A Handbook of Descriptive and Practical Astronomy

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Book X. Meteoric astronomy.

BOOK X.

METEORIC ASTRONOMY.

CHAPTER I.

Classification of the Subject.—Aërolites.—Summary of the Researches of Berzelius, Rammelsberg, and others.—Celebrated Aërolites.—Summary of Facts.—Catalogue of Meteoric Stones.—Arago's Table of Apparitions.—The Aërolite of 1492.—*Of* 1627.—*Of* 1795.—*The Meteoric Shower of* 1803.

THE phenomena, of which we are now about to speak, form a highly interesting and by no means unimportant branch of descriptive astronomy. We shall treat of the subject under three heads:—

1. Aërolites.
2. Fireballs.
3. Shooting Stars.

Of all cosmical meteors, those known as aërolites, meteorlites, or meteoric stones, are the rarest, but nevertheless not so rare as to prevent the most satisfactory evidence being given, that such occurrences have happened from time to time. It is to Chaldni that we owe much of our knowledge on this branch of the subject. Many of these meteoric stones, picked up in different parts of the world, have been subjected to chemical analysis at the hands of Berzelius, Rammelsberg, and others, whose deductions may be thus summed up:—

1. Meteoric stones are composed of elements all of which occur in terrestrial minerals.

2. Of the 65 elementary substances known, 19 have been found in meteoric stones.

3. The produce of a meteoric shower may be divided into meteoric iron and meteoric stone.

4. Meteoric iron is an alloy that has not been found among terrestrial minerals, and is composed of about 10 per cent. of nickel with small quantities of cobalt, manganese, magnesia, tin, copper, and carbon.

5. Meteoric stone is composed of minerals found abundantly in lavas and trap-rocks, and consequently of volcanic origin, a variable proportion of meteoric iron being usually admixed.

The circumstances attending the fall of aërolites differ considerably on different occasions. Not unfrequently the fall is attended by a loud detonation; but we must not therefore infer that every detonating meteor is indeed an aërolite, without the presence of positive proof to that effect. History records instances of considerable damage having been done to life and property by the explosion of these bodies: as for instance, from a Chinese catalogue, we learn that one which fell on January 14, 616 B.C., broke several chariots and killed 10 men. The chronicle of Frodoard informs us that in the year 944 A.D. globes of fire traversed the atmosphere, and burnt several houses. More recently, on the evening of November 13, 1835, a brilliant meteor was seen in the department of Aix (France). It traversed the country in a northeasterly direction, and burst near the castle of Lausière, setting fire to a barn and the stables, burning the corn and cattle in a few minutes. An aërolite was found near the place after the occurrence. Also on March 22, 1846, at 3 in the afternoon, a luminous sheaf, which traversed the air with great velocity and noise, fell on a barn in a village in the department of Haute Garonne, which instantly took fire, and was destroyed together with the adjoining stables and the beasts therein contained.[1] It is also related that the Emperor Jehangir had a sword forged from a mass of meteoric iron which fell at Jahlindu, in the Punjab, in 1620.[2]

[1] See Arago, *Ast. Pop.*, vol. iv. pp. 224–229, French Ed., where numerous other instances are given. In the English edition this and other important meteor catalogues are very improperly left out.

[2] *Phil. Trans.*, vol. xciii. p. 202. 1803.

From the above and other similar observations, we learn three things.

1. That the fact is undoubtedly established, that from time to time masses of stone, of different sizes, and often of considerable weight, are seen passing through space, and are frequently precipitated upon the Earth's surface.

2. That these bodies rarely strike the Earth in a vertical or nearly vertical direction, but fall almost always in a direction very oblique to the plane of the horizon. This is ascertained by an inspection of the manner in which they penetrate the earth, which they often do to a considerable depth.

3. That they are endued with a very great velocity, similar, in fact, to the velocities which are found to characterise the planetary members of the solar system.

