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Orbits of the Spectroscopic Components of 50 Draconis

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ORBITS OF THE SPECTROSCOPIC COMPONENTS OF 50 DRACONIS.

BY W. E. HARPER, M.A.

This star ($\alpha = 18^h\ 49^m.6$, $\delta = +75°\ 19'$, photographic magnitude 5·4) was announced as a spectroscopic binary by Frost at the Evanston meeting of the American Astronomical Society. The velocities of the ten measurable plates secured at Yerkes in June and July, 1914, were made available to the writer who undertook the determination of the star's orbit. Professor Frost said that the period seemed to be about 4·2 days as the lines were double on alternate days.

The weather during September and October was very favourable and 34 spectrograms of the star, each averaging about 70 minutes exposure, were obtained before the end of the year. Of these, two have been rejected; one, for temperature changes in the prism during exposure, and the other, for the general uncertain character of the lines. The remaining 32—the measures of which are given in detail—form the basis of this publication. Seed 27 plates and the single-prism were used throughout, the dispersion at λ4325 being 32·1Å per millimetre.

The spectrum of both components is of the A-type the intensities being nearly, though not quite, equal. When the spectra are superposed a great many lines can be seen which are not recorded when the spectra are resolved. These lines are probably too weak when standing alone to appear, but when superposed they show sufficient contrast to be measurable. The following table gives the wave-lengths of the lines and the elements to which they are due.

LINES IN 50 DRACONIS.

Element.	Wave-Length.	Element.	Wave-Length.	Element.	Wave-Length.
Fe	4584·018	*Cr Mg*	4352·006	*Si*	4128·211
Fe-Ti	4549·766	*Hγ*	4340·634	*Hδ*	4101·890
Ti	4534·139	*Fe*	4325·939	*Sr*	4077·885
Fe-Ti	4522·871	*Fe*	4308·081	*Fe*	4071·901
Ti	4515·508	*Fe*	4294·301	*Fe*	4063·756
Ti	4508·455	*Fe-Fe*	4271·760	*Fe*	4045·975
Mg	4481·400	*Fe*	4260·640	*Fe*	4005·355
Ti	4468·663	*Fe*	4233·328	*Hε*	3970·177
Fe	4466·734	*Fe-Ca*	4227·010	*Ca*	3968·625
Fe	4404·927	*Sr-Cr*	4215·668	*Ca*	3933·825
Ti	4395·286	*Fe*	4143·928		

It is customary to deduce corrections to the assumed wave-lengths by equating to zero the sum of the residuals of each line from the mean of the plate. Such residuals were formed in the case of 29 plates whose lines were considered free from any error due to the blending of the components but in only two cases did there seem to be a systematic error in the wave-length employed. Improvement would be effected in the agreement of the individual lines by decreasing the wave-length of the $H\gamma$ line 0·058Å and by increasing the K line 0·089Å but, as the lines are poor in this star and as no appreciable change would result in the velocity of the plate, the assumed wave-lengths were allowed to stand.

MEASURES OF 50 DRACONIS.

λ	6354				6375				6382					
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4549	...	...	...	...	+57·9	½	−69·9	½	...	...	...	...	...	...
4481	...	...	...	...	52·7	¾	85·3	¼	+48·7	½	−59·7	½	...	...
4340	...	...	...	...	38·0	½	80·7	½	...	...	80·7	¼	...	...
4300	...	...	...	...	...	...	109·9	½	...	...	...	...	...	...
4294	...	...	...	...	48·5	½	...	...	...	...	...	...	...	...
4233	...	...	...	...	...	...	...	...	...	...	45·9	¼	...	...
4143	...	...	...	...	65·4	¼	84·5	¼	...	...	66·8	½	...	...
4101	...	...	...	...	47·6	½	125·0	¼	...	...	44·4	¼	...	...
4077	...	...	...	...	56·3	½	...	...	...	...	...	...	...	...
4045	...	...	...	...	39·3	½	84·3	½	28·8	¾	66·9	¾	...	...
4005	...	...	...	...	...	...	...	...	+36·4	¾	61·1	¼	...	...
3933	+39·8	¾	−69·8	¾	+70·2	½	−66·3	¼	...	...	−55·0	½	...	...
Weighted mean	+ 39·80		− 69·80		+ 52·17		− 87·56		+ 36·62		− 61·22		...	
V_a	+ 4·89		+ 4·89		+ 4·80		+ 4·80		+ 4·77		+ 4·77		...	
V_d	− ·05		− ·05		− ·01		− ·01		− ·02		− ·02		...	
Curv.	− ·28		− ·28		− ·28		− ·28		− ·28		− ·28		...	
Radial Velocity	+ 44·4		− 65·2		+ 56·7		− 83·0		+ 41·1		− 56·8		...	

