Name: ________________________________ Date: ______________________________

THE SUN PRE-LAB

Using your lecture textbook and/or any other acceptable source of information, answer each question in complete sentences. Be sure to define any relevant terms.

1. Explain the following terms related to the layers of the solar atmosphere.
   a. Photosphere:

   b. Chromosphere:

   c. Corona:

2. Explain the following terms related to individual features of the solar atmosphere and describe which of the above layers they can be found in.
   a. Prominence:

   b. Sunspot:

   c. Plage:

   d. Coronal loops/holes:

   e. Filament:

   f. Granulation:

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THE SUN LAB EXERCISE

INTRODUCTION

You are going to do three things in this laboratory exercise. First, we will examine images of the Sun's four layers—the photosphere, the upper and lower chromosphere, and the corona (we will omit the transition layer)— in order to familiarize ourselves with the appearance of those layers and the active features in them. Second, we will look at evidence that active regions extend through all of the layers of the solar atmosphere. Finally, we will measure the rotation of the Sun.

The means of doing the above is a webpage that allows you to display images of the Sun. Your instructor will show you how to access the website. Click the "Sun Lab" button. This gives you a table with all of the images you will need to view. Just double click on the image you want. If you need to you can go back to a previous image.

Double click on WL.GIF. This is a white light (all visible wavelengths) picture of the photosphere of the Sun. If you do not get this picture, ask your instructor to help you.

We will now take a short tour of the layers of the solar atmosphere, starting with the deepest layer of the atmosphere, the photosphere. Your computer should now display a picture of the photosphere. On each picture are labeled features you will be asked to identify. Remember, all active regions are caused by strong magnetic fields. After you have looked at a picture, move on to the next. Remember, you can always come back to any picture.

Following is a list of the file name of each picture along with the labeled features on each.

WL.GIF a white light picture of the photosphere with sunspots and granulation.

Sunspot–a cool region in the solar photosphere. Since it is cooler, it emits less light than the surrounding area. Sunspots usually have a dark center, called the umbra, and a grayish region surrounding the umbra, called the penumbra. They often occur in pairs or in sunspot groups.
Granulation–a light/dark mottling of the photosphere caused by brighter, hotter areas of rising gas and darker, cooler areas of descending gas.
Notice that the edge of the image of the photosphere is darker than the center. This is called **limb darkening**.

CA.GIF A picture of the lower chromosphere shown in the K line of calcium.

Plage–a bright region in the solar chromosphere when observed at the wavelength of a chromospheric emission line.
HA.GIF the upper chromosphere in hydrogen α, 6563Å.

Filament–a prominence (see below) seen silhouetted against the chromosphere appearing as a dark streak.
(By the way, an image taken at one wavelength of the Sun, such as hydrogen alpha at 6563Å, is called a spectroheliogram.)

PRMNENCE.GIF A hydrogen∝ α picture of the chromosphere showing a very large loop prominence at 10 o’clock.

Prominence–gaseous material in the corona which is cooler and denser than the surrounding gas. Often it is material ejected out of the chromosphere in jets or loops. Sometimes it is material condensing out of the corona.

YK.GIF An x-ray picture of the corona taken by the Yohkoh satellite.

Coronal loop–a bright, hotter region of the corona caused by strong magnetic field loops in that region. It appears as a bright loop or group of loops.
Coronal hole–a dark region of the corona with very little hot gas. The magnetic field lines are weaker or open in this region allowing the solar wind to flow outward more easily.

ECLIPSE.GIF A picture of the corona taken during a total solar eclipse in white light. During totality, the light of the photosphere and chromosphere is blocked so that we can see the very faint corona.

Remove the laboratory worksheet page from your book and read the instructions at the top.

Test yourself on your ability to identify solar features.

Display A1.GIF. Locate one or two of the features defined above. On the worksheet list the name of each and its “coordinates.”

Do the same for A2.GIF, A3.GIF, and A4.GIF.

LAYERS OF THE SUN

Display LAYER1.GIF. The figure at right represents what you should see.

NSO stands for the National Solar Observatory in Sunspot, New Mexico. Yohkoh is a Japanese x-ray satellite.

LAYER 1. GIF is essentially a composite of four of the pictures you have already seen.

