

XII. *On the Apparent Projection of Stars upon the Moon's Disk in Occultations.* By G. B. AIRY, Esq., Astronomer Royal.

Read April 8, 1859.

A COMMUNICATION which arrives at no definite result will not, I trust, be on that account the less acceptable to the Society. Those who have ever tried to discover the causes of a perplexing phenomenon know well that the only way of proceeding with any reasonable hope of success is, to try one explanation after another, as circumstances suggest to the mind their possible applicability; and they know, also, that, next to the satisfaction of discovering a cause which really will explain the phenomenon, is the satisfaction of finding that a conjectured cause will certainly not explain the phenomenon, and may be at once dismissed from the thoughts. Such is my position in regard to the investigation of the present paper. At the same time I must add that the examination of the expressions used by different observers in reference to the phenomenon of which I am treating has suggested to me a new explanation, in the competency of which I have great confidence, but which, from its nature, does not permit investigation of a mathematical or severely accurate character.

The attention of astronomers and of this Society has sometimes been called to the curious phenomenon of the apparent projection of a star on the moon's disk in occultations. It is established by abundant evidence that when the moon's limb is approaching a star, it sometimes (but not always) appears to go at first behind the star, so as distinctly to offer the appearance which would be presented if the star were on this side of the moon; this appearance lasts only one or two seconds of time (perhaps more if the relative path is much inclined to the limb at the point of contact), and then the star, while thus seen on the moon's face, disappears suddenly. Numerous notices of this phenomenon are to be found in scattered observations; the largest collection, in fact the only express assemblage of

notices on projection with which I am acquainted, is in a paper by Sir JAMES SOUTH, in an early volume (the third) of this Society's *Memoirs*.

Nearly thirty years ago I saw the phenomenon of projection myself, in great perfection. The singularity of the appearance made a strong impression on my mind, and has induced me frequently to consider the possibility of explaining it on recognised optical principles. The only remark which appeared to lead towards a conjectural explanation was one by Sir JAMES SOUTH, that in many instances a red star was the subject of projection. It seemed then not impossible that, if the light of the moon and the light of the star differed materially in refrangibility, the rays of the star (supposed the less refrangible), though actually touching the moon's body at the instant of occultation, might be so much less bent than the rays of the moon by the action of the earth's atmosphere, that at that instant the star would actually be seen lower than the moon's limb. If, then, the occultation took place at the moon's upper limb, there would be projection of the star on the moon's disk; if it took place at the lower limb, the star would disappear at a small distance external to the limb; if the rays of the star were more refrangible than those of the moon, these appearances would be reversed. Here, then, was indicated a distinct criterion upon which the fate of the hypothesis must depend. It became necessary only to ascertain whether, in the instances of recorded projection, the star was uniformly higher or uniformly lower, as referred to the zenith of the place of observation, than the moon's centre. If either of these laws held uniformly, the hypothesis would be plausible; if neither law was sufficiently maintained, the hypothesis would be certainly false.

The arrangement of the observations with reference to this criterion involved considerable trouble and a large quantity of calculation, especially for the occultations which were observed before the "Angles of Position" were computed in the *Astronomical Ephemerides*. For these it was necessary to compute the moon's zenith distance, and to correct it for parallax, and also to compute the star's zenith distance, both with considerable approximation. The contemplation of the amount of labour and time which this operation would require has long deterred me from undertaking the work. From this difficulty I have, however, been delivered by the zeal of my excellent assistant, Mr. ELLIS. At my request, Mr. ELLIS has undertaken to examine into all the records of occultations accessible to him in

which there was notice either of projection or of non-projection, to calculate the difference between the altitude of the star and that of the moon's centre, and to present the results in a form bearing at once on the object of the present inquiry. Astronomers, I am confident, will be grateful to Mr. ELLIS for this employment of his industry and ability in removing one of the obscurities of a difficult subject.

In examining the results, as prepared for me by Mr. ELLIS, I was very much struck with the frequency of one class of remarks, which it was difficult to place under the head either of "projection" or of "non-projection;" namely, those which describe the star as "adhering to the limb," "hanging to the limb," &c. I decided, at length, upon placing these in a separate class. In the view which I shall, at the end of this communication, place before the Society, it will be seen that I consider the two classes of phenomena (projection and adherence) to be most intimately connected.

I shall now give some general explanations on the formation of the following tables:—

The works which have been consulted are,—

- The Observations of Greenwich, Cambridge, Paris, and Madras;
- The Notices and Memoirs of the Royal Astronomical Society, including (with others) Sir JAMES SOUTH's paper in the third volume, and the works to which it refers;
- The Astronomische Nachrichten;
- The Astronomical Journal.

All observations are included in which there is notice either of projection or of non-projection.

A few instances of "hanging" or "adherence" have been omitted, when it appeared that the duration of the occultation was very small, and the apparent approach of the star nearly parallel to the moon's limb.

Separate calculations have been made for the height of the star above the moon's centre in all instances where the distance between the places of observation exceeds ten miles, excepting that Cambridge, Biggleswade, and Bedford, are included in the same calculation.

The observations are arranged under four heads, thus distinguished:—

Class A. Where there is distinct record of observed projection.

Class B. Where there is record of hanging on the limb, in a form which negatives projection.

Class C. Where there is distinct record of no projection or hanging.

