

## NEW LIGHT ON THE MYSTERY OF COMETS

BY J. V. NASH

THE nature and origin of comets has been until recently one of the unsolved mysteries of astronomy. In contrast with the planets, whose orderliness is one of their most distinguishing features, comets seemed to be strange and eccentric bodies with no definite place in the general scheme of the solar system.

Because of their unexpected appearances, suddenly blazing into view in the heavens and then mysteriously departing, comets were almost universally, until a few generations ago, and still are among primitive peoples, objects of superstitious terror. The coming of a comet into the heavens was held to portend calamity to men and nations. Comets were, in many cases, believed to be evil spirits prying around, above the earth, for the purpose of doing mischief.

For instance, in Shakespeare's *Julius Caesar* (act ii, scene 2), we find these lines:

“When beggars die, there are no comets seen ;  
The heavens themselves blaze forth the death of princes.”

Again, in *Paradise Lost*, Milton wrote :

“Incens'd with indignation Satan stood  
Unterrify'd, and like a comet burn'd  
That fires the length of Ophiuchus huge  
In th' arctic sky, and from his horrid hair  
Shakes pestilence and war.”

But at last the veil of mystery which surrounded comets has been, to a large extent, removed, and they have been revealed as very harmless objects, formed in a manner that is extremely simple, once it is understood.

As in the case of everything else in the universe, their history is explained on the basis of the principle of evolution. They are,

like the planets, children of the sun, but belong to a different solar family.

The late Dr. T. C. Chamberlin, in his fascinating book, *The Two Solar Families: The Sun's Children* (University of Chicago Press, 1928), published but a few weeks before his death, tells the story of the genesis of comets. It will be found fully set forth in Part III, "The Genesis of the Cometary Family."

"The comets," says Professor Chamberlin, "are relatively rare swarm-like assemblages of small units in very open arrangement, devoid of refraction, shrinking and expanding with approach to and retreat from the sun, and giving off minute particles and molecules under repellent action from the sun, forming spectacular tails. On the average, only about half a dozen come into sight yearly, and then promptly go out again."

In brief, the material of which comets are composed is erupted from the sun by the terrific storms which are continually occurring on the sun's surface. In some of these sun-storms, immense togues of flame are thrown half a million miles above the sun's disk. Some of this material, because of the violence of the eruption, escapes into interplanetary space and gathers into swarms of elemental stuff known as chondrulites. On approaching the outermost bounds of the solar system, they encounter the repulsion of radiation from the stars, and solar gravitation draws them toward the sun once more.

"The comets," Professor Chamberlin goes on to say, "usually shrink as they approach the sun, and expand again as they retire from it. This is so peculiar and distinctive a phenomenon as practically to demonstrate that the head is formed of small bodies in very slow revolution about their mutual center of gravity."

The general aspect of a comet is well known, since many of these celestial visitors are visible with the unaided eye. Indeed, before the invention of the telescope, in 1609, some 400 comets had been recorded. More than that number of comets have been observed by astronomers since then. With the powerful telescopic apparatus now available, it is possible to detect hundreds of comets otherwise invisible. Every year from three to ten are discovered in different parts of the heavens.

The composition of a typical comet is quite simple. It consists generally of a head with a bright, starlike nucleus, and a long, lu-

minous tail, always streaming out in a direction away from the sun and gradually fading into the darkness. When the comet is receding from the sun, the tail suggests the bright beams thrown forward by the headlight of a locomotive. Sometimes, especially in the case of a small comet, the nucleus and the tail may be absent, leaving only the head, with the appearance of a circular nebula.



GREAT COMET OF 1901—PHOTOGRAPHED IN SUMATRA

Comets vary greatly in size and in degrees of brightness. A very few are so bright that they can be seen in broad daylight, while others are barely visible at night with the aid of the largest telescopes. Notwithstanding the brightness of certain comets, the material of which they are composed is exceedingly rarefied. They are, in fact, almost transparent; so much so, that faint stars are visible through them.

Until about 240 years ago, the movements of comets were a puzzle even to the greatest scientists. Doerfel, in 1681, was the first to discover that comets move in parabolas, with the sun as a focus. The great Newton devised, a few years later, a method

for computing the orbits of comets. The problem has been the subject of calculations by others since then; at the present time the orbit of a comet can often be computed with much exactness. Some four hundred have been carefully worked out, and it has been shown that the great majority of them are essentially parabolic, though some are elliptical in shape.

Comets are now recognized as permanent members of our solar system, instead of visitors from outer space, as many heretofore inferred. The point where a comet passes round the sun is called its perihelion. One or two comets have been seen to graze the sun within a few hundred thousand miles from its surface, and actually to pass through its corona.

About twenty-five comets, in circling the sun, pass within the orbit of Mercury, while nearly three-quarters of those that have been studied pass within the orbit of the earth. All of the known comets approach the sun to a point within the orbit of Jupiter. However, as the brilliancy of comets sometimes increases 100,000 times in moving from the orbit of Mars sunward to the orbit of Mercury, many of those whose perihelia are far distant from the sun would be so faint as not to be observable from the earth.

A comet's head may vary in size all the way from 10,000 miles up to more than 1,000,000 miles in diameter. A remarkable phenomenon is the fact that in approaching the sun a comet's head almost always contracts, and expands again in receding from the sun, the variation at times being as great as 100,000 to 1. The brilliant nucleus within the head may be as small as 100 miles in diameter, or as large as the earth. In one instance it was found that the head of a great comet was half a million miles in diameter, while its nucleus had a diameter of less than 500 miles.

