Introduction

Sunspot drawing refers to the drawings made by astronomical observers of the darker sunspots on the solar photosphere. Visual observations of sunspots can be traced back all the way to at least 28 BCE in China where naked-eye observations were recorded. However, one of the earliest known observation of sunspots was done by Galileo Galilei where in 1612, he made a series of observations of sunspots through a telescope by drawing them. Figure 1 shows one of Galileo's drawings on June 28, 1613 while an animation of Galileo's sunspot observations can be found in The Galileo Project[1].

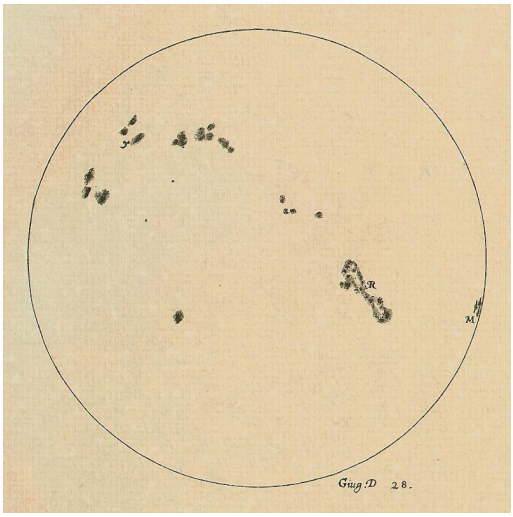

Figure 1. Galileo's sunspot observations in June 28, 1613[2].

Today, sunspot drawings are still being done regularly by the various observatories such as Solar Observing Optical Network (SOON)[3] and Mount Wilson Observatory[4]. Figure 2 shows an example of a modern-day sunspot drawing done on July 18, 2013. Here, we can see two panels. The left panel is where the solar disk and sunspots are drawn while the right panel summarizes the identified active regions. Active regions on the Sun are areas of strong magnetic field. Sunspots are used to visually identify these regions. Thus, an active region may contain one or more sunspots. The National Oceanic and Atmospheric Administration (NOAA) provides the numbers to identify these active regions. They are numbered according to which region appeared in the solar disk chronologically. The current number system started on January 5, 1972. As seen in figure 2, there were six (6) identified active regions named as AR1791, AR1793, AR1796, and AR1797.

[1] http://galileo.rice.edu/sci/observations/ssm_slow.mpg
[2] http://galileo.rice.edu/sci/observations/sunspots.html
[3] Factsheets: 2nd Weather Squadron, Solar Observing Optical Network". United States Air Force Weather Agency.
[4] Webster, Larry. "The 150-Foot Solar Tower Sunspot Drawing". Mount Wilson Observatory. Available online: http://obs.astro.ucla.edu/150_draw.html

