

EVOLUTION OF A REVERSED POLARITY ACTIVE REGION NOAA 7912 IN THE PHOTOSPHERE, THE CHROMOSPHERE AND THE CORONA

L. van DRIEL-GESZTELYI^{1,2}, T. BARANYI³, N. MEIN¹, B. CADER-SROKA⁴,
P. RUDAWY⁴, P. MEIN¹, B. ROMPOLT⁴, B. SCHMIEDER¹,
J. -M. MALHERBE¹, R. WILLSON⁵, J. N. KILE⁵ and A. RAOULT¹

¹ *Observatoire de Paris, DASOP, 92195 Meudon Principal Cedex, France*

² *Konkoly Observatory, Budapest, Hungary*

³ *Heliophysical Observatory of HAS, P.O.Box 30, H-4010 Debrecen, Hungary*

⁴ *Astronomical Institute of Wroclaw University, ul.Kopernika 11, PL 51622 Wroclaw, Poland*

⁵ *Department of Physics and Astronomy, Tufts University, Medford, USA*

Abstract. We follow the evolution and activity of NOAA 7912, a reversed polarity region, in the photosphere (Kitt Peak magnetograms and Debrecen white-light photoheliograms), chromosphere (MSDP instrument mounted on the German VTT at Tenerife), and the corona (Yohkoh/SXT, Nançay radioheliograph and the VLA) between October 12–20, 1995. We find that in spite of the high shear and creation of several mixed-polarity regions through flux emergence, the flares in the group did not exceed the M-class level. This might be due to the fact that the highly inclined bipolar fields emerging in the following part of the primary reversed dipole were relatively small and quickly “consumed” by cancellation enhanced by sunspot motions. On the other hand, the presence of high shear and minor fast-moving parasitic polarities in NOAA 7912 was sufficient to produce eruptive events like X-ray jets with important coronal and interplanetary effects.

Key words: Sun: active region, evolution, sunspot motion, magnetic field, flare, X-ray jet, radio burst

1. Introduction

Active region NOAA 7912 passed over the solar disc in October 1995 and was the target of a Meudon-coordinated multiwavelength observing campaign involving several ground-based observatories and the Yohkoh satellite between October 19–21, 1995 when the AR NOAA 7912 was approaching the west limb. Here we study the evolution of the NOAA 7912 region prior to, and during the campaign, in order to explore the evolutionary background of two X-ray jets observed on October 19, 1995 (van Driel-Gesztelyi *et al.*, 1996).

2. Magnetic configuration of NOAA 7912 and sunspot motions

The active region NOAA 7912 did not follow Hale’s law:

a negative polarity spot led this south-hemisphere group, which consisted of a round leading spot and smaller dispersed trailing spots with a few parasitic polarities disturbing the bipolar structure of NOAA 7912. Proper motions of sunspots in AR NOAA 7912 were measured in Debrecen full-disc photoheliograms, between October 11–21, 1995. The fast initial north-westward motion of the leading spot slowed down and changed to north-eastward on October 15, 1995. In the following part of the AR NOAA 7912 at least two new dipoles appeared on October 11, 1995. The opposite polarity spots of the new dipoles diverged due to the emergence of the flux tube, which contributed to the general dispersing tendency of the following part of the AR NOAA 7912. Some following spots moved westward instead of their usual eastward direction, mainly due to the appearance of reversed and highly inclined dipoles. From October 16, 1995 a new magnetic flux emerged in the preceding part of the AR NOAA 7912 and we observed collisions of small opposite polarity spots with a velocity of 0.2 km s^{-1} there, prior to the jet events of October 19, 1995. Encounter with opposite polarity magnetic fields, a necessary condition for flux cancellation, was enhanced throughout the region NOAA 7912 greatly due to sunspot motions.

3. X-ray and H α morphology and flare activity of NOAA 7912

The brightest X-ray loops appeared in the following part of the AR NOAA 7912 in the period of October 12–15, 1995 when the parasitic bipolar fields were present and cancelling there. The coronal loops appeared increasingly sheared as time proceeded, possibly due to new flux emergence in NOAA 7912 with inherent helicity. The helicity of the region NOAA 7912 was positive, indicated by the “forward S-shaped” loops. We found that the same positive sense of shear appeared at the chromospheric level of NOAA 7912, in the clockwise vortex fibril pattern, suggesting that (at least part of) the shear was due to the presence of strong electric currents. Between October 12–15, 1995, 2 M-class, 9 C-class and 9 B-class flares were observed in the AR NOAA 7912 presumably related to cancellation events, while between October 18–20, 1995 a second group of flares (3 B-class and one M-class) was linked to the mixed polarity region south-east of the leading spot of AR NOAA 7912.

