Observational Results of an Active Region (NOAA 7321) during October – November, 1992

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Abstract

NOAA 7321 was an emerging flux region (EFR) from October 24 to November 1, 1992. This EFR was born on October 24 – 25. The distribution of magnetic polarities in this region reversed from the Hale–Nicholson rules obviously. Due to the emergence of magnetic flux, magnetic structures in this region become complex. The shear of photospheric transverse magnetic field occurred in the emerging process of magnetic flux and it accompanied with flares.

Some flares were observed near the photospheric magnetic neutral line. After resolving the 180° ambiguity of the transverse field in the active region, the relationship between the flare bright points and longitudinal current density have been analyzed. Most of flare bright points did not occur at the peaks of the longitudinal current density in the emerging flux region.

1. Introduction

Photospheric vector magnetograms (FeI λ5324.19 Å), chromospheric longitudinal magnetograms (Hβ λ4861.34 Å) and corresponding Dopplergrams in the active region 7321 during October – November 1992 were observed at Huairou Solar Observing Station.

2. Formation of a New Active Region

2.1 Emergence of magnetic flux

The new magnetic flux emerged from subatmosphere to form a new active region (NOAA 7321) on October 24, 1992.

Inclination angles of the magnetic axis of main poles of this active region relative to the solar equator is about 60°. It is inverted to the Hale–Nicholson law.

2.2 Magnetic Shear near Magnetic Neutral Line

The magnetic field sheared gradually near the magnetic neutral line during the emergence of magnetic flux in the active region. The longitudinal magnetic features, as fibril-like form, were parallel to the transverse field.

The shear angles of the transverse field changed and were gradually parallel to the magnetic neutral line in Figure 1. Some of magnetic structures of opposite polarities disappeared near the magnetic neutral line as the growth of the new active region.

2.3 Velocity field of Emerging flux region

The chromospheric Dopplergrams showed that the evident upward flow of chromospheric mass occurred near the magnetic neutral line of new emerging magnetic flux and the downward flow at the foot points of the new emerging flux in the active region.

3. Direction of Vector Magnetic Field and Longitudinal Currents

3.1 Resolving the 180° Ambiguity of the Transverse Field

(a) Our first approximation was to adopt the choice of directions closest to that of the potential field fitted to the line of sight component of the observed magnetic field. This works well at most points but due to the shear of the magnetic field in the interesting regions the fits of the field probably fail, for example near the magnetic neutral line where the the transverse field were almost parallel to it.

(b) Spatial and temporal continuities of the transverse magnetic field are important parameters. We took into account the requirement of continuous change of the direction of the transverse magnetic field and their evolution in the active region.

3.2 Distribution of the Longitudinal Currents

According to a formula $J_z = \frac{\partial B_y}{\partial x} - \frac{\partial B_x}{\partial y}$, the distribution of the longitudinal current density can be obtained. The longitudinal currents of opposite directions can exist in one main pole of the magnetic field. Moreover, the relationship between the magnetic neutral line and inversion line of large-scale longitudinal current structures is not distinct in the active region 7321, but the longitudinal current of opposite directions with a tendency appeared in different sides of the main magnetic neutral line.

4. Flares

Some flares in this EFR were observed at Huairou Solar Observing Station.

27 Hβ flare bright points on October 25 and 26 in the emerging flux region were analyzed. These flare bright points occurred near the magnetic gulfs and islands of opposite polarities in the both sides of the magnetic neutral line in the active region shown in Figure 2.

Figure 2 also shows the distribution of the longitudinal electrical current density in the active region on October 25 and 26 1992, the active region was located near the solar disk center (S23, E8.5 on October 25). The statistical result of the relationship between the longitudinal current density and 27 Hβ flare bright points demonstrates that 6 bright points among them occurred at the peaks of the longitudinal current density, 17 bright points deviated from the peaks of the longitudinal current density, 4 bright points were located in the inversion lines of the longitudinal current density in the active region.

On October 27, we can find similar case. Some of Hβ flare bright points occurred at the peaks of longitudinal current density, while some not, which include some initial bright points of flares.

This means that the peaks of the longitudinal current density have not corresponding relationship with flare bright points in this emerging flux region.

5. Discussion

(a) The shear of the magnetic field near the magnetic neutral line increases with the emergence of new magnetic flux in the active region 7321. Even some flares occurred at the both sides of the magnetic neutral line.

