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direction, during which the weather vane will deviate more and more from the north towards the west; and at the end of three months the direction of the car will be due west, or at right angles to the true direction of the wind, the deviation of the vane will now be at its maximum, pointing about 20″ of a degree west of north. As the car describes the next quarter of the circle, the weather vane will gradually recede back again, and at the end of the second quarter the direction of the car will be due north, and the vane would point out the true direction of the wind. In the third quarter, while the car is going from the west to the north point of its circumference, the weather vane would again deviate by degeees to the east of north, and at the end of the third quarter the direction of the car would be due east or at right angles to the direction of the wind; and the deviation of the weather vane would again be at its maximum value, namely 20″ east of north. During the last quarter the wind would apparently recede again towards its true position; and having performed one entire revolution the direction of the car would again be due south and the vane would again point the true direction of the wind. Thus a true north wind would, by the motion of a car in a circle, appear to oscillate each side of its true position, precisely in the same manner that a star in the ecliptic appears to oscillate as the earth moves in its circular orbit.

As all the stars of heaven are affected by the combination of the earth's motion with that of light, it is evident that their true places cannot be known only as they are deduced from their apparent places. Tables of observation have been calculated by which these deductions can be conveniently made.

The phenomana of the aberration of light are evidences which can never be controverted in proof of the annual motion of the earth round the sun; for if the sun revolved around the earth while the earth remained at rest, there would be no appearance of aberration.

As we have demonstrated that the earth has an annual revolution around the sun, let us next enquire, what the form of the orbit is? It was supposed for many centuries, during the dark ages, that all the heavenly bodies revolved in exact circles; but modern astronomy has overthrown this conjecture, and has proved that the planetary orbits deviate from the circular form. We shall now point out the process by which this is ascertained.

If the sun be observed at different seasons of the year, he will be seen to vary in his apparent angular diameter. This can be easily determined by measuring with some acurate instrument the apparent breadth of his disc. It will be found that about the first of January the sun will subtend an angle of 32′ 34″. 6; on the first of April his apparent diameter will be 32′ 1″. 6, having decreased 33″ in three months; on the first of July his diameter will appear smaller than at any other time of the year, being only 31′ 30″. 2; on the first of October his apparent diameter will be the same as on the first of April. Thus it will be seen that from the first of January to the first of July, the sun decreases in its apparent size; and from the first of July to the first of January he increases in size. The difference between the greatest and least apparent diameter, is 1′ 4″. 4.

Now it cannot for one moment be supposed that the real magnitude of the sun undergoes a periodical change; therefore the difference in his apparent size must result from a change of distance. One half the sum of the greatest and least diameters is equal to 31′ 2″. 4, which is the mean diameter, or the diameter which the sun gives on the 31st of March and 3rd of October. This mean diameter must correspond to the sun's mean distance from the earth; while the greatest and least diameters correspond to the least and greatest distances of the sun from the earth. If we call the sun's mean distance 1, then the greatest and least distances may be found by the following proportions: The sun's mean apparent diameter (=32′ 02″. 4) is to the sun's greatest apparent diameter, (=32′ 34″. 6) as the sun's mean distance (=1) is to the sun's greatest distance (=1, 01675). Also the mean diameter is to the least diameter, as the mean distance is to the least distance (= 0 . 98325). Thus it is ascertained that the greatest, the mean, and the least distances of the sun from the earth are in the respective proportions of the numbers 1. 01675, 1. 00000 and 0 . 98-325. These numbers are very nearly in the proportion of 1 1 - 60, 1, and 59 - 60.

Now if the earth revolved around the sun in a circular orbit with the sun in the centre, his apparent diameter and distance would be precisely the same the year round.

But from the above numbers, it will be clearly perceived, that the situation of the sun within the earth's orbit is *Eccentric*, the *Eccentricity* amounting to 0. 01675, or nearly 1 - 60 of the mean distance. These observations and calculations do not demonstrate that the orbit of the earth about the sun is not a circle, but they merely demonstrate that the sun is placed nearly 1 - 60th of his mean distance from the centre of the orbit.

