

CLASSICS OF SCIENCE:

Halley's Comet
Astronomy

The art of calculation of orbits has progressed since Halley's day to such lengths of formulae that it is idle for the amateur astronomer or mathematician to attempt to check up Halley's calculations. Nevertheless, they have been verified by modern astronomers, and 27 returns of the comet identified, from 87 B. C. to 1910 A. D.

THE ELEMENTS OF PHYSICAL AND GEOMETRICAL ASTRONOMY, by David Gregory, M. D. To which is annex'd Dr. Halley's SYNOPSIS OF THE ASTRONOMY OF COMETS. Done into English . . . by Mr. Stone, F. R. S. London, 1726.

Elliptic Orbits of Comets

Hitherto I have considered the Orbits of Comets as exactly parabolic; upon which Supposition it wou'd follow, that Comets, being impell'd towards the Sun by a centripetal Force, would descend as from Spaces infinitely distant; and, by their so falling, acquire such a Velocity, as that they may again fly off into the remotest Parts of the Universe, moving upwards with a perpetual Tendency, so as never to return again to the Sun. But since they appear frequently enough, and since none of them can be found to move with an hyperbolic Motion, or a Motion swifter than what a Comet might acquire by its Gravity to the Sun, 'tis highly probable they rather move in very excentric elliptic Orbits, and make their Returns after long Periods of Time: For so their Number will be determinate, and, perhaps, not so very great. Besides, the Space between the Sun and the Fix'd Stars is so immense, that there is Room enough for a Comet to revolve, tho' the Period of its Revolution be vastly long. Now, the *Latus Rectum* of an Ellipsis is to the *Latus Rectum* of a Parabola, which has the same Distance in its Perihelium; as the Distance in the Aphelium, in the Ellipsis, is to the whole Axis of the Ellipsis. And the Velocities are in a subduplicate Ratio of the same: Wherefore, in very excentric Orbits, the Ratio comes very near to a Ratio of Equality; and the very small Difference which happens, on Account of the greater Velocity in the Parabola, is easily compensated in determining the Situation of the Orbit. The Principal Use therefore of this Table of the Elements of their Motions, and that which indeed induced me to construct it, is, that whenever a new Comet shall appear, we may be able to know, by comparing together the Elements, whether it be any of those which has appear'd be-



HALLEY'S COMET AS A PORTENT IN 1066, shown in the Bayeux Tapestry. Modern calculators, using more refined formulae than Halley's, find some of his early dates inexact due to confusion between several comets, and locate one of its appearances in England's fateful year

fore, and consequently to determine its Period, and the Axis of its Orbit, and to foretel its Return. And, indeed, there are many Things which make me believe, that the Comet which *Apian* observ'd in the Year 1531, was the same with that which *Kepler* and *Longomontanus* more accurately describ'd in the Year 1607; and that which I my self have seen return, and observ'd in the Year 1682. All the Elements agree, and nothing seems to contradict this my Opinion, besides the Inequality of the Periodic Revolutions. Which Inequality is not so great neither, as that it may not be owing to physical Causes. For the Motion of Saturn is so disturbed by the rest of the Planets, especially Jupiter, that the Periodic Time of that Planet is uncertain for some whole Days together. How much more therefore will a Comet be subject to such like Errors, which rises almost four Times higher than Saturn, and whose Velocity, tho' encreased but a very little, would be sufficient to change its Orbit, from an Elliptical to a Parabolical one. And I am the more confirmed in my Opinion of its being the same; for, that in the Year 1456, in the Summer-Time, a Comet was seen passing retrograde between the Earth and the Sun, much after the same Manner: Which, tho' nobody made Observations upon it, yet, from its Period, and the Manner of its Transit, I cannot think different from those I have just now men-

tion'd. And since looking over the Histories of Comets, I find, at an equal Interval of Time, a Comet to have been seen about *Easter* in the Year 1305, which is another double Period of 151 Years before the former. Hence, I think, I may venture to foretel, that it will return again in the Year 1758. And, if it should then so return, we shall have no Reason to doubt but the rest may return also: Therefore Astronomers have a large Field wherein to exercise themselves for many Ages, before they will be able to know the Number of these many and great Bodies revolving about the common Center of the Sun, and to reduce their Motions to certain Rules. I thought, indeed, that the Comet, which appear'd in the Year 1532, might be the same with that observ'd by *Hevelius* in the Year 1661. But *Apian's* Observations, which are the only ones we have concerning the first of these Comets, are too rude and inaccurate for any thing of Certainty to be drawn from them, in so nice a Matter. But, as far as Probability from the Equality of Periods, and similar Appearance of Comets, may be urged as an Argument, the late wondrous Comet of 1680/1 seems to have been the same, which was seen in the Time of our King Henry I. *Anno* 1106, which began to appear in the West about the Middle of *February*, and continued for many Days after, with such a Tail as was (*Turn to next page*)

