

SYNTHETICALLY  
OBSERVING  
EBTEL MODELED  
SOLAR FLARES  
BY BROCK PARKER



# OVERVIEW

01

## BACKGROUND

Solar flares, SDO,  
EBTEL

02

## PREVIOUS WORK

Magnetic  
Extrapolation, UFC,  
Two-phase Heating

03

## CURRENT WORK

Python SynthesizAR,  
Importing loops

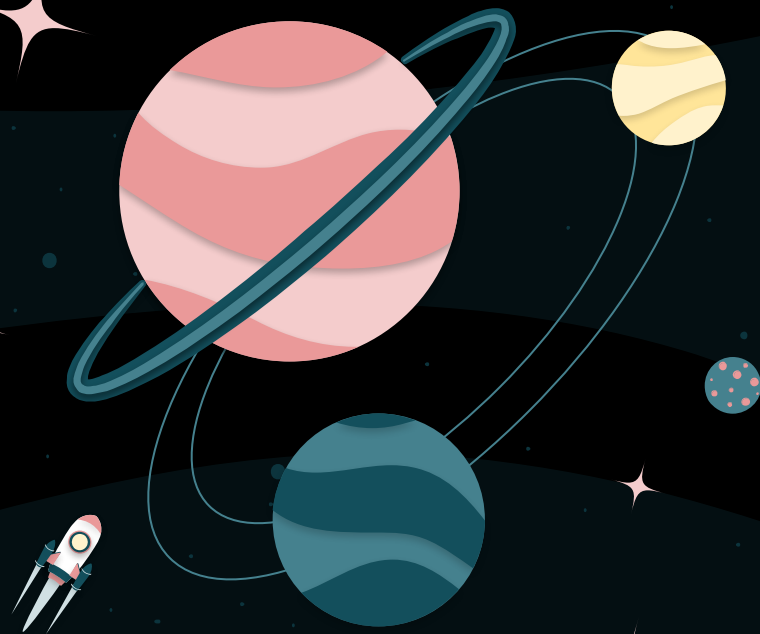
04

## FUTURE

Importing Results,  
Modifications

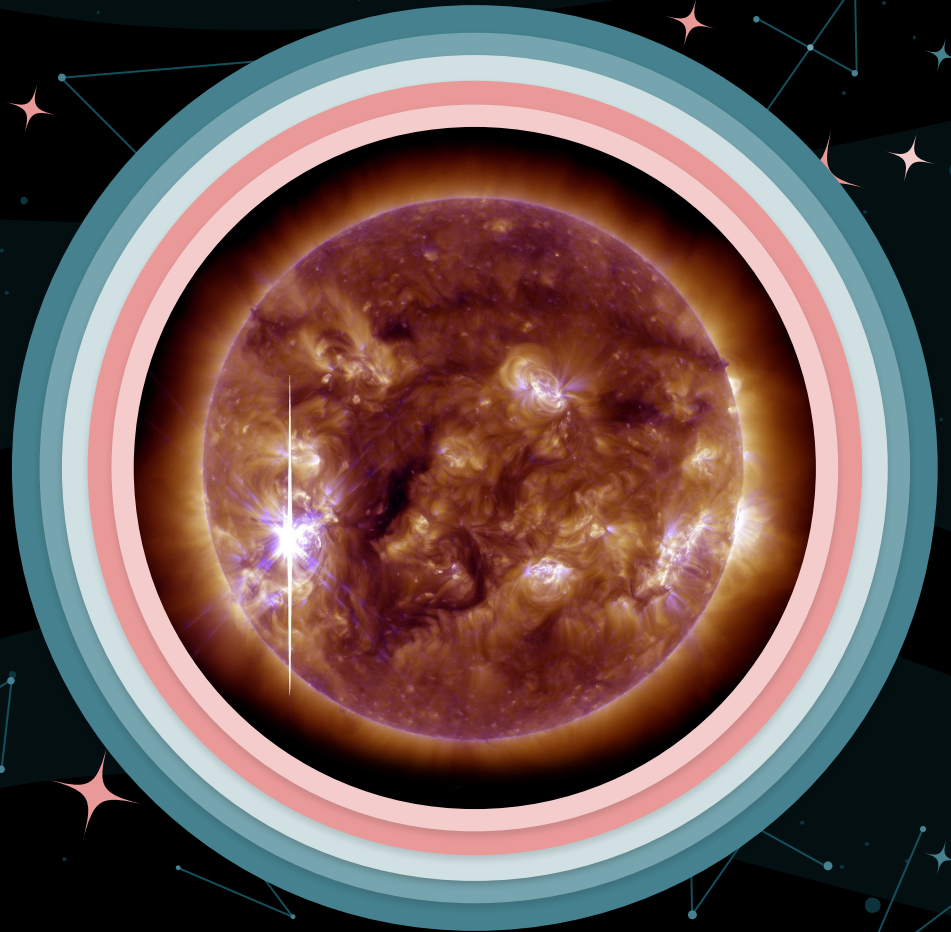
01

BACKGROUND



# SOLAR FLARES

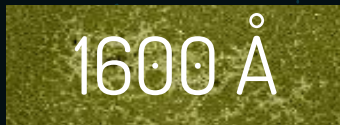
Intense eruption of electromagnetic radiation from the sun's atmosphere.



