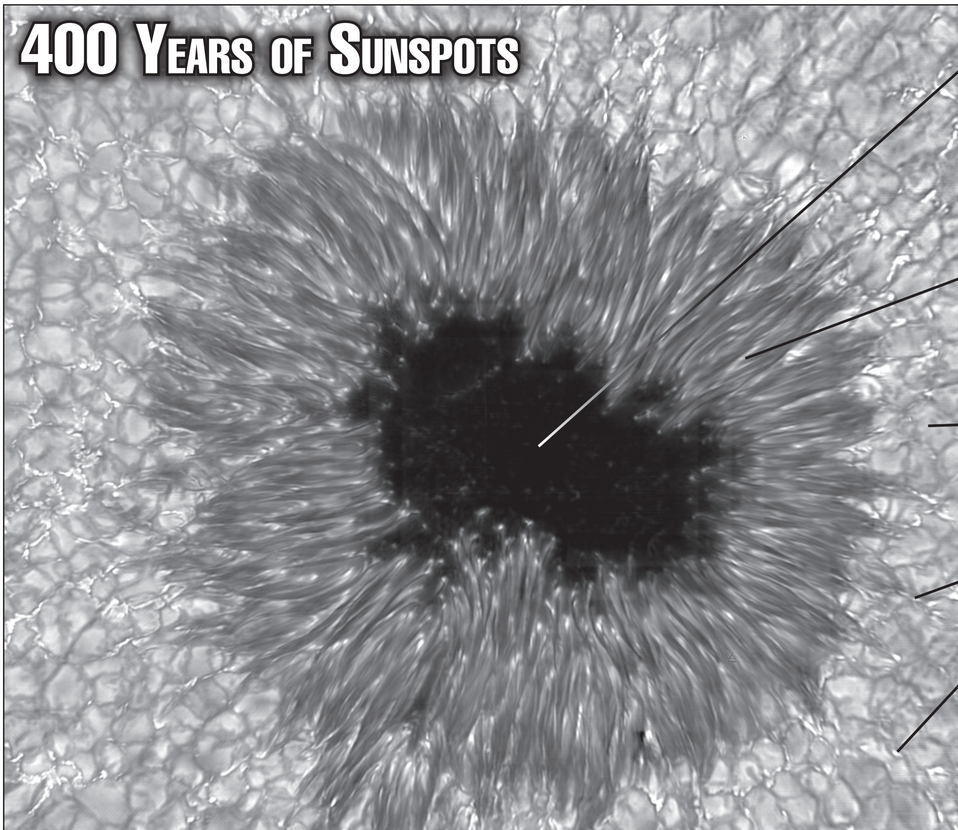
400 YEARS OF SUNSPOTS



This picture of sunspot AR 10810 was taken by Friedrich Woeger, Chris Berst, and Mark Komsa using the Dunn Solar Telescope at the National Solar Observatory in Sunspot, New Mexico.

Sunspot anatomy

Umbra (Latin: shadow): Dark center, about 1000K (1,800˚F) cooler than the Sun's 5780K (9,950˚F) surface. Magnetic field up to 6,000 times stronger than Earth's.

Penumbra (Latin: Almost shadow): Flux tubes where magnetism leaks to rest of solar surface.

Granule: Cells of hot gas circulating in the Sun. Granules are the size of Texas to the size of Alaska!

Lane: Cool gas circulating back to interior.

Bright point: Tiny area heated by intense magnetic fields.

One of the great discoveries that Galileo and his contemporaries made with their telescopes is that the Sun does not have a perfectly smooth surface, and that it changes over time. Although sunspots had been recorded as early as 28 BC, until Galileo's time, people thought they were caused by Earth's imperfect atmosphere. Systematic observations by Galileo, Johannes and David Fabricius, and Christoph Scheiner showed that these spots were associated with the Sun. In the 1800s, we learned that spot numbers rise and fall about every 11 years. In 1908, George Ellery Hale discovered that they are caused by intense magnetism.

How big are sunspots? Try this simple scaling exercise to find out.

A circle has 360 degrees. Each degree can be divided into 60 minutes of arc, and each minute of arc can further be divided into 60 seconds of arc (sometimes called arc-seconds, denoted by the same symbol we use for inches: "). We know that the Sun is 109 times wider than Earth, and has an average apparent or angular size of 1,920 arc-seconds (1,920"). Answer the following in your notebook:

a. What would be the apparent or angular size of an Earth-size object in arc-seconds if we viewed it against the Sun?

b. This image covers a diameter 56 arc-seconds wide. How much wider than Earth is it?

c. Measure the size of the sunspot image. What would be the size of Earth on this scale? How accurate would it be to use a ping-pong ball with a diameter of 40mm to represent Earth at this scale? (You could color one green and blue and hang it in front of the image for comparison.)

d. How wide would this sunspot image have to be to match the scale of a 30-cm (12-inch) classroom globe?

This isn't the biggest spot ever recorded. Often they are much bigger and appear in clusters of many spots together.

Answers:

a. Sun diameter/Earth-Sun ratio = 1,920"/109 = 17.6"

b. Image size/Earth size = relative size 56"/17.6" = 3.18 wider

c. The picture is printed to be 127 mm. Image width/Earth relative size = model size 127 mm/3.18 = 40 mm (rounded off) — about the size of a ping-pong ball. It is a good representation.

d. Calculate the ratio class globe/"ping-pong Earth" x image size = (300 mm/40 mm) x 127 mm = 7.5 x 127 mm = 953 mm (38 inches, rounded off)

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Sunspot Anatomy

Texas Essential Knowledge and Skills

Science:

§112.16. grade 5 (b)-8(d) grades 6-8: identify and compare the physical characteristics of the Sun, Earth, and Moon.

§112.18-20. grade 6-8 (b)-3(C) identify advantages and limitations of models such as size, scale, properties, and materials.

§112.18. grade 6 (b)-11(A) describe the physical properties, locations, and movements of the Sun, planets, Galilean moons, meteors, asteroids, and comets.

§112.20. grade 8 (b)-3(B) use models to represent aspects of the natural world such as an atom, a molecule, space, or a geologic feature.

Astronomy, Grade 9-12:

§112.33(c)-6(A) compare and contrast the scale, size, and distance of the Sun, Earth, and Moon system through the use of data and modeling.

§112.33(c)-6(B) compare and contrast the scale, size, and distance of objects in the solar system such as the Sun and planets through the use of data and modeling.

§112.33(c)-10(C) describe the eleven-year solar cycle and the significance of sunspots.

§112.33(c)-10(D) analyze solar magnetic storm activity, including coronal mass ejections, prominences, flares, and sunspots.

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