

Chromospheric structures evolution during the solar Carrington Rotation CR 2310

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Abstract: A 21-day sequence of daily H α observations of the Sun was acquired using an SHG700 slit spectroheliograph. The dataset clearly reveals the effects of solar differential rotation and documents the evolution of an extended active-region complex associated with NOAA AR4444–AR4447. The observations suggest the presence of a large-scale chromospheric organization spanning both solar hemispheres.

Key-words: Sun: Chromosphere; Instrumentations: H-alpha, SHG; Software: JSolEx, WinJupos

Sommario: È stata acquisita una serie continua di osservazioni giornaliere in H α della cromosfera solare tra il 16 maggio e il 5 giugno 2026 usando uno spettroeliografo a fenditura SHG700. La campagna di osservazione è stata progettata per monitorare l'evoluzione temporale delle caratteristiche cromosferiche durante una frazione significativa di una rotazione solare. Sono state ottenute immagini quotidiane a disco pieno in orari di osservazione quasi identici e successivamente elaborate per garantire scala, orientamento, risposta fotometrica e coerenza geometrica uniformi. Sono state generate proiezioni cartografiche sinottiche per studiare l'evoluzione delle regioni attive, dei filamenti e delle strutture cromosferiche su larga scala. Il set di dati risultante mostra chiaramente segni della rotazione differenziale del Sole e mette in evidenza la presenza di un complesso esteso di regioni attive che attraversano il disco solare visibile verso la fine di maggio 2026. L'analisi visiva preliminare dei dati suggerisce l'esistenza di una configurazione magnetica su larga scala che abbraccia entrambi gli emisferi solari, potenzialmente associate con una connettività magnetica trans-equatoriale.

Viene presentata una sequenza di osservazioni giornaliere del Sole in H α ottenute nell'arco di 21 giorni consecutivi mediante uno spettroeliografo a fenditura SHG700. Le immagini, opportunamente elaborate e normalizzate, hanno consentito la realizzazione di mappe sinottiche della cromosfera e lo studio dell'evoluzione temporale di filamenti, plages e regioni attive durante una frazione significativa della rotazione solare.

I risultati evidenziano chiaramente gli effetti della rotazione differenziale e documentano l'evoluzione di un esteso complesso di regioni attive associato alle NOAA AR4444–4445-4446-AR4447. L'analisi preliminare suggerisce inoltre la possibile presenza di una organizzazione cromosferica su larga scala che coinvolge entrambi gli emisferi solari. Le mappe sinottiche e le sequenze temporali evidenziano un'apparente evoluzione rotazionale in senso orario delle strutture cromosferiche associate, la cui origine potrebbe essere legata agli effetti della rotazione differenziale oppure a una più estesa organizzazione magnetica della cromosfera.

1. Introduction

The solar chromosphere exhibits a wide range of dynamic structures whose evolution is governed by the underlying magnetic field. Observations in the H α spectral line provide direct access to chromospheric phenomena such as filaments, plages, fibrils, and active-region complexes.

Long-term monitoring of the chromosphere offers an opportunity to investigate large-scale magnetic organization and solar differential rotation. Unlike a rigid body, the Sun rotates at different angular velocities depending on latitude, with equatorial regions completing a rotation significantly faster than higher latitudes (Snodgrass & Ulrich, 1990). This differential rotation plays a fundamental role in the generation and evolution of the solar magnetic field.

Recent studies have also highlighted the existence of persistent large-scale magnetic structures, including active longitudes, activity complexes, and transequatorial magnetic connections that may remain coherent over several solar rotations (Pevtsov, 2000; Benevolenskaya et al., 1999; McIntosh et al., 2017).

The present work describes a 21-day H α monitoring campaign aimed at documenting the temporal evolution of chromospheric structures during a substantial fraction of a solar rotation.

2. Setup and observations

Observations were performed using an MLastrO SHG700 slit spectroheliograph operating on the H α spectral line at 656.28 nm, connected to a 115/800 refractor telescope (Tecnosky).

The instrument configuration consisted of:

- Entrance slit width: 7 μm
- Slit length: 10 mm
- Diffraction grating: 2400 lines mm^{-1}
- Detector: ZWO ASI183MM
- Pixel size: 2.4 μm

Daily observations were obtained between 16 May and 5 June 2026 at approximately 05:45 UTC (07:45 local time). The observing strategy aimed to maintain consistent acquisition conditions throughout the campaign. Each observing session produced a complete spectroheliographic scan of the solar disk, allowing reconstruction of full-disk monochromatic H α images. The reconstruction was performed automatically with JSolex software, starting from a set of 21 raw 16-bit videos, each containing approximately 3600 frames (acquisition speed around 140fps with ROI = 3800x300 pixels).

