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Index

Index

Plan of Research

Chart of Stars in vicin
Ephemeris for Alyt.

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Authenticity Acc Mech.

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Comparison stars Arglander Schonfeld R A & Dec

Zollners mean of comparison stars.

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1877phae.proj.1137P

61
62
63
64
65
66
67
68
69
70
71 Observation March 24th R.A. of adjust clock.
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90

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1877phae.proj.1137P

91 Rules of Computation

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1877phae.proj.1187P

121
122
123
123
124
125
126
127
128
129
130 Comput. of $2v - \frac{1}{2}\sin 2v$
131
132
133
134
135
136
137
138
139
140
141
142
143
144
145
146
147
148
149
150

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1877phae.proj.1167P

181
182
183
184
185
186
187
188
189
190
191
192

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Light Curve at minimum about one 1/2 of that at Maximum (Schw)
A light that a dark body might explain this variation
but could not account for the light remaining constant
for nine tenths of the time. The theory of an irregular
revolving body could fail for a similar reason. Aug. 25th

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Causes of Variability of the Star
β Persei or Algol.

Three explanations have been offered for the variability of stars. First, an absorption, as was probably the case in the new stars in Corona and Cygnus. Secondly, a dark spot revolving with the body or an opaque ~~spot with~~ body with a luminous spot. This would cause a periodic variation and by varying the position and extent of the spot and the inclination of the axis of rotation as regards the line of sight almost any periodic variation could be accounted for. Thirdly, partial eclipses by an opaque planet.

The variation of the star Algol are remarkably uniform reaching only 70 hours with such regularity that they can be predicted within a few minutes. For 63 hours the star is at its maximum then diminishes for 3½ hours and increases for the same time. It is difficult to conceive of an eclipse recurring for a century with such regularity. The second theory would explain the periodicity but would require that the revolving body should be mainly dark since its light at a minimum is probably only a quarter of what at maximum.

The third theory appears the most probable. From the measurement of the light we may determine the elements of the ~~rotation~~ orbit of the eclipsing body.

First. The time of ~~rotation~~ equals the period of the change

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Second. The diameter of the revolving body may be found as follows. Since more than half the light is cut off at the minimum the diminution cannot be due to the two components of a double star coming in line with one another, unless the intrinsic brilliancy of one greatly exceeds that of the other. We will assume that both bodies are spherical, one uniformly bright, the other dark, and at first that both are free from atmospheres. Calling the maximum light 1 and the minimum n, the radius of the bright body 1 that of the other R we must have R equal or greater than $\sqrt{1-n}$ or it would not cut off enough light. It may have any value exceeding this, even to infinity. If the opaque body is small it cannot form an annular eclipse or for a certain time the minimum would be maintained. Assuming any given ratio of the radii of the two bodies we may compute the variations in light and compare this with observation. A trial shows that a slight change in the radius of the eclipsing body to quite inconsiderable amounts is indicated per cent. From this the relative ratio of the radii of the two bodies may be computed.

Third. Ellipticity of orbit. If the orbit is not circular or an ellipse with its transverse axis turned toward the observer the motion will be more rapid on one side of the minimum than on the other, or the minimum will not be midway between the first and last contacts. From these three points the ellipticity may be computed.

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Fourth. Apparent diminution of orbit. This will be known if we can determine the apparent diameter of Algol. If the intrinsic brilliancy is the same as that of the sun, the square root of the ratio of the lights will equal the ratio of the apparent ~~diameters~~ radii. The light compared with that of the sun may be measured directly by turning the telescope towards the star and reflecting the image of the sun reflected from a chalky ball into the field at the same time. If the intrinsic brilliancies differ the observation will be more difficult and will involve a measurement of the relative brightness of the red and blue rays. Knowing the ~~diameter~~ radius of Algol's disk and the relative radius of the other star the apparent dimensions of the orbit are readily calculated

Fifth. Apparent motion of Algol. This could only be obtained by the spider line micrometer or photographically. It would probably be too minute a quantity to be perceptible amounting to only a few hundredths of a second. It should be determined several times before and after the minimum and would have that great advantage over a measurement of rebellen. Hence the measurement could be repeated at short intervals instead of having to wait six months the stars clock temperature &c could be more readily eliminated. The ~~Sixth~~. transverse diameter of the ~~orbit~~ would also be obtained by this measurement.

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Sixth. Relative densities of the two bodies. This can only be determined roughly if at all and depends on the successful measurement of Sixth and Eighth. The ratio of the apparent orbit of the observed motion of Algol equals the ratio of the sum of the masses of Algol and its planet to the mass of its planet. Knowing the relative masses and radii the densities are easily computed.

Seventh. Absolute dimensions of orbit. These will be known if the parallax can be determined. This measurement will probably lead to no satisfactory result.

Eighth. Absolute velocity of orbit. The real velocities must be very great, unless the Object is nearer than is ordinarily supposed and in this case the parallax will be measurable. If the diameter of Algol is only equal to that of the sun (and in this case it must be one of the nearest of the fixed stars whose distance is known) its velocity would probably exceed 40 miles per second. Observations with the spectroscope at intervals of 35 hours would give results differing by 80 miles. This measurement would be greatly facilitated by the fact that the entire change would take place in a day and a half. If the change is easily measurable the velocity in different parts of the orbit may be measured. It does not follow that this may be the greatest known velocity and that the irregular velocities observed with other stars may be due to a similar cause.

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Minute. Absorption by Algol's atmosphere. In the above discussion of the variation of the light it is assumed that Algol's disk is uniformly illuminated. If, as is probable, it is surrounded by an atmosphere like our Sun, the edges will be darker and the law of diminution of light will be altered. The effect will be the same on both sides of the minimum and hence will not be confounded with Period. It might make the deviations due to the improbable case that the orbit is an ellipse with its major axis turned towards us. An approximate calculation only is to be expected of the amount of the absorption.

Feb 18th 6.6.0

1877

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The Three Kingdoms of Nature

SOME children were playing at a game called "The Kingdoms," which consists in the mention of various substances, and asking if they belong to the animal, vegetable, or mineral kingdoms. One little girl mentioned "water," and the company were puzzled as to which kingdom it should be assigned. Is there a sub-aërial or gaseous kingdom? Will you kindly enlighten the members of our NURSERY?

March 4

OUR ASTRONOMICAL COLUMN

THE VARIABLE STAR, β PERSEI (ALGOL).—Herr Julius Schmidt, Director of the Observatory at Athens, publishes in the *Astronomische Nachrichten* the results of observations on the times of minima of this variable star, extending from August 1846 to November 1875. The epochs are given in Paris mean time with correction for the light-equation. The probable error of a single determination of the time of minimum from 183 observations by Schmidt is ± 8·0 minutes; fifty observations of Argelander gave a probable error of ± 6·0 minutes, and fifty-five observations of Schönfeld, one of ± 4·6 minutes, showing by a mean of the 288 observations a probable error of ± 7·0 minutes. The period assumed by Schmidt in the discussion of his Algol observations between 1840–1875 is 2d. 20h. 48m. 53·6s.

Some interesting details respecting this star are found in Schönfeld's "Der lichtwandel des Sterns Algol im Perseus" (Mannheim, 1870). His comparison stars and their relative assumed brightnesses were :—

Star.	Brightness.
ν Persei	0·9 in grades.
α Trianguli	3·5 ,,
δ Persei	7·8 ,,
β Trianguli	9·1 ,,
γ Persei	10·9 ,,
ε Persei	12·8 ,,
β Arietis	16·7 ,,
ι Aurigæ	17·3 ,,
γ Andromedæ...	23·4 ,,

The following, extracted from the more extensive table given by Schönfeld in his treatise, will indicate the law of variation as derived from the light curve :—

Distance from Minimum. h. m.	Brightness. Before.	After.
4 30	20·7	20·8
4 0	20·2	20·2
3 30	19·6	19·2
3 0	18·7	17·7
2 30	17·4	15·8
2 0	15·3	13·2
1 30	12·1	9·8
1 0	8·5	7·6
0 30	6·3	6·2
0 0	5·6	5·6

The most probable period over which the variation extends is 9¼ hours, and the minimum lies very nearly in the middle of the same. The most perceptible diminution of brightness occurs 1h. 26m. before the minimum, when the star is somewhat fainter than the mean of γ and ε Persei, and the most perceptible augmentation when the star arrives at nearly the same degree of brightness, but 1h. 47m. after minimum. In this phase it is hardly fainter than the mean of δ Persei and α Trianguli. Schönfeld states that to his eye the variation of Algol is included between the magnitudes 2·2 and 3·7; he considers γ Andromedæ an average star of the second magnitude, δ Persei 3·5, α Trianguli about 3·1, and ν Persei 4·1.

For elements of Algol we may adopt at present the following, derived from Schönfeld's last catalogue. First minimum of 1876 . . January 2·23233 Greenwich mean time; period 2·867288.

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CONJUNCTION OF JUPITER AND β SCORPII.—Mr. J. Birmingham, Millbrook, Tuam, writes as follows with reference to the near approach of Jupiter to the bright star β Scorpii on the morning of Feb. 28.—"The weather prevented any observation until 19h. 25m. Greenwich M.T., when the western limb of Jupiter had nearly, but scarcely quite, reached the R.A. of the star. The micrometer-wire through the star then just grazed the northern edge of the planet, and so closely that it could not be said for certain that there had not been actual contact. Clouds coming on again soon put an end to the observation." Allusion was lately made to the above phenomenon in this column.

NOTE ON BIELA'S COMET.—It will be remembered that when, on the appearance of Biela's Comet in 1805, the similarity of elements to those of the comet of 1772 had been remarked, it was pointed out by Gauss that the differences between the orbits, particularly the diminution of the inclination, could not be accounted for except on the supposition that in the interval the comet had undergone perturbations from one of the larger planets, and the necessary proximity could only have been consistent with the assumption that several revolutions had been performed in the interval between 1772 and 1805, as on the next observation of the comet in the spring of 1826 was proved to have been the case.

If we adopt the elements for 1772 assigned by the late Prof. Hubbard of Washington in his masterly investigation on the motion of this comet, we shall find the following distances from the orbit of the planet Jupiter :—

True Anomaly.	Radius vector.	Distance.
+ 156° 0′	5·029	0·316
157 30	5·143	0·281
158 0	5·180	0·283
+ 160 0	5·327	0·344

A true anomaly of 157° 30′ corresponds to 645·5 days after a perihelion passage, and the comet would arrive at this point of its orbit, which may be taken as that of nearest proximity to the orbit of Jupiter about 1794·21, while the planet would be in the same longitude about 1794·43, and it thus appears that it was in the spring of the year 1794 that the very material changes in the elements of the comet's orbit were caused by the attraction of Jupiter. Another near approach of the two bodies would appear to have taken place towards the end of the year 1746.

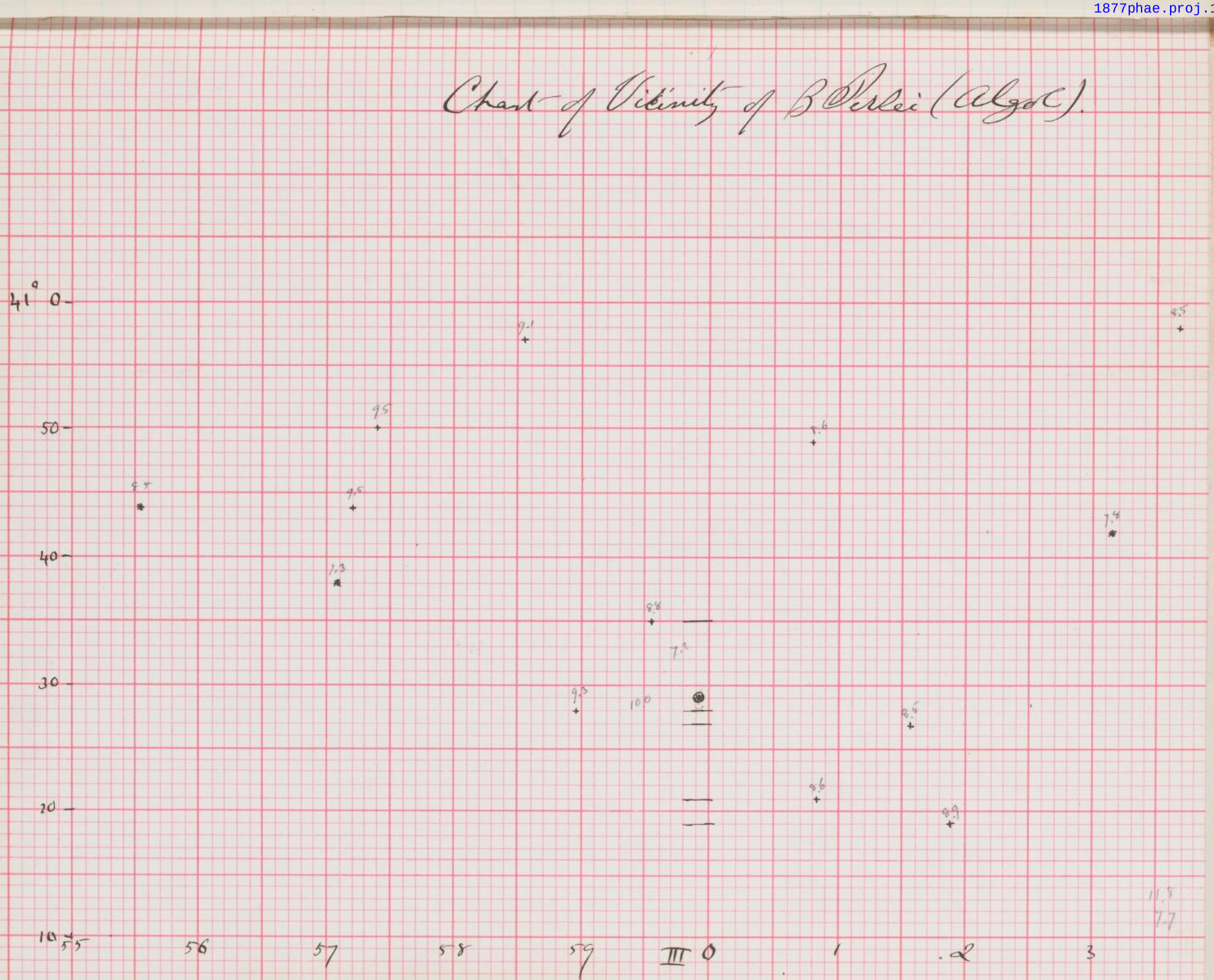
THE NEW GERMAN SCIENTIFIC EXPEDITION TO THE OBI

THE Expedition to Northern Siberia, fitted out by the "Verein für die Deutsche Nordpolarfahrt in Bremen"—the same Society which sent out the Second German North Polar Expedition, and published the excellent account of its results—left Bremen last week. The attention of the Council of the Society having been called to the immense unexplored area between the Jenisei and the Obi, it was resolved, as there were not sufficient funds for a naval expedition this year, to send out a small zoological and ethnographical expedition overland to the Obi, which appeared to be less known than the Jenisei. In this they received the warm support of the highest scientific authorities at St. Petersburg who were asked for advice on the subject. Dr. Otto Finsch, Director of the Zoological Museum at Bremen, was appointed leader of the expedition, and Dr. Brehm, the well-known author of "Das Thierleben" and many other natural history works was selected to accompany him. They were joined by Count Walburg-Zeil-Trauchburg of Stuttgardt, who made an expedition to Spitzbergen in 1870 at his own expense, and who is well acquainted with physics and is a good botanist. Professor Oscar Schmidt of Strasburg, who had likewise intended to go, was unavoidably prevented at the last moment. The route selected is by St. Petersburg

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Chart of Vicinity of β Persei (Algol).



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Ephemeris of Algol for 1877.

"Annuaire" of "Bureau des Longitudes" for 1877 & 76

	Paris M.T.			Cambridge M.T.		
January	h	m	s	d	h	m	s
	3	5	58	3	1	4
	6	2	47			
	8	23	36			
	11	20	25			
	14	17	14			
	17	14	4			
	20	10	53			
	23	7	42			
	26	4	31			
	29	1	21			
	31	22	10			
February.						
	3	18	59			
	6	15	48			
	9	12	38			
	12	9	27			
	15	6	16			
	18	3	6			
	20	23	55			
	23	20	44			
	26	17	33			
March						
	1	14	23	1	9	29
	4	11	12	4	6	18
	7	8	1	7	3	7
	10	4	50	9	23	56
	13	1	40	12	20	46

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March.

13	1	40	12	20	46
15	22	29	15	17	35
18	19	18	18	14	24
21	16	7	21	11	13
24	12	56	24	8	2
27	9	46	27	4	52
30	6	35	30	1	41

April.

