ROTATION RATES OF SOFT X-RAY CORONAL STRUCTURES

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Abstract

Characteristics of rotation of large-scale coronal structures are investigated by using soft X-ray synoptic charts constructed by daily *Yohkoh* soft X-ray images. An autocorrelation technique was used in order to obtain the rotation periods of the soft X-ray structures for every five degrees in the latitude. The analysis shows that the rotation periods in the northern hemisphere are different from those of the southern hemisphere. The rotation periods of active regions are also different from those of quiet coronal structures in the low latitudinal range. It is suggested that these differences influenced the heliospheric structure in the analyzed period.

1. Introduction

The rotation of the coronal magnetic field is different from that of the photospheric field. It is known that the coronal field rotates quasi-rigidly, while the photospheric field shows a differential rotation. The rotation of the corona has been investigated by using small- or large-scale magnetic field data (e.g. Wilcox et al., 1970; Schatten et al., 1972; Hoeksema and Scherrer, 1987; Antonucci et al., 1990), by using the white-light corona data (Fisher and Sime, 1984), and so on. Rotation of the large-scale coronal structures, however, has not been investigated in detail.

Soft X-ray images are useful for investigating the evolution of the corona because the long-term evolution of active regions, quiet coronal structures and coronal holes can be seen in the same images. A detailed study of the rotation of the coronal structures is useful not only for the study of the structures of the solar magnetic field but also for the studies of the heliospheric structure and a mechanism of recurrent geomagnetic storms (Saito, 1989). The purpose of the present study is to clarify the rotation of the soft X-ray corona and its influences on the interplanetary processes.

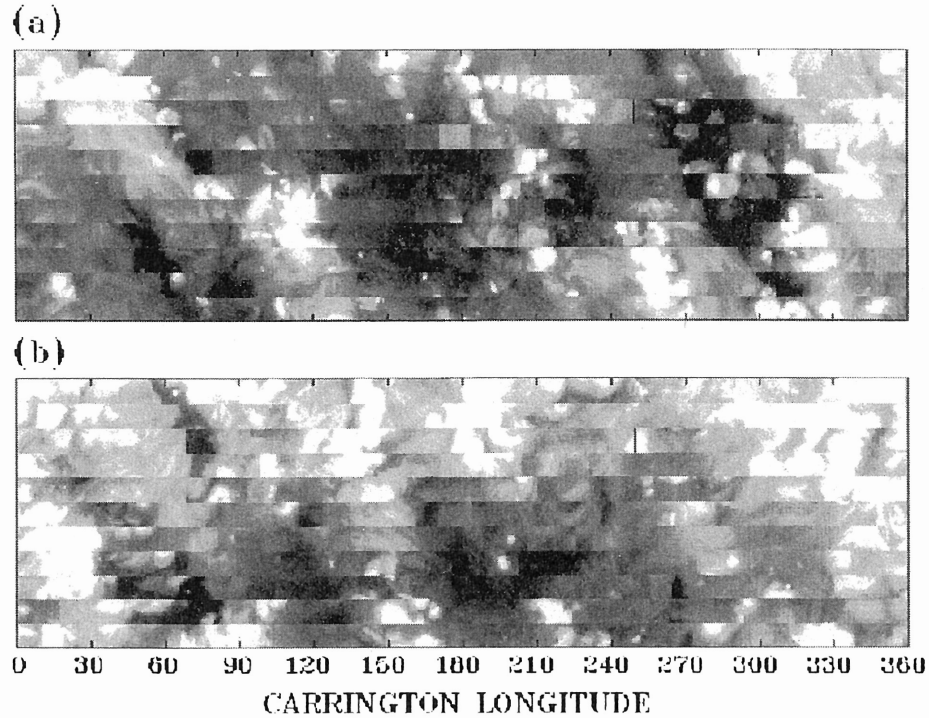

Fig. 1. Stackplots of the soft X-ray coronal structures during Carrington rotation 1851-1861. (a) Region between 10-20° N. (b) Region between 10-20° S.

2. Data and Analysis

Soft X-ray images taken with the Soft X-ray Telescope (SXT; Tsuneta et al., 1991) on board *Yohkoh* were used in this analysis. In order to investigate the long-term evolution of the corona, synoptic charts showing longitude-latitude distribution of the soft X-ray coronal parameters are useful. Synoptic charts of eleven rotations during Carrington rotation 1851-1861 were used in the present study. The synoptic charts of the soft X-ray brightness distribution were constructed from daily full images of SXT.

The obtained synoptic charts show the outstanding coronal structures such as active regions, quiet coronal structures, large-scale interconnection loops, coronal holes, and so on. Figure 1 shows stackplots made from the synoptic charts within the latitudinal range of 10° between 10° and 20° in the northern and the southern hemisphere. An autocorrelation technique was used in order to obtain rotation periods of the coronal structures. Autocorrelation coefficients for every 5° from 60° S to 60° N were calculated from the soft X-ray intensity data during Carrington rotation 1851-1861. The soft X-ray intensity data was smoothed by using a running average method in order to filter out some noise. The rotation period of each characteristic structures was also calculated from a change in the longitude on the synoptic charts.

