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On the origin of the coronal spectrum, by *A. Pannekoek.*

In our paper on „Ionization in stellar atmospheres" (*B. A, N.* 19) we suggested that the spectrum of doubly-ionized Calcium may be found among the lines of the corona. In this case the bright line spectrum of the corona must show some relation to the spectra of Argon and of ionized Potassium, as these atoms have the same number of electrons as doubly ionized Calcium and only their nuclear charge is different. The red arc spectrum of Argon has been divided by RYDBERG (*Aph. J.* **6**, 345) into four series of lines, called *A, B, C, D,* in such a way that the wave numbers of each series show a constant difference with those of the other series: $B-A=846{,}5$, $C-B=803{,}2$, $D-C=607.3$.

In their paper „On a relation between the spectra of ionized Potassium and Argon" (*Proc. Amsterdam Acad. April* 1922) P. ZEEMAN and H. W. J. DIK have established in the same way four series of lines in the enhanced spectrum of Potassium; the three differences in wave number were all found equal to 847. That this value is found in both spectra indicates that it does not depend on the nucleus but only on the outer shell of electrons.

Now the same difference is also found in the spectrum of the corona. In the following table the lines (taken from the list of CAMPBELL and MOORE, *Lick Observ. Bulletin* **318**, 11) are collected for which the difference in wave number nearly coincides with the value found for $K+$; after each wave number roughly estimated values for its possible error are added in parentheses. For another difference of nearly 890 the instances are collected in the second part of the table. In the first group with few exceptions the first series of lines are strong or at least stronger than the second series; in the second group the second series has the greater intensity. That here such a regularity in the intensities presents itself may seem strange as in the spectra of A and $K+$ the intensities are wholly irregularly distributed over the different series. It may be, however, that in the case of pure thermal excitation regularities in the intensities appear, that are destroyed by electrical excitation in laboratory experiments. Judged by this rule the cases included in brackets seem to be doubtful; some of them must be struck out from one group also because they are better included in the other group. Among the 9 corona lines, denoted as strong or fairly strong by CAMPBELL and MOORE 6 are contained in these groups.

λ	*n**)	Int.**)	λ	*n*	Int.	ν	±	ν	±	Δν
5303,1	(alw.)	v.str.	5073	(1)	f.	18857	(1)	19712	(8)	855
4567	(8)	r. f.	4398	(3)	v. f.	21896	(4)	22737	(7)	841
[4398	(3)	v. f.	4241	(3)	f.	22737	(7)	23579	(4)	842]
4280	(3)	...***)	4130	(1)	f.	23364	(5)	24213	(8)	849
[4231,4	(17)	f. str.	4086,0	(8)	f. str.	23633	(3)	24474	(3)	841]
3643,0	(8)	r. f.	3534	(1)	f.	27450	(4)	28297	(8)	847
3455	(7)	str.	3359	(3)	f.	28944	(8)	29771	(15)	827
3328,2	(2)	f. str.	3237	(1)	....	30046	(9)	30893	(10)	847
4779	(2)	f.	4586	(3)	r. f.	20925	(4)	21805	(4)	880
4533,4	(2)	f.	4359	(7)	r. f.	22058	(5)	22941	(5)	883
4398	(3)	v. f.	4231,4	(17)	f. str.	22737	(7)	23633	(3)	896
4241	(3)	f.	4086,0	(8)	f. str.	23579	(4)	24474	(3)	895
4130	(1)	f.	3986,9	(17)	f. str.	24213	(8)	25083	(3)	870
[3648	(2)	r. f.	3534	(1)	f.	27412	(4)	28297	(8)	885]
[3388	(7)	v. str.	3288	(1)	f.	29516	(10)	30414	(15)	898]

The question whether these groups have their origin in different constituents of the corona or in the same element, cannot yet be decided with certainty; there are strong arguments in favour of a common origin, and also some difficulties. The second series of the

*) *n* denotes the number of observers having recorded the line.
**) The abbreviations stand for: very faint, faint, rather faint, fairly strong, strong, very strong.
***) Not in *Lick Bull.* 318; taken from FOWLER (*Philos. Transact.* 187), observed 1893 and 1886.

