HALLEY'S COMETARY STUDIES.

HIS OWN ACCOUNT OF HIS INVESTIGATIONS ON ORBITS.

HALLEY'S treatise, which bore the title "Astronomiæ Cometicæ Synopsis," (i. e. "A Synopsis of the Astronomy of Comets") was presented to the Royal Society in 1705, and was published in 1706 in volume 24 of the Society's Transactions, page 1882-1899. The following account of this work is taken from Volume IV. of Baddam's abridgment of the Memoirs of the Royal Society (London, 1739). The original spelling and punctuation are retained here.

The ancient Egyptians and Chaldeans (if we may credit Diodorus Siculus) being furnished with a long series of observations, could predict the rising, or appearing of comets; but since, they also are said by the same arts to have foretold earthquakes and tempests, it is past all doubt, that their knowledge in these matters was rather the result of astrological calculations than of astronomical theories of the motions of the celestial bodies; and the Greeks, who were the conquerors of both these nations, scarcely found any other sort of learning among them than this; so that it is to the Greeks themselves, as the inventors, especially to the great Hipparchus, that we owe this astronomy, which is now so greatly improved; but Aristotle's opinion (viz., that comets were nothing else than sublunary vapors or airy meteors) prevailed so far amongst the Greeks, that this sublimest part of astronomy lay altogether neglected; since none could think it worth while to observe, and give an account of the wandering and uncertain paths of vapours floating in the Æther; whence it is, that we have nothing certain handed down from the ancients concerning the motion of comets; but Seneca the philosopher, considering the Phænomena of two remarkable comets of his time, made no scruple to place them amongst the celestial bodies, taking them to be stars of equal duration with the world itself; tho' he owns, that their motions were regulated by laws not then discovered; at length, he foretells (which has proved no vain prediction) that time and diligence would unfold these mysteries to some future ages, who would be surpris'd how the ancients could be so ignorant of them, after that some lucky interpreter of nature would have pointed out in what parts of the heavens comets wandered, and shewn what, and how great they were; yet almost all astronomers differed from Seneca in this; and Seneca himself has not left any account of the Phænomena of the motion, whereby he might support his hypothesis, nor assigned the time of their appearing, which might enable posterity to determine anything in this matter: So that after Mr. Halley had turned over several histories of comets, he could find nothing at all, that could give any assistance herein, before A. D. 1337, when Nicephorus Gregoras, an historian and astronomer of Constantinople, had pretty accurately described the path of a comet amongst the fixed stars; but he too loosely assigns the time, so that this undermined comet only deserved to be inserted in the catalogue, on account of its having appeared almost 400 years ago; the next comet A. D. 1472, which moved the swiftest of all, and came nearest to the earth was observed by Regiomontanus; this comet (so frightful on account both of the magnitude of its body and its tail) in the space of a day moved 40 deg. of a great circle in the heavens, and it is the very first of which, any proper observations have been handed down to us; for all those who considered comets before Tycho Brahe, that great restorer of astronomy, supposed them to be below the moon, and so took but little notice of them, imagining them to be no other than vapours: But in the year 1577 Tycho Brahe applying himself seriously to the study of astronomy, and having procured large instruments for making celestial mensurations, with greater exactness and certainty than the ancients could ever hope for; there appeared a pretty remarkable comet, to the observation of which Tycho vigorously applied himself, and he found by several unquestionable trials, that it had no sensible diurnal parallax; and consequently, that it was not only no aerial vapour, but much higher than the moon; nay, and might be reckoned amongst the planets for anything that appeared to the contrary, notwithstanding the cavilling opposition of some schoolmen; to Tycho succeeded the sagacious Kepler, who having the advantages of Tycho's observations, found out the true and physical system of the world, and vastly improved astronomy; for he demonstrated, that all planets revolved in planes passing through the centre of the sun, and describing elliptical curves, observing this law, that the area's of the elliptic sectors taken at the centre of the sun, in the Focus of the ellipsis, are always proportional to the times, wherein the corresponding arches are described; he also discovered, that the distances of the planets from the sun are in the sesquilateral ratio of their periodical times, or that the cubes of the distances are as the squares of the times; this great astronomer had the opportunity of observing two comets, one of which was very remarkable; and from his observations of these, he concluded, from several indications of an annual parallax, that comets move freely thro' planetary orbits, with a motion not much different from a rectilinear one, but which he could not determine: Next Hevelius, a noble emulator of Tycho, following Kepler's steps, embraced the same hypothesis of the rectilinear motion of comets, he himself having very accurately observed several of them; yet he complained, that his calculations did not altogether agree with the appearances in the heavens, and he was aware that the path of comets was incurvated toward the sun: At length, that extraordinary comet of 1680 descended from a vast distance, and as it were, in a perpendicular line toward the sun, and ascended from him again with an equal velocity; this comet appearing constantly for four months, by the peculiar and remarkaable curvity of its orbit, seemed above all others the most adapted for investigating the theory of their motion; and the Royal observatories at Paris and Greenwich being founded some time before, and committed to the care of the most famous astronomers, the apparent motion of this comet was (as far as human sagacity could reach) very accurately observed by M. Cassini and Mr. Flamstead: Not long after, that incomparable geometrician Sir Isaac Newton, not only demonstrated that what Kepler had found, did necessarily obtain in the planetary system, but likewise that all the Phænomena of comets plainly follow from the same principles, which he fully illustrated by the above-mentioned comet of 1680; and at the same time shewed the way of geometrically constructing the orbits of comets, and to the surprise of all men solved a problem whose intricacy rendered it worthy of so great a genius; and he proves that this comet revolved round the sun in a parabolic orb in such a manner that the areas estimated at the centre of the sun were proportional to the times: Mr. Halley pursuing the steps of so great a man attempted (and he presumes not without success) to bring the same method to an arithmetical calculation; for having collected together all the observations of comets he obtained the following table, the result of almost immense calculation.