The ancients seem to have been well aware of the phenomena of which we are now treating, inasmuch as several things are mentioned by the classic writers as having fallen from heaven: we may refer to the Palladium of Troy, the image of Diana at Ephesus, the sacred shield of Numa, as examples. The ideas of the ancients, relative to the supposed celestial origin of these things, have often met with ridicule; but however fabulous the cases referred to may have been, still the moderns have been compelled, though reluctantly, to admit the fact of the actual transmission of stony substances from space, on to the surface of the Earth. The following catalogue of some of the more important recorded falls of meteoric stones, is taken chiefly from M. Izarn's work.[1]

Substance.	Period.	Place.
Shower of stones	About 650 B.C.	Rome.
Large stone	465 B.C.	River Negos, Thrace.
Three large stones	452	In Thrace.
Shower of stones	343	Rome.
Shower of iron	54	Lucania.
Shower of mercury	Date unknown	In Italy.
Mass of iron	"	Abakauk, Siberia.
Large stone of 260 lbs.	1492 Nov. 7	Ensisheim, Upper Rhine.

[1] *Des Pierres Tombées du Ciel, ou Lithologie Astronomique.* Paris, 1803.

Substance.	Period.	Place.
About 1200 stones—one of 120 lbs., another of 60 lbs.	1510 . .	Padua, Italy.
Stone of 59 lbs. . .	1627 Nov. 27 .	Mont Vasier, Provence.
Sulphurous rain . .	1646 . .	Copenhagen.
Sulphurous rain . .	1658 . .	Duchy of Mansfield.
Shower of unknown matter.	1695 . .	Ireland.
Stone of 72 lbs. . .	1706 January .	Larissa, Macedonia.
Shower of fire . .	1717 Jan. 4 .	Quesnoy.
Shower of sand for 15 hours.	1719 April 6 .	In the Atlantic.
Shower of sulphur .	1721 October .	Brunswick.
Mass of stone . .	1750 . .	Niort, Normandy.
Shower of stones . .	1753 July 3 .	Plaun, Bohemia.
Two stones weighing 20 lbs.	1753 September	Liponas, in Bresse.
Two stones of 200 and 300 lbs.	1762 . .	Near Verona.
A stone of 7½ lbs. . .	1768 Sept. 13 .	Lucé, Le Maine.
A stone . . .	1768 . .	Aise, Artois.
A stone . . .	1768 . .	Le Cotentin.
Shower of stones . .	1789 July .	Barboutan, near Roquefort.
Extensive shower of stones.	1790 July 24 .	Near Agen.
About twelve stones .	1794 July 16 .	Sienna, Tuscany.
A stone of 56 lbs. . .	1795 Dec. 13 .	Wold Cottage, Yorkshire.
A stone of 10 lbs. . .	1796 Feb. 19 .	In Portugal.
A stone of 20 lbs. . .	1798 March 12	Sules, near Ville Franche.
A stone of about 20 lbs.	1798 March 17	Sâle, dep. of Rhone.
Shower of stones . .	1798 Dec. 19 .	Benares.
Mass of iron, 70 cubic feet.	1800 April 5 .	America.
Several stones, of from 10 to 17 lbs.	1803 April 26 .	Near L'Aigle, Normandy.
Shower of stones . .	1807 Dec. 14 .	Weston, Connecticut, U. S.
A stone of 1563 lbs. .	1810 . .	Santa Rosa, New Grenada.
A stone of 203 lbs. .	1821 June 15 .	Juvenas, Ardéche.
A large stone . .	1843 Sept. 16 .	Kleinwenden, Thuringia.

According to Arago, we find that the 206 falls of aërolites, of which we know the month of occurrence, were distributed in the following manner throughout the 12 months of the year: —

January	14	99	July	23	107
February	10		August	16	
March	22		September	17	
April	15		October	18	
May	20		November	20	
June	18		December	13	

From an inspection of the above, it appears that the monthly average from December to June (16) is less than the same average from July to November, which is 19 per month, and that, moreover, the months of March, May, July, and November exhibit maximum numbers: and we also deduce this general fact — that the Earth, in its annual course round the Sun, would seem to encounter a greater number of aërolites in passing from aphelion to perihelion, or from the summer to the winter solstice, than in going from perihelion to aphelion, or from the winter to the summer solstice.

