Probing the Inner Corona with ASPIICS aboard the PROBA-3 Formation Flight Mission: First Results

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Introduction

We report the first results from observations of the solar corona by the ASPIICS coronagraph aboard the Proba-3 mission, launched on 5 December 2024. ASPIICS (Association of Spacecraft for Polarimetric and Imaging Investigation of the Corona of the Sun) is a giant coronagraph consisting of a telescope mounted aboard one mission spacecraft and an external occulter placed on the second. The two spacecraft fly in a precise formation for up to 5.5 hours at a time, which allows the solar corona to be observed in eclipse-like conditions (i.e., close to the limb) with very low straylight, typically down to 1.099 Rsun and occasionally down to 1.05 Rsun. Therefore, ASPIICS successfully fills the gap between EUV imagers and classical externally-occulted coronagraphs. ASPIICS observes quasi-stationary structures such as coronal loops, streamers, and quiescent prominences, as well as a variety of dynamic phenomena (e.g., erupting prominences, coronal mass ejections, jets, slow solar wind outflows, and coronal inflows). In particular, weak, widespread, and persistent small-scale outflows and inflows between 1.3 and 3 Rsun are observed for the first time at a high spatio-temporal resolution (5".6, 30 s). This expands the range of scales at which the formation of the variable slow solar wind can be observed.

Imaging of the Quiescent Corona

ASPIICS provides high dynamic range images of the quiescent corona, revealing its large-scale structure (streamers, loops) as well as fine-scale features throughout the full field of view.

The measured coronal brightness profiles are consistent with previously established values for solar maximum conditions, confirming the photometric performance of the instrument.

Polarimetric measurements allow the determination of the polarized brightness and derivation of the coronal electron density, in agreement with theoretical expectations.

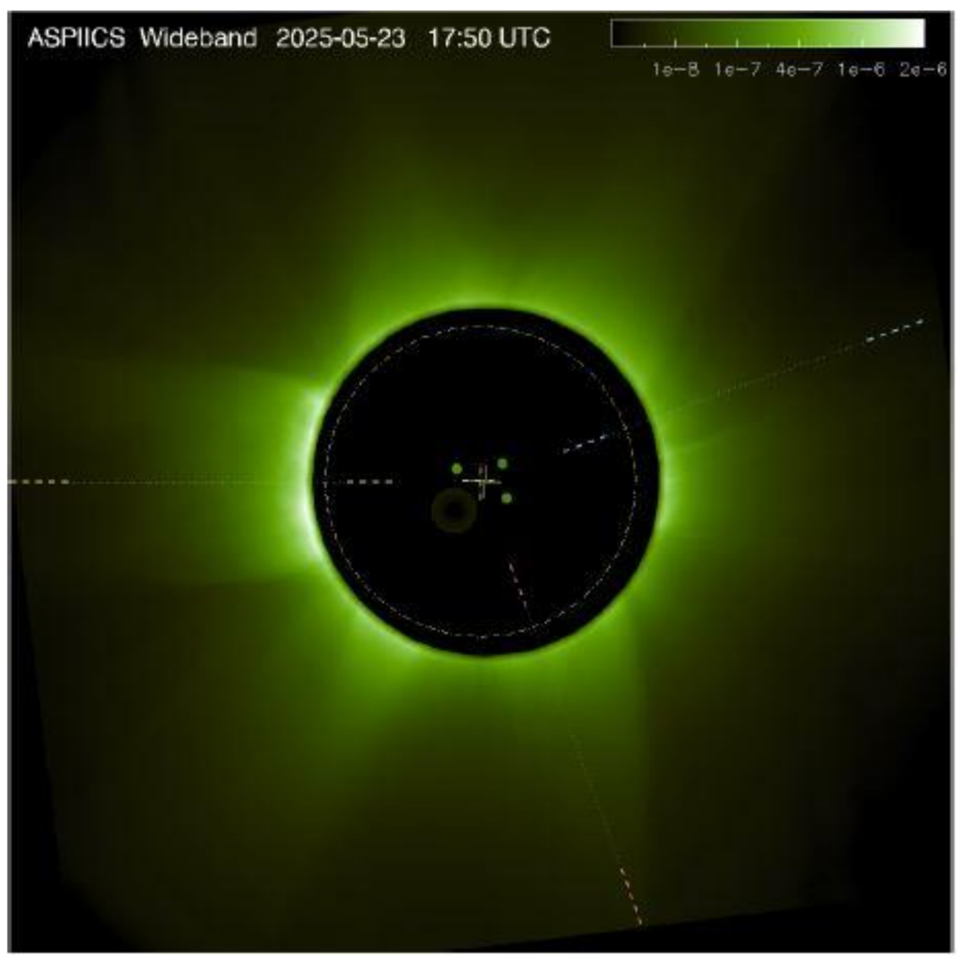

Fig. 1: High dynamic range white-light image of the solar K-corona observed by ASPIICS on 23 May 2025 at 17:50:31 UTC (orbit 207) in the wide (about 300 Å) spectral passband centered at 5510 Å. It is composed of three images taken with exposure times of 0.1 s, 1 s, and 10 s. It reveals both large-scale structures and fine-scale brightness variations across the field of view.

