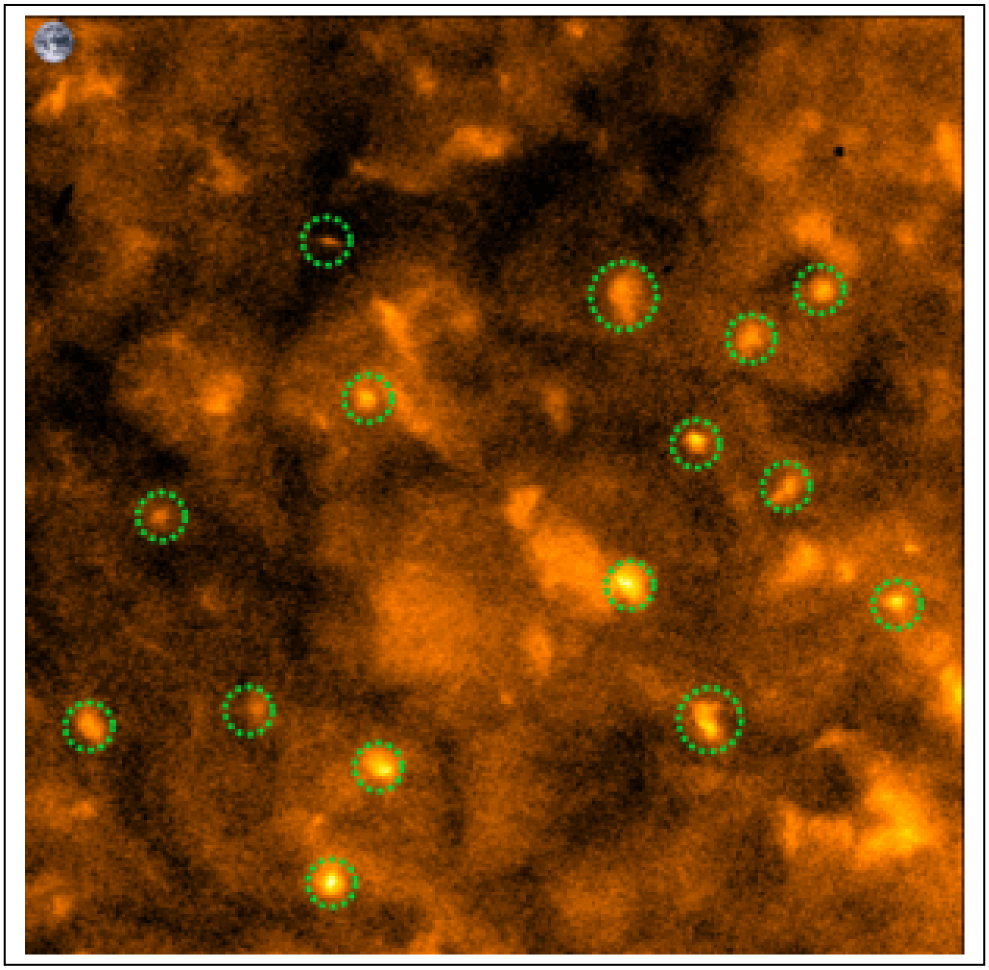
Hinode Sees Mysterious Solar Micro-flares



The Sun's surface is not only speckled with sunspots, it is also dotted with intense spots of X-ray light called 'X-ray Bright Points'. Although sunspots can be over 100,000 kilometers across and easily seen with a telescope, X-ray Bright Points are so small even the largest solar telescope only sees a few of them with enough detail to reveal their true shapes. X-ray Bright Points release their energy by converting tangled magnetic fields into a smoother ones. This liberates large quantities of stored magnetic energy. For that reason, these Bright Points can be thought of as micro-flares.

Hinode's X-ray Telescope (XRT) can now see the details in some of the Bright Points and allow scientists to see small magnetic loops. In the image above, individual bright points are circled in green. A few of them can be resolved into tiny magnetic loops. These data were taken on March 16, 2007. The image is 300 x 300 pixels in size. Each pixel views an area on the sun that is 1 arcsecond x 1 arcsecond on a side.

Problem 1: If the diameter of the Sun is 1800 arcseconds, and has a radius of 696,000 km, what is the scale of the above image in A) kilometers per arcsecond? B) kilometers/millimeter?

Problem 2: What are the dimensions, in kilometers, of the smallest circled Bright Point in the image?

Problem 3: How many Bright Points cover the solar surface if the above picture is typical?

Answer Key:

Problem 1: If the diameter of the sun measures 1800 arcseconds and has a radius of 696,000 km, what is the scale of the above image in kilometers per arcsecond?

Answer: A) The solar radius is 1800 arcseconds/2 = 900 arcseconds which physically equals 696,000 km, so the scale is 696,000/900 = 773 kilometers/arcsecond.

B) The image is 300 pixels across, which measures 115 millimeters with a ruler. Each pixel is 1 arcsecond in size, so this represents 773 km/arcsec x 300 = 232,000 km. The ruler says that this equals 115 mm, so the image scale is 232,000 km/115 mm = 2,020 km/mm.

Problem 2: What are the dimensions of the smallest circled Bright Point in the image?

Answer: With a ruler, the circled Bright Point at the top of the picture seems to be the smallest. It measures about 2 millimeters across and 1 millimeter wide. This corresponds to about 4000 x 2000 km.

Problem 3: How many Bright Points cover the solar surface if the above picture is typical?

Answer:

The sun is a sphere with a radius of 696,000 kilometers. The area of a sphere is given by $4 \pi R^2$, so the surface area of the sun is $4 \times 3.141 \times (696{,}000 \text{ km})^2 = 6.1 \times 10^{12}$ kilometers^2.

The size of the Hinode image is 300 pixels x 773 km/pixel = 232,000 km on a side. The area covered is about (232,000 km x 232,000 km) = 5.4×10^{10} km^2. Note, this is an approximation because of the distortion of a flat image attempting to represent a curved spherical surface. The actual solar surface area covered is actually a bit larger.

The solar surface is about 6.1×10^{12} km^2 / 5.4×10^{10} km^2 = 113 times larger than the Hinode image.

There are 16 Bright Points in the Hinode image, so there would be 15 x 113 = 1,695 Bright Points covering the full solar surface if the Hinode image is typical.