Note VI. on Double Stars. By M. Yvon Villarceau.

η Coronæ Borealis.

"The double stars whose elements may be regarded as approximately ascertained are four in number, viz. *ξ Ursæ Majoris*, *p Ophiuchi*, *ζ Herculis*, and *η Coronæ*. This number will be further reduced to three, if the double solution which I have announced in the *Comptes Rendus*, tome xxviii. p. 411,* should hold good till the present time. The object of this Note is to fix the one of the two solutions of the orbit of *η Coronæ*, which ought definitively to be adopted."

"It will be recollected that the ambiguity which I encountered arose from the circumstance that the two components of the system have so close a physical resemblance to each other, that it is impossible to distinguish the one from the other except by their relative positions. This distinction, which is possible when the positions compared differ slightly from each other, or are separated by a short interval of time, ceases to be so when they refer to distant epochs which do not embrace any intermediate observation. This difficulty presents itself in the case of two observations of Sir William Herschel made in 1781 and 1802, and distant from each other twenty-one years. An equal interval of time separates the latter from the epoch of 1823, whence commences a series of observations, extending without interruption down to the present day. The question arises, Ought the observations of Sir William Herschel to be employed in the same way as they have been originally presented, or ought they to be *reversed*, that is to say, modified to the extent of 180°? The condition of representing them by the same system of elements as the modern observations can alone decide this alternative."

M. Villarceau remarks, that by preserving the position of 1802 in his former researches, he was obliged to reverse that of 1781, and was hence conducted to an orbit characterised by a revolution of about sixty-six years, which no one had hitherto suspected. On the other hand, reversing the observation of 1802, and preserving that of 1781, he obtained an orbit of about forty-three years. This is the orbit which had been already announced by astronomers, and which is to be found in the greater number of the works which treat of the subject of double stars. Although a minute discussion of the physical circumstances of the two observations of Sir William Herschel suggested probabilities in favour of the orbit of sixty-six years, still, as a comparison of the two orbits did not assign any serious reasons for preferring either orbit, it was deemed expedient to refer to another epoch the question to be decided between the

* See also *Additions à la Connaissance des Temps pour* 1852.

two solutions. The year 1853 was fixed upon for this purpose; but it was announced by M. Villarceau that the two orbits might possibly be separated before that time, if the optical power of the great refractor of Pulkowa admitted of the observations being continued, notwithstanding the close approach of the component stars.

"The observations," says the author, "have been, in fact, continued till this time, and the interest excited by the subject has induced Messrs. Lassell and Hartnup to make observations in England, which they have had the kindness to communicate to me. Mr. Dawes has also been kind enough to transmit to me a series of unpublished observations, extending for η *Coronæ* down to 1849 inclusive. This circumstance enables me to present already the results which I have arrived at in so far as regards the choice between the two orbits. I have also availed myself of the new observations to correct the elements of the definitive orbit, the occasion for executing which process I pointed out at the conclusion of my first communication."

"At the first glance it was easy to see that the series of observations made since the year 1847 could not agree with the orbit of 43 years. I accordingly applied myself to the correction of the elements of the orbit of 66 years. There now occurred a difficulty which the insufficiency of the data had prevented me from encountering in my former researches, and which had already presented itself in my investigation of the orbit of ζ *Herculis*, but in a form less pronounced; I refer to the employment of distances in determining the orbits of stars so close to each other. Determining the elements of ζ *Herculis* by the aid of angles of position alone, I succeeded in representing these angles satisfactorily enough, but the distances exhibited systematic errors. Employing simultaneously the angles of position and the distances, the latter were better represented, but systematic errors appeared in the angles of position."

"In my new researches upon η *Coronæ* an attempt to correct the elements, by employing simultaneously the angles of position and the distances, has conducted me to results which leave strongly-pronounced and inadmissible errors in the comparison of the angles of position. Taking into consideration the great precision of the measures of the angles of position, I then resolved to employ solely the latter, and to reserve the measures of distance for the determination of the semi-axis major alone. On this point I may remark, that five measures of distance executed by M. W. Struve from 1826 to 1835 exceed $0''{\cdot}7$; while seventeen other measures, executed subsequently by the same astronomer and by M. Otto Struve and M. Mädler, are comprised between $0''{\cdot}6$ and $0''{\cdot}4$. When any other elements beside the semi-axis major are to be deduced from the measures of distance, the results depend especially *upon the variations of distance.* Now it is evident that the variations of distance comprised between $0''{\cdot}6$ and $0''{\cdot}4$ are quite comparable with the errors that may affect measures of such delicacy. With respect to the other five distances comprised between $0''{\cdot}7$ and

1″·15, the employment of their variations also presents difficulties to which I shall presently refer. I have consequently been induced by these considerations to employ exclusively the angles of position in the correction of all the elements except the semi-axis major."

