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アナログマグネトグラムのトレースデータを用いた１９７０年以前の磁気圏状態の推定
Estimation of Plasma Condition Before 1970 Using Digitized Data Created by Tracing Analog Magnetograms

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It is important to know the plasma mass density in the magnetosphere, since it controls the Alfven velocity, which is one of fundamental parameters for the magnetospheric phenomena. We can estimate indirectly the plasma mass density from geomagnetic pulsations, e.g., Pc3 or Pc4. But no digital data of the geomagnetic field with a time resolution of 1.0 second exists before the middle of 1980s. There is also no available satellite data of magnetospheric ion mass density before 1970. The ion composition in the magnetosphere before 1970, therefore, remains unclear.

Mashiko et al. [2013] has developed a program to convert analog magnetograms to digital values with a time resolution of 7.5-seconds, and it makes possible to study various geomagnetic pulsations. According to statistical analysis by Nose [2010], Pi2 periods are represented by the following empirical equation:

$$T = 17.65\ [\pm 0.80] \times M(amu) - 1.34\ [\pm 0.05] \times \Sigma\, Kp + 108.68\ [\pm 0.94]$$

where T and M represent the Pi2 period and the average plasma ion mass, respectively. From this equation, we can estimate the average plasma ion mass (M) in the nightside plasmasphere when we obtain T and Σ Kp.

From 7.5-seconds digital data created from analog magnetograms for 1964-1975, we estimate the average plasma ion mass in the nightside plasmasphere during solar cycle 20. We perform statistical analysis and compare the estimated average plasma ion mass with F10.7 on long-term basis so that we investigate how solar activities affect on the plasmasphere.

We find that the correlation coefficient (C.C.) between monthly average plasma ion mass and monthly F10.7 is 0.500, while that between monthly average plasma ion mass and monthly Σ Kp is 0.154. In order to consider long-term variations and increase statistical significance, we also calculate correlation coefficients between moving average of these parameters with a time window of 1 year. We find that C.C. = 0.838 between the mass and F10.7, and C.C. = 0.372 between the mass and Σ Kp. This shows that long-term variations of the average plasma ion mass, in particularly, in the time scale longer than 1 year, have stronger correlations with F10.7 than Σ Kp. It is noteworthy that during solar cycle 20, which has smaller maximum of F10.7 than other vicinity cycles, the estimated average plasma ion mass has smaller maximum value than other cycles.

One of the causes of variations in the magnetospheric plasma ion composition is upflowing ionospheric ions. The ionospheric ion upflow is enhanced by solar radiation such as ultraviolet radiation (UV) or extra ultraviolet radiation (EUV), and geomagnetic activities such as precipitation of energetic particles or aurora electrojet. Here we study the dependence of average plasma ion mass on F10.7 and Σ Kp, and find the strong correlation with F10.7. This result suggests that in long-term variations, solar radiation is dominant mechanism to produce or heat oxygen ions.

キーワード: Pi2 地磁気脈動, アナログマグネトグラム, 平均プラズマイオン質量, プラズマ圏, 太陽活動
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