

The last of these (the annulus about 2 inches wide, left by a circular stop 24 inches in diameter) will probably be the best for examining the Moon and Mars.

By excluding all the central light we protect the image of minute details upon such objects from being swamped by the presence of light, which cannot show the minute details and which would blur it together; and at the same time we retain enough of the light which furnishes the coarser details.—G. J. S.

The Geminid Meteor-Shower.

THE shooting-stars that radiate from the constellation Gemini in the first half of December are of particular interest, as the question of the shifting of their centre has yet to be firmly established or disproved.

The maximum of the shower is due about December 10–13—unfortunately in 1900 a period of moonlight. This has for many years been remarked as a noteworthy epoch for the appearance of meteors. The history of this December shower is as follows.

In the year 901, on November 30, “the whole hemisphere was filled with those meteors called falling stars from midnight till morning, to the great surprise of the beholders in Egypt.”

930, Nov. 29.—“People saw a large number of little stars which were shooting and falling.”

1571, Dec. 8, was the date of another display of shooting stars.

Prof. Newton reduced these dates to the epoch of 1850, finding that they were equivalent to December 13.3, 11.6, and 11.5 respectively. Hence there is little doubt but that the meteor-showers in question were early appearances of the Geminids.

In 1833, about the same date, as many as ten meteors were seen simultaneously, and a similar phenomenon was observed in 1836 on December 11.

1838.—After observing the return of the Andromedids on December 6, 7, and 8 of this year, Herrick and his assistants, at Newhaven (Conn.), U.S.A., recorded 18 meteors on December 11 from 8^h 45^m to 10^h, 28 on December 12 from 6^h to 13^h 30^m, and 9 on December 15 from 6^h to 9^h 15^m. These figures seemingly indicate a moderate display of Geminids.

1841, Dec. 10, 11.—Colla, at Parma, noted an unusually large number of meteors; in $\frac{1}{2}$ ^h on the night of the 11th “23 very brilliant meteors, nearly all of them having luminous trains,” were seen in the northern quarter of the heavens, their general direction being from S. to N. An assistant reported that “meteors pursuing the same direction were uncommonly abundant” on the following morning. The same observer recorded many shooting stars on 1846, December 9, 10.

A year later, 1847, December 12, many falling stars were noticed in the constellations Orion, Taurus, Gemini, and Auriga, by E. J. Lowe, Nottingham.

1848, Dec. 11, 5^h 38^m–6^h 50^m.—10 meteors, many large, with trains.—E. HERS, Aix-la-Chapelle.

Dec. 14, 15.—Many meteors.—COLLA.

1855, Dec. 12.—Numerous shooting-stars were recorded.—E. J. LOWE, Beeston.

1860, Dec. 12, 8^h 20^m–12^h.—180 meteors, 60 the maximum hourly rate, at 11^h 30^m.—F. MILLER, Montgomery Co., Maryland, U.S.A. (Several students assisted.)

1862, Dec. 10.—In 3^h between 6^h and 12^h, ten or twelve meteors of the first magnitude were seen in all quarters of the sky. “The radiant-point was perfectly marked between Auriga and Gemini.” The Geminid radiant-point was first determined in this year, by R. P. Greg, at Prestwich, Manchester, his observation being here given, and by Profs. Twining and Marsh, in the United States.

1863, Dec. 12, 9^h 20^m–11^h 16^½^m: 13 meteors. Dec. 13, 8^h 11^m–10^h 44^½^m: 4 meteors. The radiant-point was at 105°·5 + 30°·5, apparently the first definite position recorded.—Prof. A. S. HERSCHEL, Hawkhurst, Kent.

In 1864, Geminids were again fairly numerous, while in 1866, on December 10, 15 were counted between 11^h and 12^h by T. H. Waller, York. Two nights later, at about 11^h, meteors were seen falling at the rate of one per minute. These were “blue and white, of momentary duration, and the majority without trains.”—W. H. WOOD, Birmingham.

The same observer found the horary rate of meteors on 1868, Dec. 11, about 12^h–13^h, to be 20; 53 per cent. were Geminids. Their description tallies with that of two years earlier—“white, with an occasional bluish tint; brief in duration and trainless.” On 1870, Dec. 12, during $\frac{3}{4}$ ^h of observation between 11^h 30^m and 12^h 30^m, five meteors were noted. These, again, were “white or blue, and trainless.” On the same date 25 Geminids were recorded by Captain (now Lieut.-Colonel) Tupman in the Mediterranean.

