Living Around Active Stars
Proceedings IAU Symposium No. 328, 2016
D. Nandy, A. Valio & P. Petit, eds.

doi:10.1017/S1743921317003817

Evolution of the Active Region NOAA 12443 based on magnetic field extrapolations: preliminary results

André Chicrala[1], Renato Sergio Dallaqua[1], Luis Eduardo Antunes Vieira[1], Alisson Dal Lago[1], Jenny Marcela Rodríguez Gómez[1], Judith Palacios[2], Tardelli Ronan Coelho Stekel[1], Joaquim Eduardo Rezende Costa[1] and Marlos da Silva Rockenbach[1]

[1]National Institute for Space Research,
12227-010, São José dos Campos, Brazil
email: andre.chicrala@inpe.br

[2]Departamento de Física y Matemáticas,
Universidad de Alcalá
University Campus, Sciences Building, P.O. 28871, Alcalá de Henares, Spain
email: judith.palacios@uah.es

Abstract. The behavior of Active Regions (ARs) is directly related to the occurrence of some remarkable phenomena in the Sun such as solar flares or coronal mass ejections (CME). In this sense, changes in the magnetic field of the region can be used to uncover other relevant features like the evolution of the ARs magnetic structure and the plasma flow related to it. In this work we describe the evolution of the magnetic structure of the active region AR NOAA12443 observed from 2015/10/30 to 2015/11/10, which may be associated with several X-ray flares of classes C and M. The analysis is based on observations of the solar surface and atmosphere provided by HMI and AIA instruments on board of the SDO spacecraft. In order to investigate the magnetic energy buildup and release of the ARs, we shall employ potential and linear force free extrapolations based on the solar surface magnetic field distribution and the photospheric velocity fields.

Keywords. Photosphere, Sunspots, Evolution.

1. Introduction

The Photosphere, commonly referred as the solar surface, is also occasionally populated by Active Regions (ARs) that have a strong magnetic field, which can reach a few thousand Gauss, when compared to its surroundings. The evolution of such regions may be related to energetic events that occur on both small and large scales. The study of the solar magnetism is mainly supported by the Zeeman effect and polarization of light. In this sense, the parameters of Stokes are enough to fully characterize the polarization of light.

The object of this study is the AR NOAA12443 that was observed in the solar disk from 2015/10/30 to 2015/11/10. During the time in which the AR was visible on the disk X-ray flux peaks reached values that characterizes the occurrence of M-class flares. This reveals a complex magnetic structure.

Some physical quantities of the observed region, such as line-of-sight velocity and magnetic field strength, can be directly retrieved from the Stokes parameters measurements or be used as entries in inversion algorithms. For this work the available data from

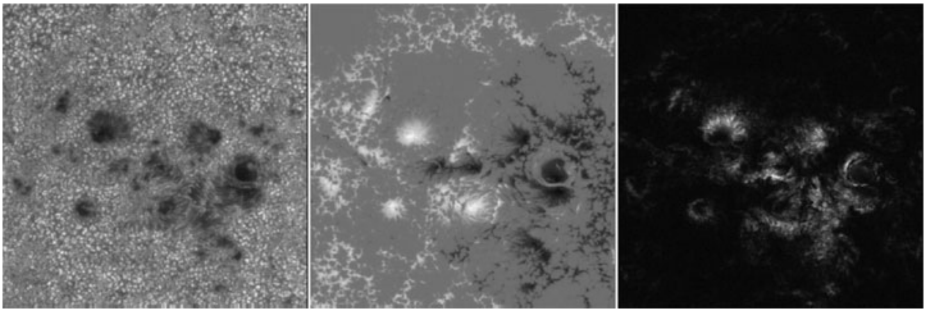

Figure 1. Left panel: it is presented a continuum map of the AR. Mid panel: Weak field approximation was performed over the same data set unveiling features of the AR such as its penumbral structure and magnetic field along the Line Of Sight (LOS). Right panel: is displayed a Linear polarization map of the region highlighting the transverse field structures such as the penumbral field.

