CMEs, Flares, Prominences in Lyα: Science Preparations for ASO-S/LST

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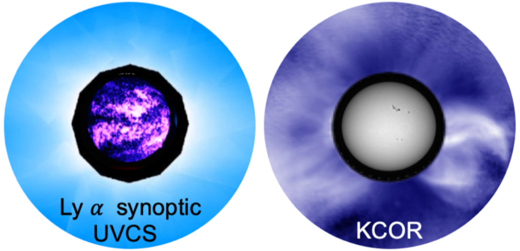
ASO-S/LST (launch time 2022)

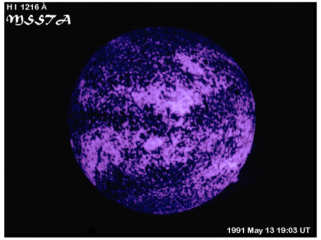
SCI

Ly α and WL coronagraph images



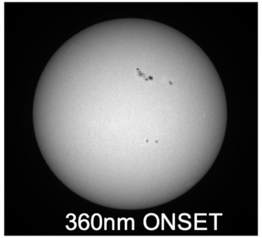
SDI

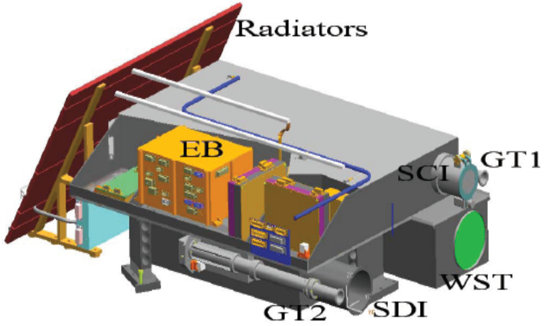
full-disk Lyα image



WST

full-disk white-light image

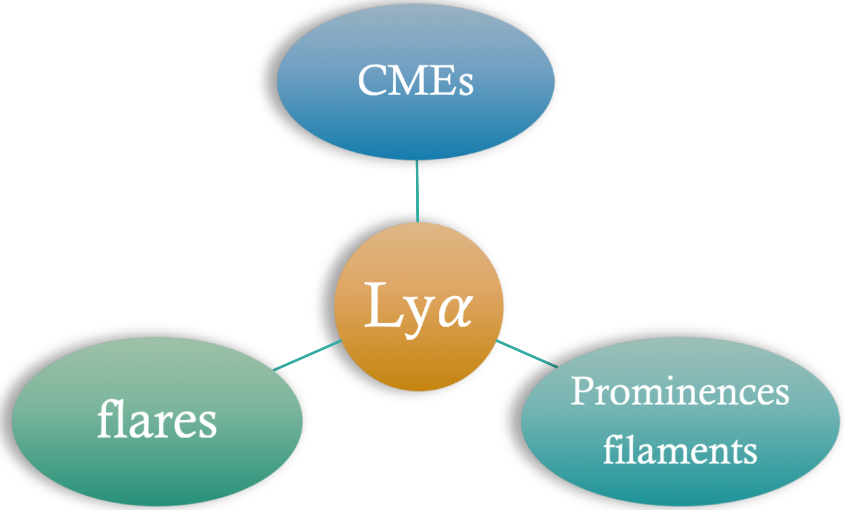




Parameter	SCI_WL	SCI_UV	SDI	WST
Waveband	$700.0 \pm 40.0\,\mathrm{nm}$	$121.6 \pm 10.0\,\mathrm{nm}$	$121.6 \pm 7.5\,\mathrm{nm}$	$360.0 \pm 2.0\,\mathrm{nm}$
FOV	$1.1 - 2.5\,R_\odot$		$0.0 - 1.2\,R_\odot$	$0.0 - 1.2\,R_\odot$
Spatial resolution	$\sim 4.8''$		$\sim 1.2''$	$\sim 1.2''$
Image size	2048×2048		4608×4608	4608×4608

