Planning Solar Corona Tomography with SolO/Metis

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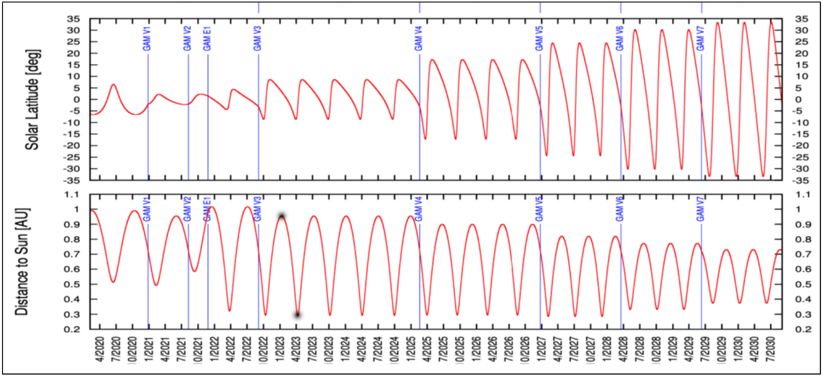
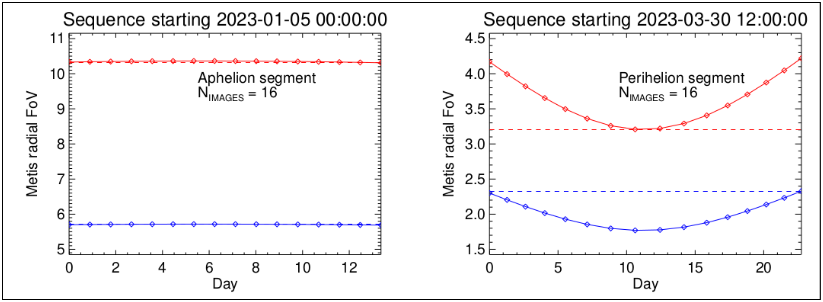
Summary

- Metis/SolO records full-Sun images of the solar corona in Lyman-α ultraviolet (UV) radiation and in visible light polarized brightness (pB).
- pB-images are a direct diagnostic of the electron density along the LOS.
- Using time-series of pB-images, the solar tomography technique can be used to determine the 3D distribution of the coronal electron density. This has been done with data from both ground-based (e.g. MLSO/KCOR) and space-borne (SoHO/LASCO-C2, STEREO/COR) instruments. All of those instruments are in (nearly) circular orbits of radius ≈ 1 au.
- In the case of Metis, the high eccentricity of the SolO orbit implies that the radial FoV of the images is a function of the orbital position.
- In this work we explore the use of Metis pB-images for tomography.
- With the orbital information of SolO and a 3D-MHD coronal model, we simulate time-series of Metis images near aphelion and perihelion to carry out tomographic reconstructions of the model.



Adapted from García Marirrodriga et al. (2021), Astron. Astrophys.

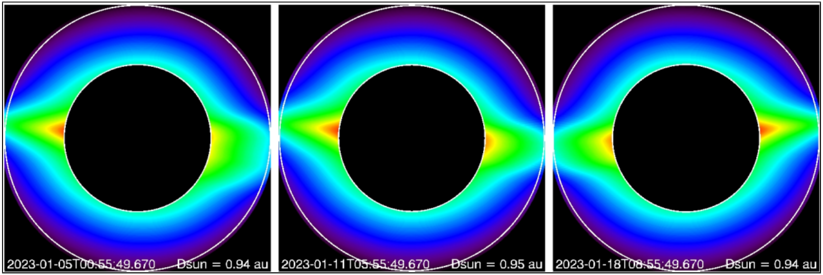
Aphelion and Perihelion Image Series: FoV vs. Time



Radial FoV as a function of time for two time series of simulated observations, around aphelion (right) and perihelion (right).

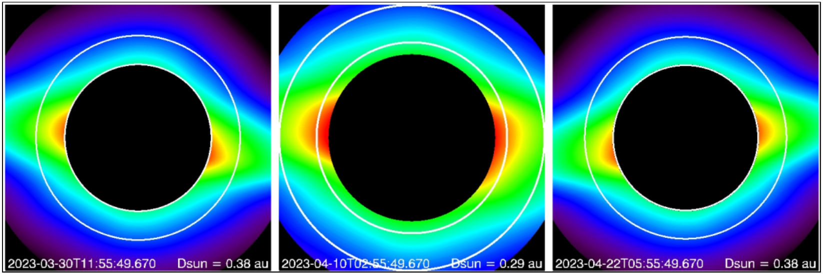
In these simulations the disk-center solar longitude ϕ seen by Metis varies by $\Delta\phi = 12^\circ$ between consecutive observations.

