

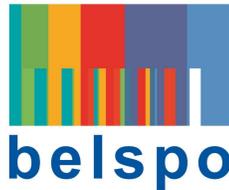
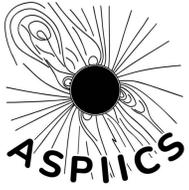
Unveiling the CME evolutions from Proba-3/ASPIICS observations

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Abstract

Coronal Mass Ejections (CMEs) are large-scale eruptive phenomena originating from the Sun, primarily observed as outward propagating structures in the white-light coronagraph images. The study of their early evolution is limited by the field of view (FOV) of most existing coronagraphs, which usually begins around ~ 2.5 solar radii (R_s). Consequently, the low corona (1 to 3 R_s) - where the initiation and acceleration phases of CMEs occur - remains largely obscured. A comprehensive understanding of the physical mechanisms driving CME initiation and early evolution therefore requires direct observations within the low corona. The Association of Spacecraft for Polarimetric and Imaging Investigation of the Corona of the Sun (ASPIICS) coronagraph aboard the Proba-3 mission of ESA addresses this observational gap. It provides the FOV of the solar corona from 1.099 R_s to 3 R_s , with a high spatial resolution (2.8 arcsec/pixel) and high temporal cadence (up to 30 s for typical CME observation programs). We present the study of the initiation and evolution of CMEs observed by ASPIICS. To construct a comprehensive, multi-perspective view of the eruptions, these unique low corona observations are complemented with observations from the Atmospheric Imaging Assembly aboard the Solar Dynamics Observatory (SDO/AIA), Large Angle and Spectroscopic Coronagraph aboard the Solar and Heliospheric Observatory, and multi-vantage point imagers including the Extreme Ultraviolet Imager (EUI) on Solar Orbiter and Extreme UltraViolet Imager (EUVI) on STEREO-A. This integrated approach enables a detailed investigation of the impulsive and evolution phases of CMEs in the low solar corona.

1. ASPIICS CME Observations

- Start Apogee activity: 2025 Sep 21 17:46:21 UTC
- Apogee (OP-Event UTC APO): 2025 Sep 21 20:46:21 UTC
- End Apogee activity: 2025 Sep 21 23:46:21 UTC
- Orbit type (SOC): CORO
- Temporal resolution: 60 s

