DYNAMIC PROPERTIES OF SOLAR SPICULES OBSERVED BY SUMER/SOHO

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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 such 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 a few minutes. Most of them have a height between $10''$ and $20''$ above the limb, and some can reach a height of $20''$ to $40''$ 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.

Key words: Sun; spicules; transition region; coronal holes; EUV radiation.

1. INTRODUCTION

Solar spicules are jet-like structures extending from the chromosphere upward into the corona, with a velocity of about 25 km s^{-1}. They are traditionally seen on the limb in the Hα line. 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, respectively. Their bases lie 1 000 to 2 000 km above the photosphere, their roots being disconnect from its surface. After having reached their height maximum, spicules are found either falling back into the chromosphere or fading out in the transition region. They are estimated to cover about 1% of the Sun's surface. The temperature of spicules is inferred to be around 10^4 K, similar to that of the upper chromosphere. Their typical density is measured to be approximately 10^{11}cm^{-3}. Spicules are reported to be slightly taller and oriented more nearly vertical in polar coronal holes (CHs), and they are somewhat more numerous in polar latitudes than in low latitudes. However, the exact physical conditions of spicules are not yet well defined from observations because of their small sizes. Comprehensive reviews of spicule properties have been given by many authors – see, e.g., Beckers (1968, 1972), as well as some recent summaries given by Sterling (2000); Wilhelm (2000).

Spicule structures can also be observed above the limb in UV and EUV wavelengths (see, e.g. Withbroe 1983; Dere et al. 1983, 1989). According to SUMER observations (Budnik et al. 1998; Wilhelm et al. 2000; Wilhelm 2000), EUV spicules have a length comparable with the Hα spicules. They have a width of about $2''$ (sometimes $1''$, depending on seasonal variations, responds to 718±12 km on the Sun viewed from SOHO) when seen at chromospheric temperatures, and are wider when seen in transition region lines. Their enhanced radiance structures can be distinguishable up to a temperature of about 2×10^5 K. The line-of-sight (LOS) velocity derived from the Doppler shift has a value between ±30 km s^{-1}. In polar CHs, spicule-like structures called macrospicules due to their much higher extension are occasionally observed (see the figures in Wilhelm 2000; Wilhelm et al. 2000). The connection between the Hα and EUV spicules has not yet been established. It is suggested that the EUV spicules are very likely a hot sheath of the cooler Hα spicules (see, e.g., Sterling 2000).

In this contribution we study the dynamic properties of the EUV spicules. The data selected for this study were obtained as time series in polar coronal holes by SUMER/SOHO. The short exposure time (compared with the lifetime of spicules) and the almost fixed position (due to a reduced effect of the solar rotation in the poles) allow us to analyse their occurrence, lifetime, LOS velocity, etc. In addition, we discuss the possible relationship between EUV spicules and other phenomena observed in EUV lines on the solar disk.

2. DATA

The data were acquired with the SUMER (Solar Ultraviolet Measurements of Emitted Radiation) spectrometer on SOHO (Solar and Heliospheric Observatory). The SUMER instrument has been described in detail elsewhere (Wilhelm et al. 1995, 1997; Lemaire et al. 1997). The data selected for this study were obtained as time series in two polar coronal holes (PCHs, see Table 1). During the observation, the SUMER slit was fixed at position $x = 0''$, $y = 909.75''$ for PCH 1, and $x = 0''$, $y = -950.25''$

