Home College Series.

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# COMETS.



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J. H. VINCENT.

NEW YORK, *Jan.*, 1883.

# COMETS.

The mysterious bodies called comets possess attractions that invest the study of astronomy with increasing interest. These bodies, from heights immeasurable, or from depths unfathomable, rush into view with a velocity of speed so great as, in many instances, to baffle calculation; and then dash away again at nearly the same rate of speed, to thus traverse the regions of space through thousands of years. Comets owe their existence, motion, and continuance to the same causes, and are subject to the same general laws as the planets. Unlike the planets, however, they are bodies of extreme lightness, small attractive power, little disturbing influence; and of such strange behavior as to almost defy calculation.

## I. General View of Comets.

The movements of these fiery-visaged strangers are the subject of great interest and close study. They have orbital motions, ranging from less than that of the earth to more than fifty times as great as Neptune. The rate of motion varies greatly at different points in the orbit of a comet. Nearest the sun it reaches the highest rate of speed. At one period it comes so near that body that it seems about rushing into it; at another time it is so remote it would seem to be forever beyond the reach of its attractive power, and could never be brought back to feel its scorching heat. The extreme point in the orbit of the comet of 1680 is estimated to be twenty-eight times the distance of Neptune, the outermost planet of our solar system, or seventy thousand millions of miles distant from the sun. Without any warning, this body of ghostly light came, suddenly sweeping down upon us from the heights above, almost in a perpendicular line to the sun; and, approaching within about one

The motion of comets.

hundred thousand miles of that body, swept around it with the startling velocity of ten hundred thousand miles an hour! The comet of 1843 attained the terrific speed of one million miles an hour as it wheeled around the sun. It approached so near as to almost graze the luminary of day. Its temperature was estimated to be forty-seven thousand times greater than the fiercest heat of the torrid zone! The heat received from the sun by the comet of 1680 was estimated, from a careful calculation made by Sir Isaac Newton, to be two thousand times hotter than red-hot iron!

Just here the question arises, How can a body subjected to such excessive heat escape being entirely consumed? That comets survive exposure to an enormously high temperature, approach so near with such great velocity, and yet do not plunge into the sun, adds no little to the difficulty of explaining their mysterious character.

Peculiar form of orbits.

One rate of speed on the curve around the sun indicates an oval-shaped orbit or path. Comets having this elliptical orbit return again and again, revolving around the sun in various periods of time, according to their distance from that body. Still greater velocity may indicate a parabolic (a wider) or a hyperbolic (a still wider) curve, precluding the possibility of return. Such comets evidently can only rush down upon us, or up to us, and dash rapidly around the sun, and then off into infinite space, never to return. Therefore certain comets are but transient visitors, many of which necessarily come and go without recognition by us. The attraction of planets may either so accelerate or so retard the speed of a comet as to change its orbit from elliptical to parabolic, or from parabolic to elliptical. But in any case only a very small part of its orbit can be studied by us, since the comet can be seen only when near the sun. Many, by reason of their dimness and small size, must entirely escape our notice. No doubt the greater number of these bodies are invisible to

Why are no more comets seen?

us because they come and go during the day and moonlight nights. Because so rarely seen, the general supposition is that there are but few comets in existence. The contrary is true. Like that of meteors, the number is exceedingly large. No doubt they are the most numerous of all the heavenly bodies. During the Christian era upward of five hundred have been seen by the unaided eye. The telescope from the time of its invention has revealed two hundred more. Taking these figures, and making due allowance for those escaping our notice, those belonging to our solar system must, unquestionably, be numbered by millions. Arago, the eminent astronomer of France, places the number at more than seventeen millions. Lambert, of the same country, says they can number no less than five hundred millions. Prof. Peirce says more than five thousand millions

Immense number of comets.