1871, Dec. 12, 9^h 45^m–11^h 30^m.—14 meteors (13 Geminids), mostly small with short paths and moderate velocities.—R. P. GREG, Buntingford.

10^h–11^h 30^m.—7 Geminids, nearly as bright as first magnitude stars.—R. McCLURE, Glasgow.

10^h 15^m–12^h.—30 shooting-stars (14 before 11^h), mostly Geminids, about half of which were brighter than the second magnitude, white, and in general not swift.—Prof. A. S. HERSCHEL.

1873, Dec. 10, 11.—23 and 39 meteors respectively. The percentage of Geminids was 59.—J. E. CLARK, Heidelberg.

14 meteors on the former date and 13 on the latter, besides 10 on December 12.—T. H. WALLER.

16 on December 11 and 24 on December 12.—W. H. WOOD.

The numbers of meteors as bright or brighter than the first magnitude given in the accounts of the three observers were 21, 27, and 28, most of these being Geminids.

1876.—Geminids were seen as early as November 21 and December 4.

Dec. 11, 11^h-13^h.—106 meteors, the majority of which were Geminids with very short tracks, were counted by Perrotin and Jean at Toulouse Observatory.

Dec. 12.—24 Geminids.—W. F. DENNING, Bristol.

The Geminids were "quick, short, and white, without trains or streaks except in the case of the larger ones."—H. CORDER, Writtle.

1877, Dec. 9, 9^h-11^h.—Nearly 20 meteors, and on December 10, 7^h-11^h 30^m, 40 out of 65 were Geminids, 25 being seen in the last hour. These were mostly small, and very few left streaks.—H. CORDER.

Dec. 9, 11.—30 Geminids.—R. P. GREG.

Dec. 11, 14^h 30^m to daybreak.—Meteors, probably Geminids, were estimated to be falling at the rate of 50 per hour.—Prof. LEWIS SWIFT, U.S.A.

1879, Dec. 7, 7^h-11^h: 3 Geminids. Dec. 9, 8^h-10^h: 2. Dec. 12, 8^h-11^h 30^m: 15. "Very short, quite bright, and very rapid." The brightest were of an emerald-green colour. In all 64 meteors were seen.—E. F. SAWYER, Cambridgeport (Mass.), U.S.A.

Dec. 10, 10^h 15^m-13^h 45^m.—69 meteors (36 Geminids).—H. CORDER.

Hardly any Geminids were recorded in the four following years.

On 1884, Dec. 11, 10^h 25^m-11^h 25^m.—10 Geminids: "very rapid; short paths, quite bright."—E. F. SAWYER.

1885.—Indications of a shifting radiant were observed in this year. Thus, from December 1 to 4, Geminids radiated from 105° + 34°, and from December 9 to 10 from 107° + 33°.—W. F. DENNING.

1887, Dec. 11, 16^h 30^m-17^h 30^m.—Large numbers of meteors were seen at Meximieux (Ain) and Beaulieu (Alpes-Maritimes).

Dec. 12, 13.—Numerous bright meteors were observed at Dresden.

1892, Dec. 9: 40 Geminids. Dec. 12, 6^h-8^h, 10^h-13^h 15^m: 66 meteors (38 true Geminids, 12 from another centre in Gemini).—H. CORDER, Bridgwater.

9^h 45^m-11^h 30^m.—20 meteors (6 true Geminids).—W. F. DENNING.

10^h 45^m-14^h 38^m.—24 meteors, and 5 earlier in the evening (6 Geminids).—Prof. A. S. HERSCHEL, Slough.

1894, Dec. 12, 19^h 30^m.—In about 10^m at this time not less than 20 meteors were counted in the N.E. sky by an observer at Montreux, Switzerland.

1895, Dec. 10, till midnight: 31 meteors. Dec. 12, 13^h 45^m-18^h:

88. From December 10 to 15 the number of Geminids seen was 78.—H. CORDER.

Dec. 11.—More than 50 meteors.—Rev. T. H. FOULKES, Devonport.

Dec. 12, 40^m near midnight.—20 meteors (horary rate of Geminids 25).—Prof. A. S. HERSHEL.

11^h 10^m–12^h 26^m.—24 Geminids.—E. R. BLAKELEY, Dewsbury.
1896, Dec. 9, 8^h 30^m–13^h (at intervals): 39 meteors (22 Geminids). Dec. 11, 10^h–15^h: 111 (89). Dec. 12, 14^h, 15^h–16^h 15^m: 30 (21); 9 were of the 1st magnitude, and only three left streaks. At midnight on December 11 the horary rates for all meteors and Geminids were 30 and 20 respectively.—H. CORDER.