MEASURES OF 50 DRACONIS—*Continued.*

λ	6390				6398				6405				6408	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4549													− 7·2	½
4481					+ 26·6	¾	− 59·4	½	+ 62·6	½			− 23·6	½
4340			− 91·4	½					54·2	1	− 90·3	½	− 21·6	½
4233									66·5	¼			− 19·7	¼
4101	+ 50·2	½	85·6	½	38·0	½	77·0	¼			80·0	¼		
4071							63·8	¼						
4063					35·1	¼	60·0	¼	49·9	¼	83·8	¼	+ 20·4	½
4045					24·9	½	65·3	¼			84·1	½	+ 29·9	¼
4005													+ 24·6	½
3933	+ 62·0	¼	− 76·6	1	+ 35·4	½	− 65·1	¾	+ 55·1	¾	− 85·8	¾	− 26·8	½
Weighted mean	+ 54·13		− 82·55		+ 31·84		− 64·46		+ 56·70		− 85·56		− 4·15	
V_a	+ 4·73		+ 4·73		+ 4·70		+ 4·70		+ 4·68		+ 4·68		+ 4·65	
V_d	− ·02		− ·02		− ·04		− ·04		− ·02		− ·02		− ·04	
Curv.	− ·28		− ·28		− ·28		− ·28		− ·28		− ·28		− ·28	
Radial Velocity	+ 58·6		− 78·1		+ 36·2		− 60·1		+ 61·1		− 81·2		+ 0·2	

MEASURES OF 50 DRACONIS.—*Continued.*

λ	6414				6121		6424				6437		6445	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4563													− 8.0	½
4549					− 9.2	½					− 21.6	¾	41.0	¾
4508													23.2	½
4501													27.9	½
4481	+ 68.3	¼	− 80.0	¼	− 8.5	¼	+ 68.7	½	− 84.0	½	− 15.1	1	20.4	1
4468							52.5	¼	105.6	¼	+ 1.7	½		
4466											− 4.8	½		
4404											+ 2.0	1		
4395											− 4.0	½		
4383					+ 19.9	½					− 24.8	½		
4352														
4340	68.5	¼	82.9	¼	− 8.7	¼	78.0	½	80.7	½	− 15.9	¾	30.9	½
4308							82.7	½					30.8	½
4271											− 31.4	½		
4260											− 14.2	½		
4233	88.0	½					93.3	¼			− 11.9	¾	21.5	½
4227														
4215											− 26.3	½	18.2	¾
4143											− 19.0	¾		
4128													15.3	1
4101					− 37.0	¼	52.1	½	67.0	½				
4077							64.5	¼	78.5	¼	− 20.7	1	33.1	½
4071							62.1	¼			− 5.9	½	27.3	½
4063	53.7	¼	75.7	¼					90.2	½			24.2	¾
4045									100.1	¼	− 10.9	1	26.1	1
3933	+ 68.7	¼	− 94.3	¼	+ 11.2	¼	+ 86.8	¾	− 85.3	¾	− 6.8	¾	− 14.6	¾
Weighted mean	+ 72.53		− 83.22		− 2.70		+ 73.05		− 84.56		− 13.29		− 23.68	
V_a	+ 4.71		+ 4.71		+ 4.58		+ 4.50		+ 4.50		+ 4.40		+ 4.33	
V_d	− .04		− .04		− .03		− .04		− .04		− .04		− .05	
Curv.	− .28		− .28		− .28		− .28		− .28		− .28		− .28	
Radial Velocity	+ 76.9		− 78.8		+ 1.6		+ 77.2		− 80.4		− 9.2		− 19.7	