# SDO - Solar Dynamics Observatory



Magnetic Field in  
the Photosphere



Upper Photosphere  
and Transition  
Region, 10,000 K



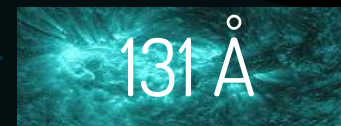
Transition Region  
and Chromosphere,  
50,000 K



Upper Transition  
Region and Corona,  
600,000 K



Corona,  
1,000,000 K



Flaring Regions,  
10,000,000 K

# EBTEL - Enthalpy Based Time Evolution of Loops

$$\frac{d\bar{P}}{dt} \approx \frac{2}{3} \left[ \bar{Q} - \frac{1}{L} (R_c + R_{tr}) - \frac{F}{L} \left( 1 - \frac{3}{2} \frac{k\bar{T}}{\varepsilon} \right) \right]$$

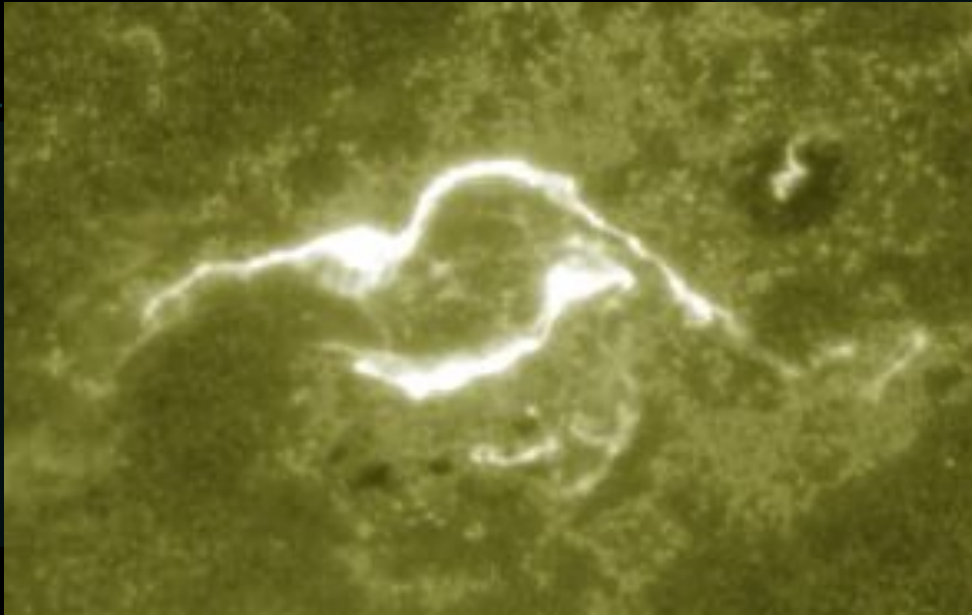
$$\frac{d\bar{n}}{dt} = - \frac{c_2}{5c_3 k L \bar{T}} (F_0 + R_{tr}) + \frac{F}{\varepsilon L} \left( 1 - \frac{c_2}{5c_3} \frac{\varepsilon}{k\bar{T}} \right)$$

## EQUILIBRIUM

Energy balance between coronal heating and losses by radiation and thermal conduction.

## ENTHALPY

Equate enthalpy flux of plasma with change in heat flux relative to radiation loss rate in the transition region.



$$H_i(t) = \lambda \left[ I_i q \left( \frac{|t - t_i|}{\tau_i} \right) \right]^\alpha$$

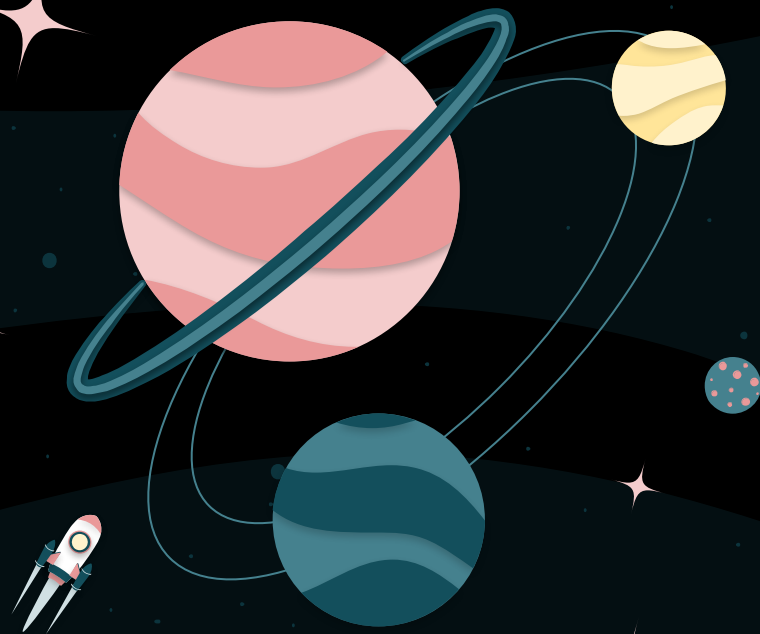
## UFC

UV Footprint Calorimeter Method. The brightness of loop feet is proportional to the heating of the loops.

(Qiu et al., 2012)

02

PREVIOUS  
WORK





# PROCESS



## LIGHTCURVES

Flare lightcurves  
for each different  
SDO EUV  
wavelength.



## PIXELS

Identification of  
flaring pixels in the  
1600 flaring  
ribbons.



