



# Solar Science Workshop



April 26, 27



# Solar Flares: Disrupters of Civilization

<https://youtu.be/oHHSSJDJ4oo>

Past:





Auroras

*Boston operator (to Portland operator):* "Please cut off your battery [power source] entirely for fifteen minutes."

*Portland operator:* "Will do so. It is now disconnected."

*Boston:* "Mine is disconnected, and we are working with the auroral current. How do you receive my writing?"

*Portland:* "Better than with our batteries on. – Current comes and goes gradually."

*Boston:* "My current is very strong at times, and we can work better without the batteries, as the aurora seems to neutralize and augment our batteries alternately, making current too strong at times for our relay magnets. Suppose we work without batteries while we are affected by this trouble."

*Portland:* "Very well. Shall I go ahead with business?"

*Boston:* "Yes. Go ahead."

# Carrington Event

Sep 1-2 1859

## A STORM OF ELECTRICITY

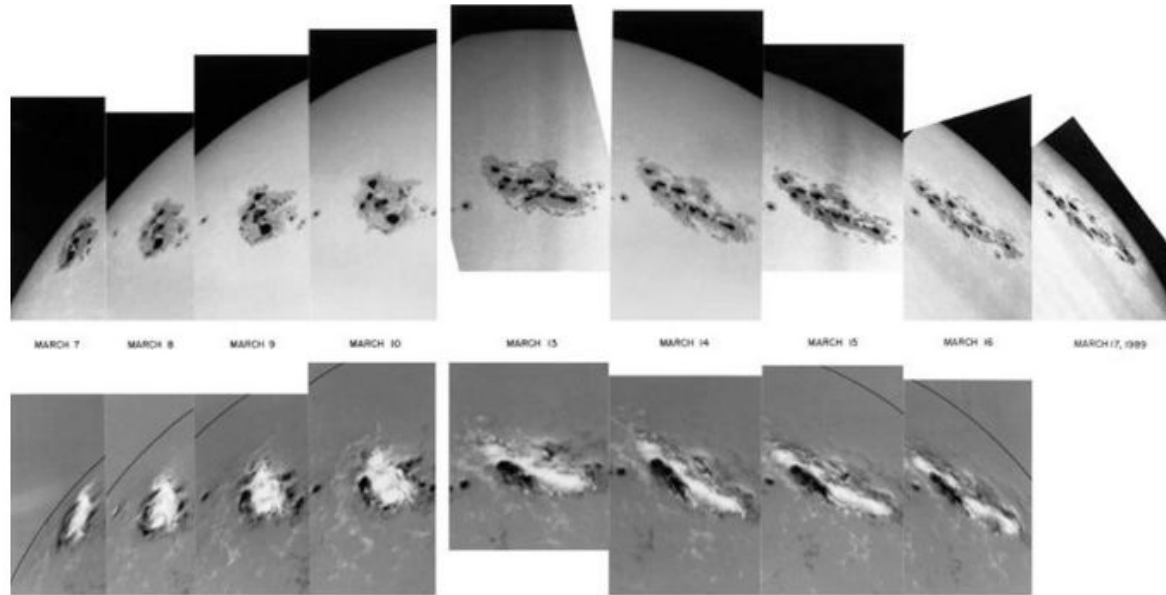
*TELEGRAPH WIRES USELESS FOR  
SEVERAL HOURS.*

ONE OF THE MOST SEVERE DISTURBANCES  
FOR MANY YEARS, EXTENDING EVEN TO  
EUROPE—TELEPHONE WIRES ALSO OB-  
STRUCTED—BUSINESS DELAYED A GOOD  
PART OF THE DAY.

Yesterday's storm was accompanied by a more serious electrical disturbance than has been known for years. It very seriously affected the workings of the telegraph lines both on the land and in the sea, and for three hours—from 9 A. M. until noon—telegraph business east of the Mississippi and north of Washington was at a stand-still.