## II. The Train of Comets.

By far the larger number of comets have no trains, and are too faintly luminous to be often seen without a telescope. These are divided into two classes: those without a nucleus, but of uniform density throughout their whole mass; and those having a nucleus or head, which is the brightest and most condensed part of the comet. Comets of this latter class are often of vast magnitude, but of extreme lightness, and having but a small quantity of matter, as compared with their bulk. Comets having a train accompanying the main body constitute a third class. It is only the members of this latter class that are generally seen by the unaided eye. The hair-like appearance of the train procured for these bodies the name "comet," from the Greek word "coma," meaning *hair*. These trains are really most wonderful. The closest and most careful investigations with our improved astronomical instruments, while definitely settling some points, have, in the main, deepened our desire to know, and yet fallen short of perfectly satisfactory results. However, with the

data at hand, an interesting and far from profitless study may be made of their composition, rapidity of formation, length, and number, or divisions. The train of a comet does not always remain single, but frequently separates into two, three, or more tails. The comet of 1744 had its fan-shaped train separating into six streamers. Its edges were very bright, while the middle was of fainter light. Altogether it presented a most beautiful and magnificent appearance. The one which so terrified Pope Calixtus in 1456 had a train curved like a cimeter, or rather like the graceful form of an ostrich feather. It was this pope who gave to the Roman Catholic Church the prayer, "Lord, save us from the devil, the Turk, and the comet." A great victory was claimed for the powerful pope, when the comet, which had been duly anathematized and excommunicated, began to recede, and soon disappeared.

Number of trains.

In 1825 a comet appeared which was visible for the unusual period of one year. Its time of revolution is supposed to be not less than four thousand years. Its train separated into five distinct parts, spreading out to an immense distance, and covering a large part of the heavens. The colors of these parts were variable, producing the most striking effects. Perhaps the most marvelous feature of these strange bodies is the fact of cometary matter streaming out to such enormous lengths, and yet remaining in actual connection with the comet. Their measurement is no mere matter of conjecture. Because of their size and distinctness, a good degree of accuracy may be realized. A most brilliant comet appeared in 1769, which passed within two millions of miles of the earth. This beautiful comet, moving with immense swiftness, was seen in London; its tail stretched across the heavens, like a prodigious, luminous arch, thirty-six millions of miles in length. The computed size of that which appeared in 1811, and which was so remarkably conspicuous, was, on October 15, according to

Length of trains.

Dr. Herschel, fifteen millions of miles at its greatest breadth, and at the same time one hundred and thirty millions of miles in length. This comet far outrivaled the brilliant comet of 1858, (Donati's,) that was forty millions of miles in length; and was surpassed in turn by the overwhelming splendors of the comet of 1843. "A fine drawing of this comet, as seen March 3, 1843, by C. Piazzi Smyth, Esq., at that time assistant astronomer at the Cape of Good Hope, now Astronomer Royal for Scotland, represents the train as highly symmetrical, giving the idea of a vivid cone of light, with a dark axis, and nearly rectilinear sides, inclosed in a cone somewhat fainter, the sides of which were bent slightly outward." The train of this amazing body streamed off to the distance of two hundred millions of miles. "It was of sufficient length to reach from the earth to the sun and back, again from the sun to the earth, and nearly twenty millions of miles over. It would have girdled the earth at the equator no less than eight thousand times." The great comet of 1861 was first seen by Mr. Tebbutt, at Sidney, in Australia, May 13; by M. Goldschmidt and others, in France and England, on June 29 and 30. The nucleus was about four hundred miles in diameter, with a long, bush-like tail, traveling at the rate of ten millions of miles in twenty-four hours. On June 30 it was suggested that we were in the tail, there being a phosphorescent, auroral glare.

M. Babinet, on May 4, 1857, affirmed that comets had so little density that the earth might pass through the tail of one without our being aware of it. It is a wonderful fact that matter so thin, thinner by far than the thinnest mist, should be able to sustain any connection with the main body of the comet, as in the case of that of 1843, at the incredible distance of two hundred millions of miles. But the wonder increases as we learn the fact, that this same matter of exceeding thinness keeps pace with the nucleus or head itself as it wheels with the frightful velocity of one million miles

an hour around the great solar orb, to sweep into the infinite heights above, or to plunge into the depths of space below.

Rapidity of formation.

