of existing protons by the hydromagnetic shockwave (Dessler). General agreement now exists about the motion of trapped particles, including the important diamagnetic effects[2]. The magnetic field at sea level and in the equatorial plane has now been calculated[3),4)], including the second order perturbation effects. A comparison with the results of Lunik[5], Explorer VI[6] and Pioneer[7] now becomes possible. Certain difficulties still exist which have been particularly stressed by Piddington[8].

The removal of the trapped protons may take place by charge exchange[2),9)], or by magnetic scattering[1], whichever process acts faster. This depends crucially on the position of the trapped protons.

An important advance in the theory has been made by Fejer[10], who considers the consequences of an asymmetric trapped particle distribution. Chamberlain[11] has constructed a new theory of the aurora based on inhomogeneities in the trapped particle distribution.

References

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Discussion

Alfvén, H.: It is interesting to note that there is only one feature in the theory of magnetic storms which everybody now seems to agree about, *viz*, that during the main phase of a magnetic storm there is a ring current consisting of particles drifting in the inhomogeneous field.

One of the main points of disagreement is how the particles get into the magnetic field of the earth. Based on laboratory experiments it is possible to conclude that a solar plasma can easily penetrate to a distance of about 6 Earth's radii under the action of an electric field.

For the understanding of what happens it is important to realise that the particles move in a magnetic dipole field *under the action of an electric field.*

Dungey, J.W.: The shocks discussed by Gardner of NYU heat the ions not the electrons, otherwise they would be of no use for fusion.

Singer, S.F.: Please refer to Gardner, *et al.* in Proc. 2nd International Conference on Peaceful Uses of Atomic Energy, **31** (1958) 230.

* The full text of this paper is printed in Appendix, since its receipt was late for compilation.

Sonett, C.P.: In answer to Dungey's question: The work of Gardner, *et al.* has shown the possibility primarily of proton acceleration in a collisionless shock in a binary plasma. However they have also obtained solutions where the rôle of protons and electrons are reversed as to heating. Which case or whether both happen in the exosphere is not known. The evidence of Pioneers I and IV would suggest that the collisionless shocks which exist at times do accelerate electrons.

Gold, T.: The electric field necessarily associated with ionospheric and magnetospheric motions, (as discussed in J.G.R., Motions in the Magnetosphere) are large enough to destroy the stability of current rings due to low energy particle. I would therefore suppose that this effect would dominate for the destruction of the ring current if this is due to kilovolt or tens of kilovolt particles. I am not sure I would agree that "trapped particles" are responsible since the quality of trapping for low energy particles is so very poor. Why does Professor Singer not consider this loss mechanism for the recovery phase?

Singer: It is quite necessary to establish first of all to what extent magnetospheric motions exist, granted that they are possible.

Next one must establish the removal time scale which they would lead to if they were the only loss mechanism of the main phase particles. Then this time must be compared with other removal time scales (*e.g.* charge exchange) to see if it is shorter. As far as I know this has not been carried out by any one.

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INTERNATIONAL CONFERENCE ON COSMIC RAYS AND THE EARTH STORM Part I

I-3-P2. Theory of Magnetic Storms

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It was pointed out several years ago that the geomagnetic storm phenomenon should be regarded as a hydromagnetic deformation of the geomagnetic field (Parker, 1956)[1]. The observed distortions of the field are the result of stresses produced by the enhanced solar corpuscular radiation, or solar wind, and by the heated gases contained within the field. The observed geomagnetic storm consists of rapid and large amplitude fluctuations (with periods from a fraction of a second to an hour) superimposed on a general increase of the horizontal component of the field at low and middle latitudes (the initial phase), followed by a general decrease (the main phase).

It now is generally assumed that the onset of the enhanced solar wind, or corpuscular radiation, is in the form of a shock wave. The general shape of the boundary of the quiet-day geomagnetic field has been investigated theoretically (see for instance Beard, 1961[2]; Hurley, 1961[3]) and it has been shown (Dessler, *et al.*, 1960[4]) that the observed rise time of the sudden commencement of the geomagnetic storm can be explained as the result of the shock wave sweeping past the geomagnetic field in interplanetary space. The initial phase appears to be a general compression of the field as the result of the increased impact pressure of the enhanced solar wind behind the shock (Chapman and Ferraro, 1932[5]; Parker, 1958[6]). The rapid fluctuations of the active phase of the storm probably result from a combination of irregularities in the solar wind and the general instability of the field—wind interface (Parker, 1958).[6]

The main phase of the geomagnetic storm represents an outward expansion of the field,