MEASURES OF 50 DRACONIS.—*Continued.*

λ	6452				6463		6473				6476		6491	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4584					− 32·1	¼					− 47·6	½		
4549					− 14·8	¾			−105·9	¾	15·6	¾	− 29·8	¾
4522									87·5	½				
4481					− 7·1	½	+ 41·4	¾	95·1	¾	13·8	¾	15·7	½
4352					+ 2·7	¼								
4340	+ 60·0	¼	− 98·0	¼	− 13·5	1	61·4	½	122·3	½	17·7	¾		
4325					− 21·2	½					14·4	½		
4308											8·5	½		
4271					− 30·9	½								
4260					− 12·2	½								
4233	60·8	¾			− 3·2	¾							1·9	½
4215											15·1	½		
4143	60·9	½			− 19·9	½	69·2	½						
4101	48·0	½	106·1	½	− 15·6	¾	83·0	½	68·0	¼	23·9	½	34·1	¼
4077					− 12·2	½					15·0	½		
4071					− 24·0	¾								
4063	70·7	¾			− 14·0	¾								
4045			91·4	¾	− 18·5	1			86·1	½				
3933	+ 71·9	½	− 78·6	½	− 10·4	¾	+ 67·6	¾	− 96·5	¾	− 8·1	½	− 34·2	½
Weighted mean	+ 62·80		− 92·70		− 15·26		+ 62·85		− 97·02		− 17·67		− 22·71	
V_a	+ 4·30		+ 4·30		+ 4·27		+ 4·23		+ 4·23		+ 4·20		+ 3·90	
V_d	− ·02		− ·02		− ·03		− ·03		− ·03		− ·02		− ·10	
Curv.	− ·28		− 28		− ·28		− ·28		− ·28		− ·28		− ·28	
Radial Velocity	+ 66·8		− 88·7		− 11·3		+ 66·8		− 93·1		− 13·8		− 19·2	

MEASURES OF 50 DRACONIS.—*Continued.*

λ	6495				6502				6519					
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4549	+ 44·6	¼	− 86·1	¼	......	...	......	...	......	...	......	...	......	...
4481	76·6	¼	53·1	⅛	......	...	......	...	+ 48·1	¼	− 95·3	¼	......	...
4340	25·6	½	97·3	¼	......	...	......	...	60·3	1	93·2	1	......	...
4315	53·3	½	......	...	......	...	......	...	......	...	......	...	......	...
4308	58·6	1	93·7	⅛	......	...	......	...	......	...	......	...	......	...
4271	......	...	84·5	¼	......	...	......	...	......	...	......	...	......	...
4233	......	...	......	...	+ 25·4	½	......	...	......	...	......	...	......	...
4101	......	...	......	...	29·2	½	− 54·8	¼	......	...	......	...	......	...
4063	46·5	¼	60·0	¼	......	...	......	...	......	...	......	...	......	...
4045	......	...	86·2	¼	......	...	......	...	54·5	¼	85·0	¼	......	...
3968	......	...	......	...	......	...	......	...	......	...	75·2	¼	......	...
3933	+ 45·6	¼	− 63·7	¼	+ 31·6	½	− 62·5	½	+ 54·8	1	− 77·0	1	......	...
Weighted mean	+ 50·42		− 78·73		+ 28·73		− 59·93		+ 56·31		− 85·12		....	
V_a	+ 3·84		+ 3·84		+ 3·78		+ 3·78		+ 3·27		+ 3·27		....	
V_d	− ·05		− ·05		− ·05		− ·05		− ·04		− ·04		....	
Curv.	− ·28		− ·28		− ·28		− ·28		− ·28		− ·28		....	
Radial Velocity	+ 53·9		− 75·2		+ 32·2		− 56·5		+ 59·3		− 82·2			