Another interesting feature of these trains is seen in the rapidity of their formation. It required but two days for the comet of 1680, which terrified the people with its near approach to the earth, to send out a train sixty millions of miles in length. In less than twenty days that of 1843 produced the enormous train of two hundred millions of miles. As might be expected,

How and of what produced?

the questions, of what material are these trains composed? and how are they formed? have excited great interest, and served to stimulate investigation. It is now generally conceded that the trains are of the same material as the nucleus or head of the comet. In reaching this result the larger telescopes have played a not unimportant part; but the most valuable service has been rendered by that modern wonder of constructive genius, the spectroscope. Through its aid these mysterious wanderers come to be known as largely gaseous bodies, having trains also of gaseous matter, only less dense than the body of the comet. This much is certain; but the nature of this matter or gas we cannot always determine. We have already referred to its extreme thinness. It is so transparent that through thousands of miles of cometary matter the faintest star may be seen. What can it be? A very little of the cloudy vapor from water obscures the vision. Hydrogen gas is too heavy and dense, though it is sixteen times as light as air. We are certainly not familiar with all the conditions of matter, since none of those with which we are acquainted serve to explain fully the ethereal, and we might almost say spiritual, form it assumes in comets. It has been claimed that Prof. Peirce has demonstrated "that the nucleus of the comets of 1680, 1843, and 1858 must have had a tenacity equal to steel to prevent being pulled apart by the tidal forces caused by its terrible sweep around the sun." The head of the comet of

1843 was diminished by the manufacture of a train. In certain instances an appreciable diminution in the size of trains has been discovered at successive returns. This indicates condensation or loss. The theory that these bodies, as the spectroscope indicates, are mainly gaseous, would permit cometary matter to be vaporized and driven off by the sun, as steam from a locomotive. But if wholly gaseous, would not comets be entirely dissipated when subjected to such intense heat from the sun, while under no form of compression other than its own? Therefore, we hold comets to be composed of both gas and small masses of matter, more or less of a liquid condition, and affording sufficient attraction to maintain their unity, though suffering some loss by vaporization when nearest the sun, and by attraction when nearest the planetary bodies. A comet, first examined in 1818 by Encke, was identified by him with the one seen in 1805, 1795, and 1786. Its return has been observed ever since at periods of $3\frac{3}{10}$ years. This comet is celebrated for having revealed, as many astronomers think, the existence of a resisting medium in the interplanetary spaces. Herschel and others dissent from this view of Encke, and attribute the change in the comet's motion to the gradual loss of its tail. The motion of a comet's train is peculiar. The nucleus obeys the law of gravity, apparently uninfluenced by this peculiar motion. The material of the train first moves toward the sun, and is then repelled from it. This evident polarity leads to the natural conjecture that the train is due largely, if not entirely, to electricity. Electricity is generated by heat; it is also produced by friction. The accumulations of electric force on the sun must be inconceivably great. It must be so, because of a temperature there so high as to be without a parallel. It could not be otherwise, from the enormous friction of its ceaselessly raging elements on such a stupendous scale. This electricity, by a process called induction, passes to other

Planetary bodies affected by the electricity of the sun.

bodies more or less remote. The electric throbs of this great heart of the solar system are felt throughout all its parts. Our globe is no exception, and doubtless many of its phenomena may be traced to this source.

In the absence of thunder-storms, and indeed of all ordinary electrical phenomena, electric currents have been known to sweep over the entire surface of the earth, and so as to seriously impede telegraphic operations. This is usually said to take place at the period of the greatest number of "sun spots," which is naturally supposed to be the period of the greatest activity of the solar forces. We find a probable explanation of the peculiar motion of trains in the powerful electrical influence which the sun exerts in a great degree upon the comets, no less than upon the planets. In this explanation we are also largely helped toward the solution of other problems concerning comets. To possess the key to cometary mysteries we must understand somewhat of the sun's electrical influence over comets. To do this we must bear in mind the twofold property of electricity; namely, its attractive and repelling force. Bodies charged with like electricities repel each other; but when with unlike they will attract. The superior attractive power of gravitation resident in the sun draws the comet to him with ever-increasing velocity, until it is at perihelion—nearest the sun—when, from some cause, it begins and continues to recede with a velocity ever growing less and less. The comet's retreat is due to the repellant power of like electricities in the two bodies. The nearer the comet's approach to the sun the greater the quantity of electricity, generated by the sun's heat, upon the surface of the comet. At perihelion the repellant force of these similarly charged bodies has reached such a degree, with the increase of electricity on the comet, as to overcome, measurably, the power of gravitation, and the comet sweeps off again into space, never to return, unless the attractive power overcomes the

