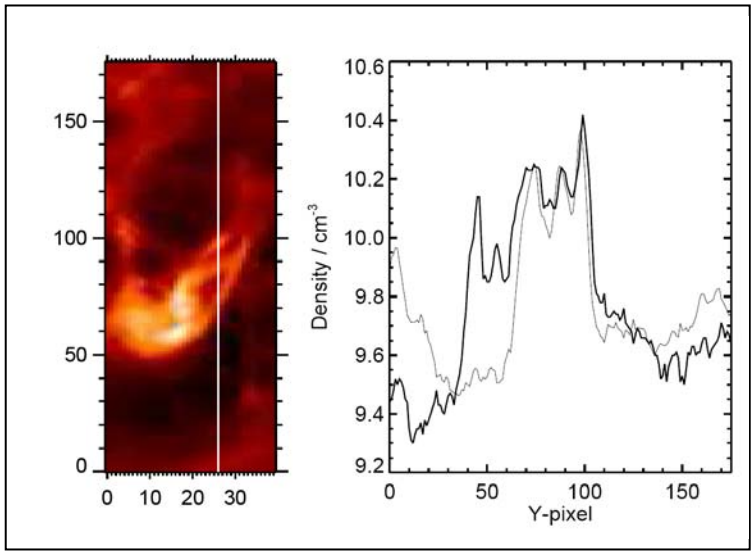
Density Structure of an Active Region

The Hinode EIS instrument has been used to study many active regions in order to determine how the density of the plasma varies through each region. One of these studies was reported by solar physicist Dr. Peter Young from the Rutherford Appleton Laboratory in England in August 2007. Below-left is an image of a coronal loop with the X and Y axes indicating the pixel number in each direction. The white line is a slice through the data at an X-pixel value of 26, and reveals the density variation in the vertical Y direction shown in the graph on the right. The density is rendered on the vertical axis in terms of the base-10 logarithm of the density value so that '10' means 10^{10} particles/cm^3



The gas densities are found by observing the same region of the sun at two different wavelengths emitted by the iron atom at a temperature near 1.5 million degrees K. *The ratio of the light intensity emitted at these two wavelengths is directly related to the density of the gas producing the light.* This shows how spectroscopy can provide vastly more information about the sun and solar activity, than what you would get from a single image alone.

Problem 1 - About what is the average density of the gas in the dark regions covered by the pixels in the range from Y=10 to Y=30? Convert answers to normal decimal units of density in scientific notation.

Problem 2 - About what is the average density of the gas in the dark regions covered by the pixels in the range from Y=140 to Y=170? Convert answers to normal decimal units of density in scientific notation.

Problem 3 - If higher gas densities tend to be found closer to the solar surface, in which part of the image may we be looking at a deeper layer of the solar atmosphere?

Problem 4 - About what is the density of the three ribbon-like features at Y= 70, Y=90 and Y=100? Convert answers to normal decimal units of density in scientific notation.

Problem 5 - What is so peculiar about the density feature near Y= 40? Can you explain what might be happening?

Answer Key:

Problem 1 - About what is the average density of the gas in the dark regions covered by the pixels in the range from Y=10 to Y=30? Convert answers to normal decimal units of density in scientific notation.

Answer: About Log D = 9.4 or $D = 10^{9.4} = 2.5 \times 10^{9}$ particles/cm^3

Problem 2 - About what is the average density of the gas in the dark regions covered by the pixels in the range from Y=140 to Y=170? Convert answers to normal decimal units of density in scientific notation.

Answer: About Log D = 9.6 or $D = 10^{9.6} = 4.0 \times 10^{9}$ particles/cm^3

Problem 3 - If higher gas densities tend to be found closer to the solar surface, in which part of the image may we be looking at a deeper layer of the solar atmosphere?

Answer: The upper end of the image has a higher density than the lower end so the upper end may be looking closer to the solar surface.

Problem 4 - About what is the density of the three ribbon-like features at Y= 70, Y=90 and Y=100? Convert answers to normal decimal units of density in scientific notation.

Answer: The log densities are LogD = 10.25, 10.25 and 10.4 respectively, for densities of $D = 1.8 \times 10^{10}$ particles/cm^3 $D = 1.8 \times 10^{10}$ particles/cm^3 and $D = 2.5 \times 10^{10}$ particles/cm^3

Problem 5 - What is so peculiar about the density feature near Y= 40?

Answer: It corresponds to a density of about Log $D = 10^{10.15}$ or $D = 1.4 \times 10^{10}$ particles/cm^3 but the picture shows a black area.

One possibility is that it is dense gas that is too faint to be emitting much light at the two wavelengths of the iron atom to be easily seen in this picture. The **ratio** of these two small intensity values could still be just large enough to indicate a large density.

For example, suppose the image only shows emission brighter than 100 units, but the two iron lines in the 'dark' region have intensities of 20 units and 5 units. The ratio would be 4.0, and indicate a large density, just as it would for a brighter region where the intensities are 400 units and 100 units and so are easily seen in the image.