MEASUREMENT OF THE RELATIVE INTENSITIES OF He\(\zeta\)-H8 LINES \(\lambda 3889\) Å IN THE SPECTRUM OF THE CHROMOSPHERIC SPICULES AT VARIOUS HEIGHTS ABOVE THE LIMB

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(Received 23 May; in revised form 1 September, 1977)

Abstract. A series of 31 large scale spectra of the spicules near H8-He\(\zeta\) lines \(\lambda 3889\) Å has been photographed at different heights (1500–5000 km) with 53-cm coronagraph. The solar image was 121 mm in diameter, dispersion and spatial resolution were respectively \(0.647\) Å \(\text{mm}^{-1}\) and 1–2". Equivalent widths of both lines have been measured and ratio \(R = \text{EW}_{\text{He}\zeta}/\text{EW}_{\text{H8}}\) was obtained. \(T_e(h)\) distribution in the averaged spicule deduced differs from that in the recent spicule model by Beckers (1972): the spicules are colder greatly than it was accepted hitherto \((T_e \leq 10,000\) K). The electron temperature in the quiescent prominence which occurred in the spectra was also estimated: \(T_e \approx 6000\) K at \(h = 4000\) and 5000 km.

The relative intensity of the apparent doublet of hydrogen (H8) and helium (He\(\zeta\)) at \(\lambda 3889\) Å is of special interest in determining the spicule physical condition. Because of the closeness of these lines they can be observed simultaneously and their relative intensities can easily be determined.

High resolution photography of H8–He\(\zeta\) in spicules above the limb was pioneered by Gulyaev (1965) out of eclipse with 25-cm coronagraph and spectrograph with spectral resolution about 0.06 Å. Then the relative intensities of H8–He\(\zeta\) in spicules were measured by Nikolskaya (1967) using the same coronagraph and Makarov, who used 53-cm coronagraph taking advantage of the high spatial resolution – some of the spicule features of lines under investigation were less than one second of arc in diameter (Makarova and Makarov, 1972). The average values of \(R = \text{EW}_{\text{He}\zeta}/\text{EW}_{\text{H8}}\) obtained were respectively 0.30, 0.37, and 0.24. Unfortunately these measurements refer to nearly the same height (\(\sim 3000\) km) not known exactly.

Hitherto any reliable information on the behaviour of the relative intensities of He\(\zeta\)-H8 along the spicules is not available. The estimations of values \(R\) at different heights in chromosphere made by Hirayama (1971) and Beckers (1972) from the eclipse integrated spectra seem to us unconvincing because the dispersion was too low to separate very close components of H8–He\(\zeta\) blend from each other.

The first attempt to take the photographs of H8–He\(\zeta\) in individual spicules at various heights has been made by the author and Nikolsky in summer of 1969 using
53-cm coronagraph. Because of the insufficient seeing condition the spatial resolution of the spectra was low. Therefore after a year the similar observations have been carried out again.

1. Instrument and Observations. Treatment and Analysis of the Data

Two height series of 31 spectra in the spicules near $\lambda 3889$ Å have been obtained by the author assisted by L. Demidova, who was a student of Moscow University, on 12th of July, 1970 with 53-cm coronagraph and large spectrograph at High Altitude Astronomical Station near Kislovodsk (Gnevyshev et al., 1967). Observations were carried out with the curved slit in the third order of grating with dispersion $0.647$ Å mm$^{-1}$. The diameter of the solar image on the slit jaws was 121 mm. Special orthochromatic film of high sensitivity RF-3 was utilized. Exposure time varied from 0.3 to 2 s at different heights. Spectra were calibrated absolutely by photographing the solar disk center through the step-wedge filter and the diaphragm placed just behind the main lens to diminish the effective aperture of the coronagraph by the factor 14.8. Film has been developed with Kodak-D19.

The observation procedure is far more difficult and consists of several nearly simultaneous operations, these have to be made before each frame:

1. the guiding for the coronagraph has no photoelectric pointing control;
2. the compensation of the rotation of the solar image around the center of the field of view in the slit jaw plane (due to coudé) to keep the solar limb parallel to the curved slit;
3. measurements of the heights;
4. the seeing control; all these operations are fulfilled by the visual control;
5. the frame change and the exposition.

The most important part of the observation procedure is the measurements of the heights that consists of two steps:

1. the height control during the observation using the triple line-shifter (Nikolsky, 1970);
2. estimation of the height of each spectrum from the analysis of faint chromospheric lines.

Three glass plane-parallel blocks mounted on the common axis are placed in front of the spectral slit in such a way that one of the glasses covers the middle part of the slit and two others are over the edges. The middle line-shifter is utilized for the height measurement and two others are used to keep the limb-slit parallel position.

During the observations the height control is carried out in the following way. The triple line-shifter is arranged in necessary tilt, calibrated in height. Then the spectral slit is shifted by the micrometric screw rectangularly to the limb till the photospheric spectrum within the middle line-shifter changes into the chromospheric one. It was a moment to start the exposure. In such a way the slit position can easily be found from the reading of the line-shifter inclination. For the visible