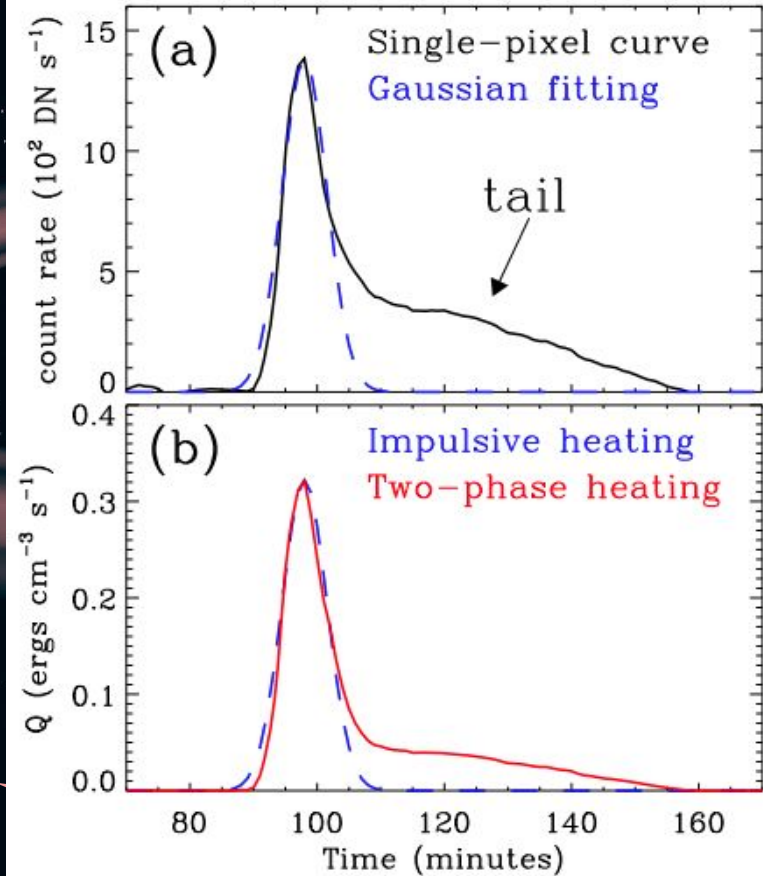
## EBTEL

Run 0D simulations  
of the loops and  
generate synthetic  
lightcurves.

