EQUATORIAL COUNTERELECTROJET: TWO DISTINCT CATEGORIES

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Abstract. It is shown that among the equatorial counterelectrojets there are two distinct categories, the fast one and the slow one, having different characteristics.

In a recent communication [Kane, 1978] it was shown that there is no clear-cut relationship between equatorial counterelectrojet and interplanetary magnetic field (IMF). In the communications Rastogi and Patel [1975] and Patel [1978], sharp decreases in the equatorial H field during daytime (also termed as counterelectrojets by these authors) are shown to be associated with rapid fluctuations of the latitude of the IMF. From private conversations and correspondence, it seems that many people consider the latter results as contradiction of the former one. Contradictory opinions in scientific matters are neither uncommon nor unwelcome, as these aid the free spirit of scientific enquiry. However, in the present case, no contradiction whatsoever is involved, as is explained below. There are two distinct categories of equatorial counterelectrojets, and their characteristics are described in the sections that follow.

The Slow Counterelectrojet (A)

In the equatorial magnetograms the H trace often shows daytime values dipping below the nighttime level. This feature has been there on equatorial magnetograms for the last several decades. But only Gouin and Mayaud [1967] had the courage to point it out and name it as 'counterelectrojet', for obvious reasons. Its characteristics briefly are as follows:

1. It is a smooth, slow drop in H values, which is observable not only on the magnetograms or in plots of 5-min or 10-min values but even in plots of half-hourly or hourly values, as the event may last for 2-3 hours.

2. These events occur predominantly around 0600, 1200, and 1500 LT [Hutton and Oyinloye, 1970], the afternoon events often lasting for 2-3 hours. The occurrence is more in quiet sun years.

3. In histograms, the occurrence frequency of these events is somewhat larger at 03 and 15 lunar hours. However, opinions about a possible lunar connection are diverse. Gouin and Mayaud [1967], Hutton and Oyinloye [1970], and Kane [1976] doubt the existence of a clear lunar influence. Onwumechili and Akasofu [1972] report days when the counterelectrojet has a strong lunar influence but sometimes in antiphase. In various papers, Rastogi seems to give different emphasis to the lunar influence. Thus in Rastogi [1973a], he also states categorically that 'these events are not caused by the moon although the lunar phase modifies the frequency of occurrence of the events.' These slow counterelectrojets can occur on stray individual days as also on sequences of successive two or sometimes even 3-4 days. In these, one can often locate events which occurred at different lunar phases. It seems, therefore, that besides the lunar influence (if any), there is some other cause as yet unidentified, which is equally (if not more) important.

4. The longitudinal extent of these events can be very narrow, sometimes limited to regions within 2 hours of LT [Rastogi, 1973a; Kane, 1973]. The latitudinal extent is roughly the same as that of a normal electrojet. Hence the name counterelectrojet.

5. During these H events, the corresponding Z variations are consistent with the idea that the overhead electrojet current has reversed. Also, the q type of Es layer disappears in the ionosphere. On some occasions the H field does not reverse completely and yet Es-q disappears, indicating the possibility of simultaneous existence of eastward and westward flowing equatorial electrojet currents, probably a few kilometers apart in altitude [Fambitakoye et al., 1973; Rastogi, 1975].

6. These slow counterelectrojets have no clear-cut relationship with IMF [Kane, 1978].

The Short-Period Fluctuations in H (B)

On some days, especially during moderate or high solar activity, the H trace shows large rapid fluctuations during daytime, sometimes touching the night level or even dropping below it for a few minutes, with the following characteristics:

1. These are very fast events, occurring and recouping within tens of minutes. Naturally, they can be located only by examining the magnetograms and not by studying plots of hourly values.

2. During these events too, Es-q generally disappeared [Bandyopadhyay and Montes, 1963; Hutton and Oyinloye, 1970]. Simultaneously, the ionospheric drift velocities also reversed [Rastogi et al., 1971; Rastogi, 1973b]. It was this fact that prompted Rastogi and Patel[1975] to term these events too as 'counterelectrojets.' Earlier, these were recognized only as short-period fluctuations, noticed and studied long ago by Onwumechili [1960] and Onwumechili and Ogbuehi [1962].

3. These fluctuations have intimate
relationship with polar magnetic variations [Onwumechili et al., 1973] as also with IMF. Nishida [1968a, b] called these as DP-2 variations and showed that the decrease of H and the subsequent recovery were intimately associated with a change of θ (latitude of IMF) from southward to northward and vice versa. A tentative explanation was also offered by him in that a reversal of Bz component of IMF from negative to positive, when crossed with the radial component Vr of solar wind velocity would yield an electric field Ey which would oppose the normal Sz field in the electrojet region, giving H depressions. Rastogi and Patel [1975] examined this possibility in greater detail in a consolidated form in conjunction with ionospheric phenomena. A theoretical difficulty, however, remains, namely, can such a magnetospheric electric field penetrate to the equatorial ionospheric E region? The problem remains unresolved.

4. The fluctuations are large in the equatorial region only and near noon hours. Onwumechili and Ogbuehi [1962] reported that the amplitude decreased fast, away from local noon and dip equator. It is interesting to note, however, that unlike the slow counterelectrojets which are not observed at all outside the electrojet region, the short-period fluctuations have some magnitudes even outside the electrojet region. Nishida [1968a, b; 1971] reported a ratio of about 4 for equatorial to nonequatorial low latitude regions.

It is obvious, therefore, that even though both the events of categories A and B are now termed as counterelectrojets, for the very valid reason that in both, the overhead electrojet currents are reversed, there is a qualitative difference in their connection with polar magnetic variations. In Kane [1978] it was shown that the slow counterelectrojets of category A had no clear-cut relationship with IMF. The work of Rastogi and Patel [1975] and Patel [1978] refers to events of category B, which do have an intimate relationship with IMF. Thus there is no contradiction whatsoever in these two studies. Apart from clearing this misunderstanding, it is hoped that this note will help in putting in proper perspective the intriguing phenomena of equatorial counterelectrojets.

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References


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