The electrical influence of the sun on comets.

ever-waning repelling force. The comet's train is due to this electrical repulsion. The lighter portions of cometary matter are driven off by this repelling force in a continuous and ever-growing train as it nears the sun. When at perihelion the train is fully developed, and remains so until, in receding from the solar center, it decreases as rapidly as it developed in its approach. Although trains have been seen at right angles to the line of motion, generally they are turned from the sun, whether the comet is approaching or retreating. This fact is an important one to the theory of electrical repulsion. The projections seen in some instances in front and at the sides of the comet, similar to the train itself, is probably produced by the electricity of the comet. This electricity, generated by the intense heat of the sun, throws off portions of the comet's more attenuated or thinnest matter, producing a hairy or brush-like appearance in the front of the body, and around the whole nucleus. The important part played by electricity in cometary phenomena is further established by the following considerations: The Aurora Borealis, or Northern Lights, are confessedly occasioned by electricity. Though not so marked, yet very similar to the Boreal phenomena, are the tremulous vibrations of light, and slight changes of color, that may sometimes be seen throughout cometary trains. In addition to this, the magnetic needle was greatly agitated on the appearance of the famous comet of 1843. The property of the magnetic needle, causing it to point to the north, comes from the currents of electricity which girdle the globe from west to east. Any natural disturbance of this needle, coming from a source outside of the earth's surface or in the atmospheric regions, we may be sure is due to electricity. Therefore, the disturbance of this needle by the appearance of this comet and its enormous train favors the already well-supported theory, that electricity was largely instrumental in developing this long

Additional evidence of electricity in comets.

appendage; and, as a subtle, mysterious fluid, pervaded the whole wondrous length of that train. It afforded more than a show of reason for the supposition that this "same subtle fluid had power to leap in an instant, as it were, across the mighty chasm between the comet and the earth, and make itself seen and felt all over the surface of our own vast globe, and doubtless on every other globe belonging to our family of worlds. What a wonderful creature of the great Creator is this invisible fluid we call electricity!" In the display of its amazing power we are led to marvel at the still more astounding power involved in its creation. It is folly to suppose it the mere product of chance. To say that it produced itself is to rave with hopeless madness. In the existence, wisdom, and power of God—the underived great First Cause —only can we account for this as well as other great and mysterious forces of both the universe of matter and the universe of mind.

## III. The Relations of Comets.

Is danger to be apprehended from comets?

Formerly comets were regarded as the forerunners of great events, and more particularly of great calamities. The ignorant masses, and even some of the learned, as in the case of Pope Calixtus, were in a remarkable degree the victims of superstitious terror on the appearance of a comet. Even to this day they still produce intense excitement among savage tribes, being looked upon as precursors of famine, pestilence, and wasting war. "They sometimes call them 'the spirits of the stars,' and employ various means to prevent the evil they are supposed always to bring—wildly and violently gesticulating toward the unwelcome visitor with fierce threats and fiercer expression of countenance, while they shoot arrows and dart javelins and hurl huge stones at the much-dreaded comet, hoping to avert the threatened danger."

Among more intelligent people of modern times superstí-

tious fear finds no place; but the danger of a comet's collision with the earth has been seriously considered. In 1832 some of the people of Paris were almost frantic with excitement in consequence of the prediction that the comet "Biela" of that date would come in contact with and destroy the earth.