$$H_{grad} = \lambda_1 I_{tail}$$

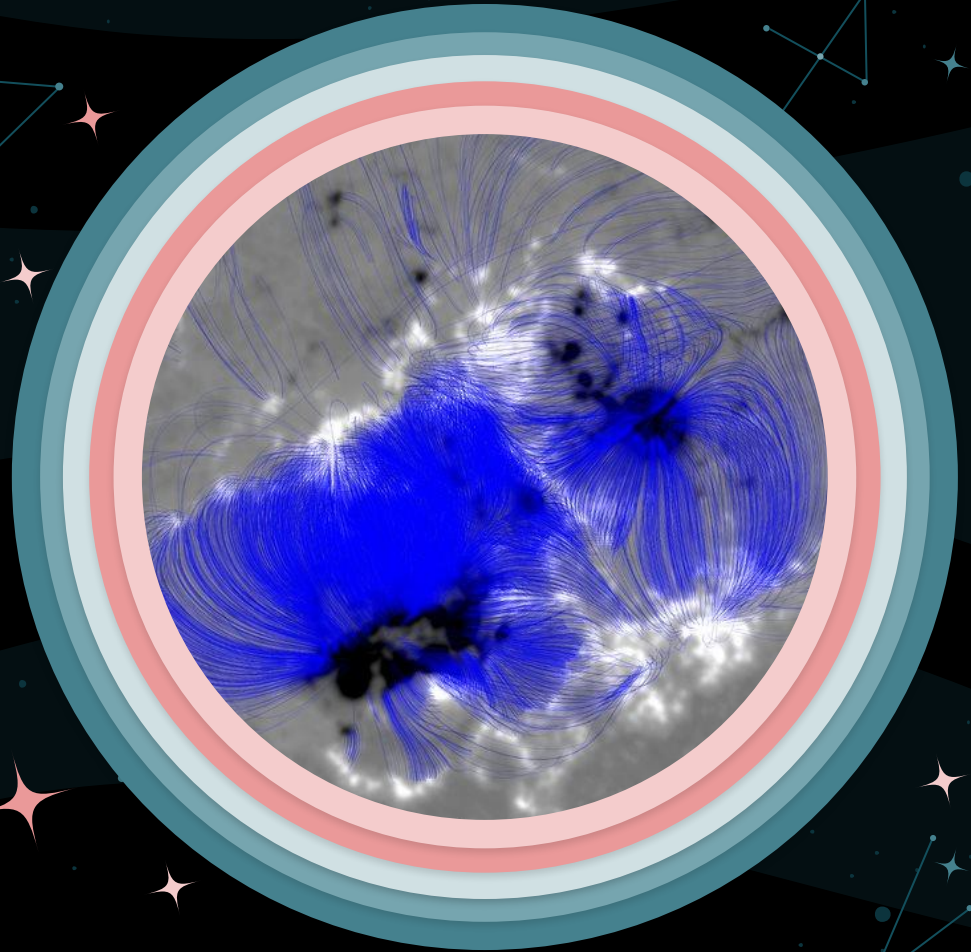
$$H_{imp} = \lambda_0 I_{imp}$$

Two-Phase Heating



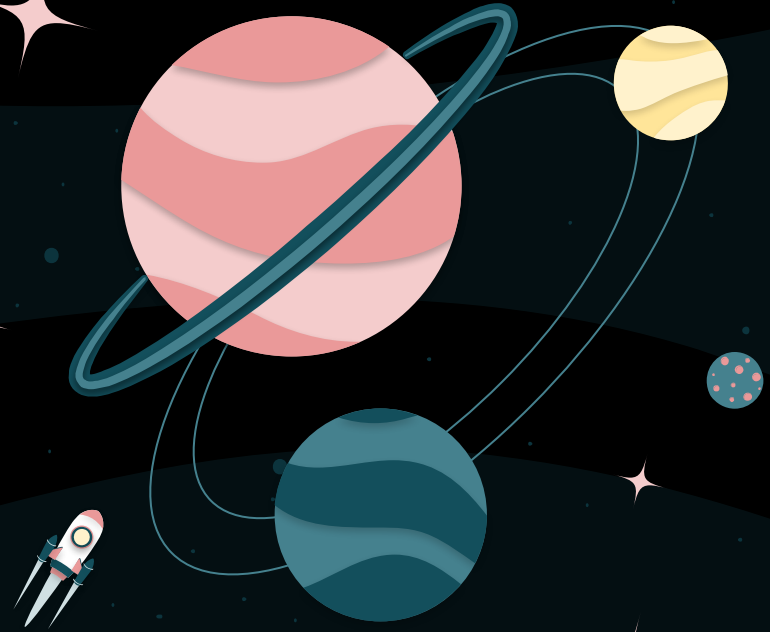
# Magnetic Extrapolation

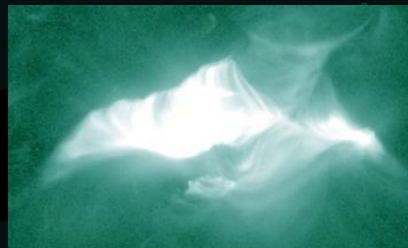
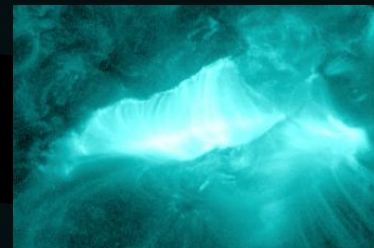
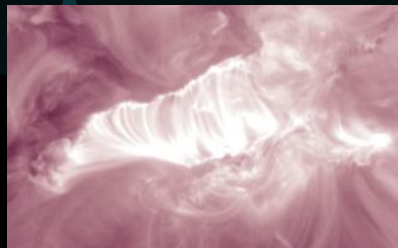
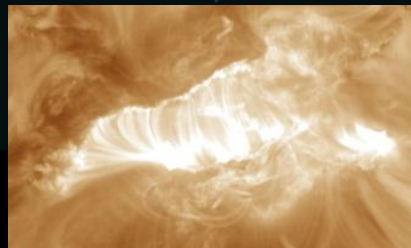
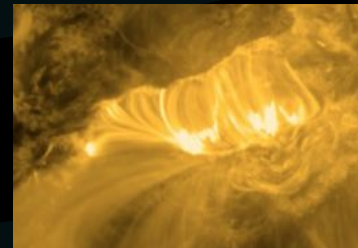
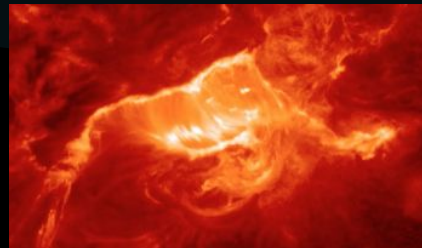
Simulating magnetic  
field loops from HMI  
data.