M. Villarceau has determined the semi-axis major of the orbit from the measures of distance executed by M. W. Struve, M. Otto Struve, and M. Mädler. With respect to the distances of M. W. Struve, which are less than 0″·8, and which, as in all other similar cases, were obtained by mere estimation, M. Villarceau has applied to them a small correction, the necessity of which was suggested to M. Struve by experiments on the distances of artificial stars, and originally announced by him in his *Mensuræ Micrometricæ*. M. Villarceau has also found it necessary to apply a similar correction to the distances comprised between 0″·4 and 0″·6 which were observed by M. Otto Struve, at Pulkowa; and also to two observations of distance executed by M. Mädler, at Dorpat.

The observations of angles of position which have been employed in correcting the elements of the orbit of η *Coronæ*, are in number 37, comprising all those with which the author was acquainted. The equations of condition have been treated by the method of least squares. The following are the new elements deduced :—

Passage of the Perihelion	1779·338; 1846·647	
Mean Annual Motion	5°·3484	
Angle of Excentricity	23° 51′·0	
Longitude of the Ascending Node	9° 52′·3	Counted from the Meridian of 1850.
Longitude of the Perihelion	194° 51′·9	
Inclination	±59° 18′·6	
Semi-axis Major	1″·2015	

Whence

	yrs.
Period of Revolution	67·309
Excentricity	0·40433

These elements differ only in a slight degree from those given in the *Connaissance des Temps* for 1852. The greatest angular difference, that relative to the position of the node, is 5° 31′; the time of revolution has been augmented by about a year; and the date of the passage of the perihelion by about three months.

The following numbers exhibit the results of a comparison of the corrected elements with the totality of the observations. In the column of observers, the names of the two Herschels are denoted by W. H. and J. H.; those of the Struves by W. S. and O. S.; the affix J. H. and S. indicates the joint observation of Sir John Herschel and Sir James South. The names of Messrs. Dawes, Hartnup, Lassell, and Mädler, are denoted by the letters D, H, L, and M.*

* The Table of M. Villarceau is more complete than that given in the text; but we are compelled from want of space to omit several of the columns.—Ed.

Date.	Observer.	Observed Angle of Position – Cal. Angle. Dihedral.		In Arc.	Cor. Distance – Cal. Dist.
		°	′	″	″
1781·7	W. H.	−0	12	−0·002	—
1802·7	id.	+1	5	+0·028	—
1823·3	J.H.&S.	−1	33	−0·038	—
1826·8	W. S.	+0	24	+0·008	−0·055
1829·6	id.	+0	19	+0·006	−0·061
1830·3	J. H.	−1	11	−0·020	−0·151
1831·4	D.	+1	10	+0·018	—
1831·4	J. H.	+2	12	+0·034	—
1831·6	W. S.	−0	38	−0·010	+0·019
1832·5	J. H.	+1	8	+0·016	—
1232·6	D.	+0	45	+0·011	—
1832·8	W. S.	−0	14	−0·003	+0·027
1833·3	J. H.	+1	53	+0·025	—
1833·4	D.	+2	36	+0·034	—
1835·4	W. S.	−2	23	−0·026	+0·157
1836·5	id.	+0	39	+0·006	+0·089
1837·5	W.&O.S.	−4	7	−0·038	−0·025
1838·4	id.	−5	17	−0·048	−0·028
1839·8	O. S.	−3	45	−0·035	+0·144
1840·5	O. S.	−1	46	−0·017	+0·073
1841·4	M.	+0	25	+0·004	+0·010
1841·5	O. S.	+0	31	+0·005	+0·041
1842·2	M.	+0	1	0·000	−0·006
1843·3	O. S.	−2	44	−0·031	+0·003
1845·6	W.&O.S.	−2	2	−0·025	−0·051
1846·6	O. S.	+1	45	+0·022	−0·070
1846·9	D.	+2	41	+0·033	—
1847·6	O. S.	+2	8	+0·026	−0·093
1848·0	D.	+1	41	+0·020	−0·025
1848·7	O. S.	−0	22	−0·004	−0·054
1849·4	D.	+3	45	+0·041	+0·073
1849·7	O. S.	−1	54	−0·020	+0·007
1850·5	id.	−4	3	−0·040	−0·017
1851·4	H.	+1	7	+0·010	—
1851·4	L.	+3	9	+0·029	—
1851·6	O. S.	−5	0	−0·045	+0·009
1852·6	id.	+4	41	+0·040	+0·032