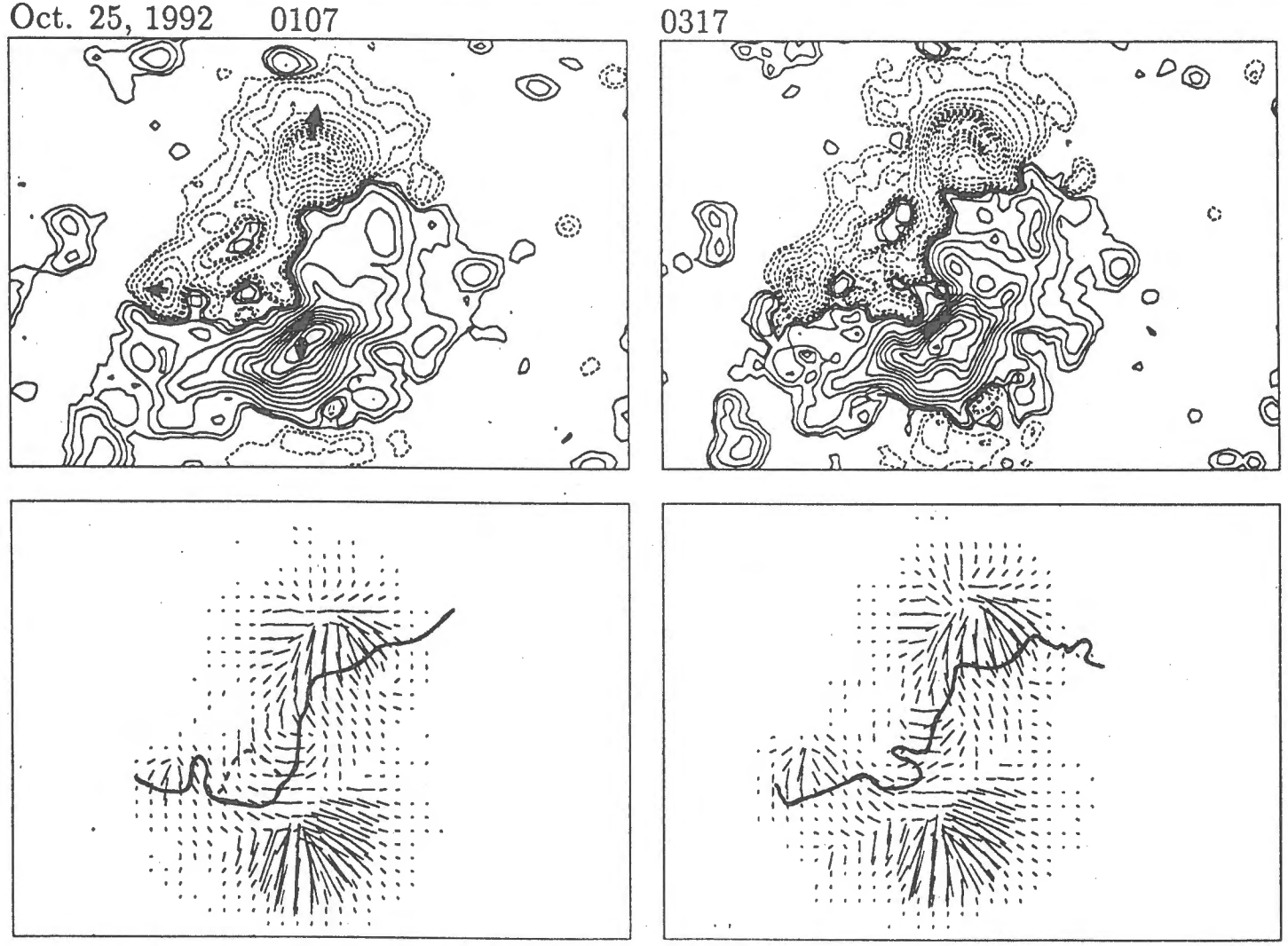

Fig. 1a. A series of photospheric longitudinal and transverse magnetograms in the active region 7321 on October 25, 1992. The thick solid lines in the transverse magnetograms mark the magnetic neutral lines. Arrows indicate the moving directions of the main poles of magnetic fields.

