Baxendell's Observations of U Geminorum. Edited by H. H. Turner, D.Sc., F.R.S., Savilian Professor.

1. These observations are published at once for the reason mentioned on p. 119 of this volume, viz.:—the University of Utrecht has offered a prize (open to Dutch astronomers) for a dissertation on this Variable, and there have been requests made for original observations.

Mr Joseph Baxendell has now put into my hands the MS. observations made by his father, which go back to 1836. Inquiry having been made as to this particular star, it was elicited that these valuable observations of variables were for the most part not ledgered, but remained in the original observation books. Of these there are—

(*a*) Three foolscap volumes, 1836–48, 1848–56, and 1856–60,
(*b*) Seven small notebooks, 1861–77,
(*c*) A quarto notebook, 1877–88,

of which (*a*) and (*b*) represent work at Manchester, and (*c*) work at Southport.

2. The material (*b*) and (*c*) has all been now copied out in ledger form (under each star), and the ledgers are deposited in a building different from that containing the original books. The material (*a*) is more difficult to transcribe in ledger form. It is scarcely possible to hand it to anyone who is not familiar with variable star records, and procedure is under consideration. I take this opportunity of saying that I should be very glad of skilled volunteer assistance, at any rate in dealing with the copied ledgers for different stars, and perhaps with these early records also. If any variable star observer has leisure for work of the kind and would communicate with me, I should gratefully accept assistance in making this mass of valuable material ready for publication as soon as possible. Unaided, my work at it must necessarily be slow.

3. The observations of the elder Baxendell (*b* 1815–*d* 1887) divide themselves into two periods:—

1836–1877 at Manchester. "With his friend Mr Robert Worthington, of Crumpsall Old Hall, he erected the Crumpsall Observatory, where the large 13-inch reflector (the speculum of which he had himself cast, ground, and polished) was mounted, beside a small 5-inch equatorial refractor" (*Monthly Notices*, xlviii. p. 157). The former instrument is designated R(13) below, and the latter A. In *M. N.*, xviii. p. 11, the focal length of A is given as 70 inches. Besides these a 12-inch reflector belonging to Mr Williamson was used, and is designated R(12); and other small instruments—a 30-inch achromatic, a 22-inch achromatic, and a Tully telescope. These are called 30(*a*), 22(*a*), and T respectively. There are also B ("Mr Bowman's $7\frac{1}{4}$-inch") and C, a comet seeker of about $2\frac{1}{4}$ inches aperture. Mr Baxendell tells me that 22(*a*) was an excellent $2\frac{3}{4}$-inch by Dancer, who also made A.

1877–1888 at Southport. "In 1871 he was appointed superintendent of a meteorological observatory in Hesketh Park, fitted up and presented by John Fernley, Esq., formerly of Manchester; and in 1877 he erected his own private astronomical observatory in Birkdale, Southport, and resumed his observations of variable stars, etc. with a 6-inch equatorial refractor by Cooke & Sons, assisted for some years (previous to 1888) by his son" (*loc. cit.*, p. 158).

4. A careful note in the quarto MS. book (*c*) above gives a more detailed description of the Southport Observatory, and the following paragraphs concern us:—

"The observatory, the equatorial and micrometer, the portable transit instrument, the sidereal chronometer, and sidereal watch belong to Thomas S. Bazley, Esq., of Hatherop Castle, Fairford, Gloucestershire, who has kindly granted me the use of them so long as I may be able or inclined to make astronomical observations, and has also borne the expense of their removal from Hatherop Castle, and of the re-erection of the observatory, and re-mounting of the equatorial and transit instrument; and I think it a duty to make this record of his unlooked-for kindness and liberality, for which I am most sincerely and deeply grateful.

"The object-glass of the equatorial is 6 inches in diameter, and has a focal length of $87\frac{1}{2}$ inches. There are six negative eyepieces, a comet eyepiece, two reflection sun eyepieces, and three sunshades. The powers of the six negative eyepieces, as determined by Mr Bazley, are 48, 80, 125, 180, 260, and 360.

This instrument is denoted by E below. In 1870 and 1871, before this instrument was erected, he used Mr Gladstone's $7\frac{1}{2}$-inch achromatic.

5. *Comparison Stars.*—The brighter comparison stars *a*, *b*, *c*, etc., are the same as those of Pogson and Knott, except that Knott's star *l* was at first denoted *x* by Baxendell. As, however, there is no doubt about the identification, and as he himself used *l* after 1864, I have (though with some misgivings) altered the notebook *x* into *l* in what follows. He made one or two determinations of the magnitudes of the brighter stars, but not many: probably he accepted these data from Pogson (or Knott?), and no discussion of his separate observations is necessary. But see the letter from Father Hagen, appended to this paper.

6. As regards faint stars, Baxendell made some noteworthy observations in the early years. One instance does not affect the observations of the variable, but may be given here as an indication of what he could see. He makes the following notes (I have written ξ and η for x and y to avoid confusion with another x and y):—

"1858 February 1. Pogson's star *c* is a delicate triple, and there is a fourth star perhaps sufficiently near to constitute it a quadruple; ξ about $13\frac{1}{4}$ mag.; η about 14 mag., and of a decided light blue colour."

"1858 February 8. Companions of Pogson's star *c*, ξ about $13\frac{1}{4}$ mag., η about 14 mag."

"1858 April 17. Pogson's star *c* quadruple; A 9·2 mag., B 12, C 13½, D 14; C a light *blue* colour, very striking for so small a star. The magnitudes merely estimated."

There are no other references to these stars except that a diagram is appended on February 1, though without any scale.

7. Now there is some confusion about Pogson's *b* and *c* (see *M. N.*, lxvii. pp. 125–8), Knott using *c* and *b*, where Pogson used apparently *b* and *c*. Assuming Baxendell's identification to be the same as Knott's, *c* is the double star Σ1158; and the position angle and apparent magnitudes given in Mr Lewis's recent catalogue of the Struve stars accord well with the diagram in Baxendell's notebook for the pair marked *c*. This supplies the scale of the diagram approximately, and it can be accordingly read as follows (very roughly):—

	Pos. Angle.	Dist.	Mags. Bax.	Mags. Σ.
A	0	0·0	9·2	8·8
Σ Companion or B	(333°)	(7″·5)	12	10·0
η or C	230	9″	13¼	
ξ or D	320	60″	14	

But there is no mention of either ξ or η in *Memoirs R.A.S.*, vol. lvi. p. 226. Perhaps some double star observer may care to look at Σ1158 again. (See note by Mr Lewis at end.)

