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ν GEMINORUM, A LONG PERIOD BINARY

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(1900, $\alpha = 6^h\ 23^m.0$, $\delta = +20°\ 17'$, mag. 4.06, type B5)

This star was announced as a spectroscopic binary by Lee in the *Astrophysical Journal*, volume XXXII, page 301, from 5 plates taken in the years 1901 to 1909 which showed a range of 27 km., and whose measures are given in the accompanying table. It was noted that the H and K lines of calcium gave velocities different to the other lines.

A series of plates were made here during the years 1910, 1911, 1912, 1913 and 1914, 52 of these plates were measured by Mr. T. H. Parker without giving any clue to the period. When Mr. Parker responded to a higher call and went overseas, the star was taken over by the writer and plates have been made from time to time, so that now we have 83 altogether. While Mr. Parker's measures were felt to be just as reliable as any that could be made upon the plates, yet, owing to the complex character of the lines and the possibility of different interpretations being placed upon them, it was thought better for the writer to measure all the plates and thereby possibly secure greater homogeneity.

While the helium lines λ 4471 and λ 4026 can be detected on most of our plates, they are, with possibly the exception of one plate, entirely too faint to be measured and consequently the results depend upon the four hydrogen lines H_β, H_γ, H_δ, and H_ϵ. H_ϵ is only rarely used, H_γ is by far the most dependable line with H_δ next in order and then H_β. The numbers 9, 4 and 3 would express the relative weights of these three. The measures of the calcium line K have been kept separate as Lee's discovery of its distinct character has been verified, even though the line lacks contrast and is of extremely poor quality for measurement. While the extreme variation shown for measures of this line is in the neighbourhood of 50 km., yet this range is only shown where the line is very poor and the measurement uncertain and it is not likely that the real range is much over half this amount. There does not seem to be any progressive variation over a long period, as is the case for the hydrogen lines; the velocities for each year average up about the same. The weighted mean velocity for the line on 33 plates is + 16.9 km. per second, while that of the center of the system is in the neighbourhood of + 38 km. per second.

That there is a short-period oscillation in the velocities would seem to be without doubt, but a satisfactory period has not as yet been obtained. As the range in velocity

of this short-period variation is small, it has been possible by combining the velocities for each season into one mean to detect a long-period variation. There are, unfortunately, a few gaps yet to be filled in, but there seems no doubt of the general trend of the velocities over a curve whose period is about 9·6 years. The Yerkes' plates and our own are used in the table of measures and in the grouped velocities following. To clear of fractions the weights assigned to plates are 8 times the total weight of the lines on the plates.

OBSERVATIONS OF ν GEMINORUM

Plate	Date	Julian Date	Vel. *H* lines	Wt.	Vel. Calcium	Wt.
	1903					
Yerkes	Dec. 1	2,416,450·953	+24·0	.....	− 6	.....
"	" 25	6,474·945	33·0	.....	+ 1	.....
	1906					
"	Feb. 26	7,268·742	6·0	.....	+22	.....
	1908					
"	Jan. 24	7,965·727	15·0	.....	+12	.....
	1909					
"	Jan. 1	8,308·777	20·0	.....	.....	.....
	1910					
3743	Oct. 12	8,957·932	97·6	5	− 4	1
3795	Nov. 2	8,978·910	59·6	8	.....	.....
3824	Dec. 5	9,011·944	62·9	6	+28	1
3848	" 9	9,015·874	78·8	7	+28	1
3882	" 16	9,022·816	75·7	4	+39	1
3892	" 21	9,027·834	81·6	8	+16	2
3910	" 30	9,036·827	48·4	4	.....	.....
	1911					
3924	Jan. 9	9,046·715	52·0	6	.....	.....
3941	" 16	9,053·852	40·9	6	+ 4	2
3950	" 17	9,054·832	49·2	4	+21	1
3975	" 30	9,067·705	94·3	12	+ 8	1
3997	Feb. 15	9,083·730	73·2	6	.....	.....
4008	" 22	9,090·714	58·4	4	+ 7	1
4021	" 27	9,095·625	61·1	7	+ 4	1
4059	Mar. 6	9,102·670	42·3	4	.....	.....
4069	" 7	9,103·628	63·7	10	.....	.....
4088	" 10	9,106·593	74·3	9	+19	4
4101	" 13	9,109·612	71·4	6	.....	.....
4115	" 14	9,110·614	70·4	10	+27	4
4119	" 16	9,112·614	72·9	6	+31	1
4133	" 20	9,116·583	73·6	13	.....	.....
4136	" 24	9,120·593	76·2	16	+ 8	4
4638	Oct. 12	9,322·924	66·5	10	+34	1
4698	Nov. 16	9,357·911	55·9	8	+24	4
4710	Dec. 3	9,374·903	72·3	7	.....	.....
4719	" 6	9,377·850	60·8	10	.....	.....
4732	" 19	9,390·718	63·4	10	+18	2
4740	" 25	9,396·784	74·5	12	.....	.....
	1912					
4752	Jan. 7	9,409·763	68·2	7	.....	.....
4763	" 10	9,412·753	57·8	9	.....	.....
4782	" 12	9,414·776	69·3	12	+ 5	1
4794	" 16	9,418·729	63·8	10	.....	.....
4803	" 19	9,421·740	+72·8	16	+31	1