2	3	24	1	22	30
5	0	13	4	19	19
7	21	2	7	16	8
10	17	51	10	12	57
13	14	40	13	9	46
16	11	30	16	6	36
19	8	19	19	3	25
22	5	8	22	0	14
25	1	57	24	20	3
27	22	46	27	17	52
30	19	36	30	14	42

May 3 comp. approx.

3	16	25
6	13	14
9	10	3
12	6	52
15	3	41
18	0	31
20	23	20
23	18	09
26	14	58

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29 11 47

June

1 8 36
4 5 26
7 2 15
9 23 04
12 19 53
15 16 42
18 13 31
21 10 21
24 7 10
27 3 59
30 0 (47 39 ?

July

2 21 28 16 34
5 18 17 13 33
8 15 5 10 11
11 11 54 7 0
14 8 43 3 49
17 5 31 0 37
20 2 20 21 26
22 23 8 18 14
25 19 57 15 3
28 16 45 11 41
31 13 34 8 40

August

3 10 22 5 18
6 7 11 2 17
9 3 57 23 5
12 0 48 19 54

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August. Cutin.

14	21	37	14	16	43
17	18	25	17	13	31
20	15	14	20	10	20
23	12	2	23	7	8
26	8	51	26	3	57
29	5	39	29	0	45

September

1	2	28	31	21	34
3	23	16	2	18	22
6	20	5	6	15	11
9	16	53	9	11	59
12	13	42	12	8	48
15	10	30	15	5	36
18	7	19			
21	4	8			
24	0	56			
26	21	45			
29	18	33			

October

2	15	22
5	12	11
8	8	59
11	5	48
14	2	37
16	23	25
19	20	14
22	17	3
25	13	52
28	10	40

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October contin.

31	7	29	33

November.

3	4	18	21
6	1	7	13
8	21	58	2
11	18	44	50
14	15	33	39
17	12	22	28
20	9	11	17
23	6	0	6
26	2	49	54
28	23	38	

December.

1	20	27	
4	17	16	
7	14	5	
10	10	54	
13	7	43	
16	4	32	
19	1	21	
21	22	10	
24	19	00	
27	15	49	
30	12	38	

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1877phae.proj.1137P

Authorities.

Argelander.

Astronomische Nachrichten.

XX, 271

XXI, 335

XXVI, 371 Argelander.

~~XXXVI~~ 69

~~XXXVIII~~ 59

918 ~~XXXIX~~ 81 Lehmann

XXXI.

~~XXXII~~, 82 Two values of 101 Light curves.

~~XXXIII~~, 83 Table for its brightness for every minute compared with three other stars from Jan 3, 1846 to Nov. 15, 1853.

XXXIV, 84 Anomaly of its light curve.

XXXIX, 87 Brightness compared with δ Persei before and after its minimum.

XXXIX, 91 Six values of the same.

931 XXXIX, 291 Observed minima at Lilienthal 1846 Oct 17 1805 and Oct 30

XXXIX 291 Argelander, the same.

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1877phae.proj.137P

Astronomische Nachrichten (continued)

xxxix 291 Minimal epochs from May 17th 1784
to Oct 8, 1854.

xxxix, 292

xxxix 292, 293 Two formulæ for the time of Minima

xxxix, 293, 18 observed minima Oct 3d 1853 to March 1854
together with the approximate reduction to the
middle epoch Dec 8d 1853

xxxix, 293, 24 observed minima from Aug 20th 1854 to
Dec 7th together with the approximate reduction to
the mean epoch Oct. 8th, 1854.

xxxix, 297. Angulares enter Light Period.

xxxix 297 Ephemeris of Minima for the year 1855

xxxix 294 Minima observed at Bonn Oct 3 '53
to Dec 7, 1853

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1877phae.proj.1197P

Astronomische Nachrichten (continued)

xliv, 354 Remarks on its variability, Schmidt.

Observations of its Minima. xlv, 317 Brahms; xliii, 264 Heis; xlv, 219, liv, 132; xlv 117 Endemann; xliv 355; li, 321, liv 350, lvii 210. Schmidt; xlv 219 van de Vin; li, 383, Winnecke.

Ephemerides of its Minima 1858 Argelander xlii, 245; xlv 103 for 1857 Argelander; xlix, 29 for 1858 Argelander; l, 219 for 1859, Pogson; lii, 109 for 1860. Pogson; lv, 183 for 1861 Pogson.

xlii 245
Light-period and Epoch Argelander

liv, 258 Wolf. Other Observations for. Hauglegues

xlvii 311 Schmidt. On its variations of light.
xlvii 257 Winnecke

~~xlvii xlii 245 Argelander, Period and Ephemeris of its minima for 1858.~~

lxi 245 Schmidt minima observed
282 Hark. Rem. " "
lxii, 36. Schmidt. Obs.
lxiv 279 Schmidt obs.
lxv 155 Schonfeld ephemeris
lxvi 157. Schonfeld Obs
271 Argelander
lxvii 30 Schonfeld "
137 " ephemeris

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1877phae.proj.1137P

lxviii 291 Schmidt. obs.
lxix 261-262 Schiaparelli 266
lxxi 103 S-t Obs 343. S-d Eph

lxxiii 261 S-t. obs.
lxxiii 3 Sol Compar. 1865-1884
lxxiv 157. S-d Eph.
lxxvi 69 Schmidt obs.
107 Schiaparelli Ephemeris
lxxvii 113 S-t Obs
lxxviii 125. S-d Ephem 129. bright- 536 two each
lxxix 113 S-t obs.
361 S-d ephem.
1906 lxxx 1217 S-d. obs.
1932 lxxxi 181 S-t obs.
1952 lxxxii 115. S-d eph.
lxxxiii 107 S-t obs.
1991 " 359 S-d
2001 lxxxiv 131 S-d Ephem
2031 lxxxv 234 S-t Obs. Shiras
lxxxvi nothing
2065 lxxxvii 7. Obs. S-d
2074 " " 145 S-t Obs
2075 " " 161 S-t Vanis- u Hollis obs
2077 lxxxvii, 193 S-t Alcott obs 1861-1875
2103 lxxxviii 234 S-t Obs
2115 lxxxix Curve of numbers 1848, '66, 76 in Cygnus

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1877phae.proj.1137P

Pigott. explains variability by dragon body
Phil. Trans. 1785, 127; 1786, 189; 1797, 133; 1805, 131

Radcliffe 1854, 283

Phil. Trans. 1783 Goodricke discovered
correct- absolution $+60^s \cos(54°12' - \odot \text{ longitude})$

Schönfeld Der Lichtwandel des Sterns Algol in
Perseus (Mannheim, 1870)
36th Yearbook Mannheimer Vereins für Naturkunde
& Wiss. 6, Rec. auth. J. Schneider.
"Der Lichtwechsel des Sterns Algol im Perseus.
1870-98

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Comparison of Brightness of Algol Comparison Stars.

		Sch. Arg.	Seidel.	Wolff.
γ	Andromedæ	23.4	9.038	.2529
ι	Aurigæ	17.3	8.697	.0350
β	Arietis	16.7	8.897	.0938
ε	Persei	12.8	8.800	.9776
ν	"	10.9	8.699	.9233
β	Trianguli	9.1	.716	.9479
δ	Persei	7.8	.741	.9255
α	Trianguli	3.5	.531	.8205
			?	.6666
ν	Persei	0.9	ν .296	.7387
ϱ	Persei			.7994
ζ	"		.778	.9890
β	"	20.75	9.140	9.3173
	"	5.6		

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W-S

.215

.338

.197

.178

.223

.232

.184

.289

211

~~.177~~

.177

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Argelander's Standard Stars

					1850.0		N.P.D.
ρ	Persei		2	55	35	51	44 40
ξ	"		3	44	43	58	33 59
δ	"	s	3	32	16	42	41 50
ε	"	s	3	47	48	50	25 44
ν	"	s	3	35	1	47	54 1
γ	"		2	53	58	37	5 8
α	Trianguli		1	44	32	61	9 15
β	"		2	0	38	55	43 30
γ	Andromedæ		1	54	43	48	23 34
β	Persei		2	58	26	49	37 34

Schumpld

γ	Andromedæ	a	23.4					
ι	Aurigæ		17.3	4	47	14	57 4	38
β	Arietis		16.7	1	46	22	69 55	39
ε	Persei	a	12.8					
γ	"	a	10.9					
β	Trianguli	a	9.1					
δ	Persei	a	7.8					
α	Trianguli	a	3.5					
ν	Persei	a	0.9					
β	Persei		20.75 / 5.6					

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Zollners Photometrie des Himmels

		1 Dec 2d	2 15th	3 Jan 12th	4 26th	5 Feb 28th	6 March 30th	7 April 10th	8 17th	9 Aug 18th	10 Sept 27d
8	ω	1.000	1.000	1.000	1.000	1.000	2.000	1.000	1.000		
7	κ		2.236	2.036	2.258	2.116	2.542	1.914		1.000	
8	ρ	3.659	3.005	2.768	3.063	2.913	3.144	2.824	3.154		
3	β		9.375	8.212						4.461	2.319
4	π					.650	.560	.662	.798		
1	ν				2.042						
	δ										1.000

• These ten centuries are all that are available and the last must be rejected since it furnishes no check.

The mean gives. $\omega = 1.000$ " $\kappa = 2.184$ " $\rho = 3.066$ $\beta = 8.793$ $\pi = .667$ The value of ν cannot be used, ρ also big variable so a little doubtful. β by $(9) = 2.184 \times 4.461 = 9.743$

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Abstract of a paper by Prof. Schönfeld
"Der Lichtwechsel des Sterns Algol in Perseus" published in the 36th Annual Report of the Mannheim "Vereins fur Naturkunde", page 70.

§1. The history of the star is briefly given in the 32d volume p. 77,78. Since that time are Argelander's investigations published in 7th vol. Bonn Observations, and the star has been specially observed by J. Schmidt, Winnecke and the writer.

Most of the works on the star treat of its period and the changes in its duration. Arg. showed that for about 27 years there has been a shortening of its period which the older observations place at $2^d\,20^h\,48^m\,58^s.5$, at the rate of a second in fifty years. This shortening continued till 1855, since which time there has been detected no diminution but possibly an increase. Little more then than the existence of this change is known; whether it is constant or interrupted by partial retrogressions is still in doubt, on account of the smallness of the change itself, and because the material for the investigation of so nice a problem is still too limited.

The course of the variability within a single period has been less studied than the periodic return of the Minima. From an examination of the oldest records of Goodricke and others which seem of greater value than the single investigations of their authors I derive the following results —

Omitting the oldest remarks of Goodricke and others as based upon too few observations, also such records as do not appear to rest upon independent (eigenen) investigations, I derive the following results —

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§2 According to Wurm, of the 68.8 hours of the period of variability, the change occupies about 6½ hours, – 3h in the diminution, 18 minutes in which the light is least and the change is absolutely nothing, and full 3 hours in the increase to full brilliancy. From him we can also conclude that the time occupied in the ~~retrocd~~ increasing is longer than in the diminishing of light, though he gives the rule to find the times when the magnitude equals that of other stars e.g. γ and δ Persei, before and after the minimum, and take the mean for the time of least brilliancy. The duration of the period of least brilliancy can be well determined; when it begins the decline of brilliancy (the velocity of the diminution of light) is very noticeable. He considers the star when faintest as seldom ~~equal~~ as bright and rarely brighter than ρ Persei, not knowing that the latter is also variable, as established by Schmidt, though noted before by Arg.

Arg. has written on these phenomena at various times. In Schumacher's Jahrbuch 1844, the maximum brightness is given as faint 2d mag., duration of period of change 3 to 4 hours, time of least light about ¼ hour, – star sometimes brighter sometimes fainter than ρ which is possibly variable. The star increases more rapidly than it diminishes in brilliancy. Arags's remark that the change is greatest when the star is passing the 3d mag. is not confirmed. In 1850 Arg. gives the period of change as 7 to 8 hours, the increasing and diminishing not uniform, but more rapid near the minimum. He also states that the star after increasing for about an hour remains at almost the same brightness for a long time and then again increases perceptibly. This opinion he reaffirms in the 7th vol. Bonn Obs. in which he gives as the reason for rejecting

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the observations of Le Récque de Monchy that he has employed not the true minimum but the time near the minimum in which the star is nearly stationary.

The true meaning then of Wurm's statement that the minimum lasts for some time is that the change, as in fact follows from the law of a maximum or a minimum, is at that point too ~~gradual~~ minute to be noticeable with our restricted means. Arg. also makes the well grounded remark that the light when the star is at its full brilliancy is not by any means constant.

§3 J. Schmidt's work (Astron. Nach 39, 918) embraces observations for 8 years preceding 1853 upon the 4 hours near the minimum. From 954 comparisons with δ Persei he finds that in both the diminishing and the increasing stages there are 3 retardations, though one of these is doubtful. But he regards it established that 90 minutes before the minimum Algol ~~begins~~ ceases to diminish, remaining stationary or possibly increasing for 10 minutes, 5 minutes later it begins again to rapidly diminish, and soon after suffers another retardation. A retardation ~~for~~ from 80 to 90 minutes after the minimum is also established beyond doubt. The duration of the diminution and the increase is about equal as is shown by comparison with δ & ε Persei and β Trianguli.

Schmidt's unit (his degree of light [lichtstufe]) represents a much larger difference of brilliancy than mine. The ratio is 1 to 2.39 and Schmidt's zero point is 7.0 in my scale. There is also an unexpectedly large difference in our estimates of the brightness of the comparison stars, Schmidt placing δ Persei as 0.66 grades fainter than ε, and ε as 0.83 fainter than β Triang. while I find from ~~both~~ naked eye observations and those made with an opera glass these results. Naked eye δ = 7.8 β Tr. = 8.9

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ε=12.4 Opera glass δ=7.8 β Tr. =9.1 ε=12.8. A comparison of my results which depend upon many stars with Schmidt's depending in their published form upon one only has therefore little interest.

§4 Without attempting a complete review of those researches of Schmidt which are distinguished from the earlier by greater accuracy, I note here essential differences between his methods and my own.

(1) Schmidt treats the comparisons of Algol with different stars, each by itself, and regards the agreement of the results from different stars as mutually confirmatory. But I hold with other astronomers that comparisons made at the same time are not wholly independent. Again for that part of the change of light investigated by him, one star alone is hardly sufficient; in greater distances from the minimum others must be employed, and the forming of a connected scale of comparison stars and consequently the closer use of Arg.'s method becomes inevitable.

(2) In combining the observations of different nights to determine the mean light curve, Schmidt makes the actually observed minimum, the zero point of the times. This would be correct were the accidental deviations of the minima from their normal return larger than the accidental errors of observation. Investigations show that such deviations do exist, but they also indicate that determinations of the same minimum by different observers give when combined better results than different minima reduced to a common epoch. Arg. finds from two complete series, a probable real deviation of 0.m60 to 0.m64. I make it somewhat larger about 2m; but the error of observation is much more significant — from 4 to 6 minutes. In my work

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therefore I start from the computed minima, as one is then much freer from all preoccupation on account of the many influences which may increase the agreement but at the expense of accuracy.

I am not aware that Schmidt has subjected his more recent observations to a similar discussion. Occasional notices in the Nachrichten lead me to infer that he considers the results of the first 8 years as firmly established. A more accurate discussion is certainly desirable. I have shown (in vol. 32) that my observations do not confirm the inequalities in the changes of light. Those which the single curves representing the observations of each minimum show, do not occur at the same distances from the minimum, though I could not say whether they are real or result from accumulation or from systematic errors of observation. They are not constant parts of the curve, and even if real must be placed among the accidental variations, just as in the problem of the sun's motion in space, the real motion of the fixed stars must be treated alongside of the errors of observation. My method rests primarily upon the principle of making parallel equalizing the objective inequalities - founded in the external world - and the subjective - errors of observation - To determine the variation of light of variables we must construct no equalizing curve, but connect the single points of light and regard the zigzag or wave line as representing the apparent change of light. But the complete representation through the errors of observation is unreliable and therefore we equalize these points by a curve which approaches regularity. The true course of the light-change bears the same relation to the given curve as e.g. the course of a stream to its representation on a map,

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upon which the smallest irregularities in the chore can not be indicated. Their omission does not essentially affect the map while the insertion of the more uncertain would considerably injure it through giving an imaginary accuracy. So in the first attempt, a light curve represents the general character of the variability, including details only when these are plainly beyond observation errors. What irregularities are real and what errors of observation cannot now be determined for general consent. My opera glass observations exhibit them as 0.5 to 0.6 for a complete observation. A nearer approach to the curve which represents the mean change at the expense of its regularity would not correspond to our design; it is only when the omission of a bend would essentially exaggerate the probable deviation of the curve from the observations that the latter can be regarded as proving an inequality in the variation.