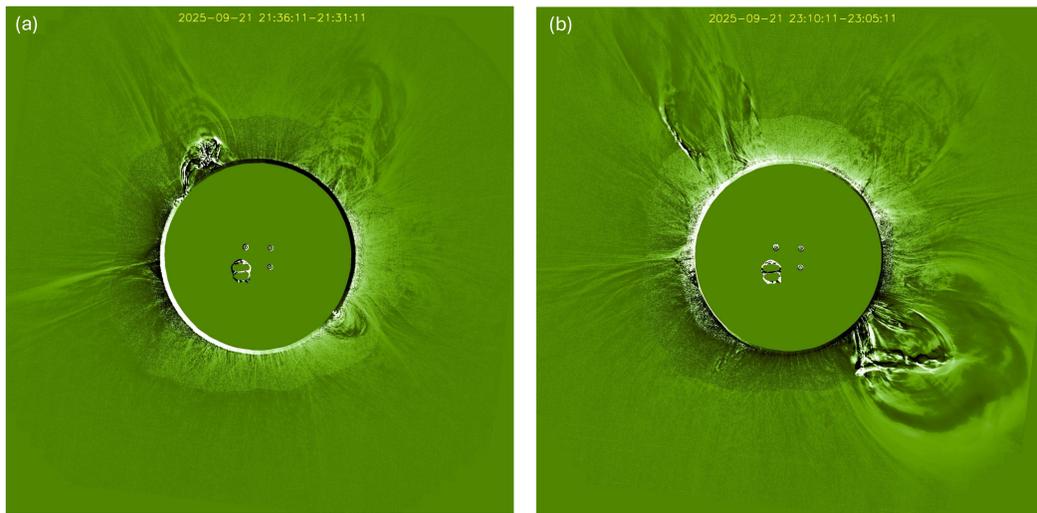


Figure 1. CMEs observed Proba-3/ASPIICS on 21 September 2025 (orbit 355). (a) Wideband difference image of the CME at 21:36:11 UTC, obtained by subtracting the image at 21:35:11 UTC. (b) Wideband difference image at 23:10:11 UTC, with the image at 23:05:11 UTC subtracted. (c) He I D3 (5876 Å) image of the erupting prominence corresponding to panel (a), acquired at 21:37:11 UTC. (d) He I D3 (5876 Å) image of the erupting prominence corresponding to panel (b) at 22:47:11 UTC.

The CME bright front, cavity, and associated erupting prominence are clearly visible at position angle of 231° .

2. Kinematics of the CME in the low corona

- Most eruptions exhibit a slow-rise phase preceding the rapid acceleration of the flux rope.
- The slow-rise phase of CMEs represents a key transitional stage between the quasi-static energy build-up and the subsequent rapid acceleration, yet its physical origin remains poorly understood (Xing et al. 2024).

ASPIICS/Proba-3 provides unprecedented solar coronal observations with a high temporal cadence (up to 30 s for typical CME observation programs) and a high spatial resolution of 2.8 arcsec/pixel (Zhukov et al. 2025).

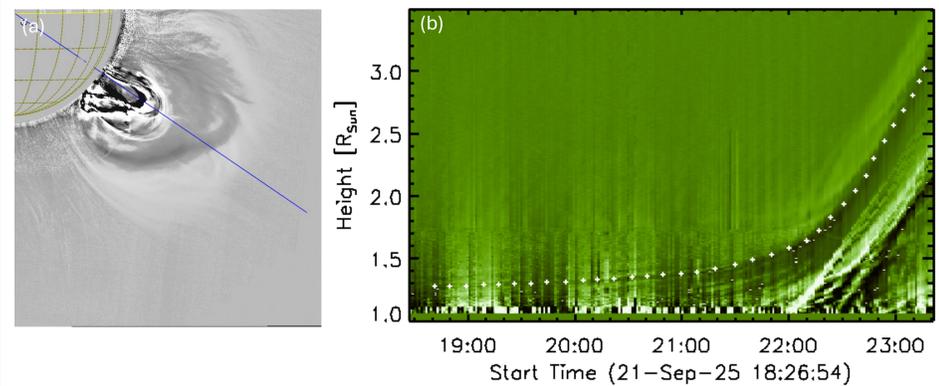


Figure 2. Panel (a): Zoomed-in view of the CME shown in Figure 1(b), with the blue line indicating the radial direction along which the CME propagation is tracked. (b) J-map constructed along the selected radial direction. (c) CME speed profile derived from fitting a linear plus exponential model to the height-time measurements.

The main-acceleration phase starts with a rapidly and nonlinearly increasing acceleration, which is consistent with earlier study by Cheng et al. (2020).