THE ASTRONOMICAL ELEMENT OF THE MOTIONS, IN A PARABOLIC ORBIT, OF ALL THE COMETS HITHERTO OBTAINED.

Passage of Perihelion, London Time.				Longitude of Perihelion.		Longitude of Asc. Node.		Inclination of Orbit.		Distance from Sun at Perihelion.
	d.	h.	m.	°	′	°	′	°	′	
1337, June	2	6	25	37	59	84	21	32	11	0.40666
1472, February	28	22	23	45	34	281	46	5	20	0.54273
*1531, August	24	21	15	301	39	49	25	17	56	0.56700
1532, October	19	22	12	111	7	80	27	32	36	0.50910
1556, April	11	21	23	278	50	175	42	32	6	0.46380
1577, October	26	18	45	129	32	25	52	74	33	0.18342
1580, November	28	15	00	109	6	18	57	64	40	0.59628
1585, September	27	19	20	8	51	37	42	6	4	1.09358
1590, January	29	3	45	216	54	225	31	29	41	0.57661
1596, July	31	19	55	228	15	3.2	12	55	12	0.5.283
*1607, October	16	3	50	302	16	50	21	17	2	0.58680
1618, October	29	12	23	2	14	76	1	37	34	0.37975
1652, November	2	15	40	28	19	85	10	79	28	0.84750
1661, January	16	23	41	115	59	82	30	32	36	0.44851
1664, November	24	11	52	130	41	81	14	21	18	1.02576
1665, April	14	5	16	71	54	228	2	76	5	0.10649
1672, February	20	8	37	47	0	297	30	83	22	0.68739
1677, April	25	00	38	137	37	236	49	79	3	0.28059
1680, December	8	00	6	262	40	272	2	60	56	0.00612
*1682, September	4	7	39	302	53	51	16	17	56	0.58328
1683, July	3	2	50	85	30	173	23	83	11	0.56020
1684, May	29	10	16	235	52	265	15	65	49	0.96015
1686, September	6	14	33	77	0	350	35	31	22	0.32500
1698, October	8	16	57	270	51	267	44	11	46	0.69129

Those marked with a star (*) are successive apparitions of Halley's Comet.

[Then follows a general table to compute the Motion of Comets in a parabolic Orbit, together with an explanation of its construction and use.]

