FLUX DISTRIBUTION OF SOLAR INTRANETWORK MAGNETIC FIELDS

JINGXIU WANG
Beijing Astronomical Observatory, Chinese Academy of Sciences, Beijing 100080, China

and

HAIMIN WANG, FRANCES TANG, JEONGWOO W. LEE and HAROLD ZIRIN
Big Bear Solar Observatory, California Institute of Technology, Pasadena, CA 91125, U.S.A.

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Abstract. Big Bear deep magnetograms of June 4, 1992 provide unprecedented observations for direct measurements of solar intranetwork (IN) magnetic fields. More than 2500 individual IN elements and 500 network elements are identified and their magnetic flux measured in a quiet region of 300 $\times$ 235 arc sec. The analysis reveals the following results:

(1) IN element flux ranges from 10^{16} Mx (detection limit) to 2×10^{18} Mx, with a peak flux distribution of 6×10^{16} Mx.

(2) More than 20% of the total flux in this quiet region is in the form of IN elements at any given time.

(3) Most IN elements appear as a cluster of mixed polarities from an emergence center (or centers) somewhere within the network interior.

(4) The IN flux is smaller than the network flux by more than an order of magnitude. It has a uniform spatial distribution with equal amount of both polarities.

It is speculated that IN fields are intrinsically different from network fields and may be generated from a different source as well.

1. Introduction

The intranetwork (IN) magnetic fields are at the tail end of the spectrum of solar magnetic fields in the photosphere. They are weakest in field strength and smallest in flux. They appear as small elements of magnetic fields inside the network (supergranular) cells. Like the network fields, their presence does not seem to be dependent on the latitude on the globe. Unlike network fields, however, the IN fields are not affected by decaying active region fields.

IN fields were first observed by Livingston and Harvey (1975) and Smithson (1975). They were described as 'discrete elements' of mixed polarities 'interior to the network'. In recent years progress was made in the understanding of IN's morphology, dynamics and some quantitative aspects from time sequences of deep magnetograms obtained at the Big Bear and Huairou Solar Observatories (Livi, Wang, and Martin, 1985; Martin, 1984, 1988, 1990; Shi *et al.*, 1990; Wang *et al.*, 1985; Wang, Zirin, and Shi, 1989; Wang and Shi, 1988; Wang and Zirin, 1988; Zirin, 1985, 1987, 1993).

The first Stokes V line ratio measurement made by Keller *et al.* (1994) has placed an upper limit on the intrinsic strength of IN fields at 1000 G and with 68%

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probability at 500 G. By using an infrared array technique, Lin (1994) was able to directly measure the Zeeman splitting of the Fe I 15648.5 Å and Fe I 15652.9 Å lines of the IN fields. His result revealed that the fields typically have field strengths around 500 G.

The current knowledge about IN fields may be summarized as follows: (1) They consist of 'point-like' elements of mixed polarities within the network cells. (2) IN flux elements move at a speed of 0.3–1.0 km s^{-1}, but they do not always move radially toward the cell boundaries (Zirin, 1985). (3) They are intrinsically weak, each estimated to have a total flux between 10^{16} and 10^{17} Mx (Zirin, 1987). (4) They interact with the network elements upon contact, either 'canceling' with opposite-polarity elements or merging with same-polarity elements (Livi, Wang, and Martin, 1985). (5) Their lifetime has been estimated by several groups, but not statistically determined. A wide range of lifetimes has been reported. High temporal resolution magnetograms show that some of the IN elements are stable for at least several hours.

While most of the network elements can be easily observed, most of the IN fields are difficult to observe because of their smaller size and low flux density. The June 4, 1992 data obtained at Big Bear provided the first set of observation with which a statistical study of the IN and network fields may be carried out.

2. Data Analysis

2.1. Data

The data on June 4, 1992 are the best quiet region observations ever obtained at BBSO. The region is near the center of the Sun at S10 W3. The magnetograms were acquired by integrating 4096 video frames, then recording in a 16-bit memory. The calibration was made by the method described by Varsik (1994). The 7-hr observation yielded 73 magnetograms, which were registered by crosscorrelation. The sequence was then made into a movie from which the motion and evolution of the magnetic elements can be traced.

Throughout this paper, the term 'magnetic element' does not imply an elementary flux tube, which is beyond our present knowledge. It merely refers to an observational entity: the intersection of a bundle of magnetic field lines with the photosphere .

Individual IN elements were identified, and their flux measured. Figure 1 is a magnetogram at 16:49 UT when the seeing was the best. The flux measurement is based on this magnetogram. Solar south is at the top, east is to the right. The field of view is 617 × 473 pixels. Each pixel is 0.5 arc sec. Enhanced network can be seen in most of the eastern part of the field of view, while quiet network can be seen in parts of the western half.

Since IN fields have low flux density (the magnitude of the vector **B** in Maxwell's equations in a medium), noise in the magnetograms could be mis-