Image processing was performed to ensure uniformity among the daily observations. Corrections included normalization of image scale, orientation, disk geometry, and overall brightness. Minor variations caused by atmospheric seeing conditions and instrumental alignment were also minimized. Custom Python routines executed on the Google Colab platform were employed for automated processing and image registration.

To facilitate temporal comparisons, daily images were transformed into cartographic projections of the solar surface. Limb-darkening effects were compensated prior to projection in order to enhance the visibility of chromospheric structures across the entire disk.

The resulting dataset provides a homogeneous representation of chromospheric evolution over a period corresponding to nearly one complete equatorial solar rotation.

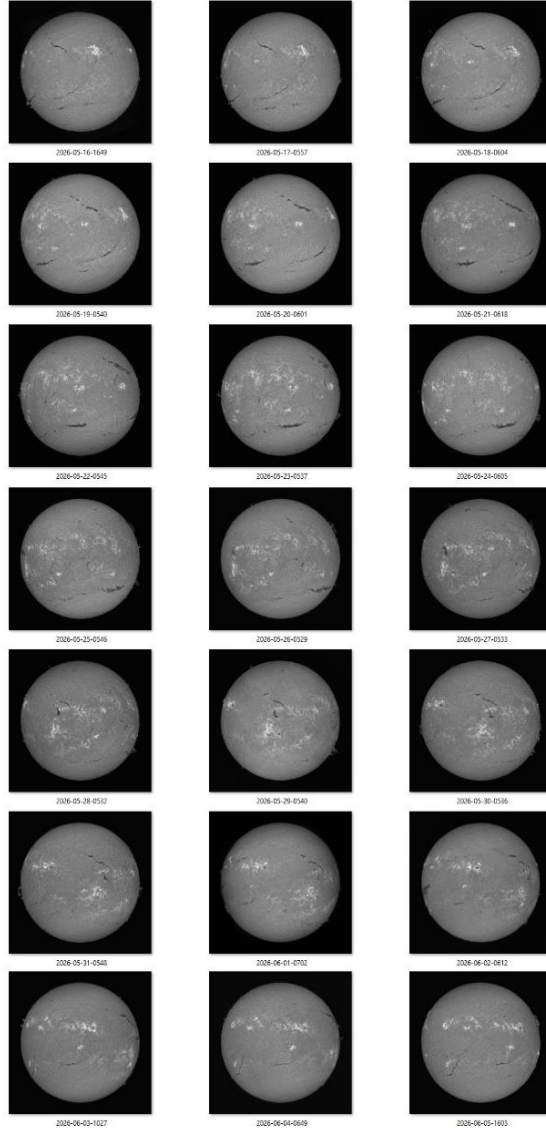


Figure 1: List of H-alpha observations from 16 may to 5 june 2026

3. Data Analysis

The time series reveals the continuous evolution of active regions, plages, and filaments across the visible solar disk.

A prominent signature of solar differential rotation is observed in composite images generated by superimposing successive daily observations. Structures located near the solar equator exhibit a greater longitudinal displacement than those situated at higher latitudes. As a consequence, chromospheric features progressively diverge from one another, producing a characteristic fan-like pattern, especially for the large filament observed in the northern hemisphere during the first part of the observations (Figure 2).



Figure 2: Composition of the first 9 observations from 16th to 24th of May, processed with inverted contrasts, to enhance the evolution of the filaments during the solar rotation

Both bright chromospheric plages and dark filamentary structures display this behaviour, providing a direct visual manifestation of latitude-dependent rotation.

Precise measurement of the position of the various chromospheric features is particularly complex due to the imaging and solar disk reconstruction technique, which is based on spectroheliographic scan. The JSoleX software reconstructs the solar disk "slice by slice," but cannot compensate for small drifts or micro-movements of the telescope/mount due to imperfect tracking consistency and small setup vibrations.

A particularly notable feature of the dataset is the evolution of the active-region complex associated with NOAA Active Regions AR4444, AR4445, AR4446 and AR4447 during late May 2026 (Figure 3). These regions formed an extended chromospheric system spanning a substantial range of heliographic longitude and involving structures located in both hemispheres.

