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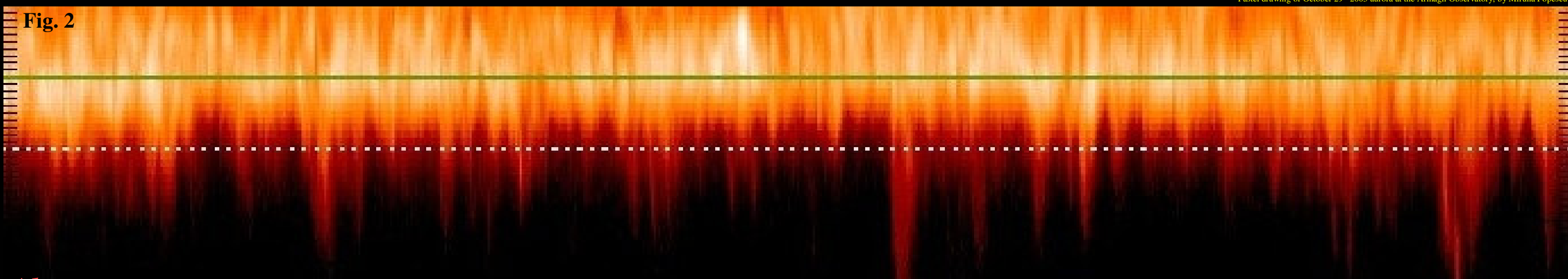
Pastel drawing of October 29th 2003 aurora at the Armagh Observatory, by Miruna Popescu

Dynamic properties of solar spicules observed by SUMER/SoHO

Fig. 2



Abstract *We present a study the dynamic properties of EUV spicules. The selected data were obtained as time series in polar coronal holes by SUMER/SoHO. The short exposure time and the almost fixed position allow the analysis of the spicule properties as: occurrence, lifetime, Doppler velocity, etc. Our data reveal that spicules occur repeatedly at the same location with a birth rate of around 0.1/min and a lifetime ranging from 15 minutes down to minutes. Most of them have a height between 10 and 20 arcsec above the limb, and some can reach a height of 20 to 40 arcsec as macrospicules. We are able to see some spicules showing a process of "falling after rising" indicated by the change of Doppler velocity signs. In addition, on the disk, the same data indicate that EUV spicules have a behaviour as brightenings, with increase of radiance and change of Doppler velocity if seen in time series radiance maps and Dopplergrams.*

Introduction

Solar spicules are traditionally seen on the limb in the Hα line. They are jet-like structures extending from the chromosphere upward into the corona, with a velocity of about 25 km s^{-1}. Typically, spicules have lengths ranging from 5 000 to 15 000 km, widths from several hundred to 2 000 km and lifetimes from 1 to 10 minutes. After having reached their maximum of height, spicules are found either falling back into the chromosphere or fading out in chromospheric spectral lines. Spicular structures can also be observed on the limb in UV and EUV wavelengths. SUMER observations showed that EUV spicules have a width of around 10 arcsec (~ 8 000 km) in the upper transition region, and disappear at a temperature above 500 000 K. It is suggested that the EUV spicules are very likely a hot sheath of the cooler Hα spicules.

Data and Observations

*The data were acquired with the **SUMER** (Solar Ultraviolet Measurements of Emitted Radiation) grating spectrograph on **SoHO** (Solar and Heliospheric Observatory).*

Data-set I (PCH1):
Date: 20 Oct. 1996
Time: 19:57 – 23:57 UTC (4 h)
Lines: N IV 76.5 nm, Ne VIII 77 nm
Exposure time: 30 sec
Detector B, Slit 2

Data-set II (PCH2):
Date: 25 Feb. 1997
Time: 00:03 – 13:58 UTC (13 h 55 min.)
Lines: N IV 76.5 nm, Ne VIII 77 nm
Exposure time: 60 sec
Detector B, Slit 2

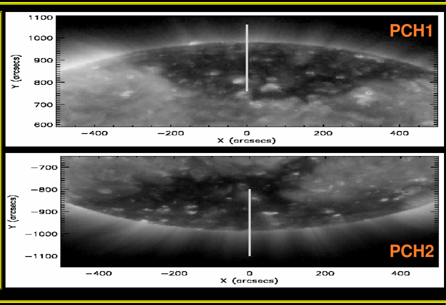


Fig. 1: The right figures illustrate the solar poles in the light emitted by the Fe XII line (19.5 nm) formed at a temperature of 1.5 MK, which was taken by EIT/SoHO. The vertical white lines in the centre show the fixed position of the SUMER slit during the observations.

Results

Fig. 2 (see colour image immediately below the title) represents the time evolution of a small region at the solar limb, inside the coronal hole (PCH2). The image is a time sequence taken repeatedly every minute for ~14 hours. Brighter colours represent higher radiance of the N IV line, originating at a temperature of approx. 140,000 K in the solar transition region.