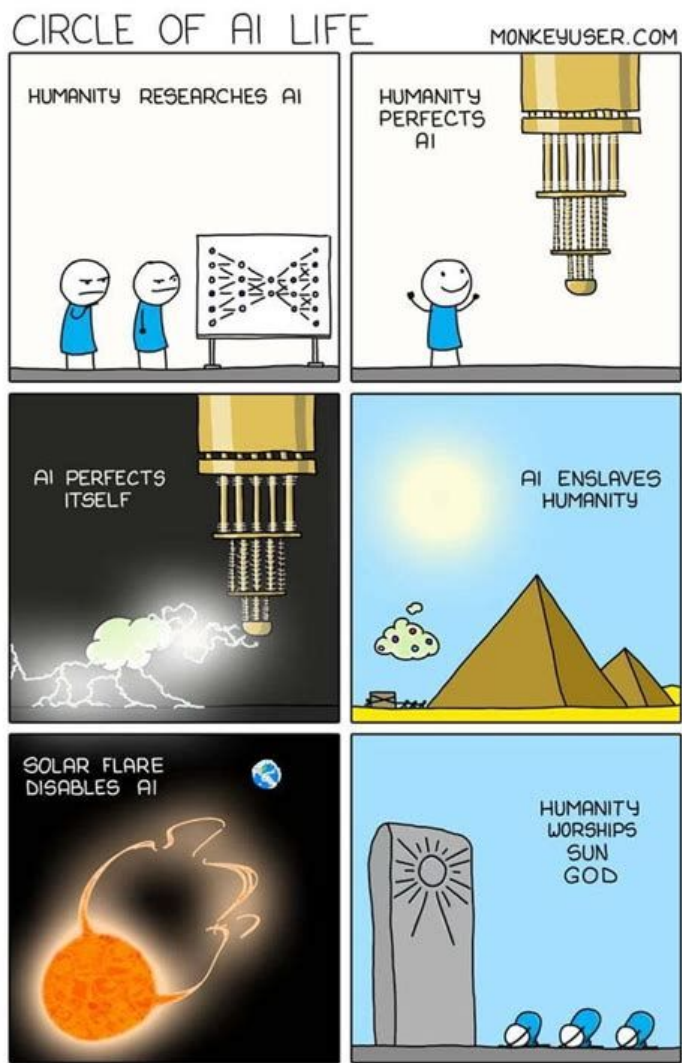


# The day the sun brought darkness



Above: Sunspot 5395, source of the March 1989 solar storm. From “[A 21st Century View of the March 1989 Magnetic Storm](#)” by D. Boteler.