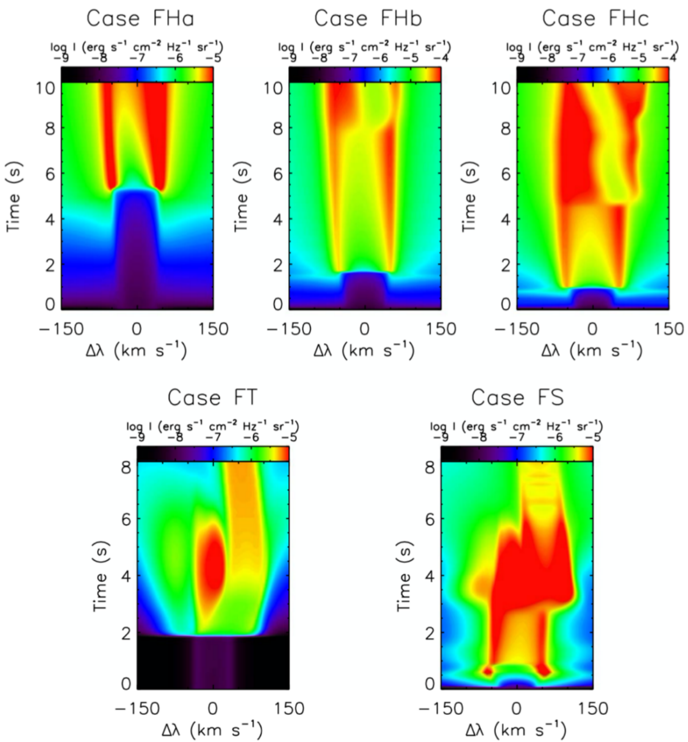
- **Seamless observations in Lyα from solar disk (SDI) to 2.5 Rs (SCI);**
- **Simultaneous dual-waveband coronagraph observations in both Lyα and WL**

CMEs, Flares, Prominences in Lyα

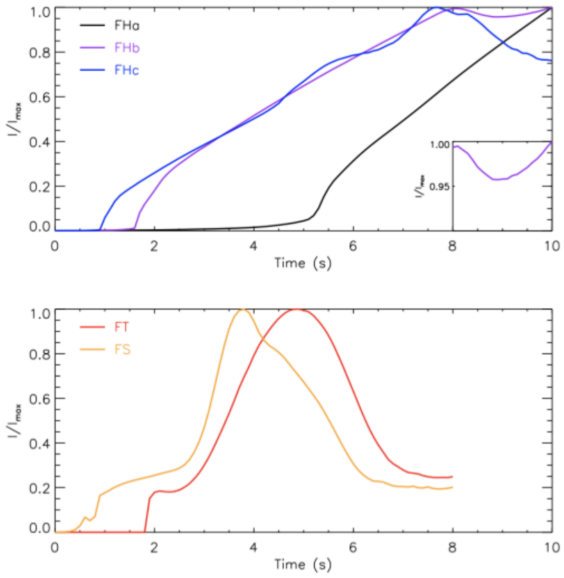


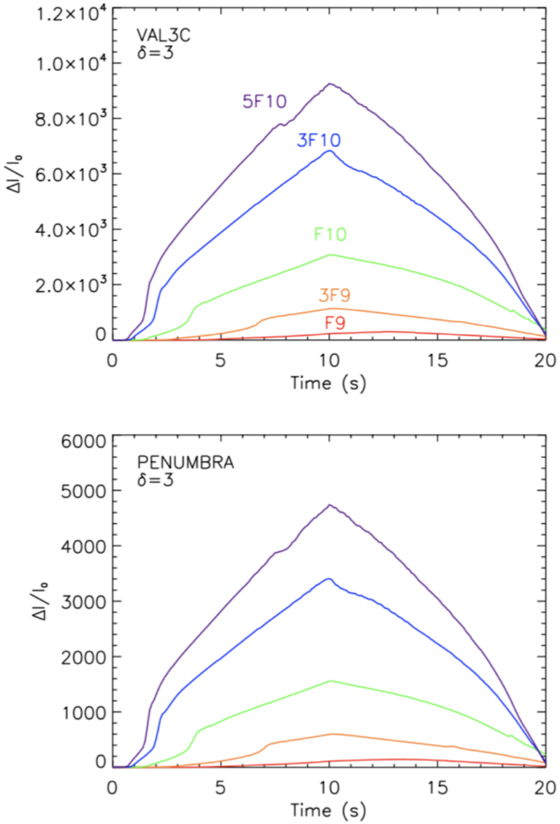
Flares in Lyα – simulations via RADYN code

evolution of Lyα line profiles



Lyα integrated intensity

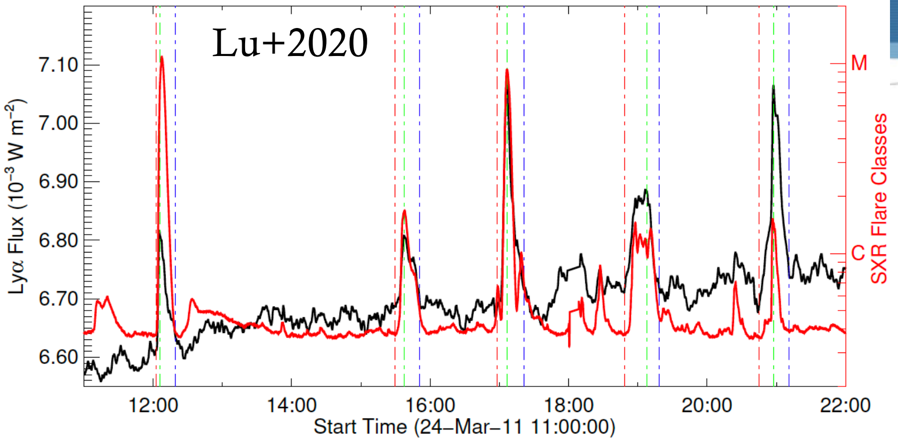




Lyα profiles **under different nonthermal and thermal heatings** reveal red and blue asymmetry, evaporation and condensation processes (Hong+2019)