"We now proceed," says the author, "to explain the mode in which we have determined the semi-axis major. The other elements obtained by means of the angles of position alone enable us to calculate the different values of the ratio of the distance to this element. Let ϱ' denote this ratio, A the semi-axis major, A ϱ the distance observed and corrected conformably to the indications of M. Struve, we have then for each observation of distance an equation of the form $\varrho = \varrho' A$.

"Treating by the method of least squares the totality of the equations founded on the observations of M. W. Struve, and submitting to a similar process the observations of M. Otto Struve and M. Mädler, we obtain the three following equations:—

By 8 Observations of M. W. Struve.....	4·3217″ = 3·5770 A;	whence	A = 1·2082″
12 — of M. O. Struve.....	3·7067 = 3·1063 A;	—	A = 1·1933
2 — of M. Mädler	0·5908 = 0·4903 A;	—	A = 1·205
By the totality of 22 Observations.....	8·6192 = 7·1736 A;	—	A = 1·2015

"The greatest deviation of these three determinations from the final result is only 0″·008. So close an agreement tends to justify the application which we have made to the observations of MM. Otto Struve and Mädler, of the corrections which were legitimately applicable only to those of the elder Struve."

"The two measures of distance obtained by Mr. Dawes were omitted, because, in consequence of the feeble optical power of his

instruments compared with those of Dorpat and Pulkowa, the measures of very small distances did not seem to be readily comparable with those made in Russia. Still the errors — 0″·025 and +0″·073 deduced from a value of the semi-axis major obtained without employing the observations of Mr. Dawes, show that the observations of that distinguished astronomer are not so far from being comparable with those of MM. Struve as one would at first have supposed. The semi-axis major which the two measures of Mr. Dawes give is 1″·241,—a value which differs only by 0″·040 from the definitive value. Moreover, it is to be borne in mind that this result being deduced from quantities which are almost a half less than the result obtained, the influence of errors of observation is almost doubled."

"It will be seen from the foregoing table that the greatest residual error of the angle of position reduced to arc does not exceed 0″·048. Their totality gives for the probable error of an angle of position expressed in the same way 0″·0188. Now M. Struve has established that the probable error of the mean of three observations of angle of position reduced to arc varies from 0″·018 to 0″·028 for the distances comprised between 0″·70 and 1″·48. The result above given accords very well with the experimental determinations of M. Struve.

"There appear, in the foregoing table, traces of a systematic error between the epochs 1837 and 1840. It is to be remarked, however, that this interval comprises *a passage of the apparent perihelion;* besides, there are no other observations than those of MM. Struve. Again, from 1846 to 1848 there appear several errors affected with the same sign, but which, however, are very small. Finally, the rather sensible errors of the two last observations may be attributed to the close approach of the two stars; for the companion is advancing towards the apparent perihelion which it ought to have passed in 1853·377, the distance being reduced at that epoch to 0″·484."

"It now remains to show how the orbit of forty-three years satisfies the observations. We shall confine ourselves to a comparison of the two last observations of M. Otto Struve with the elements (second solution) published in the *Connaissance des Temps* for 1852. The result of this comparison is:—

Date.	Obs. Angl.—Cal. Angl.	Obs. Dist.—Cal. Dist.	Cor. Dist.—Cal. Dist.
	°	″	″
1851·56	— 104·71	— 0·035	+ 0·083
1852·62	— 91·30	— 0·213	— 0·093

"A more approximate value of the deviations of the two orbits may be obtained, in so far as the angles of position are concerned, by eliminating from the observations of M. Otto Struve the errors indicated by the comparison exhibited above. In this manner here results:—

	° ′	
1851·56;	— 99 7	
1852·62;	— 96 11	
or about	— 97 5	for the beginning of 1852.