It is to be observed that the five first comets, the third and fourth of which was seen by Petrus Apianus, and the fifth by Paulus Fabricus, as was the tenth by Mestlinus in the year 1596, have not the same degree of certainty with the rest, the observations not having been made with the proper instruments or the necessary exactness, and therefore, disagreeing with each other, they can by no means be reconciled with a regular calculation; Blanchini alone observed at Rome the comet Anno 1684; and the astronomers at Paris the last comet in 1698, whose path they have described in an unusual manner; this very obscure comet, tho' swift and pretty near the earth, escaped our observations: Mr. Halley forbore to insert into his catalogue the two remarkable comets that appeared, the one in November 1689, and the other in February 1702, for want of observations; for directing their course towards the southern part of the world, and being scarcely visible in Europe, they were not observed by persons equal to the task: It is to be observed that 11 of the comets in Mr. Halley's catalogue moved direct, i. e., according to the order of the signs; viz. those in the years 1532, 1556, 1580, 1585, 1618, 1652, 1661, 1672, 1680, 1684 and 1686; and that the other 13 were retrograde, i. e., moved contrary to the order of the signs.

Upon weighing all these things, and comparing the rest of the elements of the motions of these comets with each other, it will appear, that their orbits are disposed in no certain order; and that they are not confined like the planets to the zodiac, but that they move indifferently, every way both retrograde and direct; whence it is plain, that they are not moved by Vortices; the distances of this Perihelia are found to be sometimes greater and sometimes less; whence we have reason to suspect, that there are a great many more comets, which being at remote distances from the sun, and being obscure and without a tail, may for that reason escape our observation.

We have hitherto considered the orbits of comets as perfectly parabolic, from which supposition it would follow, that comets, being impelled by a centripetal force toward the sun, do descend from infinite distances, and by their fall acquire so great a velocity, as to convey them into the remotest spaces of the system, and by a perpetual Nisus tending upward, never afterward to return again to the sun; seeing then that the appearing of comets is very frequent, and that none of them is found to move in an hyperbola, or with a greater velocity than it would acquire in falling toward the sun, it is more credible, that they revolve about the sun in very excentric orbits, and return after very long periods; for, thus their number is definite and perhaps not so very great; and the spaces between the sun and the fixed stars are so immense, that there is room for a comet to perform its period, however large it may be: for the Latus rectum of an ellipsis is to the Latus rectum of a parabola, having the same Perihelian distance, as the Aphelian distance in the ellipsis is to its whole axis; but the velocities are in the sub-duplicate ratio of the same: wherefore, in very excentric orbits, this ratio approaches very nearly to a ratio of equality, and the small difference which arises on account of the greater velocity in a parabola, is very easily compensated in determining the situation of the orbit; therefore, the principal use of the elements of the motions in this table is, that whenever a new comet appears, we may by comparing the elements, know whether it is one of those that formerly appeared; and consequently, we may determine its period, and the axis of its orbit, and foretell its return; and Mr. Halley tells us that he had several reasons to induce him to believe, that the comet in 1531, which was observed by Apian, was the same with that described in 1607 by Kepler and Longomontanus, and which he himself had seen and observed upon its return again in 1682; all the elements agree, and there is no other difference than the inequality of their periods; which yet is not so considerable, as that it may not be ascribed to physical causes; for Saturn's motion is disturbed in such a manner by the other planets, especially Jupiter, that its periodical time is for some whole days uncertain; how much more may a comet be subject to such irregularities, whose orbit rises almost four times higher than Saturn's, and whose velocity, tho' never so little augmented, may change its orbit from an ellipsis to a parabola; that it was the same comet, is farther confirmed, from that observed, in the summer of 1456, to pass retrograde, almost in the same manner, between the sun and the earth; which tho' it was not observed astronomically by any, yet Mr. Halley conjectures, that was the same with the former, from its period and the manner of its transit; whence he ventures to foretell its return in 1758, and if this happens, there will be no further cause to doubt, but that the rest may likewise return; astronomers will therefore have a large field to exercise themselves in for several ages, before they can determine the number of so many and so great bodies that revolve round the common centre of the sun, and reduce their motions to certain rules: Mr. Halley was apt to believe, that the comet of 1532 was the same as that observed by Hevelius in the beginning of 1661; but Apian's observations, which are the only ones we have, are too inaccurate, to determine anything certain from them in so nice an affair: Sir Isaac Newton delivers a method of constructing the orbits of comets by three

* Journal of the Royal Astronomical Society of Canada.

accurate observations, Philos. Natural. Princip. Mathemat. lib. III. which afterwards Dr. Gregory fully and clearly illustrated in the fifth book of his physical and geometrical astronomy.