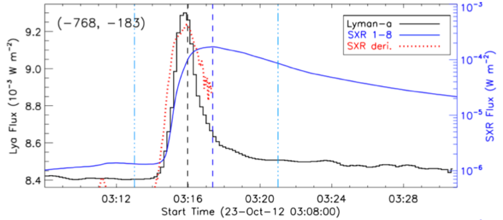
Different atmospheric models (Yang+2021)

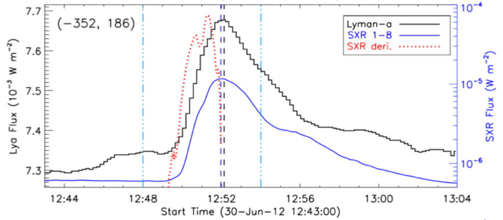
Flares in Lyα - observations



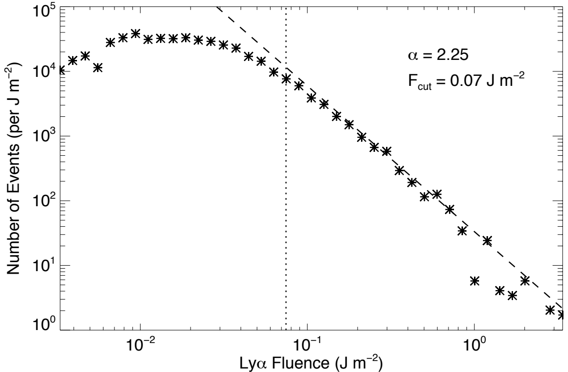
Statistical studies on Lyα flares:

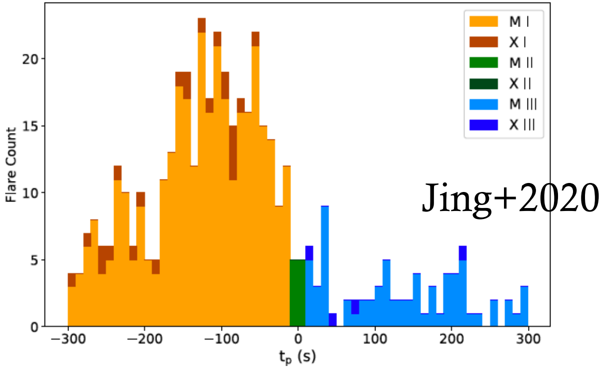
- Time properties: duration, rising, decay times
  peak time with respect to SXR peak and
  SXR time-derivative peak
- Flux properties: contrast, fluence, etc.

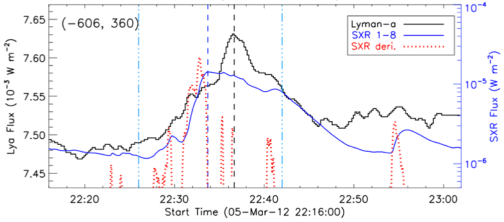




Automatic detection of Lyα flares –
a catalog of start, peak, and end times, flux etc



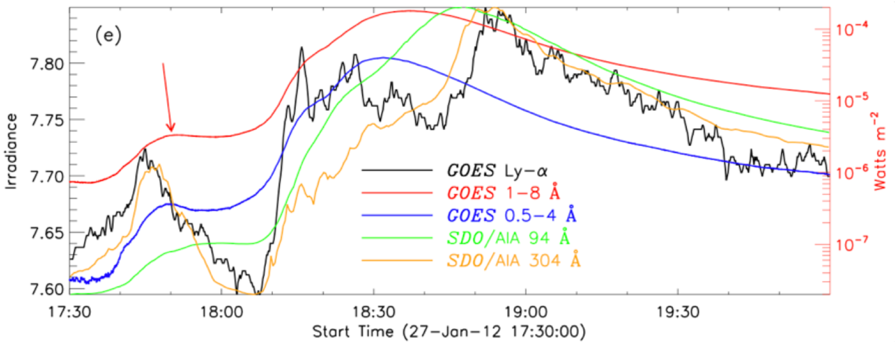




Flares in Lyα - observations

Case studies on QPPs (Quasi-Periodic Pulsations) in Lyα

1-minute and 3-minute QPPs were detected in Lyα emission during the SOL2012-01-27 Flare (X1.7)



1-min QPP: precursor, impulsive, and decay phases; a self-oscillatory regime of the magnetic reconnection, such as magnetic dripping.