The circumstances connected with the occurrence which stands 8th in the above list, are of more than average interest, more especially from its having been long considered a poetical romance of by-gone ages. The following narrative was drawn up at the time, by order of the Emperor Maximilian, and deposited with the stone in the church at Ensisheim. "In the year of the Lord 1492, on Wednesday, which was Martinmas Eve, November 7, a singular miracle occurred; for between 11 o'clock and noon, there was a loud clap of thunder, and a prolonged confused noise, which was heard at a great distance; and a stone fell from the air, in the jurisdiction of Ensisheim, which weighed 260 pounds, and the confused noise was, moreover, much louder than here. There a child saw it strike on a field in the upper jurisdiction, towards the Rhine and Jura, near the district of Giscano, which was sown with wheat, and it did no harm, except that it made a hole there; and then they conveyed it from that spot, and many pieces were broken from it which the landvogt forbade. They therefore caused it to be placed in the church, with the intention of suspending it as a miracle; and there came here many people to see this stone. So there were remarkable conversations about this stone; but the learned said they knew not what it was; for it was beyond the ordinary course of nature that such a large stone should smite the Earth, from the height of the air, but that it was really a miracle of God; for, before that time, never anything was heard like it, nor seen, nor described. When they found that stone, it had entered into the Earth to the depth of a man's stature, which everybody explained to be the will of God that it should be found; and the noise of it was heard at Lucerne, at Vitting, and in many other places, so loud, that it was believed that houses had been overturned: and as the King Maximilian was here the Monday after S. Catherine's Day of the same year, his Royal Excellency ordered the stone which had fallen to be brought to the castle; and after having conversed a long time about it with the noblemen, he said that the people of Ensisheim should take it, and order it to be hung up in the church, and not to allow anybody to take anything from it. His Excellency, however, took two pieces of it, of which he kept one, and sent the other to Duke Sigismund of Austria: and they spoke a great deal about this stone, which they suspended in the choir, where it still is; and a great many people came to see it." This relic then remained in the church for three centuries, when it was temporarily removed during the turmoil of the French Revolution, to Colmar, but it has since been restored. A fragment of it is in the British Museum, and another piece may be seen at the Jardin des Plantes, at Paris.

The fall of the aërolite of 1627 (No. 10), was witnessed by the astronomer Gassendi: he states that when in the air it was apparently surrounded by a halo of prismatic colours. This being the only instance with which he was acquainted, Gassendi was led to attribute its origin to some one of the neighbouring mountains, from the summit of which a temporary volcanic eruption had taken place.

The aërolite of December 13, 1795 (No. 28), is interesting from the fact of its being one of the few instances recorded to have taken place in this country. A loud explosion, followed by a hissing noise, was heard through a considerable portion of the surrounding district; a shock was also noticed, as if produced by the falling to the Earth of some heavy body. A ploughman saw the stone fall to the ground at a spot not far distant from where he then was standing; it threw up mould on every side, and after passing through the soil, penetrated several inches deep into the solid chalk rock. It fell on the afternoon of a mild but hazy day, during which there was neither thunder nor lightning.[1]

One of the severest falls on record was that which happened in Normandy on April 26, 1803: (No. 34). It appears that, at about 1 o'clock in the afternoon, a very brilliant fire-ball was seen traversing the country with great velocity; and, some moments afterwards, a violent explosion was heard, which was prolonged for 5 or 6 minutes. The noise seemed to proceed from a small cloud which remained motionless all the time, but at a great elevation in the atmosphere; the detonation was followed by the fall of an immense number of mineral fragments, nearly 3000 being collected, the largest weighing 17½lbs. The sky was serene, and the air calm, an atmospheric condition that has frequently been noticed at the descent of aërolites.[2]

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[1] Howard, *Phil. Trans.*, vol. xcii. p. 174. 1802.

[2] A catalogue of 273 aërolites is given in Arago's *Ast. Pop.*, vol. iv. pp. 184–203, Fr. Ed.

CHAPTER II.

The Origin of Aërolites. — The Atmospheric Hypothesis. — The Volcanic Hypothesis. — The Lunar Hypothesis. — The Planetary Hypothesis. — The last named, probably the correct one.—Poisson's Theory.—Fireballs. —Arago's Table of Apparitions. — Summary of Measurements.

