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Polar magnetic flux from SOHO/MDI data

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Abstract. The new SOHO/MDI data (1996-2003) reveal an interesting result that the total polar magnetic fluxes do not vary significantly during the polar magnetic field reversals in both hemispheres, while the positive and negative parts of the total fluxes do change.

1. Introduction

The polar magnetic fields on the Sun have been an attractive subject for solar researches since Babcocks measured them in solar cycle 19 (Babcock and Babcock, 1955). One of the remarkable features of the polar magnetic fields is their reversal during the maxima of 11-year sunspot cycles (Babcock and Livingston, 1958; Babcock, 1959). To understand the origin of the polar magnetic field reversals many investigators employed the mean-field dynamo theory (e.g. Dikpati et al., 2003).

There are several additional ideas about the decay mechanism of magnetic field in the polar regions. The first was developed by Fox, McIntosh ans Wilson (1997). They described the evolution of the large-scale fields and their association with polar coronal holes. Their question was whether the polar fields resulted from the local polar dynamo or not. There is no a certain answer to this question. However, Durrant, Turner and Wilson (2002) have observed that high-latitude flux emergence can effect the evolution of individual high-latitude plumes, but this flux does not seriously affect the whole reversal times of the polar magnetic field. Fisk and Schwadron (2001) suggested that the polar magnetic field reversals occurred because of the diffusion of open magnetic field lines on the solar surface (due to transport and decay) that were reconnected with closed loops. According to this consideration the total open flux should tend to be constant in time. A study of the EUV from SOHO/EIT and the X-ray from YOHKOH data revealed a large scale connectivity in the corona between polar regions and the following parts of complexes of solar activity in the rising phase of the solar cycle (Benevolenskaya et al., 2001). Therefore, an additional decay mechanism might exist as a magnetic energy release in these giant loops structure.

2. Polar magnetic field and magnetic flux

The polar magnetic field consists of small regions of both polarity. During the rising phase of the solar cycle, the positive polarity is dominant in The Northern hemisphere for the latitudinal zone from 78° to 88°, and the negative polarity prevails over the positive one in the corresponding South polar region. After the polar field reversals the order of the polarities is changed.

The magnetic flux (F_r) of the radial component of the magnetic field (B_r) has been estimated under the assumption that the solar magnetic field is predominantly radial in the polar regions for low-resolution ($360° \times 180°$) and high-resolution (3600×1080 pixels) synoptic maps. This assumption is reliable because Svalgaard, Duvall and Scherrer (1978) have shown that the observed magnetic field strength varies as the line-of sight component of near by radial fields.

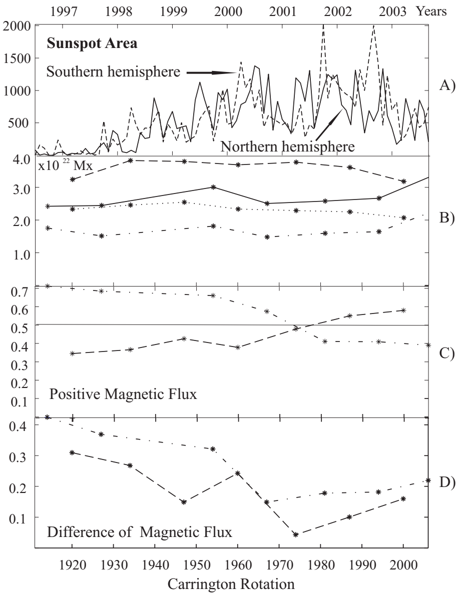

Figure 1. Plots of :A) Sunspot area in the Southern (dash line) and in the Northern (solid line) hemispheres; B) Magnetic flux of the radial field component in the latitude zones from 78° to 88° in Northern(solid line) and Southern Hemispheres (dash line) for high-resolution, and 'dash and dots line' and 'dots line' for low-resolution MDI maps; C) The relative positive polarity parts of magnetic flux in Northern (dash and dots line) and Southern (dash line) hemispheres; D) the relative difference positive and negative magnetic fluxes.

The total magnetic flux for polar caps (±(78° - 88°) is presented in Figure 1B for high- and low-resolution synoptic maps. There is a N-S asymmetry in the distributions of the total polar magnetic flux for low-resolution maps: $F_r = 1.5{-}1.8{\cdot}10^{22}$ Mx and $F_r = 2.0{-}2.5{\cdot}10^{22}$ Mx for the North and South polar caps, correspondingly. The positive ($\frac{F_+}{F_r}$) and negative ($\frac{F_-}{F_r}$) parts of the magnetic flux and difference ($\frac{F_+}{F_r} - \frac{F_-}{F_r}$) are plotted in Figures 1C, 1D. The sunspot area is shown in Figure 1A to illustrate the level of sunspot activity. Magnetic flux estimated for high-resolution synoptic maps(3600 × 1080 pixels) shows the same behavior, but values a little greater: $B_r = 2.5 - 3.0 \cdot 10^{22}$ Mx and $B_r = 3.2 - 3.7 \cdot 10^{22}$ Mx for the North and South polar caps, correspondingly. It is not surprising because value of the magnetic flux closely depends of the resolution of the magnetic field as it is shown in paper (Krivova and Solanki, 2004). There is a pronounced solar cycle dependence of the positive and negative fluxes before and after the polar magnetic field reversals. The time of reversals can be easily determined at $\frac{F_+}{F_r} = 0.5$ or $\frac{F_-}{F_r} = 0.5$. It was in CR 1979 for the southern magnetic field, it is about CR 1974 in the North. This is close to the periods obtained by Durrant and Wilson (2003): CR 1975 ± 2 in North and CR 1981 ± 1 in South.

The most important result of our analysis is that the total polar magnetic flux does not display any significant variations during the rising phase of solar cycle and at its maximum while the positive and negative parts of the magnetic flux do change. But, obviously, the total magnetic flux changes in the zones of sunspot activity.

As we understand now, the process of polar magnetic field reversal is a complex phenomena including different physical processes in the convection zone, photosphere and corona.

References

Babcock, H. W., and Babcock, H. D. 1955 *ApJ* **121**, 349.
Babcock, H. W., Livingston W. C. 1958 *Science* **127**, 1058.
Babcock, H. D. 1959 *ApJ* **130**, 364.
Benevolenskaya, E. E., Kosovichev, A. G., Scherrer, P. H. 2001 *ApJ* **554**, L107.
Dikpati, M., de Toma, G., Gilman, P. A., Arge, C. N., White, O. R., 2003 *ApJ* **601**, 1136.
Durrant, C.J., Turner, J. and Wilson, P.R. 2002 *Solar Phys.* **211**, 103.
Durrant, C. J. and Wilson, P. R. 2003 *Solar Phys.* **214**, 23.
Fisk, L. A., Scwadron, N. A. 2001 *ApJ* **560**, L425.
Fox, P. A., McIntosh, P. S. and Wilson, P. R. 1998 *ApJ* **117**, 375.
Krivova, N. A., Solanki, S. K. 2004 **417**, 1125.
Svalgaard, L., Duvall, T. L., Scherrer, P. H. 1978 *Solar Phys.* **58**, 225.

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