3-min QPP: only impulsive phase; the acoustic wave in the chromosphere.

Li+(2020)

QPPs of about 1 min and 2 mins in Lyα during solar flares were also detected in HXR and microwave, suggesting a non-thermal origin of the Lyα emission.

Table 2 Double periods observed in the Ly α, HXR, and microwave emissions during solar flares.

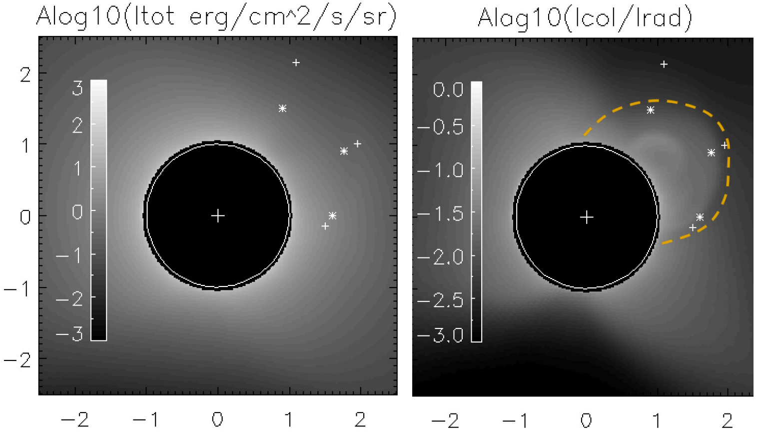
		P1 [minutes]	P2 [minutes]	Ratio (P2/P1)
SOL2011-02-15T01:44	GOES Ly α	1.09 ± 0.05	2.15 ± 0.15	1.97 ± 0.23
	RHESSI 25 – 50 keV	1.26 ± 0.19	2.13 ± 0.32	1.69 ± 0.52
	NoRP 35 GHz	1.37 ± 0.12	2.17 ± 0.36	1.58 ± 0.41
	NoRH 34 GHz	1.37 ± 0.19	2.13 ± 0.33	1.56 ± 0.47
SOL2011-09-25T04:31	GOES Ly α	1.33 ± 0.19	2.42 ± 0.24	1.82 ± 0.45
	RHESSI 25 – 50 keV	1.37 ± 0.16	2.24 ± 0.31	1.64 ± 0.43
	Fermi 27 – 50 keV	1.27 ± 0.12	2.46 ± 0.33	1.94 ± 0.45
	NoRP 35 GHz	1.12 ± 0.11	2.41 ± 0.29	2.15 ± 0.48
	NoRH 34 GHz	1.19 ± 0.10	2.39 ± 0.28	2.00 ± 0.41
SOL2012-05-17T01:25	GOES Ly α	1.12 ± 0.05	2.19 ± 0.16	1.96 ± 0.23
	NoRP 17 GH	1.12 ± 0.06	2.33 ± 0.35	2.08 ± 0.43
	NoRH 17 GH	1.25 ± 0.09	2.33 ± 0.36	1.86 ± 0.43

Lu+(2021)

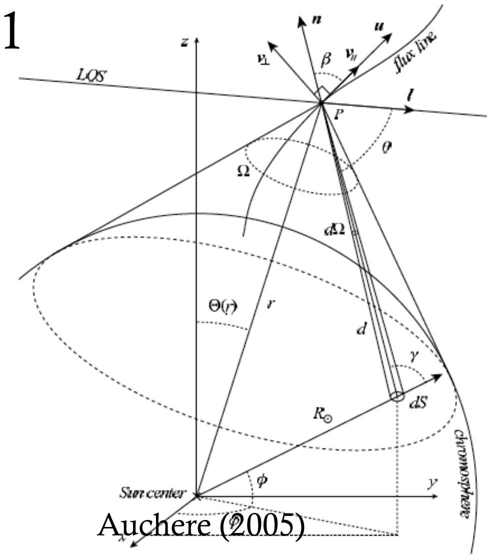
CMEs in Lyα - simulations

Starting with **two-fluid MHD simulations**, make synthetic images in Lyα considering:

1. nonuniform Lyα disc intensity
2. detailed scattering geometry
3. $T_p \neq T_e$

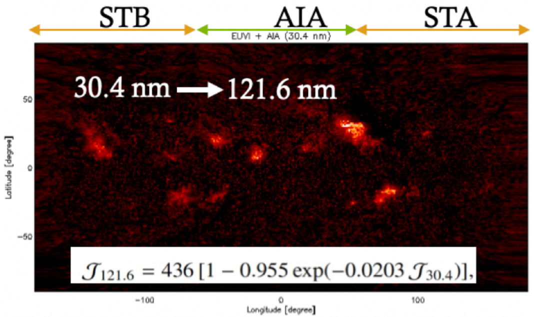


1

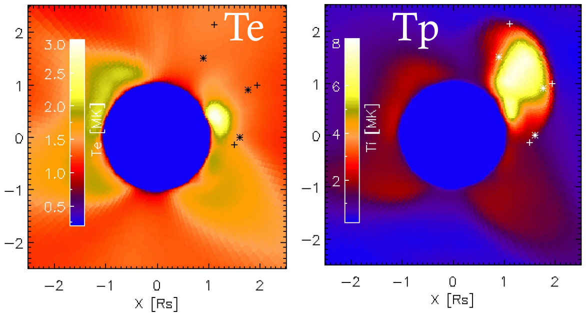


Auchere (2005)