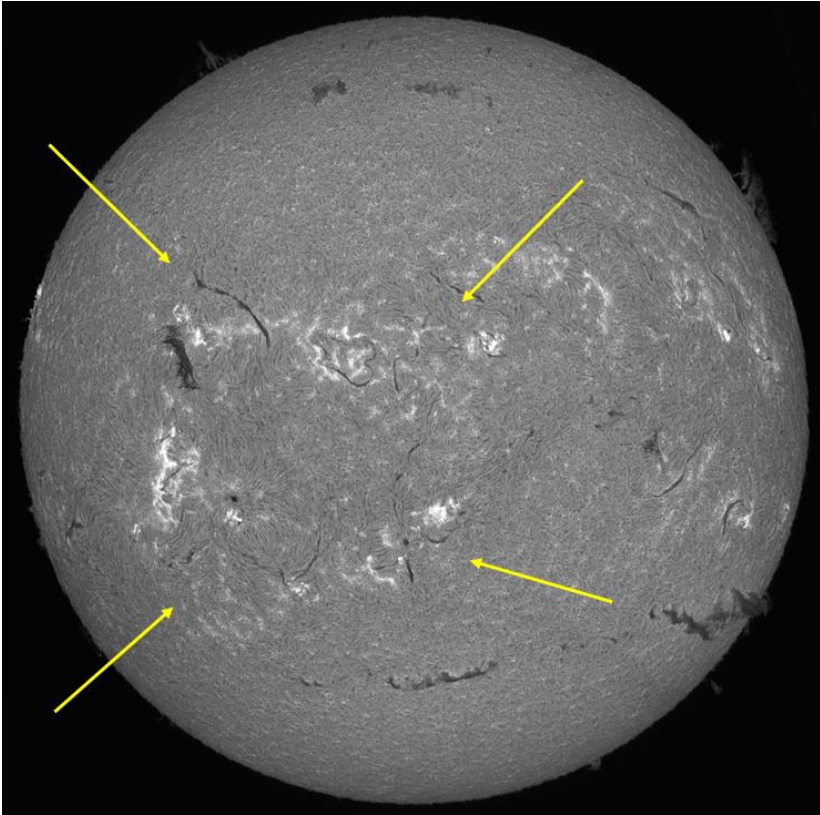


Figure 3: Image of the chromosphere taken the 26th of May, highlighting the active-region complex AR4444, AR4445, AR4446 and AR4447

Cartographic projections (Figure 4) suggest the presence of a coherent large-scale organization of plages and filaments, especially in the northern hemisphere.

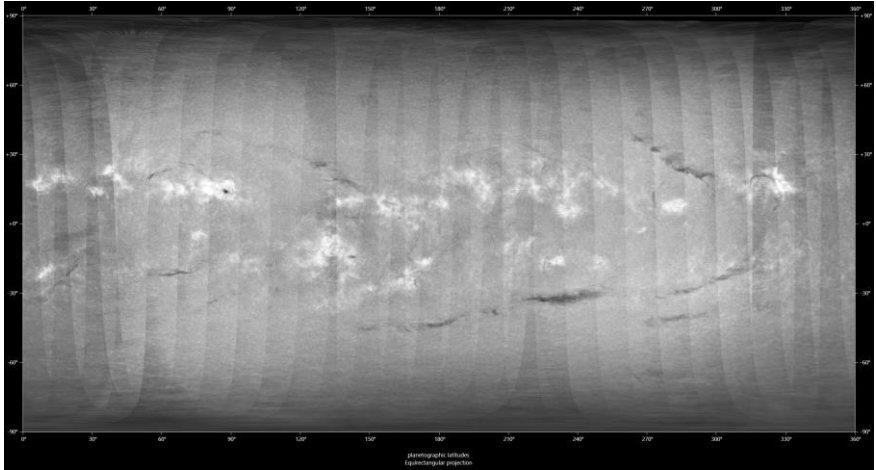


Figure 4: Equatorial projection obtained with WinJupos

To better visualize the temporal evolution of the chromospheric structures, an animation was generated by combining all daily observations (Figure 5). Visual inspection suggests that the extended active-region complex associated with AR4444–AR4447 exhibits an apparent clockwise evolution around a region located near the solar equator.