first group and the first series of the second group have two lines in common; so it seems possible to combine them to three cognate series. But now the deviation between the total differences in wave number of the corresponding lines of the third and the first series (viz 1737 and 1719) can hardly be reconciled with the possible errors of these rather well determined lines. It is also remarkable that just the second, faint series sould be more complete than either of the strong series; moreover the blank places in the first and third series now spoil the regularity in intensity just spoken of. In searching for pairs of lines of the first and third series, for which the second series is missing, we find only one case: the lines 3601.3 ($n=5$, pretty strong) and 3388 ($n=7$, very strong) have wave numbers 27768 (± 4) and 29516 (± 14) with a difference 1748. This accounts for two more among the strong coronal lines; but the deviation in $\Delta\nu$ is now made still larger. The one strong line left is 6374.2 in the red end of the spectrum. We may thus propose as a hypothetical system of series in the spectrum of *Ca*++ the following scheme. It is connected with the spectra of *A* and *K*+ not only by the first differences being all equal to 847, but also by the second differences (803 for *A*, 847 for *K*+, 890 for *Ca*++) forming an arithmetical progression. The fourth series may be absent by extreme faintness under the conditions prevailing in the solar environment. It may also be that it is represented by the lines 4244.8 ($n=2$, *f*) and 3891 ($n=1$, *f*) ($\nu=23558\pm 8, 25700\pm 10$) showing the same difference $\Delta\nu=617$ with lines of the third series; we have added them to the system of series as a still more hypothetical part. The difference between the line 5536 ($n=2$, *f*) ($\nu=18064\pm 6$) and the red line 6374.2 ($\nu=15689\pm 3$) $\Delta\nu=2375$ deviates certainly too much from the sum total $847+890+617=2354$ to place it also in this fourth series. The four series are given in the following table, where the lines denoted as strong are printed in heavy type and the differences in wave number are placed in the columns between the wave lengths.

As the bright line spectrum of the corona seems to be variable, some connection between the lines visible at the same time and these series might be presumed. There are indeed some indications of such a connection; the conspicuous lines 3987, 4086 and 4231 behaving in the same manner and having a distribution different from 5303, are united in the

E		*F*		*G*		*H*
(6374,2)					2375	(5536)
5303,1	855	5073				
		4779	880	4586		
		4533,4	883	4359	617	4244,8
4567	841	4398	896	**4231,4**		
		4241	895	**4086,0**		
4280	849	4130	870	**3986,9**	617	3891
3643,0	847	3534				
3601,3			1748	**3388**		
3455	827	3359				
3328,2	847	3237				

third series, while 3601, agreeing with 5303, belongs with it to the first series. But 4359 was invisible in 1908 when 4086 was very strong; and in 1918 the coronal rings at 3455 and 3643 had a form different from 5303 and 3388. Among the faint lines of the second series some have only been observed in 1905, others only in 1908 or 1918. In the earlier eclipses quite other lines (e. g. 4217 and 4486) are reported. Thus on the whole such a connection between the visibility of the lines and our series cannot yet be stated. Long exposure photographs of the spectrum of the corona with high dispersion in future eclipses, in order to register the faintest emissions and to give very accurate wave lengths, will be necessary to establish the system of spectral series with more certainty and at the same time to clear up the causes of the variability of the coronal spectrum.

The relations found here make it highly probable that the main part of the bright line spectrum of the corona is caused by doubly ionized Calcium.*) From the list of CAMPBELL and MOORE all lines between 4586 and 3891 are contained in our table; only some lines with greater wave length and a greater number between 3891 and 3455 (among them the never missing line 3801) are not included in it. In order to decide whether they indicate the presence of other elements, it will be necessary to produce the spectrum of doubly ionized Calcium by laboratory experiments and to investigate its series by exact measures of wave length.

*) By this origin the intimate association between the prominences (consisting in their highest parts of *Ca* +) and the coronal wings and streamers (lately emphasized by Major W. S. LOCKYER, *Monthly Not. R.A.S.* 82, 330) becomes at once intelligible.