2



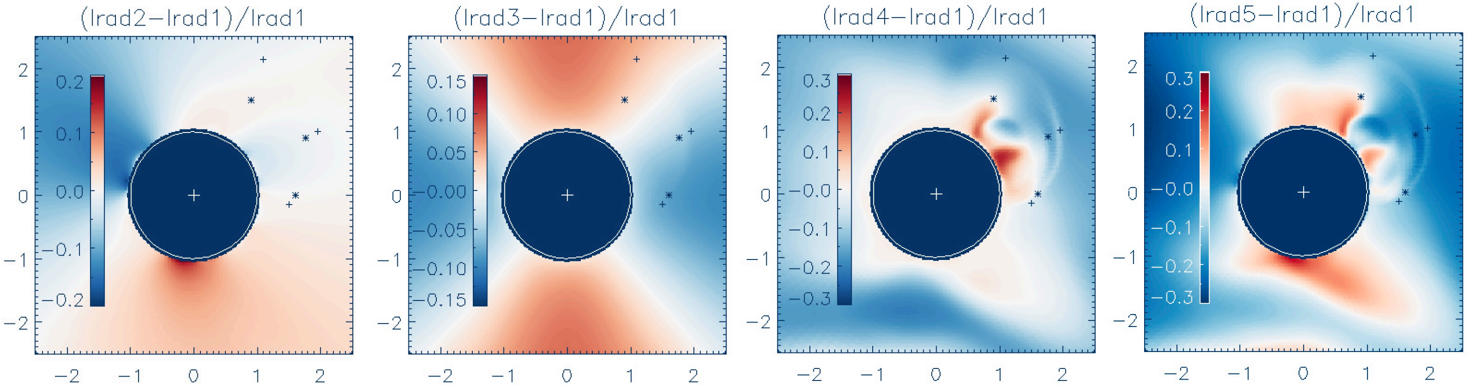
3



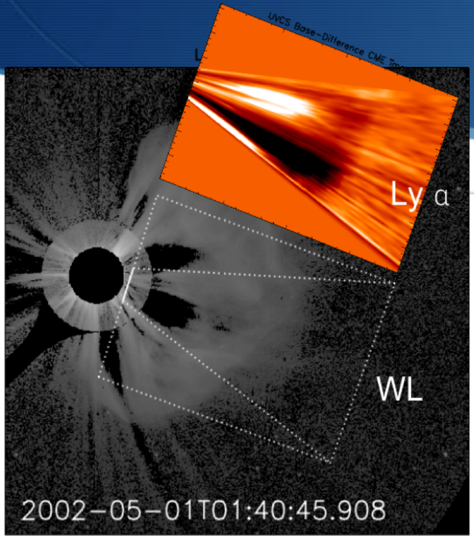
Ying+,2021, in prep

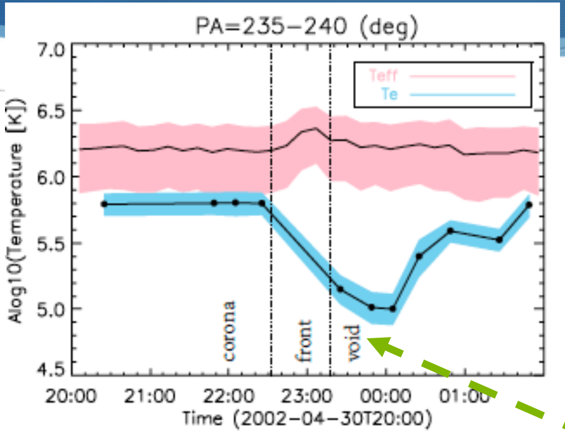
Comparison of radiative component of Lyα intensity under different assumptions