NSO CHROMOSPHERE CALCIUM	NSO CHROMOMSPHERE HYDROGEN α
YOHKOH CORONA X-RAY	PHOTOSPHERE VISIBLE (WHITE LIGHT)

The white light shows the photosphere, the calcium shows the lower chromosphere, the hydrogen shows the upper chromosphere, and the x-ray shows the corona, **all on October 31, 1994**. We see spots in the photosphere and plages in the chromosphere. The x-ray image shows a lot of variation, indicating large differences in temperature and density from one region to another. There are very bright coronal loops, a background of many fainter loops, and one or two very dark places called coronal holes. (These holes are a major source of the solar wind.) Often the x-ray images are also dark near the solar magnetic poles. You can also easily see the coronal loops extending out to the right and left at substantial distances from the Sun. In fact, if you tried to detect fainter x-ray emissions (by taking a longer exposure, for example), you would see the corona extend even further out.

Notice that the sunspots, chromospheric plages, and coronal loops are at the same positions.

Test yourself on your ability to recognize the layers of the Sun and locate active regions.

Display DATE1.GIF.

DATE1.GIF

You should see four images similar to those at right.

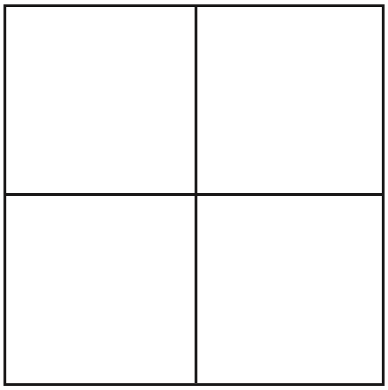
First, identify the layers in each image. In each box write PH for photosphere (visible light), LC for lower chromosphere (calcium), UC for upper chromosphere (hydrogen), and CO for corona (x-ray).

Then look at the active areas on the upper left image. From the other three images choose the one that shows activity at the same locations and put a large ‘X’ in that box. These two images, the upper left and the one you marked with an ‘X,’ were taken on the same day and show the magnetic activity in two different layers of the Sun. Do the same for DATE2.GIF, DATE3.GIF, etc., always comparing one image to the upper left image. Remember to identify each layer with PH, LC, UC or CO.

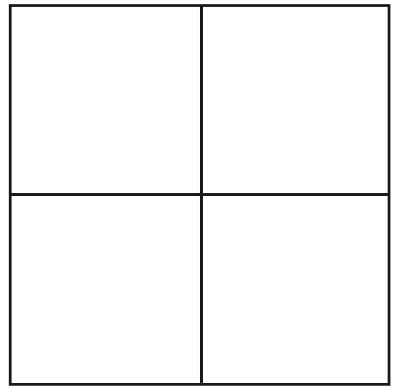
DATE2.GIF

DATE3.GIF

DATE4.GIF



DATE5.GIF



ROTATION

Since Galileo's time the rotation of the Sun has been measured by noting a feature on the sun and tracking that feature as it moves across the face of the Sun. If we are fortunate enough to have the feature persist through more than one revolution, we can watch it reappear as it comes out from behind the Sun. For centuries the Sun's rate of rotation has been determined by tracking sunspots. We will use much more modern data from the x-ray satellite Yohkoh. However, this will not make our determination more accurate. In fact, the larger size of the x-ray feature makes it harder to measure the x-ray feature's position than that of a sunspot. On the other hand, the x-ray feature demonstrates that active areas in the corona persist for many days and also rotate just as the photosphere does.

Display ROTATION 1
You should see nine x-ray images:

ROTATION 1 looks like this:

YOHKOH X-RAY Sept. 1, 1994	YOHKOH X-RAY Sept. 2, 1994	YOHKOH X-RAY Sept. 3, 1994
YOHKOH X-RAY Sept. 5, 1994	YOHKOH X-RAY Sept. 6, 1994	YOHKOH X-RAY Sept. 7, 1994
YOHKOH X-RAY Sept. 8, 1994	YOHKOH X-RAY Sept. 9, 1994	YOHKOH X-RAY Sept. 10, 1994

ROTATION 2 looks like this:

YOHKOH X-RAY Sept. 10, 1994	YOHKOH X-RAY Sept. 12, 1994	YOHKOH X-RAY Sept. 13, 1994
YOHKOH X-RAY Sept. 16, 1994	YOHKOH X-RAY Sept. 17, 1994	YOHKOH X-RAY Sept. 19, 1994
YOHKOH X-RAY Sept. 20, 1994	YOHKOH X-RAY Sept. 21, 1994	YOHKOH X-RAY Sept. 22, 1994