# Future:







# Solar Observations

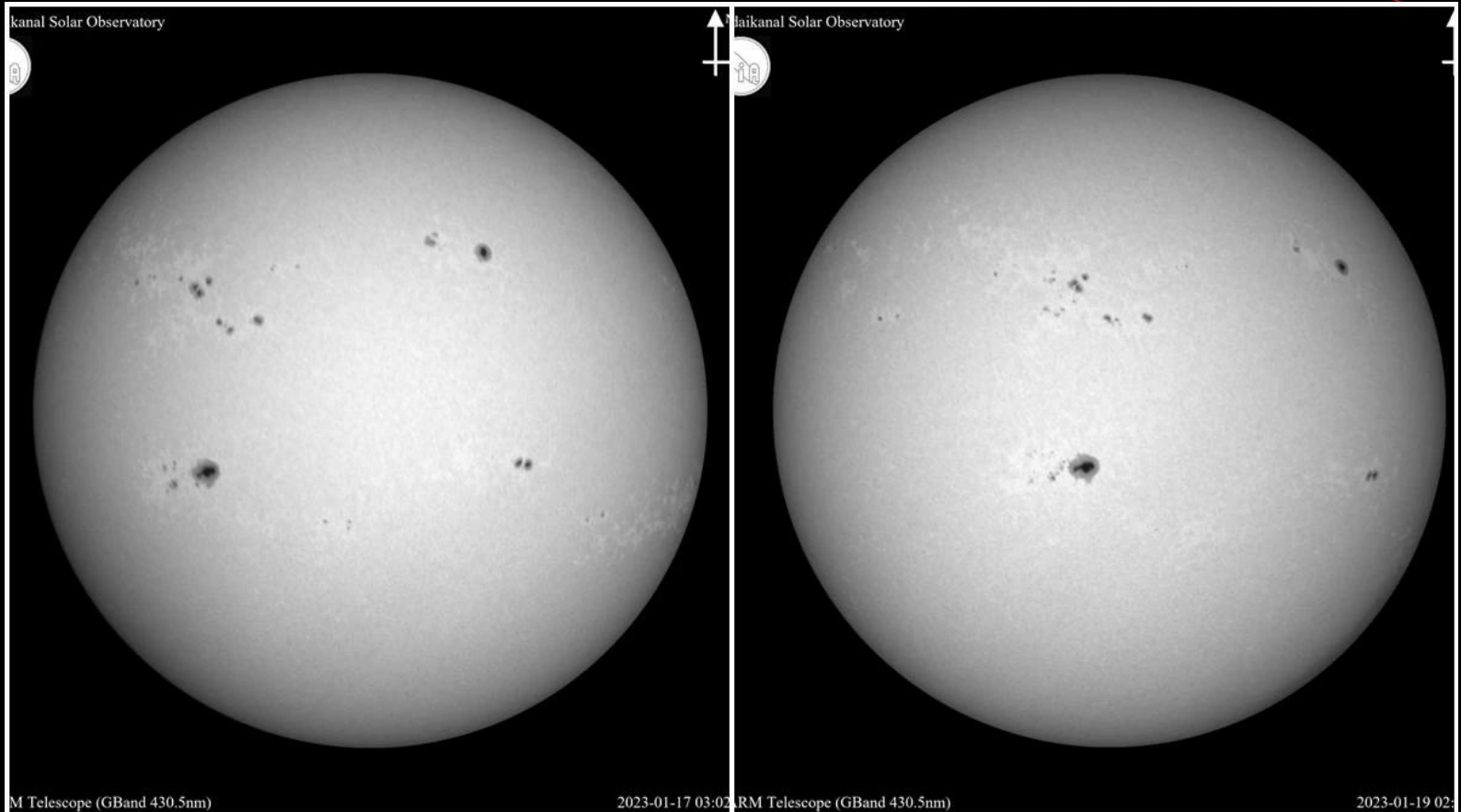


- Ground based
  - Space based
- 

# Kodaikanal Solar Observatory



# Kodaikanal Solar Observatory



# Udaipur Solar Observatory



GMRT:

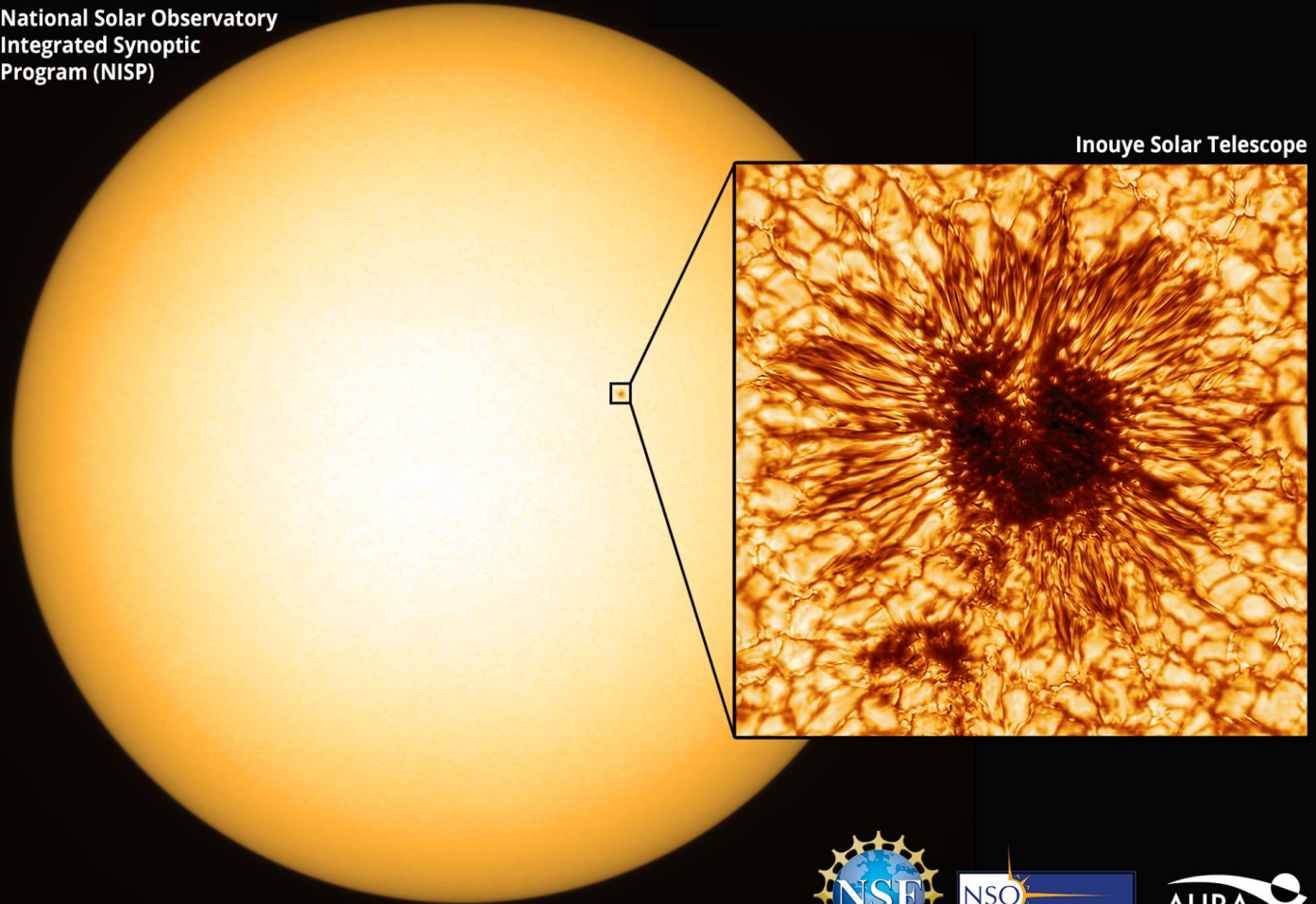




# Inouye:

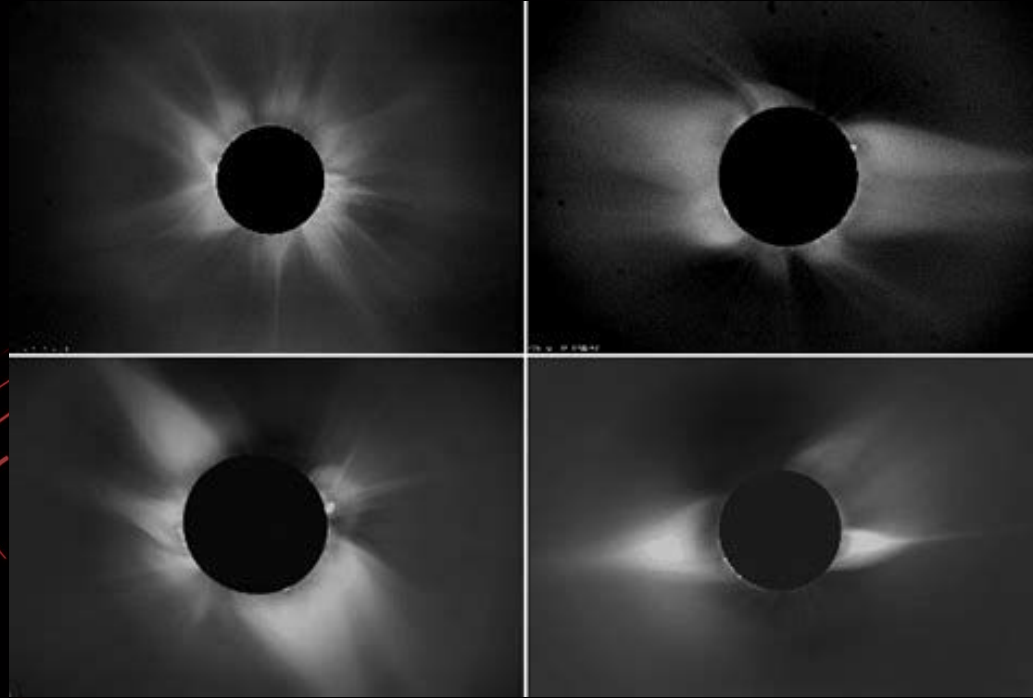