8. The faint stars in the neighbourhood of the variable, used in comparisons, are given in a diagram on 1858 February 1, which includes Knott's *f*, *g*, *h*, and *l*, so that there is no difficulty in reading it. In the neighbourhood of U there are no less than *five* other stars, two in ink, and three in pencil perhaps added afterwards. One of these is lettered as the variable U, but this identification can only be taken as provisional, as subsequent notes show. The best plan seems to be to give the positions of these stars as below (so that anyone can make an accurate diagram for himself in a few moments if he so desires), and the relevant notes just as they stand in the notebooks. For reading the diagram, the particulars given in Hagen's *Atlas Stell. Var.* have been used. A scale was constructed to fit them as nearly as possible, and the comparison of data with results shows the skill with which Baxendell made such diagrams.

TABLE I.

Knott's Letter.	Hagen's No.	Hagen's Δα	Hagen's Δδ	Baxendell's Δα	Baxendell's Δδ	Baxendell's Letter.
		m s	′	m s	′	
f	18	+0 2	+5·4	+0 0	+5·4	*f*
g	25	+0 18	−0·1	+0 18	+0·5	*g*
h	24	+0 6	+4·4	+0 6	+4·0	*h*
	23	+0 7	−3·8	+0 9	−3·8	*k*
l	39	−0 2	+2·1	−0 1	+2·2	*l*
k	33	+0 4	−2·9	+0 5	−1·5	*w*
				0 0	+0·3	U ; ink.
				+0 2	+0·1	Pencil.
				+0 2	−0·3	Ink.
				+0 4	−0·2	Pencil.
				+0 4	+1·0	Pencil.

9. The notes are as follows :—

1858 February 1. 9^h to $9\frac{3}{4}^h$. Mr Worthington's 13-inch reflector.

h 1·3 > *l* ·4 or ·5 > U Gem.
h ·7 > *w* ·7 or ·8 > U ·3 to ·5 > min. vis.

I believe the star which I have marked U will prove to be the variable, now on its march to another maximum; though very small it is distinctly defined, has no haziness about it, and has a dull yellow colour. The above estimations make U = 14·0 mag., *w* = 13·17, *l* = 13·62, and the vanishing mag. with 13 inches aperture = 14·4 to 14·5.

1858 February 4. 7 to $9\frac{1}{2}$ *h*. 13-inch reflector.
h ·7 or ·8 > *w* ·5 or ·6 > *l*. *h* 1·5 > *l* ·6 > U. *w* 1·0 or 1·2 > U. U ·4 > a small star *y* not noticed February 1. U is therefore 14·3 mag., or ·2 or ·3 less than on the 1st inst., and is perhaps therefore not the variable. *y*, which *is* perhaps the variable, is 14·7 mag.

1858 February 6. 7^h to 8^h. Mr Williamson's 12-inch reflector.
l about ·4 > *min. visible*. Supposed U and *y* occasionally seen by transient glimpses, and *y* is perhaps the brightest (say both under 14·2 mag.).

1858 February 7. 8^h to $9\frac{1}{2}^h$. 13-inch reflector.
h ·8 > *w* ·7 > *l* ·8 > supposed U (say *u*) ·2 > *y* *f* ·4 > *k* ·4 > *g*.
∴ *u* = 14·5 or 14·6 mag., and *y* = 14·8 mag.

1858 February 8. 8^h to $9\frac{1}{2}^h$. 13-inch reflector.
l ·6 > *u* ·3 > *y* a glimpse star near to and following *y*. *u* = 14·4 and *y* = 14·7 mag.

1858 February 17. 9^h to 10^h. Mr Williamson's 12-inch reflector.

h 1·2 > w ·3 > l ·6 > u ·2 or ·3 > y. w still appears to be decreasing. The light of u very changeable, sometimes appearing fully equal to l, and at other times quite disappearing. h 1·5 > l.

Say u = 14·5 y = 14·7 mag.

1858 February 18. $8\frac{1}{2}^h$ to $9\frac{1}{2}^h$. 13-inch reflector.

w ·4 or ·5 > l ·6 > u ·3 > y. h 1·0 > w.

Say u = 14·5. y = 14·8 mag.

u precedes g 19^s·0 and on same parallel; or, if any difference, u south, but not to the extent of 5″; observation difficult, as u will not bear an illumination sufficient to render the spider lines distinctly visible.

1858 February 19. 9^h to 10^h. 13-inch reflector.

h 1· or 1·2 > w ·4 > l ·5 > u ·2 or ·3 > y.

1858 February 20. $8\frac{1}{2}^h$ to $9\frac{1}{2}^h$. 13-inch reflector.

w ·4 > l ·5 > u ·2 or ·3 > y, suspicion of a glimpse star near to and sf star u. Fluctuations in the brightness of u, which I have frequently observed lately, are very striking to-night.

1858 February 22. 8^h to 9^h. 13-inch reflector. w and l both seen occasionally pretty steadily; u seen two or three times by glimpses, but no change since last observed. Moon too near for a very satisfactory observation.

1858 February 25. 9^h to $9\frac{1}{2}^h$. 13-inch reflector. Owing to the strong moonlight, I can only say that U Gem. is below 13 mag., star w glimpsed occasionally.

1858 February 28. $8\frac{1}{2}^h$. 13-inch reflector. w and l both occasionally seen, but owing to the moonlight, etc.

1858 March 6. 8^h to 10^h. 13-inch reflector.

h ·1 > g ·9 or 1·0 > w ·3 > l ·4 or ·5 > u ·2 > y. Fluctuations in brightness of u noticed again to-night.

1858 March 13. $9\frac{1}{4}^h$. 7-inch reflector, p. 130.

w and l occasionally seen pretty steadily by glimpses, and even u two or three times seen in transient glimpses, or u and y, as in the best glimpses u had the *cometary* appearance of a very faint coarse double star. The difference of mag. between w and l cannot be more than ·2.

1858 March 16. 8^h to 10^h. 13-inch reflector, p. 196.

g = or ·1 > h: f 1·0 to 1·2 > h: w ·4 > l ·4 or ·5 > u ·2 > y. Occasionally a suspicion of a small companion sf u about 15″ distant.