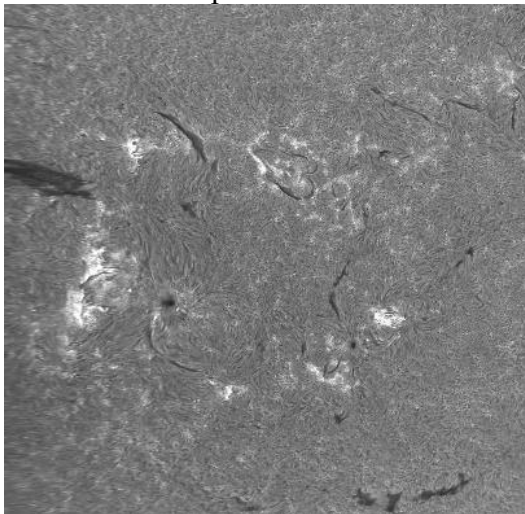


Figure 5: Temporal evolution of the AR4444/7 active-region complex

Supplementary animations illustrating the complete observational sequence and the corresponding heliographic projection are available online:

- <https://youtu.be/WfAJdTBZK6I>
- https://youtu.be/4_EAnHpYTvs

To assess the reliability of the reconstructed chromospheric maps and minimize the possibility of processing artefacts, the observations were systematically compared with contemporaneous H α full-disk images obtained from the Global Oscillation Network Group (GONG). In addition, independent heliographic projections were generated using WinJUPOS and compared with those derived from the SHG700 dataset. The resulting maps showed excellent agreement in the position and morphology of the principal chromospheric features, indicating that the observed structures and their temporal evolution are consistent with independent observations and are unlikely to originate from reconstruction or registration errors (video available here: <https://youtu.be/CFIRWsj9Bl4>).

Within this complex, an equatorial filament exhibited a noticeably larger longitudinal displacement than surrounding structures, consistent with the expected effects of differential rotation but not consistent with the average rotational speed of the chromospheric structures. The active regions AR4444 and AR4447 appear to exhibit a smaller longitudinal displacement than the associated equatorial filamentary structures. (Figure 6).

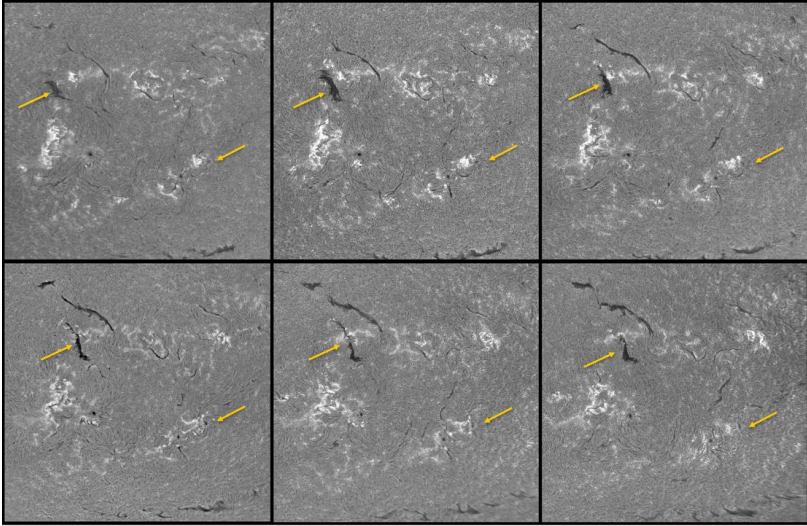


Figure 6: Movement of southern AR4444/7 and northern filaments

To further investigate the magnetic environment associated with the observed chromospheric structures, a multi-wavelength dataset from the Solar Dynamics Observatory (SDO) acquired on 28 May 2026 at 06:40 UTC was examined (Figure 7). The figure includes observations from AIA 304 Å and AIA 171 Å together with HMI continuum and line-of-sight magnetogram data.

The AIA 304 Å image reveals an extended distribution of chromospheric and transition-region activity spanning both solar hemispheres, consistent with the large-scale morphology observed in the H α dataset. The corresponding AIA 171 Å image shows a complex coronal environment characterized by numerous magnetic loops and extended coronal structures connecting the major active regions present on the disk.

The HMI continuum image confirms the distribution of sunspot groups associated with NOAA active regions AR4444–AR4447, while the line-of-sight magnetogram indicates that these regions are embedded within a broader magnetic environment extending over a significant fraction of the visible solar disk. Although the

magnetogram does not provide direct evidence of a single coherent transequatorial magnetic structure, it supports the presence of large-scale magnetic organization linking multiple active regions and chromospheric features. This interpretation remains consistent with the large-scale morphology inferred from the H α observations and warrants further investigation through detailed magnetic field analysis.

