Detailed evolution and rotation of the active regions NOAA 11101, 11106 from the SDO/HMI data

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Differential Rotation and Magnetism across the HR Diagram’, Nordita, Stockholm, Sweden, 12April 2013
For our purpose we have analyzed the 720 sec cadence of line-of-sight component of the strength of the magnetic field (LOS) and images in continuum (INT) using magnetic data of the Solar Dynamics Observatory obtained by the Helioseismic and Magnetic Imager (HMI). The HMI observes the full solar disk at 6173 Å (Fe I line) with a resolution of 1 arcsec and as a result we have a matrix with values of LOS and INT for 4096x4096 pixels.
Comparison of line-of-sight magnetograms from the Helioseismic and Magnetic Imager (HMI) onboard the Solar Dynamics Observatory (SDO) and the Michelson Doppler Imager (MDI) onboard the Solar and Heliospheric Observatory (SOHO). The line-of-sight magnetic signal inferred from the calibrated MDI data is greater than that derived from the HMI data by a factor of 1.40.

Y. Liu · J.T. Hoeksema · P.H. Scherrer · J. Schou · S. Couvidat · R.I. Bush · T.L. Duvall Jr · K. Hayashi · X. Sun · X. Zhao, 2012
Figure 2  Distribution of noise in the line-of-sight magnetic field over Sun’s disk derived from 11 520 HMI 45-second magnetograms at a cadence of 720 seconds taken in June–August 2010 (left), and from 10 800 HMI 720-second magnetograms at a cadence of 720 seconds taken in June–August 2010 (right). The median of the noise is 10.3 Mx cm\(^{-2}\) for the 45-second magnetograms, and 6.4 Mx cm\(^{-2}\) for the 720-second magnetograms. Note that the color bars are different in order to show comparable detail in the two images.
A simulation with HMI filter transmission profiles and velocity algorithm indicates that, for a disk-center field greater than 3200 G, the uncompensated HMI measurements become saturated every 12 hours when the satellite reaches its maximum radial velocity.
Figure 5 Top panel: The temporal profile of the mean unsigned field of AR11092 (solid line), over-plotted by a third-degree polynomial that fits the data (dashed line). Pixels with unsigned field greater than 600 Mxcm$^{-2}$ are chosen to compute the mean field in order to examine periodicity in strong field. 600 Mxcm$^{-2}$ is arbitrarily selected here. Middle panel: residual of the mean unsigned field, i.e. the difference between the mean unsigned field and the fitted polynomial shown by the dashed line in the top panel. Bottom panel: Power spectrum of the residual of the unsigned field (in the middle panel). The observation runs eight days, from 30 July to 6 August. 24-hour and 12-hour periodicities are clearly seen. The variation due to the periodicities is about 2.7% of the signal on average.
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The wavelet transform is usually used to analyze time series that contain non-stationary power at many different frequencies.

Here, the Morlet wavelet with $\omega_0 = 6$ is applied because of this Morlet wavelet scale is almost equal to Fourier period.
Total magnetic flux:

\[ F_{\text{total}} = R_{\odot}^2 \int_{\varphi_1}^{\varphi_2} \int_{\theta_1}^{\theta_2} |B_r| \, d\theta \, d\varphi, \]

Где \( \theta \)- co-latitude. \( B_r \approx B_{||} / \sin \theta \).

Signed magnetic flux:

\[ F = R_{\odot}^2 \int_{\varphi_1}^{\varphi_2} \int_{\theta_1}^{\theta_2} B_r \sin \theta \, d\theta \, d\varphi \]

Positive Magnetic flux:

\[ F = R_{\odot}^2 \int_{\varphi_1}^{\varphi_2} \int_{\theta_1}^{\theta_2} B_r \sin \theta \, d\theta \, d\varphi, \quad B_r > 0 \]

Negative Magnetic Flux:

\[ F = R_{\odot}^2 \int_{\varphi_1}^{\varphi_2} \int_{\theta_1}^{\theta_2} B_r \sin \theta \, d\theta \, d\varphi, \quad B_r < 0 \]
Questions

• The oscillations in the east of the solar disk visible in variations of the longitude of the center of mass (umbra and penumbra).

  Is it an instrumental effect?

• Is it some kind of sunspot oscillations?

• Or the result of the interaction between the rotation and a sunspot flux tube?

• ???