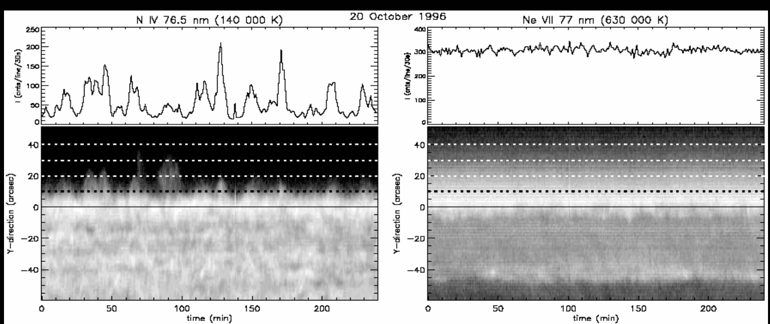


Fig. 3: The north polar coronal hole (PCH1) seen in the N IV (left) and Ne VIII (right) lines. Spicule structures are clearly seen in the transition region line N IV (140 000 K), but not in the Ne VIII line with a higher formation temperature (630 000 K). Note that the radiance varying with time is plotted for both lines at the height of 10 arcsec above the limb.

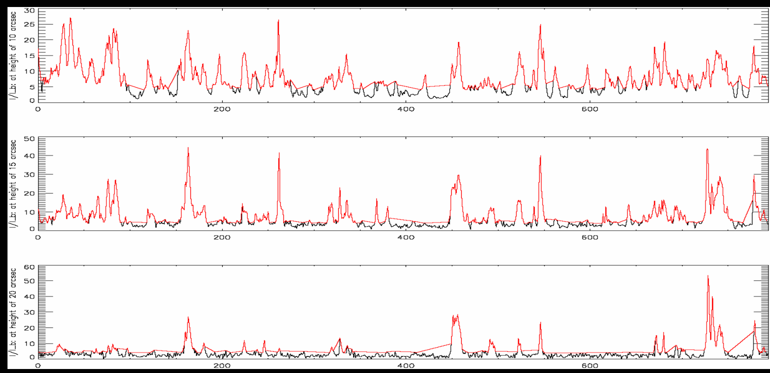


Fig. 4: Radiance ratio I/I_b (I_b is the background radiance taken from the darkest pixel at each height) versus time at heights of 10, 15 and 20 arcsec. The red curves over-plotted represent the radiance ratio larger than 4; we use them to count the number of spicules. The occurrence rate of spicules during the entire observation, viewed by eye, is estimated to be about 1.6/min below 15 arcsec and 0.07/min at 20 arcsec. We find that spicule lifetime ranges from 15 minutes down to a few minutes.

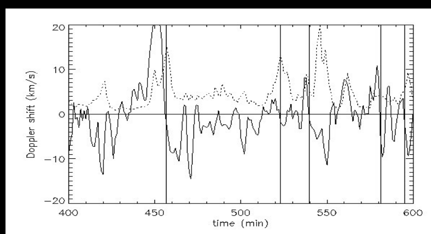


Fig. 5: *Falling after rising?* A segment plot taken from data set II (PCH2) shows Doppler shift (solid curve, relative to its average value) and radiance (dotted curve) of the N IV line varying with time. Vertical lines show locations where the velocity changes its sign. This transition of the spicule Doppler shift could be caused by the material falling after the initial rise phase.

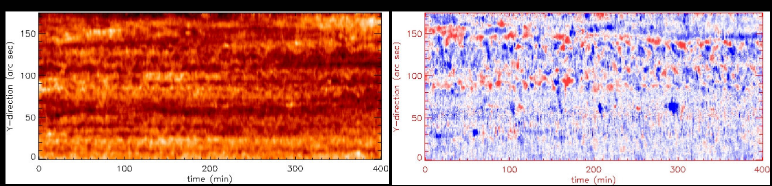


Fig. 6: *How do UV/EUV spicules look like on the solar disk?* Polar coronal hole (**PCH2**) seen in the N IV line on the disk. Left: radiance map; right: Dopplergram (full scale: ±15 km s^{-1}; Doppler shift is relative to the average value). Note the temporal change between red and blue shift in the Dopplergram and the temporal brightness variation in the radiance map. We suggest these variations are closely related to what we have seen on the limb.

Summary

• Several solar UV spicules have been seen during a single observing sequence (~14 hours). The data reveal the lifetime of spicules from 15 minutes down to a few minutes, as well as many other important dynamic characteristics of those structures, some of which have never been observed before.

• What is even more interesting about spicules is that it is still not known how they appear on the solar disc, compared to how they look at the limb. Preliminary work suggests that spicules are actually seen on the disc as brightenings, with increases of radiance and changes of Doppler velocity, which themselves are made up from bursts of jet-like features.

More detailed quantitative analysis is being done in order to establish the connection between different events (bi-directional jets, EUV brigtenings and spicules) occurring in the solar transition region.