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COMMENT ON "LARGE-SCALE RESPONSE OF THE MAGNETOSPHERE TO A SOUTHWARD TURNING OF THE INTERPLANETARY MAGNETIC FIELD" BY J.A. SAUVAUD ET AL.

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RESUMO-NOTAS/ABSTRACT-NOTES

Using ISEE-3 observations of the interplanetary plasma and magnetic field it is shown that the substorm reported by Sauvaud et al. (1987), that occurred at 22:40 UT of March 4, 1979, was directly driven by the solar wind. This result was found when the solar wind ram pressure is taken into account in the solar wind-magnetosphere coupling function and is in conflict with the result found by Sauvaud et al., who claimed that the energy necessary to drive this substorm came form a magnetospheric reservoir (stored energy).

OBSERVAÇÕES/REMARKS

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COMMENT ON "LARGE-SCALE RESPONSE OF THE MAGNETOSPHERE TO A SOUTHWARD TURNING OF THE INTERPLANETARY MAGNETIC FIELD" BY J. A. SAUVAUD ET AL.

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Sauvaud et al. [1987] performed a study of the overall magnetospheric response to a southward turning of the interplanetary magnetic field (IMF) on March 4, 1979, by using a set of coordinated measurements in the solar wind, in the magnetotail, at geostationary orbit, in the auroral ionosphere, and on the ground.

For such a southward IMF episode, that lasted for about 1 hour and 40 min, the authors showed that the magnetosphere responds in general without any appreciable delay to changes in B_z (Z component of the IMF in solar magetospheric coordinates). They also showed that two out of the three main AE (auroral electrojet index) intensifications of this time interval closely followed notable intensifications in the $|-B_z|$ amplitude. Their Figure 15 shows these points, in which one can observe that the first two AE intensifications at about 2150 UT and 2220 UT followed the $|-B_z|$ intensifications at about 2135 UT and 2200 UT, respectively. Furthermore, they claimed that the interplanetary coupling function ε followed closely the behavior of B_z, thus explaining the magnetospheric energization and the fairly rapid driving of the first couple of AE intensifications.

However, the authors also showed that the most intense substorm of their studied interval, for which the corresponding AE intensification occurred around 2240 UT, did not have a corresponding intensification in $|-B_z|$, or in ε, as observed in their Figure 15. Therefore, they concluded that this substorm was not directly driven by the solar wind, but that the required energy was provided by a magnetospheric reservoir (stored energy).

Note that Sauvaud et al. reached such a fundamental conclusion because the coupling function ε did not show any appreciable intensification prior to the occurrence of the main substorm, in contrast to the ε intensifications prior to the previous two AE events.

Our point in this comment is that the coupling function ε does not necessarily always represent well the magnetospheric energization due to possible combinations of solar wind parameters that are expected to influence the coupling. Several recent works [e.g., Murayama, 1986; Bargatze et al., 1986; Gonzalez, 1986] suggest that in some cases, other coupling functions can represent the solar wind-magnetospheric energization better than ε. In fact, we show that this seems to have been the case during the interval studied by Sauvaud et al.

As already claimed by Gonzalez and Gonzalez [1981, 1984], the function ε is pressure independent. Thus notable changes in the solar wind ram pressure do not have a clear counterpart in the ε expression, apart from a dependence on the first power of the solar wind speed. For the interval studied by Sauvaud et al., we have plotted on the top panel of Figure 1 the solar wind density (N) and speed (V) values. Apart from the data gap, the N and V values during the main AE event, labeled 3 in Figure 1, were correspondingly larger than those during the previous (1 and 2) AE events. This fact prompted us to look into a solar wind ram pressure modulation of the magnetospheric coupling during this time interval.

From possible coupling functions which can represent better than ε such pressure modulation (W. D. Gonzalez et al., Solar wind-magnetosphere coupling during intense magnetic storms (1978 1979), submitted to Journal of Geophysical Research, 1988; hereinafter W. D. Gonzalez et al., 1988), we selected the function $F = p^{1/2} VB_z \sin^4(\theta/2)$, where p is the solar wind ram pressure and θ is the same angle as in ε. This expression is similar to that given by Bargatze et al. [1986], although with a stronger dependence on the pressure, as suggested by Murayama [1986]. One observes in Figure 1 that this function describes better than ε the three intensifications of AE and, most important of all, it also seems to explain the direct solar wind energization of the main substorm, AE event 3, of the interval studied by Sauvaud et al. Furthermore, the correlation coefficient obtained between F and AE for the whole interval was close to 0.8, whereas that obtained between ε and AE was around 0.65. From this figure one also observes that the magnetospheric response to ram pressure changes in the solar wind was fairly rapid, within a time lag of about 10 to 15 min.