At the instance of the Government the French Academy of Science carefully estimated the chances of collision between our globe and these apparently lawless wanderers. The report made by the great French astronomer Arago was that out of 281,000,000 of chances there was only one single chance for a collision. This amounts to but little more than a bare possibility. Should a collision take place, evil results might or might not follow. If the nucleus encountered was in mass and solidity equal to that of Donati's comet, as estimated by M. Faye and Prof. Peirce, "its impact with the earth would develop heat enough to melt and vaporize the hardest rocks." If the comet were composed of small meteoric particles, the result would be a brilliant shower, exceeding such showers as we have seen only in degree. Were the colliding body a hydrogen comet of sufficient size to encompass the entire globe, it might so mingle with the oxygen of our atmosphere as to form such an explosive compound that the lighting of a single match would produce a mighty flame which, in an instant, would consume every living thing on the surface of the earth. Still further, since water is the result of burning hydrogen gas in oxygen, this same fierce and terrible flame would be as speedily followed by a mighty deluge of water, enveloping the entire surface of our planet. If the body of the comet were not of an inflammable nature, but composed of noxious gases, it would poison our atmosphere, render it unfit for respiration, and thereby entail the most serious consequences. Were it an innoxious gaseous body, owing to its extreme lightness it would float in or upon our atmosphere as do the clouds, without reaching the surface of our globe.

It has been affirmed that the earth passed through the tail of the comet of 1861, a peculiar phosphorescent mist being the only observable effect. The comet of 1779 was diverted from its course by the four moons of Jupiter, and though carefully sought for it has never since that been seen. So little attracting power did this comet exert that the moons were not perceptibly effected, and continue in their old paths. Hence it is possible the small quantity of matter contained in this comet was so powerfully attracted by these moons of Jupiter as to be drawn quite to, and become an atmosphere for, one or more of these globes. It is, at least, a plausible conjecture that our planet is indebted for its atmosphere to some comet or comets of the remote past. "It is possible that the air we now breathe, and which gently fans our fevered brows, comes to us laden with so many rich and delicate perfumes from the flowers of spring, it is possible that this same air was once careering wildly through the vast abysses of space, a raging comet, attracting the wondering gaze of millions of inhabitants of other world." So far as we know, our world has not as yet suffered from these flaming sky-wanderers. An almighty and beneficent Creator upholdeth all things by the word of his power, and can, and no doubt does, compel these bodies of threatening appearance to exercise a beneficial influence upon our planet. Certainly they serve a moral purpose by leading us to the contemplation of the boundless resources of our Creator. Possibly they supply our atmosphere with some necessary gaseous elements, which are consumed or absorbed in the support of animal or vegetable life. In No. 42 of this Series mention is made of the intimate relation of meteors to comets—a relation the most intimate as to origin, flight through space, and service to other bodies. It is a supposition, which has great show of reason, that comets and meteors probably furnish a portion of the fuel which aids in sustaining

Comet affected by Jupiter's moons.

A conjecture.

Utility of comets.

the heat of the sun. Meteors, owing to the superior attraction of the sun, doubtless fall more frequently into its atmosphere than into that of the earth. The fact of the decrease of the periodic time of certain comets looks toward their ultimate absorption in the sun. After revolving around him for thousands of years, comets may at last be drawn to his surface by his superior attraction overcoming his repelling force. Modern discoveries tend to fix upon the sun and the stars as the birthplaces for the comets. Origin of comets.

The projectile or volcanic force of the sun, and that of a similar nature, though even greater in degree, upon the stars, sends matter out into space so far that it may never return, since it comes immediately under the influence of the sun's electric or repelling force. The theory of solar and of stellar expulsion and repulsion is the most plausible one for the origin of comets.

Comets emit a great deal of light; but, after all, they are not self-luminous. Like the moon and the planets, they shine by the reflected light of the sun. As the comet changes its position around the sun, it exhibits phases similar to those of the moon as it revolves around the earth. If they shone by native light they would always appear the same, as does the sun. But at one time the comet appears in the form of a crescent; again as gibbous or bulging; and yet again as round or full. In the development of these phases, however, comets differ from the moon. This difference is determined by the moon always moving in a fixed orbit, while comets move in all conceivable directions —"now coming from the east and going to the west; from the north and going to the south; from the south and going to the north; and then dashing down from the heights above, or rushing up from the depths beneath, and thus reaching the sun from all points of the compass." Some of the comets known to us are remarkable for the long intervals between their appearances. These long periods The light from comets. Cometic periods.

