

Observing the Sun

NEVER LOOK DIRECTLY AT THE SUN!!!

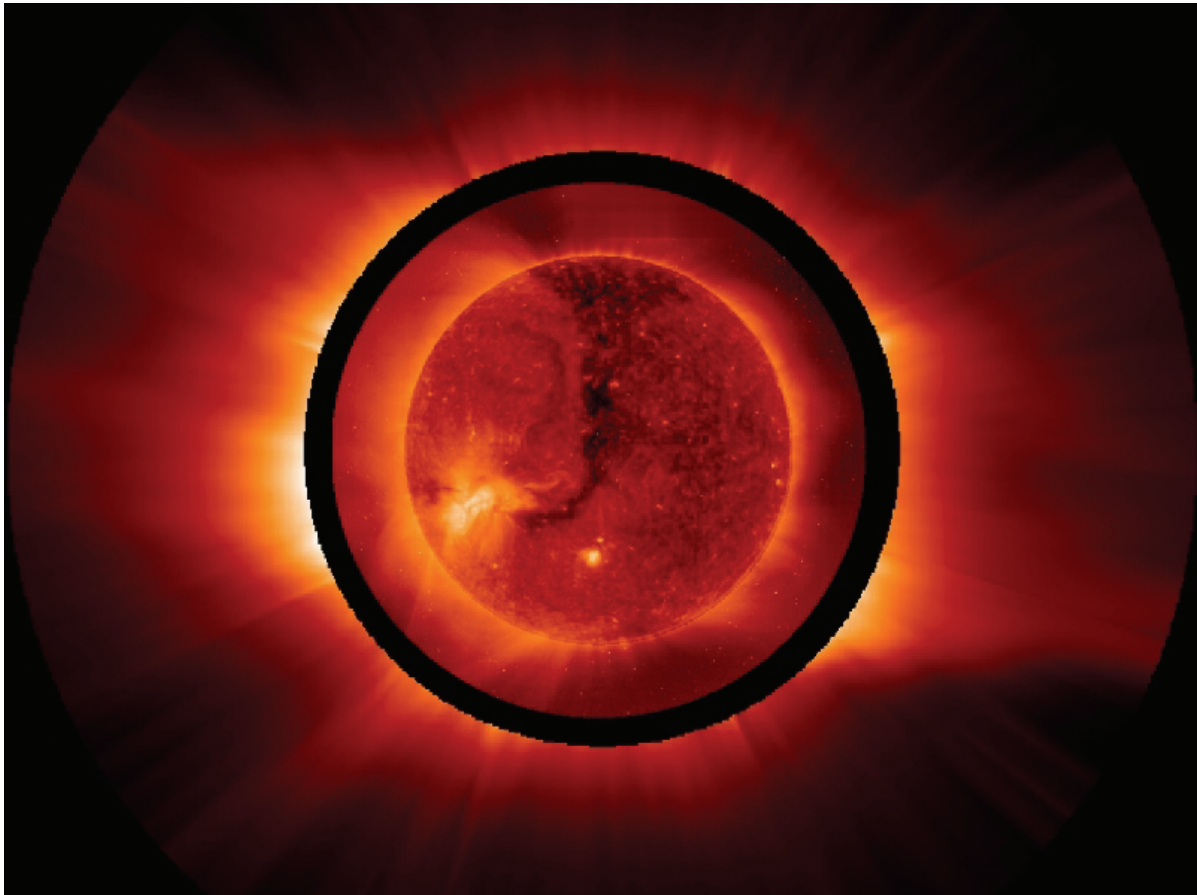


Image taken from the SOHO web-site

<http://sohowww.nascom.nasa.gov/gallery/SolarCorona/uvc003.html>

Explanation: The Sun is a pretty active star. You see the Sun's outer atmosphere as it appears in ultraviolet light emitted by electrically charged oxygen flowing away from the Sun to form the solar wind (region outside black circle), and the disk of the Sun in light emitted by electrically charged iron at temperatures near two million degrees Celsius (region inside circle). This composite image taken by two instruments (UVCS, outer region and EIT, inner region) aboard the SOHO spacecraft shows dark areas called coronal holes at the poles and across the disk of the Sun where the highest speed solar wind originates. UVCS has discovered that the oxygen atoms flowing out of these regions have extremely high energies corresponding to temperatures of over 200 million degrees Celsius and accelerate to supersonic outflow velocities within 1.5 solar radii of the solar surface. The structure of the corona is controlled by the Sun's magnetic field which forms the bright active regions and the ray-like structures originating in the coronal holes. The composite image allows one to trace these structures from the base of the corona to millions of kilometers above the solar surface.

