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# The Skew of Polar Crown X-ray Arcades

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**Abstract.** The one-to-one relationship between the chirality of filament channels and the skew (relative orientation) of the overlying coronal arcades can be coupled with the predictions for the axial component of polar crown filaments based on past magnetic field observations to predict the skew of polar crown arcades in the recent cycle 22. We have surveyed the actual skew as seen in the Yohkoh SXT images over the declining phase of cycle 22 and found a result opposite to that expected. The SXT arcades have been compared with numerical models to show that while some of this result can be explained by flux distribution around switchbacks, other mechanisms such as differential rotation are also needed.

## 1. The Basic Structure of Filament Channels

The natural potential field across a photospheric polarity inversion line takes the form of a series of nested arcades. Soft x-ray images from Skylab and the Yohkoh Soft X-ray Telescope (SXT) show that the coronal structures above inversion lines do show this general form. Due to asymmetrical distributions of photospheric flux many arcades are comprised of loops that cross the underlying polarity inversion line at an angle other than 90°. This angle has been called the skew of the arcade by Martin and McAllister (1998) (see Figure 1).

Strong axially aligned photospheric magnetic fields along an inversion line under a coronal arcade create a filament channel in which a filament may form (e.g., Gaizauskas 1998, these proceedings). These axially aligned fields in filament channels and filaments have been found to come in two varieties, defined as 'dextral' and 'sinistral' (e.g., Martin 1998, these proceedings, and Figure 1). In the quiet sun filaments often have barbs or legs which allow a topological determination of filament chirality (Martin 1998, these proceedings).

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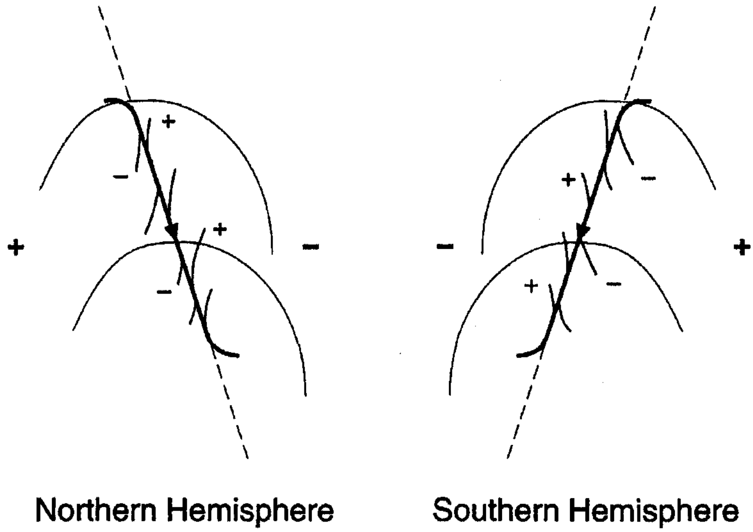


Figure 1. A cartoon showing the structure of (a) 'dextral' and (b) 'sinistral' filaments and under overlying a) 'left-skewed' and b) 'right-skewed' arcades. The ends of the filament backbone, like the arcade loops, are rooted in the dominant polarities (large '+' and '–'). The barbs are represented by the small side lines rooted in the minority polarity (small '+'s and '–'s). (Martin and McAllister 1998, Figure 5).

Recently it has become apparent that there are certain clear relationships between these structures.

## 2. Previous Observations and Correlations

Observations of the axial fields of filaments have been made using both the Zeeman effect (e.g., Rust 1967) and the Hanle effect (e.g., Leroy et al. 1983, Bommier and Leroy 1998, these proceedings). These workers have found that i) the axial field along each polar crown was consistent over each solar cycle (the interval from one polar reversal to the next), ii) these fields were opposite in the northern and southern polar crowns, and iii) they reversed direction with the change of the polar fields near the maximum of each sunspot cycle. Martin, Marquette, and Bilimoria (1992) applied the topological chirality test to filaments through four solar cycles confirming the older findings and extending them into cycle 22.