To account for the nature and origin of aërolites, the following hypotheses have been propounded: —

First.—It is supposed that the matter composing them has been drawn up from the surface of the Earth in a state of infinitely minute subdivisions, as vapour is drawn from liquids; that, being collected in clouds in the higher regions of the atmosphere, it is there agglomerated and consolidated in masses, and falls by its gravity to the surface of the Earth; being occasionally drawn from the vertical direction which would be imparted to it by gravity by the effect of atmospheric currents, and thus occasionally striking the Earth obliquely. We shall call this the *atmospheric hypothesis.*

Secondly.—It is supposed that meteoric stones are ejected from volcanoes, with sufficient force to carry them to great elevations in the atmosphere, in falling from which they acquire the velocity and force with which they strike the Earth. The oblique direction with which they strike the ground is explained by the supposition that they may be projected from the volcanoes at corresponding obliquities, and that, by the principles of projectiles, they must strike the Earth at nearly the same inclination as that with which they have been ejected. This we shall call the *volcanic hypothesis.*

Thirdly.—It has been suggested that the aërolites may be bodies which have been ejected from lunar volcanoes, with such a force that they may have departed from the Moon to a distance so great as to come within such a distance of the

Earth, that the terrestrial attraction exerted upon them predominating over that of the Moon, they may have either fallen down directly upon the Earth, or may have revolved round it in a curvilinear orbit, with a motion constantly retarded by the Earth's atmosphere, the consequence of which would be that they would continually approach the Earth, and at length fall upon its surface. We shall call this the *lunar hypothesis*.

Fourthly.—It has been supposed that aërolites are planetary bodies; that they revolve in orbits round the Sun; that these orbits intersect the annual path of the Earth; that when the Earth passes through the point of intersection of its path with their orbits, they either encounter it directly, and fall upon its surface, or, entering its atmosphere, are rapidly retarded by the resistance of that fluid, and are then drawn to the surface by the terrestrial attraction. This may be termed the *planetary hypothesis*.

In a popular sketch like the present, it is of course impossible to adduce all the arguments that have been brought forward in support of and in opposition to the above theories; we shall therefore pass on, merely remarking that the 4th on the list seems fairly to represent the case, and is the explanation very generally adopted by men of science at the present day. The periodicity before alluded to also seems to countenance this opinion. The luminous appearance which attends their progress has been accounted for by supposing that their rapid motion so condenses the atmospheric air lying in their path, that it either itself becomes luminous, or acquires so intense a heat as to render the stone incandescent. This surmise is supported by the well-known experiment of the fire syringe. M. Poisson, the eminent French geometer, has suggested that there exists above the atmosphere, a layer, as it were, of electricity, and that the friction caused by the passage of the aërolite is such as to decompose the electric fluid, and thus produce a kind of spark, as occurs in the case of an electric machine.[1]

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[1] *Recherches sur la Probabilité des Jugements*, p. 6. Paris, 1837.

Fireballs appear to hold an intermediate position between aërolites and shooting stars. They appear suddenly, and after exhibiting a brilliant flame of light for a few seconds, as suddenly vanish. Their form is generally circular, or slightly oval, and of a perceptible magnitude. Not unfrequently they leave behind them a train of sparks, their own illuminating power being somewhat more feeble than that of the Moon. Sometimes they explode into fragments, which continue their course, or are precipitated, as we have already seen, upon the surface of the Earth in the form of aërolites.

If we classify the apparition of all the fireballs the dates of which are known, we find, according to Arago, that their number amounts to 813, distributed as follows: —

January	55	305	July	74	508
February	57		August	123	
March	48		September	64	
April	52		October	77	
May	50		November	90	
June	43		December	80	

Thus showing that the periodicity which prevails with the aërolites, also obtains with the fireballs, only in a much more marked manner.