Class D. Where the accounts at the same place or in the same vicinity are contradictory; some being of the Class A or B, while others are of the Class C. When there are records of the same observation which belong to the Classes A and B, without C, they are placed under A and B, and not under D.

As many of the observers' remarks are repeated in the same or equivalent words, I have thought it best to cite them by reference-numbers, thus:—

Remarks under Class A:—

1. Entamer le disque, indent the moon, imbedded in the limb, imbedded in the body, in die Licht-gränze völlig eindrang.
2. Avancer sur la lune, advanced upon the moon's face, schien sich einwärts zu bewegen.
3. Within the dark part, inside of the limb, within the edge, within the disk.
4. Sur le disque, on the disk, on the face, auf der Mondscheibe, sobre el disco.
5. Projection, projected upon, projété sur.
6. Vor der Mondscheibe, as if it were on this and not on the other side of the moon.
7. A travers la partie claire, as if it had been seen through a transparent moon.

Remarks under Class B:—

8. Sur le bord, auf dem Mondrande, upon the limb, im Mondrande, projected on the limb, bisected by the limb,

toucher le bord, en contact avec le bord, touching the limb, coinciding with the limb (with words expressive of measure, or of sensible duration of time).

9. Avancer sur le disque la moitié de son image et y rester.
10. Adhérente au bord, attachée au bord, adhering to the limb, attached to the limb, hung in the immersion, hang on the limb, hängt am Rande, am Mondrande zu verweilen, sticking to the limb, dancing in the limb, der Stern am Rande klebte (usually with measure of time).
11. Parcourir le bord, slide on the moon but not visible on its face.
12. Ne se detacha du bord que deux secondes après, tems écoulé entre le contact et l'occultation, did not separate immediately, was not immediately quite detached from the limb, 2^s or 3^s after reappearance before there was a visible space.
13. Immersed gradually, détachée lentement.

Remarks under Class C:—

14. Besondere Erscheinungen hat Niemand bemerkt.
15. Pas aperçu sur le disque, a très peu empiété sur le disque.
16. Keine projection, no projection on the disk, pas vu se projéter sur le disque, limb did not appear behind the star.
17. Détachée du bord jusqu'à son entrée, er verschwand als der Mondrand ihn erreichte und nicht später, disappeared on coming into contact, came out with full brightness instantaneously and did not hang.
18. The last rays vanished instantaneously as if the centre of the star was within the moon's limb, distinctly dichotomized at the moment of occultation, bisected at the instant of disappearance, rather more than half the disk was projected instantaneously from behind the limb.

I shall now give, in a tabular form, the record of the occultations:—

Class A. *With distinct Record of Projection.*

No.	Year and Day.	Star's Name.	Disapp. or Reapp.	Bright or Dark Limb of Moon.	Place of Observation.	Observer.	Refer- ence for Re- marks.	Reference for Account.	Height of Star above Moon's Centre.	
									+	-
1	1699, Aug. 18	Aldebaran	D	B	Paris	De La Hire	4	Mem. de l'Acad., 1699, p. 151	'391	
2	1738, Aug. 8	Aldebaran	D	B	Paris	Le Monnier	2	Mem. de l'Acad., 1738, p. 303	'423	
3	1738, Oct. 2	Aldebaran	D	B	Toulouse	De Garipuy	7	Acad. de Toulouse, i., p. 275		'087
4	1755, Sept. 25	Aldebaran	D	B	Paris	Pingré	1	Conn. d. Tems, 1810, p. 336	'891	
5	1757, July 11	Aldebaran	D	B	Paris	Messier	4	Conn. d. Tems, 1810, p. 339		'616
6	1792, Mar. 27	Aldebaran	D	D	Greenwich	Maskelyne	3	Gr. Obs., vol. iii., Transits, p. 205		'174
7	" "	"	R	B	Paris	Messier	7	Conn. d. Tems, An vii., p. 215		'988
8	1792, Aug. 10	Aldebaran	D	B	London	Troughton	3, 5	R. Ast. Soc. Mem., iii., p. 313		'139
9	" "	"	"	"	"	Crosley	3, 5	" " " "		'139
10	" "	"	"	"	Toulouse	Darquier	5	Hist. Cél. Française, p. 403		'616
11	1793, Oct. 21	Aldebaran	D	B	Paris	Messier	1	Conn. d. Tems, An vii., p. 216	'995	
12	1794, Sept. 14	Aldebaran	D	B	Toulouse	Darquier	5	Hist. Cél. Franc., p. 425		'174
13	1808, Oct. 8	♄ Tauri	D	B	San Fernando	Canelas	4	Ast. Nachr., vol. ix., p. 389		'242
14	1810, May 10	60 ^a Cancri	D	D	Paris	Mathieu	4	Paris Obs., vol. i., Transits, p. 8		'139
15	1810, Sept. 18	Aldebaran	D	B	Paris	Arago	5	Paris Obs., vol. i., Transits, p. 19		'755
16	" "	"	"	"	"	Mathieu	4	" " " "		'755
17	1811, July 15	γ Tauri	D	B	San Fernando	Canelas	4	Ast. Nachr., vol. ix., p. 391		'982
18	1811, Sept. 2	λ Aquarii	D	B	Paris	Arago	5	Paris Obs., vol. i., Transits, p. 46		'906
19	" "	"	"	"	"	Bouvard	4	" " " "		'906
20	1811, Sept. 2	78 Aquarii	D	D	Paris	Arago	2	Paris Obs., vol. i., Transits, p. 46		'156
21	1811, Oct. 5	γ Tauri	D	B	San Fernando	Canelas	4	Ast. Nachr., vol. ix., p. 393		'995
22	1811, Nov. 29	Aldebaran	D	B	San Fernando	Canelas	4	Ast. Nachr., vol. ix., p. 393	'707	
23	1812, July 30	μ Ceti	D	B	San Fernando	Canelas	4	Ast. Nachr., vol. ix., p. 394		'358
24	1821, Feb. 6	δ Piscium	D	D	London	Sir J. South	5	R. Ast. Soc. Mem., vol. iii., p. 304	'995	
25	" "	"	"	"	Cambridge	Catton	3	R. Ast. Soc. Mem., vol. xxii., p. 23	'990	
26	1821, July 30	Regulus	R	B	Cape Frio	Sir T. Brisbane	4	R. Ast. Soc. Notices, vol. ii., p. 25		'292
27	" "	"	"	"	"	Rümker	3	" " " "		'292
28	1821, Dec. 1	Lal. 43324	D	D	Prag	David	2	Ast. Nachr., vol. i., p. 163	'208	
29	1823, Mar. 30	π Scorpii	D	B	Marseille	Gambart	4	Ast. Nachr., vol. iii., p. 460		'970
30	1829, Aug. 21	Aldebaran	D	B	Paris	Mathieu	4	Paris Obs., ii., Transits, p. 197		'375
31	" "	"	"	"	"	Savary	4	" " " "		'375
32	" "	"	"	"	"	Arago	4	" " " "		'375
33	" "	"	"	"	Liverpool	Lassell	3	R. Ast. Soc. Notices, xvii., p. 143		'191
34	1829, Oct. 15	Aldebaran	D	B	Bedford	Smyth	3	R. Ast. Soc. Mem., iv., p. 642	'407	

