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MAGNETIC BIPOLES IN EMERGING FLUX REGIONS ON THE SUN

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ABSTRACT. We analyse magnetograms and H-alpha filtergrams of an Emerging Flux Region. Small bipoles have been observed on the magnetograms emerging between opposite polarities. Separation velocities of the opposite poles for 45 bipoles observed on June 9, 1985 have been measured and are in the range 0.5 < Vs < 3.5 km/s. A significant magnetic flux increase in the region was observed due to contributions from the emerging bipoles.

RESUMEN. Se analizan magnetogramas y filtrogramas en H-alfa de una region de flujo emergente. Se observan pequenos dipolos en los magnetogramas emergiendo entre polaridades opuestas. Se midieron velocidades de separacion de polos opuestos para 45 bipolos observados en junio 9 de 1985 y estan en el intervalo 0.5 < Vs < 3.5 km/s. Se observo un aumento significativo del flujo magnetico en la region debido a contribuciones de los bipolos emergentes.

Key words: SUN-CHROMOSPHERE — SUN-MAGNETIC FIELDS

I. INTRODUCTION

We study the birth of bipoles in Emerging Flux Regions (EFR) on the Sun using H-alpha filtergrams and line-of-sight magnetograms obtained on June 7-13, 1985 at the Big Bear Solar Observatory by Sara Martin. Emerging Flux Regions are defined as the first stage of active regions and are recognized on H-alpha filtergrams as two bright plages connected by Arch Filament Systems. The bright plages correspond to the higher magnetic field patches and usually separate from each other as they grow.

On the first day of emergence, (June 9, 1985) the Emerging Flux Region was oriented East-West, extending for 60000 km in Solar longitude and 40000 km in latitude. On the day before the appearance of the Emerging Flux Region, the photospheric magnetic fields on the site were very weak. No sign of perturbation could be identified on the previous days. Three pores formed overnight between 02:00 UT and 15:30 UT, June 9; two more were detected during the observing day (from 15:30 UT June 9, to 01:00 UT June 10). The tendency to increase in complexity occurred very soon after the region birth due to new bipoles emerging in and near the region. During the whole day, the fine structure in the magnetic field was mantained by successive emergence of small bipoles.

On the next day a new bipolar region emerged on the following part and the total span in longitude reached more than 90000 km. Following the development of the region on June 9, 1985 we verified the sucessive appearance of small bipoles in the middle of the region. The opposite poles of each individual bipole moved apart, tending to separate faster at the beginning, as observed in Ephemeral Active Regions.

Ephemeral Active Regions are small bipolar regions that are first seen as a small compact unit with almost balanced magnetic flux that grows as the opposite poles separate. Bright plages and organized fibril structures or Arch Filament Systems are seen on the H-alpha filtergrams corresponding to bigger Ephemeral Active regions and some might even develop pores. Ephemeral Active Regions are characteristically small, extending over 20000 to 40000 km and having areas less than $7x10^8$ km^2 (Harvey and Martin 1973). Ephemeral Active Regions were defined by their short lifetimes and the region observed on 9 July 1985 lasted during the following days and was too big to be classified as ephemeral. The smallest Ephemeral Active Regions appear on the limit of detection of the better magnetograms; as the opposite poles separate from each other without clear increase in magnetic flux they lose their identity in a few hours interacting with surrounding fields; their identification based strictly on H-alpha is difficult. Each individual bipole within the region behaved as an Ephemeral Region and had a short lifetime, but they are a substructure of the region and Ephemeral Regions are independent entities.

II. ANALYSIS OF THE MAGNETIC BIPOLES

We studied the behavior of 45 of these bipoles verifying: the point of appearance, the separation velocity, the orientation and the fate of the opposite poles after the separation.

EMERGENCE : we define the center of emergence as half the distance between the opposite poles at the moment of appearance of the bipoles, and we mark this point for each bipole observed. We noted that the centers of emergence come one after the other, forming well-defined lines, in regions among larger structures of opposite polarities.

VELOCITIES : for each bipole, we plot the distance between the opposite poles vs time. We noted that the separation velocity decreases as the poles get apart. Then, we calculated the maximum separation velocity (the steepest portion of the distance vs time graphic) and we obtained velocities in the range $0.5 < V_s < 3.5$ km/s, with a mean of $<V_s> = 1.7$ km/s. Previous data indicated $V_s = 2$ km/s (Born 1974) and 5 km/s (Chou and Wang 1986) for the separation of the peaks of the whole Emerging Flux Region. We found that the "preceeding" poles tend to move faster than the "following" poles.

ORIENTATION : the new sets of bipoles appear with different orientations and contribute to change the general orientation of the whole region. A similar effect was observed by Weart (1970) in H-alpha filtergrams: the main cause of rotation of the Arch Filament System was not the rotation of the individual arches, but the emergence of new arches with different orientation and the vanishing of the old ones.

FATE OF OPPOSITE POLES : we observe the opposite poles of each bipole verifying the occurrence of cancellations or additions to elements of the same polarity (mergings). We observed that 28% of the poles cancel, whereas 72% merge. This clearly indicates a flux increase in the region due to the contribution of the emerging bipoles.

Due to cancellations and mergings, the magnetic flux of opposite poles is not balanced, as observed by Livi et al. (1985) for Ephemeral Regions. These processes also contribute to the loss of identity of individual bipoles in a few hours. As a whole, the complex emergence of small bipoles in the middle of the region contribute to a continuous increase of magnetic flux in both polarities.

This analysis is relevant because the appearance of bipoles is just beginning to be observed in detail. As quoted by Zirin (1989): "I have searched for, but never found, small magnetic flux elements spreading to the two ends of the bipole; subsequent loops are independent entities." In founding the elements searched by Zirin, we might explain why the separation velocities observed by Chou and Wang (1987) were not correlated with the magnetic flux as expected theoretically: the buoyance might have to be applied to individual small bipoles that have much less magnetic flux than the whole region, but not smaller separation speed. Besides the 45 bipoles that have been measured, others can be distinguished, but are too small and short lived to be followed in detail.

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