1858 May 1. $9^h\ 25^m$. 13-inch reflector, p. 199.
u ·2 > l. When u first became visible in the twilight l was quite invisible. $9^h\ 40^m$ u ·2 > l. 10^h (after interruption by clouds) l = or > u: $10^h\ 10^m$ l ·2 > u: w ·6 > u.

1858 May 3. $9\frac{1}{2}^h$ to $10\frac{1}{2}^h$. 13-inch reflector, p. 199.
w ·4 > l ·4 > u ·3 > y. No indications of any minute star near u, although carefully looked for.

1858 May 4. $9\frac{1}{2}^h$ to $10\frac{1}{2}^h$. 13-inch reflector, pp. 199 and 350.
w ·4 > l ·4 or ·5 > u ·3 or ·4 > y. Could not satisfy myself of the existence of any minute star near u.

1858 November 12. 12^h. 7-inch reflector, p. 130.
l glimpsed; two or three transient glimpses of u. ? U 14 mag.

1858 November 14. 12^h. 7-inch reflector, p. 40.
U Gem. has suddenly burst forth, and is now = Pogson's b = 9·3 mag. With power 130 it is much less sharply defined than a, b, or c, and compared with them has somewhat of a nebulous appearance. Its colour is *white*. It appears to be exactly on the place of my star u.

1859 February 27. 9^h. 13-inch reflector, p. 199.
f ·8 > U ·2 > h U 12·2 mag. Neither with achromatic p. 223 nor reflector pp. 199 and 300 is U so well defined as the neighbouring stars; but I think it is not so hazy-looking as it was in November last. y only seen by glimpses, and no star seen or suspected near U.

1859 February 28. 13^h. 13-inch reflector, pp. 199 and 300.
U ·2 > w h ·8 > U ∴ U 13·1 mag. No small star visible very near U, and from the position of U with respect to w, x, and y, I can have no doubt that U and Winnecke's star are identical. U *white* or *bluish white*; light steady and haziness still perceptible.

1859 April 22. $9\frac{3}{4}^h$. 13-inch reflector, p. 196.
l ·4 or ·5 > u ·3 or ·4 > y. From the position of u with respect to w, l, and y, I have no doubt it is the variable. It has, however, a ruddy appearance, and is, when best seen, very sharply defined.

1859 November 30. 13-inch reflector, pp. 81 and 196.
u and y both seen. U below 14·2 mag.

This last note is interpreted to mean, "if U is not the same as u, it is below 14·2 mag.," for it seems clear that Baxendell considered u to be the variable.

10. These are practically all the notes that help in any way to identify the small stars. When, as on 1858 February 28, moonlight or haze interfered, the note has been curtailed, and generally notes that do not help us have been omitted. The comparisons of

these small stars are collected below in Table II. It will be seen that Baxendell observed sometimes to 0·05, taking his unit as approximately 0·1 magnitude, which by comparison with Hagen's magnitudes we see is very nearly correct. Adjusting the differences to fit the four stars *g*, *h*, *w*, *l* as nearly as possible, we have—

	$25=g$	$24=h$	$33=w$	$39=l$	u	y
Hagen	11·1	11·0	12·1	12·6	...	...
Baxendell . . .	11·05	11·10	12·05	12·45	12·90	13·20

And we may compare with these Baxendell's own absolute determinations for *u* and *y*, viz. $u=14·5$ (four nights), $y=14·8$ (four nights); showing that his adopted magnitudes are in excess, as is indicated above in the case of Σ1158.

TABLE II.

Baxendell's Comparisons of Faint Stars.

Date.	g		h		w		l		u		y
1858 Feb. 1		...		7		...		4½		...	
4		...		7½		5½		6		4	
7		...		8		7		8		2	
8		...		...		...		6		3	
17		...		12		3		6		2½	
18		...		..		4½		6		3	
19		...		11		4		5		2½	
20		...		...		4		5		2½	
Mar. 6		−1		11		3		4½		2	
13		−1		...		2		...		...	
16		+½		...		4		4½		2	
Apr. 1		+1		10		2½		4½		4	
4		+2		9		4		4		5	
6		+1		...		4½		3		5½	
10		+1		...		4½		3½		...	
13		...		...		4½		2½		...	
17		...		...		3		4		...	
May 3		...		...		4		4		3	
4		...		...		4		4½		3½	
5		..		...		4		4		...	
6		...		...		4		4		...	
10		...		...		4		3½		3½	
11		...		...		4		4		...	
1859 Apr. 22		...		...		...		4½		3½	
Mean		+·05		+·95		+·40		+·45		+·30	

11. *The Observations of the Variable.*—The observations are collected in Table III. in a concise form. Baxendell used the symbol $>$ in his notebooks; but as it can always be inferred from the order of the other symbols, it has been omitted. When he gives alternative readings such as ·5 or ·6, the mean has been taken. Finally the decimal points have been omitted. Thus his record

$$h \cdot 7 \text{ or } \cdot 8 > w \cdot 5 \text{ or } \cdot 6 > l$$

becomes

$$h\ 7\tfrac{1}{2}\ w\ 5\tfrac{1}{2}\ l.$$

Other contractions will be readily understood. Thus on 1859 May 20 the inference $< b + 15$ means that the faintest star visible was judged to be a magnitude and a half fainter than b.

The letter u has been retained where Baxendell used it, although he afterwards decided that it was the variable near minimum. It seems advisable to indicate as closely as possible the gradual exploring of the small stars by keeping the notebook records.

12. The early observations are difficult to give in tabular form, and are better simply transcribed as follows:—

1857 February 25. Mr W.'s 5 in. ach. p. 68. Several very small stars about the place of U Gem.; but all much less than the star to the south, about 9½ mag.

1857 March 4. 10^h. With 5 in. achr. Stars not brighter than 11 mag. in the place of U Gem.

1857 March 8. 11^h. With 5 in. ach. p. 68. A star of about 11 mag. in the place of U Gem., and another near it nf 2′ or 3′ distant and about half a mag. less.

1857 March 16. About 8^h. 5 in. ach. p. 68. No star brighter than 11 mag. about the place of U Gem.

1857 March 21. 11½^h. 30 in. ach. Nothing visible in the place of U Gem.

[1857 March 24 is the last date in the book preceding April 13.]

