THE RADIAL VELOCITIES OF THE BRIGHTER STARS IN THE *PLEIADES*.

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THE only attempt which has hitherto been made to determine either the relative or absolute radial velocities of the stars in the *Pleiades* group is that of Pickering,[1] who used an objective prism, and found that the relative motion of the seven brightest stars is probably less than 30km a second. The great difficulty in the way of such a determination, and the one which has led to the neglect of these important stars in modern radial velocity work, is the character of their spectra. These are of the advanced helium type, as Miss Clerke well designates them, and it is in this type that the greatest difficulty is found in securing lines upon which accurate measurements can be made; the helium lines having lost the strength and relatively well defined character which they possess in the representative helium stars, while the type is not sufficiently advanced to show, to any measurable extent at least, the metallic lines which are characteristic of the Sirian stars.

It is clear that in dealing with spectra of this nature the best results are to be expected from the use of comparatively low dispersion. The loss of scale in the plates is more than counterbalanced by the superior definition and increase in apparent strength of the lines present, and the gain in the extent of measurable spectrum is of very great importance in the case of spectra in which the lines are so extremely limited in number. An interesting comparison of results in a case of this nature is given by Hartmann[2] for δ *Orionis*, and his conclusions may be applied with still more emphasis to the stars in the *Pleiades*, since the lines present are considerably weaker and more diffuse than in δ *Orionis*. An exception should be made here in the case

[1] ASTROPHYSICAL JOURNAL, 4, 372–3, 1896.

[2] *Sitzungsberichte der Kgl. Akad. der Wissenschaften zu Berlin*, 14, 14, 1904.

of *Maia* (20 *Tauri*), the spectrum of which can be studied to advantage with high dispersion. Reference will be made later to the characteristic features of its spectrum.

All of the plates used in this investigation, with two exceptions, were obtained with the Bruce spectrograph modified for use with one prism, a form in which it has been employed for a large part of the radial velocity work during the past year. The remaining two plates, both of *Maia*, were obtained with the regular three-prism train. The scale of the low-dispersion plates for the position of minimum deviation at $\lambda 4480$ is .1 mm = 30 tenth-meters, and the extent of spectrum within which measures have been made is from the helium line at $\lambda 4026$ to $H\beta$ at $\lambda 4862$.

Six stars are included in this discussion, for all of which at least three plates have been obtained. It was originally intended to include *Pleione* and *Celaeno* as well, but unfortunately the lack of suitable observing weather has made this impossible. The remarkable character of the spectrum of *Pleione* would make the investigation of this star of particular interest.

In view of the extreme difficulty of the measures involved, it has seemed best to repeat so far as possible, and accordingly duplicate measurements have been made throughout. Every effort has been used to keep these entirely independent: the second measurement has always been at a considerable interval after the first so that there might be no tendency on the part of the observer unconsciously to carry in his mind any recollection of the estimated positions of the lines involved. This is a matter of considerable importance in the case of such spectra as those of the *Pleiades*, since the excessively broad and ill-defined character of the lines occasionally gives rise to an option in the estimated position of a line, and complete independence of judgment in such a case is essential to guard against systematic error.

The wide range in the quality of the lines measured has made some process of weighting necessary, and accordingly the procedure has been adopted of assigning a weight to each line at the time of measurement, and combining these weights to form

the result given by the plate.[1] In the case of two measurements of the same plate, however, the simple mean of the two results has been taken as the final value. The difference in the number of lines measured in such cases is usually small, and the additional lines included are invariably of low weight, and would affect the result but slightly.

The table which follows gives the results for five of the stars. In addition to the name of each star, Bessel's number is added for convenience in reference. The magnitudes given are those of the *Harvard Photometry*. The velocities are, of course, in all cases referred to the Sun.

Electra (17 *Tauri*); Mag. 3.8.

Plate	Date	First Measure		Second Measure		Mean Velocity
		Velocity	No. of lines	Velocity	No. of lines	
		km		km		km
IB 110	1903, October 10	+16.2	4	+17.5	4	+16.8
165	October 30	11.0	5	15.4	5	13.2
271	1904, January 29	12.7	4	14.4	3	13.5
						Mean +15

Taygeta (19 *Tauri*); Mag. 4.4

IB 257	1904, January 23	+4.5	5	+4.1	4	+4.3
295	March 19	3.9	6	1.5	6	2.7
303	April 15	2.6	5	1.8	4	2.2
						Mean +3

Merope (23 *Tauri*); Mag. 4.2

IB 234	1903, December 27	+6.0	4	+6.7	5	+6.4
293	1904, March 19	3.9	5	6.0	6	5.0
313	April 16	8.4	4	6.7	4	7.5
						Mean +6

Alcyone (25 *Tauri*); Mag. 3.0

IB 164	1903, October 30	+16.4	3	+18.3	4	+17.3
216	December 4	12.3	5	15.5	3	13.9
221	December 25	14.8	4	11.8	5	13.3
						Mean +15

[1] See Frost and Adams, "Radial Velocity of Twenty Stars Having Spectra of the *Orion* Type." *Publications of the Yerkes Observatory*, **2**, 151, 1903.

