THE SOLAR DIFFERENTIAL ROTATION FROM THE EIGHTTEENTH SOLAR CYCLE

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Abstract. The sidereal daily rotation of the Sun, $\xi(\phi)$, depends on the data used. From an appropriate selection of the data – sunspots with regular motion – it is found that $\xi(\phi) = 14.31 - 2.70 \sin^2 \phi$, where $\phi$ denotes the heliographic latitude. Moreover, it seems that there is a variation, of the order of 3%, with the solar activity.

1. Introduction

The differential rotation of the Sun can be generally expressed by

$$\xi(\phi) = a - b \sin^2 \phi,$$

where $\xi(\phi)$ is the sidereal rotational rate at heliographic latitude $\phi$ and $a$ and $b$ are constants.

Sunspots data has been used by many investigators (e.g., Newton and Nunn, 1951; Ward, 1965; 1966; and very recently by Kearns, 1979; Balthasar and Wöhl, 1980) to study the differential rotation of the Sun. Moreover, Eddy et al. (1976) showed that the differential rotation of the Sun has not always been the same.

In the present study the sidereal daily motion $\xi(\phi)$ given by (1.1) is found using data from the Greenwich Photoheliographic Results during the eighteenth solar cycle (1945–1954).

2. The Data

From the Greenwich Photoheliographic Results for the eighteenth solar cycle (1945–1954) three sets of data were chosen as follows:

Set A: Including 221 single sunspots or groups of A, C, and I types (after Zurich classification) the daily motion of which was found to be regular.

Set B: Including 153 single sunspots or groups of A, C, and I types the daily motion of which was found to be irregular.

Set C: Including 189 groups of every type (their daily motion was found to be irregular).

Figure 1 represents the sidereal daily rotation $\xi$ against the angular distance $\phi$ from the central meridian of the Sun for two sunspots, one with regular sidereal daily motion and one with irregular. To avoid projectional errors $\phi$ was taken only up to $\pm 60^\circ$, in all cases.

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From the 374 sunspots of sets A and B, 204 were recurrent and 170 non-recurrent, 200 were in the north hemisphere of the Sun, and 174 in the south. On the other hand, from the 189 groups of Set C, 96 were in the north hemisphere of the Sun and 93 in the South.

3. Results

The data was divided into 5° width belts, according to their heliographic latitude \( \varphi \); and their sidereal daily rotation \( \xi \) was found. Table I gives \( \xi \) (in degrees per day) for each 5° belt as it was derived from the data of set A and C.

<table>
<thead>
<tr>
<th>( \varphi )</th>
<th>( \xi ) (Set A)</th>
<th>( \xi ) (Set C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( 0^\circ -5^\circ )</td>
<td>14.31 ± 0.02</td>
<td>14.655 ± 0.04</td>
</tr>
<tr>
<td>( 5^\circ -10^\circ )</td>
<td>14.26 ± 0.02</td>
<td>14.519 ± 0.04</td>
</tr>
<tr>
<td>( 10^\circ -15^\circ )</td>
<td>14.22 ± 0.02</td>
<td>14.426 ± 0.04</td>
</tr>
<tr>
<td>( 15^\circ -20^\circ )</td>
<td>14.08 ± 0.02</td>
<td>14.365 ± 0.04</td>
</tr>
<tr>
<td>( 20^\circ -25^\circ )</td>
<td>13.90 ± 0.03</td>
<td>14.019 ± 0.05</td>
</tr>
<tr>
<td>( 25^\circ -30^\circ )</td>
<td>13.79 ± 0.07</td>
<td>13.879 ± 0.07</td>
</tr>
<tr>
<td>( 30^\circ -... )</td>
<td>13.50</td>
<td>13.617</td>
</tr>
</tbody>
</table>

Moreover, in Table II \( \xi \) is given, for every 5° belt, as it comes out considering the data of sets A and B as well as the data of three sets together. In the same Table II the results of Newton and Nunn (1951) for 6 solar cycles, 1878–1944, as well as those of Ward (1965) for five solar cycles, 1905–1954 are given for comparison.

From the results of Tables I and II we notice that the values of \( \xi \) for every 5° interval of latitude according to the data used, are:

(a) Similar to those of Newton and Nunn (1951) if we consider the data of sets A and B together; that is all the 374 sunspots or groups of A, C, and I types independently of their sidereal daily rotation, being it regular or irregular.

(b) Similar to those of Ward (1965) if we consider all three sets of data together.