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Unipolar Moving Magnetic Features: An Observation

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Abstract. Utilizing SOHO/MDI data of two active regions (ARs 08398 & 10373), we identify and trace the whole lifetimes of 26 positive and 68 negative unipolar Moving Magnetic Features (MMFs). The statistical properties of several kinematic and magnetic quantities are studied.

Keywords. Sun: magnetic fields, Sun: sunspots

1. Introduction

Moving Magnetic Features (MMFs) are small photospheric magnetic elements moving outward in the radial direction from the penumbrae of sunspots. They can be bipolar (Type I), or unipolar with either the same polarity of the sunspots (Type II) or the opposite (Type III)(Shine & Title 2001). A large sample of opposite-polarity MMFs was studied by Zhang *et al.* (2003).

We investigate the statistical properties of unipolar MMFs associated with two stable positive sunspots using available 1-minute-cadence high-resolution-mode SOHO/MDI magnetograms. We identify 26 positive and 68 negative unipolar moving magnetic features and trace them from emergence to the stage of loosing their identities and measure several kinematic and magnetic quantities.

2. Properties of MMFs

We regard a MMF is born when it appears as a recognizable point above the background noise; it dies when it's flux density drops to the same level as the background or it conglomerates with another MMF. The average lifetime is 1.92 hours for positive ones and 1.64 hours for negative ones. The distributions are slightly polarity-dependent.

Most MMFs spent their entire lifetimes within the moat. While the mean total radial distances covered by MMFs of different polarities are pretty close (3.52 Mm for positives and 3.56 Mm for negatives), positive MMFs emerge and vanish closer to the penumbrae than negative ones (the mean distance to the penumbra boundaries at first appearance is 2.46 (positive)/3.93 (negative) Mm; the mean distance at last appearance is 5.98 (positive)/7.48 (negative) Mm). Few samples were born inside the penumbrae. The boundaries of the penumbrae are located by corresponding MDI filtergrams; two ellipses that fit the boundaries best are employed in the calculation.

Table 1. Properties of the Studied Data Sets

NOAA	*Year*	*Time Interval*	*Geocentric Coordinates*	*TypeI*	*TypeII*
08398	1998	Nov 29/23:00–Dec 02/16:59	(-277",308")–(286",324")	12	33
10373	2003	Jun 01/20:00–Jun 04/00:05	(-261",136")–(205",127")	14	35

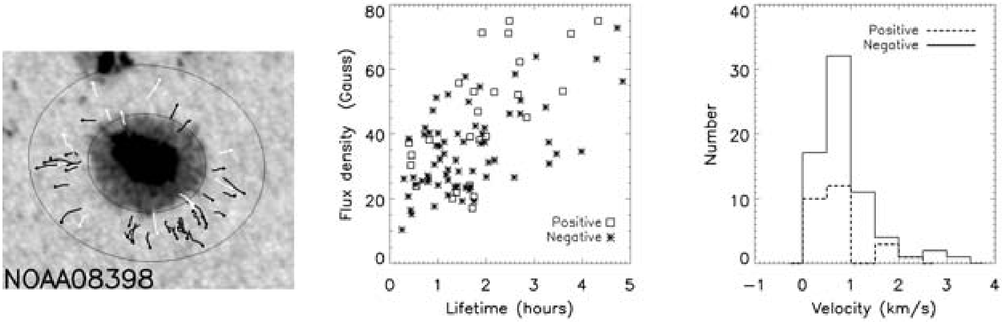

Figure 1. *left*: An illustration of all the tracks of the unipolar MMFs that we have identified in AR 08398. White arrows represent positive MMFs and black for negative ones, all superposed upon a MDI filtergram. The smaller and larger ellipses are the approximations of the inner and outer boundaries of the moat. *middle*: a plot of flux densities of selected MMFs in both ARs versus their lifetimes. *right*: a histogram of the velocities of MMFs in both ARs.

The velocities of our MMFs are reversely proportional to their lifetimes, i.e. the longer a MMF lives, the slower it moves. The mean velocity of the positive MMFs (0.73 km/s) is slightly lower than that of the negative ones (0.88 km/s)(figure 1, *right*) which nearly double the average velocity of bipolar MMFs recorded in literature (Zhang *et al.* 2003).

Although the paths of most of the MMFs in our collection do not show strong azimuthal deviation from radial directions (figure 1, *left*), they are attracted by polar regions of both polarities around the moat. Those MMFs heading towards neighboring polar areas generally have higher velocities than those running into quiet regions.

The magnetic fluxes of MMFs are proportional to both their flux intensities and areas. The mean flux per MMF element is 2.83×10^{18} (positive)/2.45×10^{18} (negative) Mx. MMFs that have strong flux densities usually have longer lifetimes (figure 1, *middle*) and lower velocities while those weak ones live shorter and move faster. This might due to the fact that most MMFs in our sample pool died of decaying.

3. Discussions

We identify only well-isolated unipolar MMFs, which might bias our selection and influence the results of statistics. Our number of negative MMFs is 2.6 times the number of positive ones; further analysis are yet to be done to confirm or refute this ratio. MMFs around sunspots of different sizes, polarities, and developing phases should be studied to discover the relationships between properties of MMFs with mother sunspots.

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