In order to obtain the true form of the earth's orbit, let the sun's apparent diameter be taken when he is at the beginning of each of the twelve signs in the ecliptic, or in other words, observe his apparent diameter for every 30 deg. of longitude; from these observations, calculate the proportional distances corresponding to the apparent diameters, assuming the mean distance equal to 1.00000. With these data the form of the orbit can be delineated on paper in the following manner: Let any point on the paper be chosen representing the place of the sun; from this point lay off the proportional distance, making an angle with each other of thirty degrees; connect the extremities of these distances by continuous curves; it is evident that this will be a correct representation of the orbit of the earth about the sun. The curve thus constructed will be preceived to deviate from a circular figure, being longer than it is broad, that is of an elliptical form. The point representing the position of the sun will not be in the centre of the ellipse, but will be in one of the foci at a distance from the centre equal to about 1-60th part of the mean distance of the sun from the earth.

This representation will be still more accurate if the sun's longitude and apparent diameters be observed a greater number of times during the year; as for instance, every day, and his proportional distances be calculated from the observed diameters according to the above rule; for then, if each of these 365 proportional distances be drawn from any point on a sheet of paper, making angles with each other equal to the observed daily differences of longitude, the extremeties of these lines will determine a greater number of points in the continuous curve connecting them, and consequently the form of the curve will be more accurately represented.

The form of the curve may be exactly determined by referring to the properties of the ellipse. If an ellipse be described whose eccentricity is equal to about 1-60th of its semi-major axis, any point in this ellipse may be expressed in terms of its angular distance in respect to the major axis and one of the foci. Now let different points in this ellipse be chosen, corresponding to the observed longitudes of the sun, or to the angle which they make with the earth's major axis; let the distances of these points from the focus be calculated, and they will be found to coincide most perfectly with those derived from the calculations founded on the measurement of the sun's apparent diameters.

In this way the elliptical form of the earth's orbit has been demonstrated, and the amount of its eccentricity determined to a very great degree of exactness. It will be very difficult for those who are unacquainted with the geometrical properties of the ellipse, to fully comprehend these demonstrations; therefore such will be under the necessity of relying upon the testimony of mathematicians until they shall qualify themselves to understand the nature of such demonstrations.

We will now more fully define some terms, that will be of frequent use, in our future investigations.

The mean distance of a planet from the sun, or of a satellite from a planet, is equal to the semi-major axis of its orbit, or half of the longest diameter; or in other words, one half the sum of its greatest and least distances. The distance from either focus of an ellipse to either extremity of its shortest diameter is equal to the mean distance.

The Major and Minor Axes of an elliptic orbit are respectively the longest and shortest diameters.

The Foci of an elliptic orbit are two points situated in the major axis at equal distances from the centre and at the mean distances from the extremities of the minor axis.

The Eccentricity of an elliptic orbit is the distance from its centre to either focus; —expressed in fractional parts of its semi-major axis.

That point of the elliptic orbit of the planet which is the nearest to the sun, is called the Perihelion, and the most distant point of the orbit from the sun, is called the Aphelion.

The nearest and most distant points of the moon's orbit, or of the sun's apparent orbit about the earth, are called respectively, the Perigee and the Apogee.

These same points are also called Apsides, the former is called the Lower Apsis, and the latter the Higher Apsis. The line joining these points, or the Major Axis, is termed the Line of Apsides.

The Equator is a great circle of the Heavens, equally distant from the two poles, the plane of which is at right angles to the earth's axis.

The Ecliptic is a great circle of the heavens, the plane of which contains the elliptic orbit of the earth as also the apparent orbit of the sun.

The Obliquity of the Ecliptic is the inclination of its plane to that of the equator which is equal to 23° 27′ 30″.

The Poles of the Ecliptic are two points in the heavens 90° distant from the ecliptic, the line joining the poles is at right angles to the plane of the ecliptic, and is inclined to the earth's axis at an angle equal to the obliquity of the ecliptic.