Synthetic Images near Aphelion

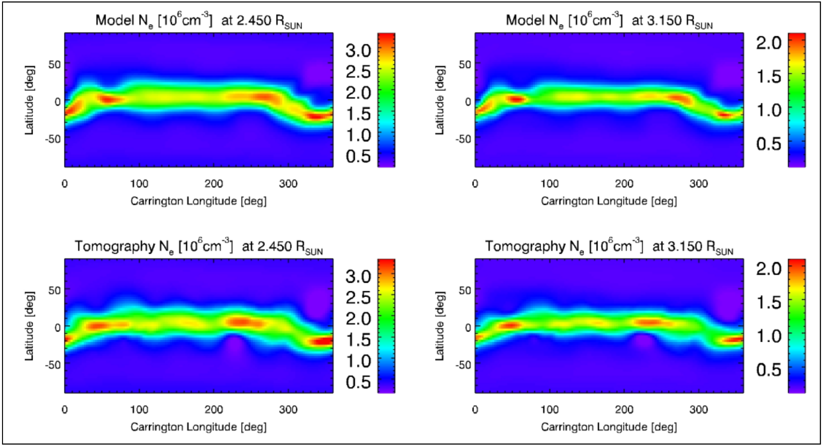


First, middle and last image of the aphelion time-series.
The white circles indicate the radial FoV $5.7 - 10.3\ \mathrm{R}_\odot$.

Synthetic Images near Perihelion

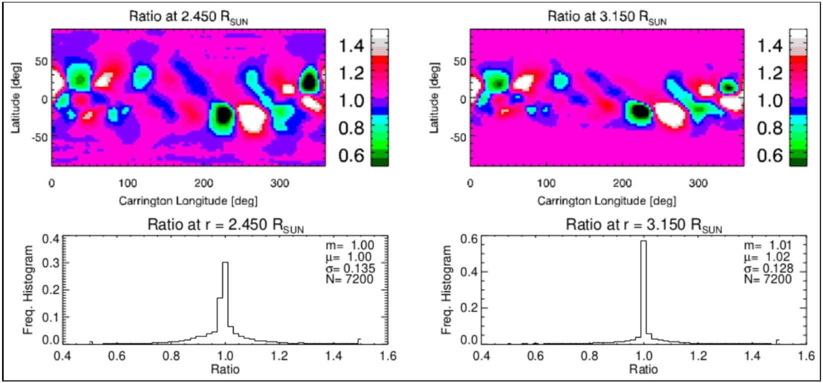


First, middle and last image of the perihelion time-series.
The white circles indicate the radial FoV $2.3 - 3.2\ \mathrm{R}_{\odot}$.



Latitude/Longitude maps of the electron density of the model at two heights (top panels), and their tomographic reconstruction (bottom panels).

Perihelion-Tomography versus Model



Latitude/Longitude maps of the ratio between the electron density of the tomographic reconstruction and the model (top panels), and their respective histograms (bottom panels).

Conclusions

- Aphelion segment: Data gathered over a period of ≈ 13 days. Range of heights over which N_e can be reconstructed $\approx 5.7 - 10.3\ \mathrm{R}_\odot$.

- Perihelion segment: Data gathered over a period of ≈ 22 days. Range of heights over which N_e can be reconstructed $\approx 2.3 - 3.2\ \mathrm{R}_\odot$.

- Mean observational cadence in these simulations ranges from ≈ 1.2 images/day (aphelion) to ≈ 0.7 images/day (perihelion).

- For orbital segments in between aphelion and perihelion, the data gathering period and the range of heights over which the density structure can be reconstructed are intermediate to the results informed above.

- A Metis observational synoptic program of 4 images/day will allow tomographic reconstructions of the solar corona along the full orbit of SolO. This study has just been submitted to Solar Physics.

- As a next step we will explore combining VL tomography with tomography based on Metis H I Lyman-α images. This will in principle allow 3D mapping of the Lyman-α Doppler dimming factor. Those results could then be inverted to derive 3D maps of the solar wind velocity.