1857 April 13. 30 in. ach. A very minute star occasionally visible about the place of U Gem., and therefore about 10¼ mag.

[1857 April 14, 15, 16. Other stars observed, but U Gem. apparently not looked for.]

[1857 April 18. 9½^h. 5 in. ach. A diagram is made of the stars f, h, g and three brighter (Hagen's 18, 24, 25, 22, 21, 19), and the remark made "small companion of f" (that is $h = 11{\cdot}0$) "almost a *min. visible*, and therefore about 12½ mag." Baxendell's magnitudes are too large, as shown elsewhere.]

1857 April 19. 10^h. 30 in. ach. Nothing visible on the place of U. Gem.

[1857 April 20. 10^h. 5 in. ach. p. 68. Sketch of April 18 referred to, and Hagen's 18 judged ·1 or ·2 brighter than 21.]

13. There is nothing more before October, and the observations from this point may be given in tabular form.

Table III.

Date.	d	h	Telescope and Power.	Observations and Inferences.
1857.				
Oct.	28		T 35	Not seen.
Nov.	18		T 35	,, < 11·0.
	23		,,	,,
	26	11½	,,	,,
1858.				
Jan.	20	9½	A 68	,,
	21	13	T 35	,,
	25	11½	T 40	,, < b + 10.
	31	10	R(12)	,, < 13·0.
Feb.	1	9½	R(13)	l 4½ u ; w 7½ u 4 limit.
	4	7–9½	R(13)	l 6 u : w 11 u 4 y.
	6	7–8	R(12)	u = y.
	7	8–9½	R(13)	l 8 u 2 y.
	8	8–9½	R(13)	l 6 u 3 y.
	17	9–10	R(12)	l 6 u 2½ y.
	18	8½–9½	R(13)	l 6 u 3 y.
	19	9–10	R(13)	l 5 u 2½ y.
	20	8½–9½	R(13)	l 5 u 2½ y.
	22	8–9	R(13)	Not seen < l.
	25	9–9½	R(13)	,, < w.
	26	8½	R(13)	,, < w.
	28	8½	R(13)	,, < l.
Mar.	3	9	T 35	,, < g.
	6	8–10	R(13)	l 4½ u 2 y.
	11	10	A 68	Not seen < l.
	13	9¼	R(7) 130	,, < l.
	14	8	A 68	,, < w.
	16	8–10	R(13)	l 4½ u 2 y.
	20	8–10	A 40	Not seen < g.
	24	8	R(13) 81	,, < 12·6.
	26	8¼	R(13) 81	,, < g.
Apr.	1	8–10	R(13) 196	l 4½ u 4 y.
	4	8½–9½	R(13) 196	l 4 u 5 y.
	6	8½–9½	R(13) 196	l 3 u 5½ y.
	9	9½	R(7) 40	Not seen.
	10	8½–10	R(13) 196	l 3½ u 4 limit.
1858.				
Apr.	12	9½	A 40	Not seen < w.
	13	8½–9½	R(13) 196	l 2½ u.
	17	9–11	R(13) 199	l 4 u 3 limit.
	21	9¾	R(13) 196	Not seen < w.
	23	9½	R(13) 196	,, < l.
	25	9	R(13) 196	Not seen < 13.
May	1	9½	R(13) 199	See above notes.
	3	9½–10½	R(13) 350	l 4 u 3 y.
	4	9½–10½	R(13) 199	l 4½ u 3½ y.
	5	9¾–10½	R(13) 199	l 4 u.
	6	10–10½	R(13) 199	l 4 u.
	10	10–10½	R(13) 199	l 3½ u 3½ y.
	11	10–11	R(13) 199	l 4 u.
	16	10–10½	R(13) 199	Not seen < w.
	18	10–10½	R(13) 199	,, < 12·8.
Sept.	20	15	R(13) 196	u = l.
Nov.	2	...	(22)a	Not seen < c + 5.
	5	...	(22)a. 21	,, < 10·2.
	6	...	(22)a. 21	,, < 10·5.
	10	12½	R(7) 130	,, < l.
	11	12½	R(7) 130	,, < l.
	12	12½	R(7) 130	u glimpsed.
	15	12	R(7) 40	U = b.
	16	11	R(7) 40	b 1½ U.
	17	11–11¾	R(7) 40 } 130 }	b 5½ U 13½ f.
	18	13	R(13) 81	b 12 U 2½ e.
	21	12½	R(13) 199	Not seen < w.
Dec.	2	9½	R(13) 199	,, < l.
1859.				
Feb.	22	10½	A 68	a 2½ U 2½ b.
	23	12¾	(22)a 21	c 2 U : b 1 U.
	24	7	A 68	c = U.
	26	12⅓	(22)a	e 2 U.
	27	7	A 68	f 7 U 3 h.
	27	9	R(13) 199	f 8 U 2 h.
	28	13	R(13) 300	h 8 U 2 w.