Of the above 813 fireballs of which we possess any recorded account, 35 only, gave rise to aërolites the fall of which was actually witnessed. Small though this proportion undoubtedly is, yet we cannot but consider these 2 classes of phenomena to be intimately associated. It is, however, true, that cases have been known in which aërolites have fallen, which were not preceded by any luminous exhalation: an instance occurred on September 16, 1843, at the fall of the great aërolite of Kleinwenden.[1]

Many fireballs have been submitted to measurement as regards their size and distance, but, owing to the very sudden appearance, and in general the short visibility of these bodies, it seldom happens that the observer is able to attain to any

[1] *Compt. Rend.*, vol. xxv. p. 627.

great precision. The following results must, therefore, be received with caution : —

1. As to the height at the instant of apparition.

Greatest known.	Miles.	Least known.	Miles.
1844 October 27 . .	318·1	1846 March 21 . .	7·5
1718 March 19 . .	297·5	1852 April 2 . . .	10·0
1842 June 3 . . .	184·0	1754 August 15 . .	15·0

2. As to absolute diameter.

Greatest known.	Feet.	Least known.	Feet.
1841 August 18 . .	12,795	1852 April 2 . . .	105
1718 March 19 . .	8,399	1846 July 23 . . .	321
1837 January 4 . .	7,216	1850 July 6 . . .	705

3. As to velocity per second.

Greatest known.	Miles.	Least known.	Miles.
1850 July 6 . . .	47·22	1718 March 19 . .	1·67
1844 October 27 . .	44·74	1807 December 14. .	2·80
1842 June 3 . . .	44·74	1676 March 31 . .	3·11

It is desirable to remark, that the axial rotation of the Earth at any point situated on the terrestrial equator is 1524 feet per second, and that the Earth's orbital motion is 18·89 miles. We see, moreover, that the velocity of many of these fireballs is greater than that of any of the planets ; it is also worthy of mention that the general direction of their motion is contrary to that of the Earth.[1]

[1] A catalogue of 854 fireballs is given in Arago's *Ast. Pop.*, vol. iv. pp. 230–279, Fr. Ed.

CHAPTER III.

Shooting Stars.—Have only recently attracted Attention.—To be seen in greater or less Numbers almost every Night.—Tabular Summary of the Results of the Observations of Coulvier-Gravier, Saigey, and Schmidt.—Early Notices of Meteoric Showers.—Shower of 1799.—Showers of 1831, 2, and 3.—The Meteors of 1833 divided into 3 Groups.—Table of Apparitions.—Singular Result.—Olmsted's Theory.—Herschel's Theory.

Shooting stars, although noticed in former times, have only within the last half century attracted any particular attention. This branch of the science may therefore be considered to be, comparatively, in its infancy. We must possess a long and carefully made series of observations before we are likely to be acquainted, with any degree of precision, with the physical nature of these objects. They were formerly considered to be merely atmospheric meteors, caused by the combustion of inflammable gases. This opinion has, however, now lost much, if not all, of its force, and they are now recognised as bodies which, although they become inflamed on coming in contact with the Earth's atmosphere, yet have their origin far beyond it.

It is now an established fact, that there is no night throughout the year on which shooting stars may be not seen; and that, on an average, from 5 to 7 may be noticed on a clear night every hour. These occasional meteors may be termed sporadic, in contradistinction to those swarms which appear at certain times of the year, and which are periodic. There is, moreover, an *horary* variation in their number, and the maximum occurs at 6 P.M., the mean at midnight, and minimum at 6 A.M., as shown by the following table[1]:—

[1] *Month. Not.* R. A. S., vol. xvii. p. 47.

Hours P.M.	6-7.	7-8.	8-9.	9-10.	10-11.	11-12.
Mean no. of meteors .	3·3	3·5	3·7	4	4·5	5

Hours A.M.	12-1.	1-2.	2-3.	3-4.	4-5.	5-6.
Mean no. of meteors .	5·8	6·4	7·1	7·8	8	8·2

If we designate the numbers coming from the N. E. S. W. by those letters respectively, we find E. > 2 W.; N. = S. nearly, and that E. + W. = N. + S.