03

CURRENT  
WORK



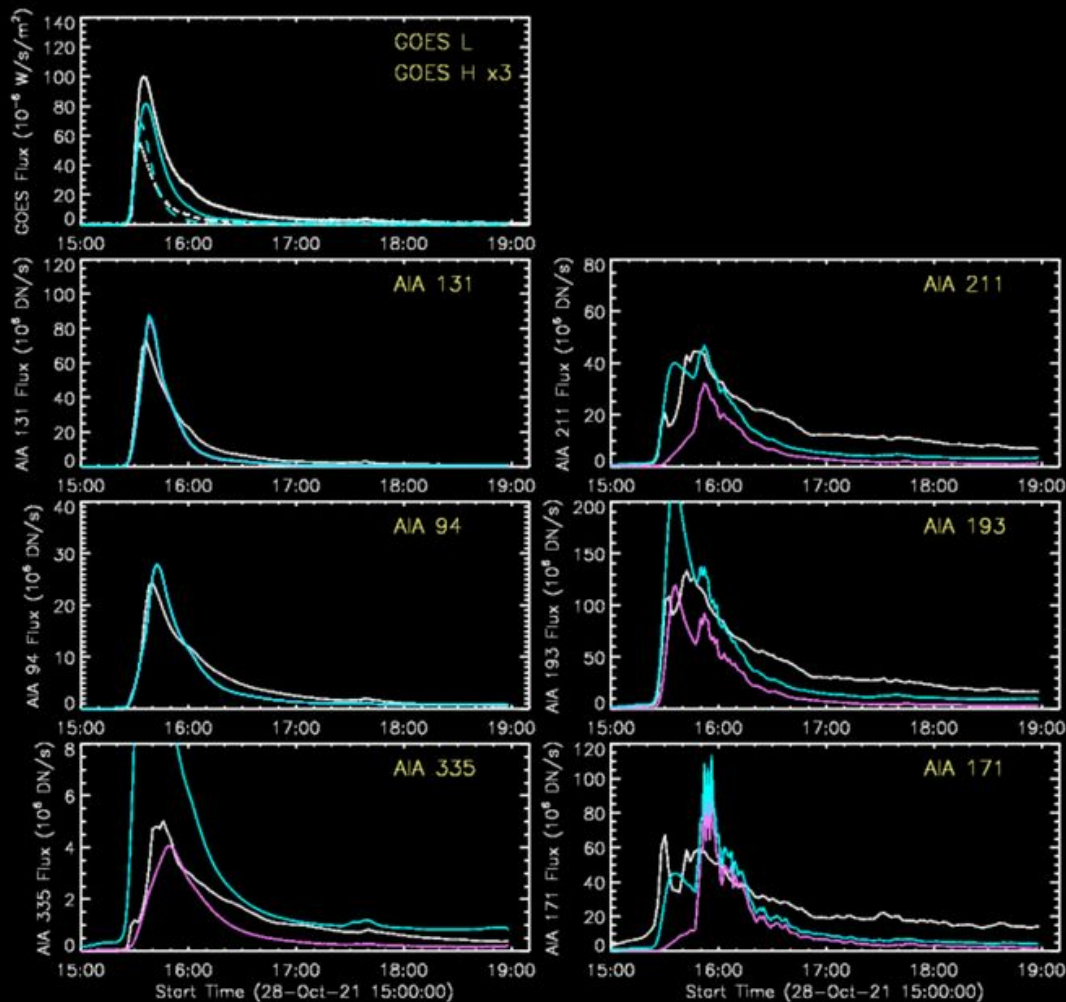


OUR FLARE

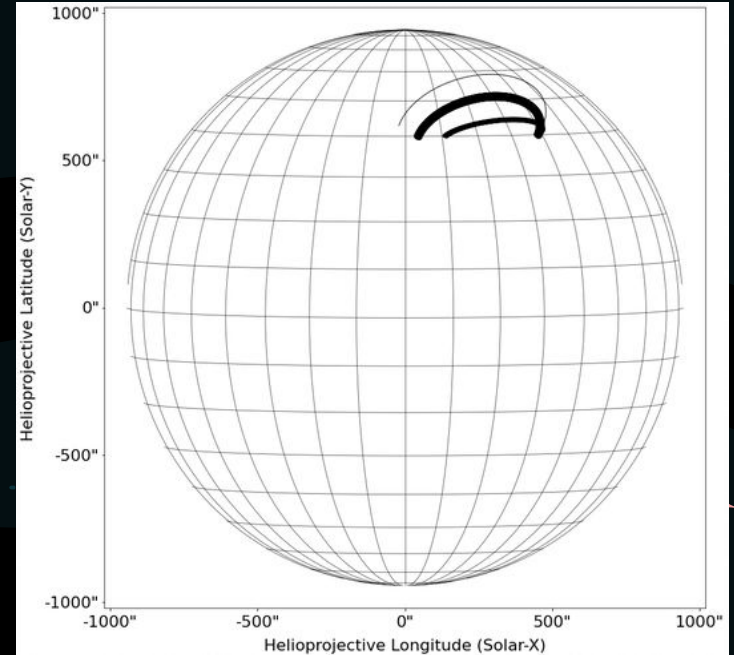
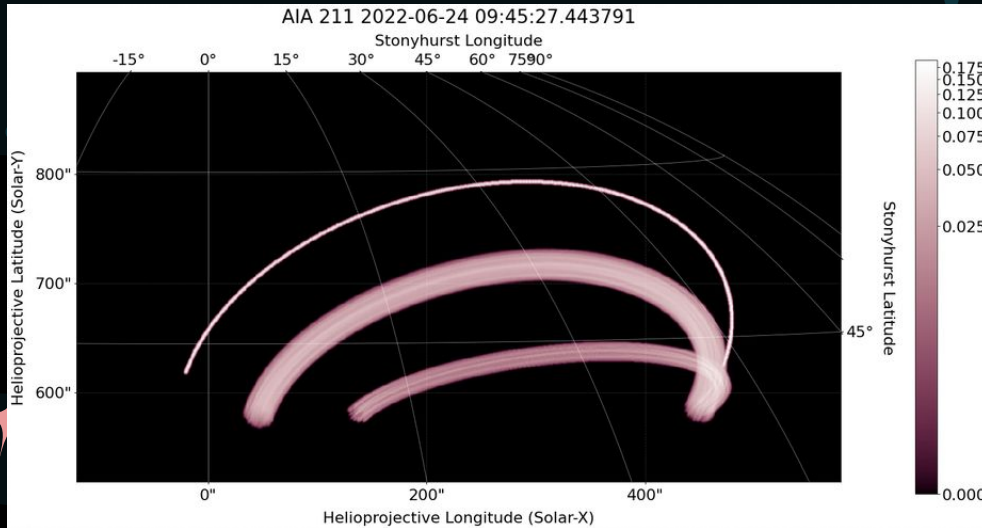
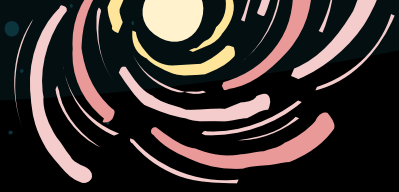
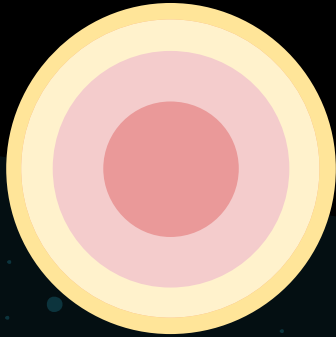
20211028 X1.0