TABLE III.—*continued.*

Date.	d	h m	Telescope and Power.	Observations and Inferences.
1859.				
Mar.	10	8½	R(13) 300	*y* seen.
Apr.	22	9¾	R(13) 196	*x* 4½ *u* 3½ *y*.
May	13	10½	A 40	Not seen.
	16	10	A 40	,, < 11·0.
	20	10	A 40	,, < *b*+15.
	22	10½	A 40	,, < *b*+15.
	23	10½	A 40	,, < 10·7.
Nov.	30	...	R(13) 196	*u* and *y* seen.
Dec.	3	...	A 68	Not seen < 10.
	5	...	R(13) 196	,, < *l*.
	14	...	R(13) 196	*u* and *y* seen.
1860.				
Feb.	16	10	R(13) 199	*l* 5 U.
	26	9	A 68	Not seen < *w*+.
	28	9¼	A 68	,, < 13·8.
Mar.	2	8	A 223	,, < 11·0.
	8	8	A 223	,, < 13·0.
	14	10	R(13) 199	U = 14·3.
	18	9¼	A 39	Not seen < 10·3.
	21	9	A 223	,, < 13·7.
	25	10	R(13)	,, < 14·0.
Apr.	10	8¾	A 68	,, < 13·0.
	15	10	A 68	,, < 13·0.
	20	9½	A 68	*a* 2 U.
	21	9	A 68	*a* 3½ U 3 *c*.
	22	9	A 68	*a* 2 U 4½ *c*.
	23	9	A 68	*a* 6 U 1 *c* : U 1½ *b*.
	24	9¼	A 68	*c* 1½ U : *b* ½ U.
	25	9	A 68	*c* 1½ U : *b* ½ U.
	27	9	A 68	*b* 2 U : *a* 10 U.
May	1	10½	...	*f* 4 U.
	3	9½	R(13) 196	*g* 10 U : *h* 7½ U 2½ *w*.
1861.				
Jan.	1	10 50	C 39	Not seen < 10·0.
	3	13 +	R(7) 39	,, < 12·3.
	4	9 +	A 68	,, < 12·3.
	6	9 5	A 68	Not seen < 13·0.
	15	10 10	A 68	,, < 13·3.
	28	9 35	A 68	,, < 11·0.
Feb.	6	12 25	C 39	,, < 12·0.
	10	9 5	A 68	,, < 13·3.
	24	7 40	A 68	,, < 11·0.
	28	10 25	C 39	,, < 11·0.
Mar.	8	10 15	C 39	,, < 10·5.
	13	8 35	R(13) 81	*l* 5 U.
	16	10 5	A 68	Not seen < 13·3.
	21	8 30	A 68	,, < 9·5.
	30	8 35	A 68	,, < 13·3.
Apr.	3	9 10	A 68	,, < 13·3.
	6	8 30	A 68	,, < 12·5.
	9	10 40	C 39	,, < 10·5.
	10	10 30	R(13) 196	*l* 4 U.
	11	8 50	A 68	Not seen < 13·3.
	14	9 30	R(13) 81	*l* 4 U.
	20	8 30	A 68	Not seen < 11·0.
	28	10 0	A 68	,, < 13·3.
May	4	10 0	A 68	*a* 2 U 3 *c*; U 3½ *b*.
	9	9 30	A 68	*b* 2 U ; *c* 2 U.
	13	9 30	A 68	Not seen < 10·5.
	14	10 25	A 68	U 4 *f*.
Oct.	28	11 40	,,	Not seen < 12·5.
Dec.	28	9 0	,,	*w* 3½ U = *l*.
1862.				
Jan.	5	9 15	,,	*a* 8 U : *b* 1 U 1 *c*.
	10	9 30	,,	? visible < 10·2
	11	8 15	,,	*f* = U.
	22	8 15	,,	Not seen < 12·5.
Mar.	15	...	,,	,, < 11·0.
	19	10 0	,,	,, < 13·3.
	22	9 0	,,	,, < 11·0.
	31	10 5	,,	,, < 12·0.
Apr.	8	10 30	,,	,, < 10·5.
	10	8 25	,,	,, < 11·5.

TABLE III.—*continued.*

Date.	d	h m	Telescope and Power.	Observations and Inferences.
1862.				
Apr.	11	8 50	A 68	Not seen < 10·5.
	12	...	,,	Suspected < 11·0.
	13	...	,,	Not seen < 12·0.
	23	9 15	,,	Glimpsed < 13·1.
	28	10 0	,,	?glimpsed < 13·5.
	29	10 30	,,	Not seen < 13·3.
	30	9 45	,,	Not seen < 13·3.
May	3	9 45	R(13) 81	Barely glimpsed < 13·3.
	5	10 30	A 68	Not seen < 12·5.
	16	10 10	A 68	,, < 11·0.
Oct.	18	12 50	C 39	,, < 10·5.
Nov.	15	13 10	,,	,, < 10·0.
	16	10 10	R(13) 81	,, < 13·5.
	23	...	A 68	,, < 13·0.
Dec.	26	9 0	,,	*e* ½ U 6 *f*.
	29	11 30	,,	Not seen < 12·2.
	30	14 0	,,	,, < 12·2.
1863.				
Jan.	23	7 40	,,	,, < 13·3.
Feb.	8	7 50	,,	Glimpsed ? < 13·3.
	12	11 0	,,	Not seen < 13·3.
	14	9 0	C 39	,, < 12·0.
	15	9 0	A 68	,, < 13·3.
	17	...	B 88	,, < 14·0.
	21	8 10	A 68	,, < 13·7.
Mar.	3	9 40	,,	,, < 11·0.
	15	11 0	,,	,, < 13·3.
	21	11 0	,,	,, < 13·0.
	23	9 0	,,	,, < 13·3.
	26	8 45	,,	,, < 13·0.
Apr.	1	9 30	,,	,, < 10·0.
	11	8 40	,,	*b* 2 U 6½ *d* : U 14 *e c* 3 U.
	13	9 0	,,	*e* 2½ U 1 *f* : *d* 8½ U.
Apr.	15	9 0	A 68	Not seen < 13·0.
Nov.	2	12 0	,,	,, < 11·0.
	4	12 20	C 39	,, < 10·5.
	5	12 40	,,	,, < 11·5.
	8	13 30	,,	,, < 10·5.
Dec.	2	13 0	,,	,, < 10·5.
	5	10 15	A 68	,, < 12·0.
	17	8 30	,,	,, < 10·5.
	27	7 30	,,	*b* 4 U.
	29	9 30	C 39	Not seen < 10·7.
1864.				
Jan.	4	8 30	A 68	,, < 13·3.
Feb.	12	...	,,	,, < 13·0.
Mar.	15	9 10	,,	,, < 10·9.
	23	9 40	,,	,, < 12·0.
	28	9 40	,,	,, < 13·3.
Apr.	11	9 0	,,	,, < 13·3.
	13	...	,,	,, < 11·5.
	18	...	,,	,, < 11·5.
	21	...	,,	,, < 12·3.
	25	...	,,	,, < 13·0.
	28	...	,,	Suspected < 13·0.
May	7	10 10	,,	Not seen < 13·2.
Oct.	7	..	R(13)	Glimpsed < 13·7.
	31	..	A 68	Not seen < 12·5.
Nov.	5	...	R(13)	Doubtful < 13·5.
	28	...	A 68	Not seen < 13·3.
Dec.	21	...	,,	,, < 13·0.
	30	7 40	,,	*b* 1 U = *c*.
	31	11 10	,,	*a* 6 U 3 *b* = *c*.
1865.				
Jan.	4	8 20	,,	*a* 12 U = *c* : *b* 1½ U.
	6	...	,,	*c* 1½ U.
	20	...	,,	Not seen < 13.
Mar.	30	...	,,	,, < 13.
Apr.	10	...	,,	,, < 10·5.
	15	...	,,	,, < 12·5.