The following table contains the monthly mean of the hourly number of shooting stars as assigned by 3 eminent continental observers[1] : —

	MM. Coulvier-Gravier and Saigey.		M. Schmidt.	
January	... 3·6	3·4	... 3·4	4·0
February	... 3·7		... ?	
March	... 2·7		... 4·9	
April	... 3·7		... 2·4	
May	... 3·8		... 3·9	
June	... 3·2		... 5·3	
July	... 7·0	8·0	... 4·5	4·7
August	... 8·5		... 5·3	
September	... 6·8		... 4·7	
October	... 9·1		... 4·5	
November	... 9·5		... 5·3	
December	... 7·2		... 4·0	

Notwithstanding the discordances in the above results, both tables agree in showing that there are more shooting stars in the 2nd than in the 1st half of the year, a coincidence which we have already seen holds good both with aërolites and fireballs. This has also been confirmed by the observations recorded in the Chinese annals.

[1] Quoted in Arago's *Pop. Ast.*, vol. ii. p. 505, Eng. Ed.

We now come to speak of the well-known and very beautiful showers of shooting stars seen at certain seasons in such great abundance. One of the earliest notices we find in history of this phenomenon is by Theophanes the Byzantine historian, who relates that, in November, 472 A.D., the sky at Constantinople appeared to be on fire with flying meteors. Condé, in his history of the dominion of the Arabs, speaking of the year 902 A.D., states that in the month of October, on the night of the death of King Ibrahim-Ben-Ahmed, an immense number of falling stars were seen to spread themselves over the face of the sky like rain, and that the year in question was thenceforth called the "Year of Stars." In some Eastern Annals of Cairo, it is related that, "In this year, in the month Redjet [August, 1029] many stars passed, with a great noise, and brilliant light;" and in another passage it says, "In the year 599, on Saturday night, in the last Moharrun [October 19, 1202], the stars appeared like waves upon the sky, towards the east and west; they flew about like grasshoppers, and were dispersed from left to right; this lasted till daybreak: the people were alarmed." It is also recorded that a remarkable display took place in England and France on April 4, 1095. The stars seemed "falling like a shower of rain from heaven upon the Earth," and an eye-witness, having noticed where an aërolite fell, "cast water upon it, which was raised in steam with a great noise of boiling." In the Chronicle of Rheims, we read that the stars in heaven were driven like dust before the wind, and Rastel says that, "By the report of the common people in this kynge's time [William II.,] divers great wonders were sene: and therefore the kynge was told by divers of his familiars that God was not content with his lyvyng; but he was so wilful and proud of mind, that he regarded little their saying."

In modern times, the earliest shower of falling stars of which we have any detailed description is that of November 13, 1799, visible throughout nearly the whole of North and South America. It was seen in Greenland by the Moravian missionaries. Humboldt, then travelling with M. Bonpland, in South America, says:—"Towards the morning of the 13th, we witnessed a most extraordinary scene of shooting meteors. Thousands of bodies and falling stars succeeded each other during 4 hours. Their direction was very regular from north to south. From the beginning of the phenomenon there was not a space in the firmament equal in extent to 3 diameters of the Moon, which was not filled every instant with bodies or falling stars. All the meteors left luminous traces, or phosphorescent bands behind them, which lasted 7 or 8 seconds." Mr. Ellicott, an agent of the United States, at sea in the Gulf of Mexico, thus describes the scene: — "I was called up about 3 o'clock in the morning, to see the shooting stars, as they are called. The phenomenon was grand and awful. The whole heavens appeared as if illuminated with sky-rockets, which disappeared only by the light of the Sun after daybreak. The meteors, which at any one instant of time appeared as numerous as the stars, flew in all possible directions, except from the Earth, towards which they were all inclined more or less; and some of them descended perpendicularly over the vessel we were in, so that I was in constant expectation of their falling on us." The same observer also states that his thermometer suddenly fell 24°, and the wind changed from S. to N. W., whence it blew with great violence for 3 days. Meteoric showers were also witnessed in North America, in the years 1814, 1818, and 1819.