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Class A (continued).

No.	Year and Day.	Star's Name.	Disapp. or Reapp.	Bright or Dark Limb of Moon.	Place of Observation.	Observer.	Refer- ence for Re- marks.	Reference for Account.	Height of Star above Moon's Centre.	
									+	-
35	1829, Oct. 15	Aldebaran	D	B	Bedford	Lee	3	R. Ast. Soc. Mem., iv., p. 642	'407	
36	" "	"	"	"	Biggleswade	Maclear	2	" " " "	'407	
37	" "	"	"	"	"	Bromhead	2	" " " "	'407	
38	" "	"	"	"	Greenwich	Pond	5	R. Ast. Soc. Mem., iv., p. 637	'375	
39	" "	"	"	"	"	Taylor	5	" " " "	'375	
40	" "	"	"	"	"	Henry	5	" " " "	'375	
41	" "	"	"	"	"	Richardson	5	" " " "	'375	
42	" "	"	"	"	"	T. G. Taylor	5	" " " "	'375	
43	" "	"	"	"	"	Rogerson	5	" " " "	'375	
44	" "	"	"	"	Green. Hospital	Riddle	4	R. Ast. Soc. Mem., iv., p. 641	'375	
45	" "	"	"	"	Blackheath	Wrottesley	5	R. Ast. Soc. Mem., iv., p. 642	'375	
46	" "	"	"	"	Chiselhurst	Hussey	1	" " " "	'375	
47	" "	"	"	"	London	Epps	5	R. Ast. Soc. Not., i., p. 136	'375	
48	" "	"	"	"	Kensington	Beaufort	3	R. Ast. Soc. Not., i., p. 137	'375	
49	" "	"	"	"	"	Wilson	1	" " " "	'375	
50	" "	"	"	"	"	Stratford	1	" " " "	'375	
51	" "	"	"	"	Islington	Simms	5	R. Ast. Soc. Mem., iv., p. 641	'375	
52	" "	"	"	"	Woolwich	Prof. Barlow	4	R. Ast. Soc. Not., i., p. 139	'375	
53	" "	"	"	"	"	Barlow	4	" " " "	'375	
54	1830, Mar. 28	Aldebaran	R	B	Dorchester, U.S.	W. C. Bond	5	Ast. Nach., vol. viii., p. 354	'515	
55	1830, July 15	Aldebaran	D	B	Nantucket	Paine	5	R. Ast. Soc. Mem., iv., p. 636	'105	
56	1830, Sept. 6	μ Ceti	D	B	Ormskirk	Dawes	3	R. Ast. Soc. Mem., v., p. 371	'819	
57	1831, Jan. 6	94 Virginis	R	D	Biggleswade	Maclear	5	R. Ast. Soc. Mem., v., p. 364	'485	
58	1831, Oct. 23	ρ Tauri	D	B	Armagh	Robinson	5	Ast. Nach., vol. x., p. 273	'940	
59	1831, Oct. 23	Aldebaran	D	B	Armagh	Robinson	5	Ast. Nach., vol. x., p. 273	'292	
60	" "	"	"	"	Cambridge	Airy	5	Camb. Obs., 1831, p. 141	'407	
61	" "	"	"	"	Biggleswade	Maclear	2	R. Ast. Soc. Mem., v., p. 373	'407	
62	" "	"	"	"	Bedford	Smyth	3	R. Ast. Soc. Mem., v., p. 367	'407	
63	" "	"	"	"	Munich	Lamont	4	Ast. Nachr., vol. x., p. 119	'545	
64	1831, Dec. 17	Aldebaran	D	B	Mannheim	Nicolai	1	Ast. Nachr., vol. x., p. 92	'799	
65	1836, Nov. 5	γ Virginis	D	B	San Fernando	D. F. de Hoyos	4	Ast. Nachr., vol. xvii., p. 25	'927	
66	1845, Mar. 15	* 7 Magn.	D	D	Parsonstown	Sir J. South	7	Ast. Nachr., vol. xxxiii., p. 117		
67	1849, Mar. 1	B.A.C. 1517	D	D	Cambridge, U.S.	W. C. Bond	5	Ast. Journal, i., p. 174	'122	
68	1849, Sept. 8	ρ Tauri	D	B	Ashurst	Snow	5	R. Ast. Soc. Not., x., p. 16	'574	
69	1849, Nov. 29	B.A.C. 1391	D	B	Cambridge, U.S.	W. C. Bond	5	Ast. Journal, i., p. 174	'469	
70	1850, Aug. 2	Aldebaran	D	B	Marburg	Schönfeld	6	Ast. Nachr., vol. xxxi., p. 249	'276	
71	1855, April 18	Venus	D	D	Washington	Ferguson	6	Ast. Journal, iv., p. 95	'174	
72	1856, Sept. 18	23 Tauri	D	B	Madras	Jacob	4	R. Ast. Soc. Notices, xvii., p. 17	'588	
73	1856, Sept. 18	η Tauri	D	B	Madras	Jacob	4	R. Ast. Soc. Notices, xvii., p. 17	'326	
74	1857, Oct. 6	17 Tauri	D	B	Madras	Jacob	5	R. Ast. Soc. Notices, xviii., p. 29	'857	