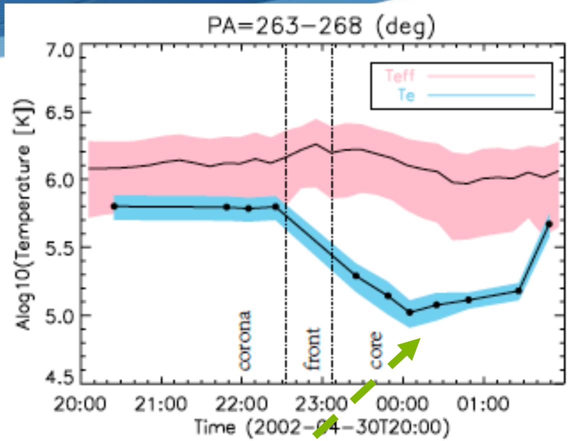
	Irad1	Irad2	Irad3	Irad4	Irad5
nonuniform Lyα disk intensity	Y	uniform	Y	Y	uniform
detailed scattering geometry	Y	Y	Sun as a point-source	Y	Sun as a point-source
$T_p \neq T_e$	Y	Y	Y	$T = T_e$	$T = T_e$
Max uncertainty to Irad1	/	~15%	~10%	~25%	~30%



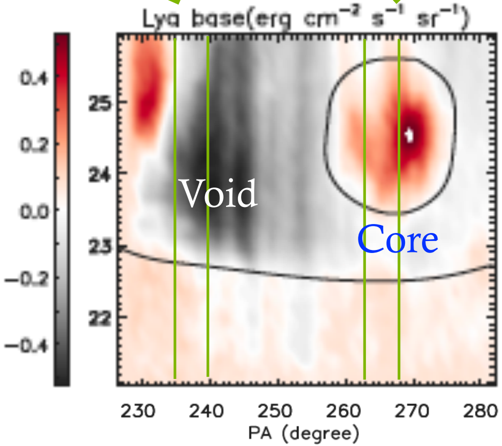
CMEs in Lyα - observations





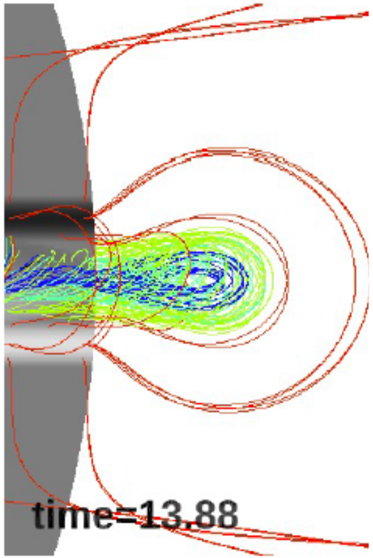


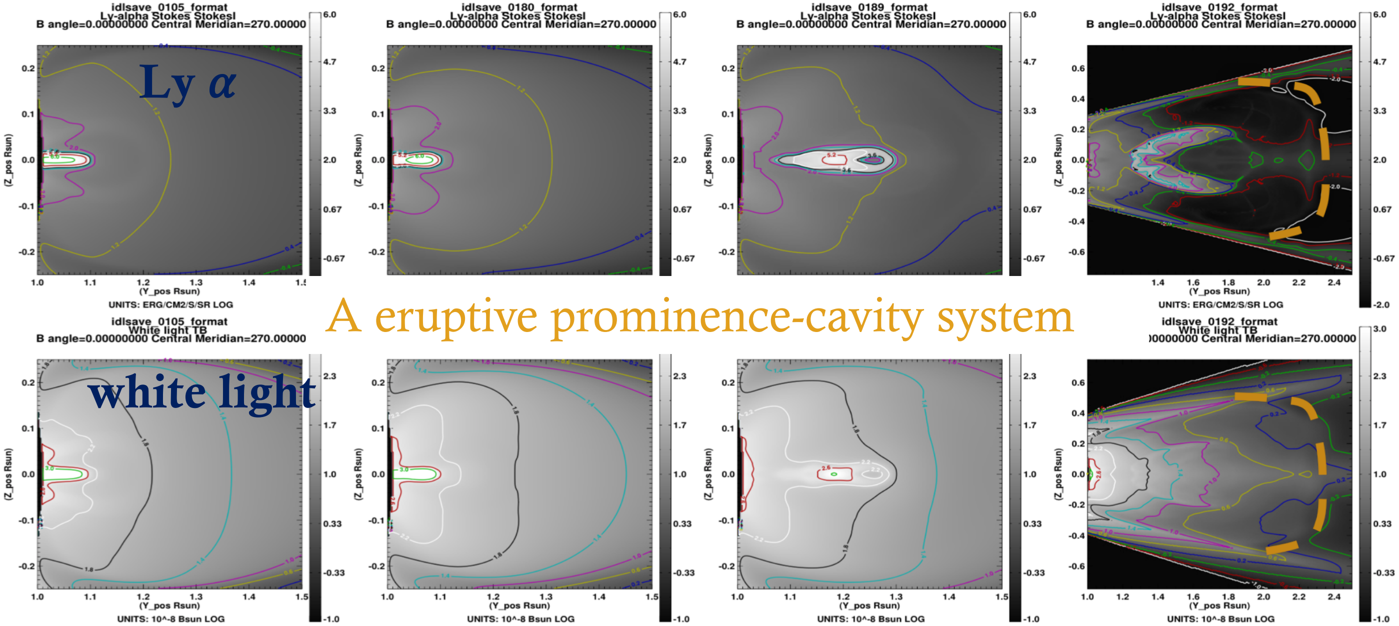
The observations by **UVCS/SOHO** show different CME structures in Lyα and white light (WL) and reveal different thermodynamic evolutions in its void and core.