3. Kinematics of the CME in the high corona

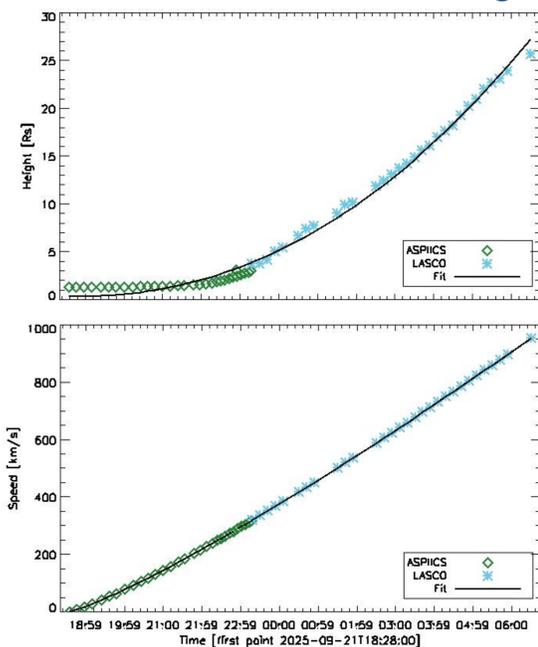


Figure 3. Kinematics of the CME (Figure 1b) as observed by ASPIICS and SOHO/LASCO C2 and C3. The top and bottom panels display the temporal evolution of the leading-edge height and radial velocity, respectively. The CME kinematics is fitted using a linear plus polynomial function and the resulting fit is indicated by the black curve.

The increasing radial velocity derived from the linear plus polynomial fit indicates that the CME undergoes acceleration in the ASPIICS-LASCO field of view.

4. 3D reconstruction of the CME

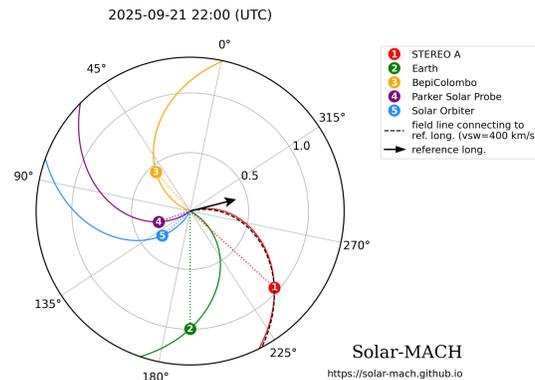


Figure 4. The Solar-Mach diagram showing the positions of individual spacecrafts on 21 September 2025, 20:00 UTC. The Sun is at the center.

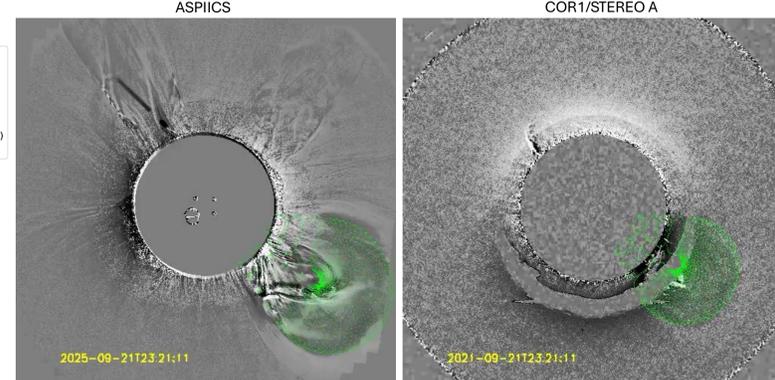


Figure 5. GCS reconstruction for the CME observed by Proba-3/ASPIICS (left panel) and STEREO/COR1-A (right panel) at around 23:21 UT on 21 September 2025.

The GCS reconstruction indicates that the CME propagates along latitude of -32° and a longitude of 296° .

5. Conclusions:

- The CMEs exhibit spectacular flux rope structures in the ASPIICS FOV.
- Our preliminary results suggest that the speed of CMEs reaches up to 500 km/s in ASPIICS FOV and up to 600 km/s in LASCO FOV.
- The Solar Orbiter along with STEREO provide multi-vantage observations of source region of CMEs.
- The 3D speed derived from the GCS fitting of the CME observed by ASPIICS and COR1 was 314 km/s.

References:

Zhukov, A., et al. (2025), The ASPIICS solar coronagraph aboard the Proba-3 formation flying mission. Scientific objectives and instrument design [https://arxiv.org/pdf/2509.00253].
Cheng, X., et al. (2020), Initiation and Early Kinematic Evolution of Solar Eruptions.
Xing, C., et al. (2024), Unveiling the Initiation Route of Coronal Mass Ejections through Their Slow Rise Phase.

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