Class B. *With Record of Hanging on the Limb.*

No.	Year and Day.	Star's Name.	Disapp. or Reapp.	Bright or Dark Limb of Moon.	Place of Observation.	Observer.	Refer- ence for Re- marks.	Reference for Account.	Height of Star above Moon's Centre.	
									Moon's Radius = 1	+
75	1755, Sept. 25	δ^1 Tauri	D	B	Paris	Messier	11	Conn. d. Tems, 1810, p. 335		'799
76	1755, Sept. 25	δ^2 Tauri	D	B	Paris	Messier	11	Conn. d. Tems, 1810, p. 336		'995
77	1755, Sept. 25	Aldebaran	D	B	Paris	Messier	10	Conn. d. Tems, 1810, p. 336	'891	
78	" "	"	"	"	"	De Barros	8	" "	'891	
79	1756, Dec. 12	ζ Leonis	D	B	Paris	Messier	10	Conn. d. Tems, 1810, p. 338		'707
80	1757, Feb. 25	Aldebaran	R	B	Paris	Messier	8	Conn. d. Tems. 1810, p. 339		'358
81	" "	"	"	"	"	Pingré	10	" "		'358
82	1757, Mar. 24	γ Tauri	D	D	Paris	Messier	8	Conn. d. Tems, 1810, p. 339	'000	'000
83	1757, July 11	Aldebaran	D	B	Paris	Le Monnier	8	Conn. d. Tems, 1810, p. 339		'616
84	1758, June 9	δ Cancri	D	D	Paris	Messier	8	Conn. d. Tems, 1810, p. 340	'259	
85	1774, Apr. 14	Aldebaran	R	B	Paris	Messier	12	Conn. d. Tems, An ix., p. 436		'669
86	1776, Jan. 29	Aldebaran	R	B	Paris	Messier	8	Conn. d. Tems, An viii., p. 309		'819
87	1786, Mar. 5	20 Tauri	D	D	Greenwich	Maskelyne	10	Gr. Obs., vol. ii., Transits, p. 384	'951	
88	1793, Oct. 21	Aldebaran	D	B	Toulouse	Darquier	8	Hist. Cél. Française, p. 413	'951	
89	1794, Sept. 20	Regulus	D	B	Toulouse	Darquier	8	Hist. Cél. Française, p. 425		'951
90	1794, Nov. 8	Aldebaran	D	B	Paris	Messier	8	Conn. d. Tems, An vii., p. 217		'731
91	1794, Dec. 18	γ Libræ	D	B	Toulouse	Darquier	8	Hist. Cél. Franc., p. 428		'993
92	" "	"	"	"	"	Hadancourt	8	" "		'993
93	1795, Oct. 6	δ Cancri	R	D	Cambridge	Catton	10	R. Ast. Soc. Mem., xxii., p. 19	'292	
94	1801, Mar. 30	Spica	D	B	Paris	Méchain	8	Conn. d. Tems, An xv., p. 432		'545
95	" "	"	"	"	Lisbon	Ciera	12	Conn. d. Tems, 1817, p. 318		'946
96	1801, Oct. 23	24 Tauri	D	B	Greenwich	Firminger	13	Gr. Obs., vol. iv., Transits, p. 85	'500	
97	1801, Oct. 23	n Tauri	D	B	Greenwich	Firminger	13	Gr. Obs., vol. iv., Transits, p. 85	'423	
98	1801, Oct. 23	27 Tauri	D	B	Greenwich	Firminger	13	Gr. Obs., vol. iv., Transits, p. 85		'174
99	1801, Oct. 23	28 Tauri	D	B	Greenwich	Firminger	13	Gr. Obs., vol. iv., Transits, p. 85	'139	
100	1805, June 10	σ Scorpii	R	B	San Fernando	Canelas	8	Ast. Nach., vol. ix., p. 375	'966	
101	1810, May 10	$60 \alpha^1$ Cancri	D	D	Paris	Arago	8	Paris Obs., vol. i., Transits, p. 8		'139
102	1811, Mar. 1	Aldebaran	R	B	Paris	Arago	10	Paris Obs., vol. i., Transits, p. 31		'731
103	" "	"	"	"	"	Mathieu	13	" "		'731
104	1811, Mar. 27	Lalande 6134	D	D	Paris	Arago	10	Paris Obs., vol. i., Transits, p. 33	'407	
105	1811, July 15	Aldebaran	D	B	Havannah	Ferrer	12	Conn. d. Tems, 1817, p. 318		'961
106	1811, Sept. 2	78 Aquarii	D	D	Paris	Mathieu	8	Paris Obs. vol. i., Transits, p. 46		'156
107	1811, Oct. 5	Aldebaran	D	B	Havannah	Ferrer	12	Conn. d. Tems, 1817, p. 318		'999
108	1812, Jan. 23	Aldebaran	R	B	Paris	Arago	10	Paris Obs., vol. i., Transits, p. 57	'891	
109	1812, Aug. 28	Aldebaran	D	B	Havannah	Ferrer	12	Conn. d. Tems, 1817, p. 318		'391
110	1812, Oct. 22	Aldebaran	D	B	Cambridge	Catton	8	R. Ast. Soc. Mem., xxii., p. 22	'423	
111	1812, Nov. 24	Regulus	D	B	Havannah	Ferrer	12	Conn. d. Tems, 1817, p. 318		'191
112	1822, Feb. 27	19 Tauri	R	B	Dorpat	Struve	10	Ast. Nach., ii., p. 53		'921
113	1822, Dec. 25	17 Tauri	R	B	Dorpat	Struve	10	Ast. Nach., ii., p. 56	'276	