I have employed quite fully in this investigation Args.'s method unfold in his treatises upon β Lyrae.

§ 5 My observations 1853-9 were made with the naked eye, since 1859 with an opera glass of 13 lines aperture and mag. power of 2. For the sake of uniformity I do not use the 1st series; the 2d series neglecting uncertain observations includes 677 complete determinations to the last of March, 1870. each depending upon comparisons of Algol with 2 stars. Except the first 14 they were made here, and only 35 lie more than ± 5 hours from the minimum. I have compared with ρ, δ, γ, ε Persei, β Trianguli, β Arietis, ι Aurigæ, γ Andromedæ. ρ being variable was itself determined on the each evening by comparison with ν Persei. [The comparison scale is here appended p. 80] γ Persei was seldom used, β Arietis and γ Andromedæ were employed in the brighter phases, ι Aurigæ in preference

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to β Arietis in western hour angles; it appeared from its yellow color brighter than β in the opera glass though to the naked eye fainter. By this scale the observations were expressed in numbers using the same unit and zero point. They were to be arranged according to the time interval from the nearest minimum, but first the elements for reckoning the minima must be obtained. We can regard the periods of Algol during the 10¾ years as uniform. Arg. has derived for epoch 7954 the period $2^d\ 20^h\ 48^m\ 53.^s813$. From his elements [here given] $2^d\ 20^h\ 48^m\ 54.^s02$ the yearly mean of the minima observed by me differs from those reckoned by quantities [here tabulated p.82] which show that the round numbers $-54.^s00$ can be taken for the mean period. For years preceding 1840 these elements make the epochs too early throughout, and we must derive a formula which at least shall regard the squares of the times. [Formulæ here given] They agree with the epochs derived from the first elements within a minute from epoch 8008 to the end, previous to that epoch they make the epochs somewhat later, the difference in epoch 7600 amounting to $3.^m365$. In epoch 8453 they agree. I derived from both values the normal ~~equations~~ magnitudes of Algol which serve for the determination of the light curve, but after having shown as I had expected that the near agreements of the two computations was not at all prejudiced by any accumulation of chance deviations, I gave the preference to the second not from its exhibiting absolute accuracy but because it accorded better with the observations during the time in which the bulk of my observations was made.

§6 The accompanying table gives the mean numbers used for deriving the curve. The observations being sufficiently abun-

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dant nearest the minimum, each mean number was derived from an equal number of single observations. At the limits a less number was necessarily used not to include those which were at the time carried too far. No sure observation is excluded. A correction $-2^m.8$ explained in §7 as belonging to the whole, is included, and a comparison with the final curve appended.

[Here follows the table]p. 84, 85[ ]

§7 The last seven numbers fall into the full light of the star. They appear to indicate a small irregularity as if the maximum was reached $1^d\,20^h$ after the minimum, and that the full light was not constant. But the probable error is greater than the difference shown, and the four which happen to be irregular represent difficult comparisons with ι Aurigæ; if these are excluded 20.65 is obtained instead of 21.10. I treat the irregularity as accidental and Algol when in full light as of constant brilliancy, for which I use 20.8 as the value.

The careful ~~comparison~~ equalization of the above 71 normal numbers by a ~~normal~~ continuous curve with ~~possibly~~ as simple a curvature as possible gave on the second approximation the lowest point of the curve as $2^m.8$ before the zero point of the times reckoned from the second elements, and therefore the correction to the minimum from the second elements equals $-2^m.8$.

[Here is appended the Lightcurve of Algol, p. 87]

We can characterize the light-change of Algol thus – The duration of variability occupies more than 8 hours, its probable value being about 9¼ hours, and the minimum lies very nearly half way in this time. But the decrease in the greater distances from the minimum seems to move slower than the increase in the corresponding distances, and more

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rapidly in the smaller intervals. Hence in general a greater degree of brightness characterizes the time intervals preceding the minimum than those following it. The largest decrease is found $1^h 26^m$ before the minimum when the star is somewhat fainter than the mean of γ and ε Persei, the largest increase at about the same brightness but $1^h 47^m$ after the minimum. At the minimum it is scarcely fainter than the mean of δ Persei and α Trianguli, at full magnitude it remains fainter than γ Andromedæ; its difference from γ Androm. bears to its difference from the fainter star β Arietis, the ratio of 5 to 8. The whole change is 15¼ grades of the scale. To reduce this to the common scale of magnitudes, I regard γ Androm. as $2.^m0$, δ Persei as $3.^m5$, α Trianguli $3.^m9$ ν Persei $4.^m1$. From this the light change is from $2.^m2$ to $3.^m7$.

The comparison of the curve with the normal expressions of the brightness shows not only that my observations favor the hypothesis of a nearly uniform variation, but they make every departure from uniformity of any considerable amount, by delays, retrogressions and the like, as improbable. It is true that the v column shows greater succession of signs in some places than in others, e.g. between $1^h 8^m$ and $0^h 32^m$ before the minimum, by an accumulation of greater errors with remarkable progression, but from the 71 points by which the curve is to be determined such an occurrence is to be expected a priori, and a probable error of satisfying amount will result. The sum of the pvv is 43.123 and we can regard the curve as determined by 7 independent constants. Hence the probable error of each

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observation, inclusive of the uncertainty of their reduction to the comparison scale is 0.554 + 0.065 grades, — no larger than was to be expected, but not so small as to make it seem that the curve was a forced one.

I have already shown that it would not be strictly right to say that no irregularities in the light curve occur as special disturbances in single occurrences of the phenomenon. They give the value of the deviation of the form of the curve from the mean. But since the observations for determining any one minimum follow each other at so short intervals, many sources of systematic error are at work to distort the curve. E.g. Vacillations in the nicety with which differences in the light are apprehended are not completely eliminated by combining the comparisons with brighter and fainter stars, and so Algol if nearly equal to any comparison star may appear to tarry longer at this phase, and the curve show here a bending. Every long continued change in the external conditions can affect the curve, as the rising and setting of the moon, the difference in altitude of the star, weariness or exercise of the eye, and the like. To wait for the most favorable conditions, even if we could tell when they occur, would be fatal in this climate to the obtaining of sufficient observations. E.g. The minimum of Nov. 19, 1866 by 19 good observations in 3 hours 5 minutes, ~~gives~~ is when determined according to this mean light curve $7^h 29.^m 8$; according to the single curve known to be correct by revision, it is $7^h 42.^m 3$. The decrease is here slower, the increase more rapid than in the mean curve, the deviation greatest in the hour and a half which include the minimum. But on this evening ρ Persei appeared very

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faint, so that greater differences in the faintest phases of Algol appear than usual. This circumstance is as far as possible the subjective ground of the anomaly — a new proof of the superiority of Arg.'s method to the usual method of drawing the curve in which the observations lying nearest have a preponderating influence.

§8 We can also determine from the light curve according to Arg's method the times of the single minima from their respective observations. Assuming the details of the method known, I only remark that the weight with which each observation affects the result is determined by the differences in the series of magnitudes i.e. the velocity of the change in the phase treated. The numbers in the foregoing section are strictly useful for my observations only, and others must be reduced to my scale. But without this reduction very accurate results can be obtained by combining the equal or nearly equal magnitudes before and after the minimum.

Were the two branches of the curve symmetrical, Wurm's rule that the mean of the times of equal brilliancy is the time of the minimum would be true. This mean requires a small correction which can be tabulated with the observed time interval as the argument, the weight of this correction being the sum of the weights of the times in the light curve. The velocities of the change give also the corrections to be applied when the observed magnitudes are unequal. If only small differences of tenths of a grade are used, then only a rough knowledge of the relation of my scale to others will be necessary to give the necessary accuracy in applying the table.

[Here follows the table, p. 93.]

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The possibility of reckoning in this way the times of the minima is ~~especially~~ advantageous ~~in the smaller series~~ of observations which do not give an independent determination of a scale of brightness, but especially useful in the many minima which depend wholly or essentially upon ρ Persei.

§9 The minima which are determined from my observations by parts of the diminution and increase of brilliancy, I have again reckoned by comparison with the table of §7, and insert them here as a basis for further investigation. The mean of the times differs from the 1st elements by $-2^m.90$ (the correction $-2^m.8$ was shown §7 to belong to all the observations compared with the 2d elements). This value I have adopted as a correction to the 1st elements and obtain Ep. E = 1867 Jan. 0 $11^h 1^m.2$ M. T. Paris $+2^d 20^h 48^m.9$ (E-8534). I have used the ~~observations~~ deviations of the magnitudes observed from those of the table to derive the minimum brilliancy for the time. The table gives the no. of the epoch, Mannheim time of observation, the reduction to the sun and the Paris time at which an observer at the sun would have seen the minimum, the deviation of the 3d elements (just given) and the smallest magnitude. [Here follows the table p. 95]

It follows that the probable error of a minimum reckoned by the table in §7 is $4^m.467$. My earlier comparison with angle curves published in the Astron. Nachr. is $5^m.652$. As the errors in the elements affect both alike, the comparison by means of the table is at all events of essential advantage. Whether the v's of the last table are to be explained by accidental disturbances in arriving at the minima or wholly from errors of observation and the elements is a subject for future research.

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The mean of the h's gives the mean value of minimum brilliancy 5.50 with the probable error ±0.067, agreeing within this amount with the value 5.56 from the table. The probable error of a single h is 0.374. As this depends upon 5.2 observations with the probable error 0.054, we should expect the number 0.243 unless there were a number of sources of error common to the observations which were combined for a value of h. Moreover almost every h to a great extent depends upon the corresponding brightness of p which is not as reliable as the other values of the scale. I think we can express this unreliability by 1/5 of a grade and therefore change the number 0.243 to 0.315. We cannot then conclude from the numbers of the table that a fluctuation exists in the minimum brightness of Algol. The same result I obtained though with less certainty from 11 minima observed with naked eye by me in Bonn.

The independent testing of the results obtained in the foregoing is for the time to be obtained by the discussion of Arg's observations 1840-1866. But before this can be thoroughly done, an investigation upon the lack of uniformity in the period, which was far more strongly marked 1842-55 than since 1855, must be had. For this a new reckoning of all cotemporaneous observations by a uniform method is almost necessary, for which it seems to me the tables of §§7 and 8 can be employed with advantage.

(W. Upton. Trans.)

Aug. 27, 1877.

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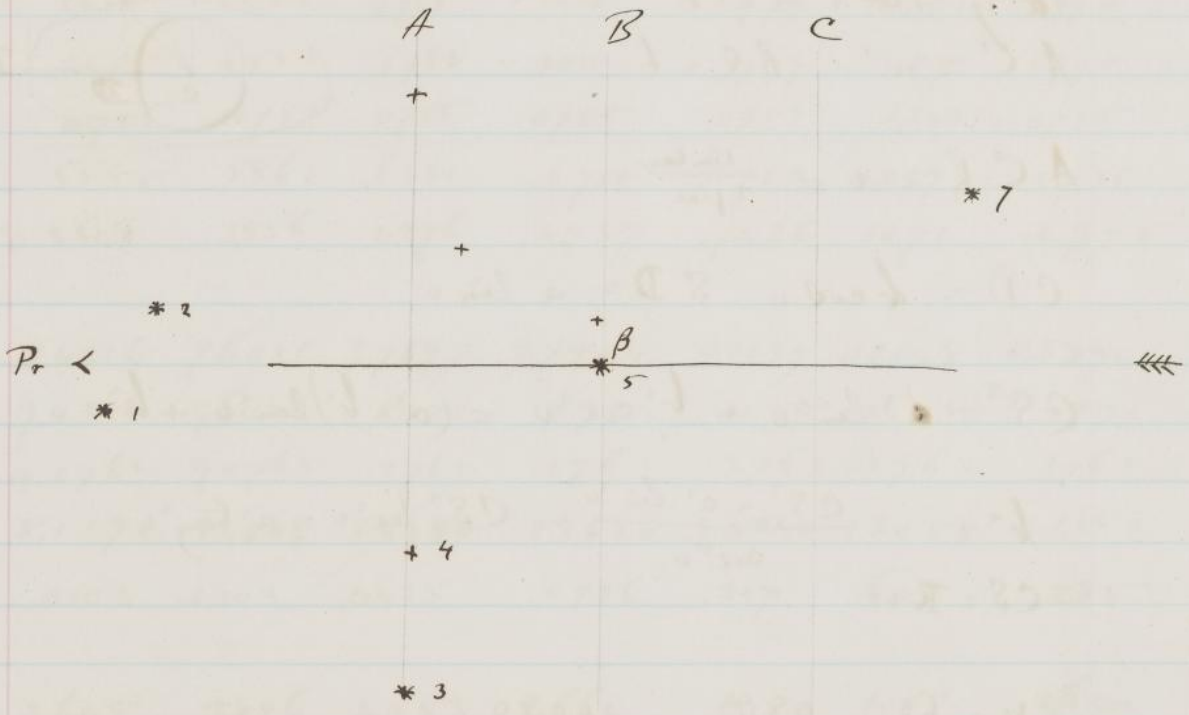
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Observations

Saturday March 24th 1877. R.A. of Stars near Gl 26



Order of brightness 5=β, 7, 3, 1, 2.

Obs. 9h 6m 5 – 9h 5-3m Sid T. chron 3651 eyepiece 150 diam. a & Equal cast. Wire illum. Vernier A, 127°25' B, 307°26' Attached thermom. 40°

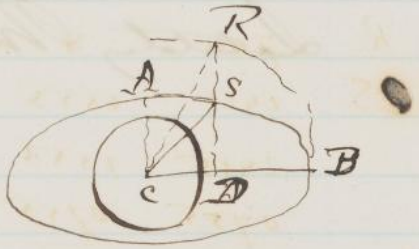
1 6 β	2 5 β	3 C β	β C 6	β C 7
15.8	12.1	exactly		55.0
16.0	11.4	equal C		55.1
15.9	12.1	distance		54.8
16.1	12.0	between		54.8
15.6	~~12.0~~	wires		55.0
				4.7
15.9	11.9			54.9

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$b^2y^2 + a^2x^2 = a^2b^2$

$AC = a \qquad BC = b$



$ACR = v = \frac{\text{latitude}}{\text{complement}}$

$CD = b \cos v \qquad SD = a \sin v$

$CS^2 = a^2 \sin^2 v + b^2 \cos^2 v = (a^2 - b^2)\sin^2 v + b^2$

$b^2 = \frac{CS^2 - a^2 \sin^2 v}{\cos^2 v} = CS^2 \sec^2 v - a^2 \operatorname{tg}^2 v$

$CS = R + l$

$p = 68 \quad 48.9$

6

408

48.9

4569 minutes

10800 | 41289

64800 | .2

6480 | 413

4413

2351

2065

2860

2478

3820

3717

1030

926

1040

40.80

48.9

41289 | 30 = 360

15.69225 = 30 min time

9

14 12.325 = 23° 32' 19".5

2° 36' 55".5 the half hour

5° 13 51" " hour

23 32 21

0377 3

555

Log. cos. 23° ,601 9.962700 sin 0.075460

Log 23 9.638 1046 Log sin 9.276092

55.4

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Computation of b & Absolute $90° - v$

R	.744	.8	.9	1.0	1.5	2.0	4.0	∞
log S	.2415	.2553	.2788	.3010	.3979	.4771	.6990	
	.2415	.2553	.2788	.3010	.3979	.4771	.6990	
	.0755	.0755	.0755	.0755	.0755	.0755	.0755	
log	.5585	.5861	.6331	.6765	.8713	1.0297	1.4735	
$CS^2 \sin^2 v$	3.618	3.856	4.296	4.737	7.436	10.71	29.75	
log a	9.4216	9.6021	9.7597	9.7924	0.1139	0.2648	0.5894	
	9.4216	9.6021	.6021	.7924	.1139	0.2648	.5894	
	9.2762	9.2762	.2762	.2762	.2762	9.2762	.2762	
	8.1194	8.4804	8.6380	8.8610	9.5040	9.8058	0.4550	
	.0103	.0302	.0435	.0726	.319	.640	2.85	
CS^2	3.608	3.826	4.253	4.664	7.117	10.07	26.90	
b	1.90	1.96	2.06	2.16	2.67	3.17	5.19	
$b \sin^2 a$	.264	~~.40~~	.575	.62	1.30	1.84	3.885	

Angle.