Here one thing is to be observed, viz., that some of these comets have their nodes so near the annual orbit of the earth, that should it happen at the time of the return of a comet, that the earth was near its node, whilst the comet passes with an incredible velocity, it would also have a very sensible parallax, and which would be to the sun's parallax in a given ratio; whence, upon such like transits, there would be a very favorable opportunity (which yet seldom happens) of determining the distance of the sun from the earth; which hitherto could be concluded but very loosely, and that only by means of the parallax of Mars in opposition to the sun, or that of Venus in the Perigæum: and tho' indeed it is thrice greater than the parallax of the sun, yet it is scarcely perceptible with any instrument, and this use of comets was suggested by the famous geometrician Nio Facia; for the comet of the year 1472 had a parallax 20 times greater than that of the sun; and had the comet Anno 1618 arrived, about the middle of March at its descending node, or had the Comet Anno 1864 come a little sooner to its ascending node, being very near the earth they would have had still more sensible parallaxes; of all the comets there were none that approached nearer the earth than Anno 1680; for, upon a calculation, it was no further distant towards the north from the annual orbit, than the sun's semidiameter (or the radius of the moon's orbit, as Mr. Halley suppose) and that too in November 10th 1 hr. 6 min. P. M.; at which time it had been in conjunction with the earth as to longitude, there might have been observed in its motion a parallax equal to that of the moon: Mr. Halley leaves it to philosophers to discuss what consequences would arise from the appulse, contact or collision of the celestial bodies, which yet is not altogether impossible.

THE CHINESE CALENDAR.

To the Editor of the SCIENTIFIC AMERICAN:

IN my article on the Chinese calendar in the preceding issue of SCIENTIFIC AMERICAN SUPPLEMENT, pages 114 and 115, I did not refer to the fact that the sexagenary cycle was used for days as well as for years by China. That is to say, the days are named and numbered in continuous groups of sixty, and as this method does not synchronize with the days of the month, or moon, it leads to a curious mixture of dates that often puzzle historians. For example, the current native almanacs from China show the first day of the first month quite correctly, but just below these dates the reader finds the stem and branch characters which indicate the sexagenary day. It may be anywhere from Kiah-Tsu to Kwei-Hai (1st to 60th day). It so happens that the current Chinese year began on the day known as Ping-Woo, or 43d day. It, therefore, follows that the 18th day of the month will be the 60th day. Then the next day, the 19th of the month, will be day first. This makes the first Chinese month end on Kiah-Suh or the 11th day of the next cycle of 60 days. In other words, this first Chinese month, which begins with the first day and ends with the 29th in the monthly order, also begins (strange as it may sound) on the 43d day and ends on the 11th day.

As Japan used this same system until a comparatively recent time, many Japanese calendar clocks in our museums and private collections contain this 60-day feature. As many owners of these artistic timepieces do not know what the characters mean, it was thought best to bring this point out clearly. Both China and Japan now use our clocks and watches, and Japan has adopted our Gregorian calendar. But China adheres to her ancient method of counting her days.

Just one more little point. Near the end of the article I speak of a "sidereal lunation." Please read this sidereal month. This is a period of time between 27 and 28 days, and ancient records show that a lunar zodiac of these numbers of lunar mansions or domiciles were used, but the later figure was favored because it was capable of being quartered into periods of 7 days. It is, therefore, my firm opinion that this fact fixed our 7-day week and that these 7 days came under the influence of, or were later named after the sun, moon, and five of the planets, thus pushing the origin of the Jewish Sabbath and the Christian Sunday very far back. Modern skygazers who have had the chance to see the moon and stars in the clear atmosphere of the East can realize how natural it was that these early calendar constructors should mark off the moon's zone of action into a stellar dial of 28, sometimes by single stars equally spaced, at other times by groups of stars not so well placed. This slightly arbitrary, but even number (28) being divisible by the much-used 4, which was more or less connected with the four cardinal points of the compass, the four corners of the world, the four seasons, and so on, made the creation of the 7-day period a most logical and natural step. DANIEL ARTHUR.