Martin, Bilimoria, and Tracadas (1994) have shown that the chirality of filaments is always the same as that of the associated filament channel, and Martin and McAllister (1998) found that for mid- and low-latitude filaments the axial component of the magnetic field is the same in the overlying coronal arcades as it is in the filaments. Physically this means that the axial magnetic field is in the same direction from the photosphere up into the corona, but the transverse magnetic field reverses with height.

Based on this work the cycle 22 post-reversal polar crown axial fields are ex-

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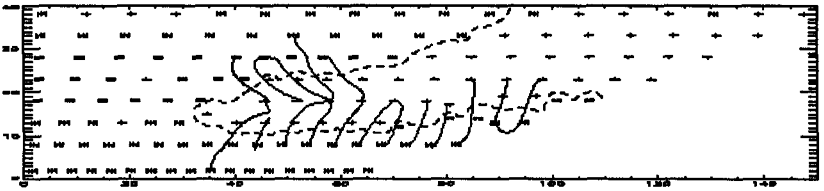
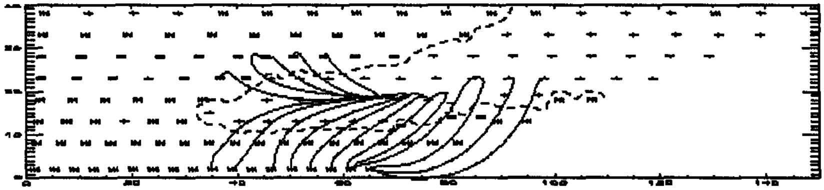


(a)



(b)

Figure 2. (a) Field lines plotted at a height of 140,000 km showing a left skew on the horizontal arm and a right skew on the diagonal arm. (b) Oblique view of the field lines at heights of 200,000 km on the horizontal arm and 140,000 km on the diagonal arm.

pected to be eastward in the northern hemisphere and westward in the southern hemisphere, implying that the polar crown arcades will be right-skewed in the southern hemisphere and left-skewed in the northern hemisphere, if the Martin and McAllister relationship holds there as well.

## 3. Coronal Observations

To test this prediction we have surveyed the SXT images of the corona over polar crown neutral lines from October 1991 through August 1994 cataloging all indications of skew. Due to observational constraints most of our sample is made up of events in which the corona rises above its normal brightness. These are either large-scale dynamic arcade events following a CME (McAllister et al. 1998), or transient brightenings of loops due to a local event near one end (Solberg and McAllister 1998, these proceedings).

The main result was that the skew indications along the polar crowns are generally not in agreement with the prediction. There were predominantly left-skewed arcades along the southern polar crown and right-skewed arcades along the northern polar crown. This result is based on 47 cases over the three years. In contrast the skew of non-polar crown arcades was dominantly as expected from the previous work. We note that the clarity of the statistics improved from mid 1992 on, as the southern polar reversal was completed.

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## 4. Models

As a first step in understanding our result we have compared the observations with potential models. A model of an idealized switchback (the eastern end of a polar crown neutral line [McAllister et al. 1998]) was created by nesting two pie shaped opposite-polarity regions. At the corner of the switchback this produces a local flux imbalance which is responsible for the skew of the arcades reversing on the polar crown switchback arm (see Figure 2).

On the sun switchbacks are formed, in part, due to the transport of denser lower latitude magnetic fields to high latitude (van Ballegoojen, Cartledge and Priest 1998). Using synoptic magnetograms obtained from the NSO archive we tested our model on a well-formed polar crown switchback that produced two dynamic arcades on February 24–25, 1993 (Figure 2). The comparison shows that in both the SXT data and the potential model the skew reverses on the polar crown.

## 5. Discussion

While potential models can explain the unexpected skew near the switchbacks, our data suggest that it persists along most of the polar crown. Thus, other mechanisms, such as differential rotation, may also play a role (van Ballegooijen and Martens 1990). The second interesting point is that the possibility of an axial field reversal with height cannot be ruled out along the polar crown.

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