OBSERVATIONS OF ν GEMINORUM—*Concluded*

Plate	Date	Julian Date	Vel. *H* lines	Wt.	Vel. Calcium	Wt.
	1912					
4813	Jan. 25	2,419,427·763	+52·6	10	+36	1
4821	" 26	9,428·734	25·5	8	+11	1
4836	Feb. 12	9,445·690	72·9	10	.....	.....
4841	" 13	9,446·635	61·4	12	.....	.....
4872	Mar. 5	9,467·716	64·2	12	+13	2
4883	" 12	9,474·697	65·5	6	.....	.....
4886	" 13	9,475·635	56·9	6	+ 2	1
4903	" 20	9,482·600	63·0	8	.....	.....
4907	" 22	9,484·600	76·2	10	.....	.....
4915	" 25	9,487·604	64·8	9	+24	1
4924	" 29	9,491·645	50·7	7	+20	1
4933	Apr. 3	9,496·581	62·7	16	.....	.....
4940	" 8	9,501·524	75·3	16	.....	.....
4965	" 19	9,512·538	58·8	9	−10	1
4976	" 23	9,516·543	58·1	8	.....	.....
5285	Dec. 16	9,753·871	58·2	8	.....	.....
	1913					
5311	Jan. 8	9,776·830	58·3	10	− 3	4
5315	" 12	9,780·771	65·6	12	+25	4
5339	Feb. 3	9,802·750	56·2	10	+46	1
5350	" 6	9,805·708	43·1	6	.....	.....
5356	" 10	9,809·687	44·2	8	+ 6	2
5362	" 12	9,811·690	57·1	8	.....	.....
5372	" 17	9,816·658	53·1	10	.....	.....
5387	" 23	9,822·632	53·6	14	+16	2
5394	" 24	9,823·697	58·7	14	.....	.....
5409	" 28	9,827·641	63·5	10	.....	.....
5418	Mar. 7	9,834·680	60·0	8	.....	.....
5429	" 11	9,838·674	60·5	8	.....	.....
5447	Apr. 7	9,865·590	38·9	8	.....	.....
5456	" 9	9,867·589	54·5	10	.....	.....
5469	" 14	9,872·607	56·8	6	.....	.....
5496	" 21	9,879·593	53·5	10	.....	.....
5851	Dec. 22	2,420,124·836	31·3	8	.....	.....
5866	" 31	0,133·751	47·8	5	.....	.....
	1914					
5895	Jan. 21	0,154·727	47·1	10	.....	.....
5923	Feb. 9	0,173·740	37·8	3	.....	.....
5940	" 15	0,179·633	36·9	10	+ 9	2
	1916					
7482	Jan. 13	0,876·620	3·2	10	.....	.....
7519	Feb. 23	0,917·653	13·0	6	.....	.....
7528	" 29	0,923·664	4·4	4	.....	.....
7533	Mar. 1	0,924·548	26·7	6	.....	.....
7606	Apr. 10	0,964·549	26·2	6	.....	.....
7622	" 27	0,981·561	19·4	7	.....	.....
	1919					
8701	Jan. 21	1,980·676	37·8	10	− 2	1
8702	" 24	1,983·676	48·2	8	.....	.....
8708	" 31	1,990·616	37·4	10	.....	.....
8710	Feb. 10	2,000·571	33·0	12	.....	.....
8712	" 12	2,002·583	33·2	14	.....	.....
8713	" 16	2,006·647	30·5	8	.....	.....
8714	" 16	2,422,006·695	+33·6	10	.....	.....