PART I → OBSERVING THE SUN

First meet in class for a brief discussion then walk over to CSI's Astrophysical Observatory. The telescopes will already be set up – you will look a projection of the Sun onto cardboard, and you will observe the Sun **WITH** a solar filter and an H-alpha filter.

Never look directly at the Sun, especially NOT through a telescope!!

1. Explain what would happen to your eyes if you looked at the Sun through a telescope.

A. The Projection of the Sun

Look at the projection of the Sun. You should identify the following features: granulation, limb darkening, chromatic aberration, faculae, and sunspots].

B. The H-alpha Image of the Sun

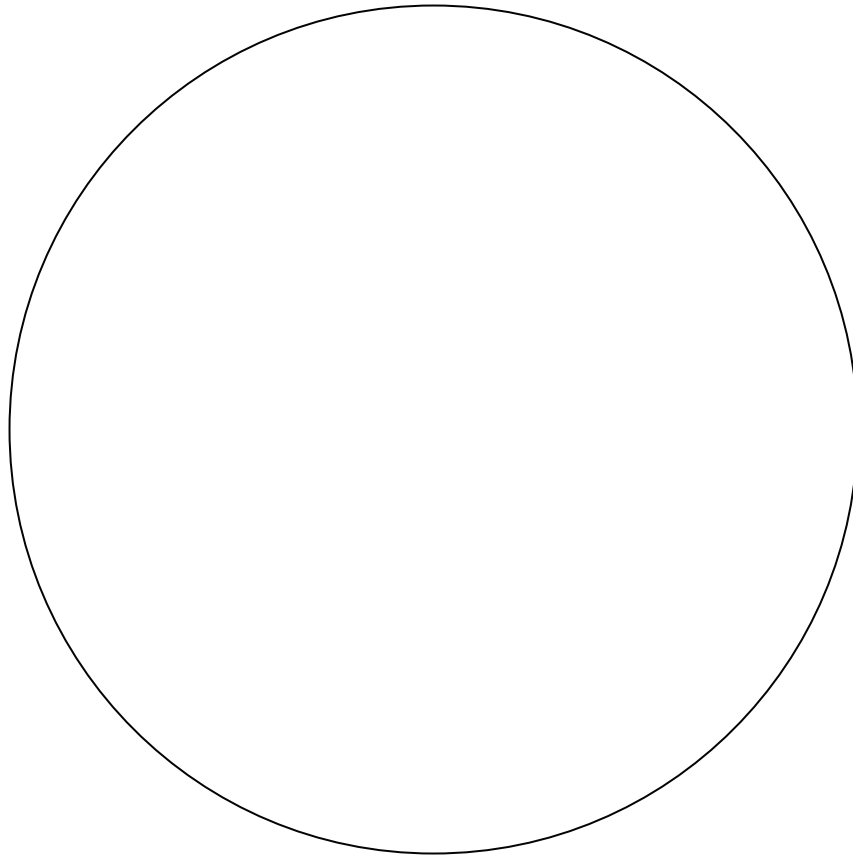
Look at the Sun through the H-alpha (H_{α}) filter. You will see the sunspots again, but they will be smaller. It will also be somewhat more difficult to differentiate between the umbra and the penumbra. Look at the limb of the Sun and adjust the focus. Observe any prominences at the limb.

2. Why do we use an H_{α} filter?

3. Why are the sunspots smaller and more difficult to differentiate with the H_{α} filter?

PART II → DRAWING SOLAR FEATURES

1. Carefully draw the projected image of the Sun including any features you see [label the following: granulation, limb darkening, chromatic aberration, faculae]. Also draw the sunspot groups including the umbra and penumbra (label the umbra, penumbra).



2. Give a brief written description of all those features.

PART III → THE SIZE OF SOLAR FEATURES

A. The Projection of the Sun

1. Measure the size of the sun's diameter **with a ruler**. Write down five measurements, then average.

Measurements of five students: _____

Average linear diameter (*in cm*) and its error _____ ± _____ cm

2. Look up the actual diameter of the Sun in your TOOLKIT. _____ km
3. Calculate the image scale of the projection. [Hint: One cm in projection corresponds to ?? km]

1 cm = _____ km

4. Measure the size of a sunspot (*in cm*) in the projection **with a ruler**. _____ cm
5. Calculate the diameter of the sunspot in *km*.

_____ km

6. Look up the diameter of the Earth in your TOOLKIT. _____ km
7. Spell out how the size of a sunspot compares to the size of the Earth.

B. The H-alpha Image of the Sun

8. *Estimate* the size of the prominences (a ratio) compared the Sun's diameter? _____ d_{Sun}
9. Calculate the size of the prominence in *km*. _____ km

10. Draw the Earth (to scale!) into your drawing on the previous page.
11. Finally, spell out how the size of a solar prominence compares to the size of the Earth.