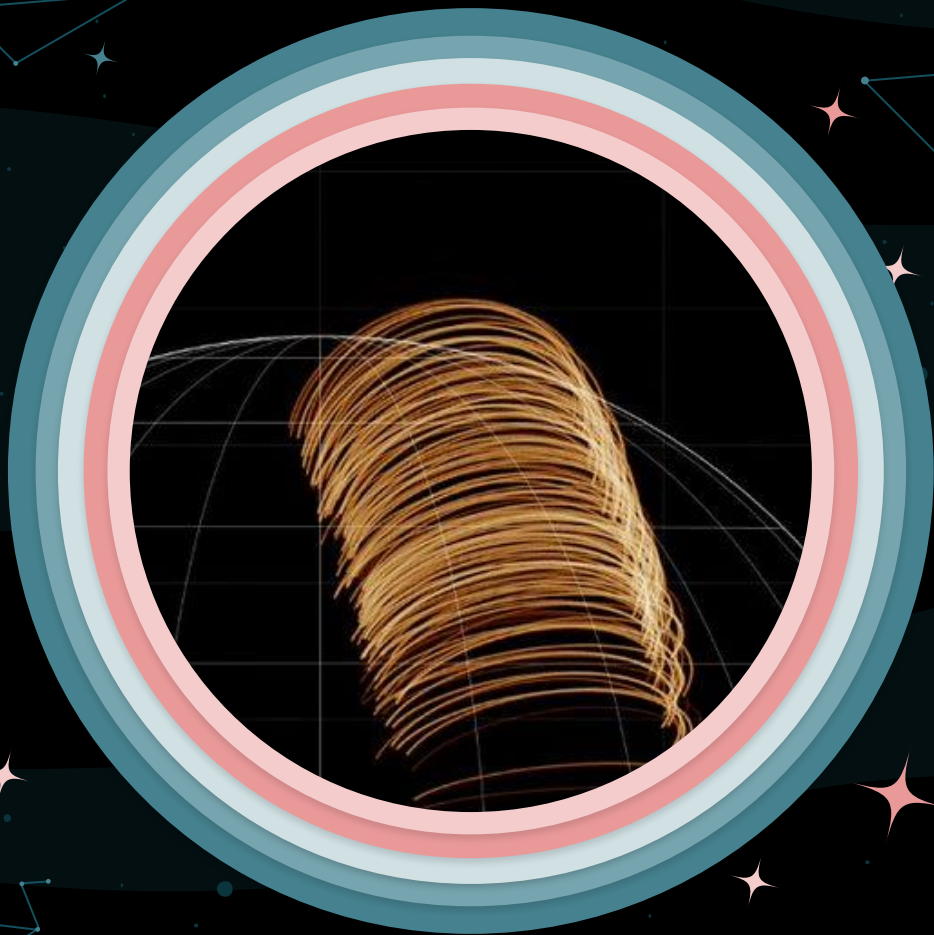
# LIGHT CURVES

Light curves of the entire flaring region from observational data compared with synthetic.