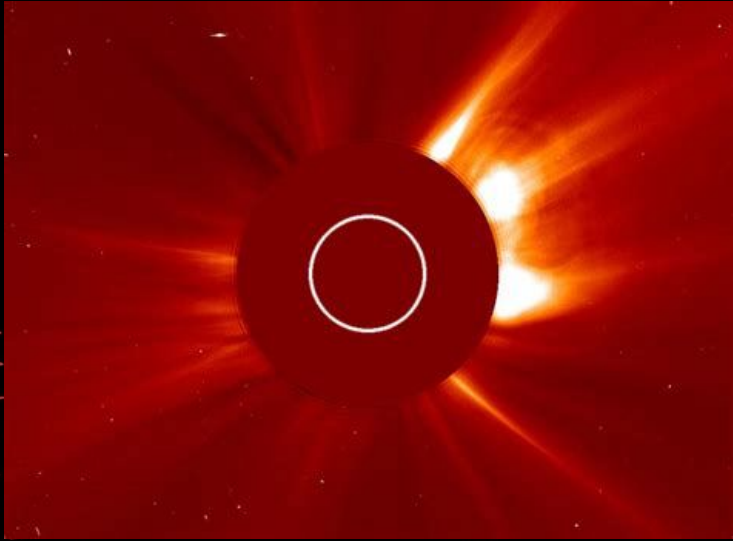
National Solar Observatory  
Integrated Synoptic  
Program (NISP)