Prominences and Fine Structures

ASPIICS observations reveal fine structures in quiescent prominences with spatial resolution close to the instrumental limit, demonstrating the ability to resolve structures down to a few pixels.
Comparisons with EUV observations (e.g. SDO/AIA) show consistent large-scale morphology, while ASPIICS uniquely provides detailed white-light and He I D3 imaging in the low corona.

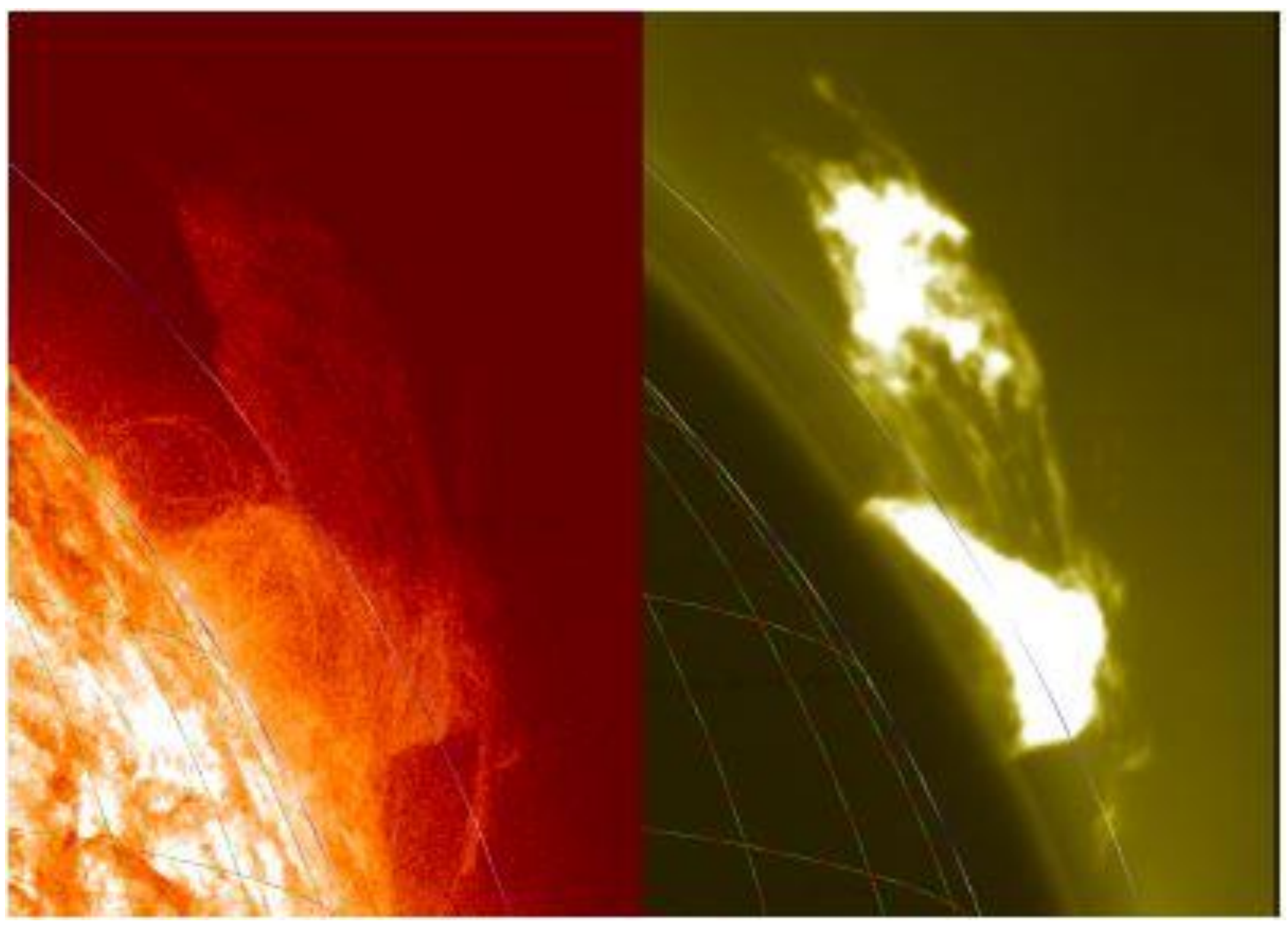

Fig. 2: Left panel: a quiescent prominence observed by SDO/AIA in the He II passband (304 Å) on 25 March 2025 at 19:23:29 UTC. Right panel: a co-aligned image of the same prominence taken by ASPIICS in the He I D3 passband (5876 Å) on 25 March 2025 at 19:23:23 UTC (orbit 135). In both panels, the solar coordinate grid is shown as well as the nominal inner edge of the ASPIICS field of view at 1.099 Rsun.