# SynthesizAR





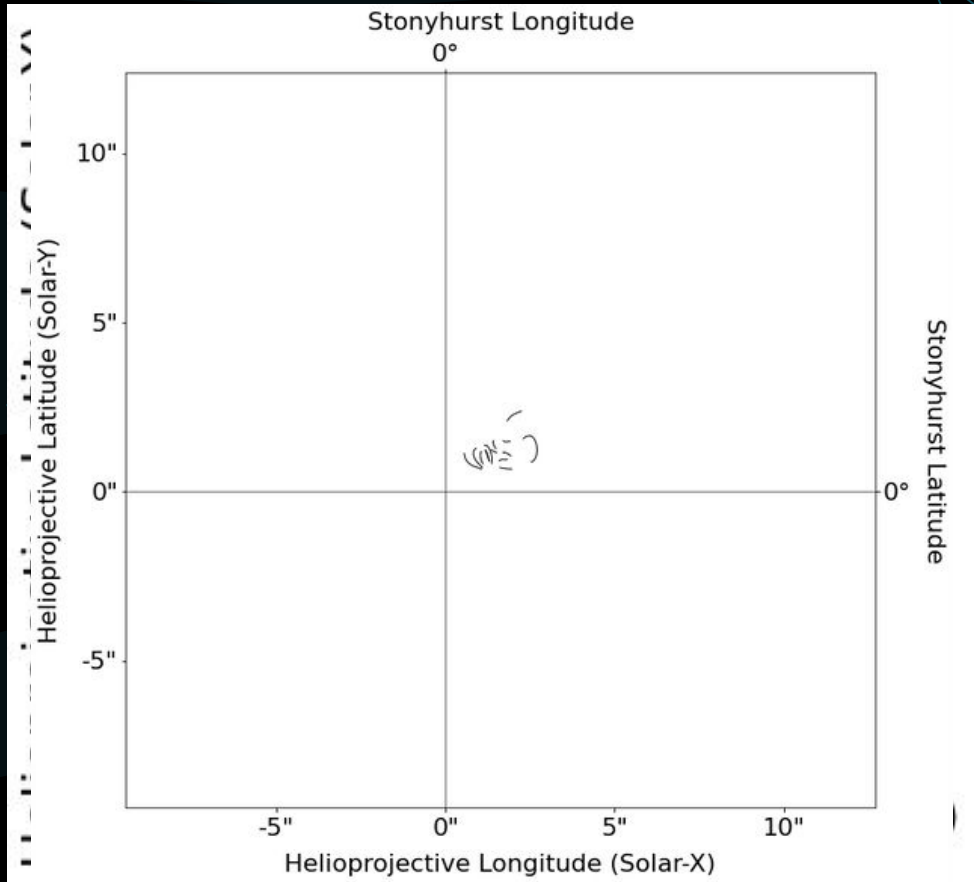
# RANDOM LOOPS

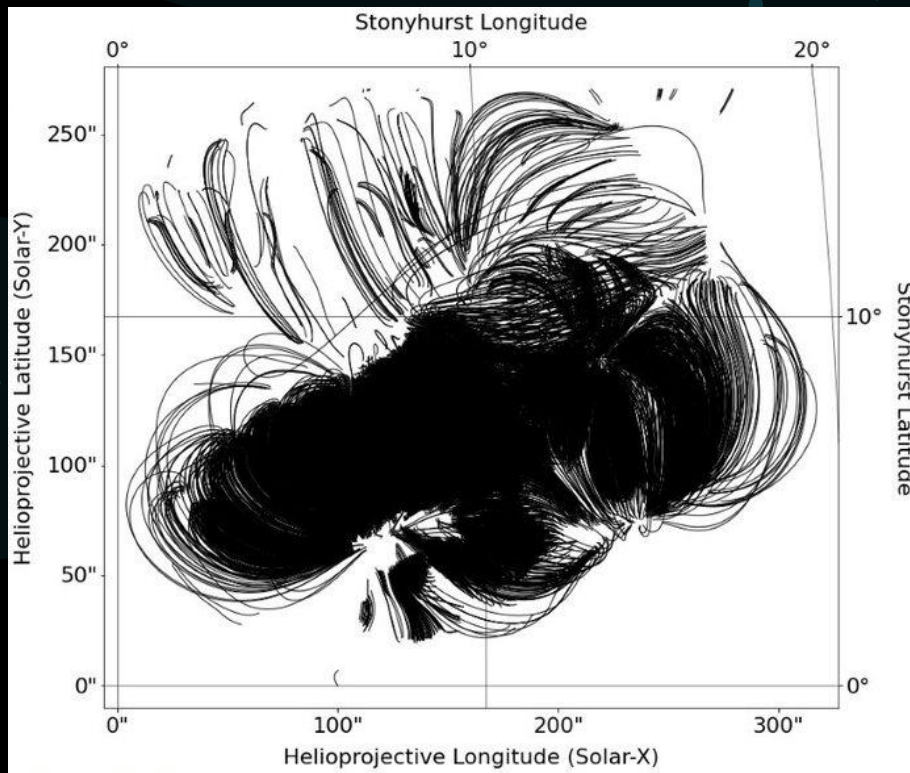
Modification to Python  
standards plus  
adaptation to arbitrary  
numbers of loops.



# IMPORTING LOOPS

Modifying loop coordinates  
to be processed by  
SynthesizAR.



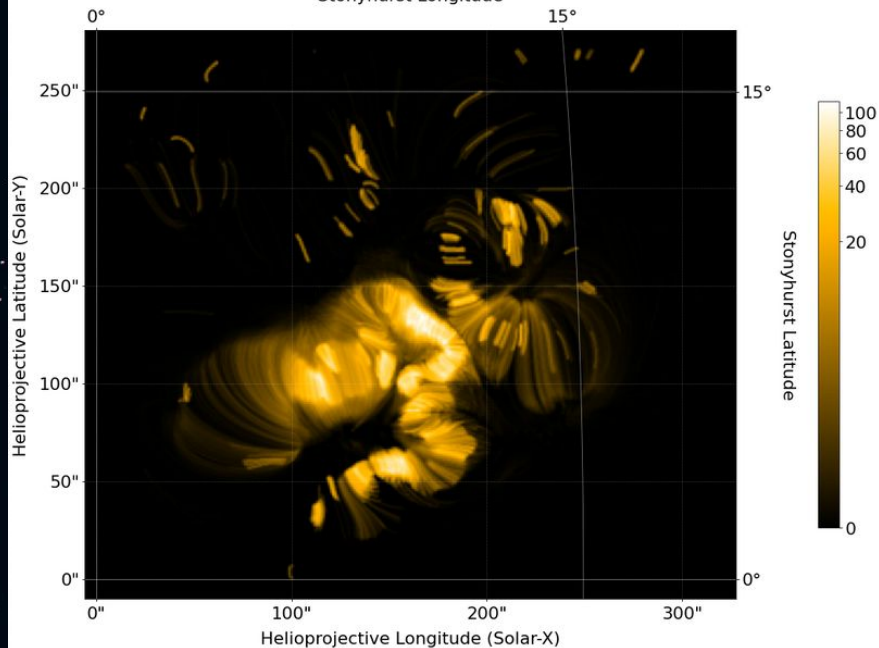


# IMPORTING LOOPS

Modifying loop coordinates to be processed by SynthesizAR.