The vernal Equinox is that point in the ecliptic intercepted by the equator through which the sun apparently passes from the south to the north side of the equator.

The autumnal equinox is that point in the ecliptic througn which the sun apparently passes from the north to the south side of the equator.

The right ascension of a heavenly body is reckoned on the equator and is its angular distance east of the vernal equinox.

The declination of a heavenly body is its angular distance north or south of the equator.

The longitude of a heavenly body is its angular distance reckoned eastward from the vernal equinox on the ecliptic.

The latitude of a heavenly body is its angular distance north or south of the ecliptic, reckoned in a direction at right angles to the elliptic.

The tropics are two smaller circles situated on each side of the equator at an angular distance of 23° 27′ 30″, and whose planes are parallel to the plane of the equator. The northern tropic is called the tropic of Cancer; the southern, the tropic of Capricorn.

The solstitial points are two points in the ecliptic which touch the tropics, and are 90 deg. distant from the vernal and autumnal equinox.

The Summer solstice lies north of the equator; the Winter solstice lies south.

The polar circles are two circles parallel to the tropics; their angular distance from the poles is equal to the obliquity of the ecliptic. The one to the north is called the Arctic Circle; the one to the south, the Antarctic Circle.

The poles of the ecliptic are contained in the polar circles; these centres are the poles of the earth prolonged to the heavens.

Having proved that the earth has an annual motion around the sun in an elliptic orbit, and that the sun is not situated in the centre of the ellipse, but in one of the foci; and that the eccentricity of the orbit or the distance of the sun from *the centre* of the ellipse is equal to nearly 1-60th of his mean distance from the earth, we shall next proceed to investigate the law of the angular velocity of the earth around the sun; this will evidently be the same as the apparent angular velocity of the sun around the earth, supposing the earth and sun to change places.

Now let us suppose that the real velocity of the earth, in its elliptic orbit was uniform, it is evident that its angular velocity around the focus of the ellipse would be different at different distances; that is, the greater the distance, the less the angular velocity. A body moving at right angles to the line of vision at twice the distance with a uniform motion, would have one half the angular velocity; at three times the distance, one third the angular velocity, and so on. Now when we observe the apparent angular velocity of the sun, or, which is the same thing, his daily change of longitude in different parts of his apparent orbit, we find that about the 31st of December, when the sun is nearest to the earth, his apparent angular velocity is the greatest, amounting to 1°01′09″.7 in 24 mean solar hours; and about the 1st of July, when he is the most distant from the earth, his apparent angular velocity is the least, being only 57′10″.2 in a mean solar day. The average change of longitude in a day is found by dividing 360 degrees by 365. 24224, which is the number of mean solar days in a tropical year; the quotient amounts to 59′08″.33. Thus it will be perceived that from the perigee to the apogee, the sun's apparent angular velocity decreases, and from the apogee to the perigee it increases. Does this variation depend wholly upon a change of distance, or is there actually a change of real velocity in different parts of the orbit?

This question may be determined by comparing the rate of variation in the angular velocity with the rate of variation in the distance. If the mean distance, and also the mean angular velocity, be each assumed equal to unity or 1.00000, then the extremes of distance will be 1.01675, 0.98325, and the extremes of angular velocity will be 1.03420, 0.96671.

By a comparison of these numbers, it will be seen that the deviation of the angular volocity from the mean is much greater than the deviation of the distance from the mean. Therefore, the rate of variation of the angular velocity must be much greater than what would result from a mere change of distance alone; hence the excess must be dependant upon a real change of velocity.

If the extremes of distance be compared with the extremes of angular velocity, the latter will be found nearly equal to the inverse squares of the former; they would be quite equal were the observations from which they were deduced perfect. And if we compare the angular velocities at any other point of the earth's orbit, they will be found to vary exactly as the inverse squares of their respective distances from the sun. The real motion of the earth, therefore, in its orbit, cannot be uniform; its actual velocity decreases from the perihelion to the aphelion, and it increases from the aphelion to the perihelion. At corresponding points on each side of the major axis, its velocity is equal.