3	54
7	48
11	42
15	36
19	30
23	24

3	53.4
7	50.8
11	46.2
15	41.6
19	37.0
23	32.4

$CS^2 = a^2 \cos^2 v + b^2 \sin^2 v$ $\quad US = R + 1 - DC$

$= a^2 + (b^2 - a^2) \sin^2 v$

$b^2 = \frac{CS^2 - a^2}{\sin^2 v} + a^2$

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ν	3 55.4	7 50.8	11 46.2	15 41.6	19 37.0	~~23 32.4~~
$\log \sin \theta$	8.83519	9.13520	9.30960	9.43115	9.52598	9.60440
$\log \sin^2 \theta$	7.67038	8.27040	8.61920	8.86230	9.05196	9.20280
	.004682	.01864	.04161	.07289	.1127	.1595
$R = 7.44$	.016	.066	.147	.258	.402	.562
$\rho' = CS$	~~.085~~ ~~3.594~~	~~.136~~ ~~3.542~~	~~.217~~ ~~3.164~~	.328	.572	.634
$CS = \rho$	.293	.369	.466	.573	.756	.796
$R = 1^{(b-a)/b}$	.020	.080	.178	.312	.607	.682
$(b-a)b + a^{3.44}$	.404	.464	.562	.696	.991	1.066
	~~.201~~	~~.215~~	~~.255~~	~~.264~~	~~.315~~	
ρ	.636	.681	.750	8.34	9.95	1.033
~~$R = 2$~~ $R = 2^{3.39}$	.0317	.124	.278	.486	.948	1.07
	3.42	3.57	3.67	3.88	4.54	4.46
	1.85	1.87	1.91	1.97	2.08	2.11

$\rho = 7.44$

100.0

94.4

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R	.744	.8	.9	1.0	1.5	2.0	4.0
b^2	3.608	3.826	4.253	4.664	7.117	10.07	26.90
a^2	1.070	.160	.331	.384	1.690	3.39	15.09
b^2-a^2	3.538	3.666	3.922	4.280	5.427	6.68	11.81
$(b^2-a^2)^{\frac{1}{2}}$							

R	.744	1.0	2.0
a	.26	.62	1.84
b	4.32	5.10	6.21
.5	.13	.31	.92
	2.16	2.55	3.10
.866	.23	.54	1.61
	3.76	4.46	5.43

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	R = .744	Vollm.
v.s.		0
.1	98.8	.293
.2	96.6	369
.3	~~93.7~~	.466
.4	90.3	.573
.5	87.0	.756
.6	82.6	.796
.7	78.4	
.8	74.2	
.9	69.6	
1.0	65.1	
1.1	60.3	
1.2	55.6	
1.3	51.3	
1.4	47.1	
1.5		

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$\log L_{2v}$	7.6704	8.2704	8.6192	8.8623	9.0520	9.2028
	"	"	"	"	"	
$R = .744$ ($L_{2v} + (b^2 a^2)$)	8.9405	9.5405	9.8893	0.1324	0.3221	0.4729
	.0872	.347	.775	1.356	~~1.643~~	2971
$\rho^2 =$ $+a^2$	.1572	.417	.845	1.426	~~1.713~~	3.041
ρ	.396	.646	.919	1.194	1.647	1.744
$R = 1$	9.0158	9.6158	9.9646	0.2077	0.4974	0.5482
	.104	.413	.922	1.613	3.143	3.616
	.488	.797	1.306	1.997	3.527	~~4.300~~ ~~3.918~~
	.699	.893	1.143	1.413	1.875	2.580 ~~2.777~~
$R = 2$	9.1166	9.8166	0.1654	0.4085	0.6982	0.7490
	.131	.656	1.464	2.561	4.991	5.611
	3.521	4.046	4.854	5.951	8.381	9.001
	1.577	2.011	2.203	2.440	2.795	3.000
$R = 1$	~~9.999~~	~~9.609~~	9.958	9.201	9.391	9.542
	.0998	.397	.887	1.552	2.404	3.404
	9.009	9.609	9.958	9.201	0391	0.542
	.1021	.4065	.908	1.588	2.460	3.484
	.620	.924	1.426	2.106	2.978	4.002
ρ	.785	.961	1.194	1.451	1.726	2.001

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Cont- of b^2

R	.744	.8	.9	1.0	1.5	2.0	4.0	1.0
CS^2	3.041	3.24	3.61	4.00	6.25	9.00	25.00	4.00
a^2	.070	.160	.331	.384	1.690	3.39	15.09	.518
CS^2-a^2	2.971	3.080	3.279	3.616	4.560	5.61	9.91	3.482
$\log CS^2-a^2$	0.47290	.4885	.5157	.5582	.6590	.7490	.9961	.5418
ζL^{-2}	9.2028	2028	2028	2028	2028	2028	2028	9.2028
$\log \frac{CS^2-a^2}{L^2}$	1.2701	1.2853	1.3129	1.3454	1.4562	1.5462	1.7933	1.3390
$\frac{CS^2-a^2}{L^2}$	18.63	19.31	20.56	22.15	28.59	35.17	62.13	21.33
$b^2 = \frac{CS^2-a^2}{L^2}+a^2$	18.70	19.47	20.89	26.00	30.28	38.56	77.22	21.85
b	4.32	4.41	4.57	5.10	5.50	6.21	8.79	4.67

.3221
2.099
2.169
1.473

.3974
2.497
2.881
1.697

.5982
3.946
3.9
7.336
2.709

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	Bf.	Aff.	Mean	.744	1.00	2.00	Lin
0	45.1	45.1	45.1	45.1	45.1	45.1	45.1
1	49.2	48.5	48.8	49.2	48.8	47.4	48.4
2	59.4	54.7	57.0	60.5	58.6	56.0	58.8
3	77.1	68.9	73.0	73.2	71.2	67.6	72.5
4	87.9	82.8	85.3	84.8	83.6	80.6	86.3
5	95.7	94.6	95.1	94.6	94.1	92.4	96.6
6	99.8	100.0	99.9	100.0	100.0	100.0	100.0

	.744-M	1.00-M	2.00-M	S-M
0	0.0	0.0	0.0	0.0
1	+.4	0.0	-1.4	-.4
2	+3.5	+1.6	-1.0	+1.8
3	+.2	-1.8	-5.4	-.5
4	-.5	-1.7	-4.7	+1.0
5	-.5	-1.0	-2.7	+1.5
6	+.1	0.0	+.1	0.0
Σ+	4.1	1.6	0	4.3
Σ-	1.0	4.5	15.2	.9
Σ±	5.1	6.1	15.2	5.2
M	1.0	1.2	3.0	1.0
Chg S.	1	1	0	3

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R = .744

	Diff Cur.	U. Sin.	
0	.264	148.0	45.1
1	.396	134.8	49.2
2	.646	109.8	60.5
3	.919	82.5	73.2
4	1.194	55.0	84.8
5	~~1.473~~	~~27.1~~	~~94.6~~
6	1.744	00.0	100.0

R = 1

0	.620	138.0	38.7	.720	128.0	44.9
1	.899	130.1	57.3	.788	121.2	48.8
2	.893	110.7		.961	103.9	58.6
3	1.143	85.7		1.194	80.6	71.2
4	1.413	58.7		1.451	54.9	83.6
5	~~1.698~~	~~30.3~~		1.726	27.4	94.1
6	2.000	0.0		2.000	0.0	100.0

R = 2

0	1.84	1.16.0	45.0
1	1.877	1.12.3	47.4
2	2.011	98.9	56.0
3	2.203	79.7	67.6
4	2.440	56.0	80.6
5	~~2.709~~	~~29.1~~	~~92.4~~
6	3.000	0.0	100.0

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Table of Segments Encyc. Brit. 8th Ed. Vol XIV, 525

Ht	Area Circle Radius 1	Area Circles of Height			
1	.001883	26	239997	57	631563 17490 26 1.095445
2	.005317	7	253558	2	649053 17599 7 1.114885
3	.009754	8	267333	3	666652 17706 8 1.134372
4	.014994	9	281315	4	684358 9 1.153904
5	.020923	30	295499	5	702168 80 1.173479
6	.027462	1	309879	6	720079 1 1.193095
7	.034553	2	324449	7	738087 2 1.212750
8	.042151	3	339206	8	756191 3 1.232441
9	.050219	4	354142	9	774387 4 1.252167
10	.058726	5	369253	60	792673 5 1.271925
11	.067646	6	384538	1	811047 6 1.291714
12	.076957 09311 09722	7	399988	2	829505 7 1.311531
13	.086679 09995	8	415601	3	848046 8 1.331374
14	.096674 10372	9	431371	4	866666 9 1.351241
15	.107046	40	447295	5	885363 90 1.371130
16	.117741	1	463370	6	904135 1 1.391040
17	.128745	2	479590	7	922979 2 1.410967
18	.140047	3	495953	8	941893 3 1.430911
19	.151636	4	512455	9	960875 4 1.450868
20	.163501	5	529092	70	979922 5 1.470838
21	.175633	6	545860	1	999032 6 1.490818
22	.188022	7	562757	2	1.018202 7 1.510805
23	.200661	8	579779	3	1.037431 8 1.530799
24	.213542	9	.596923	4	1.056716 9 1.550797
25	.226658	50	.614185	5	1.076055 100 1.570796 2.141592

N.S.

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Tables Desired.

I. Area segment in terms of ~~x~~ or y.



II. For various values of R areas of eclipsed segments for given distances of Centres.



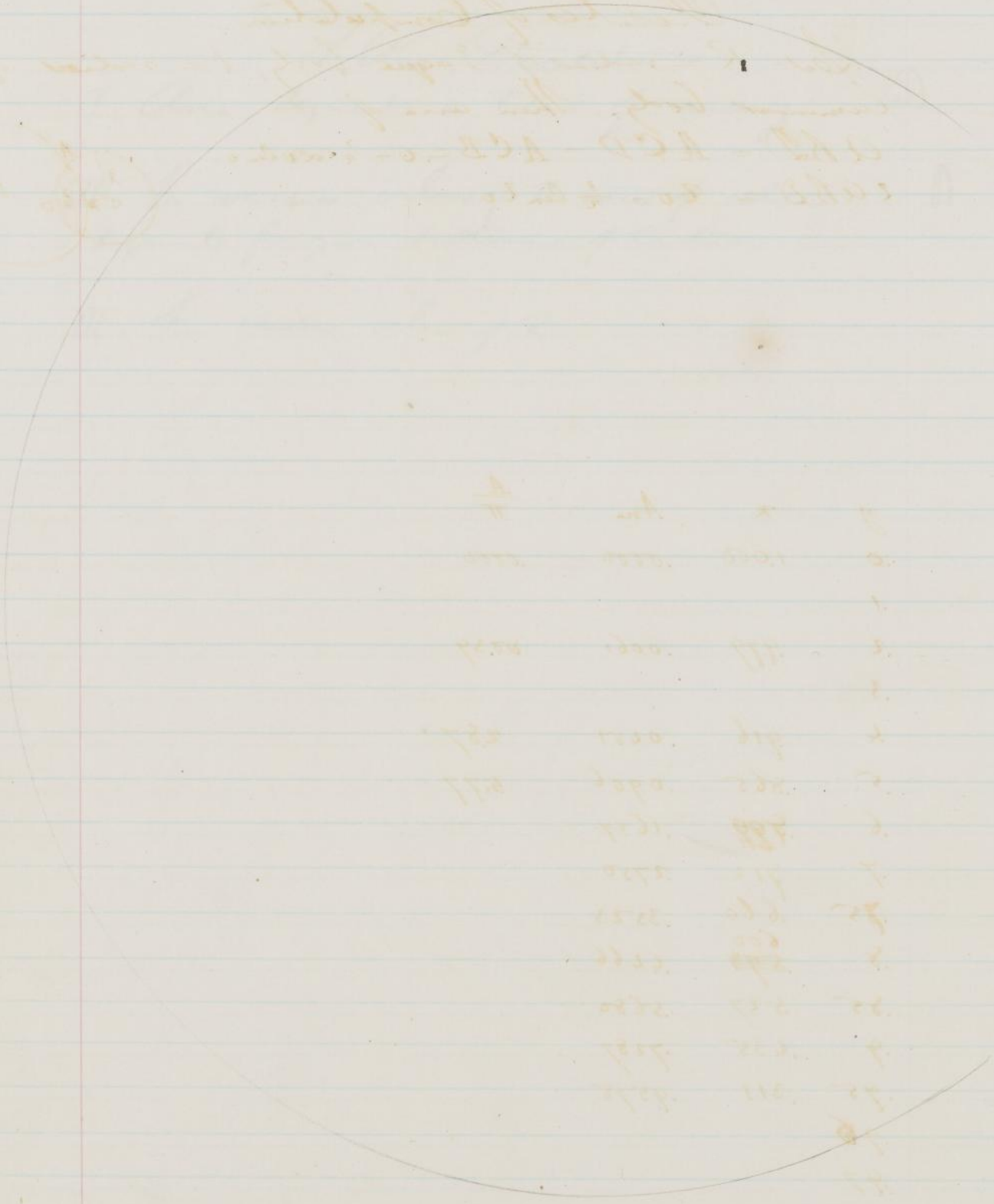
III. For various values of R

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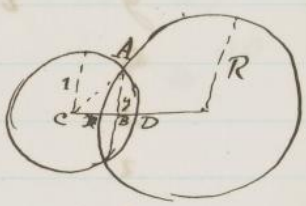
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Results of Computation

Let R = radius of opaque body, l = radius of luminous body. Then area of

$ABD = ACD - ACB = v - \frac{1}{2}\sin 2v$

$2ABD = 2v - \frac{1}{2}\sin 2v$



y	x	Area	$\frac{A}{\pi}$
.0	1.000	.0000	.0000
.1			
.2	.979	.0061	00.39
.3			
.4	.916	.0451	2.87
.5	.865	.0906	5.77
.6	.800	.1639	
.7	.712	.2750	
.75	.660	.3523	
.8	.600	.4466	
.85	.527	.5680	
.9	.435	.7287	
.95	.311	.9578	
.96			
.97			
.98	.199		
.99	.141		
1.00	.000		

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Area of Segments.

y	z	A	x	$100-(A+x)$	Area pend. $\frac{2}{3}y(1-x)$
0		.0	1.00.0	0.0	
.1		.3	99.50	.4	.042
.2		.3	97.98	1.7	.134
.3		1.2	95.39	3.4	1.17
.4		2.8	91.65	5.6	2.83
.5		5.7	86.60	7.7	5.66
.6		10.5	80.0	9.5	10.18
.7		17.5	71.41	11.1	17.56
.75		22.4	66.14	11.5	
.8		28.5	60.0	11.5	
.85		36.2	52.7	11.1	
.9		46.3	43.6	10.1	
.92		51.4	39.19	9.4	
.94		57.4	34.14	8.5	
.95		60.9	31.22	7.9	
.96		64.8	2800	7.2	
.97		69.3	24.31	6.4	
.98		74.8	19.91	5.3	
.99		82.1	14.10	3.8	
1.00		100.0	0.00	0.0	

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Brightness of Unoccupied Portion

Dist. center	2.0	Radius of bright body 1.0	2.0	dist edge ∞	4.0	.25	1.5	.67
.0	0.0	0.0	75.	0.0		0.0		0.0
.1		8.4						
.2		12.8						
.3		19.1						
.4		25.3						
.5		31.6						
.6		37.6						
.7		43.6						
.8		49.6						
.9		55.2						
1.0		60.8		100.0				
1.1		66.2						
1.2		71.5						
1.3		76.5				100.0		
1.4		81.2						
1.5	100.0	85.4						
1.6	"	89.5						
1.7	"	93.2						100.0
1.8	"	96.4						
1.9	"	98.6						
2.0		100.0						
2.1		"						
2.2		"						
2.3		"						
2.4		"						
2.5							2.5	
2.6								
2.7								
2.8								
2.9								
3.0		100.0						

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Table of Areas of Segments.



y	z	A	A/yz²	
.00	1.000	.000	100.00	
1	99.995	000	98.72	
2	99.980	000	97.46	
3	99.95	001	96.17	
4	.92	003	94.90	
5	.87	005	.02	93.63
6	.82	010	92.35	
7	.75	016	91.08	
8	.68	024	89.81	
9	.59	036	88.55	
1.0	.99.499	047	.06	87.29
1	.39	062	86.02	
2	.27	079	84.76	
3	.15	101	83.50	
4	.02	120	82.24	
5	98.86	154	.16	80.99
6	.71	187	79.73	
7	.54	224	78.48	
8	.37	266	77.22	
9	.18	312	75.97	
20	97.980	.365	.36	74.72
1	.77	.421	73.48	
2	.55	.483	72.24	
3	.32	553	71.00	
4	.08	630	69.77	
5	96.82	713	.72	68.53
6	.56	803	67.31	
7	.29	900	66.09	
8	96.00	1.007	64.86	
9	95.70	1.129	63.65	

