Sunspots Handout

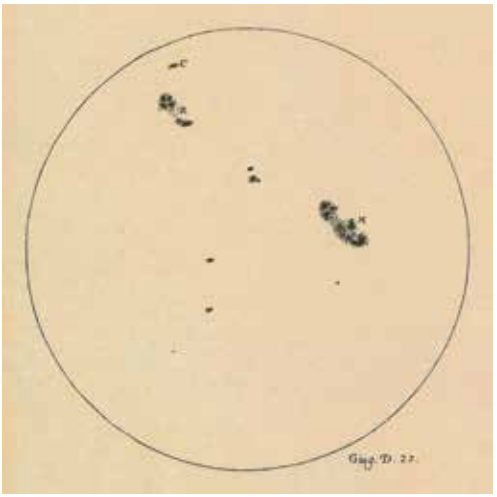
Some History

Galileo Galilei is often given credit for discovering sunspots in 1611, when he pointed his *spyglass* at the Sun. (Today, we call that spyglass a telescope.) We now know that he was not the first person to see sunspots by any means! There are records from ancient Greece and ancient China showing that people almost 2,000 years before Galileo had noticed dark spots on the Sun without a telescope but didn't know what they were.

Galileo looked at the Sun through his telescope only briefly and when the Sun was low in the sky and its light had to go through a large amount of the Earth's air. He could also look when clouds or mist cut down the Sun's light.

Safety note: Looking directly at the Sun is dangerous to your eyes, so don't try viewing the Sun without your teacher's guidance. A telescope or a pair of binoculars makes everything brighter, so a view of the Sun through them can damage your eyes even more quickly.

However, soon Galileo didn't have to look through his telescope at all to see the Sun. One of his students, Benedetto Castelli, came up with a better idea. He projected an image of the Sun through his telescope at a wall or a big sheet of paper. In this way, Galileo became one of the first people to observe the Sun over a long period of time using a telescope. He made drawings of the spots, which was necessary because the camera had not yet been invented to take photographs (see figure). (Others who did this at about the same time as Galileo include Christoph Scheiner in Germany and Thomas Harriot in England.)



One of Galileo's drawings of the Sun showing sunspots

All three observers found that the spots—whatever they were—moved across the face of the Sun as the days went on. Groups of spots would move out of sight on one edge of the Sun and, days later, would sometimes reappear on the other edge. Galileo also suggested that the spots must be on the Sun itself, that they were something that happened in its outer layer or atmosphere. If so, this showed that the Sun was rotating, that is, spinning on its axis just like the Earth. Galileo's idea turned out to be correct.

What Are the Spots?

Today we understand that sunspots are darker areas on the Sun's visible surface (see figure below). Like everything about the Sun, sunspots are huge compared with human sizes. The typical spot you can see with your eyes is bigger than the entire planet Earth. Some of the biggest spots we've seen were more than 100,000 mi. across—a size so big, it boggles our imaginations. The Earth is about 8,000 mi. across, for comparison, and Jupiter, the largest planet in our solar system, is 87,000 mi. across.

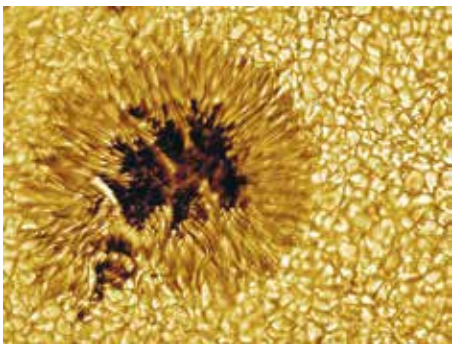
The spots last different amounts of time, depending on their size. Smaller ones last only a few hours, while the biggest spots can last for months. After a spot disappears from view, other spots often form in the same neighborhood of the Sun's surface.

Sunspots look darker because they are cooler than the rest of the Sun's outer layer (called the *photosphere*, meaning the sphere from which the Sun's visible light emerges). Temperatures in the dark sunspots can range from 2700°C to 4200°C, which is from 4900°F to 7600°F. The Sun's photosphere, on the other hand, is generally at 5500°C or 9900°F.

(By the way, those numbers are also pretty mind boggling. Water boils at 100°C or 212°F. When we are talking about the Sun's temperatures, it's good to bear in mind that things are so hot there that our bodies would not only boil but also evaporate. The heat would tear our bodies apart until we were just individual atoms of gas, by which time we would long be dead. The Sun is made entirely of superheated gases—so hot that the electrons are separated from their parent atoms.)

It's important to remember that the spots are only dark compared with how super-bright the rest of the Sun is. If, somehow, we could remove the sunspot regions from the Sun, they would glow a rich red and be bright with light.

What cools the sunspot areas? Twentieth century astronomers discovered that the Sun, filled as it is with negative electrons and positive atoms, is electric and magnetic in complicated ways. Astronomers now know that magnetic forces are so strong in the areas of sunspots that they keep hot material from flowing up from below, allowing the region of the spot to cool.



A close-up of a sunspot, taken with a large solar telescope