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The Hemispheric Sign Rule of Current Helicity during the Rising Phase of Cycle 23

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Abstract. We compute the signs of two different current helicity parameters (i.e., $\alpha_{\rm best}$ and $H_{\rm c}$) for 87 active regions during the rise of cycle 23. The results indicate that 59% of the active regions in the northern hemisphere have negative $\alpha_{\rm best}$ and 65% in the southern hemisphere have positive. This is consistent with that of the cycle 22. However, the helicity parameter $H_{\rm c}$ shows a weaker opposite hemispheric preference in the new solar cycle. Possible reasons are discussed.

Key words: Sun: activity—magnetic fields—photosphere.

1. Introduction

In the last decade observations have revealed that a hemispheric preference of magnetic chirality (handedness) exists throughout the solar atmosphere, such as sunspot whirls (Richardson 1941), signs of current helicity in active regions (see Table 1), quiescent filaments (Martin *et al.* 1994), sigmoid coronal loops (Rust and Kumar 1996) and interplanetary magnetic clouds (Rust 1994). Table 1 shows that the hemispheric asymmetry in sign of current helicity seems to be stronger in the Huairou Solar Observing Station (HSOS) data (Abramenko *et al.* 1996, Bao & Zhang 1998) than in the Mees Solar Observatory (MSO) data (Pevtsov *et al.* 1995, Longcope *et al.* 1998). Bao *et al.* (2000) studied the origin of this phenomenon and concluded that it is mostly due to a choice of two different helicity parameters ($\alpha_{\rm best}$ and $H_{\rm c}$) used in these studies, rather than a disagreement between the two data sets. The interpretation of all these patterns and their possible connection to the dynamo are open to question. In addition, current helicity of magnetic fields also plays an important role in solar flare evolution (Bao *et al.* 1999). The purpose of this paper is to examine whether the hemispheric helicity changes its sign from one solar cycle to another.

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2. Data analysis and results

We chose 87 active regions observed with the vector magnetograph at HSOS during the rising phase of cycle 23 to compute the sign of their current helicity. All data used in our study were acquired with favorable weather and seeing conditions during the time in which active regions were located near the central meridian. Considering that the noise level of transverse field measurements is generally higher than that of line-of-sight field measurements by an order of magnitude, we did not transform our data into disk-center heliographic coordinates to avoid dirtying of the vertical components by the projection correction. The 180° azimuth ambiguity was resolved following Wang *et al.* (1994). A detailed description of the HSOS instruments and observational technique may be found elsewhere (e.g., Bao *et al.* 2000).

Table 1. Signs of photospheric current helicity computed by different groups.

Group	Hemisphere	$\alpha_{\rm best}$		$H_{\rm c}$		Total
		Negative	Positive	Negative	Positive	
Pevtsov et al.	Northern	25(76%)				33
(1995)	Southern		25(69%)			36
Longcope et al.	Northern	58(62%)				93
(1998)	Southern		73(66%)			110
Abramenko et al.	Northern			15(79%)		19
(1996)	Southern				18(86%)	21
Bao & Zhang	Northern			168(84%)		199
(1998)	Southern				177(79%)	223

Table 2 shows the signs of both $\alpha_{\rm best}$ and $H_{\rm c}$ for 87 active regions during the rise of cycle 23. The value of the parameter $\alpha_{\rm best}$ is determined by the best match between the x and y components of the computed constant-α force-free and observed horizontal magnetic field in the sense of a minimum least-squares difference (Pevtsov *et al.* 1995), and the other parameter $H_{\rm c}$ is given by computing $B_z \cdot (\bigtriangledown \times \mathbf{B})_z$ (Bao & Zhang 1998). From this table we can notice that 59% of active regions in the northern hemisphere have negative $\alpha_{\rm best}$, and 65% in the southern hemisphere have positive $\alpha_{\rm best}$. This result is consistent with those results of cycle 22. However, $H_{\rm c}$ shows a weaker opposite hemispheric preference, in disagreement with the cycle 22. The variation of current helicity with solar latitude for all 87 active regions is displayed in Fig. 1(a)–1(b). Each plus symbol marks the value of $\alpha_{\rm best}$ or $H_{\rm c}$ and the latitude (of magnetogram center) for one active region. For comparison, Fig. 1(c)–1(d) shows the variation of $\alpha_{\rm best}$ and $H_{\rm c}$ with solar latitude for the data of cycle 22. These plots demonstrate that current helicity has a maximum at about 15°–25° latitude and decreases toward both the equator and the poles (Pevtsov *et al.* 1995). On the other hand, we can clearly see that there is consistency between two dashed lines in Fig.