ROTATION 3 looks like this:

YOHKOH X-RAY Sept. 23, 1994	YOHKOH X-RAY Sept. 24, 1994	YOHKOH X-RAY Sept. 26, 1994
YOHKOH X-RAY Sept. 27, 1994	YOHKOH X-RAY Sept. 28, 1994	YOHKOH X-RAY Sept. 29, 1994
YOHKOH X-RAY Sept. 30, 1994	YOHKOH X-RAY Oct. 2, 1994	YOHKOH X-RAY Oct. 3, 1994

Each of the three images, Rotation 1, Rotation 2, and Rotation 3 consists of nine smaller images of the Sun's corona. The smaller images are taken about one to three days apart. The first image (top left) of Rotation 2 follows the last image (bottom right) of Rotation 1. Likewise, the first image of Rotation 3 follows the last image of Rotation 2.

Among the first three images of Rotation 1 choose one where a coronal loop just comes around the left limb of the Sun's face. Record the position of the feature in clock face coordinates (see worksheet at the end of this lab) and the date of the image under "Left limb (beginning location)" below. Observe how this feature moves across the face of the Sun over the following days. You may have to go to one of the smaller images in Rotation 2 to get to the image where the feature is about to disappear around the right limb. Record the position of the feature and the date of this image under "Right limb (disappearance location)" below. Subtract the beginning and disappearance dates and record this difference between the two dates (roughly half the rotation period of the Sun). Now, double this number to get an estimate of the full rotation period. Add this number to the beginning date to get an estimate of when the feature will come back around the left limb after completing a full rotation. Use this estimated reappearance date as a guide when you look for the actual small image in Rotation 3 where the feature reappears around the left limb. Record the actual reappearance date of the feature below. Find and record the difference between the reappearance and beginning dates to get the full rotation period of the Sun.

Feature ________________

Left limb (beginning location) ______________ Date ______________

Right Limb (disappearance location) ________________ Date ______________

Difference between dates = about half the rotation period ______________

Left limb (reappearance location) __________________ Date ______________

Difference between beginning and reappearance = rotation period _______________

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Date: ______________________________ ______________________________

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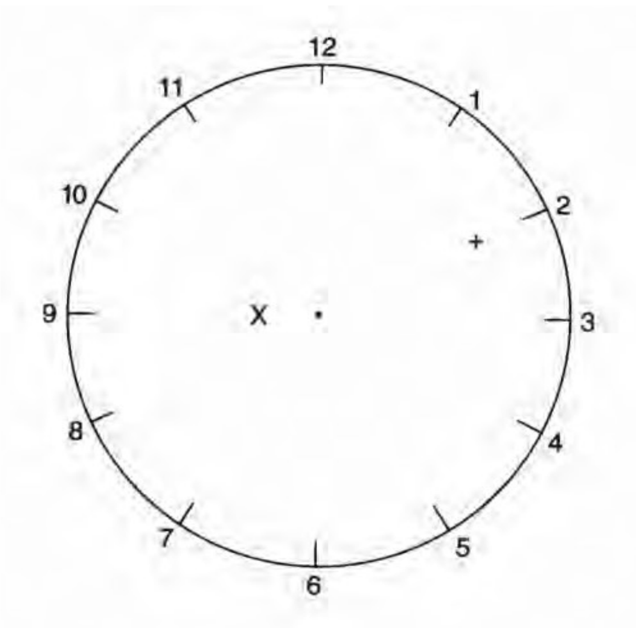
WORKSHEET

In order for you to try your hand at identifying some features in the sun's atmosphere we need to find a way to have you locate a specific position on the sun. Since we don't need anything too sophisticated for approximate location, we chose to use the familiar clock face. That is, think of each disk of the sun as a clock face with 12 at the top (see the figure below). By adding the distance from the center of the disk as the other coordinate we can give a crude location of any feature. This distance is to be a decimal fraction of the radius (0 at the center 1.0 at the limb). You don't have to be excruciatingly precise! For example, the coordinates for the + and × below are at 2/0.7 and 9/0.2 respectively.



FEATURES

Image Name	Feature	Location
A1	____________________	____________________
	____________________	____________________
A2	____________________	____________________
	____________________	____________________
A3	____________________	____________________
	____________________	____________________
A4	____________________	____________________
	____________________	____________________