MEASURES OF ν GEMINORUM

λ	3743		3795		3824		3848		3882		3892		3910	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4861	+74·5	⅛	+42·8	¼	+82·3	⅛	+102·6	⅛	+65·6	⅛	+73·2	⅛	+55·6	⅛
4340	81·4	¼	47·2	½	42·9	½	53·5	½	79·0	¼	83·6	¾	41·4	¼
4101	+54·1	¼	+35·0	¼	+59·8	⅛	+ 86·8	¼	+58·6	⅛	+57·9	⅛	+63·4	⅛
Weighted mean	+ 69·10		+ 43·05		+ 52·28		+ 70·03		+ 70·55		+ 79·09		+ 50·45	
V_a	+ 28·83		+ 16·81		+ 11·13		+ 9·19		+ 5·64		+ 3·02		− 1·58	
V_d	− ·04		·00		− ·27		− ·18		− ·18		− ·18		− ·21	
Curv.	− ·28		− ·28		− ·28		− ·28		− ·28		− ·28		− ·28	
Radial Velocity	+ 97·6		+ 59·6		+ 62·9		+ 78·8		+ 75·7		+ 81·6		+ 48·4	

λ	3924		3941		3950		3975		3997		4008		4021	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4861	+68·4	⅛	+72·6	⅛	+84·1	⅛	+98·6	¼	+101·0	⅛	+97·8	⅛	+85·3	¼
4340	55·9	½	42·4	½	46·8	¼	122·7	¾	94·9	½	89·3	¼	91·6	½
4101	+63·8	⅛	+69·4	⅛	+61·3	⅛	+101·7	½	+100·0	⅛	+60·0	⅛	+79·7	⅛
Weighted mean	+59·30		+51·93		+59·75		+111·68		+96·77		+84·10		+88·10	
V_a	− 6·90		−10·50		−10·04		− 16·95		−23·11		−25·24		−26·50	
V_d	− ·09		− ·28		− ·27		− ·18		− ·22		− ·23		− ·18	
Curv.	− ·28		− ·28		− ·28		− ·28		− ·28		− ·28		− ·28	
Radial Velocity	+52·0		+40·9		+49·2		+94·3		+73·2		+58·4		+61·1	

λ	4059		4069		4088		4101		4115		4119		4133	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4861	+70·9	⅛	+104·8	¼	+105·2	¼	+ 95·9	⅛	+64·9	⅛	+94·2	⅛	+110·6	½
4340	72·4	¼	92·4	¾	103·9	¾	99·0	½	109·9	¾	107·0	½	100·7	1
4101	+67·5	⅛	+ 79·8	¼	+ 96·0	⅛	+113·7	⅛	100·0	¼	+93·8	⅛	+ 99·2	⅛
3970	.....	....	.....	....	.....	....	.....	....	+75·9	⅛	.....	....	.....	....
Weighted mean	+70·80		+92·36		+103·31		+100·93		+100·02		+102·67		+103·63	
V_a	−27·97		−28·14		− 28·55		− 29·00		− 29·11		− 29·31		− 29·60	
V_d	− ·23		− ·23		− ·14		− ·20		− ·19		− ·21		− ·18	
Curv.	− ·28		− ·28		− ·28		− ·28		− ·28		− ·28		− ·28	
Radial Velocity	+42·3		+63·7		+74·3		+ 71·4		+ 70·4		+ 72·9		+ 73·6	

MEASURES OF ν GEMINORUM—*Continued*

λ	4638		4698		4710		4719		4732		4740		4752	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4861	+34·8	¼	+48·5	¼	+55·2	¼	+56·1	¼	+67·6	¼	+82·1	¼	+63·1	¼
4340	40·1	¾	42·3	½	59·2	½	53·3	¾	61·7	¾	73·0	¾	82·1	½
4101	+34·6	¼	+13·5	¼	+76·4	⅛	+36·3	¼	+59·5	¼	80·0	¼	+65·9	⅜
3970	.....	....	.....	....	.....	....	.....	....	.....	....	+61·9	¼	.....	....
Weighted mean	+ 37·94		+ 36·65		+ 60·51		+ 50·46		+ 62·44		+ 73·83		+ 74·36	
V_a	+ 28·86		+ 19·69		+ 12·24		+ 10·80		+ 1·15		+ 1·07		− 5·76	
V_d	− ·02		− ·14		− ·21		− ·14		− ·11		− ·11		− ·14	
Curv.	− ·28		− ·28		− ·28		− ·28		− ·28		− ·28		− ·28	
Radial Velocity	+ 66·5		+ 55·9		+.72·3		+ 60·8		+ 63·4		+ 74·5		+ 68·2	