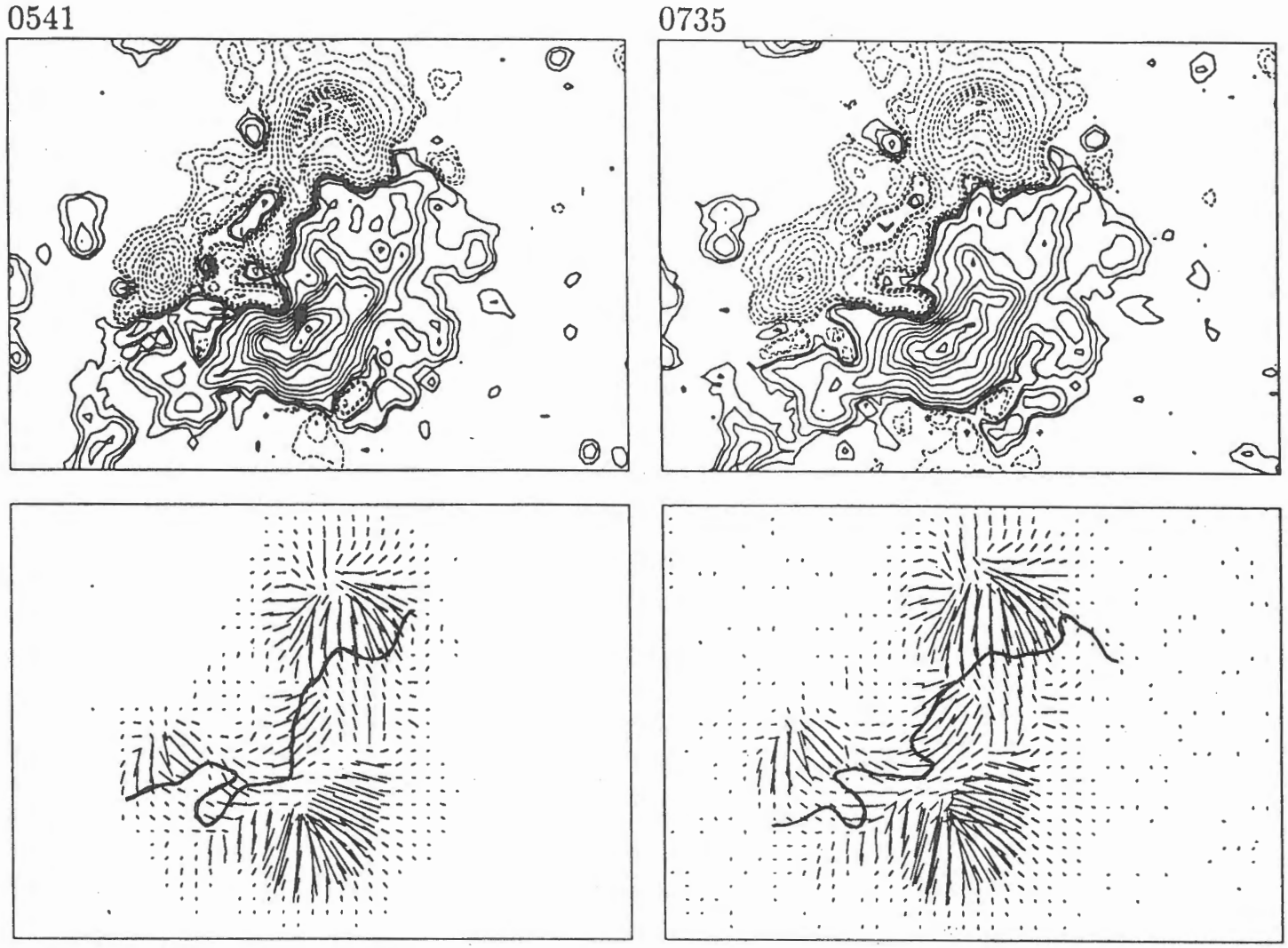

Fig. 1b.