New York, N. Y.

SCIENCE NOTES

A bulletin of the University of California announces the discovery of further proof of the identity of heliotropism in animals and plants. The new results were obtained by Professors Loeb and S. S. Maxwell. Since fish and Daphnia are too large to allow very exact determinations of the relative heliotropic effect of the different parts of a spectrum, experiments were also made with a smaller form of animals, namely, the newly hatched nauplii of Balanus perforatus, which they were able to obtain in unlimited quantities. These animals possess the most intense positive heliotropism of any form thus far found. The frequency curve for the distribution of these animals in the spectrum gave the maximal density of the gathering in the freen, the highest ordinate being possible toward the yellowish green. Experiments proved that the heliotropic reactions of swimming animals are identical with those of swimming algæ.

Dr. Franz Fischer has discovered that when air is heated under certain conditions there is formed ozone. If we heat air to a very high temperature and then cool it quickly down to the normal, this sudden cooling has the effect of producing ozone. A Vienna electric firm has constructed an ozone-producing fan on this principle, using a Nernst radiator which gives a heat of 2,000 deg. C. The fan brings a current of air over the incandescent substance which is fixed, and the air becomes heated and is then cooled by mixing with the surrounding air. Ozone is thus formed which is sent out by the air fan. The apparatus consists of a small flywheel and air fan combined which is run by an electric motor; the fan draws in the air and sends it by a funnel-shaped vessel into the part containing the Nernst heater. The whole apparatus mounted on a base does not weigh more than 30 pounds. About 4 per cent of the oxygen is ozonized, and this amount cannot be exceeded on the present principle, so that there is nothing to fear from a too great amount of ozone. One such device will suffice to purify the air of a large hall, and the amount of power used is very low.

In an article published in the Astrophysical Journal Mr. W. H. Mitchell says that many of the characteristic features of the sun-spot spectrum appear to be due to the absorption of various oxides and hydrides existing as vapors in the spot regions. As most of these are regarded as low-temperature products, it is further supposed that water-vapor may also exist on account of the reduced temperature. Unfortunately many of the recorded observations in the region 5,860-6,000 are widely discordant so far as their identification with water-vapor lines is concerned, and it is possible that they may really be faint solar lines of other elements so close to the water-vapor positions as to be mistaken for them unless very great dispersion is employed. Determinations made with a powerful spectroscope at Haverford indicate that the supposed widening of the water-vapor lines in the spot-spectrum band may be a subjective effect caused by the dark umbral background. Hale has noted that the water-vapor lines show no evidences of circular polarisation in the sun-spot spectrum, suggesting that it is probable that they are unaffected by sun-spot absorption. From this it would appear that up to the present we have no definite evidence of the presence of water-vapor in sun-spots.

The London Times reports that a novel method of killing moths and other insects which are harmful to grape vines has been adopted near Rheims. Posts supporting 5-candle-power electric lamps were placed in the vineyards, from each of which a dish, containing water with a top layer of petroleum, was suspended. During the first night these traps were placed in three parallel rows at distances of about 200 feet from each other, the distance between each lamp being about 75 feet. On the first clear evening late in July the current was turned on about eight o'clock, and the lamps remained burning until an hour or so after midnight. Soon after the lamps were lighted the insects swarmed toward them and were rapidly killed, either by the fumes of the petroleum or by the petroleum itself. The same operation was resumed the next clear night, but the lamps of the two outside rows were placed about 25 feet closer to those of the center row, and this was repeated in each of five subsequent clear nights, so as finally to bring the three rows within about 50 feet of each other. During the succeeding six or seven clear nights the movement was reversed in the same manner, so as to return the lamps to their position of the first night. As to the position of the lamps, numerous experiments were made during these trials, and it was proved that the greatest number of insects were killed when the petroleum dish was elevated only a few inches above the ground. These experiments were witnessed by representatives from a number of leading champagne makers, and this method was recommended to all wine growers who can avail themselves of the services of electricity.—Science.