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Class B (continued).

No.	Year and Day.	Star's Name.	Disapp. or Reapp.	Bright or Dark Limb of Moon.	Place of Observation.	Observer.	Refer- ence for Re- marks.	Reference for Account.	Height of Star above Moon's Centre. Moon's Radius = 1	
									+	-
114	1822, Dec. 25	16 Tauri	R	B	Dorpat	Struve	10	Ast. Nach., ii., p. 57	.799	
115	1822, Dec. 25	7 Tauri	R	B	Dorpat	Struve	10	Ast. Nach., ii., p. 57		.469
116	1829, Oct. 15	Aldebaran	D	B	South Kilworth	Pearson	10	R. Ast. Soc. Mem., iv., p. 643	.438	
117	" "	"	"	"	Cambridge	Catton	8	R. Ast. Soc. Mem., xxii., p. 27	.407	
118	" "	"	"	"	Prag	David	10	Ast. Nachr., viii., p. 15	.052	
119	" "	"	"	"	Near Prag	Hallaschka	10	Ast. Nachr., viii., p. 108	.052	
120	1830, Jan. 5	Aldebaran	R	B	Boston, U.S.	Paine	10	Ast. Nachr., viii., p. 352		.999
121	1830, Mar. 28	Aldebaran	R	B	Boston, U.S.	Paine	10	Ast. Nachr., viii., p. 352		.515
122	1831, Oct. 23	Aldebaran	D	B	Aberdeen	Innes	10	Ast. Nachr., x., p. 211		.139
123	1831, Dec. 22	Regulus	D	B	Cambridge	Airy	10	Camb. Obs., 1831, p. 144	.276	
124	" "	"	"	"	"	Whewell	8	Camb. Obs., 1831, p. 144	.276	
125	" "	"	"	"	Bedford	Smyth	8	R. Ast. Soc. Mem., v., p. 368	.276	
126	" "	"	"	"	Aberdeen	Innes	10	Ast. Nachr., x., p. 211	.259	
127	1835, Dec. 4	7 Tauri	D	B	Cambridge	J. Glaisher	10	Camb. Obs., 1835, p. 225		.848
128	1836, Jan. 12	8 Libræ	D	B	Ashurst	Snow	10	R. Ast. Soc. Mem., ix., p. 264		.993
129	1836, Jan. 12	α Libræ	D	B	Ashurst	Snow	10	R. Ast. Soc. Mem., ix., p. 264		.988
130	1836, July 23	δ Scorp̄ii	R	B	Cambridge	Challis	10	Camb. Obs., 1836, p. 144	.574	
131	" "	"	"	"	"	J. Glaisher	10	Camb. Obs., 1836, p. 144	.574	
132	1837, Aug. 24	136 Tauri	D	B	Ashurst	Snow	12	R. Ast. Soc. Mem., x., p. 345	.105	
133	1837, Sept. 14	27 Piscium	D	B	Cambridge	J. Glaisher	10	Camb. Obs., 1837, p. 62	.616	
134	1841, May 23	ω Geminorum	D	D	Greenwich	Main	8	Gr. Obs., 1841, p. 75		.766
135	1845, Oct. 18	ε Tauri	D	B	Christiania	[not given]	10	Ast. Nachr., xxvi., p. 145		.545
136	1846, June 13	c ¹ Capricorni	D	B	Cambridge	Challis	8	Camb. Obs., 1846, p. 79	.829	
137	1848, Feb. 12	Aldebaran	R	B	Altona	Petersen	8	Ast. Nachr., xxvii., p. 231		.839
138	1849, Sept. 8	81 Tauri	D	B	Cambridge	Todd	10	Camb. Obs., 1849, p. 149		.588
139	1850, Jan. 23	Aldebaran	R	B	Greenwich	Dunkin	8	Green. Obs., 1850, p. 58	.242	
140	" "	"	"	"	"	Rogerson	10	" "	.242	
141	" "	"	"	"	"	H. Breen	10	" "	.242	
142	1850, Aug. 2	Aldebaran	D	B	Cambridge	J. Breen	8	Camb. Obs., 1850, p. 291	.225	
143	1850, Aug. 14	γ Libræ	R	B	Cambridge	J. Breen	8	Camb. Obs., 1850, p. 291		.087
144	" "	"	"	"	"	Todd	12	Camb. Obs., 1850, p. 291		.087
145	1852, Mar. 28	μ Geminorum	R	B	Madras	Jacob	10	Madras Obs., 1848-52, p. 96	.998	
146	1854, Apr. 4	ε Geminorum	R	B	Greenwich	Dunkin	12	Gr. Obs., 1854, p. 71		.951
147	" "	"	"	"	Ashurst	Snow	12	R. Ast. Soc. Notices, xiv., p. 184		.951
148	1855, Mar. 5	{ γ Virginis (2d Star) }	D	B	Highbury	Burr	10	R. Ast. Soc. Notices, xvi., p. 29	.208	
149	1856, Mar. 26	Antares	D	B	Greenwich	H. Breen	8	Greenw. Obs., 1856, p. 57	.574	
149*	" "	"	"	"	Portsmouth	Shadwell	10	R. Ast. Soc. Notices, xvi. p. 148		.616
150	1856, July 25	α ² Arietis	D	B	Wilna	Gussew	10	Ast. Nachr., xlvi., p. 343	.485	
151	1856, Nov. 12	7 Tauri	D	B	Madras	Jacob	11	R. Ast. Soc. Notices, xvii., p. 53	.208	
152	1856, Nov. 12	27 Tauri	D	B	Madras	Jacob	11	R. Ast. Soc. Notices, xvii., p. 53	.788	
153	1857, May 6	Spica	R	B	Highbury	Burr	10	R. Ast. Soc. Notices, xvii., p. 203	.500	
154	1858, May 19	Regulus	R	B	Greenwich	Dunkin	12	Green. Obs., 1858	.906	
155	" "	"	"	"	"	Criswick	10	Green. Obs., 1858		.906