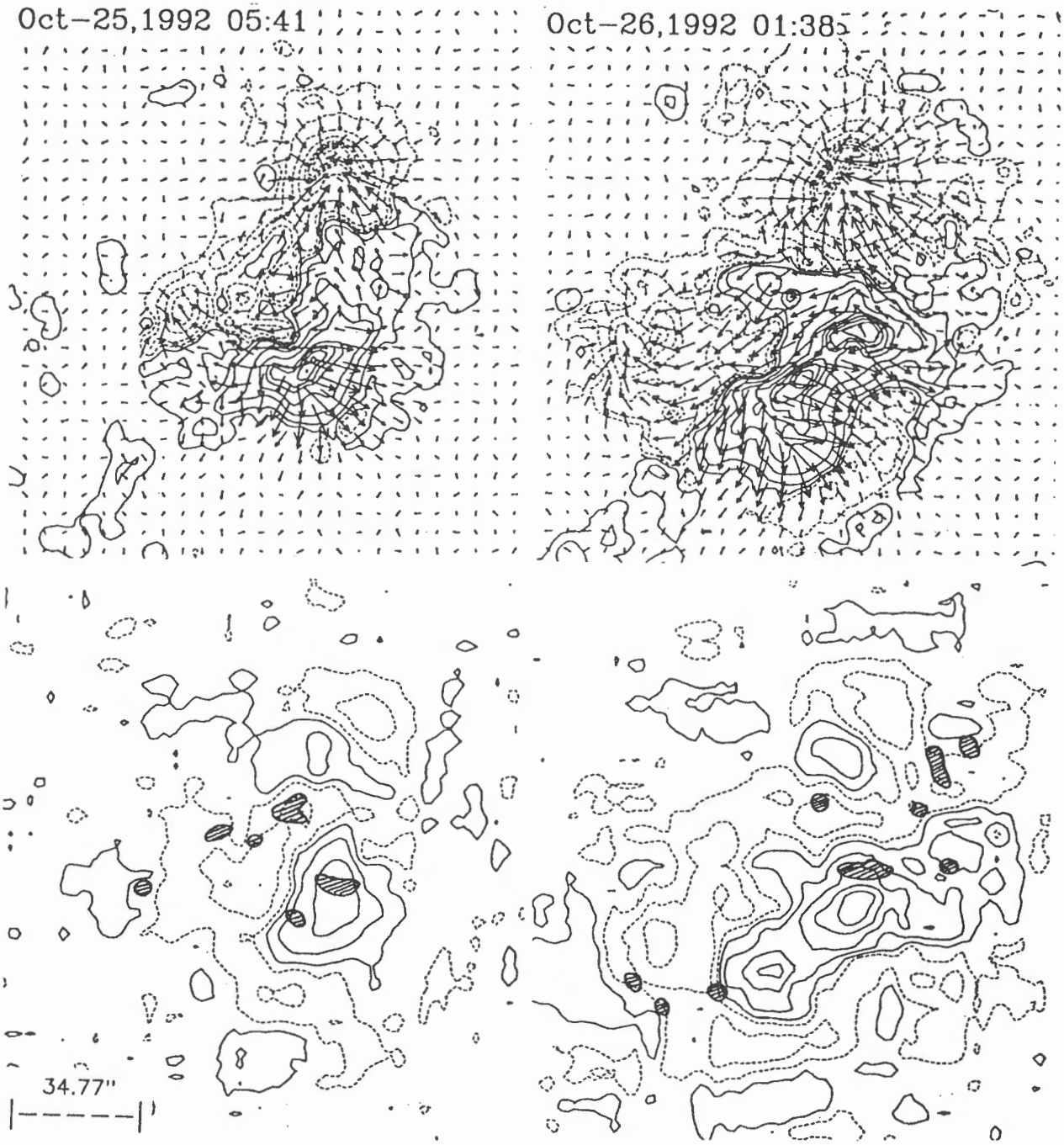

Fig. 2. Ambiguity-resolved vector magnetograms (top) on October 25 and 26 1992 and corresponding maps of longitudinal current density (bottom) in the active region 7321. The shadow areas in maps of longitudinal current density mark some flare bright points closed to the observational time of magnetograms and contours indicate the distribution of longitudinal current density of ± 0.2, 0.4, 0.8, 1.0, 1.4, 1.6, 2.0×10^{-2} Am^{-2}. The thick solid lines mark the magnetic neutral lines.

(b) We can find that the longitudinal currents of opposite direction can exist in the one main poles of magnetic field. It is possible that in the emerging flux region the effect of the mass motion and gas pressure are not negligible. It deviates from force free approximation evidently.

(c) The flare ribbons avoid the stronger magnetic main poles, except the powerful flares, even where the magnetic twist or shear is strongly. Some flare ribbons do not occur at the peaks of the photospheric longitudinal current in the growing active region.

(d) The longitudinal current density only reflects the line-of-sight component of the current density inferred by the photospheric transverse field, but it is not contain all of the information of the photospheric vector current density. The analysis of the relationship between the longitudinal currents and flares need more carefully.

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