Fine meteoric displays took place in 1831 and 1832, in both cases on November 13. Captain Hammond, of the ship "Restitution," then in the Red Sea, off Mocha, thus describes the latter: — "From 1 o'clock A.M. till after daylight, there was a very unusual phenomenon in the heavens. It appeared like meteors bursting in every direction. The sky at the time was clear, the stars and Moon bright, with streaks of light and thin white clouds interspersed in the sky. On landing in the morning, I inquired of the Arabs if they had noticed the above. They said they had been observing it most of the night. I asked if ever the like had appeared before. The oldest of them replied that it had not." This shower was seen from Arabia, westward to the Atlantic, and from the Mauritius to Switzerland.

By far the most splendid display of shooting meteors on record was that of November 13, 1833, and one which, from its recurring after so exact an interval of time, served to point out a periodicity in the phenomenon. It seems to have been visible over nearly the whole of the northern portion of the American continent, or, more exactly, from the Canadian lakes nearly to the equator. Over this immense area a sight of the most imposing grandeur seems to have been witnessed. The phenomenon commenced at about midnight, and was at its height at about 5 A.M. Several of the meteors were of peculiar form and considerable magnitude. One was especially remarked from its remaining for some time in the zenith over the falls of Niagara, emitting radiant streams of light. In many parts of the country the population were terror-struck by the beauty and magnificence of the spectacle before them. A planter of South Carolina thus narrates the effect of the phenomenon on the minds of the ignorant blacks: — "I was suddenly awakened by the most distressing cries that ever fell on my ears. Shrieks of horror and cries for mercy, I could hear from most of the negroes of the 3 plantations, amounting in all to about 6 or 8 hundred. While earnestly listening for the cause, I heard a faint voice near the door calling my name. I arose, and, taking my sword, stood at the door. At this moment, I heard the same voice still beseeching me to rise, and saying, 'O my God, the world is on fire!' I then opened the door, and it is difficult to say which excited me the most — the awfulness of the scene, or the distressed cries of the negroes. Upwards of 100 lay prostrate on the ground — some speechless, and some with the bitterest cries, but with their hands raised, imploring God to save the world and them. The scene was truly awful; for never did rain fall much thicker than the meteors fell towards the Earth; east, west, north, and south, it was the same." [1]

The meteors of which the above shower was composed, seem to have been seen of 3 different kinds: —

1. Phosphoric lines, apparently described by a point. These

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[1] Quoted in Milner's *Gallery of Nature*, p. 140.

were the most abundant; they passed along the sky with immense velocity, as numerous as the flakes of a sharp snow storm.

2. Large fireballs, which darted forth at intervals across the sky, describing large arcs in a few seconds. Luminous trains marked their path, which remained in view for a number of minutes, and in some cases for half an hour or more. The trains were commonly white, but the various prismatic colours occasionally appeared, vividly and beautifully displayed. Some of these fireballs were of enormous size; indeed, one was seen larger than the Moon when full.

3. Luminosities of irregular form, which remained stationary for a considerable time. The one mentioned above as having been seen at the falls of Niagara was of this kind.[1]

For the last 25 years, the month of November has been distinguished by an unusual number of shooting stars; but none of the showers have ever equalled the one we have just described.

Subdividing the showers of shooting stars according to the month of the year, we obtain the following results: —

January	10	55	July	14	163
February	10		August	56	
March	12		September	19	
April	17		October	13	
May	4		November	29	
June	2		December	17	

We thus find, and it is worthy of especial remark, that the coincidence we have already pointed out in the case of aërolites, fireballs and sporadic meteors also obtains with the showers of shooting stars — namely, that the Earth encounters a larger number of these bodies in passing from aphelion to perihelion, or from the summer to the winter solstice, than in passing from perihelion to aphelion, or from the winter to the summer solstice.[2]

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[1] Quoted in Milner's *Gallery of Nature*, p. 141 (abridged).

[2] A catalogue of 221 meteoric showers is given in Arago's *Ast. Pop.*, vol. iv. pp. 292–314. Also a catalogue, extending from 538–1223 A.D., by Chasles, in *Compt. Rend.*, vol. i. pp. 499–509. 1841.