TRADE NOTES AND FORMULÆ.

Syndeticon, Liquid Fish Glue.—Dilute 100 parts of concentrated fish glue with 120 parts of acetic acid and dissolve separately 20 parts of gelatine in 120 parts of water. Well mix both fluids and add 20 parts of shellac varnish to the mixture, stirring constantly.

Zapon Varnish.—Over 2 parts of colorless celluloid waste (obtainable at celluloid factories) pour 20 parts of acetone and allow the mixture to stand for several days in closed vessels with frequent stirring till the whole is dissolved to a clear, thick mass. Then add 78 parts of amylacetate and let the varnish settle for some weeks till it is completely clear.

Luminous Paint.—Twenty parts non-acid white gelatine, dissolved in 100 parts of water, to this add (dissolved) 3 parts chromate of potash and combine, with 10 parts of thickly liquid white lead or zinc white varnish, as pale as possible, by vigorously stirring into a homogenous mass. After thorough stirring incorporate 15 parts of a previously prepared phosphorescent powder.

Universal Spirit Varnish. — To 60 parts each of bleached shellac, crushed Manila copal and mastic and 15 part of Venice turpentine add 1,000 parts of 82-95 per cent. alconol and some crushed glass and allow the mxiture to stand for 1 to 2 weeks, stirring frequently. Then add about 1 part of boracic acid and filter. The varnish may be used for metal, wood, paper, etc. In aniline colors soluble in alcohol are added to it, the so-called "brilliant varnish" (Brillantlack) is obtained, adapted for varnishing bottles, metal-plate and capsules.

Paint for Wooden Posts.—Fifty parts of rosin, 40 parts of finely crushed chalk, 500 parts of fine white and sharp sand; 4 parts linseed oil, 1 part natural red oxide of copper, 1 part sulphuric acid. First heat the rosin, the chalk, the sand and the linseed oil in an iron pot, then add the oxide, and, with great care, the sulphuric acid; mix all very carefully and by means of a stiff brush, apply to the wood while still hot. If the mixture does not appear to be sufficiently fluid, thin it with a little linseed oil. When this paint is cold and dry, it constitutes a coating as hard as stone, through which no moisture can penetrate.

Uralite is a fire-proof building material composed of pulverized asbestos wtih the addition of chalk, silicates, sulphuric acid, aluminium sulphate, etc. The compound is first pressed, dried and saturated with an adhesive and mineral colors, then pressed into forms, again dried and cut to the desired measure. It combines the advantages of stone with those of wood. It is fireproof; does not stretch; does not warp with heat or damp; can be nailed, glued or riveted; is a bad conductor of heat, electricity and sound, and is not sensitive to the action of acids, frost, or of cold and hot water. Its weight, it is true, is double that of oak, but it is said to be of peculiar excellence as a weather and fire-proof substance.

Zeiodelite.—Under this title is recognized a mixture of sulphur and pulverized fragments of stoneware or glass. It is best prepared from 19 parts of sulphur and 42 parts of powdered stoneware or glass powder. The mass is heated until the sulphur melts when it is mixed by stirring and poured into molds. By this means we may make slabs that can be employed in place of lead for the construction of sulphuric acid cells, for the mass withstands the effects of air and acids, no matter how concentrated the latter may be. As it retains its solidity in boiling water and melts only at about 248 deg. F. it is well adapted for various other purposes for which we use asphalt; it even replaces hydraulic lime, as it cements stones together with the greatest tenacity. Where zeiodelite is used for the construction of sulphuric acid cells, in place of lead plates, great advantage is obtained, for the substance completely resists the acids. Although plates of 1½ centimeter thickness are used, while the lead plates are but 3 millimeters thick, its cost is but one-fourth that of lead plates and an acid, wholly free from lead, is obtained. To join the plates together they are set 2 centimeters apart and the joints filled with melted zeiodelite, heated to 636 deg. F. (300 deg. C.).

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