Dec. 11.—About 20 Geminids.—D. BOOTH, Leeds.

About midnight 30 per hour, all meteors (20 Geminids).—E. R. BLAKELEY.

11^h 55^m–12^h 25^m: 9 meteors. Dec. 12, 10^h–12^h: 10 or 12 Geminids.—Prof. A. S. HERSHEL.

1898.—A few Geminids were recorded on December 9.

Dec. 12, in 2^h 5^m between 7^h and 13^h 22^m, 19 meteors out of 25 were Geminids.—T. W. BACKHOUSE, Sunderland.

7^h 25^m–11^h.—52 meteors.—R. SERVICE, Dumfries.

9^h 5^m–10^h 5^m.—36 meteors (35 Geminids).—V. NIELSEN, Hartlepool.

9^h 30^m–12^h 30^m.—41 meteors.—A. KING, Leicester.

12^h 30^m–14^h 45^m.—5 true Geminids, and 12 from other radiants in Gemini.—W. E. BESLEY, Westminster.

1899, Dec. 8 and 9.—A considerable number of Geminids.—T. H. ASTBURY, Wallingford.

Dec. 10, 12^h 10^m–13^h 30^m.—17 meteors (15 Geminids): short paths; several appeared almost stationary.—I. F. H. C. GREGG, Malvern.

Prof. Kirkwood has tabulated the early appearances of the Geminids in the same manner as those of the Lyrids, and deduces a period of about $29\frac{1}{8}$ years, thus:—

A.D. 901 to 930 =	1 period of 29.000 years.
930 to 1571 =	22 periods of 29.136 years.
1571 to 1833 =	9 periods of 29.111 years.
1833 to 1862 =	1 period of 29.000 years.

This period is to a large extent borne out by the strength of the display of 1892, though this was apparently exceeded by those of 1895 and 1896. It is a curious fact that the return of 1862 was also followed in four years by another striking display of Geminids.

From the accounts of the various observers detailed above it will have been gathered that the Geminids are usually short and quick, streak-leaving only as regards the brighter members of the shower, and that not invariably, and of a pale tint, the most

brilliant being sometimes of a vivid green. The average speed of six meteors of this class of which the real paths have been calculated is 40 miles per second.

The mean centre of 61 radiants of Geminids collected by Mr. Denning in his 'General Catalogue' is $106^{\circ}.0 + 32^{\circ}.4$ (Radiant No. lxxxviii.). This is very near the earliest position recorded—that by Prof. A. S. Herschel in 1863. Meteors have been seen issuing from the vicinity of this radiant on many dates between September and March.

The point as to which observations are needed is that as regards the suggested shifting character of the radiant. For this purpose watches should be kept for the shower on several nights preceding and following the date of maximum.

75 The Chase, Clapham Common.

W. E. BESLEY.

Changes in the Stellar Heavens.

ASTRONOMERS would like to know what the appearance of the heavens was about the dawn of human history, say 6000 years ago, and whether any of the stars then visible have since disappeared, or have increased or diminished in brightness. But no such knowledge is available, either in the form of maps or catalogues, and we must be content with the catalogues and descriptions which have been made in more modern times.

The first known catalogue of stars was made by Hipparchus about 134 B.C. The next catalogue was constructed by Ptolemy, who observed at Alexandria between the years A.D. 127 and A.D. 151, and is contained in the 7th and 8th books of the famous 'Almagest.' It seems doubtful, however, that Ptolemy's catalogue represents genuine observations made by Ptolemy himself, or is merely the catalogue of Hipparchus slightly modified. However this may be, we have a catalogue or description of the heavens made in the tenth century by the Persian astronomer Al-Sufi, which is undoubtedly the result of original observations made by Al-Sufi himself, and it is the oldest catalogue on which we can place any reliance. This most interesting and valuable work is preserved in two Arabic manuscripts, one in the Royal Library of Copenhagen and the other in the Imperial Library of St. Petersburg*. A French translation of these manuscripts was published in 1874 by the Danish astronomer Schjellerup, and some account of a comparison I have made of this work with modern observations may prove of interest.

Not very much is known of the details of Sufi's life. His full name was Abd-al-rahman Bin Umar Bin Muhammed Bin Sahl

* There are also three copies of Al-Sufi's work in the Imperial Library of Paris, but these are inaccurate. There is also one in the British Museum and another in the Indian Office Library; but these are imperfect, considerable portions of the original work being missing.