SOLAR OBSERVING

19

OBJECTIVES

After completing this lab exercise the student will be able to:

1. locate limb darkening on a solar image.
2. identify umbra and penumbra portions of sunspot.
3. obtain the Relative Sunspot Number (RSN) on a solar image.
4. estimate the position of the solar equator and poles using sunspot alignments.

STUDENT MATERIALS

The student is expected to bring the following items:

- pencil
- calculator (optional)
- drawing compass
- mm scale

LAB MATERIALS

The instructor should provide the following items:

- small telescope w/ wide field eyepiece
- front aperture solar filter
- projection screen

STUDENT REQUIREMENTS

Students are expected to work individually. Each student should turn in a drawing of the white light sun and the Hα sun (Fig. 1), and a completed concept map of the sun.

INTRODUCTION

Our sun is the closest star to the Earth. Because it is so close astronomers can actually observe details on its surface. The surface of the Sun is about 5870 Kelvins, and so it is gaseous not solid. The bright part which emits the light seen here on the Earth is call the Photosphere, the sphere of light. It is therefore more proper to refer to the visible portion of the Sun as the Photosphere and not the surface. The term surface implies a solid object, which the sun clearly is not.

Sunspots are the main features visible on the Photosphere. These spots appear to have to part, a dark central portion called the umbra and a less dark perimeter called the penumbra. Sunspots are produced by the Sun's differential rotation which twist the solar magnetic field lines. When these magnetic field lines project through the Sun's "surface" they produce the dark sunspots. Therefore sunspots tend to form in pairs or groups of pairs. One spot in each pair is magnetic north and its companion is magnetic south. Sunspots are dark because they are a few hundred degrees cooler than the rest of the photoshere. When they are seen superposed against the brighter photoshere they appear dark, or black.

In addition to sunspot other features can be viewed in white light. These include limb darkening, plages, flares, and granulation. When viewing the Sun its edge, or limb, appears somewhat darker than the central portion of the visible disk. This effect is called limb darkening and is a result of projecting a spherically light emitting Sun onto a flat 2-dimensional screen. The Sun has areas which are slightly hotter than average and can be seen as small brighter patches on the photoshere. These plage areas are not easily seen but may occasionally be viewed within the limb darkened area. Solar flares are intense eruptions on the Sun's surface which manifest themselves as large bright areas on the photsphere. Only the most intense flare can be seen in visible light. Flares are more easily seen in Hα light. Sometimes the Solar surface can have a salt and pepper look to it. This effect is called granulation and is caused by the boiling gases near the Sun's surface. The rising, hotter, convective cells appear brighter than the cooler, sinking, convective cells. These convective cells are best seen with large white light telescopes or in Hα light.

Viewing the Sun with an Hα filter allows astronomers to see the chromosphere, the sphere of color. The chromosphere is the portion of the solar atmosphere directly above the photosphere. Gases in the chromosphere are less dense than in the photosphere and the density falls off with height above the photosphere. However, the temperature in the chromosphere increases from about 4500 Kelvins near the photoshere up to 100,000 Kelvins near the chromosphese's top.

Features visible with an Hα filter include the most intense sunspot umbras, granulation effects, flares, prominences and filaments. Of these prominences are the most common and visually the most interesting. Prominences appear as flame like projections rising from the Sun's limb. These can be seen to change within a few minutes. Some appear as loops and others take the shape of curtains or sheets. When a prominence is rotated around so the it is seen as a against the bright solar disk they appear to be long dark snake-like object which are called filaments. So, prominences and filaments are the same phenomenon which are seen against different back grounds.

Viewing the Sun directly is dangerous and can cause permanent blindness. **NEVER LOOK DIRECTLY AT THE SUN**. The only safe way to view the Sun is using eyepiece projection or some type of aperture filter. Eyepiece projection can be used to project an image of the sun onto a screen so that a large group can view the Sun simultaneously. So, the telescope is unfiltered and used like a giant slide projector. Aperture filters cover the entire front of the telescope and allow direct viewing of the Sun through the telescope. These filters reject 99.99% of the Sun's light before it even enter the telescope. Some telescopes come with an EYEPIECE SOLAR FILTERS. These are UNSAFE and should be THROWN AWAY. They allow 100% of the Sun's rays to enter the telescope. These rays are then focused on the eyepiece filter which does get amazingly hot and ultimately cracks. If it is cracked when you look into the telescope you can kiss one eye goodbye. DO NOT USE EYEPIECE TYPE SOLAR FILTERS.

PROCEDURE

I. Observing the Solar Photosphere in White Light

1. Go outside and set up a small telescope for direct viewing of the Sun using a front aperture solar filter, AND/OR set up the telescope to project an image of the Sun on a screen.

2. View the Sun's photosphere and identify:
   - sunspots (umbra & penumbra),
   - limb darkening,
   - plage (may be seen near sunspots and within the limb darkened region),
   - flares (only seen occasionally in white light).

3. On Fig. 1 make a detailed sketch of the Sun as viewed with the telescope. Try to include every individual umbra visible in each spot grouping. You are looking at an active astronomical object that can change within a few minutes. Therefore, be sure to include the following information on Fig. 1:
   - date,
   - time (h:m, am or pm, EST or EDT),
   - telescope aperture.

II. Observing the Solar Chromosphere in Hα.

4. After everyone has completed their sketch of the photosphere replace the white light filter with an Hα filter if one is available. If no Hα is available, then observe the Hα sun using Big Bear Solar Observatory's Web site at http//:www.bbso.njit.edu/.