TABLE III.—*continued.*

Date.			Telescope and Power.	Observations and Inferences.
1865.	d	h m		
Apr.	24	10 0	A 68	f 9 U 3 h : U 1 g 12·1.
	25	10 0	,,	g 4 U 12·6.
	26	10 0	,,	k 1 U 13·4.
Nov.	21	...	,,	Not seen < 13·3.
Dec.	14	...	,,	,, < 13·3.
	22	...	,,	,, < 12·5.
	26	...	,,	,, < 12·3.
1866.				
Jan.	15	9 40	,,	,, < 13·3.
	16	10 25	,,	h 6½ U 5 k, g 4 U 12·9.
	18	13 30	C 39	a 6 U 2 c ; U 3 b.
	20	8 15	A 68	a 6½ U 2 b ; U 1½ c.
	22	7 10	,,	c 1 U, b 1½ U.
	23	11 20	,,	a 6 U 1½ b ; U 2 c.
	28	...	,,	Not seen < 10·3.
	29	...	,,	,, < 10·5.
Feb.	2	8 40	,,	k 4½ U ; l = U 13·7.
Mar.	13	...	,,	Not seen < 13·5.
Apr.	13	...	,,	,, < 13·3.
	21	9 50	,,	f 3 U 8 h.
	22	10 30	,,	h 4½ U.
Oct.	9	...	,,	Not seen < 12½.
1867.				
Jan.	2	...	,,	,, < 13·3.
	8	...	,,	Suspected < 13·3.
	11	...	,,	Not seen < 13·3.
	16	...	,,	,, < 10·2.
	28	...	,,	,, < 13·4.
Feb.	2	...	,,	,, < 13·2.
	20	...	,,	,, < 13·0.
	26	...	,,	,, < 13·0.
Apr.	21	...	,,	,, < 13·0.
May	5	...	C 39	,, < 10·5.
	14	...	A 68	,, < 12·0.
1867.	d	h m		
Nov.	17	...	A 68	Not seen < 13·0.
Dec.	18	8 10	,,	U 2 f.
	22	8 50	,,	Not seen < 12·8.
1868.				
Apr.	11	...	,,	,, < 13·3.
	23	...	,,	,, < 13·2.
1869.				
Feb.	5	...	,,	,, < 12·8.
Mar.	2	...	,,	,, < 13·5.
Dec.	23	...	,,	,, < 12·5.
1870.				
Mar.	25	...	G 60	l 3½ U.
1871.				
Mar.	13	...	C 39	Not seen.
Apr.	7	...	G	,, < 14·0.
	10	...	,,	,, < 13·7.
1877.				
Dec.	12	...	E 80 & 180	Not seen < 13·5.
1878.				
Jan.	9	...	...	,, < 13·0.
Mar.	24	...	E 80	,, < 13·5.
	31	...	,,	,, < 13·5.
April	1	...	,,	,, < 13·5.
	5	...	,,	Glimpsed 13·7.
	6	...	,,	Barely glimpsed.
	8	...	,,	Not seen < 12·5.
	17	...	,,	,, < 13·0.
May	1	9 40	,,	f 6 U 4 h ; U 7 g.
	3	10 30	,,	Not seen < 13.
Nov.	2	11 50	,,	,, < 13·5.
	4	5 15	,,	,, < 13·5.
	25	...	,,	,, < 13·0.
	28	...	,,	,, < 13·5.
Dec.	7	...	,,	,, < 12·5.
	23	...	,,	,,
	30	...	,,	,, < 12·5.

Table III.—*continued.*

Date.	d	h m	Telescope and Power.	Observations and Inferences.
1879.				
Jan.	13	7 40	E 80	*b* 2 U: *c* 1 U; *a* 10 U.
		8 0	,,	*b* 1 U = *c*.
	15	6 50	,,	*b* 1½ U; *c* 1 U *a* 10½ U.
		8 15	,,	*b* 1½ U; *c* 1 U.
	16	8 20	,,	*b* 3 U; *c* 2 U 13 *e*.
		8 35 – 9 45	...	*b* 2½ U; *c* 1½ U; *a* 14 U 10 *d*.
	19	7 10	...	U ½ *e*; U 7½ *f*.
	22	8 30	E 80	*h* 7 U 3 *k*.
		8 40	E 125	*h* 8 U 4 *k*.
	23	9 45	E 80	*k* 3 U 2 *l*.
	25	10 30	...	Not seen < 13·0.
April	10	9 15	...	Not seen < *l* + 2.
Sept.	19	14 30	...	,, < *k* + 3.
Oct.	14	12 50	...	,, < 13·5.
	15	13 0	...	,, < *k* + 3.
	20	13 0	...	,, < *k*.
Nov.	1	12 0	...	,, < *h* + 7.
1880.				
Jan.	18	12 0	...	Glimpsed = 13·5
	19	11 0	...	Not seen < *k* + 3.
	22	12 15	...	,, < 13·0.
	28	7 0	...	*a* 9 U = *b* 1½ *c*.
	29	10 40	...	*b* = U *a* 8 U.
	31	12 20	...	*b* 2½ U 12½ *e*; *c* 1 U 10½ *d*.
Feb.	1	9 30	...	*b* 1½ U; *c* ½ U.
	3	7 10	...	*b* 4 U 5 *d*; U 10 *e*.
	5	9 25	...	*d* 2 U 5 *e*.
	8	9 0	...	*h* ½ U: *g* 7½ U.
	14	...	...	Not seen < *k*.
Apr.	29	10 0	...	,, < 13·0.
	30	11 0	...	Glimpsed 13·7.
May	1	9 50	...	Not seen.
	3	10 45	...	Glimpsed: *k* 2½ U.