PART IV → SOLAR LIMB DARKENING

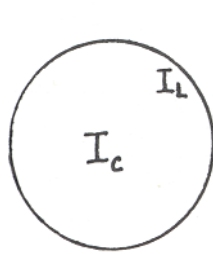
Look at the projection of the solar image. The Sun appears darker near the limb. Also look at the Sun through the H-alpha filter. Notice that the darker limb looks redder than the center of the Sun. Darker and redder means cooler. Thus we are looking at cooler layers of the photosphere at the limb.

A. The Intensity

- With the light meter, take five measurements of the intensities, than take the mean:

INTENSITY of the Sun at disk center _____
 INTENSITY of the Sun near the limb _____
 INTENSITY of the background _____

Mean I_C _____
 Mean I_L _____
 Mean I_B _____



I_C → INTENSITY of center
 I_L → INTENSITY at limb
 I_B → INTENSITY of background

- Compare the measured INTENSITY values and calculate the following ratios:

a) $\frac{I_L}{I_C}$ _____

b) $\frac{I_L - I_B}{I_C - I_B}$ _____

- The actual ratio of limb INTENSITY to center INTENSITY is $\frac{2}{5}$. Calculate the percent difference in the INTENSITY ratios with and without subtracting away the background.

[The percent difference is defined as: $\frac{\text{measured} - \text{actual}}{\text{measured}} \times 100$]

a) $\frac{I_L}{I_C}$ _____

b) $\frac{I_L - I_B}{I_C - I_B}$ _____

- Which of the ratios is closer to the expected value? Comment on **why** it is important to make accurate measurements of the background.

B. The Temperature

5. Write down the correlation between TEMPERATURE and INTENSITY (or FLUX) [refer to the back page of your TOOLKIT]. This is known as Stefan-Boatman's Law.

6. Calculate the ratio of limb TEMPERATURE to center TEMPERATURE. [Hint: You just determined the ratio of limb INTENSITY to center INTENSITY on the previous page. Also, remember that Stefan-Boltzmann's Law states that INTENSITY (or FLUX) is proportional to TEMPERATURE to the 4th power.]

In other Words, calculate $\frac{T_L}{T_C}$

$$\frac{T_L}{T_C} = \underline{\hspace{2cm}}$$

7. Look up the effective TEMPERATURE of the Sun in your TOOLKIT.

$$T_{\text{eff}} = \underline{\hspace{2cm}} \text{ K}$$

8. Calculate the TEMPERATURE at the limb (assuming the effective temperature is T_C).

$$T_L = \underline{\hspace{2cm}} \text{ K}$$

9. Let's understand this. You just looked up the effective TEMPERATURE of the Sun, which is the Sun's SURFACE temperature. So then, why are the values for the TEMPERATURE at the limb and the center different? Make some suggestions. Discuss these suggestions with your partners. This is a difficult question, so you will need to do some real thinking. [Hint: What parts of the solar photosphere are you seeing? What is the temperature of that "part"? How far is that "part" from the center of the Sun? Think of a reason why this distance differs at the limb and the center of the projection.]

C. The Color

10. Write down the correlation between WAVELENGTH and TEMPERATURE [check the TOOLKIT *and pay attention to your units!!! Specify which units will use*]. This is known as Wien's Law.

11. Calculate the peak WAVELENGTHS (in Å) of the limb and the center of the Sun (λ_{maxL} & λ_{maxC}).

$$\lambda_{\text{max}} \text{ of the center of the Sun} = \underline{\hspace{2cm}} \text{ \AA}$$
$$\lambda_{\text{max}} \text{ of the limb of the Sun} = \underline{\hspace{2cm}} \text{ \AA}$$

12. What colors do these WAVELENGTHS correlate to?

the calculated color of the center of the Sun = _____
the calculated color of the limb of the Sun = _____

13. Look at the image of the sun through the H-alpha filter. What colors do YOU see?

the observed color of the center of the Sun = _____
the observed color of the limb of the Sun = _____

Are the colors you observe comparable to the calculated colors? _____

14. Okay, let's understand this. Redder means cooler, and we definitely see that the Sun looks redder at the limb. Is this an optical illusion or is this real? Explain that answer. [Hint: the color tells you something about the temperature.]

Standard Lab Report

If your instructor requires a “Formal Report” consult the instructions on the following two pages and hand in a neatly typed report. If this is not required hand in the entire lab including this page, i.e. pages 1 to 8 (in that case you can earn extra credit if you do the Formal Report).

1) Objective of the Lab.

2) Describe in a few sentences what you observed.