λ	4763		4782		4794		4803		4813		4821		4836	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4861	+88·3	⅛	+83·3	¼	.....	....	+93·9	½	+109·2	⅛	+23·0	¼	+102·0	¼
4340	66·2	½	78·9	¾	+79·4	¾	90·0	1	67·3	¾	46·1	½	94·2	¾
4101	45·0	¼	+74·2	½	+67·3	½	80·3	¼	53·5	¼	+48·8	¼	+ 92·1	¼
3970	+73·3	¼	.....	....	.....	....	+52·7	¼	+56·9	⅛	.....	....	.....	....
Weighted mean	+65·52		+78·07		+74·56		+85·10		+67·69		+41·00		+95·34	
V_a	− 7·30		− 8·33		−10·32		−11·79		−14·64		−15·09		−21·99	
V_d	− ·18		− ·18		− ·11		− ·18		− ·21		− ·18		− ·18	
Curv.	− ·28		− ·28		− ·28		− ·28		− ·28		− ·28		− ·28	
Radial Velocity	+57·8		+69·3		+63·8		+72·8		+52·6		+25·5		+72·9	

λ	4841		4872		4883		4886		4903		4907		4915	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4861	+99·3	¼	+ 84·0	¼	+123·0	⅛	+83·0	⅛	+98·3	¼	+115·2	¼	+ 70·0	¼
4340	80·0	1	101·3	1	92·3	½	85·7	½	88·5	½	113·1	½	98·7	½
4101	+85·1	¼	+ 67·2	¼	+ 78·0	⅛	+93·1	⅛	+97·0	¼	+ 95·4	½	109·7	¼
3970	.....	....	.....	....	.....	....	.....	....	.....	....	.....	....	+101·6	⅛
Weighted mean	+84·07		+ 92·73		+ 95·03		+ 86·50		+ 93·08		+106·44		+ 95·09	
V_a	−22·32		− 27·93		− 28·98		− 29·06		− 29·64		− 29·72		− 29·77	
V_d	− ·11		− ·28		− ·28		− ·23		− ·21		− ·21		− ·21	
Curv.	− ·28		− ·28		− ·28		− ·28		− ·28		− ·28		− ·28	
Radial Velocity	+61·4		+ 64·2		+ 65·5		+ 56·9		+ 63·0		+ 76·2		+ 64·8	

MEASURES OF ν GEMINORUM—*Continued*

λ	4924		4933		4940		4965		4976		5285		5311	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4861	+76·2	¼	+82·7	½	+116·0	¼	+81·9	⅛	+ 75·8	¼	+33·6	¼	+94·3	¼
4340	83·8	½	95·1	1	106·5	1	87·9	½	81·6	½	71·4	½	62·6	½
4101	+79·4	⅛	95·9	¼	110·4	½	91·4	¼	+100·8	¼	+47·6	¼	58·4	¼
3970	.....	....	+99·4	¼	+ 74·9	¼	+81·3	¼	.....	....	.....	....	+50·0	¼
Weighted mean	+ 81·00		+ 92·65		+104·71		+ 86·54		+ 84·95		+ 56·00		+ 65·58	
V_a	− 29·72		− 29·45		− 28·98		− 27·19		− 26·30		+ 2·78		− 6·71	
V_d	− ·27		− ·23		− ·18		− ·21		− ·23		− ·25		− ·25	
Curv.	− ·28		− ·28		− ·28		− ·28		− ·28		− ·28		− ·28	
Radial Velocity	+ 50·7		+ 62·7		+ 75·3		+ 58·8		+ 58·1		+ 58·2		+ 58·3	