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30	95.39	1.24	1.22	62.44
1	95.07	1.37		61.22
2	94.74	1.50		60.01
3	94.40	1.65		58.80
4	94.04	1.80		57.59
5	93.67	1.96	1.90	56.39
6	93.29	2.13		55.20
7	92.90	2.30		54.01
8	92.50	2.49		52.82
9	92.08	2.68		51.64
40	91.65	2.875	2.92	50.476
1	91.21	3.10		49.2
2	90.75	3.34		48.1
3	90.28	3.60		46.9
4	89.80	3.87		45.8
5	89 30	4.12	4.18	44.7
6	88.79	4.45		43.6
7	88.27	475		42.4
8	87.73	5.08		41.3
9	87.23	5.42		40.1
50	86.60	5.785	5.82	39.118
1	86.02	6.16		380
2	85.42	6.56		369 ~~376~~
3	84.80	6.97		358
4	84.17	7.40		348
5	83.52	7.85	7.88	337
6	82.71	8.31		326
7	82.16	8.80		316
8	81.46	9.30		30.6
9	80.74	9.83		29.5 ~~30.0~~

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		A	A x=7	
60	80.00	10.39 1048	28.572	
1	79.24		27.6	
2	78.46		26.6	
3	77.66		25.6	
4	76.84		24.6	
5	75.99		23.6	
6	75.13		22.7	
7	74.24		21.7	
8	73.32		20.7	
9	72.38		19.8	
70	71.41		18.833	
1	70.42		17.9	
2	69.40		17.0	
3	68.34		16.1	
4	67.26		15.3	
5	66.14		14.4	
6	64.99		13.6	
7	63.80		12.8	
8	62.58		12.0	
9	61.31		11.2	
80	60.00	28.57 2854	10.39	
1	58.64			
2	57.24			
3	55.78			
4	54.26			
5	52.68	36.2 362	6.83	
6	51.03			
7	49.30			
8	47.50			
9	45.60			

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90	43.59	46.3	51.6	3.74
1	41.46			
2	39.20			
3	36.76			
4	34.12			
5	31.23	60.9	60.9	1.40
6	28.00	64.86		1.00
7	24.31	69.36		.657
8	19.90	74.84		.361
9	14.10	82.12		.123
100	0.00	100.00	100.0	0.00

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Areas of Segments in terms of x

x^2	A
0	100.00
1	98.72
2	97.46
3	96.17
4	94.90
5	93.63
6	92.35
7	91 08
8	89.81
9	88.55
10	87.29
1	86 02
2	84.76
3	83.50
4	82.24
5	80.99
6	79.73
7	78 48
8	77.22
9	75.97
20	74.72
1	73 48
2	72.24
3	71.00
4	69.77
5	68 53
6	67.31
7	66.09
8	64.86
9	63 65

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Dist Centre	R=1	Deficit	Δ q 3
0	100.0	0.0	0.0
.1	93.6	6.4	0.0
.2	87.3	12.7	+.1
.3	81.0	19.0	+.1
.4	74.7	25.3	.0
.5	68.5	31.5	+.1
.6	62.4	37.6	0
.7	56.4	43.6	0
.8	50.5	49.5	+.1
.9	44.7	55.3	−.1
1.0	39.1	60.9	+.1
.1	33.7	66.3	−.1
.2	28.6	71.4	+.1
.3	23.6	76.4	+.1
.4	18.8	81.2	0
.5	14.4	85.6	−.2
.6	10.4	89.6	−.1
.7	6.9	93.1	+.1
.8	3.7	96.3	+.1
.9	1.4	98.6	0
2.0	0.0	100.0	0

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Reeder 2 101. Bright: R = 2 — 1 R = ½

x	A	Δx	A′	x	A R=1.5
3.000	100.0	1.50	100.0	2.50	100.0
2.970	99.7	1.485	99.9		
2.876	97.8	1.438	99.4	2.174	98.6
2.708	92.3		98.1	1.960	82.2
2.588	87.4		96.8	1869	77.7
2.432	80.0		95.0	1763	72.2
2.222	68.6		92.1	1.636	65.2
2.107	61.7		90.4	1.473	55.5
1.944	51.7		87.9	1.268	43.0
1.732	38.4		84.6	1.118	33.3
1.540	26.5		81.6	.986	25.0
1.424	19.2		79.8	84.9	16.4
1.350	14.8		78.7	76.4	11.4
1.232	8.5		77.1	70.9	8.3
1.160	4.8		76.2	66.9	6.3
1.108	2.7		75.7	63.8	~~2.7~~ 48
1.044	.7		75.2	57.4	2.0
1.010	.1		75.0		
1.000	0		75.0	50.0	0.0

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R = 2 and 1.5

y	.2	.4	.6	.7	.8	.9	1.0
A	.36	2.87	10.39	17.4	28.57	46.2	100.00
$A^{\frac{7}{2}}$	.047	.365	1.24	1.96	2.875	4.12	5.785
$A' = 4A^{\frac{7}{2}}$	.168	1.46	4.96	7.84	11.50	16.48	23.14
$A' + A^2$	.528	4.33	15.35	25.26	40.07	62.68	123.14
$A_1 - A'$	199.5	195.7	184.6	174.8	159.9	137.3	86.9
	.19	1.41	5.4	9.6	17.1	29.7	6
x	98.0	91.6	80.0	71.4	60.0	43.6	0.0
x'	99.5	98.0	95.4	92.7	91.6	89.3	86.6
2x'	199.0	196.0	190.8	187.4	183.2	178.6	173.2
x+x'	297.5	287.6	270.8	258.8	243.2	222.2	
x-x'	198.5	104.4	110.8	116.0	123.2	135.0	173.2

R = 1.5

y	.94	.98	.60	.75	80	85	90	95
A	57.5	74.8	10.39	22.6	28.57	36.1	46.2	60.9
	4.75	5.42	2.87	5.78	7.11	8.64	10.39	12.5
	19.00	21.7	6.46	13.00	16.00	19.44	23.37	28.1
	76.5	96.5	16.85	35.6	44.6	55.5	69.6	89.0
	123.5	103.5	153.2	144.4	155.4	144.5	130.4	111.0
	38.5	53.1	3.93	7.4	12.6	16.7	22.8	32.8
x	34.12	19.90	80.0	66.14	60.0	52.68	43.59	31.23
x'	88.37	87.23	91.6	86.6	84.6	82.40	80.0	77.38
.5x'			45.8	43.3	42.3	41.2		38.7
1.5x'	176.54	174.46	137.4	129.9	126.9	123.6	120.0	116.1
	210.66	194.36	217.4	196.0	186.9	176.3	163.59	147.3
	142.42	154.56	57.4	63.8	66.9	70.9	76.4	84.9

Computations and segments.

2.87 × 5.74 = 16.46

5.78 × 2 = 11.56

11.22 − 1.78 = 16.00

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y	.99	100.0	40	60	75	80	85	90
A	~~11.10~~ 12.08	100.0	2.87	10.39	22.6	28.57	36.1	46.2
$\alpha A'$	14.2	14.8	.047 "	.154 "	.300	.365 "	.436	.518
$x' A'$	32.0 ~~32~~	33.3	.75	2.56	4.80	5.85	.697	9.29
$A+A'$	114.1	133.3	3.6	12.9	27.4	34.4	43.0	57.5
$2-A+A'$	85.9	66.7	~~196.4~~	~~187.1~~	~~172.6~~	~~165.6~~	~~157.0~~	~~142.5~~
$A-A'$	50.0	66.7	2.1	7.83	17.8	22.72	29.1	36.9
			197.9	192.17				
x	1410	0.0	91.65	.80.0	66.14	.60.0	52.68	43.59
x'	75.13 37.66	74.53 37.22	99.50	~~97.86~~ 98.86	98.22	97.98	97.72	97.43
$\alpha x'$	112.7	111.8	398.00	395.44	392.88	391.92	390.88	389.72
$x+x'$	126.8	118.8	489.65	475.44	459.02	451.92	443.56	433.31
$x-x'$	98.6	111.8	306.35	315.44	326.74	331.92	338.20	346.13

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95	99	100.0
60.9	82.08	100.0
.611	.692	.713
9.78	11.07	10.408
70.7	93.1	111.4
~~129.3~~	~~106.9~~	~~88.6~~
51.1	71.0	88.6

31.23	14.10	0.00
97.14	96.89	96.82
398.56	387.56	387.28
419.79	401.66	387.28
357.33	373.46	387.28

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Values of R = ∇

	D = 0	.2	.4	.6	1.0	1.5
	0.0					
	.1					
	.2	0.0				
	3	22.36				
	4	22	0.0			
	5			0.0		
	6			33.17		
	7			48.99		
	8			62.45		
	9			74.83		
	1.0			86.60	0.00	
	1			97.98	45.83	
	2			109.09	66.33	
	3			120.00	83.07	
	4			130.77	97.98	
	5			141.42	111.80	0.00
256	6			151.99	124.90	55.68
289	7			161.86	137.48	80.00
324	8			172.92	149.67	99.50
361	9			183.30	161.55	116.62
	2.0			193.65	173.21	132.29

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Area of Segment R = 1, 1

X

A.	x	.5	
	0.0		
	10.0		
	20.0		
	30.0		
	40.0		
	50.0	0.0	
	60.0	33.2	
	70.0	49.0	
	80.0	62.4	
	90.0	74.8	
	100.0	86.6	0.0.0
	110.0	98.0	
	120.0	111.8	
	130.0	124.9	
	140.0	137.5	
	150.0	149.7	
	160.0		
	170.0		
	180.0		
	190.0		
	200.0		

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Annuli and Annulus when R = ∞

A	R=.5	.0	+.5	+1					
	R=0	-.0	+.5	+.5					
	-.1	-.5	0	+.5					
0.0	0.0	0.0				0.0			
6.4	10.0	22.4				22.4			
12.6	20.0	31.6				31.6			
18.8	30.0	38.7							
24.7	40.0	44.7	—				—		
30.4	50.0	50.0	0.0				0.0		
35.7	60.0	54.8	22.4						
40.6	70.0	59.2	31.6						
44.8	80.0	63.2	38.7						
48.1	90.0	67.1	44.7	—				—	
50.0	100.0	70.7	50.0	0.0				0.0	
51.9	110.0	74.2	54.8	22.4					
55.2	120.0	77.5	59.2	31.6					
59.4	130.0	80.6	63.2	38.7					
64.3	140.0	83.7	67.1	44.7	—				—
69.6	150.0	86.6	70.7	50.0	0.0				0.0
75.3	160.0	89.4	74.2	54.8	22.4				44.8
81.2	170.0	92.2	77.5	59.2	31.6				63.2
87.4	180.0	94.7	80.6	63.2	38.7				77.4
93.6	190.0	97.5	83.7	67.1	44.7				89.4
100.0	200.0	100.0	86.6	70.7	50.0	100.0	100.0	100.0	100.0
A	π	$\sqrt{\pi}$					1		

This Table gives the amount of light <u>unobstructed</u> by a body of infinite Radius transiting over an of finite size. The first column gives the amount of light remaining when the

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Areas and abscissae when $R = 1$

A	~~0~~	.5	1.0	1.5	1.5	0	5	1.0	1.5
0.0	~~0.0~~					0.0			
6.4	~~5.0~~					5.0			
12.7	~~10.0~~					10.0			
19.0	30.0					15.0			
25.3	40.0	—				20.0	—		
31.5	50.0	0.0				25.0	0.0		
37.6	60.0	33.2				30.0			
43.6	70.0	49.0				35.0			
49.5	80.0	62.4				40.0			
55.3	90.0	74.8	—			45.0		—	
60.9	100.0	86.6	0.0			50.0		0.0	
66.3	110.0	98.0	45.8			55.0			
71.4	120.0	109.1	66.3			60.0			
76.4	130.0	120.0	83.1			65.0			
81.2	140.0	130.8	98.0	—		70.0			—
85.5	150.0	141.4	111.8	0.0		75.0			0.0
89.6	160.0	152.0	124.9	55.7		80.0			
93.1	170.0	161.9	137.6	80.0		85.0			
96.3	180.0	172.9	149.7	99.5		90.0			
98.6	190.0	183.3	161.5	~~166~~		95.0			
100.0	200.0	193.6	173.2	132.3		100.0	100.0	100.0	100.0

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$R = .667$

		Dist-cent	Area		
55.5	33.3	133.3	55.5	500+ε4	
	38.3	128.4	56.4	508.0	1.0
	42.5	124.2	57.7	519.2	1.2
	44.6	122.1	58.4	525.2	58
	47.3	119.4	59.2	533.2	
	50.9	115.8	60.6	545.6	
	56.6	110.1	62.8	565.6	
	65.7	101.0	66.6	600.0	
	74.5	92.2	70.4	633.2	
	84.5	82.2	74.7	672.0	
	98.2	68.5	80.2	722.0	
	109.4	57.6	84.5	760.8	
	117.5	49.2	87.6	788.8	
	124.6	42.1	90.1	810.8	
	131.0	35.7	92.1	828.8	
	145.0	21.7	96.3	866.4	
100.0	166.7	0.0	100.0	900.0	

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$R = 1.5 \; \lambda \; 10a - 101$

A	x	Dict-Comb.	
0.0	50.0	200.0	
2.0	57.4	192.6	
4.8	63.8	186.2	*
6.3	66.9	183.1	
8.3	70.9	179.1	
11.4	76.4	173.6	
16.4	84.9	165.1	
25.0	98.6	151.4	?
33.3	111.8	138.2	
43.0	126.8	123.2	
53.5	147.3	102.7	
65.2	163.6	86.4	
72.2	176.3	73.7	
77.7	186.9	63.1	
8.23 81.1	196.0	54.0	*
91.6	217.4	32.6	*
100.0	250.0		

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R = .5

l	A	x	Dist into crater
100.0	75.0	50.0	100.0
99.9	75.0	50.5	99.5
99.4	75.2	52.2	97.8
98.1	75.7	55.4	94.6
96.8	76.2	58.0	92.0
95.0	77.1	61.6	88.4
92.1	78.7	67.5	82.5
90.4	79.8	71.2	78.8
87.9	81.6	77.3 86.6	72.7
84.6	84.6	97.2	63.4
81.6	87.9	105.3	52.8
79.8	90.4	111.1	44.7
78.7	92.1	121.6	38.9
77.1	95.0	129.4	28.4
76.2	96.8	135.4	20.6
75.7	98.1	143.8	14.6
75.2	99.4	148.5	9.2
75.0	99.9		4.5
75.0	100.0	150.0	~~0.0~~ 0.0

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$R = 2.0$

A	z	
0	100.0	200
.1	101.0	199.0
.7	104.4	195.6
2.7	110.8	189.2
4.8	116.0	184.0
8.5	123.2	176.8
14.8	135.0	165.0
19.2	142.4	157.6
26.5	154.6	145.4
38.4	173.2	126.8
52.7	194.4	105.6
61.7	210.7	89.3
68.6	222.2	77.8
80.0	243.2	56.8
87.4	258.8	41.2
92.3	270.8	29.2
97.8	287.6	12.4
99.7	297.0	3.0
100.0	300.0	0.0

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R=.25

0.0
2.6
6.1
10.2
12.0
14.1
16.7
20.0
24.6
28.2
31.6
35.7
38.5
40.4
42.0
43.3
46.1
48.4
50.0

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$R = 4.0 \lambda 102.3$

A	x	Dist. to Earth
100.0	500.0	0.0
98.2	489.6	10.4
93.5	475.4	24.6
86.8	459.0	41.0
82.8	451.9	48.1
78.5	443.6	56.4
71.2	433.3	66.7
64.6	419.8	80.2
53.4	401.7	98.3
44.3	387.3	112.7
35.5	373.5	126.5
25.5	357.3	142.7
18.4	346.1	153.9
14.5	338.2	161.8
11.4	331.9	168.1
8.9	326.7	173.3
3.9	315.4	184.6
1.0	306.3	193.7
0.0	300.0	200.0

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R = 1 Comb 146-7

A	.0	.25	.50	.75
0.0	0.0	—		
	20.0	—		
	40.0	6.3		
	60.0	10.2		
	80.0	69.6		
	100.0	91.9	~~58.8~~	
	120.0	113.3	~~88.8~~	
	140.0	134.3	114.3	57.8
	160.0	155.0	138.0	96.7
	180.0	175.6	160.8	127.1
100.0	200.0	196.1	182.9	154.1
R La a=0	0.0	39.5	80.9	127.5

1.