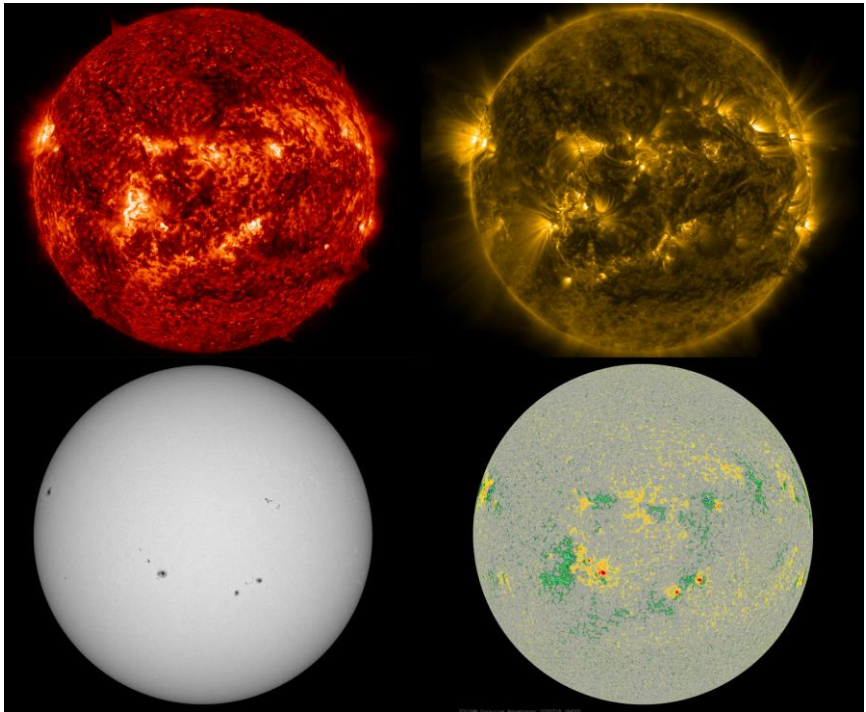


Figure 7: Multi-wavelength observations of the Sun acquired by the Solar Dynamics Observatory (SDO) on 28 May 2026 at 06:40 UTC. Upper left: AIA 304 Å image showing chromospheric and transition-region structures. Upper right: AIA 171 Å image highlighting coronal loops and large-scale coronal connectivity. Lower left: HMI continuum image showing the distribution of sunspots associated with NOAA active regions AR4444–AR4447. Lower right: HMI line-of-sight magnetogram

illustrating the photospheric magnetic field distribution. The figure reveals that the active-region complex is embedded within an extended magnetic environment spanning a substantial fraction of the visible solar disk, consistent with the large-scale chromospheric organization inferred from the H α observations.

4. Conclusions

A homogeneous sequence of 21 daily H α observations was successfully acquired using a slit spectroheliograph, covering a substantial fraction of a solar rotation. The resulting dataset enabled a detailed investigation of the temporal evolution of chromospheric structures, including filaments, plages, and active regions.

The observations provide a clear visual demonstration of solar differential rotation, as evidenced by the progressive divergence of chromospheric features located at different heliographic latitudes. The synoptic maps and composite images obtained during this campaign highlight the dynamic nature of the chromosphere and the large-scale evolution of its magnetic structures.

Particular attention was drawn to the extended active-region complex associated with NOAA AR4444, AR4445, AR4446, and AR4447, which crossed the visible solar disk during late May 2026. The corresponding chromospheric structures displayed a coherent large-scale morphology involving both solar hemispheres and extending over a significant range of heliographic longitude.

Visual inspection of the synoptic sequence suggests the presence of an apparent rotational evolution within this complex. While such behavior is likely influenced, at least in part, by the effects of differential rotation acting on structures located at different latitudes, the possibility of a more extended magnetic organization cannot be excluded.

At the present stage, the available observations do not allow a

definitive determination of the magnetic topology underlying the observed configuration.

The present work demonstrates the scientific value of systematic high-cadence spectroheliographic monitoring and highlights the potential contribution of long-term amateur H α observations to the study of large-scale solar magnetic activity.

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AI disclaimer The author also notes that generative artificial intelligence tools (ChatGPT, OpenAI) were used exclusively as programming assistance for the development of custom Python scripts employed in the normalization and registration of the JSolex reconstructions, as well as for the generation of heliographic map projections. No AI tools were used for image processing, scientific analysis, feature identification, or interpretation of the observational results. The software workflow was based on the Python libraries NumPy, SciPy, OpenCV, Pillow (PIL), Matplotlib, and Astropy.

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