3. Characteristics of Rotation of Coronal Structures

Figure 2 shows the autocorrelation of the soft X-ray coronal brightness. The autocorrelations for every ten degrees in the latitude are shown for heliographic latitudes from 60° S to 60° N. For each latitude the horizontal line adjacent to the label on the left represents an

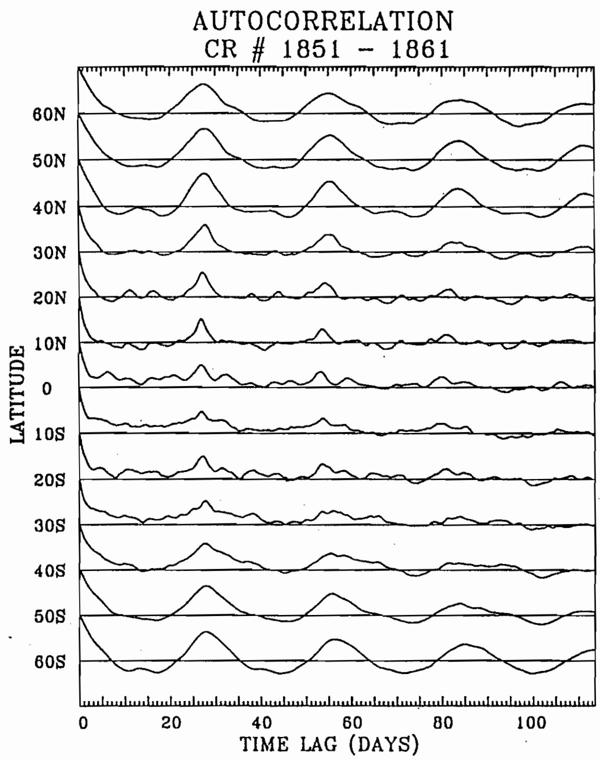

Fig. 2. Autocorrelations of the soft X-ray brightness as a function of time lag for latitudes 60°S to 60°N.

autocorrelation coefficient of zero, and the horizontal line above it represents an autocorrelation coefficient of 1.0. A width of a recurrent peak is expected to indicate a characteristic size of the coronal structure. The first recurrent peaks have a narrow width near the low latitudes and a broader width at the higher latitudes. The second and the third peaks can not be seen clearly at the low latitudes, while the peaks at the high latitudes keep its configurations. These results suggest that the autocorrelation near the low latitudes mainly indicates the rotation of the active regions and that the autocorrelation at the higher latitudes mainly indicates that of the large-scale structures including the quiet structures and the coronal holes.

Figure 3 shows the rotation periods of the soft X-ray coronal structure from autocorrelation peaks for every five degrees in the latitude. The rotation periods from the autocorrelation peaks indicate a differential rotation for the low latitude region, while for the high latitude region structures rotate quasi-rigidly. This result also suggests that the autocorrelation tends to reflect the rotation of the quiet corona at the higher latitudes. The figure also shows that the rotation periods in the northern hemisphere are different from those of the southern hemisphere. In the analyses using magnetic field data, Hoeksema and Scherrer (1987) pointed out that the north-south asymmetry exists in the coronal field. Antonucci et al. (1990) also reported a similar result using the photospheric field data.

We calculated the rotation period of each structures including the active regions and the quiet coronal structures by using the stackplots shown in Figure 1. In the low-latitudinal range the rotation periods of the active regions seem to be different from that of the quiet structures. Such a difference is expected to change the distributions of the coronal and the interplanetary magnetic field (Kozuka et al., 1994). It is suggested that these differences of the rotation periods influenced the heliospheric structure in the analyzed period.

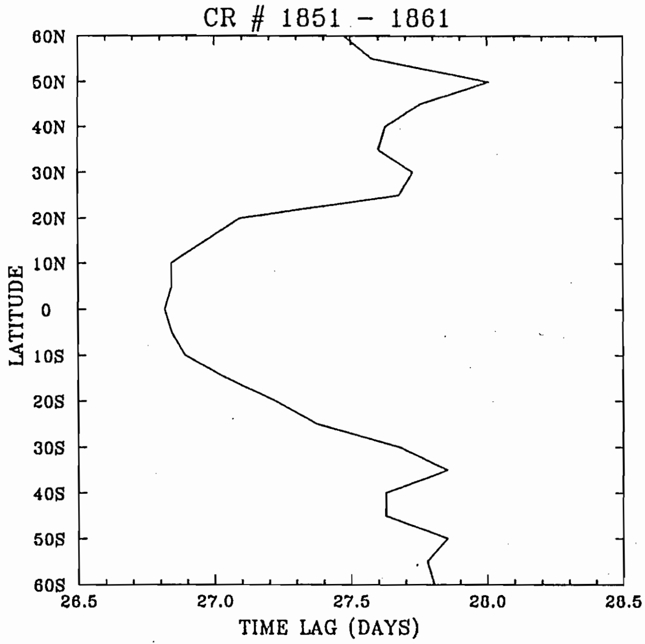

Fig. 3. Rotation periods of the soft X-ray coronal structure from autocorrelation peaks.

4. Conclusion

Characteristics of the rotation of the soft X-ray coronal structures observed by the *Yohkoh* SXT were investigated by using the autocorrelation technique and tracing the characteristic structures. Our conclusion is summarized as follows:
(1) The autocorrelation analysis indicates that for the low latitude region the soft X-ray corona shows a differential rotation, while for the high latitude region structures rotate quasi-rigidly.
(2) The autocorrelation analysis also shows that the rotation periods in the northern hemisphere are different from those of the southern hemisphere.
(3) The rotation periods of the active regions are different from those of the quiet coronal structures in the low latitude region.
It is suggested that these differences of the rotation periods influenced the heliospheric structure in the analyzed period.

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