MEASURES OF 50 DRACONIS.—*Continued.*

λ	6528		6540		6554		6567				6577			
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4584														
4549			− 15·9	½	− 41·0	½	+ 32·2	½						
4534					− 14·3	¼								
4481			− 18·1	¾	− 31·3	½					+ 55·5	½	− 54·5	½
4415											56·8	¼		
4340			− 14·2	½	− 8·1	¼					97·4	¼	77·4	¼
4308			− 5·5	½							40·6	½	119·0	¼
4271					+ 13·3	½								
4233			− 11·4	½										
4215			+ 2·0	½										
4101			+ 1·8	½					− 23·0	¼				
4077											+ 62·9	½	− 62·4	½
4063					− 29·1	½			44·7	¼				
4045	− 47·2	¼	− 11·6	¾	− 16·6	¼			46·8	¼				
3970			− 0·8	½										
3968			− 3·5	½										
3933	− 40·9	½	− 15·0	1¼			+ 41·0	¾	− 53·6	¼				
Weighted mean	− 43·03		− 9·61		− 19·53		+ 37·50		− 42·02		+ 58·50		− 71·60	
V_a	+ 3·20		+ 2·55		+ 1·62		+ ·85		+ ·85		+ ·60		+ ·60	
V_d	− ·07		− ·08		− ·10		− ·10		− ·10		− ·11		− ·11	
Curv.	− ·28		− ·28		− ·28		− ·28		− ·28		− ·28		− ·28	
Radial Velocity	− 40·2		− 7·4		− 18·3		+ 38·0		− 41·5		+ 58·7		− 71·4	

MEASURES OF 50 DRACONIS.—*Continued.*

λ	6578		6589				6602				6622			
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4584	…	…	…	…	…	…	+ 31·8	¼	−127·9	¼	…	…	…	…
4549	…	…	+ 86·2	1	− 76·1	1	54·3	¾	94·1	½	…	…	…	…
4481	− 1·0	½	…	…	93·9	½	53·8	¼	90·8	½	+ 59·2	1	− 86·3	1
4340	13·1	½	94·2	¼	88·1	¼	52·7	¼	94·1	¼	48·6	½	92·8	¼
4308	…	…	65·1	¼	101·2	¼	…	…	…	…	…	…	89·8	¾
4271	…	…	95·7	¼	…	…	63·7	¼	98·8	½	…	…	…	…
4260	…	…	74·0	½	…	…	…	…	…	…	…	…	94·4	½
4101	25·6	¼	…	…	…	…	68·7	¼	88·5	¼	60·3	½	…	…
4077	…	…	65·1	¼	…	…	…	…	…	…	…	…	…	…
4071	26·3	¼	…	…	…	…	…	…	…	…	…	…	…	…
4063	…	…	69·3	½	…	…	…	…	…	…	…	…	…	…
4045	8·2	¼	+ 70·9	¼	− 81·6	¼	…	…	100·0	½	…	…	…	…
3933	− 7·2	½	…	…	…	…	+ 80·0	¼	− 87·7	½	+ 70·2	½	− 94·8	¼
Weighted mean	− 11·33		+ 78·64		− 84·80		+ 57·07		− 96·37		+ 59·48		− 90·73	
V_a	+ ·52		− ·11		− ·11		− ·27		− ·27		− ·99		− ·99	
V_d	− ·10		− ·11		− ·11		− ·10		− ·10		− ·10		− ·10	
Curv.	− ·28		− ·28		− ·28		− ·28		− ·28		− ·28		− ·28	
Radial Velocity	− 11·2		+ 78·1		− 85·3		+ 56·4		− 97·0		+ 58·1		− 92·1	

MEASURES OF 50 DRACONIS.—*Concluded.*

λ	6624		6634				6659							
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4549	− 7·5	½					− 74·2	½						
4481	+ 8·5	¾	+ 66·6	1										
4415							59·0	½						
4340	− 5·4	½	72·7	½	− 97·0	½								
4233							43·9	¼						
4101	− 20·2	¼	39·7	½	91·4	½								
4045			39·6	¼	73·6	¼	47·0	¼						
4005							40·4	¼						
3968			45·4	½	79·8	½								
3933	− 6·5	¾	+ 70·4	¾	− 77·0	¾	− 47·0	½						
Weighted mean	− 3·64		+ 59·44		− 84·12		− 54·68							
V_a	− 1·10		− 1·16		− 1·16		− 1·92							
V_d	− ·11		− ·11		− ·11		− ·10							
Curv.	− ·28		− ·28		− ·28		− ·28							
Radial Velocity	− 5·1		+ 57·9		− 85·7		− 57·0							

The following table contains all the data of the measures. The phases are reckoned from the periastron finally adopted J. D. 2420293·930 using the period 4·120 days. The number of lines measured and the weight assigned each plate follow. The residuals O-C are scaled from the curve representing the adopted elements. They are given only for those plates whose lines are fully resolved. Corresponding data is given for the Yerkes' observations.