5. Sketch features visible in the solar chromosphere on Fig. 2. Be sure to include any of the following feature visible:
   - promenances
   - filaments
   - flares
   - umbras of largest sunspots

III. Sunspot Counting

6. From your sketch of the Sun's photosphere make a sunspot count for the day. Solar astronomers use sunspot counts to determine how active the sun is. An inactive Sun has low counts such as 0-50, and an active Sun may have spot counts of 100 or more. Astronomers use a number called the relative sunspot number (RSN). To obtain the RSN shown on your diagram:

   a) Count all sunspot groups visible on your diagram. Isolated individual spots which seem to be alone and not part of a group count as a group. Individuals within an obvious group do not count as a group. Record the number of groups as G on Fig. 1.

   b) Now count every individual umbra visible in all groups. This means that isolated spots which have already been counted during the groups count get counted again as individuals. Record the number of individual umbras as N.

   c) It is assumed that any group represents an area that is 10 times more active than the individual umbras. So, the relative sunspot number (RSN) is calculated using

   $$RSN = 10G + N.$$

   Calculate the RSN for the Sun as drawn on Fig. 1.

IV. Concept map of the Sun.

7. Obtain a concept map of the Sun from your instructor.

8. Complete the map by filling in the proper words in the ovals on the map.

SOLAR OBSERVING

NAME: ______________________

SECTION: ______________________

Fig. 1: Visible Light

Spots ______________________

Groups ______________________

Total ______________________

Fig. 2: Hα Light

URL(s) ______________________

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Other Information: ______________________

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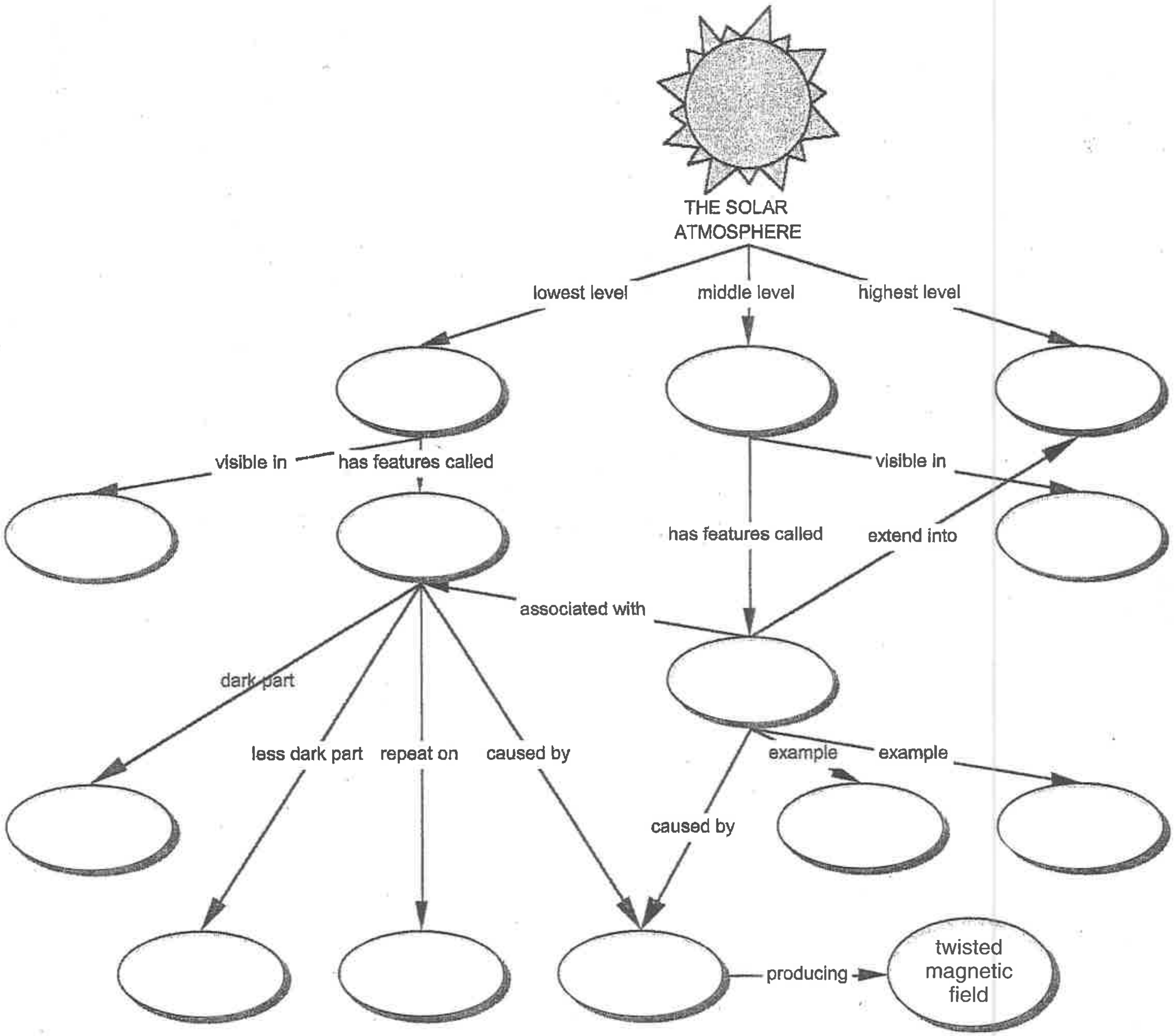

Use these terms to complete the diagram. Place one term in each blank oval.

infared light
white light
H alpha light
corona
solar wind
sunspots
prominances
photosphere
loops
penumbra
sheets
11 year cycle
umbra
differential rotation
chromosphere