Halley's Comet—Continued

seen in that of 1680/1. And again, in the Consulate of *Lampadius* and *Orestes*, about the Year of Christ 531, such another Comet appeared in the West, of which *Malela*, perhaps an Eye-Witness, relates that it was . . . a great and fearful Star; that it appeared in the West, and emitted upwards from it a long white Beam; and was seen for 20 Days. It were to be wish'd the Historian had told us what Time of the Year it was seen; but, 'tis however plain, that the Interval, between this and that of 1106, is nearly equal to that between 1106 and 1680/1, viz. about 575 years. And, if we reckon backward such another Period, we shall come to the 44th Year before *Christ*, in which *Julius Caesar* was murder'd, and in which there appear'd a very remarkable Comet, mentioned by almost all the Historians of those Times, and by *Pliny* in his *Natural History*, lib. 11. c. 24, who recites the Words of *Augustus Caesar* on this Occasion, which lead us to the very Time of its Appearance, and its Situation in the Heavens. These Words being very much to our Purpose, it may not be amiss to recite them. *In ipsis Ludorum meorum diebus, sydus crinitum per septem dies, in regione Coeli quae sub Septentrionibus, est conspectum. Id oriebatur circa undecimam horam diei, clarumq; & omnibus terris conspicuum fuit.* Now these *Ludi* were dedicated *Veneri genetrici*, (for, from *Venus* the *Caesars* would be thought to be descended, and began with the Birthday of *Augustus*, viz. *Sept. 23* (as may be collected from a Fragment of an old *Roman Calendar* extant in *Gruter*, pag. 135.) and continued for 7 Days, during which the Comet appeared. Nor are we to suppose that it was seen only those 7 Days, but, possibly, both before and after. Nor, are we to interpret the Words *sub Septentrionibus*, as if the Comet had appeared in the North, but that it was seen under the *Septem triones*, or brighter Stars of *Ursa major*. And as to its Rising, *Hora undecima diei*, it can no ways be understood, unless the word *diei* be left out, as it is by *Suetonius*; for it must have been very far from the Sun, either to rise at five in the Afternoon, or at eleven at Night; in which Cases it must have appear'd for a long Time, and its Tail have been so little Remarkable, that it coul'd by no Means be call'd *clarum & omnibus Terris conspicuum Sydus*. But sup-

posing this Comet to have traced the same Path with that of the Year 1680, the ascending Part of the Orb will exactly represent all that *Augustus* hath said concerning it; and is yet an additional Argument to that drawn from the Equality of the Period. Thus 'tis not improbable, but this Comet may have four Times visited us at Intervals of about 575 Years: Whence the transverse Diameter of its elliptic Orb will be found the cube root of 575 x 575 Times greater than the annual Orb; or 138 Times greater than the mean Distance of the Sun; which Distance, tho' immensely great, bears no Proportion to that of the Fix'd Stars.

I have lately found out a ready Method to compute the Motion of Comets in these elliptic Orbs, of which, perhaps shortly, we may exhibit a Specimen, giving this Comet for an Example. In the mean Time, those that desire to know how to construct Geometrically the Orb of a Comet, by three accurate Observations given, may find it at the End of the third Book of *Sir Isaac Newton's Principles of Natural Philosophy*, entitled, *De Syemate Mundi*, in the Words of its renowned Inventor. Which have since been more fully explained by my very worthy Colleague, *Dr. Gregory*, in his learned Work of *Astronomia Physica & Geometrica*.

Collision with Earth

One Thing more, perhaps, it may not be improper or unpleasant to advertise the Astronomical Reader; That some of these Comets have their Nodes so very near the annual Orb of the Earth, that if it shall so happen, that the Earth be found in the Parts of her Orb, next the Node of such a Comet, whilst the Comet passes by; as the apparent Motion of the Comet will be incredibly swift, so its Parallax will become very sensible; and the Proportion thereof, to that of the Sun, will be given. Wherefore such Transits of Comets do afford us the very best Means, tho' they seldom happen, to determine the Distance of the Sun and Earth: Which hitherto has only been attempted by *Mars*, in his Opposition to the Sun; or else *Venus* in *Perigaeo*, whose Parallaxes, tho' triple to that of the Sun, are scarce any Ways to be perceived by our Instruments; whence we are still in great Uncertainty in that Affair. This Use of Comets was the ingenious

Thought of that excellent Geometrician *Mr. Nicholas Fatio*. Now the Comet of 1472, had a Parallax above twenty Times greater than the Sun's. And if the Comet of 1618, had come down, about the Middle of March, to his descending Node; or if that of 1684, had arrived a little sooner at its ascending Node, they would have been yet much nearer the Earth, and consequently have had more notable Parallaxes. But hitherto none has threatened the Earth with a nearer Appulse, than that of 1680. For by Calculation I find, that *Novemb. 11^o, 1^h, 6', P. M.* that Comet was not above the Semi-diameter of the Sun, to the Northwards of the Way of the Earth. At which Time, had the Earth been there, the Comet would have had a Parallax equal to that of the Moon, as I take it. This is spoken to Astronomers: But what might be the Consequences of so near an Appulse; or of a Contact, or lastly of a Shock of the coelestial Bodies, (which is by no Means impossible to come to pass,) I leave to be discuss'd by the Studious of physical Matters.

Edmund Halley (1656-1742) had shown evidences of unusual ability in mathematics and astronomy even before he entered Oxford at the age of 17. At 20 he went to the island of St. Helena to make observations of the southern stars, for the purpose of more accurate determination of longitude at sea—a vital problem in those days, in which Halley continued his interest throughout life. After devoting two years to the southern stars, he returned, and travelled on the continent. At the age of 24 he studied his first comet, in company with *Cassini* in Paris. This was the comet of 1680. Another, in 1682, was the one whose elliptical orbit he afterward calculated, as he tells above. Halley was 28 when his studies on the problem of gravitation led him to Cambridge to consult *Newton*, a journey which resulted in his publishing the "Principia" for his friend. Gravitation, motion of heavenly bodies, longitude calculation, and navigation problems involved also the study of compass variation, and at the age of 42 he obtained his papers as captain of the "Paramour Pink" for an expedition to study that phenomenon. Government, university and Royal Society business occupied the next two decades, then, at the age of 64 he became astronomer-royal. He began a series of observations on the moon which he planned to complete at the age of 82. He did complete it, nearly four years before his death.

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Oil of citronella, popularly associated with mosquitoes, is an important ingredient in soap and perfume industries, its perfume resembling that of the rose.