Names:_____ Date: _____

Module 1B: Galileo's Claim Lab Worksheet

Part 1: Galileo's Claim

Sunspots are located on the surface of the Sun and are not objects that orbit in space around the Sun.

Explain how your team can investigate Galileo's scientific claim about sunspots:

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Part 2: Collect and Assess Evidence

Sunspot Observation Tips:

- It is very important that scientists collect and record data accurately!
- Most (but not all) sunspots appear in groups, so we will call all sunspots **sunspot groups**, even in cases where there is a single sunspot.
- When measuring sunspots, measure only the large "blotches" and don't measure the much smaller "dots" or the spread-out areas that look like lace.
- Start with the current day's image. Record the necessary solar data on your team's "Daily Sunspot Observations" and "Solar Latitude & Longitude Grid" data sheets.
- If you have less than two weeks available for research or if there are not any substantial sunspots in recent images, use solar images from a previous 14-day period of time that have sunspots.

A) Sunspot Image Collection:

1. Each day, navigate to the Solar Dynamics Observatory "The Sun Now" webpage (http://sdo.gsfc.nasa.gov/data/). In the left sidebar, click on "AIA/HMI Browse Data" tab.
2. Dates: In the first date field, select a day as a start date and a time that day (e.g. 28 September 2014, 18:00). In the second date field, select the same date and a time 15 min. later than the start time (e.g. 28 September 2014, 18:15).
3. Telescopes: Scroll down and select the "**HMI Intensitygram (gray)**" image of the Sun (NOT the HMI Intensitygram (orange) or HMI Magnetogram).
4. Choose a format: Select "Frames Download".
5. Resolution: Choose 1024x1024.
6. Submit: Click the "Submit" button. Your image will be saved as a zip file in downloads labeled "(number)hmii.tar". Click on this zip file and the information will be available in downloads via a folder labeled "data", which contains multiple sub-folders. The "img" sub-folder contains an hmii.jpg file of the solar image. Rename the file by using the correct image date as the saved file name (e.g. "Image_11_05_13" is the file name for the HMI Intensitygram on Nov. 5, 2013). If you receive an error message, check that the date and time selected are correct (it may be necessary to try different dates/times to get a solar image).
7. Print the image; write the date and time range on it

B) Sunspot Data Recording:
Follow these steps to record SDO sunspot image data for a 14-day period of time. Keep track of up to five of the same sunspot groups over the two-week period. Identify and track the major sunspot group(s) as follows:

1. Use each day's SDO HMI Intensitygram solar image to identify and plot major sunspot groups. Accurately monitor up to five of the same sunspot groups for two weeks.
2. On the "Solar Latitude & Longitude Grid" data sheet, locate the latitude and longitude coordinates and sketch a picture of each sunspot group and label each sunspot group with its name and observation date (e.g. SG 1, Date 9/28/14).
3. On the "Daily Sunspot Observations" data sheet, record the date, latitude, longitude, and location (distance of center of sunspot group from the left edge of Sun in 0.0 cm.) for each sunspot group.
4. Record any observed changes for each sunspot group (change in size, shape, increase (new) or decrease (loss) of sunspot groups). Check all work!

C) Sunspot Data Analysis:
Use the recorded information from the "Daily Sunspot Observations" data sheet to complete the "Tracking Sunspot Movement" data sheet. Next, use the "Tracking Sunspot Movement" data sheet to make a "Tracking Sunspot Movement" graph to visually represent your sunspot data.

1. On the "Tracking Sunspot Movement" data sheet, record the date each sunspot group is first observed, the date it is last visible on the Sun, and the distance the sunspot group is located from the left edge of the Sun on each of these two dates.
2. Create a "Tracking Sunspot Movement" line graph to show the same sunspot groups' change in distance over time. On the x-axis, label it "Observation Date" and list the dates for Day 1 through Day 14.
3. On the y-axis, label it "Observed Sunspot Location (cm)" and use a suitable, incremental scale.
4. For each sunspot group, use the "Tracking Sunspot Movement" data sheet to plot the day the sunspot group is first observed (x coordinate) and its observed location on that date (y coordinate) and do the same to plot the last day the same sunspot is visible and its location on the Sun.
5. Draw a line between each sunspot group's starting and ending points to show its movement across the Sun over time.
6. Include a title, origin, and key on the graph.

D) Discussion Questions:
Write your team's responses to the following questions in the "Galileo's Claim" lab sheet. State specific data from your team's SDO "HMI Intensitygram (gray)" solar images, "Solar Latitude & Longitude Grid", "Daily Sunspot Observations", "Tracking Sunspot Movement" data sheets, and "Tracking Sunspot Movement" graph to provide supporting scientific evidence for your answers.

1. Were there any changes in the shape, size and/or number of the sunspot group(s) during your investigation or did the sunspot(s) remain the same the entire time?

2. Do sunspot groups stay stationery (in the same place) or do they move? If they move, which direction do sunspots move horizontally across the Sun's disc (visible face of the Sun)? Do sunspots move vertically up or down on the Sun's disc?

3. Do sunspots only appear and disappear on the solar limb (edge of the Sun's disc) or do sunspots appear and disappear anywhere within the Sun's disc?

4. Discuss and decide if your scientific evidence supports Galileo's claim that sunspots are features on the Sun's surface and that they are not objects in space that orbit around the Sun. Give three specific examples of evidence that support your team's decision.

Part 3: Concluding Statement - Claim, Evidence and Reasoning
Based upon your team's analysis, write a concluding statement. Make a **claim** stating that sunspots are either located on the surface of the Sun or that sunspots are objects that orbit around the Sun. Use scientific information from your team's data sheets, graph and "Data Analysis" and "Discussion" responses as **evidence** to support your team's claim. Use suitable scientific principles as **reasoning** to connect your team's evidence to your claim.

Note: Ensure that you use complete sentences with correct capitalization, punctuation, spelling, and grammar when writing your conclusion.
Re-read and edit your scientific statement so that your team effectively communicates details about the science you learned together!

a) First, restate Galileo's **claim** regarding sunspots in relation to the Sun.

b) Second, state whether your team's scientific **evidence** does or does not support Galileo's claim.

c) Third, provide scientific **reasoning** that explains why your evidence does or does not support Galileo's claim about the relationship between sunspots and the Sun. Use specific evidence from your data to support your claim, such as patterns in the data, measurements including units, visual evidence, etc.