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Unveiling the heating source inside an erupting prominence as observed by Solar Orbiter/Metis and ASO-S/LST

Shuting Li[1], Alessandro Bemporad[2], Li Feng[1], Beili Ying[1], Jinhan Guo[3]
[1] Purple Mountain Observatory, Chinese Academy of Sciences, [2] INAF-Turin Astrophysical Observatory, [3] School of Astronomy and Space Science and Key Laboratory of Modern Astronomy and Astrophysics, Nanjing University
e-mail (speaker): lisht@pmo.ac.cn

Solar prominences are bright structures above the solar limb, whose thermal property during the eruption remains poorly understood. A quiescent prominence erupted from the limb and caused a CME on 2023 April 12. It was observed by both the multi-channel Metis Coronagraph on board the Solar Orbiter (SolO) mission and the Lyman-alpha Solar Telescope (LST) on board the Advanced Space-based Solar Observatory (ASO-S) mission, from different perspectives. We take the observational advantage of the two instruments to do the 3D reconstruction, and analyze the plasma thermal properties of the prominence during the evolution from images at Lyα line. The prominence appears in Metis ultraviolet (UV) channel at Lyα line as a very bright arch structure, while the signal in the visible light (VL) images is much fainter. The large deviation of the propagation panel of the prominence from the Metis plan of sky results such a significant difference between the two channels. Starting from the formation mechanism of the VL and the Lyα line, we respectively estimated the electron density and the temperature from VL and UV images. The Carrington map of Lyα emission from chromosphere measured by SDI has been used to constrain the radiative component of the Lyα emitted by the prominence plasma expanding through the corona, showing that the prominence Lyα emission is mostly due to collisional excitation. Based on the conclusion, we applied a new approach that is independent of the radiometric calibration of UV data to derive the temperature and, consequently, to understand the thermal properties of the prominence. Our Results show that the temperature remains almost constant during the evolution, indicating that the prominence undergoes isothermal expansion rather than the adiabatic expansion. It means that there must be some heating processes taking place to compensate the adiabatic cooling. Some heating parameterizations, for instance, the heating law that contribute to the fast solar wind[1], and heating by the Alfvén wave dissipation[2],[3] have been estimated. By comparing the energy budget of the erupting prominence and the heating terms, we find that the most probable heating source for this event is likely the dissipation of internal magnetic fields due to the magnetic reconnection[4].

References

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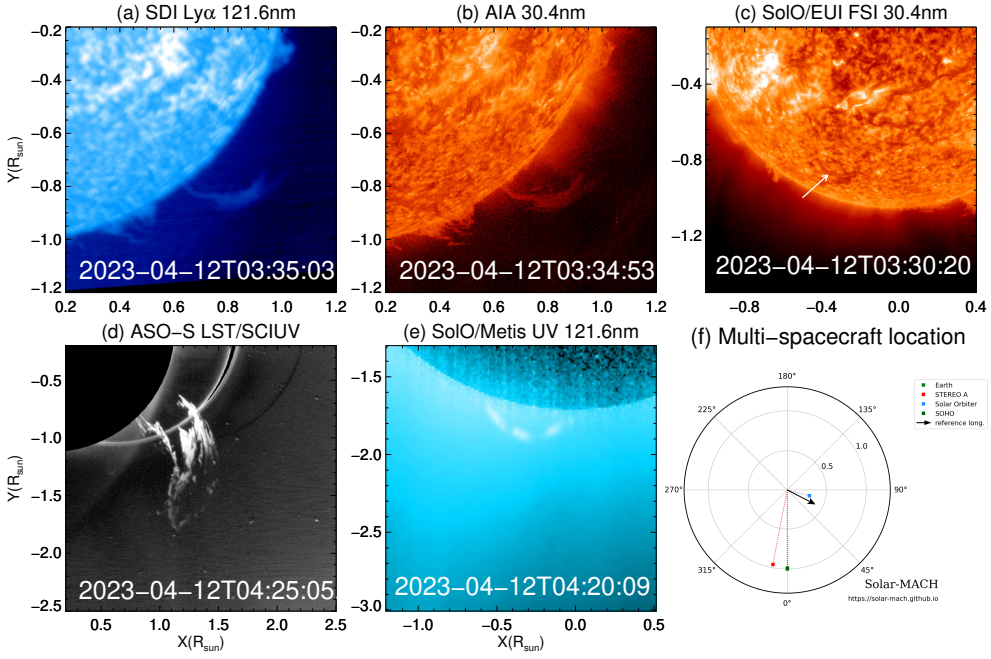

Figure 1. An overview of the prominence observed by different instruments, as well as the location of different spacecraft and Earth on 2023 Apr 12 as seen projected onto the ecliptic plane.