A&A, 690, A342 (2024)
https://doi.org/10.1051/0004-6361/202451143
© The Authors 2024

Astronomy & Astrophysics
Special issue

Solar Orbiter First Results (Nominal Mission Phase)

First Solar Orbiter observation of a dark halo in the solar atmosphere

S. M. Lezzi[1,2,⋆], D. M. Long[3], V. Andretta[2], D. Baker[4], A. Dolliou[5], M. Murabito[6,7], S. Parenti[5], and N. Zambrana Prado[4]

[1] Università di Napoli "Federico II", C.U. Monte Sant'Angelo, Via Cinthia, I-80126 Napoli, Italy
[2] INAF Istituto Nazionale di Astrofisica, Osservatorio Astronomico di Capodimonte, Salita Moiariello 16, I-80131 Napoli, Italy
[3] School of Physical Sciences, Dublin City University, Glasnevin Campus, Dublin D09V209, Ireland
[4] University College London, Mullard Space Science Laboratory, Holmbury St. Mary, Dorking, Surrey RH5 6NT, UK
[5] Institut d'Astrophysique Spatiale, Bâtiment 121, Rue Jean Dominique Cassini, Université Paris Saclay, 91405 Orsay, France
[6] INAF Istituto Nazionale di Astrofisica, Osservatorio Astronomico di Roma, I-00078 Monte Porzio Catone, Roma, Italy
[7] Space Science Data Center, Agenzia Spaziale Italiana, Via del Politecnico, s.n.c., I-00133, Roma, Italy

Received 17 June 2024 / Accepted 29 August 2024

ABSTRACT

Context. Solar active regions (ARs) are often surrounded by dark large areas of reduced emission compared to the quiet Sun, observed at various wavelengths corresponding to the chromosphere, transition region (TR), and corona, known as dark halos (DHs). The mechanisms behind the darker emission of DHs remain unclear and merit a wider scope of study.
Aims. This study aims to investigate for the first time the fine structure of a DH observed by the EUV High Resolution Imager (HRI_{EUV}) on board the ESA's Solar Orbiter (SO) mission and its appearance in the TR.
Aims. We utilized the extensive 1 hour dataset from SO on 19 March 2022, which includes high-resolution observations of NOAA 12967 and part of the surrounding DH. We analyzed the dynamics of the HRI_{EUV} DH fine structure and its appearance in the $HRI_{Ly\alpha}$ image. We also analyzed the Spectral Imaging of the Coronal Environment (SPICE) Lyβ, C III, N VI, O VI, and Ne VIII lines, which sample the TR in the $\log T(\mathrm{K}) \sim 4.0$–$5.8$ range. This analysis was complemented with a simultaneous B_{LOS} magnetogram taken by the High Resolution Telescope (HRT).
Methods. We report the presence of a peculiar fine structure that has not been observed for the quiet Sun. It is characterized by combined bright EUV bundles and dark regions, arranged and interconnected in such a way that they cannot be clearly separated. They form a spatial continuum extending approximately radially from the AR core, suggesting a deep connection between the DH and the AR. Additionally, we find that the bright EUV bundles are observed in all the SPICE TR lines and the $HRI_{Ly\alpha}$ band and present photospheric B_{LOS} footprints in the HRT magnetogram. This spatial correlation indicates that the origin of the 174 Å DH may lie in the low atmosphere: the photosphere and chromosphere.

Key words. Sun: atmosphere – Sun: chromosphere – Sun: faculae, plages – Sun: transition region – Sun: UV radiation

1. Introduction

Dark halos (DHs; Lezzi et al. 2023, hereafter Paper I, and references therein) are regions characterized by reduced emission compared to the quiet Sun observed around solar active regions (ARs) at various wavelengths and wavebands covering the chromosphere, transition region (TR), and corona. These regions are usually large-scale structures that are difficult to observe in their entirety, except with instruments such as the Atmospheric Imaging Assembly (AIA; Lemen et al. 2012) on board the Solar Dynamics Observatory (SDO; Pesnell et al. 2012). However, SDO has limited TR coverage and does not provide spectral information. For this reason, DHs have been poorly studied in the past and their origin, global structure, and evolution are still unknown.

The DHs observed in the AIA 171 Å band have been shown to influence the total solar EUV irradiance. Indeed, Toriumi et al. (2020) found that during extremely quiet solar conditions, the 171 Å disk-integrated irradiance decreases from the quiet-Sun level when transiting events (e.g., an isolated sunspot, spotless plage, or emerging flux) cross the disk and the DH is seen to be contributing to the disk emission more than the AR. Moreover, as shown in Wang et al. (2011), Singh et al. (2021), and Paper I, DHs are normally found in proximity to ARs. This coexistence suggests that they are intimately related to the global AR's magnetic configuration and unveiling the specific physical mechanism behind their darker appearance is of crucial importance to our understanding of the heating mechanisms involved in ARs and of the solar atmosphere itself.

Recently, in Paper I, we took advantage of the full-disk mosaic observing mode of the Interface Region Imaging Spectrograph (IRIS; De Pontieu et al. 2014) to study the emission properties of the DH around NOAA 12706 by combining IRIS chromospheric and TR lines with SDO/AIA filtergrams and SDO/Helioseismic and Magnetic Imager (HMI;Schou et al. 2012) magnetograms. In line with studies conducted by previous researchers (e.g., Rutten 2007; Pietarila et al. 2009), we

⋆ Corresponding author; serena.lezzi@inaf.it

Open Access article, published by EDP Sciences, under the terms of the Creative Commons Attribution License (https://creativecommons.org/licenses/by/4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.
This article is published in open access under the Subscribe to Open model. Subscribe to A&A to support open access publication.