Date.	d	h m	Observations and Inferences.
1880.			
May	6	10 20	Not seen < 13·0.
	9	...	,, < *g*.
	10	10 40	,, < *k*.
	12	10 35	,, < 13·5.
Oct.	9	12 40	,, < *k*.
	10	13 20	,, < *k*.
Nov.	26	11 30	*k* 5 U; *l* 2½ U.
	27	12 42	= 13·7.
Dec.	1	10 15	Not seen < *k*.
	24	9 20	*f* 10 U 1½ *g*; U 4½ *h*.
	25	8 25	U 2 *k*; U 5 *l*.
1881.			
Apr.	1	8 50	*f* 10 U 2 *h* 1 *g*.
		11 55	U 1½ *f*: U 12½ *h*.
		12 14	U 4 *f*; U 3 *e*; *d* 2 U 15 *h*.
		12 35	U 5 *f*: *d* 1½ U 3 *e*.
	2	8 15	U 1 *b*: *a* 5 U.
	3	9 5	*a* 5½ U 1½ *b*: U ½ *c*.
	5	8 40	*b* 1 U; *c* 2 U: *a* 7 U.
	6	10 40	*b* 1½ U; *c* 2½ U; *a* 7 U 12 *d*.
	7	9 5	*b* 1 U: *c* 2 U.
	8	8 35	*b* 4 U: *c* 5 U *a* 10 U 10 *d*.
	9	9 15	*b* 7 U 8 *d*: *a* 13 U: *c* 8 U.
	17	9 10	Not seen < 13·8.
Oct.	26	...	,, < *k*.
Nov.	14	...	,, < 13·5.
	17	...	,, < *l*.
Dec.	27	...	,, < *k*.
1882.			
Mar.	6	8 15	*f* 5 U 4 *g*: U 8 *h*.
	8	11 20	Not seen < *h*.
	12	12 0	Glimpsed < *l*.
Oct.	28	12 0	Not seen < *k*.
1883.			
Jan.	30	7 45	*a* 5 U = *b*.
1884.			
Jan.	20	...	Not seen < *k*.

TABLE III.—*continued.*

Date.	d	h	m	Observations and Inferences.
1884.				
Feb.	2	...		Not seen $< k+2$.
May	18	10	30	$c\ 12\ U\ 5\ e : d\ 3\ U$.
	19	10	20	$d\ 6\ U\ 4\frac{1}{2}\ e : c\ 17\ U$.
Dec.	20	12	0	$l\ 3\ U$.
1885.				
Jan.	5	10	30	$e\ 4\frac{1}{2}\ U\ 2\frac{1}{2} f$.
	6	7	35	$f\ 12\ U\ 2\ h ; U\ 3\ g$.
	7	10	5	$h\ 6\ U\ 7\ l : g\ 5\ U\ 5\ k$.
	8	...		$k\ 3\ U = l$.
Mar.	22	...		Not seen $< k$.
Apr.	2	...		,, $< l$.
	8	8	40	$a\ 7\ U = b ; U\ 1\frac{1}{2}\ c$.
Nov.	15	11	0	Not seen $< 12{\cdot}5$.
Dec.	1	10	0	,, $< 13{\cdot}0$.
1886.				
Jan.	4	...		,, $< 13{\cdot}5$.
	5	10	50	,, $< 13{\cdot}7$.
	29	...		,, $< k$.
	30	...		,, $< l$.
1886.				
Jan.	31	...		Not seen $< l$.
Feb.	14	...		,, $< g ; h\ 5\ g$.
	23	...		,,
Mar.	3	11	5	$k\ 2\ U\ 2\ l$.
	6	8	0	$b\ 3\frac{1}{2}\ U ; c\ 2\ U\ 8\ d$.
	7	8	30	$b\ 4\ U ; c\ 2\ U$.
	8	7	55	$b\ 2\frac{1}{2}\ U ; c\ \frac{1}{2}\ U\ 8\frac{1}{2}\ d$.
	9	7	50	$b\ 1\frac{1}{2}\ U = c ; U\ 10\ d$.
	10	7	45	$b\ 3\ U ; c\ 1\ U\ 10\ d$.
	11	7	35	$b\ 4\frac{1}{2}\ U : c\ 3\frac{1}{2}\ U\ 8\ d$.
	12	7	50	$b\ 6\ U : c\ 5\ U\ 7\ d$.
Nov.	30	10	5	$b = U\ 1\frac{1}{2}\ c$.
Dec.	1	11	20	$b = U\ 1\frac{1}{2}\ c$.
	4	9	5	$c\ 4\ U\ 7\ d$.
	4	10	15	$c\ 3\frac{1}{2}\ U\ 7\ d ; g\ 5\ h$.
1887.				
Feb.	26	8	0	about $= f$.
	27	8	0	$f\ 7\ U\ 3\ h$.
	28	9	30	$h\ 10\ U\ 7\ k : f\ 8\ h\ 1\ g$.

[The only remaining entries in the book are on March 3 (three stars), June 7 (one star), June 10 (five stars). From 1879 April there are no special entries about the telescope, which may be assumed to be E throughout.]

The following letter from Father Hagen explains itself. He draws attention to an unlucky misprint in my paper on p. 128, viz. Pogson's number for *m* in the first column should be, not 113, but 115, as in the diagram. After some consideration I have assumed that Baxendell's *k* was not Knott's *k*, but this star *m* (Hagen's 23): and Baxendell must have used *w* for Knott's *k* (Hagen's 33). The identification of these faint close stars is rather troublesome.

Letter from Father Hagen on the Comparison Stars for U Geminorum.

My Dear Professor Turner,—Your publication of Pogson's observations of *U Geminorum* in the *Monthly Notices*, vol. lxvii. pp. 119–131, will prove very useful to students interested in this line of astronomy. The publication might perhaps be enhanced in its value by a few statements regarding Pogson's comparison stars. In making a final discussion of Pogson's observations, one will naturally not be satisfied with the identification of the comparison stars from diagrams alone, or with the preliminary magnitudes assigned to them by Pogson and Knott.

The exact identification of all the stars of his chart was made by Pogson himself in a manuscript catalogue now preserved at the Harvard College Observatory. The catalogue was made within the years 1856 to 1860 at the Radcliffe and Hartwell Observatories. On five pages it gives the R.A. and Decl. of all the stars on the chart, reduced to 1860·0. A complete illustration of Pogson's catalogues may be seen in a publication of Georgetown College Observatory, entitled "Supplementary Notes," etc., pp. 28–31. There is no chart of this Variable among the manuscripts preserved at Harvard. It is, however, not necessary to consult these manuscripts, since all of Pogson's comparison stars of *U Geminorum* can be identified by means of chart 2815 of the *Atlas Stellarum Variabilium* (Series II.).