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Table I

Diff. mag.	.25	.33 .25	.50	.67 .50	1.0 ~~1.7~~	1.5	2.0	4.0	16.0	∞
0	100.0	100.0 100.0	0.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
.1	~~98.6~~	98.8			98.6		98.4			98.1
.2	~~96.3~~	96.9		96.6	96.3	96.0	95.7			94.8
.3		94.6		93.9	93.1	92.6	92.2			90.6
.4		91.8		90.9	~~89.6~~	88.5	87.9			85.7
.5	—	88.6		8~~7~~.5	85.5	84.2	83.3			80.4
.6		85.6		83.6	81.2	79.6	78.4			74.7
.7		82.4		79.5	76.4	74.1	73.0			68.8
.8		79.4		75.5+	71.4	68.9	67.4			62.6
.9		76.6		71.4	66.3	63.0	61.4			56.3
1.0		75.0		67.3	60.9	57.0	55.3			50.0
1.1				62.8	55.3	51.0	48.8			43.7
1.2				59.1	49.5	44.9	42.5			37.4
1.3				56.2	43.6	38.7	36.4			31.2
1.4				~~55.5~~	37.6	32.4	30.1			25.3
1.5				—	31.5	26.0	23.6			19.6
1.6					25.3	19.7	17.7			14.3
1.7					19.0	13.5	11.8			9.4
1.8					12.7	7.7	6.7			5.2
1.9					6.4	2.9	2.5			1.9
2.0					0.0	0.0	0.0			0.0

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Table II

R = .25

0	125.0	~~125.0~~ 122.5			
.1	100.0				
.2	75.0				
.3	50.0				
.4	25.0				
.5	0.0	25.0	50.0	75.0	100.0

R = .50

.0	150.0					
.1	120.0					
.2	90.0					
.3	60.0					
.4	30.0					
.5	0.0	25.0	50.0	75.0	100.0	125.0

R = .667

0	166.7			
1	133.3			
2	100.0			
3	66.7			
4	33.3			
5	0.0	50.0	100.0	150.0

R = 1.00

.0	200.0	200.0	200.0	200.0
.1	160.0			
.2	120.0			
.3	80.0			
.4	40.0			
.5	0.0	50.0	100.0	150.0

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Min. Light = 0.0

R	D	Dab
1.0	8.0	.0
1.5	.5	.5
2.0	1.0	1.0
4.0	3.0	8.0
∞	∞	∞

Min Light = .50.0

1.0	119.2	80.8
1.5	111.6	138.4
2.0	108.3	291.7
4.0		
∞	100.0	

Min Light = 75.0

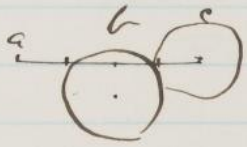
.50	100.0	50.0
.67	81.7	75.0
1.00	72.9	127.1
1.50	68.7	186.3
2.00	66.4	233.6
6.00		
∞	59.6	

Min Light 25.0

1.0	160.7	39.3
1.5	151.6	98.4
2.0	147.8	152.2
4.0		
∞	140.5	

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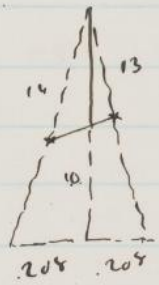
1877phae.proj.1127P



time of $ab = 4\ 20 = 260$ m.

$\therefore\ bc = 4\ 40 = 280$ m.





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Computation $2v - \frac{1}{2}\sin 2v$

1 y	.1	.2	.3	.4	.5	.6	.7	.75
2 y	5.74	11.53	17.46	23.58	30.00	36.87	44.42	48.6
~~4 $\sin 2v$~~	.199	.392	.573	.7332	.866	.9600	.9998	.9921
~~3 $2v$~~	~~11.48~~	~~23.06~~	~~34.92~~	~~47.16~~	~~60.00~~	73.74	88.84	97.2
~~5 $\frac{1}{2}\sin 2v$~~	.2002	.402	.609	.822	1.047	1.286	1.550	1.696
$2v$	.100	.201	.3045	.411	.5235	.643	.775	.848
~~6~~ $\frac{1}{2}\sin 2v$	.099	.196	.2865	.367	.433	.480	.500	.496
$2v - \frac{1}{2}\sin 2v$	.001	.005	.018	.044	.090	.163	.275	.352
$\frac{a}{1.57}$	.1	.3	1.2	2.8	5.7	10.4	17.5	22.4
x						80.		
						90.4		

correct for y	of cent.	.95	.94	.92	95	94	.92	99
v	Table nat. lines.	71.8	70.05	66.93	71.8	70.05	66.93	81.9
$2v$	double.	143.6	140.1	133.86	143.6	140.1	133.86	163.8
$4v$ in arc.	$\times 349$ Cally	1.002 ~~1.001~~	.9772 ~~.4886~~	.933 ~~.466~~	2.305	2.243	2.335	2.858
$\frac{1}{2}\sin 2v$	nat. lines.	.593 ~~.595~~	.641	.721	.593	.641	.721	.2790
$4v - \frac{1}{2}\sin 2v$	subtract.	.409	.336	.211	1.912	1.802	1.614	2.579
$2v - \frac{1}{2}\sin 2v$	div. 2.				.956	.901	.807	1.2895
$100\,\frac{2v - \frac{1}{2}\sin 2v}{\pi \div 2}$	div. 157(Cy)				.609	57.4	51.4	81.5
						34.12	39.19	14.1
						91.5	90.6	95.6

$1-a$

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1877phae.proj.13197P

.8	.85	.90	.95	.96	.97	.98	.99	1.00
53.13	58.2	64.16	71.8	73.74	75.9	78.5	81.9	90°
.9600	.8957	.7846	.5934	.5378	.4726	.3907 .5446	.2790	000
106.26	116.4	128.32	143.6	147.48	151.8	157.0	163.8	180°
1.854	2.031	2.239	2.525	2.573	2.648	2.739	2.837	3141
.927	1.0155	1.1195	1.2525	1.2865	1.324	1.3695	1.429	1.5705
.480	.4478	.3923	.2967	.2689	.236	~~.2723~~ 1953	.1395	000
.447	.568	.727	.956 .609	1.018	1.088	~~1.097~~ 1.174	~~1.295~~ 1.2904	1.571
28.5	36.2	46.3	~~.61~~ 33	64.8 45	69.3 53	74.8 77	~~82.5~~	100.0
60.0	52.7	43.6	31.22 32	28.00 37	24.31 44	19.91	14.10 9812	0.
88.5	~~89.7~~	89.9	92.7	92.8	93.6	94.7	~~96.6~~	100.0

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1877phae.proj.1137P

"71

y	1-x	x²y	$\frac{x^2y}{784}$	
0	0.0	0.0	0.0	0.0
10.	.50	5.0	42	.042
2	2.02	40.4	~~173~~	.342
3	4.61	138.3	394	1.172
4	8.35	334.0	708	2.832
5	13.40	670.0	1436	~~11.36~~ 5.68
6	20.0	1200.0		10.17
7	29.59	2071.3		17.58
8	40.0	3200.		27.17
8	76.4	23.6	4.9	
85	67.8	32.9	4.3	
9	55.5	44.5	1.8	
92	49.9	50.1	1.3	
94	43.5	56.5	.9	
95	39.8	60.2	.7	
96	35.7	64.3	.5	
97	31.0	69.0	.3	
98	25.4	74.6	.2	
99	17.9	82.1	0	
100				

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1877phae.proj.1137P

C.

1 deg = arc = .017453

2 34,9060 —

349 + 1/6000 —

58

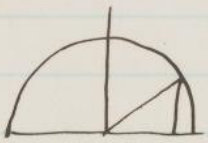
arc is reduced to arc by multip by 349 (cancelled)
adding 1/6000 the = 1/170,000 ie nearly to quad.

Area when x nearly equals 1 approaches closely to Parab.

Area = $\frac{2}{3}(1 \cdot x)y$

$\frac{2}{3}$ 15.7 | 471 $\frac{31416}{15.708}$ $\frac{4712}{2356}$





$x^2 + y^2 = 1$

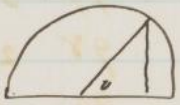
$\int y\,dx = \sqrt{1 - x^2}\,dx$

$(1-x)^{\frac{1}{2}} =$

$a^n + n a^{n-1} x + n \frac{n-1}{2} a^{n-2} x^2 + \frac{n(n-1)}{1.2.3} a$ $\quad - \frac{\frac{1}{2} \cdot -\frac{1}{2} \cdot -\frac{3}{2}}{1.6}$

$1 + \frac{1}{2}x^2 - \frac{1}{8}x^4 - \frac{1}{16}x^3$

$v = 45^\circ$ $\quad \frac{3.1416}{8} - .35 = .3927 - .25 = .1427$



$y = .707$ A $\quad \frac{.1427}{.7854} = 18.17$

1427 / 7854 $\qquad$ .1427 / 15

28540 / 15.708

2853 / 157

157 / 18.17

1283 / 18

1099

+840

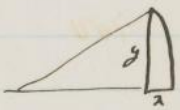
.1256

270

157

1130

360
60
2160



$x(2r - x) = y^2$

$\frac{x(2-x)A}{\pi}$

$\frac{2v - 2 \cdot 2v}{157}$ $\qquad$ v $\quad 2$

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1877phae.proj.1197P

Area Segments.

$\int y\,dx = \int \sqrt{2x - x^2}\,dx$



$(a-b)^{\frac{1}{2}} = a^{\frac{1}{2}} - \frac{1}{2}a^{-\frac{1}{2}}b + \frac{1}{2}\frac{-1}{2}a^{-\frac{3}{2}}b^2 - \frac{1}{3}\frac{-1}{2}\frac{-3}{2}$

$1-(-x)^2$

$(1+b)^{\frac{1}{2}} = 1 + \frac{1}{2}b + \frac{\frac{1}{2}\frac{-1}{2}}{2}b^2 + \frac{\frac{1}{2}\frac{-1}{2}\frac{-3}{2}}{6}b^3$

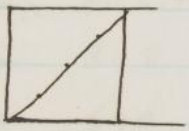
$\sqrt{1-x} = 1 - \frac{1}{2}b - \frac{1}{8}b^2 - \frac{1}{16}b^3$

Area $= x^{\frac{1}{2}}\left(1 - \frac{1}{2}x - \frac{1}{8}x^2 - \frac{1}{16}x^3\right.$

$\int x\,dy =$



y	.1	.2
$\frac{1}{y}$		
v		
$\frac{v}{10800}$		
$\log \frac{1}{v}$		

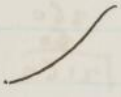


(y = Area
x Dist.

R = .25 .5 .67
1.00 1.5 2.0 4.0 ∞

(y = Area
x = Dist.

D = 0 .5 1.0 1.5 2.0
R = 1
R = 2 .4. .6



(y = Area. R = var.
x = Dist = 100



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1877phae.proj.1137P

Computation $R = 2$

y	.2	.4	.6	.8	1.0
$\log R = 1$					
$\log R = 2$					
x of $R = 1$					
x of $R = 2$					

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1877phae.proj.11377P

y	.1	.2	.3	.4	.5	.6	.7
x	.99499	.97980	.95394	.91652	.86603	.80000	.71415
v	5° 44.3	11° 32.2	17° 27.5	23° 34.7	30°	36° 52.2	44° 25.6
v'	344.3	692.2	1047.5	1414.7	1800.	2212.2	2665.6
v'/10800	114.76 / 12752	230.73 / 2564	349.17 / 3880	471.57 / 5240	600 / 666.6	737.4 / 8082	888.53 / 98725
2v	11° 28.6	23° 4.4	34° 55.0	47° 9.4	60°	73° 44.4	88° 51.2
lg(1+2v)	9.298785 / 803603	.593146	.75769	.86523	.93753	.96000 / .98228	.99991
lg π/π	.803603	.803603	.80360	.80360	.80360	.80360 / .76360	.80360
lg (2l-2v)/π	9.102388 / 12752	.396749 / 2564	.56129 / 3240	.66883 / 5240	.74113 / 6667	.78588 / 8082	.80351 / 98725
Δ	.12659	.24917	.36319	.46648	.55098	.61036 / .20 / .19	.63608 / .25.117 / .36.117
Diff	.00093	.00.73	.0248	.0575	.11569	10.39 / 9.84	17.559 / 16.058
Sum	.25411	.50557	.75119	.99048	1.21765	142856 / 71428	162333 / 81166
	12.705	25.278	37.56	49.524	60.882	28572	18.823
	87.295	74.722	62.44	50.476	39.118		

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1877phae.proj.1137P

6	.7
.8000	.71415
3652	
44 6	44 c
2212.	2665
737	888.
8182	987

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1877phae.proj.11138

y	x	A	A	y^3	Δ
0	1.00000	.047		.0	0
.1	.99499	.365	.047	.05	-.003
.2	.97980	1.24	.365	.40	-.035
.3	.95394	2.875	1.24	1.35	-.11
.4	.91652	5.785	2.875	3.2	-.325
.5	.86603	9.87	5.785	6.25	-.465
.6	.8		10.39	10.80	-.41
			17.556		+.406
.7	.71415			17.15	
.707	.7071				
.71415	.7		18.833		2.97^2
.80000	.6		28.57^2	25.6	3.57^2
.86603	.5		39.118	36.5	+2.618
.91652	.4		50.476	49.2	+1.276
.95394	.3		62.44	61.9	+.54
.97980	.2		74.722	74.6	+.122
.99499	.1		87.295	87.5	-.205
1.00000	.0				.00

$D = \frac{y^3}{y_2} + k$ for $y > 0 < .6$

$D = 1 - 1.25x + k$ for $x > 0 < .5$

0	.000	000
1	.000	000
2	.000	000
3	.001	001
4	003	003
5	006	.005
6	011	010
7	017	.016
8	026	.024
9	.036	034
1.0	.050	047

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1.0	.050	.003	.047
1.1	0.067	5	.062
2	.086	7	.079
3	.110	9	.101
4	.132	12	.120
5	.169	15	154
6	.205	18	.187
7	.246	22	.224
8	.292	26	.266
9	.343	31	.312
20	0.400	.035	.365
1	.463	.042	.421
2	.532	49	.483
3	.608	55	.553
4	.691	61	.630
5	.781	68	.713
6	.879	76	.803
7	.984	84	.900
8	1.098	91	1.007
9	1.219	1.00	1.119
30	1.350	.110	1.240
1	1.490	.121	1.37
2	1.638	134	1.50
3	1.797	15	1.65
4	1.965	16	1.80
5	2.144	18	1.96
6	2.333	20	2.13
7	2.533	23	2.30
8	2.744	25	2.49
9	2.966	28	2.68
40	3.200	33	2.875

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1877phae.proj.1147P

0	100.00	.00	62.50	-6	62.44	32.50	33
1	98.75	.03		-3	61.22	3.4.46	34
2	97.5	6.	60.00	+1	60.01	37.04	36
3		8		5	58.80	39.75	37
4	95.0	10	57.50	9	57.59	42.59	39
5		12		14	56.39	45.56	41
6	92.5	15	55.00	20	55.20	48.67	42
7		17	75	26	54.01	51.91	44
8	90.0	19	52.50	32	52.82	55.30	45
9		20	25	39	51.64	58.82	46
10	87.5	-.215	50.00	+47.6	50.47	62.50	48
1		23	48.75		48.2	66.33	47
2	85.0	24	47.50		48.1	70.30	47
3		25	6 25		46.9	74.44	47
4	82.5	26	45.00		45.8	78.73	47
5		26	43.75		44.7	83.19	47
6	80.0	27	42.50	1.1	43.6	87.81	47
7		27	41 25	1.2	42.4	92.59	46
8	77.5	28	40.00	1.3	41.3	97.55	45
9		28	3875	1.4	40.1	102.7	44
20	75.0	-.278	37.50	1.62	39.12	10.8	+41
1		27	3625	1.8 1.8	38.0		
2	72.5	26	35.00	2.0 1.9	37.0	36.9	
3		25	3375	2.2 2.1	35.9	35.8	
4	70.0	23	32.50	2.5 2.3	35.0	34.8	
5		22	31 25	2.7 2.5	33.9	33.7	
6	67.5	19	30.00	3.0 2.8	33.0	32.7	
7		16	2875	3.2 2.9	31.9	31.6	
8	65.0	14	27.50	3.5 3.1	31.0	0.6	
9		10	26 25	3.8 3.3	30.0	0.5	

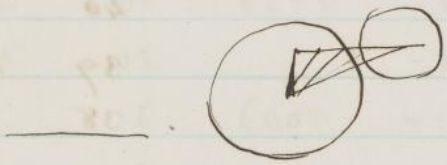
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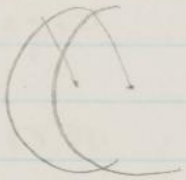
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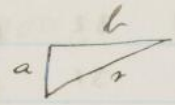
2.87	y			40	.88	39.1
3.10	5	5.785		39	1.0	38.0
3.34	6	10.39		38	1.0	37.0
3.60	7	17.536		37	1.1	35.9
3.87	8	28.572		36	1.1	34.9
4.12				35	1.2	33.8
4.45				34	1.3	32.7
4.75				33	1.3	31.7
5.08	$\frac{x}{4}$	50476	+.476	32	1.4	30.6
5.42	5	39.118	-.882	31	1.4	29.6
5.78	6	28.572	-1.428	30	1.43	28.6
6.16	7	18.833	-1.167	9	1.4	27.6
6.56	8	10.39	+.39	8	1.4	26.6
6.97				7	1.4	25.6
7.40	-24	.35		6	1.4	
7.85	124	121		5	1.4	
8.31	1.40	1.40		4	1.3	
8.80	.48	.58		3	1.3	
9.30				2	1.3	
9.83				1	1.2	
10.39				20	1.17	
		.25		9	1.0	
		-.5		8	1.0	
		.67		7	.9	
		-1.00		6	.7	
		1.5		5	.6	
		-2.0		4	.4	
		4.0		3	.2	
		-∞		2	0	
				1	.2	
					.39	

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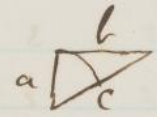
Log r — r^2

Log a — b^2

Log $\frac{a}{r} = \sin v$ — $r^2 - b^2$

Log $\frac{b}{r} = \cos v$ — $b = \sqrt{r^2 - b^2}$

a r



a constr.

b given

c to find

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Computation of Sec. for given Coy.