4. Jet events of NOAA 7912

X-ray jets and surges are normally related to relatively small chromospheric flare events, while their impact on the corona and the interplanetary space may be much more important. Normally, jets occur in regions with high shear and certain magnetic complexity: i.e., at their footpoint there is a parasitic (included) polarity. On October 19, 1995, in the NOAA AR 7912 two X-ray jets were observed with the Yohkoh/SXT at 10:29 UT and 16:59 UT, which had major consequences at radio wavelengths (type III or V bursts), while they were related to two small flares of the B GOES level (B3.2 and B1.3, respectively) corresponding to 1B and 1N importance in H α . The flare and jet events occurred in a mixed magnetic polarity region of AR NOAA 7912 along a filament. Unfortunately, the October 19, 1995, 10:29 UT jet was out of the MSDP field of view, but after the jet we observed important velocities along the filament. The jets in X-rays expanded with a speed of at least 700 km s⁻¹ and reached the length of 2.5–3 $\times 10^5$ km. On October 19, 1995, between 10:25–10:32 UT, with the Nançay Radioheliograph, Type III bursts were observed at 236 and 327 MHz frequency, providing evidence for the presence of propagating electron beams along the jet path. For the second jet event at 16:59 UT the VLA did not detect Type III burst activity, but there was a Type V emission in the 30–80 MHz range, reported in the Solar-Geophysical Data, indicating that electron beams have been formed during the event.

5. Conclusion

Such reversed polarity groups, as NOAA 7912, are possible products of twisted (knotted) magnetic flux emergence and may become highly flare-active “monsters” when such knots emerge interleaved and form a magnetic δ configuration. The magnetic configuration of NOAA 7912 did not become really complicated, thus it did not become as flare-active and famous as the reversed polarity groups of former cycles, like McMath 11976 (August 1972) and NOAA 4474 (April 1984). Although several reversed “knots” of magnetic flux surfaced in the AR NOAA 7912, they were relatively small and flux cancellation enhanced by sunspot motions “consumed” them in a few days, accompanied by flare activity up to the M-class level. On the other hand, the presence of high shear and fast-moving minor parasitic polarities in NOAA 7912 were sufficient to produce eruptive events like several type III bursts and spectacular X-ray jets with important coronal and even interplanetary effects. The WIND spacecraft observed the passage of a large magnetic cloud between October 18–20, 1995 and the compilation of multiple experiments showed that at least one end of the twisted force-free flux rope connected to AR 7912 and its eruption was apparently related to the activity there (Larson et al., 1997).

Acknowledgements. We thank the Yohkoh Team and the YDAC at Mullard Space Science Laboratory for the SXT data. The NSO/Kitt Peak magnetogram data used in the paper were kindly provided us by Dr. Karen L. Harvey, the data are produced cooperatively by NSF/NOAO, NASA, GSFC, and NOAA/SEL. We acknowledge the research grants OTKA T17325 (LvDG), OTKA F019829, as well as the U.S.–Hungarian Joint Found for Science and Technology No. 95a-524 (TB).

References

- van Driel-Gesztelyi, L., Willson, R. F., Kile, J. N., Raoult, A., Mein, N., Rudawy, P., Cader, B., Rompolt, B., Schmieder, B., Mein, P. and Malherbe, J.-M.: 1997, in Proc. 10th Cambridge Workshop on Cool Stars, Stellar Systems and the Sun (eds. B. Donahue and J. Bookbinder), in press
- Larson, D. E., Lin, R., McTietnan, J. M., McFadden, J. P., Ergun, R.E., McCarthy, M., Reme, H., Sanderson, T. R., Kaiser, M. and Lepping R. P.: 1997, in Bull. American Astron. Soc., SPD meeting 29, 08.06
- Solar Geophysical Data*, No.615, part I and No. 620, part II