Class C. *With Denial of Projection or Hanging.*

No.	Year and Day.	Star's Name.	Disapp. or Reapp.	Bright or Dark Limb of Moon.	Place of Observation.	Observer.	Refer- ence for Re- marks.	Reference for Account.	Height of Star above Moon's Centre. Moon's Radius=1	
									+	-
156	1738, Jan. 2	Aldebaran	R	B	Paris	Le Monnier	15	Mém. de l'Acad., 1738, p. 303		'375
157	1801, Mar. 30	Spica	D	B	Greenwich	Firminger	18	Green. Obs. iv., Transits, p. 67		'602
158	1821, Feb. 6	♃ Piscium	R	B	London	Sir J. South	16	R. Ast. Soc. Mem. iii., p. 304		'530
159	1821, Feb. 6	Lalande 1396	D	D	London	Sir J. South	16	R. Ast. Soc. Mem. iii., p. 305	'602	
160	1829, July 25	Aldebaran	D	B	Dorpat	Struve	16	Ast. Nachr. viii., p. 303		'122
161	" "	"	"	"	"	Preuss	16	Ast. Nachr. viii., p. 303		'122
162	" "	"	"	"	Königsberg	Bessel	17	Ast. Nachr. viii., p. 190		'191
163	1829, Aug. 21	Aldebaran	D	B	Boston, U.S.	Paine	16	Ast. Nachr. viii., p. 351		'276
164	" "	"	"	"	Dorchester, U.S.	W. C. Bond	16	Ast. Nachr. viii., p. 351		'276
165	1829, Sept. 17	Aldebaran	D	B	Boston, U.S.	Paine	16	Ast. Nachr. viii., p. 351	'695	
166	1829, Oct. 15	Aldebaran	D	B	Dorpat	Struve	16	Ast. Nachr. viii., p. 303		'375
167	1829, Dec. 9	Aldebaran	R	B	Göttingen	Harding	16	R. Ast. Soc. Notices, i., p. 169		'545
168	" "	"	"	"	Königsberg	Bessel	17	Ast. Nachr. viii., p. 191		'407
169	" "	"	"	"	Dorpat	Struve	16	Ast. Nachr. viii., p. 305		'342
170	1830, Mar. 28	♁ Tauri	D	D	Kensington	Sir J. South	16	R. Ast. Soc. Notices, i. p. 174	'454	
171	" "	"	"	"	"	Babbage	16	" " "	'454	
172	" "	"	"	"	"	Baily	16	" " "	'454	
173	" "	"	"	"	"	Rothman	16	" " "	'454	
174	1830, Mar. 28	♁ Tauri	D	D	Kensington	Sir J. South	16	R. Ast. Soc. Notices, i., p. 174	'105	
175	" "	"	"	"	"	Babbage	16	" " "	'105	
176	" "	"	"	"	"	Baily	16	" " "	'105	
177	" "	"	"	"	"	Lubbock	16	" " "	'105	
178	" "	"	"	"	"	Rothman	16	" " "	'105	
179	1830, Mar. 29	117 Tauri	D	D	Ormskirk	Dawes	18	R. Ast. Soc. Mem. v., p. 371	'000	'000
180	1830, Mar. 29	117 Tauri	R	B	Ormskirk	Dawes	17	R. Ast. Soc. Mem. v., p. 371		'940
181	1832, Feb. 10	Aldebaran	R	B	Armagh	Robinson	16	Ast. Nachr. x., p. 273	'156	
182	" "	"	"	"	Ormskirk	Dawes	18	R. Ast. Soc. Mem. v., p. 376	'035	
183	1847, Aug. 19	♄ Ophiuchi	D	D	Cambridge, U.S.	W. C. Bond	16	Ast. Journal, i., p. 173		'559
184	1848, Aug. 21	γ Tauri	R	D	Greenwich	Main	17	Green. Obs. 1848, p. 67	'695	
185	1851, Jan. 16	ζ Geminorum	R	B	Madras	Jacob	17	Madras Observ. 1848-1852, p. 94		'559
186	1851, April 6	m Tauri	D	D	Cambridge	J. Breen	16	Camb. Obs. 1851, p. 417	'682	
187	1852, April 24	6 Geminorum	D	D	Madras	Jacob	16	Madras Obs. 1848-1852, p. 96	'545	
188	1853, Mar. 28	β ¹ Scorpii	D	B	Greenwich	Dunkin	17	Green. Obs. 1853, p. 48		'883
189	1855, Mar. 5	γ ¹ Virginis	D	B	Highbury	Burr	17	R. Ast. Soc. Notices, xvi., p. 29	'208	
190	1857, Oct. 6	19 Tauri	D	B	Madras	Jacob	16	R. Ast. Soc. Notices, xviii., p. 29		'819
191	1858, May 19	Regulus	R	B	Manchester	Worthington	16	R. Ast. Soc. Notices, xviii., p. 276		'891
192	" "	"	"	"	"	Baxendell	18	" " "		'891

