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HIGH ALTITUDE OBSERVATORY

Solar Research Memorandum No. 23

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Subject: Study of the Broadening of Coronal Lines in Active Centers

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Roberts (1) and Dolder (2), looking at spectra taken with the Climax coronagraph, have already called attention to a marked Doppler broadening of the red coronal line λ6374 in certain unusual cases, generally associated with abnormally active regions of the sun. Such regions, they noted, also exhibit sunspot-type prominences of great activity and the emission of the rarely-observed yellow coronal line λ5694. We have tried to measure the broadening and to give to it an interpretation.

(1) We have traced the spectra of the coronal regions that appear to exhibit the broadening with the new High Altitude Observatory microphotometer. We determined the resolution of the microphotometer-coronagraph combination by comparing the shapes of the D-lines of sodium (in absorption) derived from our microphotometer tracings with the shapes of the same lines in the Utrecht solar atlas.

We next derived theoretical Doppler profiles for a range of temperatures from 10^6 to 2×10^7 degree K., then applied the same "smearing" to them that affected our experimental values as a result of instrumental profiles. We then compared the resulting curves with our experimental ones. The shapes showed good fit.

(2) We also traced profiles of the coronal lines in quiet regions of the sun, choosing for the determination spectrum plates where the activity was very low. The profiles thus determined were very much narrower, corresponding to lower temperatures. We derived a mean profile from five separate quiet region tracings.

The experimentally derived half-width (width at half-intensity) for the quiet region red coronal line was 0.92 A $\pm$ 0.05, after correction for instrumental smearing. This value is in close agreement with the recent values of Lyot and Dollfus (3), which are more precise than ours.

Since the profiles have a very regular thermal Doppler shape, it is reasonable to suppose that the temperature T of the region of origin of the emission is given by the expression:

$$b = \frac{2\lambda}{c}\sqrt{\frac{2kT}{\mu m_0}\log_e 2} = 7.16\,10^{-7}\lambda\sqrt{\frac{T}{\mu}}$$

where μ is the atomic weight of the responsible atom, Fe X - 56; b is the half-width; λ the wavelength - 6374 A; m_0 is the proton mass; and the other constants are obvious.

The temperature T deduced from this equation, for the half-width of the red line and for the quiet sun is 2.3 x 10^6 degree K.

(3) We then studied a number of spectrograms in strong active regions. The results are given in the table below.

In the second column we have given the temperature T_q obtained by comparing the experimental profiles with the theoretical profiles. In the third column we have given the temperatures T_a similarly derived for the active regions. Where the wings of the line were not strictly symmetrical, as was sometimes the case, we took the mean of the temperatures which we obtained. The weakness of the line intensities and the importance of film grain would make any detailed interpretation of the asymmetries difficult and hazardous.

The fourth column gives the excess temperature of each active region over and above the temperature of the quiet regions, taken as 2.3 x 10^6 degree K in all cases.

The fifth and sixth columns give the velocities V_a and ξ corresponding to T_a and $T_a - T_q$. The velocity ξ can be interpreted as thermal or as due to motions of material either on a small or large scale. We will discuss this point in a detailed article to be published soon.

	Mean Apparent Temperature				
Date	Quiet region T_q	Active region T_a	Difference $T_a - T_q$	V_{active} km/s	km/s
14 June 1947	2.3 10^6			26	
		1.5 10^7	1.27 10^7	67	61
31 Dec. 1947		5.5 10^6	3.2 10^6	40	31
3 Dec. 1948	2.3 10^6			26	
		3.25 10^6	0.95 10^6	31	17
		4.75 10^6	2.45 10^6	37	27
24 July 1949		6.25 10^6	3.95 10^6	(43	(34
		6.50 10^6	4.2 10^6	(44	(35
7 Nov. 1949	2.3 10^6			26	
		7.0 10^6	4.7 10^6	45	37
19 Nov. 1949		5.5 10^6	3.2 10^6	40	31
2 Feb. 1950		(6.0 10^6	(3.7 10^6	(42	(33
		(5.0 10^6	(2.7 10^6	(38	(28
		(6.0 10^6	(3.7 10^6	(42	(33
		(4.0 10^6	(1.7 10^6	(34	(22
25 June 1951	2.1 10^6			25	

The different values given for the active regions of 3 December 1948 and for 24 July 1949 correspond to two different spectra for the same region. The four values for 2 February 1950 correspond to two different spectra, and to two different heights above the active region at the solar limb for each.

References

1. W. O. Roberts, Ap. J. 115, 488, 1952.
2. F. Dolder, HAO Technical Report "Solar Activity and the Yellow Coronal Line 5694A", 10 November 1952.
3. A. Dollfus, C.R. Acad. Sci., 236, 996, 1953.