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THE SPECTRUM OF ζ PUPPIS.

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THE announcement was made in *Circular* No. 12 that the spectrum of the star ζ Puppis contained, in addition to the usual series of lines due to hydrogen, a second series of rhythmical lines. A remarkable relation exists between these two series, from which it appears that the second series, instead of being due to some unknown element as was at first supposed, is so closely allied to the hydrogen series, that it is probably due to that substance under conditions of temperature or pressure as yet unknown. The wave-lengths of the lines of hydrogen may be computed by the formula $\lambda = 3646.1 \frac{n^2}{n^2 - 16}$ which is the formula of Balmer, slightly modifying the constant term so that the standard wave-lengths of Rowland shall be represented, and substituting $\frac{1}{2} n$ for m. The wave-lengths of the lines of hydrogen may be determined by this formula if we substitute for n the even integers 6, 8, 10, 12, etc.

In the annexed table the values of n, the designations of the corresponding lines of hydrogen, their computed wave-lengths, their observed wave-lengths, and the observed minus the computed values are given in the first five columns. If now we substitute for n the odd integers 5, 7, 9, 11, etc., we obtain the wave-lengths of the second series of lines in the spectrum of ζ Puppis, as is shown in the second part of the table. The sixth column gives the value of n, the seventh the corresponding computed wave-length, and the eighth and ninth the wave-lengths of the lines in ζ Puppis as derived from two series of measures. Miss A. J. Cannon has found that the same series of lines occurs in the star 29 Canis Majoris (*H. P.* 1380) whose position for 1900 is R. A. $= 7^h\ 14^m.5$, Dec. $= -24^\circ\ 23'$. As this star has the magnitude 4.8, only three lines of the series are measurable in the photographs so far taken, but, unlike ζ Puppis,

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many additional lines are present. Measures of the lines common to ζ Puppis are given in the tenth column of the table and the observed minus the computed values for the two stars are given in the last three columns.

n	Des.	Comp.	H	O—C
4	- -	∞	—	....
6	$H\alpha$	6563.0	6563.0	0.0
8	$H\beta$	4861.5	4861.5	0.0
10	$H\gamma$	4340.6	4340.7	—0.1
12	$H\delta$	4101.9	4101.8	+0.1
14	$H\epsilon$	3970.2	3970.2	0.0
16	$H\zeta$	3889.2	3889.1	+0.1
18	$H\eta$	3835.5	3835.5	0.0
20	$H\theta$	3798.0	3798.1	—0.1

n	Comp.	ζ	ζ	29	ζ	ζ	29
5	10128.1	.....	.....	.....	.....	.....	.....
7	5413.9	.....	.....	.....	.....	.....	.....
9	4543.6	R	R	R	.....	.....	.....
11	4201.7	4199.2	4201.6	4201.1	—2.5	—0.1	—0.6
13	4027.4	4027.1	4026.5	4025.4	—0.3	—0.9	—2.0
15	3925.2	3924.6	3924.9	.....	—0.6	—0.3	.....
17	3859.8	3858.7	3858.6	.....	—1.1	—1.2	.....
19	3815.2	3814.7	3817.2	.....	—0.5	+2.0	.....
21	3783.4	.....	3783.4	.....	.....	0.0	.....

The wave-lengths here given depend upon the lines of hydrogen and were determined from them by a form of graphical interpolation. The interval between $H\beta$ and $H\gamma$ is so great that the errors of interpolation are large for lines in that part of the spectrum. These errors are still greater in the approximate measures given in *Circular* No. 12, although the results there given for the five lines of the series of shorter wave-length than $H\gamma$ agree closely with those given above. Comparing the spectrum of ζ Puppis with the spectra of other stars, it appears that the four lines between $H\gamma$ and $H\beta$ probably coincide with the lines having wave-lengths 4472, 4544, 4633, and 4688. The first of these lines is very faint and appears to coincide with the

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principal line distinguishing stars of the Orion type. The second line is well marked and is the line computed above when $n=9$. The third and fourth lines are bright and coincide with the principal lines in spectra of stars of the fifth type. These four lines are also present in 29 Canis Majoris. Several of the lines in the above table appear bright in stars of the fifth type. Thus in *H. P.* 1311 the lines for which n equals 8, 9, 10, 11, 12, 13, and 14 are bright. In γ Velorum these lines are also present, some being bright and some dark. The line for which $n=7$ is one of the most conspicuous in the visual spectra of stars of the fifth type. Its wave-length has been found by Campbell to be 5412.4, which agrees closely with the computed value 5413.9. He also finds the line 4540, which is probably identical with the line for which $n=9$. From photographs recently taken at Arequipa, but not yet received at Cambridge, it is expected that the wave-lengths of all these lines can be accurately determined.

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