Class D. *With discordant Remarks in the same Place or Neighbourhood.*

No.	Year and Day.	Star's Name.	Disapp- or Reapp.	Bright or Dark Limb of Moon.	Place of Observation.	Observer.	Class of Re- mark.	Refer- ence for Re- mark.	Reference for Account.	Height of Star above Moon's Centre.	
										+	-
193	1755, July 5	Aldebaran	D	B	Paris	Messier	B	8	Conn. d. Tems, 1810, p. 335		'485
194	" "	"	"	"	"	Le Gentil	B	10	" " "		'485
195	" "	"	"	"	"	Cassini	C	17	" " "		'485
196	1829, Aug. 21	Aldebaran	D	B	Geneva	Gautier	C	16	R. Ast. Soc. Notices, i., p. 135		'438
197	" "	"	"	"	"	Bouvard	A	5	" " "		'438
198	" "	"	"	"	"	Gambart	A	5	" " "		'438
199	1829, Oct. 15	Aldebaran	D	B	Paris	Nicollet	A	5	Paris Obs. ii., Transits, p. 199		'174
200	" "	"	"	"	"	Bouvard	C	16	" " " "		'174
201	" "	"	"	"	"	Sir J. South	C	18	" " " "		'174
202	" "	"	"	"	"	Mathieu	B	9	" " " "		'174
203	" "	"	"	"	"	Savary	C	15	" " " "		'174
204	" "	"	"	"	"	Arago	C	18	R. Ast. Soc. Notices, i. p. 138		'174
205	" "	"	"	"	"	Damoiseau	B	10	" " " "		'174
206	" "	"	"	"	"	Zach	C	17	" " " "		'174
207	" "	"	"	"	"	Pouillet	C	17	R. Ast. Soc. Notices, i., p. 139		'174
208	" "	"	"	"	"	Francœur	A	5	" " " "		'174
209	" "	"	"	"	"	B. Delessert	C	17	" " " "		'174
210	" "	"	"	"	"	F. Delessert	C	17	" " " "		'174
211	" "	"	"	"	"	G. Delessert	C	17	" " " "		'174
212	1829, Dec. 9	Aldebaran	R	B	Altona	Schumacher	C	14	Ast. Nachr. viii., p. 55		'574
213	" "	"	"	"	"	Nehus	C	14	" " "		'574
214	" "	"	"	"	"	Petersen	B	10	" " "		'574
215	1830, Mar. 28	Lalande 8411	D	D	Kensington	Lord Ashley	A	5	R. Ast. Soc. Notices, i., p. 174		'934
216	" "	"	"	"	"	Sir J. South	A	5	" " "		'934
217	" "	"	"	"	"	[not named]	C	16	" " "		'934
218	" "	"	"	"	"	[not named]	C	16	" " "		'934
219	" "	"	"	"	"	[not named]	C	16	" " "		'934
220	" "	"	"	"	"	[not named]	C	16	" " "		'934
221	" "	"	"	"	"	[not named]	C	16	" " "		'934

Class D (continued).

