On the absorption of He I 10830 Å line by spicules

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Abstract. The possible applications of the time-dependent measurements of the equivalent width of the He I 10830 Å line for a better understanding of the growth of spicules and the evolution of coronal holes and x-ray bright points on the sun are discussed.

Key words: sun-spicules—He I 10830 Å

A significant fraction of the solar chromosphere is in the form of spicules. Spicules, when seen on the limb, resemble jets of cold dense gas shooting out with velocities $\sim$20 km s^{-1} and penetrating into the lower corona. Several models exist (Beckers 1972) but it is only recently that time-dependent models have been considered (Hasan & Venkatakrishnan 1981; Suematsu *et al.* 1982). A better understanding of the processes leading to the formation of spicules can be obtained if these could be observed on the disc. The earlier investigations in this direction have concentrated on the Hα line. However, this line has several drawbacks related to the fact that it is formed over a wide range of densities and can either be emitted or absorbed along the line of sight Thus the identification of the disc counterparts of spicules has remained a major problem to this day (Beckers 1981, personal communication).

The use of UV lines of highly ionized elements for such identifications is not satisfactory since most of the spicule is in the form of cool (6000 K) dense gas. This is probably the reason for the failure to detect the effects of spicules in EUV emission lines using skylab data by Vernazza *et al.* (1975). It is interesting to note in this connection that De Jaeger, Namba & Neven (1966) have identified the He-mottles with spicules.

Observations in He I 10830 Å by Giovanelli & Hall (1977) with a resolution of 2 arcsec indicate that the assumption of a uniform chromosphere is incompatible with the data. These highly resolved observations have revealed that the line-depth over supergranular cell centres ($\sim$0.021) is smaller than over the network boundary ($\sim$ 0.075). By assuming a triangular profile for the 10830.3 Å line with a width of 2 Å at the continuum, one can crudely estimate the equivalent width to be 21 mÅ at the centre and 75 mÅ at the boundary. If one further assumes that network centre is completely devoid of spicules and the boundary is filled with them, then the widths of 21 mÅ and 75 mÅ could be attributed separately to "inter-spicule" and "spicular" material.

However, spicules are not long-lived structures as is well seen from the limb observations (Kulidzhanishvili & Nikolsky 1978) Typically they begin as bright points in Hα and then quickly ($\sim$ 30 s) extend to their maximum height ($\sim$ 10,000 km) which they maintain for $\sim$5 min before fading away One would, therefore, expect the spicule to be projected over a given area on the disc only for a finite time. During such time as when the spicule exists, the absorption by the denser matter would produce an equivalent width of 75 mÅ which would drop to 21 mÅ when the spicule disappears (either by falling back or by expanding into a rarer state). With sufficient temporal (~ 1 min) and spatial resolution (~ 2 arcsec), but with only moderate spectral resolution (~ 200 mÅ), it would be possible to detect these changes in the equivalent width. The frequency of the occurrence of spicules as well as their distribution on the disc could then be studied, and used as input data for developing stochastic models for the appearance of spicules in the light integrated over the visible hemisphere of the sun. Such models in turn would be extremely useful for the detection of similar phenomena in stellar chromospheres.

A similar monitoring of the absorption of 10830 Å line on a longer time-scale (~ hours) over the boundaries of the evolving coronal holes on the sun could indicate the time-scale for change in intensity of the coronal soft x-radiation. The x-ray observations of Solodyne, Krieger & Nolte (1977) have given only an upper limit for this time-scale. If the formation of a coronal hole occurs due to a transient readjustment of the coronal magnetic field geometry, then the associated changes in density could be equally rapid (Hasan & Venkatakrishnan 1982). Thus the 10830 Å absorption measurements could give a valuable insight into the mechanism of the formation of coronal holes. The evolution of smaller structures like x-ray bright points could likewise be observed in He I 10830 Å. In this case, however, the absorption would be due to atoms excited by coronal radiation as well as by collisions in the regions heated by thermal conduction along the legs of the x-ray emitting flux-tube.

In conclusion, we have pointed out that measurements of the absorption of the He I 10830 Å line with sufficient spatial and temporal resolution could give useful information on the growth and decay of spicules as well as on the evolution of coronal inhomogeneities like the coronal holes and x-ray bright points.

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