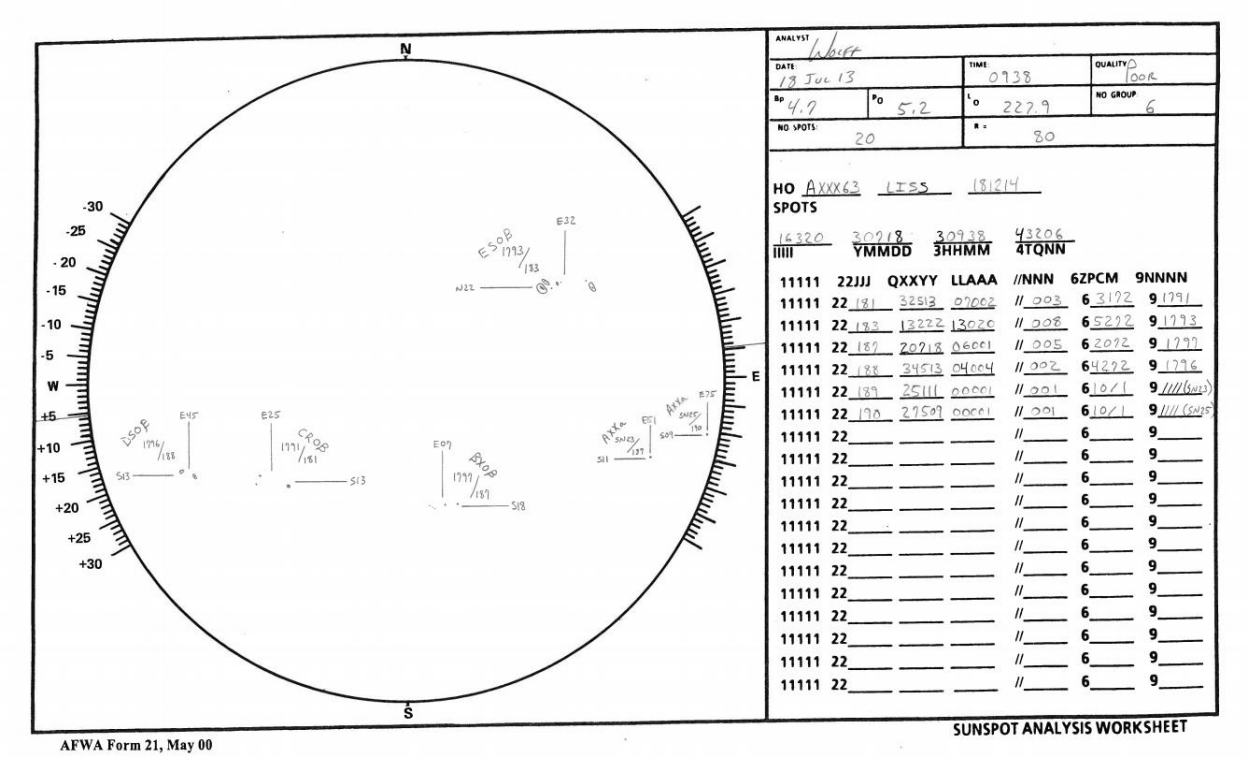

Figure 2. Sunspot drawing obtained from San Vito Solar Observatory on July 18, 2013.

In figure 3, we can see the Intensitygram of the solar disk at the same date together. Here, the active regions have been identified. This is obtained from the Helioseismic and Magnetic Imager (HMI) of the Solar Dynamics Observatory (SDO). This Intensitygram is a continuum filtergrams that shows a broad-wavelength photograph of the solar protosphere[5].

We can notice several things here. First, the orientation is reversed relative to the sunspot drawing. This is because the sunspot drawing is projected on a piece of paper through a telescope, which reveres the image of the Sun. Second, sunspots some of the active regions, especially the weaker ones, are visually faint in the Intensitygram. This is the reason why sunspot drawings are necessary.

In this activity you will use a series of sunspot drawing to identify the active regions in an Intensitygram.

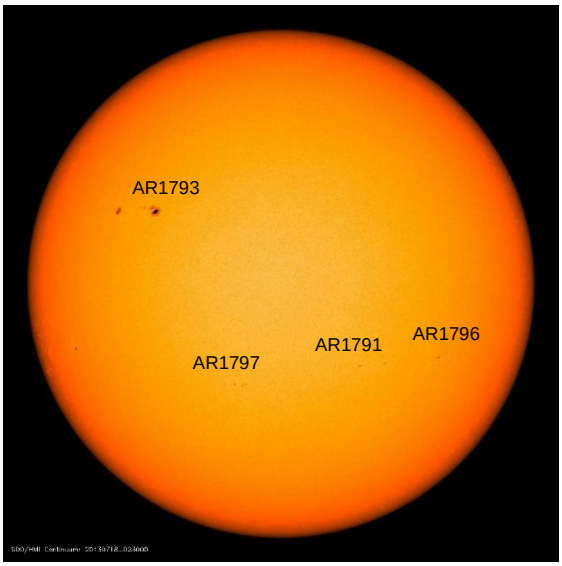

Figure 3. The Intensitygram from the SDO/HMI of the solar disk. The six (6) identified active regions, AR1791, AR1793, AR1796, and AR1797, were labeled.

[5] Joint Science Operations Center (JSOC) Science Data Processing (SDP). Available online: http://jsoc.stanford.edu/

MATERIALS:

- Computer
- Internet
- Photo Editing software
- Word Processor Software

INSTRUCTIONS:

1. In your group, identify the birthdays of your group members.
2. Download the Sunspot drawing and Intensitygram for these dates in years 2013, 2014 and 2015 from the following links:
    a. Sunspot drawing: https://www.ngdc.noaa.gov/stp/space-weather/solar-data/solar-imagery/photosphere/sunspot-drawings/
        i. Select archive site (e.g, *boulder*, *charles-schott*, *soon, etc.*). Each site includes certain years of observation.
        ii. Navigate through the directory by choosing the desired year and month.
        iii. Choose any available file (based on the date) that suits your requirement. Use any observatory code (e.g., *khmn*, *liss*, *aplm*, etc.) whichever is available.
    b. Intensitygram: http://jsoc.stanford.edu/data/hmi/images/
        i. Navigate through the directory by choosing the desired year, month, and day.
        ii. Choose any available "**`Ic`**" file (regular or flat) that suits your requirement with at least 1K resolution.
3. From the sunspot drawing label the active region in the Intensitygram.
4. Document your results in a word processor software (e.g., *Microsoft Word*, *Google Doc*, *Libre Office Writer*, *Apple Pages*, etc.)
5. Compare your results with each other in different years.

CHALLENGE 1:

1. Extend your data, intensitygram with labeled active regions, from 2010 to 2019. It is okay if there will be no active regions. That is normal.
2. Make a line or bar graph of the number of active regions per year for your birthday.
3. Make a temporal (time series) analysis. Compare your result with each other.

CHALLENGE 2:

1. Download all Intensitygrams within your birth month for year 2013, 2014 or 2015.
2. Label the active regions.
3. Animate using these images. This can be in video or animated GIF format.
4. Observe which active regions stayed or did not stayed. Compare them with these size and number of sunspots per region.

Last updated: June 3, 2021