Coy	Sec.
0.0	1.000
.1	1.005
.2	1.020
.3	1.044
.4	1.077
.5	1.118
.6	1.166
.7	1.221
.8	1281
.9	1345
1.0	1414
1.2	1562
1.4	1720
1.5	1803
1.6	1887
1.8	2059
2.0	2236
2.5	2693
3.0	3.162
3.5	3.640
4.0	4.123
4.5	4.610
5.0	5.099
6.0	6.083
7.0	7.071
8.0	8.062
9.0	9.055
10.0	10.050
20.0	20.025

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1877phae.proj.11367P

$\alpha = f(R\alpha$



$R = 2$

y ~~α~~ 2 ~~α~~ x $\frac{x}{2}$

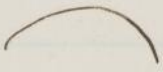
0 .5 1.0 1.5

$R = 1, 2, .5, 1.5, .67, 4, 25, \infty$

.25 .5 .67 1 1.5 2 4 ∞

$R = \infty \quad y^2 = 2Rx - x^2 = 2Rx$

R								
.25	.25	.50	.75	1.00	1.25			
.5	.5		1.0		1.5			
.67								
1.00	0	.5	1.0	1.5	2.0			4.
1.50	0	.5	1.0	1.5	2.0	2.5		5.
2.00	0	.5	1.0	1.5	2.0	2.5	3.0	6.
4.	0	1.0	2.0	3.0	4.0		.5	5
∞	0	.5	1.0	1.5	2.0			4.





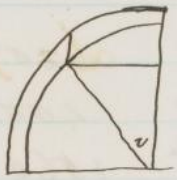
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1877phae.proj.0137P

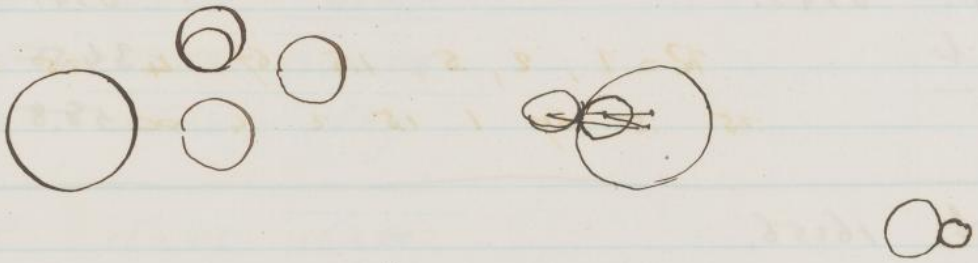
Absorption of Solar Atmosphere.

$I = a^{\sec v}$

$y = a \sin v$



$I = m + a^{\sec v}$



light red. 6 0 1. 1.5 2. ∞

.25
.50
.75 .5 .67

time disc = time dis'g
" equd. -- "
less disc = 2 eq disc

R	Max time dis. or equd	
.25	.5 : 1.5	3.0
.50	1.0 : 1.0	1.0
.67	1.33 : .67	.5
1.00	2.0 : 0	.0
1.5	2. : 1	.5
2.0	2. : 2	1.0
4.0	2. : 6	3.0
∞	2. : ∞	∞

$(1+R)^2 - D^2 = n^2\left((1-R)^2 - D^2\right)$

$1 + 2R + R^2 - D^2 = n^2 - 2Rn^2 + R^2n^2 - n^2D^2$

$D^2 = \dfrac{(1+R)^2 - n^2(1-R)^2}{1-n^2}$

~~2 3~~

$n = 2$

$D^2 = \frac{1}{3}\left(1 + 2R + R^2 - 4 + 8R - 4R^2\right) = \frac{1}{3}\left(-3 + 10R - 3R^2\right) = -1 + R + 3.33R$

$D^2 = \frac{1}{4}\left(1 + 2R + R^2 - 9 + 18R - 9R^2\right) = \frac{1}{4}\left(-8 + 8R^2 - 20R\right)$

$(1-R)^2 - .5R$

$D^2 = (1-R)^2 - \frac{4}{5}R \qquad D^2 = (1-R)^2 - \frac{1}{2}R$

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Computation of x when I = .25 .50 .75

x	20.0	40.0	60.0	80.0	100.0	120.0
x^2	4000.	1600.0	3600.0	6400.0	10000.	14400.
$b=39.5$ b^2	1560.25	1560	1560	1560	1560	1560
x^2-b^2		40.	1040	4840.	8440	12840
$\sqrt{}$		6.3	10.2	69.6	91.87	113.3
$b=80.9$ b^2	6545.				6545	6545
x^2-b^2					3455	7855
$\sqrt{}$					58.8	88.6
$b=127.5$ b^2	16256.					16256
x^2-b^2						~~44~~
$\sqrt{}$						

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R = 1

140.0	160.0	180.0	200.0
19600	25600	32400	40000
1560	1560	1560	1560
18040	24040	30840	38440
134.3	155.0	175.6	196.1
6545	6545	6545	6545
13055	19055	25855	33455
114.3	138.0	160.8	182.9
16256	16256	16256	16256
3344	9344	16144	23744
57.8	96.7	127.1	154.1

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When value of b is of no consequence.

698970

$$\begin{array}{r} 20.75 \\ 5.6 \\ \hline 15.15\,/\,2 \\ \hline 303 \end{array}$$

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Deter. val. a from Lehmstedt cont. chart.

1.253	= 23.4 a + b	
1.035	17.3	
1.094	16.7	
.978	12.8	
.923	10.9	
.948	9.1	
.925	7.8	
.820	3.5	
.667	0.9	
8.643	= 102.4 a + 9 b	
1.317	20.75	+ b
9.960	123.15	+ 10 b

23×12 =	2.9.32	547.6 a + 23.4 b
	1.7.905	299.29 17.3
	1.8.270	278.89 16.7
	1.2.518	163.84 12.8
	1.0.061	118.81 10.9
	.8.627	82.81 9.1
	.7.215	60.84 7.8
	.2.870	12.25 3.5
	.0.600	~~13.85~~ 0.9
10.7.390		1565.14 a 102.4 b
	2.7.32	430.56 20.7
	~~7.0053a~~	1995.70 123.1

13.4.71
y = Wolff
x = Schm.

y = .0225 x + .704 excluding B Bellaï
y = .0315 x + .608 including " "

8.643 = 102.4a + 9b
~~+1.013 = 1995.70a + 123.1b~~
.960 = 11.38a + b
10.7.39 = 1565.14a + 102.4 b
98.40 = 1166.4 a + 102.4 b
~~87.66 = 398.7a~~
~~99.93 = 400a~~
~~a = .2198~~
~~b = .960 + 1.364 = 2.324~~

a = +.02
b = +.7

8.99 1/3 = 398.7 a
9.02 = 400 a
a = .0225
b = +.960 − .256 = .704

a = .0225
b = .704
y = .0225 x + .704
y = Wolff's value
x = Lehmstedt's value
excluding B Bellaï
.996 = 12.315a + b
13.4.71
~~11.0132~~ = 1995.70 + 123.1 b
122.7 = 1616.5 a + 123.1 b
12.0 = 379.2a
a = .0315
b = .996 − .3879
b = .608

1137 / 2/2 / 2274 / 250 14 / 1137 / 13644
1138 / 225 / 5690 / 2276 / 2276 / 256050
12315 / .0315 / 6157 / 12315 / 36945 / 5879722
36945 / 12315 / 615 / 387911

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$\begin{array}{r} 468.00 \\ 465.75 \\ \hline 13.75 \\ 466.875 \end{array}$





$466.9 \quad (1+R)^2 - D^2 = n^2\left[(1-R)^2 - D^2\right]$

$$D^2 = \frac{n^2(1-R)^2 - (1+R)^2}{n^2 - 1}$$



$\frac{1}{.5}$

lim disc = tang disp. $n = 3$

$$D^2 = 9 - 18R + 9R^2 - 1 - 2R - R^2 = 8 - 20R + 8R^2$$

$$D^2 = (1-R)^2 - \tfrac{1}{2}R$$

lim disc = $\frac{1}{2}$ disp $n = 2$



$$3D^2 = 4 - 8R + 4R^2 - 1 - 2R - R^2$$

$$3 - 10R + 3R^2 = 3(1-R)^2 - 4R$$

$$D^2 = (1-R)^2 - \tfrac{4}{3}R$$

R	1.5	2.0	4.0
$(1-R)^2$	.25	1.0	9.0
$D^2 =$	-.50	0	7.0
$D^2 =$	~~1.08~~	—	—

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Reduction of Schm. by Wolff. & Intend.

x	y
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	
20,75	
21	

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Sch Grad.	Sh. x0225	.4669-38.025	Cila Light
20.7	465.75	.9988	99.7
20.2	454.50	.9876	97.2
19.6	441.00	.9751	94.4
18.7	420.75	.9538	89.9
17.4	391.50	.9246	84.1
15.3	344.25	.8773	75.4
12.1	272.25	.8053	63.9
8.5	191.25	.7243	53.0
6.3	141.75	.6748	47.3
(5.6	126.00	.6591	45.61
6.2	139.50	.6726	47.1
7.6	171.00	.7041	50.6
9.8	220.50	.7536	56.7
13.2	297.00	.8301	67.6
15.8	355.50	.8886	77.4
17.7	398.25	.9313	85.4
19.2	432.00	.9651	92.3
20.2	454.50	.9876	97.2
20.8	468.00	1.0011	100.3

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Cooper Reduct. Sch. grad. de of Algol & Cabel of 4614.

Mins	Sch. 20.8	Wolff 9.218	Log.	Light
-4.5	20.70	.212	.998	99.5
4	20.24	.204	.990	97.7
	19.59	.182	.968	92.9
3	18.68	.160	.946	88.3
	17.35	.122	.908	80.9
2	15.28	.072	.858	72.1
	12.05	.000	.786	61.1
1	8.48	.913	.699	.500
	6.26	.888	.674	47.2
0	5.56	.868	.654	45.1
	6.20	.884	.670	46.8
1	7.60	.919	.705	50.7
	9.81	.960	.746	55.7
2	13.17	.023	.809	64.4
	15.78	.083	.869	74.0
3	17.71	.132	.918	82.8
	19.19	.173	.959	91.0
4	20.23	.204	.990	97.7
4.5	20.75	.213	.999	99.8
4.35	20.8	9.218	000	

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	dec	mc	d -	Mean.		vellin	Dist Cents.
	100.0			100.0	∞	108	~~992~~ ∞
4.5	99.5	99.8	-.3	99.6 -	10	109.	9.91
4	97.7	97.7	.0	97.7	4	111.5	3.885
	92.9	91.0	+1.9	92.0	2	116.	1.84.
3	88.3	82.8	+5.5	85.5 -	1.5	120.	1.30
	80.9	74.0	+6.9	77.4	1.25	122.5	1.025
2	72.1	64.4	+7.7	68.2	1.1	125.5	.845
	61.1	55.7	+5.4	58.4 -	1.0	128.	.62
1	50.0	50.7	-.7	50.3	.9	132.5	.575
	47.2	46.8	+.4	47.0	.8	140.	.40
0	45.1			45.1 -	.75	146.	.29
					.744	148.	~~.264~~ .2964

~~54.9 74.1~~
~~74.1 - 67.1 = 6.7+~~ ∴ Dark body must be greater than .741 ~~.670~~

Min. Dist. for 4444 Dist Cents 437.5 45.

R				
∞	1.076	1.090	∞	1.100
2	1.159	1.172		1.182
1.5	.196	1.206		1.220
1.		1.290		1.300
.75		1.494		1.504
.666				

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4 30	20.70	9.213	.999	99.8
3.45	19.94	9.195	.981	95.7
3.00	18.68	9.158	.944	87.9
2.25	16.45	9.101	.887	77.1
1.30	12.05	8.990	.774	59.4
.45	7.15 ~~18.13~~	8.906	.692	49.2
0	5.56	~~8.886~~	~~.648~~	~~45.1~~
45	6.83	8.900	.686	48.5
1.30	9.81	8.952	.738	54.7
2 15	14.60	9.~~06~~ 50	.~~936~~	68.9
3	17.71	9.132	.918	82.8
3 45	19.76	9.190	.976	94.6
4 30	20.75	9.216	1.002	100.0

	Obs.	Calc.	O-C	
4 30	99.8	100.0	+.2	99.9
3 45	95.7	94.6	-1.1	95.1
3 00	87.9	82.8	-5.1	85.3
2 15	77.1	68.9	-8.2	73.0
1 30	59.4	54.7	-4.7	57.0
45	49.2	48.5	-.7	48.8
0	45.1			45.1

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Abstract of Argelander's Variable Stars.

317 Introduction by Dreckmeyer - undertaken for 30 years. Manner has abridged. give data and methods and reference to older determinations Either give light-curves in his own figures or the mean and min. deduced from them as desirable. Besides only give comparison stars with their brightness and most elaborate part of his work. Does not mention to print as this is completed. Eth can to keep eye clear of light even moonlight. Bonn in Apr. May 1843. Koenigsberg July. Aug. 1853 have been noted only to diff of latitude.

318 Began observing with naked eye but found eye fatigued by it. Proper way of accomplishing this was by Argelander then never he used both eyes. For very faint stars or dusky moonlight used opera glass very rarely. At first marked C.G. afterwards dropped since he always used. Does not often change both glass, probably as early as 1846. This is confirmed by second table a 6 degree which proved that he thought 10 degrees years ago. Further confirmation in this star in Aurig Bonn in which he did not use 6 degree and probably added a note that the star was double. Until has naked eye he was unable to divide this star. As not mentioned probably C.G. was used at that time. A change in his estimation may have resulted in comparing stars of very diff. color but even then he could not see little with opera glass that he could before without. A attempt to determine this point through the gradation of diff stars give no results

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lines being measured entirely each other.
The relative mag. of the Capteyn stars used with
β Cygni remained fixed for twenty years and
it was the same with γ Cassiopeiæ and ε Cephei.
ε on the other hand & Cephei and ξ Cephei
there was a change of a whole grade. ε and
ξ are both of them reddish, and γ B. white
But reddening would amount of one grade it
is not remarkable that this change should take
place. Besides this the diff. is 5 grades, and
in many cases the variable did differ by three
or four grades from one of the stars. An example
of this is found in Lalande Equinox 6 the variable
5, which diff. although all its colors made 6½
gradually rose from 5 to 6.5 while no such
change took place in the case of stars which
were near each other in brightness. In the case
of stars invisible to naked eye he used a 24"
Cassegrain reflector of usual construction. This he has
always marked C.S. He used this same either
for stars never or seldom seen with naked eye.
In observing min of S Cancri after having seeking
of this star he used 5' transit or 8' heliometer.
The times are (with single exception of Berlin
observations) Dun mean time, including Bonn.
They are given to tenths of hours. The noted time
at beginning of observation and at end of a series
related uniformly. With β Ursæ and S Cancri
he observed the nearest minute exclusively &

319

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clock time and gives in addition the clock error. In rifle case Bonn time is given direct.