Coronal Mass Ejections (CMEs)

A key result is the ability to follow the propagation of CME cores in the range 1.5–3 Rsun, a region previously difficult to observe. capturing the early acceleration phases of CMEs.

The observed CME kinematics exhibit an initial slow rise followed by a rapid acceleration phase, consistent with a combination of linear and power-law behavior.

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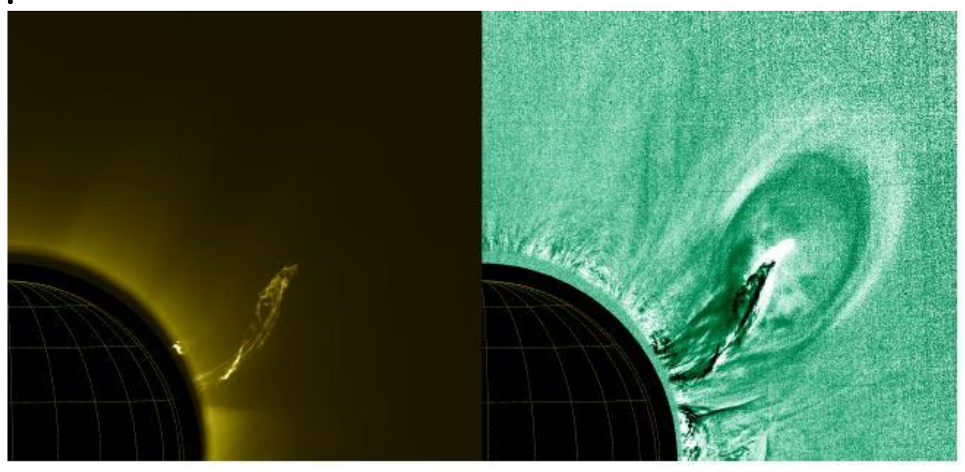


Fig. 3a: A CME observed by Proba 3/ASPIICS on 16 June 2025 (orbit 236). Left panel: He I D3 (5876 Å) image of the corresponding erupting prominence taken at 07:27:41 UTC. The prominence twist is clearly visible. Right panel: Fe XIV (5303 Å) image of the CME taken at 07:38:47 UTC, with the image taken at 07:28:58 UTC subtracted. The CME bright front, cavity, and the erupting prominence can be seen.