W. D. Gonzalez et al. (1988) have also shown that coupling functions of the F type, namely with the $p^{1/2}$ modulation, describe better than other functions (including ε) the ring current energization during intervals with large ram pressure variations in the solar wind. In addition, among recent experimental evidence, Tsurutani et al. [1985] have also claimed that ram pressure changes in the solar wind can have considerable impact on the development of substorms.

We conclude that the main substorm studied by Sauvaud et al. [1987] seems to have been driven by the solar wind. One important parameter was the solar wind ram pressure, which is not well taken into account by the coupling function ε. This conclusion is in conflict with that reached by Sauvaud et al., who claimed that the energy necessary to drive the main substorm mainly came from a magnetospheric reservoir (energy previously stored).

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FIGURE CAPTIONS

Fig. 1. (Top) Solar wind density (N) and speed (V), as measured by ISEE 3. (Second from top) B_z component (in solar magnetic coordinates) of the IMF, as measured by ISEE 3. (Third from top) Coupling functions F and ε computed at the magnetopause. (Bottom) AE index with the events 1, 2 and 3 discussed in the text.

Paragraph to be inserted between paragraphs 7 and 8:

When B_z is interchanged with the IMF amplitude B in the coupling function F, the behavior of the function is very much similar to that involving B_z (shown in Figure 1), although its correlation coefficient with AE is lower (0.71) but still higher than that obtained for ε. However, the physical meaning of the function involving B could be more in accord with standard reconnection models than that in terms of B_z. This latter point still needs a closer study.

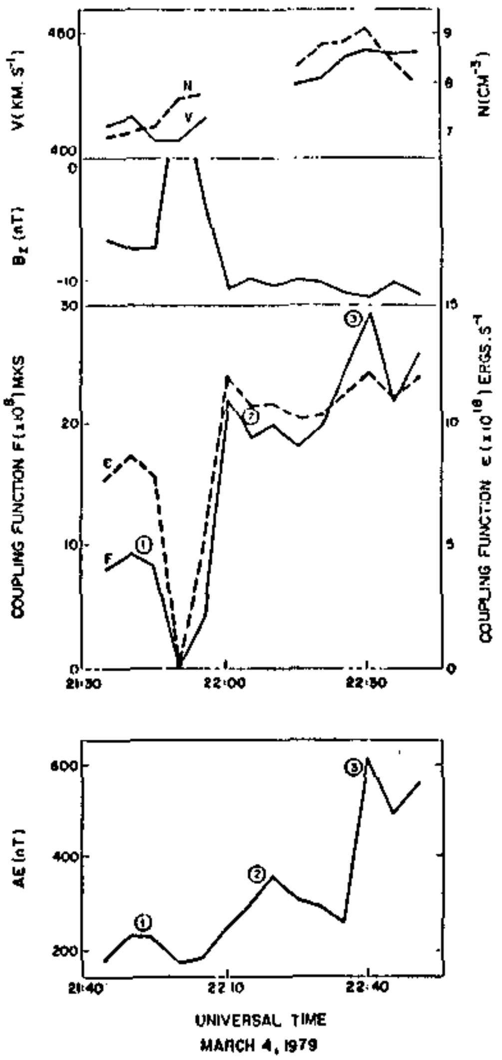

Fig. 1. (Top) Solar wind density (N) and speed (V), as measured by ISEE 3. (Second from top) B_z component (in solar magnetic coordinates) of the IMF, as measured by ISEE 3. (Third from top) Coupling functions F and ϵ computed at the magnetopause. (Bottom) AE index with the events 1, 2 and 3 discussed in the text.

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RESUMO - NOTAS / ABSTRACT - NOTES

In these comments we argue that the Sauvaud et al (1987) conclusion about the unloading state of the magnetosphere, during a negative IMF-B_z episode, may not necessarely be so if one takes into account the solar wind-ram pressure variations in the coupling function that describes the magnetospheric energization.

OBSERVAÇÕES / REMARKS

This work was partially supported by the "Fundo Nacional de Desenvolvimento Científico e Tecnológico" under contract FINEP-537/CT. This work will be submitted to Journal of Geophysical Research.