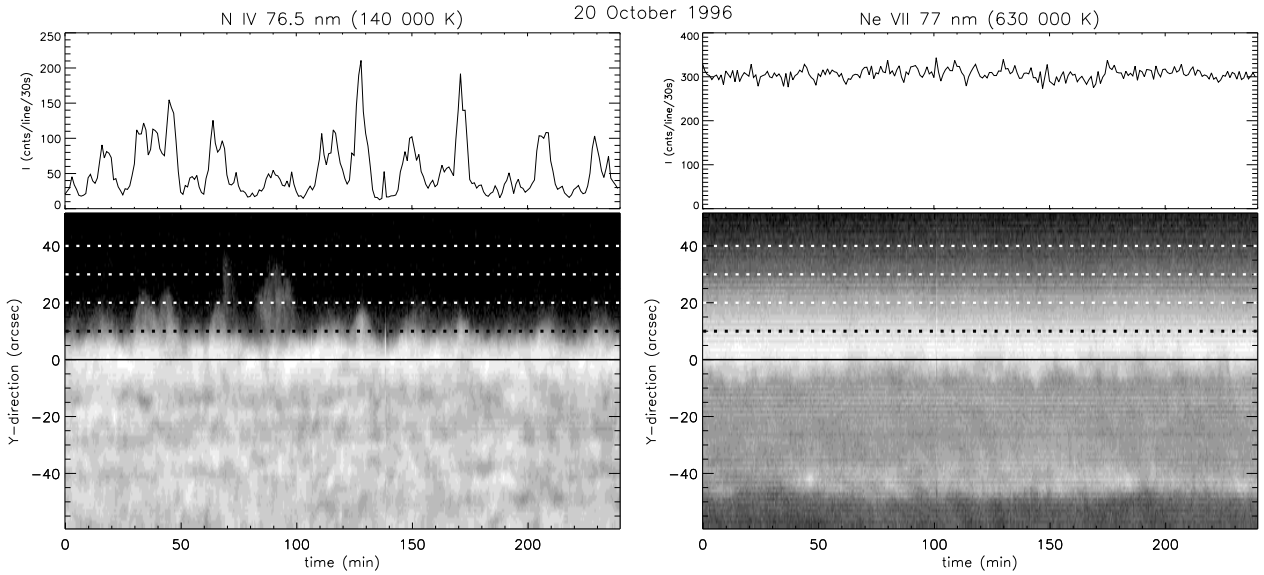

Figure 2. The north polar coronal hole (PCH 1) seen in the N IV *(left) and Ne* VIII *(right) lines. Spicule structures are clearly seen in the transition region line N* IV *(140 000 K), but not in the Ne* VIII *line with a higher formation temperature (630 000 K). The radiance, varying with time, is plotted for both lines at the height of 10″ above the limb (see top of the plots).*

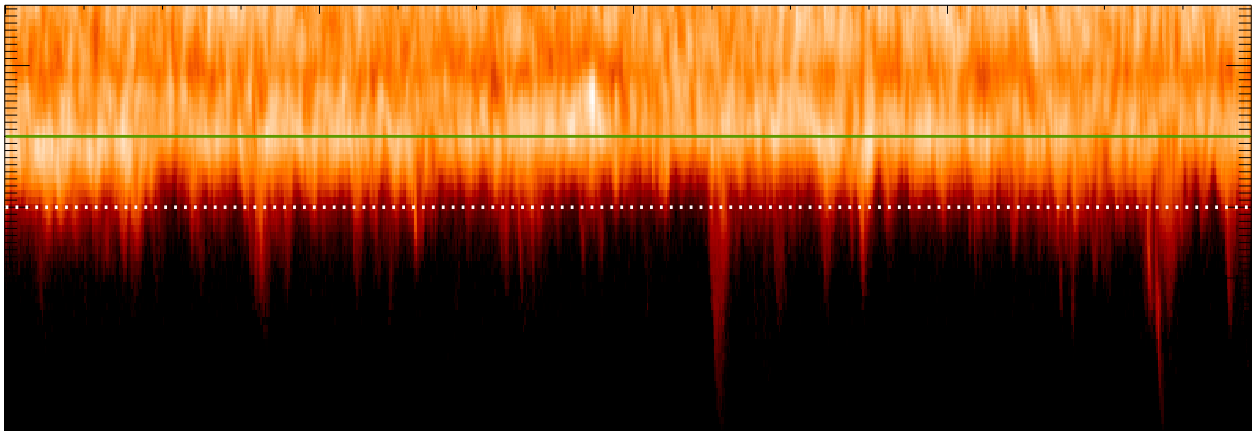

Figure 3. The time evolution of a small region at the solar limb, inside the northern coronal hole (PCH 2). The image is a time sequence taken repeatedly every minute for ≈ 14 hours. Brighter colours represent higher radiance of the N IV *line, originating at a temperature of ≈ 140 000 K in the solar transition region. The dotted white line corresponds to a height of 10″ above the limb, while the green line represents the limb.*