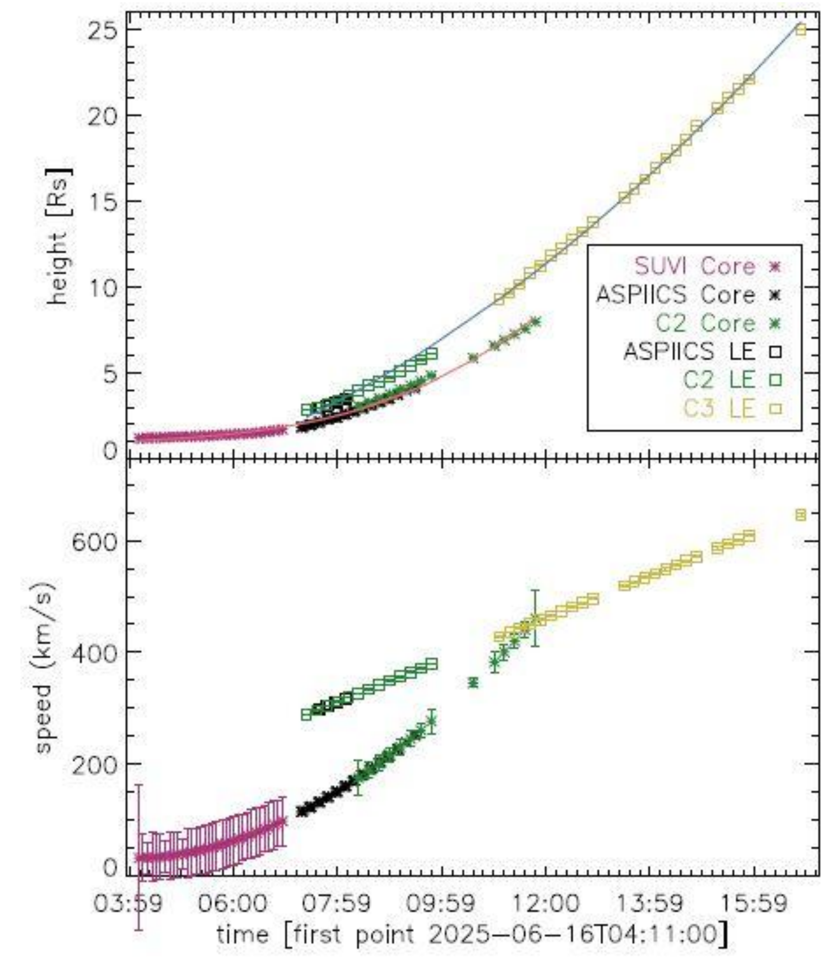


Fig. 3b: Kinematics of a CME observed by Proba-3/ASPIICS on 16 June 2025 (orbit 236), GOES/SUVI, and SOHO/LASCO C2 and C3. Top and bottom panels show the evolution of the height and radial velocity. Asterisks and squares show the propagation of the CME core and the leading edge (LE) respectively. A linear plus power law fit for the CME core propagation is shown as a purple line. A quadratic fit for the leading edge propagation is shown as a blue line. The velocity was calculated using the three-point differentiation.

Small-Scale Dynamics & Solar Wind Formation

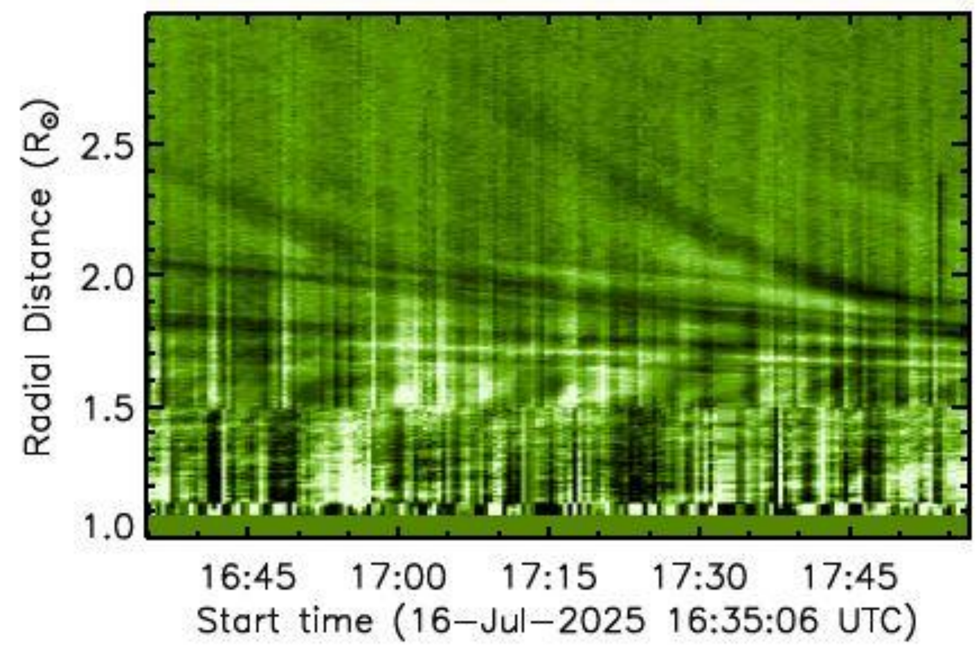
The coronagraph ASPIICS reveals a rich variety of weak, small-scale dynamic structures in the corona, including outflows, inflows, and jets, observed continuously between 1.3 and 3 Rsun.

Small-scale outflows (blobs) are observed down to a few thousand kilometers in size, moving at speeds between 100 and 400 km/s, without clear acceleration, and occur at all position angles.

Coronal inflows often interpreted as signatures of magnetic reconnection processes are also abundant, and propagate at speeds around 100 km/s, though some decelerate from 350 km/s to 100 km/s as they descend towards the solar surface.

These observations suggest that the solar wind formation region is highly dynamic, with coexisting inflows and outflows possibly related to S-web dynamics.

Fig. 4: Distance-time map of the radial propagation of small-scale structures at the position angle of 204∘. The coronal brightness was averaged over the 2∘-wide sector. An image taken 5 minutes earlier was subtracted from every image. The cadence of the data was 30 s.



Conclusions

ASPIICS successfully demonstrates coronagraphy using formation flying.
- → It provides continuous observations of the corona down to ~1.05 R?
- → It fills the observational gap between EUV imagers and classical coronagraphs
- → It reveals previously unresolved small-scale dynamics in the solar wind formation region

These results open new perspectives for understanding the origin of the slow solar wind and the early evolution of CMEs