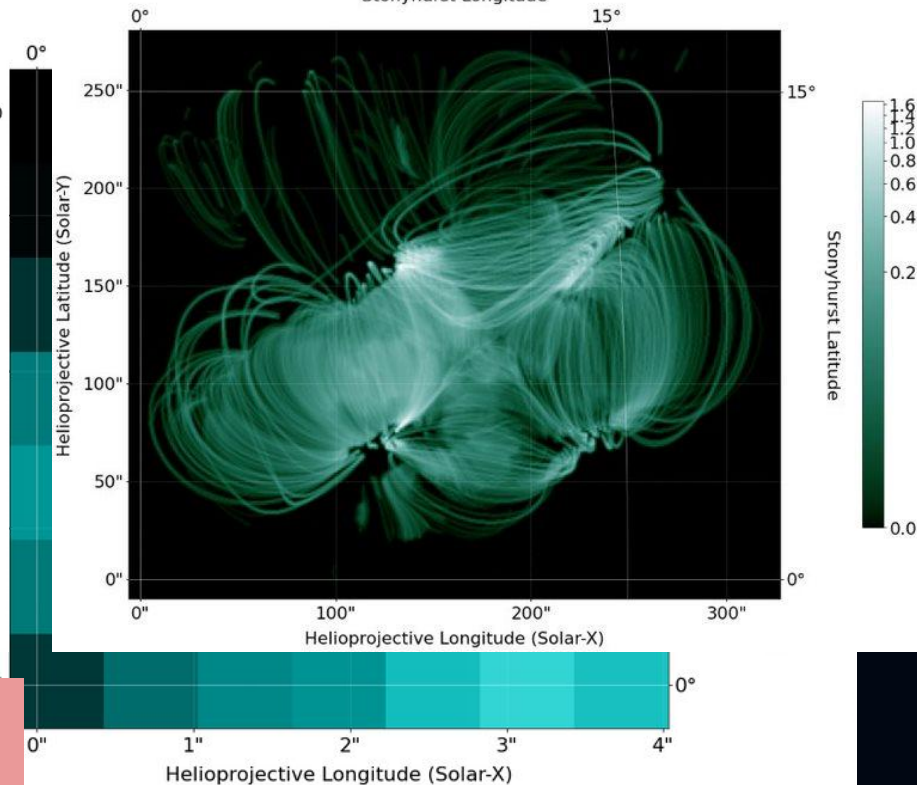
AIA 171 2022-06-30 05:12:35.530924

Stonyhurst Longitude



AIA 94 2022-06-30 05:12:35.530924

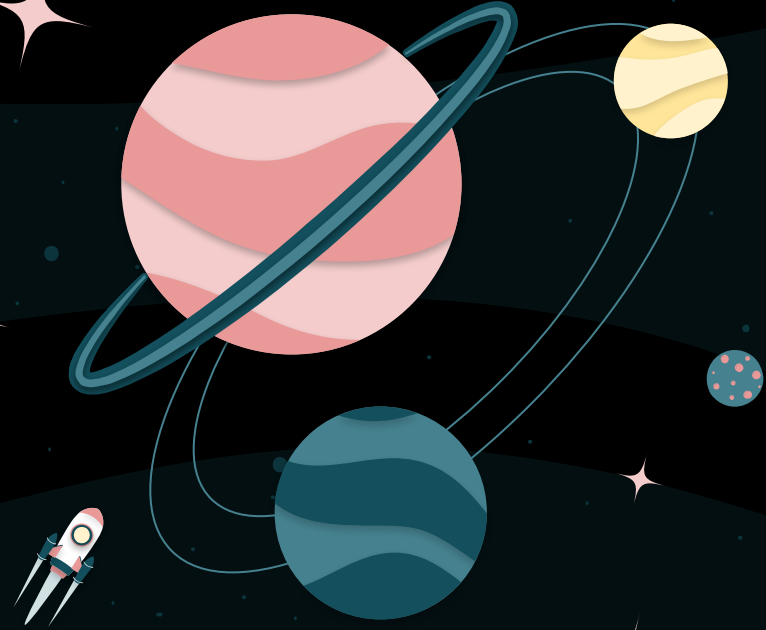
Stonyhurst Longitude



SYNTHETIC LOOPS

04

FUTURE  
WORK



# NEXT STEPS

## COORDINATES

Accurately import loop coordinates in Stonyhurst frame.

## EBTEL

Read in EBTEL results for each loop.

## TIME

Iterate synthetic observations over actual time evolution.

## COMPARE

Compare synthetic images to actual data.

```
as u
port readsav
IDLInterface']
Interface(object):
interface to pregenerated IDL EB
Parameters
-----
loop : '~synthesizAR.Skeleton'
      Skeleton object containing a
file : '~string'
      File location of the EBTEL n
"""
name = 'IDL'

def __init__(self, file):
    self._file = file

def load_results(self, loop):
    print('Successfully loaded t
    print(loop)
    print('Loading file: ' + str
    _tel_data = readsav(self._f

    ebtel_data['nntime']
    ebtel_data['densit
    ebtel_data['v0']
    ebtel_data['te
```

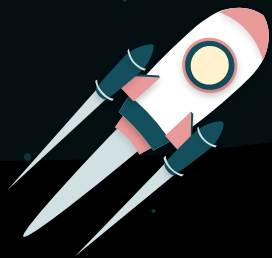
# BIBLIOGRAPHICAL REFERENCES

- **J. A. Klimchuk, et al. 2008, *ApJ*, 682, 1351.**  
Highly Efficient Modeling of Dynamic Coronal Loops
- **Jiong Qiu, et al. 2012, *ApJ*, 752, 124.**  
Heating of Flare Loops with Observationally Constrained Heating Functions (UFC or UV Footprint Calorimeter Method)
- **Jiong Qiu and Longcope, Dana 2016, *ApJ*, 820, 14.**  
Long Duration Flare Emission: Impulsive Heating or Gradual Heating?
- **Chunming Zhu, et al. 2018, *ApJ*, 856, 27.**  
Two-Phase Heating in Flaring Loops
- **W. T. Barnes, et al. 2019, *ApJ*, 880, 56.**  
Understanding Heating in Active Region Cores through Machine Learning. I. Numerical Modeling and Predicted Observables



# THANKS!

Do you have any questions?



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<https://solar.physics.montana.edu/home/www/reu/2022/bparker/index.html>

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## CREDITS:

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