1(c)–1(d). Fig. 1(a)–1(b) show no consistency between atitudinal trends in α_{best} and H_{c}. This means that H_{c} no longer follows the hemispheric sign rule in the current cycle.

Table 2. Distribution of hemispheric helicity signs for the two cycles.

Cycle	Hemisphere	α_{best}		H_{c}		Total
		Negative	Positive	Negative	Positive	
22	Northern	152(76%)		168(84%)		199
	Southern		159(71%)		177(79%)	223
23	Northern	26(59%)		14(32%)		44
	Southern		28(65%)		21(49%)	43

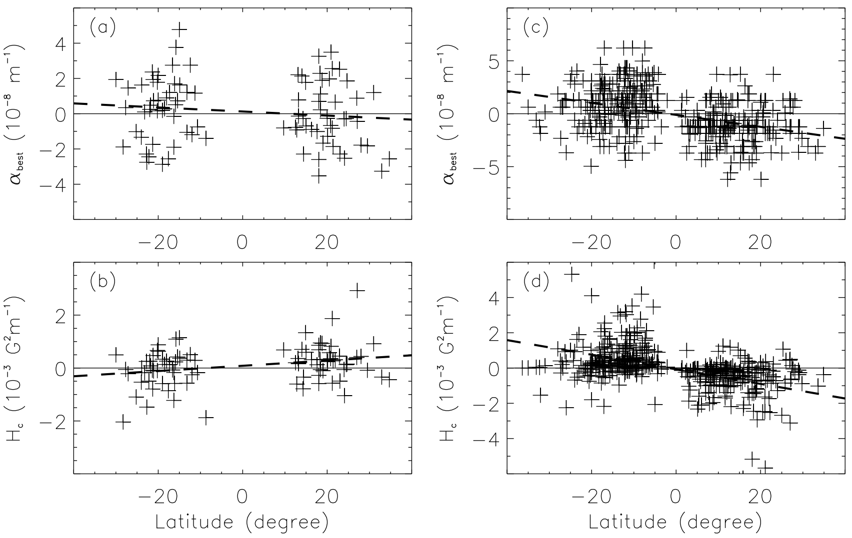

Figure 1. (a)–(b) variation of α_{best} and H_{c} with solar latitude for 87 active regions observed during the rise of cycle 23. (c)–(d) variation of these two parameters with solar latitude for 422 active regions studied by Bao & Zhang (1998), respectively. The dashed line shows a linear fit to the data.

3. Discussion

The hemispheric sign rule of photospheric current helicity in active regions was established for the cycle 22 (see Table 1). We expect to see the same hemispheric asymmetry for both α_{best} and H_{c} in a new solar cycle. However, our observations indicate that the helicity parameter H_{c} does not obey such a hemispheric rule during the rising phase of cycle 23, unlike α_{best}. How to explain it? Our views are that:

• Although such a primary result is interesting, it would be premature to make a serious conclusion based on these data. More samples are required to answer this question.
• Since Faraday rotation will produce a counterclockwise rotation of the azimuth for a line-of-sight field of positive polarity, and during cycle 23 the polarity of leading sunspots is positive in the northern hemisphere, some active regions with negative current helicity in the northern hemisphere may reverse their original twist and show positive helicity as a result of Faraday rotation. In addition H_c may be more susceptible to Faraday rotation than α_{best} because it is mainly related to the areas where the line-of-sight field is strong. Considering the Hale-Nicholson polarity rule, the Faraday rotation action should be opposite to cycle 22 (see Table 2).
• The cause of the hemispheric tendency is still uncertain. Perhaps these two parameters reflect different physical nature of subphotospheric origin.
• A single sign of α_{best} or H_c averaged over a whole active region is not appropriate. It ignores the small-scale patterns of oppositely directed twist which are known to exist inside active regions.

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