TABLE OF MEASURES OF 50 DRACONIS.

Plate.	Observer*	Date.	Julian Date.	Phase.	Component I.				Component II.			
					n	Wt.	Vel.	O-C.	n	Wt.	Vel.	O-C.
		1914										
6354	P	Sept. 11	2420387·607	3·037	1	1	+ 44·4	+9·0	1	1	− 65·2	− 7·2
6375	Y	Sept. 15	391·523	2·833	9	6	+ 56·7	+9·7	8	5	− 83·0	−10·0
6382	G	Sept. 16	392·535	3·845	8	5·5	− 56·8	−1·8	3	2·5	+ 41·1	+1·1
6390	H	Sept. 17	393·522	·712	3	2·5	− 78·1	−5·3	2	1·5	+ 58·6	− 1·4
6398	C	Sept. 18	394·577	1·767	6	4	+ 36·2	+2·0	5	3·5	− 60·1	− 1·1
6405	H	Sept. 19	395·523	2·713	5	4	+ 61·1	+2·6	5	3·5	− 81·2	+ 2·0
6408	Y	Sept. 20	396·563	3·753	8	5·5	+ 0·2					
6414	H	Sept. 21	397·564	·634	5	3	− 78·8	−0·8	4	2	+ 76·9	−11·9
6421	Y	Sept. 22	398·542	1·612	6	4	+ 1·6					
6424	P^1	Sept. 25	401·542	·492	8	5·5	− 80·4	+4·6	9	6	+ 77·2	+ 5·0
6437	P^1	Sept. 28	404·531	3·481	17	12	− 9·2					
6445	G	Sept. 30	406·570	1·400	16	11	− 19·7					
6452	H	Oct. 1	407·504	2·334	6	4·5	+ 66·8	+3·4	4	3	− 88·7	+ 2·7
6463	C	Oct. 2	408·514	3·344	16	11	− 11·3					
6473	P	Oct. 3	409·510	·220	7	5·5	− 93·1	−6·7	5	4	+ 66·8	− 6·8
6476	Y	Oct. 4	410·490	1·200	10	7	− 13·8					
6491	G	Oct. 12	418·539	1·009	5	3·5	− 19·2					
6495	Y	Oct. 13	419·503	1·973	7	5	+ 53·9	+4·3	8	4	− 75·2	+ 0·2
6502	P^1	Oct. 14	420·516	2·986	3	2	+ 32·2	−5·0	2	1·5	− 56·5	+ 6·0
6519	H	Oct. 22	428·478	2·708	4	3	+ 59·3	+1·3	5	4	− 82·2	+ 1·2
6528	C	Oct. 23	429·510	3·740	2	1·5	− 40·2					
6540	P	Nov. 2	439·517	1·387	11	8	− 7·4					
6554	P	Nov. 14	451·513	1·023	7	5	− 18·3					
6567	C	Nov. 23	460·483	1·753	1	1	+ 38·0	+5·0	1	0·5	− 41·5	+15·7
6577	H	Nov. 26	463·550	·700	4	2·5	− 71·4	+2·0	5	3·5	+ 58·7	− 2·0
6578	C	Nov. 27	464·485	1·635	6	4	− 11·2					
6589	C	Dec. 4	471·497	·407	5	3·5	− 85·3	+1·3	8	5	+ 78·1	+ 3·7
6602	Y	Dec. 6	473·451	2·361	7	4	+ 56·4	−7·4	8	5	− 97·0	− 5·0
6622	P^1	Dec. 14	481·517	2·187	4	3	+ 58·1	−1·5	5	3·5	− 92·1	− 4·7
6624	Y	Dec. 15	482·500	3·170	5	3·5	− 5·1					
6634	H	Dec. 16	483·520	·070	5	3·5	− 85·7	−4·3	6	4·5	+ 57·9	−10·8
6659	H	Dec. 25	492·562	·872	6	3	− 57·0	+2·6				

*P = Plaskett; Y = Young; G = Gibson; H = Harper; P^1 = Parker; C = Cannon.