Atlas (27 *Tauri*); Mag. 3.8

IB 163	1903, October 30	+ 15.6	4	+ 12.4	5	+ 14.0
220	December 25	11.5	3	13.3	5	12.4
272	1904, January 29	14.7	4	14.5	3	14.6
282	February 26	9.5	6	9.9	4	9.7

Mean + 13

So far as any estimate can be formed of the degree of accuracy of the above determinations, it is probable that those for *Taygeta* are most accurate, and those for *Merope* least so, with little to choose among the other three stars. The conclusion in regard to *Taygeta* is due to the fact that its spectrum differs sensibly from that of the other stars in the list, the lines being stronger and narrower as well as slightly better defined. None of the plates of *Alcyone* show evidence of the presence of a bright line at $H\beta$.

The observations of *Maia* lead to the interesting conclusion that the velocity of this star is variable. Seven plates have been obtained, as indicated in the list which follows. B 545 and B 552 were taken with a dispersion of three prisms.

Maia (20 *Tauri*); Mag. 4.0.

Plate	Date	First Measure		Second Measure		Mean Velocity
		Velocity	No. of lines	Velocity	No. of lines	
		km		km		km
IB 166	1903, October 30	− 7.0	5	− 7.8	4	− 7.4
219	December 25	+ 21.0	2	+ 20.8	5	+ 20.9
235	December 27	− 6.5	4	− 4.0	5	− 5.2
244	1904, January 2	+ 0.8	7	+ 7.8	4	+ 4.3
B 545	January 9	+ 1.7	6	+ 2.3	7	+ 2.0
IB 294	March 19	+ 10.0	9	+ 7.8	8	+ 8.9
B 552	March 25	+ 2.0	6	+ 1.5	4	+ 1.8

Though the range here indicated is not very large, the character of the spectrum fortunately is such as to make it almost certainly real. The lines without exception are greatly superior to those in the spectra of any of the other stars in the list for purposes of measurement, the hydrogen lines being strong and narrow, and the magnesium line at λ 4481 well defined. The spectrum is, in fact, decidedly at variance with what we should expect

for a star closely involved in nebulosity, and is in marked contrast to that of the similarly situated star *Merope*. This fact, considered in connection with the low absolute velocity which an inspection of the measures indicates with reasonable certainty for the system of *Maia* (assuming its binary character to be proven), may perhaps warrant the suspicion that this star as well as its neighbor *Taygeta*, is not physically connected with the nebulosity. On the other hand, the character of the spectrum of the remaining four stars is precisely of the sort which is encountered among nebulous stars, and would furnish a strong presumption in favor of their connection with the nebulosity in this case. As is well known, the proper motions of all the brighter stars in the *Pleiades* are small. Newcomb[1] finds for *Alcyone* the annual proper motion

$$\Delta\alpha = +0''.0132;\ \Delta\delta = -0''.0587;\ \text{in a great circle } 0''.060;$$

and this motion is found to satisfy the remaining stars within the limits of error of the observations. A similar conclusion is reached by Elkin[2] as to the absence of relative motion among the bright stars of the group. The small value of the radial velocity of *Merope* would seem to argue against its association with *Alcyone*, *Atlas*, and *Electra*, but, in view of the low degree of accuracy attained in its determination, the argument is by no means strong.

The following brief summary of the results for the stars which we have considered here may be of convenience:

Electra	+ 14 km
Taygeta	+ 3
Maia	Variable
Merope	+ 6
Alcyone	+ 15
Atlas	+ 13

In conclusion, emphasis should once more be laid upon the character of measures on spectra of this nature. It is certainly not too much to say that ranges of at least 5 km between succes-

[1] *Standard Clock and Zodiacal Stars.*

[2] "Relative Positions of the Principal Stars in the Group of the *Pleiades*." *Transactions of the Astronomical Observatory of Yale University*, 1, Part 1, 1887.

sive plates of the same star, or between duplicate measurements of the same plate, may well be expected in the case of any one of the stars in the above list, except perhaps *Maia* and *Taygeta*. Accordingly, care should be taken not to draw conclusions from accordances which may easily be illusory.

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