ARE PULSATIONS WITHIN THE MAGNETOSPHERE AFFECTED BY THE ORIENTATION AND MAGNITUDE OF IMF?

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The paper discusses observational and theoretical characteristics of geomagnetic pulsation having a source in the solar wind (Pcsw) and in the magnetosphere (Pcmg), respectively. Possible pathways of propagation are also shown.

Keywords: geomagnetic pulsations; interplanetary magnetic field; solar wind; upstream waves

Introduction

At the present time, the pathways of penetration of the upstream wave energy from the solar wind, as well as their input into pulsation activity within the magnetosphere and at the ground surface, are still unclear. In clarification of this persisting uncertainty, it is very important that we deal only with trustworthy experimental results as such data will provide the bases for selection of the correct model of energy transfer. In this connection, it is critical to determine whether the pulsations recorded on board stationary satellites within the magnetosphere do or do not display the following dependencies: a) is the frequency of occurrence of the pulsations inside the magnetosphere controlled by the orientation of Interplanetary Magnetic Field (IMF) as it is for upstream waves (Russell and Hoppe 1983) and pulsations on the ground (Bolshakova and Troitskaya 1968, Plyasova-Bakounina 1972, 1993, Webb and Orr 1976, Greenstadt and Olson 1977), and b) are the frequencies (F) of pulsations within the magnetosphere controlled by the magnitude B of IMF in the same manner as exists for upstream waves (F = 6B) in the solar wind (Fairfield 1969, Plyasova-Bakounina et al. 1978, Russell and Hoppe 1983) and on the ground (Troitskaya et al. 1971, Plyasova-Bakounina 1972, 1993, Gul'elmi et al. 1973, Verő 1986).

Arthur and McPherron (1977) and Takahashi et al. (1981, 1984), when analyzing pulsation data of ATS-6, found clear negative correlation between the angle of the IMF measured from the sun-earth line and the amplitude of pulsations. The frequency of occurrence and the amplitude of both compressional Pc3 and torroidal pulsations Pc3-4, measured at geostationary satellites GEOS-2 and AMPTE, has been associated with low IMF cone angle (Yumoto et al. 1985, Engebretson et al. 1986, Anderson et al. 1991).

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On the ground, the amplitude and frequency of occurrence of the Pc2-4 pulsations increases with decreasing cone angle of IMF, a fact demonstrated by Bolshakova and Troitskaya (1968), Plyasova-Bakounina (1972), Webb and Orr (1976), Greenstadt and Olson (1977), Wolf et al. (1980, 1987), Yumoto et al. (1985) and Engebretson et al. (1986). Analyzing this “angle effect” separately for Pc_sw (the solar wind-controlled pulsations, which display $F = 6B$ correlation) and for Pc_mg (the magnetosphere-controlled pulsations, i.e. standing resonance oscillations on the local field lines, the frequency of which is controlled by magnetosphere structure and plasma parameters), Plyasova-Bakounina (1993) demonstrated that the frequency of occurrence of Pc_sw increases when the azimuthal angle of IMF is close to 140° and close to 180° for Pc_mg pulsations. Both pulsations are strongly dissipated when the azimuthal angle of IMF is 90°. Another unambiguous indication of the two types of pulsations was made by Miletits et al. (1988).

Several contradictory results have been published relative to the dependence of the periods of the pulsations ($T$) observed within the magnetosphere on the IMF magnitude ($B$). Kovner et al. (1976), Plyasova-Bakounina et al. (1982), Plyasova-Bakounina (1993) investigated the $T(B)$ dependence of monochromatic pulsations in the period band 20–150 sec which were recorded simultaneously by ATS-1 in geosynchronous orbit and on the ground at two ground stations. Analysis showed that that portion of the monochromatic pulsations recorded within the magnetosphere with periods coinciding with the periods of ground-based Pc activity displays a strong $T(B)$ correlation ($T = 160/B$, or $F = 6B$). That portion of the monochromatic pulsations with periods that do not coincide with those of ground pulsation activity did not display any dependence of $T$ on $B$.

When analyzing data of ATS-6, Arthur and McPherron (1977) found no pulsation activity which displayed an $F(B)$ correlation. Takahashi et al. (1984) demonstrated that the high-harmonic standing waves within the magnetosphere display weak negative correlation of frequency $F$ on $B$. When analyzing data from the synchronous satellite AMPTE CCM, Engebretson et al. (1989) found that the central frequency of the envelope of Pc3 power correlates with $B$.

In contrast to the work cited above, Yumoto et al. (1984) attempted an analysis of compressional waves recorded at geosynchronous orbit by GEOS-2. They reported a dependence of the frequency of the compressional waves on $B$ as $F = 6B$ (see Fig. 1 of their paper). They have reported also that, in contrast with compressional waves, the transverse waves do not display such dependence. Also, they analyzed simultaneously recorded ground pulsation data, concluding that such data display an $F = 6B$ correlation. Yumoto et al. came to the conclusion that $F$ vs. $B$ correlation is good inside the magnetosphere and worse on the ground.

The main purpose of this paper is to reanalyze data of Yumoto et al. and to illustrate the error of their conclusion.