YERKES' OBSERVATIONS, 50 DRACONIS.

Date.	Julian Date.	Phase.	Component I.			Component II.		
			n	Vel.	O-C.	*n*	Vel.	O-C.
1914.								
June 9..........	2420293·930	3·95	5	− 71	− 4	5	+ 48	− 3
June 15..........	299·693	1·64	3	− 28	......	......	......	......
June 16..........	300·654	2·60	4	+ 84	+23	4	− 92	− 4
June 17..........	301·677	3·62	5	− 5	......	......	......	......
June 22..........	306·725	0·43	2	− 80	+ 6	2	+ 78	+ 4
June 29..........	313·807	3·40	4	− 6	......	......	......	......
July 2..........	316·637	2·11	4	+ 73	+17	3	− 82	+ 2
July 3..........	317·680	3·15	3	+ 29	......	......	......	......
July 20..........	334·661	3·65	6	+ 4	......	......	......	......
July 21..........	335·626	0·50	1	− 68	+17	2	+ 95	+23

Comparison of Yerkes' observations with our own indicated a period of 4·120 days. No attempt was made to improve this value by least-squares.* The Ottawa plates were grouped on the basis of phases into the following normal places. Nos. 1–10 refer to Component I, Nos. 11–20 to Component II.

*Further observations will be made to improve the value.

NORMAL PLACES.

No.	Mean Phase.	Mean Vel.	Wt.	O-C	Eq.-Eph.
1	3·45	− 7·9	1·5	+ 3·8	−·1
2	3·85	− 53·2	·7	+ 3·3	·0
3	·31	− 86·2	1·8	+ 1·3	·0
4	·74	− 70·2	1·0	+ 1·1	+·1
5	1·33	− 13·4	2·0	− 1·2	+·1
6	1·77	+ 36·8	·5	+ 2·9	−·1
7	1·97	+ 54·0	·5	+ 4·9	+·2
8	2·30	+ 60·9	1·2	− 2·2	+·1
9	2·77	+ 58·3	1·3	+ 4·8	+·1
10	3·00	+ 36·3	·3	− 0·3	+·1
11	3·45	− 7·9	1·5	+ 0·3	+·1
12	3·85	+ 40·7	·3	− 0·1	+·1
13	·32	+ 70·9	2·0	− 4·0	·0
14	·67	+ 67·9	1·0	+ 5·6	·0
15	1·33	− 13·4	2·0	− 5·6	−·1
16	1·77	− 58·0	·5	+ 0·3	·0
17	1·97	− 75·2	·4	+ 0·1	·0
18	2·30	− 93·3	1·2	− 2·7	·0
19	2·75	− 82·3	1·2	− 1·0	·0
20	3·00	− 60·0	·3	+ 1·4	−·1

The plates, where the lines were not fully resolved, were grouped into two groups about the crossing points, care having previously been taken to have the plates balanced in phase on either side of these points. The two groups thus formed were each subdivided into two, (Nos. 1 and 11, 5 and 15), half the weight being assigned to each, and the residuals from each curve taken in the solution. No great objection can be taken to this as the grouped observations refer equally to both components and for all practical purposes the intensities of the component spectra are the same.

It was seen that the eccentricity was very small, though from a few preliminary trials there was no doubt of there being a slight eccentricity. The value of ω could be stated as lying somewhere between 120° and 240°, but it was hard to state from graphical methods just what value in this interval suited best. Recourse was had to the method of least-squares, and the resulting value of Σpvv was lowest for $\omega_1 = 151°$, though $\omega_1 = 203°$ was a good second. A least-squares solution was also carried through for $e = 0$. The results were:—

For $e = 0$ $\Sigma pvv = 271$
For $\omega_1 = 203°$ $\Sigma pvv = 230$
For $\omega_1 = 151°$ $\Sigma pvv = 226$