Professor Olmsted, of Yale College, U. S., has proposed the following theory, to account for the above phenomena:— That the meteors of November 13, 1833, emanated from a nebulous body, which was then pursuing its course, along with the Earth, around the Sun; that this body continues to revolve around the Sun in an elliptic orbit, but little inclined to the plane of the ecliptic, and having its aphelion near the orbit of the Earth; and, finally, that the body has a period of nearly 6 months, and that its perihelion is a little within the orbit of Mercury.[1]

The following summary, useful for amateur observers, is by Arago.

January.—It would seem from the recorded results, that we may look for a period of shooting stars somewhere about January 1—4.

February.—Modern observations do not indicate a period of shooting stars for February. The ancient showers of meteors, announced for this month by the chroniclers, seem to have failed for the last 8 or 9 centuries.

March.—Shooting stars have been perceived from time to time in this month.

April.—Apparitions of shooting stars are somewhat more numerous in this month than in the 3 preceding. We may look for them about April 4—11, and 17—25.

May.—Shooting stars are rare in May.

June.—Shooting stars are *very* rare in June.

July.—The apparitions of showers begin now to increase in number. We may expect them about July 26—29.

August.—Shooting stars are, as is well known, seen in great abundance in this month, particularly about August 9—11.

September.—Shooting stars are somewhat rare in September. We may, however, mention September 1 ±, and September 18—25 as possible periods.

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[1] See Olmsted's theory, given in full in his *Mechanism of the Heavens*, pp. 329–341. Edin. Ed.

October.—Shooting stars occur about the middle of the month.

November.—Shooting stars, in past years, have appeared in remarkable numbers about November 11—13; but they are now less abundant than formerly.

December.—Showers of shooting stars may be looked for about December 5—15.

With reference to the periodicity Sir J. Herschel says: "It is impossible to attribute such a recurrence of identical dates of very remarkable phenomena to accident. Annual periodicity, irrespective of geographical position, refers us at once to the place occupied by the Earth in its annual orbit, and leads directly to the conclusion, that at that place it incurs a liability to *frequent* encounters or concurrences with a stream of meteors in their progress of circulation around the Sun. Let us test this idea, by pursuing it into some of its consequences. In the first place, then, supposing the Earth to plunge in its yearly circuit, into a uniform ring of innumerable small meteoric planets, of such breadth as would be traversed by it in one or two days; since, during this small time, the motions, whether of the Earth or of each individual meteor, may be taken as uniform and rectilinear, and those of all the latter (at the place and time) parallel, or very nearly so, it will follow that the relative motion of the meteors, referred to the Earth as at rest, will be also uniform, rectilinear, and *parallel.* Viewed, therefore, from the centre of the Earth (or from any point of the circumference, if we neglect the diurnal velocity, as very small compared with the annual), they will all appear to diverge from a common point, *fixed in relation to the celestial sphere*, as if emanating from a sidereal apex.

"Now this is precisely what happens. The meteors of the 12th—14th of November, or at least the vast majority of them, describe apparently arcs of great circles, passing through or near γ Leonis. No matter what the situation of that star, with respect to the horizon or to its east and west points, may be at the time of observation, the paths of the meteors all appear to diverge from that star. On the 9th—11th of

August, the geometrical fact is the same, the apex only differing; B Camelopardi, being for that epoch, the point of divergence. As we need not suppose the meteoric ring coincident in its plane with the ecliptic, and as for a *ring* of meteors we may substitute an elliptic annulus of any reasonable eccentricity, so that both the velocity and direction of each meteor may differ to any extent from the Earth's, there is nothing in the great and obvious difference *in latitude* of these apices at all militating against the conclusion.

"If the meteors be uniformly distributed in such a ring or elliptic annulus, the Earth's encounter with them in every revolution will be certain, if it occur once. But if the ring be broken—if it be a succession of groups revolving in an ellipse in a period *not* identical with that of the Earth, years may pass without a rencontre; and when such happen, they may differ to any extent in their intensity of character, according as richer or poorer groups have been encountered.

"No other plausible explanation of these highly characteristic features (the annual periodicity and divergence from a common apex, *always alike for each respective epoch*) has been ever attempted, and, accordingly, the opinion is generally gaining ground among astronomers, that shooting stars belong to their department of science, and great interest is excited in their observation, and the further development of their laws." [1]

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[1] *Outlines of Ast.*, p. 661.