3) Summarize what you learned about the properties of the Sun.

Formal Laboratory Report

A SUGGESTION OF HOW TO WRITE A FORMAL REPORT
(The drawings on the last page illustrate what the final report might look like)

· Main title of report	OBSERVING THE SUN
· Date of the report or the due date	observations made ??/??/????
· Name of writer	<i>your name</i>
· Social Security Number	###-##-####
· Course number with section	AST 103 — Section ###
· Course instructor	Instructor: Whoever
· Department Name	Engineering Science & Physics
· School	College of Staten Island — CUNY
· Term	Fall/Spring ????

1. Abstract

Summarize the objective of the lab, make a short comment on the methodology, list your basic results, and make one concluding remark. [*Be brief — one paragraph is enough — but make sure you describe the entire the lab and your results.*]

2. Objective

State the purpose of the lab exercise. [*Be brief — one paragraph — but make sure you state the entire purpose of the lab*]

3. Introduction

Provide the reader with ALL necessary background information that will help in understanding this lab. Mention what is known already, how this lab fits into the picture, and how it will impact on your general understanding of the material. Also, explain in more detail the purpose of this lab. In other words, why are you doing this? [Besides the fact that it's required ☺!] HINT → A way to approach this is to summarize the basic principle(s) and offer relevant information you think is critical in carrying out this lab (including any formulae). [*Be detailed — one or two paragraphs — remember a paragraph is more than two sentences.*]

4. Procedure

Give a narrative description of what you did — explain how the observations were made (what did you do, how did you do it and why did you do it that way). **DO NOT** rewrite the instructions given in the hand-out. Include a list of apparatus [*telescope, screen, light meter*]. You may include a drawing of the setup to complement your description. From your description, the reader should be able to duplicate the experiment.

5. Data Presentation & Calculations

For each part, show detailed sketches of observations [*sunspots, prominences*] and include numerical data gathered for use in calculations. Provide descriptions of sketches, explain how you do your calculations, write down the formulae used, and the relevant parts of your calculations. Do not write down all the steps, but provide enough information so that the reader will be able to replicate and check your results. Finally list your results, including the uncertainty in the results. Summarize these results in words.

6. Interpretation

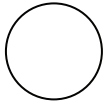
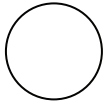
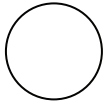
Draw conclusions from observations and offer a connection to stated objectives of the lab. Restate the results of your calculations and give a thorough explanation of these results. What do they indicate to you? What do they mean? State the accuracy of results and discuss sources of error. Offer recommendations or suggestions for improvement of the experiment.

Finally, include a discussion of the overall results of all three parts. What was the connecting thread through the whole lab? Was the objective met? Go beyond this experiment and make suggestions how to continue this study.

7. References

Quote references – list the literature that you used to make sense of this lab.

<p style="text-align: center;">Observing the Sun</p> <p style="text-align: center;">Your name _____ Date _____ AST 103 – Section _____ Engineering Science & Physics College of Staten Island CUNY</p> <p style="text-align: center;">ABSTRACT</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>_____</p>	<p style="text-align: center;">OBJECTIVE</p> <p>_____</p> <p>_____</p> <p>_____</p> <p style="text-align: center;">INTRODUCTION</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>_____</p>	<p style="text-align: center;">PROCEDURE</p> <p>Location, Time, Conditions</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>Experimental Setup</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>How you did your observations</p> <p>_____</p> <p>_____</p> <p>_____</p>
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<p style="text-align: center;">Data Presentation & Calculations</p> <table style="width: 100%; border: none;"> <tr> <td style="width: 50%; border: none;">Observations</td> <td style="width: 50%; border: none;">Description</td> </tr> <tr> <td style="border: none; text-align: center;">  </td> <td style="border: none;"> <p>_____</p> <p>_____</p> <p>_____</p> <p>_____</p> </td> </tr> </table> <p style="border: none;">Data & Calculations</p> <p>_____</p> <p>_____</p> <p>_____</p>	Observations	Description		<p>_____</p> <p>_____</p> <p>_____</p> <p>_____</p>	<p style="text-align: center;">Discussion & Interpretation</p> <p>Comment on the Method</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>Comment on Results</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>Answer main questions in Objective</p> <p>_____</p> <p>_____</p> <p>_____</p>	<p>Critically discuss these Answers</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>Add your own Opinions</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>What's next?</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>Other Comments - optional</p> <p>_____</p> <p>_____</p> <p>_____</p>	<p style="text-align: center;">CONCLUSIONS</p> <p>Summarize ENTIRE Lab including the objective, results, and their meaning</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>_____</p> <p style="text-align: center;">REFERENCES</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>_____</p>
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