The observation and normal equations for the latter only will be given. In this case T had to be fixed, otherwise the solution became indeterminate. The preliminary values adopted were:—

$P = 4 \cdot 120$ days
$e = \cdot 03$
$\omega_1 = 150°$
$\omega_2 = 330°$
$K_1 = 75$ km.
$K_2 = 82 \cdot 1$ km.
$\gamma = -11 \cdot 0$ km.
$A_1 = 73$
$B_1 = 77$
$A_2 = 84 \cdot 3$
$B_2 = 79 \cdot 9$
$T =$ J. D. 2420293·93

The following substitutions were made and the equations resulting from both components were combined* into one set of normals:—

$x = \delta\gamma$
$y = \delta K_1$
$z = \delta K_2$
$u = 100 \ \delta e$
$v = 100 \ \delta\omega$

*Publications of the Dominion Observatory, Vol. I, No. 11, p. 327.

OBSERVATION EQUATIONS 50 DRACONIS.

—	x	y	z	u	v	$-n$	Wt.
1	1·000	....	....	+ ·678	− ·739	− 3·1=0	1·5
2	1·000	− ·600	....	− ·123	− ·603	− 2·8	0·7
3	1·000	−1·026	....	− ·667	− ·006	− 1·8	1·8
4	1·000	− ·827	....	+ ·181	+ ·460	− 2·0	1·0
5	1·000	− ·040	....	+ ·651	+ ·761	− 0·6	2·0
6	1·000	+ ·563	....	− ·165	+ ·617	− 5·6	0·5
7	1·000	+ ·768	....	− ·536	+ ·466	− 7·4	0·5
8	1·000	+ ·958	....	− ·739	+ ·144	− 0·1	1·2
9	1·000	+ ·849	....	− ·030	− ·352	− 5·7	1·3
10	1·000	+ ·634	....	+ ·452	− ·552	+ 0·2	0·3
11	1·000	....	....	− ·742	+ ·809	− 3·1	1·5
12	1·000	....	+ ·600	+ ·135	+ ·660	− 2·5	0·3
13	1·000	....	+1·026	+ ·715	− ·008	+ 2·3	2·0
14	1·000	....	+ ·879	− ·048	− ·441	− 6·8	1·0
15	1·000	....	+ ·040	− ·712	− ·833	+ 5·6	2·0
16	1·000	....	− ·563	+ ·181	− ·676	+ 0·7	0·5
17	1·000	....	− ·768	+ ·587	− ·511	+ 1·1	0·4
18	1·000	....	− ·958	+ ·808	− ·158	+ 3·6	1·2
19	1·000	....	− ·862	+ ·079	+ ·365	+ 0·5	1·2
20	1·000	....	− ·634	− ·495	+ ·604	− 3·1	0·3

NORMAL EQUATIONS.

$$
\begin{aligned}
21 \cdot 200x - \cdot 065y + \cdot 229z + \cdot 199u - \cdot 295v - 19 \cdot 540 &= 0 \\
5 \cdot 446y \ldots\ldots\ldots + \cdot 033u - \cdot 151v - 3 \cdot 839 &= 0 \\
5 \cdot 496z + \cdot 244u - \cdot 314v - 5 \cdot 862 &= 0 \\
7 \cdot 144u - \cdot 050v + 4 \cdot 038 &= 0 \\
6 \cdot 346v - 10 \cdot 610 &= 0
\end{aligned}
$$

From these equations resulted the corrections,

$$
\begin{aligned}
x &= +0 \cdot 94 \\
y &= +0 \cdot 77 \\
z &= +1 \cdot 16 \\
u &= -0 \cdot 622 \\
v &= +1 \cdot 786
\end{aligned}
$$