Ying+(2020)

Prominences in Lyα - simulations





Synthetic Lyα and WL images: optically thin assumption

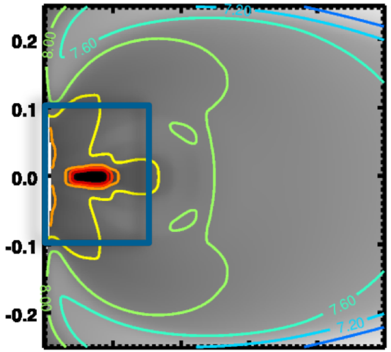
Yuhong Fan+ (2019)

Yuhong Fan(2017)

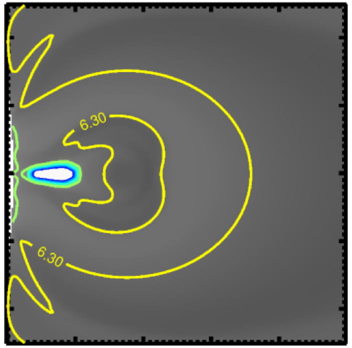
Zhao, Zhang+,2021, in prep

Prominences in Lyα – optically thick regime

POS electron density

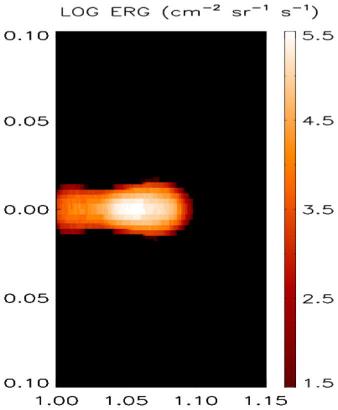


POS temperature

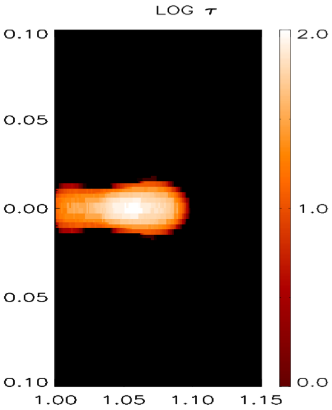


Zhao, Zhang+,2021, in prep

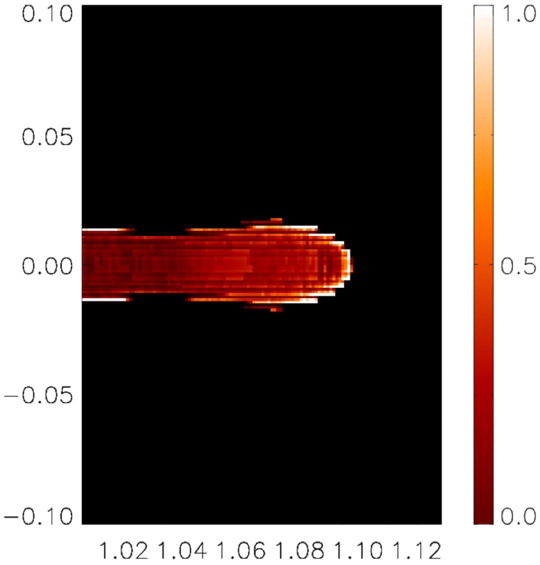
Lyα intensity



Optical thickness



ratio of the optically thick intensity to optically thin intensity



1D NLTE radiative transfer code - PRODOP