λ	5315		5339		5350		5356		5362		5372		5387	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4861	.....	....	+55·6	¼	.....	....	.....	....	+82·2	¼	.....	....	.....	....
4340	+71·9	¾	80·6	½	+61·2	½	+62·7	¾	79·9	½	+74·9	¾	+81·2	1
4101	79·7	½	84·0	¼	+68·5	¼	+76·8	¼	+77·3	¼	+81·0	½	+77·5	¾
3970	+73·5	¼	+77·2	¼	.....	....	.....	....	.....	....	.....	....	.....	....
Weighted mean	+ 74·80		+ 75·60		+ 63·63		+ 66·22		+ 79·82		+ 77·36		+ 79·66	
V_a	− 8·69		− 18·88		− 20·03		− 21·53		− 22·26		− 23·89		− 25·62	
V_d	− ·18		− ·25		− ·20		− ·17		− ·18		− ·16		− ·14	
Curv.	− ·28		− ·28		− ·28		− ·28		− ·28		− ·28		− ·28	
Radial Velocity	+ 65·6		+ 56·2		+ 43·1		+ 44·2		+ 57·1		+ 53·1		+ 53·6	

λ	5394		5409		5418		5429		5447		5456		5469	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4861	+82·1	½	+76·5	¼	+106·2	¼	+98·2	¼	+81·4	¼	+83·3	¼	+85·1	¼
4340	87·0	¾	95·5	½	84·9	½	88·6	½	60·0	½	82·2	¾	80·5	¼
4101	+85·4	½	+93·4	½	+78·8	¼	+84·2	¼	+72·6	¼	+89·9	¼	+91·1	¼
Weighted mean	+ 85·14		+ 90·86		+ 88·70		+ 89·90		+ 68·50		+ 83·96		+ 85·57	
V_a	− 25·89		− 26·85		− 28·22		− 28·81		− 29·12		− 28·89		− 28·16	
V_d	− ·25		− ·18		− ·25		− ·27		− ·25		− ·25		− ·28	
Curv.	− ·28		− ·28		− ·28		− ·28		− ·28		− ·28		− ·28	
Radial Velocity	+ 58·7		+ 63·5		+ 60·0		+ 60·5		+ 38·9		+ 54·5		+ 56·8	

MEASURES OF ν GEMINORUM—*Concluded*

λ	5496		5851		5866		5895		5923		5940		7482	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4861	+86·1	¼	.....	....	+53·2	½	+58·1	¼	+59·9	½	+60·4	¼	+12·2	½
4340	81·4	¾	+19·3	½	45·6	¾	56·7	½	+59·1	¼	60·6	¾	15·7	½
4101	+74·1	¼	+39·6	½	+54·2	¼	+65·5	½	.....	....	+60·0	¼	+ 4·6	¼
Weighted mean	+ 80·88		+ 29·45		+ 50·56		+ 60·50		+ 59·37		+ 60·44		+ 12·08	
V_a	− 26·83		+ 2·37		− 2·33		− 12·97		− 21·09		− 23·16		− 8·74	
V_d	− ·23		− ·20		− ·10		− ·14		− ·25		− ·11		+ ·09	
Curv.	− ·28		− ·28		− ·28		− ·28		− ·28		− ·28		− ·28	
Radial Velocity	+ 53·5		+ 31·3		+ 47·8		+ 47·1		+ 37·8		+ 36·9		+ 3·2	

λ	8701		8702		8708		8710		8712		8713		8714	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4861	+76·1	¼	+76·4	¼	+85·2	¼	+63·1	½	+61·9	½	+93·8	¼	+76·7	½
4340	41·0	¾	62·1	½	48·6	¾	52·0	¾	52·4	¾	33·4	½	35·7	½
4101	+56·8	¼	+50·8	¼	+44·4	¼	+45·1	¼	+53·7	½	+56·7	¼	+63·0	¼
Weighted mean	+ 50·98		+ 62·85		+ 55·08		+ 54·55		+ 55·50		+ 54·32		+ 57·56	
V_a	− 12·81		− 14·26		− 17·35		− 21·32		− 22·04		− 23·43		− 23·43	
V_d	− ·06		− ·09		− ·02		+ ·04		·00		− ·13		− ·21	
Curv.	− ·28		− ·28		− ·28		− ·28		− ·28		− ·28		− ·28	
Radial Velocity	+ 37·8		+ 48·2		+ 37·4		+ 33·0		+ 33·2		+ 30·5		+ 33·6	