The tails of comets, likewise, are very extraordinary. Their lengths range all the way from a few million to over 100,000,000 miles. They are fanlike in shape, spreading out as they recede from the head, and have diameters of thousands, or even tens of thousands, of miles, increasing with the distance from the head. As already noted, the tail always points away from the sun, regardless of whether the comet is coming or going. It is supposed that this is due to a repulsive force, of an electrical nature, exerted by the sun. Faint when the comet is first perceived by observers on the earth, as it approaches the sun the tail increases greatly in ap-

parent size and luminosity. Some comets, however, for little understood reasons, show slight if any indications of tails.

While the total volume of all the known comets is greater than that of the sun and all the planets combined, the inconceivable thinness of the material of which they are composed prevents their producing an observable disturbance in the motions of the planets among which they pass.

Another interesting fact about comets is that although they seem to be highly individualistic, there are several groups of comet families, the members of which bear an intimate relation to one another or to some particular planet. The planet Jupiter has a large comet family, which it seems to have captured by reason of its immense size and hence the powerful attraction which it exerts upon a passing comet.

The earthlike planets (Mercury, Venus, the Earth, and Mars) do not have comet families, partly because of their small mass, and partly by reason of the terrific speed which comets attain when they approach so close to the sun.

The distances which many comets traverse in their orbits is almost inconceivably vast; most of them pass from the sun to regions in the heavens several times as distant as the planet Neptune. Some go much farther. The geometrical patterns of their orbits, however, indicate that they do not go beyond the influence of the sun—a fact tending to confirm Chamberlin's theory of comet origin.

As Dr. F. R. Moulton points out in his remarkable new textbook, *Astronomy* (Macmillan, 1931), if a comet's aphelion (farthest point from the sun) "is only 32,000 times the distance from the sun to the earth, it does not arrive at its far turning point until after the lapse of about 2,000,000 years."

Comets are subject to disintegrative processes. The particles forming the tail come from the head and never return, for the tail is constantly being dispersed into space. It was noted that Halley's comet, at the time of its latest visit in 1910, was somewhat less brilliant than on former occasions; in fact, many persons, including the present writer, were disappointed by the poor showing it made. Again, when passing near the sun, the tidal forces which operate upon comets tend to tear them apart. Instances have been observed in which comets were broken into a number of fragments.

It goes almost without saying that the material of which comets



are composed is gaseous. Spectroscopic observation shows the presence of such gases as hydrogen, hydro-carbon gas, and ionized carbon monoxide.

The larger comets which have been noted during recent centuries have made their appearance in our skies every twenty-five or thirty years. With the improved apparatus and more delicate instruments now available, it will be possible to study such comets much more thoroughly than has been the case heretofore, and thus learn more about their constitution. Our improved photographic processes, especially, will show very clearly just what happens to such comets in their dash about the sun.

In 1910, when Halley's famous comet heralded its approach, there was a great deal of popular discussion as to the possible danger to the earth and its inhabitants from the presence of deadly gases in the tail. While it is true that carbon monoxide and other gases known to exist in comets' tails are highly deleterious, they are dispersed more thinly than the highest vacuum obtainable by artificial means. Indeed, the escaping fumes from automobiles passing along the street make the air far more deeply impregnated with poisonous gas than any comet's tail could possibly impregnate it.

During recent centuries, there have been many comets of extraordinary interest observed from the earth. In 1680, there appeared a great comet which was carefully studied by the astronomers of that day. Newton computed its period of traversing its orbit as about 600 years. In passing perihelion, it tore along at the rate of 370 miles per second, and passed through the solar corona within 140,000 miles of the sun's surface. Its tail was 100,000,000 miles long.

Another famous comet of the long ago was the great comet of 1811, which was visible in the skies for over a year.

One of the most interesting of such visitors during the last hundred years was Donati's comet of 1858, which was visible with the unaided eye for 112 days, and with a telescope for more than nine months.

Then there was Tebbutt's comet in 1861. The earth passed through the tail of this comet, without the slightest observable terrestrial disturbance.

The comet of 1882 was of an unusual type. It swept through the sun's corona without apparently disturbing its own orbit. It

appeared, however, to have been subjected to tremendous disruptive forces, for at least five nuclei were observed in its head, and in the immediate vicinity there were discovered six or eight small comet-like masses which apparently had broken from the parent body and were traveling in orbits parallel with it.

Halley's comet is probably better known to the public than any other. It is a regular visitor to our part of the heavens at intervals of seventy-five years, more or less, so that it may be seen twice in a long lifetime. Mark Twain, born at the time of this comet's visit in 1835, had a whimsical belief that he would go out of life with it when it called again; and, as the event turned out, when the comet reappeared in 1910 it found the old humorist on his death-bed. For hundreds of years, the visits of this spectacular comet had been noted before men knew that it was the same visitor every time. It was named for Edmund Halley, a distinguished British scientist who had charge of the printing of Sir Isaac Newton's great work, the *Principia*.

Shortly after the comet's appearance in 1682, Halley computed its orbit, and proved that the comet was identical with the ones which had aroused apprehension and excitement in 1607, 1531, 1456, and so on back to 1066, the year in which William the Conqueror landed in England.

Halley predicted the comet's return in 1759. His prediction was received with much ridicule; but, though he did not live to see it, the comet appeared in the sky and passed perihelion within one month of the time predicted by Halley. The verification of this prediction was one of the triumphs of astronomy.

At the time of the reappearance of Halley's comet, it was known that the earth would pass through a part of the comet's tail. As we have already noticed, there was a good deal of apprehension as to the possibly disastrous results that might be expected. The alleged danger was magnified and exploited by certain newspapers. As usual, nothing happened. Comets are curious but perfectly harmless visitors. No one need fear them. Even if a comet should strike the earth head on, there probably would be no great damage done. If the collision occurred in some uninhabited portion of the earth's surface or on the broad expanse of the ocean it might pass unnoticed. And such a collision is an exceedingly remote contingency.