"Now, a discordance of this magnitude cannot be made to disappear by a slight change in the elements. We are then authorised to reject the orbit of forty-three years of revolution, and to consider the orbit of sixty-seven years as being that which the companion of η *Coronæ* really describes.

"The revolution of 67·309 years does not appear to me to be susceptible of being sensibly modified by ulterior observations, seeing that the position corresponding to the ancient observation of Sir William Herschel has been attained and surpassed within the last few years. The period of revolution is henceforward affected only by an uncertainty, at the utmost equal to the time during which an angle of position would be described corresponding to the algebraic difference of the mean error of the modern observations and that of Sir William Herschel. It will be easily seen that this uncertainty cannot exceed a year. Now, the number 66·257 years already satisfies the totality of the observations anterior to 1848. It is plain, therefore, that the true time of revolution, if it exceed 67·309 years, cannot deviate from it more than a fraction of a year.

"I may add, in conclusion, that having applied to the observations of MM. Struve alone, the method presented in my third Memoir upon double stars, without subjecting them to a correction relative to the distances, I have obtained immediately an orbit, still somewhat indeterminate, it is true, but in which the time of revolution was found to be 69·3 years. Thus, without having recourse to the ancient observations of Sir William Herschel, the series of observations of MM. Struve suffices already to give an approximate idea of the orbit of η *Coronæ*."

Instructions and Suggestions for Mariners observing the total Solar Eclipse of Nov. 30, 1853.*

(Appended to a Letter from M. Jul. Schmidt, of the Observatory of Bonn, to Lieut. Maury, U.S.N., and communicated by Admiral W. H. Smyth.)

Every mariner navigating the Pacific Ocean in the neighbourhood of the line of central eclipse is requested (if possible to make observations) to direct his attention to the following points:—

I.—Observations with the Telescope during the total Eclipse.

1. Note the duration of total darkness in seconds of sidereal or mean time.

2. Note the time when, before the beginning of the eclipse, *the corona* (white ring round the dark moon) makes its appearance.

3. Note the time when, in the reappearance of the sun's light, the corona disappears.

4. Observe, if the corona is circular, if it has rays; and if so, are they perpendicular to the moon's limb?

* This eclipse will be total along a certain belt of the Pacific Ocean between the coast of Peru and the Sandwich Islands.

5. Note the diameter of the corona in parts of the moon's diameter.

6. Note the colour of corona.

7. Observe how many *red flames*, prominences, or protuberances, are visible.

8. On what points (counting eastward from the highest point) on the moon's periphery are the prominences situated?

9. Estimate the extent in length and breadth, if one or more prominences, either in minutes, of space or in parts of the moon's diameter.

10. Do the prominences on the east side of the moon decrease and disappear?

11. Do those on the west side increase, and disappear with the reappearance of the sun's light?

12. Does there appear at the beginning and end of total darkness a *red limb* (a series of small and combined red flames)?

13. Give a sketch as accurate as possible of the forms and relative situations of the prominency.

14. Note the colour or tint of the red flames.

15. Are the prominences red at the commencement of their visibility, or do they redden later?

16. What other appearances in the vicinity of the red flames in the corona?

17. Are there in the nearest vicinity of the sun's limb to the prominences *solar spots*?

18. Note the colour of the moon's disc.

II.—Observations without a Telescope during the whole Eclipse.

1. Note the changes in the colour of the sky during the increase and decrease of the eclipse, as well as the totality.

2. Note the variations of the temperature of the atmosphere.

3. Note the variation in the direction of the wind.

4. Observe the dew.

5. Observe the behaviour of sea-birds in the vicinity of the vessel.

6. Observe the colour of the sea, before, during, and after the total darkness.

7. How many stars, and of what magnitude, besides the most splendid, are visible during the totality?

8. Are the prominences visible to the naked eye?

9. What is the colour and form of the corona as seen with the naked eye?

It must be left to the direction of the navigator which of the above observations he, in accordance with the means in his power, will make himself, and which he will distribute among his subordinates.

Lastly, it is desirable for each observer to note—