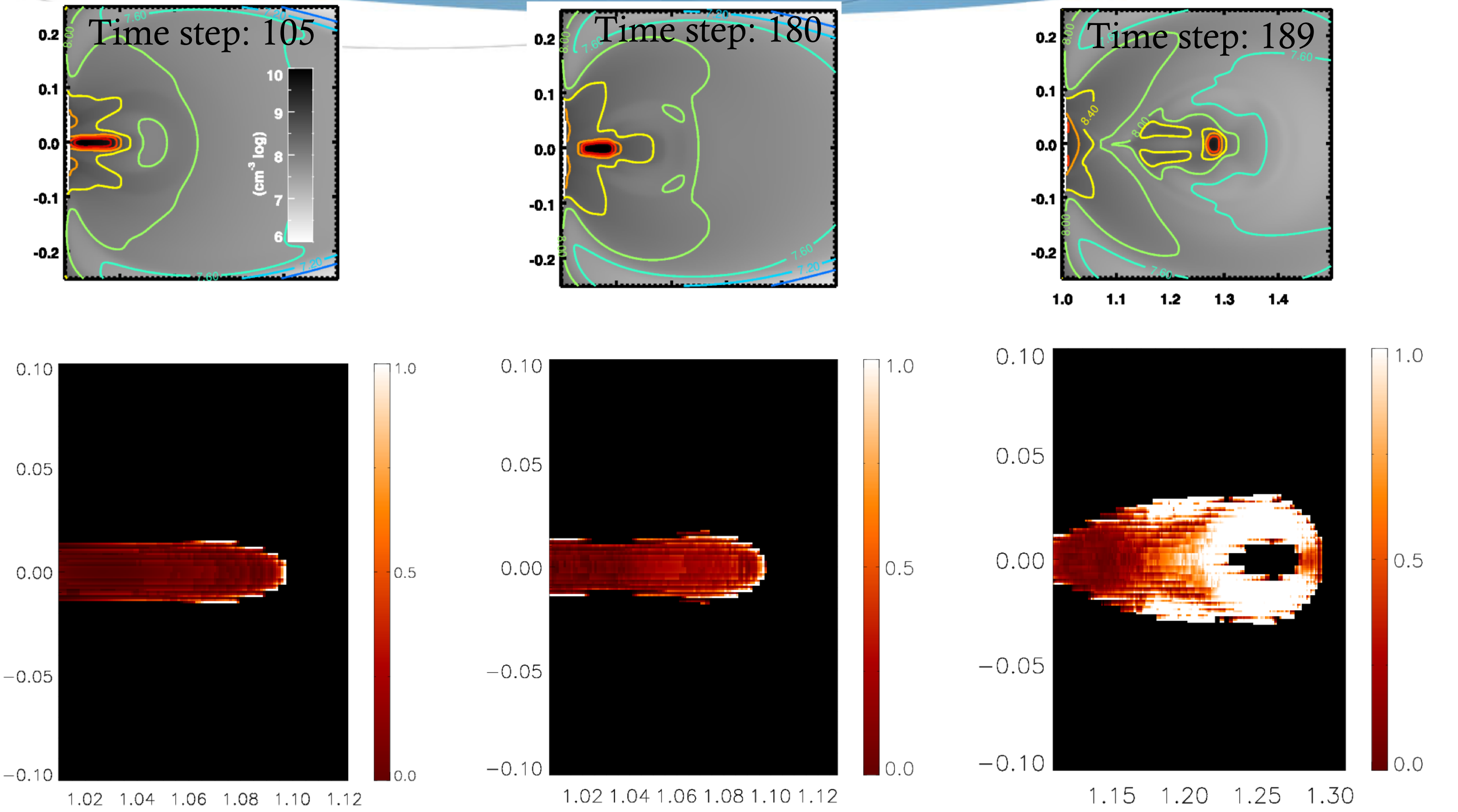
The Lyα line intensity and optical thickness are computed in the region with density larger than $1X10^{9}cm^{-3}$ and temperature less than 100 000K.

Prominences in Lyα –
comparing optically thin and thick results

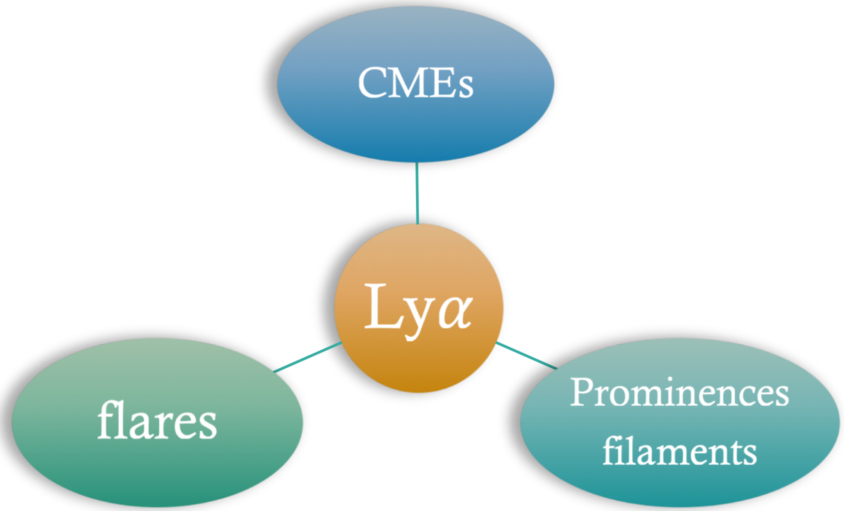
density

I(thick)

I(thin)



Science preparations for ASO-S/LST



Synergy with SolO/Metis and EUI:

- Stereoscopic observations: LST and Metis-EUI have different perspectives and the same Lyα wavelength
- LST can provide synoptic Lyα disk intensity images for calculating the Lyα intensity in the corona.
- …