Inouye Solar Telescope





Space based:



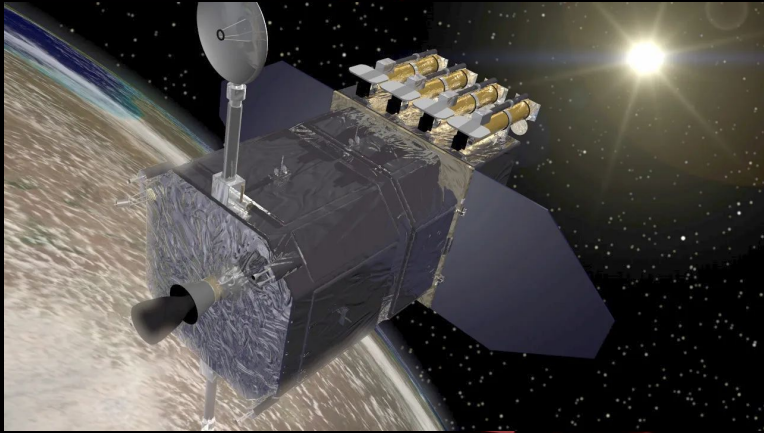


2017  
August 21

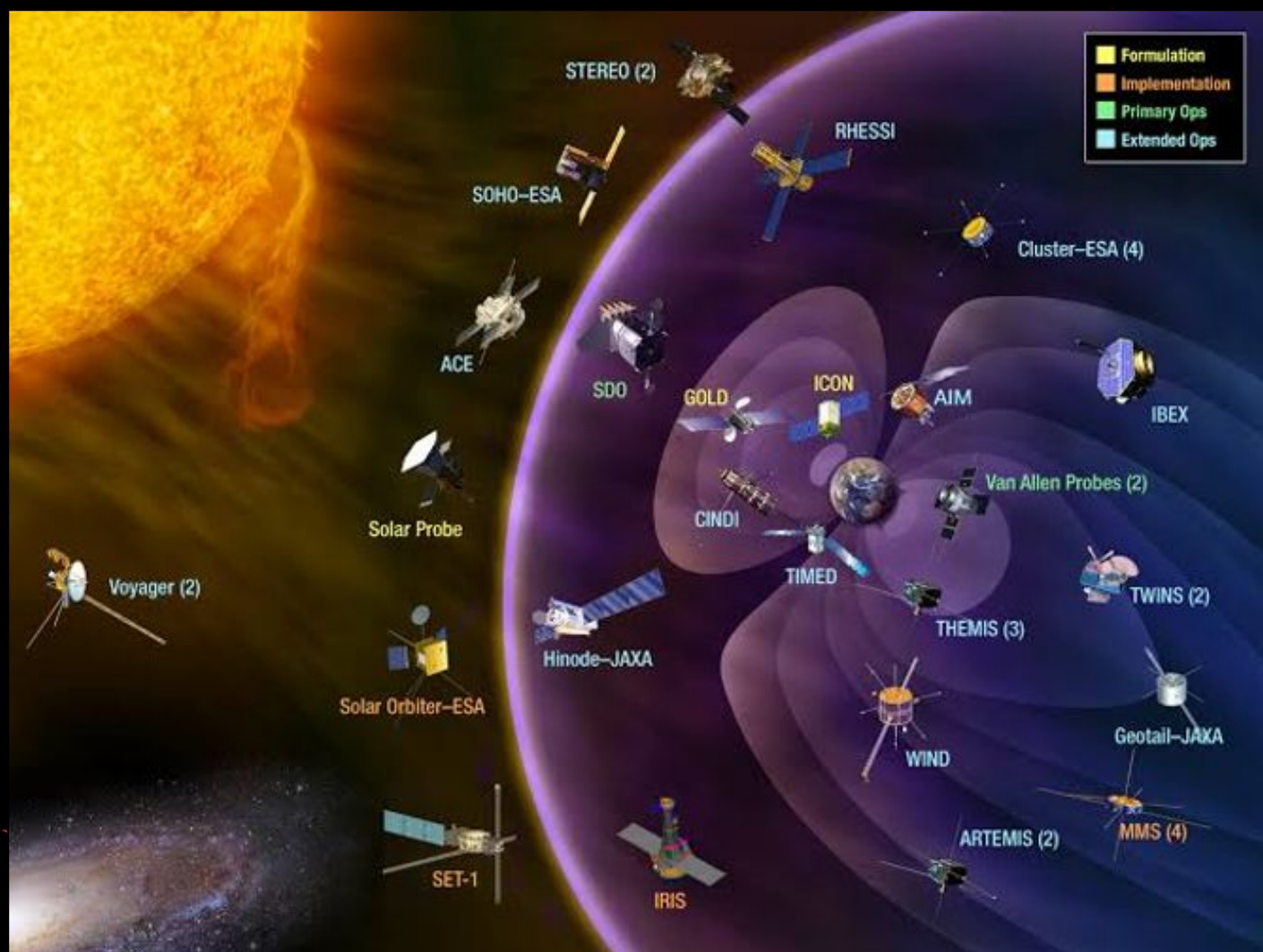
# NuStar and SDO:

The first image of the sun captured by NASA's Nuclear Spectroscopic Telescope Array (NuSTAR), which is sensitive to high-energy X-ray light. X-rays seen by NuSTAR show up as green and blue in the photo, which is overlaid on an image taken by NASA's Solar Dynamics Observatory.









# Different Perspectives:



HMI Dopplergram  
Surface movement  
Photosphere



HMI Magnetogram  
Magnetic field polarity  
Photosphere



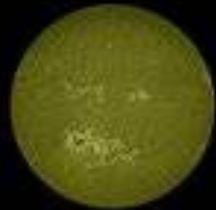
HMI Continuum  
Matches visible light  
Photosphere



AIA 1700 Å  
4500 Kelvin  
Photosphere



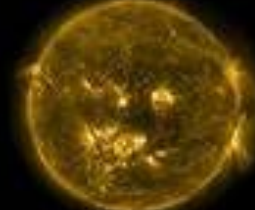
AIA 4500 Å  
8000 Kelvin  
Photosphere



AIA 1600 Å  
10,000 Kelvin  
Upper photosphere/  
transition region



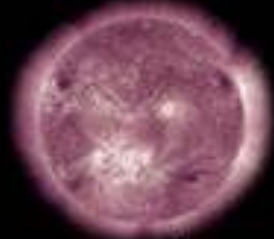
AIA 304 Å  
50,000 Kelvin  
Transition region/  
Chromosphere