The method of making extinct (see Schumacher Jahrbuch 1846, two treatises a β Lyrae) also for unit of measurement also for precautions and degree of accuracy. Not to repeat too much he refers to these treatises and added as follows. He began by carefully observing with his predecessors. By taking stars & use only a few expeditions and giving each a different value. In order to make work more accurate he followed Hirsch's precept after Nov. 1840 and in using lights which are explained in Astron. Nach. 18 113 (1841.6). After that he added those methods & units previously used, it thus appeared that he had not been as accurate as he had hitherto still he holds that he made the change without sufficient reason. As the sign and & decimal change it actually doubled & his & reflex change by mistake. This change took place March 8th 1842 and was only an extract on the results previously deriving real quantities. Since this time he has used this system without change. In this work he has not introduced the figures exclusively but has considered it necessary & explain as above. This does and almost entirely by kindly a few can give of his pupils that names by mentioned above it arises.

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4075 The word good before a magnitude denotes that it is two tenths brighter eg. just good 8 means 7.8 and bull bright one tenth. Vacuum one tenth pointed and otherwise two tenths pointed. The letters a and b in the text. If two stars are of equal brightness, the two letters are simply written after each other and it is immaterial which is written first, but if one as a is one grades brighter than b this is indicated by a > b. The Bess of the compared as variable with two by estimating the difference of its relative difference from both. In this case both stars are put in parentheses, the brighter generally first, and according as the third is nearer to the brighter or the pointed is brightness it is placed either before or after the parentheses as the case may be with the number between. When two asterisks are separated by a straight line, it shows that there was uncertain which asterisk was well compared.

a b denotes that a and b are equally bright
a 2.5 b that a is 2.5 grades brighter than b.
a 2.5-3 b that a is 2.5 to 3.0 " " "
a > 2 (b c) that a is more than 2 grades brighter than b by 2 grades than it is to the pointed are c. and consequently are grade brighter than the mean between b and c
a + > b indicates that a is at least 5 grades generally more than brighter than b, consequently this is an indefinite expression. When there is no accurate determination

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of the difference but—merely a recognition that a is brighter or fainter than b this is expressed by the sign of inequality briefly $a > b$ or $a < b$

408 Sometimes a letter will be found with one figure after it as two with a Betarabet by a dash with two Roman letter after it. This is a comparison with the sky and shows that a star so many grades fainter could have been seen. a 2–3 hence denotes that star 2 or 3 grades fainter than a might still have been seen. and therefore the variable star had not as yet reached a by two or three grades.

For a time the observations were not made by the ordinary Mercy Comet seeker but—with a Fraunhofer Comet-finder of 27" height and 27 lines aperture. This inst. gives sharper images than the Mercy one, but—does not—give as much light.

Both observers stars of equal brightness so that no distinction has been made in ordering the observations. Tevall has made a correction to his obs remarks about—I says that he did not see it double. This must have been with his spectacles, and in twilight as the observation is the last difficult, so that—this observation does not—destroy the argument of the time comming the use of the spies glass. for an hour later he could not—see the star double

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Table II Continued from p. 119.

	∞	10:	4.	2.	1.5	1.25	1.1	1.0
0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
10	98.1	98.2	98.3	98.4	98.5	98.5	98.6	98.6
20	94.8	95.0	95.3	95.7	96.0	96.1	96.2	96.3
30	90.6	91.0	91.5	92.2	92.6	92.8	93.0	93.1
40	85.7	86.3	86.9	87.9	88.5	88.8	89.3	89.6
50	80.4	81.0	81.9	83.3	84.2	84.8	85.2	85.5
60	74.7	75.5	76.6	78.4	79.6	80.4	80.9	81.2
70	68.8	69.7	71.0	73.0	74.2	75.2	75.9	76.4
80	62.6	63.6	65.0	67.4	68.9	70.0	70.8	71.4
90	56.3	57.4	59.0	61.4	63.0	64.4	65.4	66.3
100	50.0	51.0	52.5	55.3	57.0	58.6	59.7	60.9
110	43.7	44.4	45.4	48.8	51.0	52.8	54.0	55.3
120	37.4	38.1	39.4	42.5	44.9	46.7	48.2	49.5
130	31.2	31.9	33.3	36.4	38.7	40.7	42.3	43.6
140	25.3	25.9	27.2	30.1	32.4	34.4	36.1	37.6
150	19.6	20.0	21.1	23.6	26.0	28.1	30.0	31.5
160	14.3	14.7	15.6	17.7	19.7	21.8	23.6	25.3
170	9.4	9.6	10.1	11.8	13.5	15.6	17.2	19.0
180	5.2	5.3	5.6	6.7	7.7	9.2	10.8	12.7
190	1.9	2.0	2.1	2.5	2.9	3.9	4.9	6.4
200	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

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1.25	1.1
100.0	
98.6	98.7
96.0	96.1
92.7	92.9
88.8	89.3
84.6	85.2
80.1	80.6
74.9	75.7
69.6	70.5
64.2	65.2
58.3	59.6
52.3	53.7
46.1	47.6
40.0	41.7
34.1	35.7
27.6	29.6
20.9	22.9
14.8	17.0
8.8	10.2
3.3	4.4
00	

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0.0	
+.1	+.1
-1.	-1
-1	-1
0	0
-2	0
-3	-3
-3	-3
-4	-3
-2	-2
-3	-1
-5	3
-6	6
-7	6
-3	4
-5	4
-9	7
-8	2
-4	2
-6	6
0	5
73	59
.36	.3

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Ratio of Radii	.745	1.0	2.0
" " Volumes	.413	1.0	8.0
Radius Orbit	4.33	5.1	
Ceres " Mds.	186,0000	219.0000	
Ceres "	11,69.0,0000	13,76,0000	
per hour.	167,000	197.000	
" min.	2,500		
Ceres = 247734	46.8	55.	

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Sun & Sirius Wollaston. (Phil Trans 1829, 27) 20,000,000,000.
" " " Bond 6,000,000,000
" " a Lyrae Lockyer 10.
" " a Bootis Steinheil

See Herschel Outlines 478.

Cly Lirius 20,000,000,000
β Bootis. = 40 × Lirius 800,000,000,000

$\frac{\beta \text{ Bootis}}{\text{Sun}} = \frac{1}{900,000} \times 1800'' \quad .002''$

If β Bootis = Sun its paral. would be .24"

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Schumpfel Comparede.

Phot			R.A. h m	Dec °	S	W	h	A	H.	Dm.
3 3.6	κ									
2 4.05	γ	Pleiadi	0.9	3 37	42		3.33	4	4	4.1
1 3.2	α	Tri.	3.5	1 46	29	3.67	2.95	4.3	4.3	3.3
3 3.1	δ	Pleiadi	7.8	3 34	47	3.15	2.69	3.77	3	0.4	2.5
1 3.0	β	Triangoli	9.1	2 2	34	3.21	2.63	3.76	3	3	3.0
1 3.1	γ	Pleiadi	10.9	2 56	53	3.25	2.69	3.74	3	3	3.2
3 3.10	ε	Pleiadi	12.8	3 ~~59~~	40	3.00	2.56	~~3.05~~ 3.67	3.4	3.4	3.2
1 2.8	β	Aristi	16.7	1 48	20	2.76	2.26	3.50	3	3	2.5
	ζ	Aurigae	17.3	4 47	33	3.26	2.91	3.70	3	3	3.0
3 2.00	γ	Andromedae	23.4	1 57	42	2.41	1.87	2.91	2.3	2.3	2.0
3 2.70	δ	Cass									
6 2.05	β	Pleiadi									
1 3.3	ρ	"									
3 3.1											

3.03

$+30 = .9a + b$ $\quad +27.0 = .81a + .9b$

$+71 = 3.5a + b$ $\quad +248.5 = 12.25$

$+100 = 7.8a + b$ $\quad +780.0 = 60.84$

$+59 = 9.1a + b$ $\quad +536.9 = 82.81$

$-16 = 10.9a + b$ $\quad -174.4 = 118.81$

$+5 = 12.8a + b$ $\quad +64.0 = 163.84$

$-5 = 16.7a + b$ $\quad -83.5 = 278.89$

$-53 = 17.3a + b$ $\quad -916.9 = 299.29$

$-56 = 23.4a + b$ $\quad -1310.4 = 547.56$

$+265 \quad 102.4$
-130

$+135 = 102.4a + 9b$ $\quad +16564 - 2485.2 = 1665.10 + 102.4b$

$+15 = 11.38a + b$ $\quad -828.8 = 1665.10a + 102.4b$

$-8.094 = 16.26a + b$

$11.38a - 15 = 16.26a + 8.094$ $\quad 15 = -53.8 + b$ $\quad b = +68.8$

$4.88a = 6.906$ $\quad a = 1.41$ $\quad b = -105$ $\quad -8.1 = -76.9 + b$ $\quad b = +68.8$
-23.094

$a = -4.73$ $\quad b = +68.8$

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S	W	R	$\frac{S+W}{2}$ (8.50+3 yr.)	W−S	W−R	O−C
	8.6			89		+.030
8.531	8.9			~~89~~		+.071
8.741	8.			85	78	+.100
8.716	8.			32	98	+.059
8.699	8	15.24	.381	24	71	−.016
8.880	8	14.57	.364	78	108	+.005
8.897	9	12.76	.319	97	182	−.005
8.697	9	~~9.87~~ 9.63	.247	88		−.053
9.038	9	6.58	.164	15	141	−.056
				5.8		
				~~20~~		
351		4.74	.118			−31.4
667		2.60	.0.065			+660
664						+538.2
622		1.41	0.036			+309.4
778		.56	0.014			−337.9
991						− 12.4
732		.08	.0.002			+133.6
291		.00	.0.000			− 228
						− 210
						Σ +1047.2
						−1215.6

l_9 = 8.

= 8.9

may

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S	W	R	$\frac{S+W}{2}$	(8.50 + 3 gr.)	W − S	W − R	C − C
	8.667		8.557	8.527	289		+.030
8.531	8.820		8.676	8.605	~~+ 89~~		+.071
8.741	8.926	8.848	8.834	8.734	185	78	+.100
8.716	8.948	8.850	8.832	8.773	232	98	+.059
8.699	8.923	8.852	8.811	8.827	224	71	−.016
8.800	8.978	8.870	8.889	8.884	178	108	+.005
8.897	9.094	8.912	8.996	9.001	197	182	−.005
8.697	9.035	8.864	8.866	9.019	338		−.053
9.038	9.253	9.072	9.146	9.202	215	181	−.056
					1758		
					~~220~~		

351	670 20	.022	8.592	−36		−31.4
667		.088	8.658	+18		+66.0
664		.195	8.765	+69		+538.2
622		.228	8.798	+34		+309.4
778		.272	8.842	−31		−337.9
991		.320	8.890	−1		−12.4
732		.418	8.988	+8		+133.6
291		.432	9.002	−36		−622.8
		.585	9.155	−09		−210.6
				+129		+1047.2
				−112		−1215.6
				241		
				±.027		
				±07 mag		

$l_y = 8.50 + .03g - .00473g + .0688$

$= 8.569 \pm .025g$

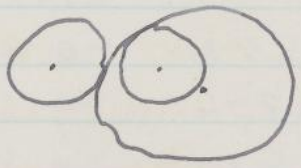
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Difficulties of Case of Annular Eclipse

$r = .764$ $\Delta = .416$

$r^2 = .5837$



$w = 23°.0$ $1.764^2 = a^2 .1526 + b^2 .8474$

$w = 1°.0$ $0.236^2 = a^2 .1526 + b^2 .8474$

$3.1117 = a^2 .1526 + b^2 .8474$

$.0557 = a^2 .0003 + b^2 .9997$

$a^2 = 20.070$

056

$a^2 - b^2 = 20.014$

$r = .764$ $.416$

$b = .236$ $.584$ $\log b$ 9.3729 $\log$ 1.3013

$1.764^2 = a^2 .1526 + .0557 \times .8474$

3.1117

$\log \cos w$ 9.9640 a^2 20.088

$\cos^2 w$ 9.9280 b^2 ~~0.00~~

$\log b^2$ ~~8.7457~~ $(a^2 - b^2)$ 20.038

8.6738 .0472 $\log (a^2 - b^2)$ 1.3018

Annular

$a^2 .1526$ 3.1117 $.0472$ 3.0645

0.4864

9.1838

$\log a^2$ 1.3026

$\log a$ .6513

a 4.480

$.006 = b^2 .0017 + .0003 a^2$

$.0557 = .0062 - b^2 .0017 + b^2 .2997$

$\frac{.0495}{1} = b^2 .9980$

$b^2 = .0496$

$b = .2227$

$b = .2227$

8.6955

9.9280

8.6235

3.1117

$.0472$

3.0697

$\log = 0.4864$

9.1838

1.3030

$.6515$

$.4482$

$a = 4.482$

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								9454
$\cos^2 w$	9.9992	0.9966	9926	9888	.9796	9694	9584	~~.9427~~
$\log c^2 - b^2 = 1.3013$								
$(a^2-b^2)\cos^2 w$	1.3005	.2979	2939	2881	2809	.2707	.2597	2467
	19.9786	19.8556	19.674	19.413	19.094	18.651	18.185	17.658
20.070								
	~~.09~~	~~.21~~	.40	.66	~~.98~~	1.42	~~1.89~~ 1.884	~~2.42~~
D^2	.094	.214	.396	.657	.976	1.419	1.885	2.422
D	.307	.463	.629	.8~~1~~8	.988	1.191	1.373	1.556
.4163								
$1-R^2+D^2$	.570	.630	.812	1.073	1.392	1.835	2.301	2.838
$\log 1-R^2+D^2$	9.7076	.7993	.9096	.0306	.1436	.2636	.3619	4532
$\log^2 D$	.7882	.9666	.0997	.2101	.2958	.3769	.4387	.4930
$\log \cos \alpha$	.9194	.8327	.8099	.8205	.8478	.8867	.9232	.9602
$\log D$	.831	.680	.645	.661	.764	.770	.838	.912
	.169	320	.355	.339	.296	.230	.162	.088
$D - \log$	~~-.527~~	~~-.217~~	-.016	+.160	.284	.421	.535	.644
$\div .764$	.686	.284	.021	.196	.372	.551	.700	843
$1-$	.314	.716	.979	.804	.628	.449	300	.157
Anom D	.316	1.010	1.529	1.181	.844	.527	.295	.115
Anom .584	.1~~8~~5	.590	.893	.690	.493	.308	.172	.067
	.127	.324	.377	.353	.290	.201	.120	.032
	1.642	1.247	1.524	1.043 .337	.783 .259	509 .162	293 .093	.099 .032
	1.779 .566	1.571 .500	1.921 .611					1.2~~9~~5
1.3018								
$(a^2-b^2)\cos^2 w$	1.3010	1.2984	1.2944	1.2886	1.2814	1.2712	1.2602	1.2~~4~~65
	19.999							
	~~20.006~~	19.879	19.697	19.436	19.116	18.672	18.205	17.669
20.098								
	.09	.21	.39	.65	.97	1.42	1.88	2.42
D^2	.089	.209	.391	.652	.972	1.416	1.883	2.419
D	~~.798~~	.457	.625	.807	.986	1.190	1.372	1.553
.4138								
$1-R^2+D^2$	.505	.625	.807	1.068	1.388	1.832	2.299	2.835
$\log$	.7033	.7959	.9069	.0286	.1424	.2629	.3615	4526
	.7752	.9609	.0969	.2079	.2949	.3766	.4384	.4928
	.9281	.8350	.8100	.8207	.8475	.8863	.9231	.9598
	.847	.684	.646	.662	.704	.770	.838	.912
	153	316	354	338	296	230	162	.088
	-.549	-.227	-021	+.145	.282	.420	.534	.643
	.719	.297	.028	.190	.369	.530	.699	.842
	281	703	.972	.810	631	450	301	.158
	.269	.986	1.515	1.193	.850	.529	297	.116
Anom .584	.157	.576	.885	.696	.496	.309	.173	.068
$\cdot \log A$	.110	.318	.375	.367	.290	.201	.120	.032
	1680	1.261	.952	1047 .333	.786 .250	570 .162	293 .093	.101 .032
	1.790	1.579	1.327					
	.570	.603	.427					

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$a - (a-b)\cos^2\omega$ $\quad r = 7.30 - 7.43\cos^2\omega$

	9.999²	9966	9926	9868	9796	9694	9584	9454
$\log(a-b)$	0.8702	.8676	.8636	.8578	.8506	.8404	.8294	0.8164
	7.416	7.372	7.305	7.208	7.089	6.925	6.752	6.552
	−.116	−.072	−.005	+.092	+.211	+.375	+.548	+.748
	.884	.928	.995	908	.789	.625	452	.252
	1.340	1.427	1.561	1.387	1.152	.839	.632	.229
	.427	.454	.497	.441	.367	.267	169	.073
				559	633	.733	831	.927

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1977phac.proj..115T



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