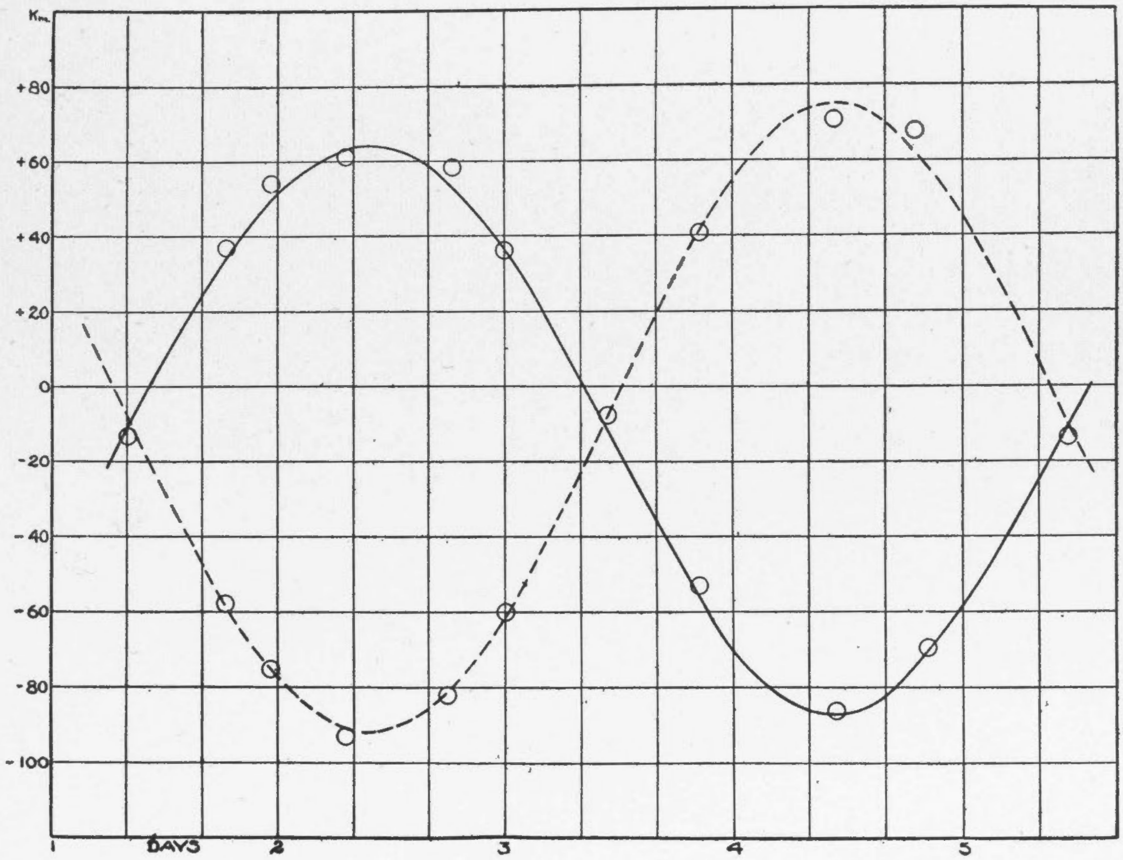
One solution was seen to be sufficient, as the differences between equation and ephemeris residuals were very small.

The final values of the elements with their probable errors are, then, as follows:—

P	$= 4 \cdot 120$ days	A_1	$= 74 \cdot 18$ km.
e	$= \cdot 024 \pm \cdot 001$	B_1	$= 77 \cdot 36$ km.
K_1	$= 75 \cdot 77$ km. $\pm 1 \cdot 57$ km.	A_2	$= 85 \cdot 01$ km.
K_2	$= 83 \cdot 26$ km. $\pm 1 \cdot 56$ km.	B_2	$= 81 \cdot 51$ km.
γ	$= -10 \cdot 1$ km $\pm 0 \cdot 8$ km.	$a_1 \sin i$	$= 4291000$ km.
ω_1	$= 151^\circ \cdot 0 \pm 0^\circ \cdot 8$	$a_2 \sin i$	$= 4716000$ km.
ω_2	$= 331^\circ \cdot 0 \pm 0^\circ \cdot 8$	$m_1 \sin^3 i$	$= 0 \cdot 90 \odot$
T	$=$ J. D. $2420293 \cdot 930$	$m_2 \sin^3 i$	$= 0 \cdot 82 \odot$

The graph accompanying represents the final elements and the observations as grouped. The probable error of a plate is $\pm 3 \cdot 7$ km. per second.

Dominion Observatory,
Ottawa,
February, 1915.



VELOCITY CURVE OF 50 DRACONIS.