No.	Year and Day.	Star's Name.	Disapp. or Reapp.	Bright or Dark Limb of Moon.	Place of Observation.	Observer.	Class of Re- mark.	Refer- ence for Re- mark.	Reference for Account.	Height of Star above Moon's Centre.	
										Moon's Radius = r	
										+	-
222	1830, Mar. 28	85 Tauri	D	D	Kensington	Lord Ashley	A	3	R. Ast. Soc. Notices, i., p. 174		'358
223	" "	"	"	"	"	[not named]	C	16	" " "		'358
224	" "	"	"	"	"	[not named]	C	16	" " "		'358
225	" "	"	"	"	"	[not named]	C	16	" " "		'358
226	" "	"	"	"	"	[not named]	C	16	" " "		'358
227	" "	"	"	"	"	[not named]	C	16	" " "		'358
228	1831, Dec. 22	Regulus	D	B	Kensington	Sir J. South	C	18	R. Ast. Soc. Mem., v., p. 375	'276	
229	" "	"	D	B	London	Snow	A	3	" " "	'276	
230	1832, Mar. 9	120 Tauri	D	D	Islington	Simms	B	8	R. Ast. Soc. Mem., v., p. 377	'292	
231	" "	"	"	"	London	Snow	C	15	" " "	'292	
232	1857, May 6	Spica	R	B	Greenwich	Main	C	17	Greenwich Obs., 1857, p. 67	'500	
233	" "	"	"	"	"	Dunkin	B	12	" " "	'500	

An inspection of these Tables will show that there is no connexion between Projection and the geometrical circumstance of a + or - sign in the last columns. And I at once dismiss the conjectural explanation with which this paper commenced.

I have now to point out a remark which appears to me to throw light on the origin of this phenomenon.

In the record of the disappearance of *Aldebaran* at the moon's bright limb on 1831, October 23, as observed by Mr. GEORGE INNES at Aberdeen (No. 122 of the preceding Tables), the following Notice is found (*Astronomische Nachrichten*, Vol. X., p. 211) :—

“When *Aldebaran* came within about six seconds of the moon's limb it passed through the remaining distance with great rapidity, its apparent velocity becoming five or six times as great as before. It appeared to hang on the moon's limb for about five seconds of time, and then suddenly disappeared.”

I need not say that, in strict language, instead of treating the approach

as produced by the motion of *Aldebaran*, it ought to have been treated as produced by the motion of the moon's limb.

Mr. INNES was, I believe, a most careful and accurate observer. And I do not doubt that in these his words, interpreted as I have just said, is contained a severely correct account of the appearances which might have been observed in other cases if the observers had been equally cool and accurate. And the first step to the explanation of the phenomenon therefore is this, that the disk of the moon appears suddenly to swell or to extend itself into what was previously the dark space. And we have now to consider whether this swelling can be explained on recognised optical and physiological principles.

Now it must be remarked that, on the undulatory theory of light, the image in a telescope of any luminous point (whether a star, or a portion of the moon's illuminated surface) is not a point. The actual distribution of light in the neighbourhood of the brightest point of the image (which agrees perfectly with the theoretically computed distribution) is familiarly known in the bright rings which surround the image of a star as seen in a good telescope.

It is to be conceived that every luminous point of the moon's disk is accompanied with a similar system of rings; and therefore that the aggregate of light, produced by the aggregate of all the luminous points of the moon's disk, is not a luminous image bounded by a sharp outline at what we consider the geometrical outline of the image, but that the geometrical outline is fringed by a band of illumination, produced by the interlacing and superposition (not interference) of all the systems of rings. The integral which determines the brightness is so unmanageable that I am unable at present to assign the numerical values of the brightness at different distances from the geometrical outline (though there would be no difficulty in finding them by the troublesome method of quadratures); but as the light from the different sources is actually superposed and aggregated, it is certain that there must be a considerable quantity of light external to the geometrical limb. And when, with a very fine telescope, we see the moon's limb very sharply defined, and apparently surrounded by immediate darkness, we do in reality see it erroneously. Probably some operation of the mind, under the conviction that the outline of light ought

to fall in a given curve, acts on the animal faculty of sensation to incapacitate the visual organs from perceiving the fainter light beyond that curve.

But in the excitement and intentness of observing an occultation, the state of the sensational organization is probably much changed. And as the presumed time of the phenomenon comes nearer and nearer, the eye probably becomes more and more sensible to the faint diffused light, and the visible boundary of light extends further and further into the darkness. And this presents that appearance of rapidly increasing velocity of approach which is so graphically described by Mr. INNES.

In numerous instances, when the boundary of the moon's light has swelled till it touches the star, it swells no further, and the star "hangs" on the moon's limb. It seems perfectly conceivable that the mental contemplation of the relation of the positions of the moon and star which is implied in the phenomenon that is to be observed, may frequently so far act on the sensibilities that when that relation (namely, contact) is once gained, the mental effort does not make the sense more acute than is necessary, and may even somewhat relax as the denser light of the moon approaches the star.

The explanation which I have offered of these curious phenomena does in reality bring them under the general category of irradiation. But it is a kind of irradiation which has not, so far as I know, been noticed in other instances, an irradiation which sometimes exists and sometimes (under the same astronomical circumstances) does not exist, which at the same place is seen by one observer and not by another, which sometimes remains apparently constant for at least several seconds of time and sometimes varies from instant to instant. It is probable that there is irradiation of a similar kind when the wire of a meridional instrument is placed on the moon's limb, but critical observations are yet wanting.

Royal Observatory, Greenwich, 1859, April 2.