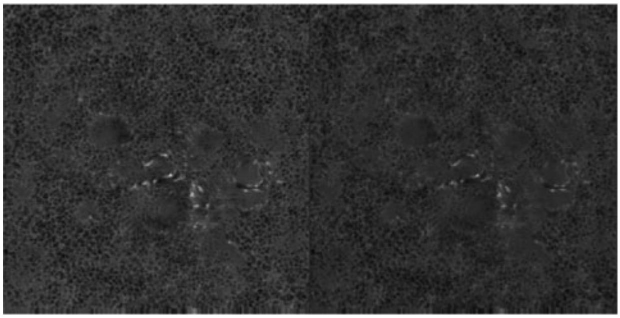

Figure 2. On the left-hand side it displays the velocity map produced around the Fe I 6301.5107 Å line using the COG method in Stokes I and on the right-hand side the same calculation was performed using a Gauss fit. White colors indicate downflows and Dark colors represents upflows.

Hinode telescope were used and processed from the instrument Solar Optical Telescope (SOT/SP).

2. Results

Maps of the solar surface, as illustrated in Figure 1, were drawn to identify the AR physical structures. Complex structures, for example a light bridge, are clearly observed.

The solar plasma motion along the LOS can be calculated considering the Doppler shift in the measured wavelengths FeI 6301.5Å and 6302.5Å. In order to map the downflow and upflow velocities, two different methods were applied, Center of Gravity (COG) and fitting a Gaussian, yielding similar results as displayed in Figure 2. Comparing the results, it can be noticed that the map produced with the COG method appears to have more contrast indicating that the velocities obtained were slightly different. This difference arises from the slight asymmetries on Stokes I profiles. Typical values found reach up to 2 km s^{-1} for both downflows and upflows.

Assuming, in a first guess, that flows with a speed greater than 4km s^{-1} are supersonic, the two data sets coordinates of the supersonic flows could be found and then overploted on the continuum map as shown in Figure 3. Even though the results of COG and Gauss fit were different, the supersonic flows obtained were found in the same coordinates.

The integral of the red and blue lobes of Stokes V can be used in order to investigate the presence of velocity and magnetic field gradients being the asymmetry of the line integral

https://doi.org/10.1017/S1743921317003817 Published online by Cambridge University Press

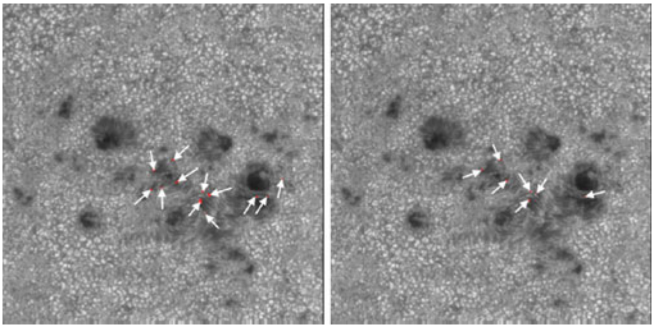

Figure 3. The regions pointed by the white arrows indicated where supersonic velocities were found considering the COG (left) and fitting a Gaussian (right) approaches over the continuum map. No supersonic upflow was found among the calculations performed over all data sets using both methods.

associated with the gradients. The Stokes V profiles were normalized and integrated for each pixel of each map in order that the integral value distribution could be studied.

3. Conclusion and perspectives

The positions where the supersonic downflows were identified are probably regions of penumbral development. Also, considering that the Evershed effect, the downflows might be evidence of regions where there is a net mass flow. It can be seen in Figure 3 and all the other maps that were produced that the supersonic downflows appeared within or at the border of the penumbra region probably due to the penumbra development and the boundary of the Evershed effect. Checking the values of the LOS magnetic field on those points were found values usually between +1kG and -1 kG.

The histogram has a peak at zero, where Stokes V can be considered symmetric, however, there are plenty of values for different levels of asymmetry which are later going to be used to identify regions according to their asymmetry level.

The data analysed so far wield promising results that can be used to further study the AR's behaviour and, eventually, evolution. Advanced algorithms that are able to perform the inversion of Stokes procedure and coronal magnetic field extrapolation are already being employed so that, with the preliminary results, more complex features of this AR can be unveiled.

References

Borrero Santiago, J. M. & IMPRS theses, 2004, *Dissertation.*
del Toro Iniesta, J.C., "Introduction to Spectropolarimetry", Cambridge Ed., 2003
del Toro Iniesta, J. C. & Ruiz Cobo, B., 1992, *ApJ*, 398, 375.
González, N. B. IMPRS theses, 2006, *Dissertation.*
Joshi, J. IMPRS theses, 2014, *Dissertation.*
Riethmüller, T. L. IMPRS theses, 2013, *Dissertation.*
Solanki, S. K. 2003, *A&AR*, 11, 153