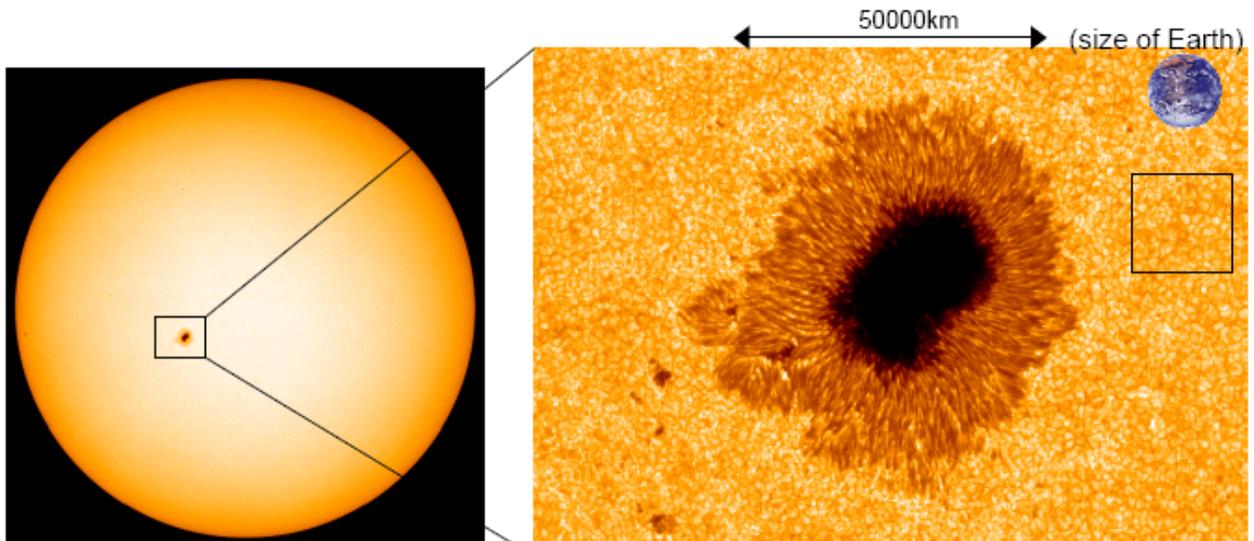


# Hinode - Close-up of a Sunspot

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After a successful launch on September 22, 2006 the Hinode solar observatory caught a glimpse of a large sunspot on November 4, 2006. An instrument called the Solar Optical Telescope (SOT) captured this image, showing sunspot details on the solar surface.

**Problem 1** - Based on the distance between the arrow points, what is the scale of the image on the right in units of kilometers per millimeter?

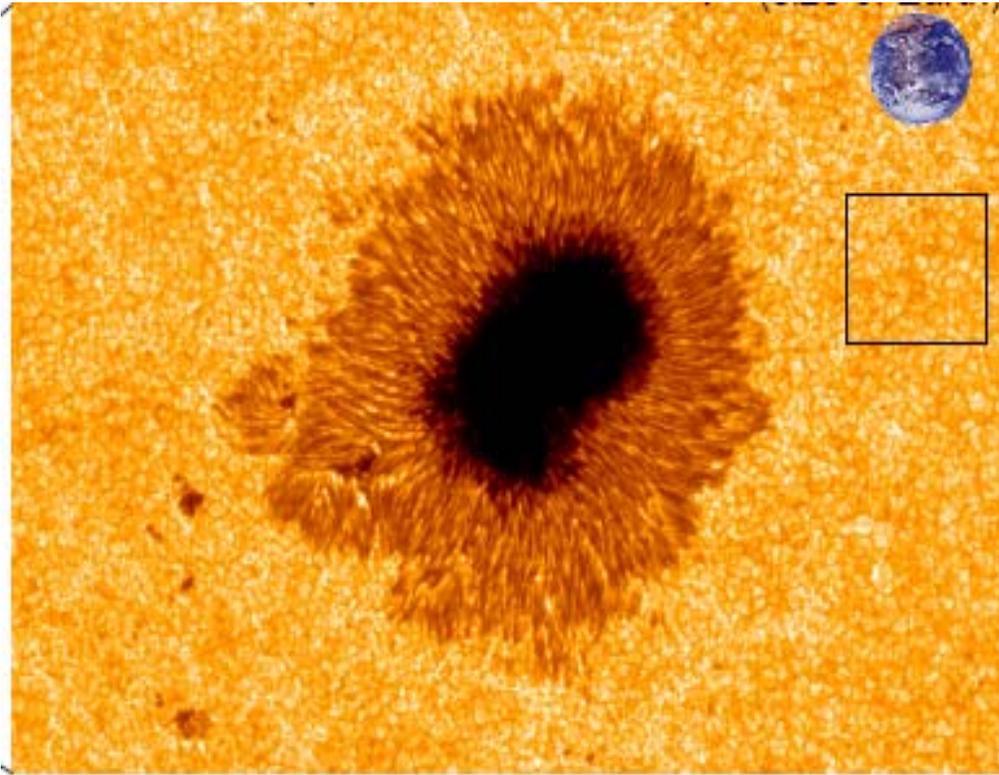
**Problem 2** - What is the size of the smallest detail you can see in the image?

**Problem 3** - Compared to familiar things on the surface of Earth, how big would the smallest feature in the solar image be?

**Problem 4** - The gold-colored textured surface is the photosphere of the sun. The texturing is produced by heated gas that is flowing up to the surface from the hot interior of the sun. The convecting gases form cells, called granulations, at the surface, with upwelling gas flowing from the center of each cell, outwards to the cell boundary, where it cools and flows back down to deeper layers. What is the average size of a granulation cell within the square?

**Problem 5** - Measure several granulation cells at different distances from the sunspot, and plot the average size you get versus distance from the spot center. Do granulation cells have about the same size near the sunspot, or do they tend to become larger or smaller as you approach the sunspot?

## Answer Key:



Problem 1 - From the 40 millimeter length of the 50,000 km arrow marker, the scale of the image is  $50,000 \text{ km}/40 \text{ mm} = 1250 \text{ kilometers per millimeter}$

Problem 2 - Depending on the copy quality, the smallest detail is about 0.5 millimeters or  $0.5 \times 1250 = 625 \text{ kilometers}$  across but details that are 1 or 2 mm across are also acceptable.

Problem 3 - Similar features on Earth would be continents like Greenland (1,800 km) or England (700 km).

Problem 4 - Measure about 5 cells to get: 1.5 mm, 1.0 mm, 0.8mm, 1.2mm and 1.4 mm. The average is about 1.2 mm, so the average size is  $(1.2) \times 1250\text{km} = 1,500 \text{ km}$ .

Problem 5 - Students should measure about 5 granulation cells in three groups; Group 1 should be far from the center of the spot. Group 3 should be as close to the outer, tan-colored, 'penumbra' of the spot as possible, and Group 2 should be about half-way in between Group 1 and 3. The average granulation sizes do not change significantly.