from one visit to another are owing to the immense distances journeyed by them. This will be better understood if we recall to mind that the path or orbit traversed by a comet describes a very long oval-shaped figure. One end of this oval, in some instances, is only about one hundred thousand miles from the sun, while the other end is often many thousands of millions of miles distant in the opposite direction. Some comets visit us quite frequently. We have already spoken of the short period of Encke's comet. Biela's comet, which caused such fear in Paris, had a periodic time of six years and eight months. In January, 1846, it was observed to have separated into two parts of unequal brightness. When last seen in that year the parts were 200,000 miles asunder. At its next appearance they were 1,500,000 miles apart. It should have made three revolutions since that time, but no trace of it has been discovered since it vanished, in September, 1852. Donati's comet of 1858 is estimated to have a period of about 2,000 years. A period of 102,050 years is attributed to the comet of 1844. The comet of 1744 is said to have the longest period yet known to astronomers. It requires 122,683 years for this comet to make one revolution around the sun. We have already noticed the intense heat to which comets are exposed when nearest the sun. Must they not experience a corresponding extreme of cold when receding so far from the sun into the depths of space? The lowest temperature of our Arctic regions must be mild in comparison. Is it not possible that these bodies—thinner than the thinnest vapor known to us—are greatly condensed by this intense cold, perhaps even to solidification? Then, on again approaching the sun, they are once more converted into a gaseous condition.

Cometic extremes of heat and cold.

We are helped to, at least, a faint conception of the immensity of space from the mighty wanderings of comets. What unexplored regions of space must be visited by a comet, traveling

Ideas of space, repulsion, and attraction, obtained from these wanderers of the skies

all the time in nearly one direction from the sun, for upward of 60,000 years! How great must be the electric force of the sun to send this comet so far out into the dark abysses of space! What wonderful power of attraction is exerted by the great luminary of day to arrest this fugitive in his farther flight! This seemingly "lawless vagabond of the skies, apparently subject to no law, is, nevertheless, every moment of that flight feeling the strong grasp of its great Controller, standing majestically and blazing gloriously at the center of his great system, and at last this vagrant of the skies acknowledges his allegiance by turning back to its material lord, nor tarries in all the way until it has done its customary obeisance in his burning presence."

## NOTES.

"The laws of nature do not account for their own origin."—JOHN STUART MILL.

"It is certain that matter is somehow directed, controlled, and arranged, while no material forces or properties are known to be capable of discharging such functions."—LIONEL BEALE.

> "Science was Faith once; Faith were science now,
> Would she but lay her bow and arrows by,
> And arm her with the weapons of the time."—J. R. LOWELL.

"As we perceive the shadow to have moved along the dial, but did not perceive it moving; and it appears that the grass has grown, though nobody ever saw it grow; so the advances we make in knowledge, as they consist of such insensible steps, are only perceivable by the distance."

"Ignorance is the curse of God, knowledge the wing wherewith we fly to heaven."—SHAKESPEARE.

"The whole earth is but a single mote in the star-dust with which God's creative hand has strewn the skies."

"Overhead the countless stars
Like eyes of love were beaming,
Underneath the weary earth
All breathless lay a-dreaming."

"The twilight hours like birds flew by,
As lightly and as free;
Ten thousand stars were in the sky,
Ten thousand in the sea;
For every wave with dimpled cheek
That leaped upon the air,
Had caught a star in its embrace,
And held it trembling there."

"Flowers are stars wherein wondrous truths are made manifest."

"Thoughts which fix themselves deep in the heart, as meteor stones in earth, dropped from some higher sphere."

## COMETS.

[THOUGHT-OUTLINE TO HELP THE MEMORY.]

1. Laws by which Comets are governed? Motion of Comets? Peculiar form of orbits? When Comets are seen? Their number?
2. Nucleus? Train? Number of trains? Length of them? Illustrations? Theories about formation of trains? Electrical effects? Sun's influence? Disturbances on our Earth?
3. Danger? Arago's theory? Jupiter's moons? Atmospheric theory? Use of Comets? Periodical appearance? Extremes of heat and cold?

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