As to the magnitudes of the stars, those of Pogson and Knott have apparently a common scale, and seem to be based on the theoretical limit of visibility in their instruments. The table subjoined gives, in addition, the magnitudes of the fainter stars by Winnecke, and those of all the stars, computed from the grades of the *A.S.V.* The latter two sets of magnitudes have again a common scale, and are both based upon the B.D. system.

The first two columns of the following table explain themselves from page 128 of your article. The third gives the letters and magnitudes of Winnecke, and is taken from the *Astr. Nachr.*, vol. xlvii. No. 1120. The two columns headed A.S.V. contain the numbers and magnitudes of the atlas chart 2815. From the same atlas are taken the columns $\Delta\alpha$ and $\Delta\delta$, which give the positions of the comparison stars relative to the Variable in R.A. and Decl. To them are appended two columns *D*, with the mean results deduced from your readings of the two diagrams. They may serve to show, on the one hand, how accurate the diagrams are, and, on the other, that there is no doubt left in the identifications.*

* In vol. xvii. of the *Astrophysical Journal*, p. 282, I suggested that Pogson's star 8·9 might be No. 5 of the Atlas Chart, instead of No. 1, judging from the B.D. magnitude of this star, and not having seen Pogson's diagram.

Pogson's Comparison Stars for U Geminorum.

Pogson.	Knott.	Winnecke.	A.S.V.		Δα.	D.	Δδ.	D.	Bax. [H.H.T.]
M	M	M		M	m s	s	′	′	
a 8·8	*a* 8·6		1	8·6	+0 4	7	−19·8	19·5	
b 9·2	*c* 9·2		3	8·8	+1 26	28	− 6·9	7·0	
c 9·4	*b* 9·3		4	9·0	+1 19	20	− 9·6	9·0	
d 10·3	*d* 10·3		9	9·6	−1 10	11	+14·5	14·5	
n 10·2			11	9·6	−0 46	46	+16·7	16	
e 10·8	*e* 10·6		16	10·0	−0 27	27	− 9·9	9·5	
f 11·3	*f* 11·2	*f* 10·9	18	10·3	+0 2	1	+ 5·4	6·0	*f*
m 11·5		*g* 10·7	23	10·8	+0 7	4	− 3·8	5	*k*
h 12·3	*h* 12·3	*e* 11·3	24	11·0	+0 6	6	+ 4·4	4·5	*h*
g 11·9	*g* 12·3	*d* 11·4	25	11·1	+0 18	18	− 0·1	+0·5	*g*
l 13·0	*k* 13·3	*b* 12·2	33	12·1	+0 4	5	− 2·9	1·5	*w*
k? 13·7	*l* 13·7	*a* 12·6	39	12·6	−0 2	5	+ 2·1	2	*l*

One word I wish to add about the remarkable fluctuation of light in this Variable as seen by Pogson on March 26, 1856. Attention has been called to this record, in substantially the same words, by Mr J. Baxendell in the *Astronomical Journal*, vol. xxii., 1902, p. 127. In the year following I had occasion to illustrate Pogson's observation of 1856 by four other instances of a similar nature, and to suggest that instantaneous fluctuations in the light of stars, when recorded by good authority, should not be rejected as unconfirmed (see *Astrophysical Journal*, vol. xvii., 1903, pp. 281–285).—Very faithfully yours, J. G. Hagen, S.J.

Specola Vaticana:
January 27, 1907.

Note by Mr Lewis.

The evening of 1907 March 11, on which I received the proof of Professor Turner's paper, being fairly good, the 28-inch refractor was set on Σ 1158 and measures made of the faint stars near. The results are:—

	Magnitudes.	Position.	Distance.
		°	″
AB,	8·5 and 9·8	332·0	7·74 = Σ 1158
AC,	8·5 ,, 12·0	256·0	18·70
AD,	8·5 ,, 12·0	304·7	65·30
AE,	8·5 ,, 13·5	154·2	58·35

The measure of AB is a mean of Mr Eddington's and my own. The measures of C, D, E are by myself.—T. Lewis.

On the Classification of Long-period Variable Stars, and a possible Physical Interpretation. By H. H. Turner, D.Sc., F.R.S., Savilian Professor.

Summary.

§ 1. Reference to previous analysis of light-curves of long-period variables, and classification by A, the coefficient of sin θ in a harmonic analysis, counting θ from maximum.

§§ 2–6. Inclusion in the series of 12 curves determined by Mr J. A. Parkhurst, and formation of a set of seven typical light-curves.

§§ 7–13. The maximum calculated from the harmonic analysis does not agree with that assigned by the observer. Is the latter systematically wrong, owing to the fact that the method commonly adopted of bisecting chords is really no guide?

§§ 14–17. General sketch of physical hypothesis. If the variation in light is due to faculæ or flocculi which arise in high latitudes and approach the equator throughout most of the period, and then rather suddenly return to high latitudes, the aspect presented by the star would modify the light-curve, owing to the greater importance of the faculæ near the centre of the disc. If one of the star's poles were towards the observer, the faculæ in high latitudes would be most obvious, the equatorial faculæ being subject to foreshortening and absorption. The minimum would then follow the maximum early. Conversely, if the star's equator were towards us, it would be late.

§§ 18–21. Consideration of the actual case of the Sun, which does not give satisfactory results.

§§ 22–24. Reasons why the case of the stars may be entirely different from that of the Sun, owing to the smallness of the variation in the latter case.

§§ 25–29. Investigation of the average factor for foreshortening for different aspects of the star.

§§ 30–33. Inquiry whether foreshortening alone can explain the range in type of light-curves. The mean latitude of the faculæ must apparently change from nearly 80° to about 5°, which seems too large a range.

§§ 34–35. If we add the effect of absorption near the limb, these limits will be reduced. In default of any information as to the amount of such absorption, we can neither affirm nor deny the adequacy of the hypothesis. But a factor $\cos^2 \zeta$ for the combined effect of absorption and foreshortening, instead of $\cos \zeta$ for foreshortening alone (where ζ is the distance from the centre of the visible disc), would be quite sufficient to make the range in latitude comparable with that on the Sun.

§§ 36–37. Collection of data given by Chandler for $M - m$, the