AIA 171 Å  
600,000 Kelvin  
Upper transition  
Region/quiet corona



AIA 193 Å  
1 million Kelvin  
Corona/flare plasma



AIA 211 Å  
2 million Kelvin  
Active regions



AIA 335 Å  
2.5 million Kelvin  
Active regions



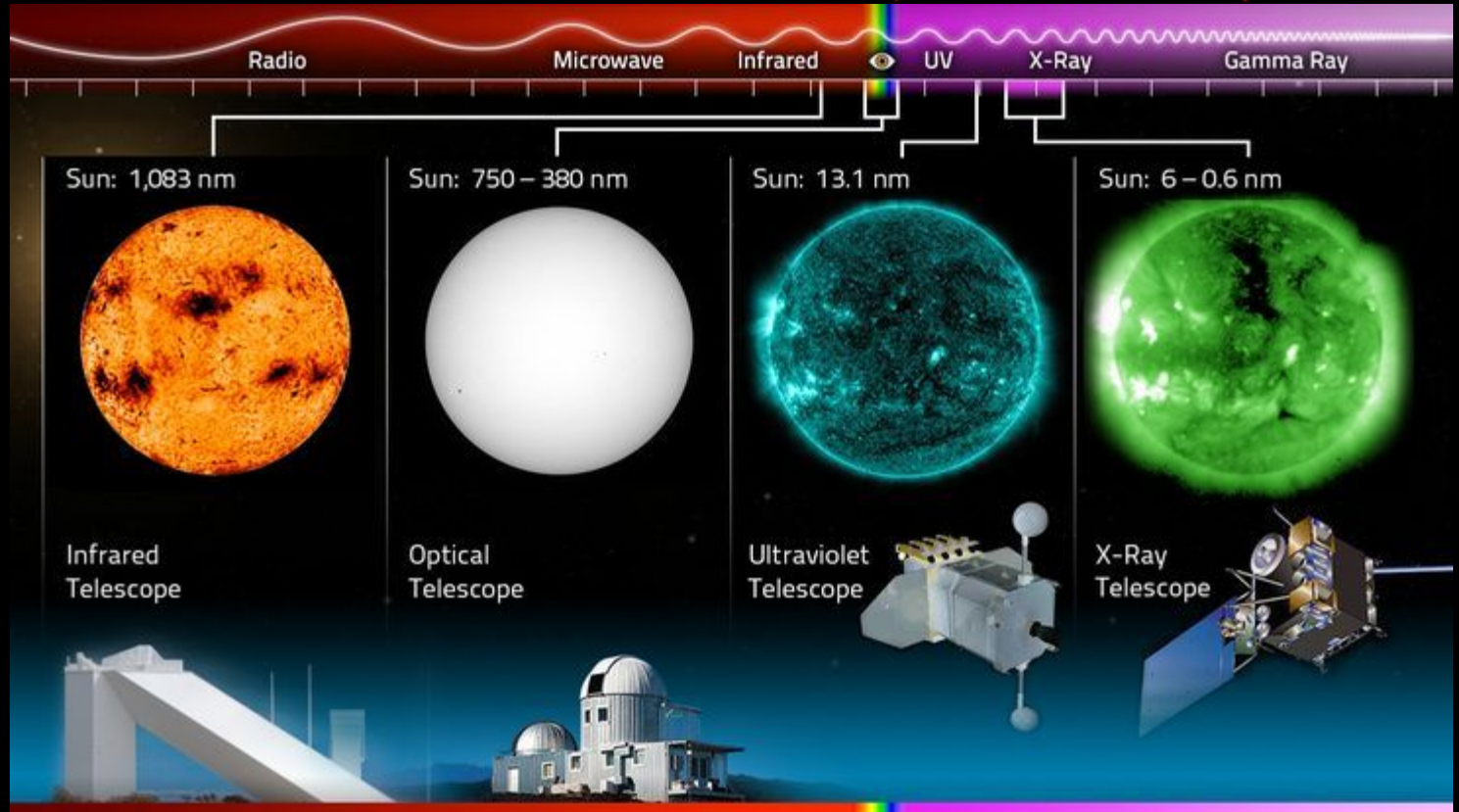
AIA 094 Å  
6 million Kelvin  
Flaring regions



AIA 131 Å  
10 million Kelvin  
Flaring regions



# WHY?



# WHY?