GROUPED VELOCITIES

Observatory	Epoch	Number of Plates	Velocity	O−C
Yerkes	1903·95	2	+27·5	−18
"	1906·16	1	6·	−12
"	1908·07	1	15·	+ 3
"	1909·00	1	20·	− 6
Ottawa	1910·97	22	70·0	+ 0·4
"	1911·95	26	63·9	− 3·0
"	1913·13	17	55·6	+ 2·7
"	1914·05	5	40·1	0·0
"	1916·18	6	14·9	0·0
"	1919·09	7	+36·0	0·0

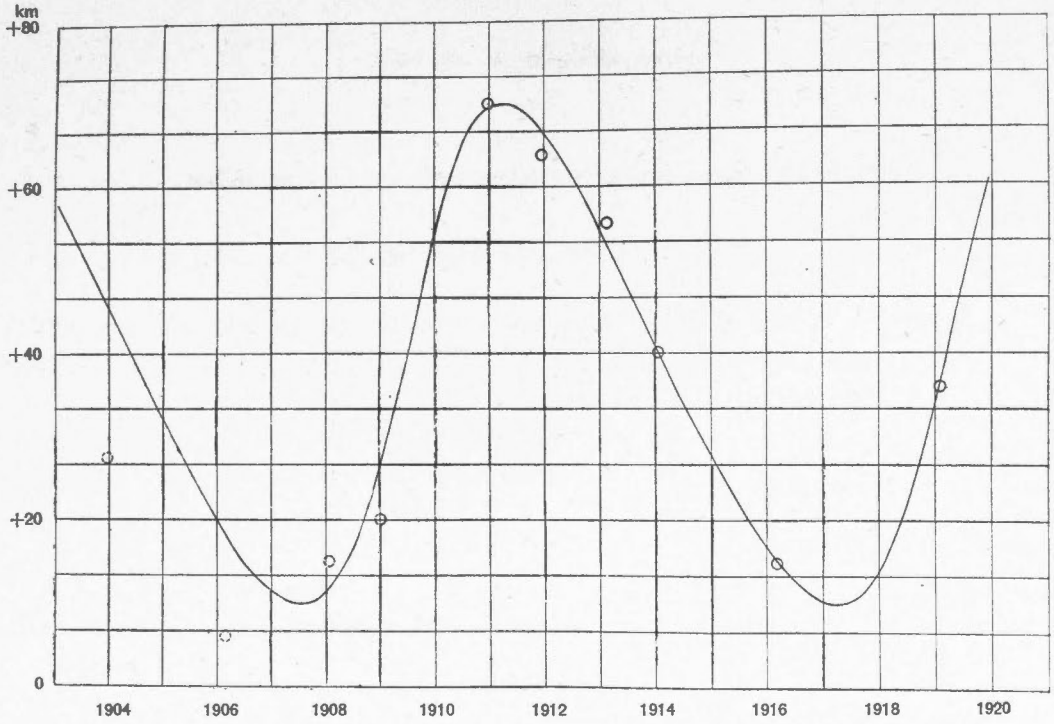
These velocities are plotted on the accompanying graph, in which the curve shown represents the following elements. The curve was obtained graphically with only a few trials and no attempt has been made to improve the elements by a least-squares solution.

PROVISIONAL ELEMENTS

$$P = 9\cdot6 \text{ years}$$
$$e = \cdot20$$
$$\omega = 285^\circ$$
$$\gamma = +38\cdot45 \text{ km.}$$
$$K = 30\cdot0 \text{ km.}$$
$$T = 1909\cdot75$$
$$a \sin i = 1{,}417{,}000{,}000 \text{ km.}$$

The general character of the spectrum would seem to bear out this long-period variation. The spectrum of the star which gives the fairly sharp lines whose measures are here recorded, and which may be called component 1, would seem to overlie that of one (component 2) consisting of faint and very broad bands, so broad in fact that they were never separated from the other. When the velocities for component 1 were at their maximum around 1911, the spectral lines were nearly at the extreme red edge of the broad bands corresponding to component 2. The minimum is not so well recorded, but apparently at that time there is more of the band showing to the red than to the violet. At intermediate points the principal lines are more nearly central on the bands. Minor variations, due possibly to the third component of the triple system, whose period is as yet undetermined, complicate matters but the foregoing, while given with a certain amount of reserve, seems to describe the general character of the spectrum. It is hoped to follow the star from time to time to more definitely determine the elements.

Dominion Observatory
Ottawa
February, 1919.



Radial Velocity Curve of ν Geminorum