The law of the angular velocity having been determined to be as the inverse square of the distances, we will next investigate the law of its actual velocity.

If we suppose a line drawn from the earth to the sun, it is evident that it will sweep over the whole surface or area of the elliptic orbit in one year. — This line is called the Radius Vector. Now it has been determined by observations that the Radius Vector moves over equal areas of the ellipse in equal times. If the velocity of the earth were uniform, this could not take place; for the Radius Vector as it increased in length would, with equal velocities, describe an increased area; therefore as the Radius Vector increases in length, the velocity of the earth must decrease in such a proportion as to have the areas swept over in equal times, exactly equal.— Consequently the areas described must be proportional to the times. This is the law of the actual velocity of the earth in its orbit.

All we have stated thus far gives us no information in regard to the mode of obtaining the true distance of the earth from the sun. We have heretofore merely assumed the mean distance to be equal to unity; and pointed out the method of determining the proportional distances in different parts of its orbit, as well as the law of its proportional velocities. But these proportional distances and velocities do not inform us whether the sun is ten miles off, or ten thousand millions of miles. To persons unacquainted with the principles of trigonometry, it may seem impossible to measure the distance to an inaccessible object like the sun. But it must be admitted that the results derived from trigonometrical calculations do, with the greatest accuracy, correspond with actual measurements where the objects are accessible, and therefore, it cannot be doubted but that the same rules, when applied to inaccessible objects, will give just as accurate results.

If any person wishes to know the exact distance from this Tabernacle to some visible object on an island in the Salt Lake, let him accurately measure a base line in some convenient direction, not directly towards or from the object; let this line be some two or three miles in length; from each extremity of this line, take the angle which it makes with the object, and if the measurements of these angles and base line be correct, he can in a few minutes calculate the exact distance to the object. It is exactly upon this principle that we calculate the distance from the earth to the sun.

The semi-diameter of the earth is chosen as the base line; observations upon the sun's apparent place in the heavens, as seen from the extremities of this base line, are accurately taken. The amount of angular displacement, arising from the difference of the positions from which the observations were taken, is called the Sun's Horizontal Parallax. This displacement, or parallax, may be more clearly understood by supposing three observers to be stationed upon the same meridian about the time when the sun crosses the equinoctial; let one of these observers be stationed at this city, another be stationed on the equator due south, and the third as far south of the equator as we are north. At noon the observer at the equator will see the sun directly over head, or in the Zenith; it will appear to him in the same position as it would to an observer placed at the centre of the earth; this may be termed its true position. But the observer at this city would behold the sun displaced a short distance to the south of its true place; while the observer in the Southern hemisphere would see the sun a little north of its true place; the distance that it deviates, either north or south of its true place, is called its Parallax.

The greater the distance of the stations, either north or south, the greater will be the parallax. This parallax may be measured by astronomical instruments at any two stations of equal latitudes on the same meridian in the Northern and Southern hemispheres; and the distance between the stations, being equal to the sum of the sines of the latitude, is known; and therefore it is easy from these data to compute the sun's real distance.

The sun's great distance, compared with the semi-diameter of the earth, renders the horizontal parallax very small; and consequently a very small error in the observed parallax will make many millions of miles error in the computed distance of the sun. Toward the last of the seventeenth century, Dr. Halley pointed out a method of obtaining the sun's horizontal parallax with far greater accuracy than what was ever before known. His method depended upon the observations of the transit of Venus across the sun's disc; this happens only once or twice in a century. Dr. Halley, in 1691, predicted a transit of Venus that happened in 1761. He showed how astronomers, by being stationed in different parts of the earth, and by observing the exact time of the beginning and end of the transit, might calculate with a great degree of accuracy the sun's horizontal parallax. Accordingly, when the time drew near, several nations fitted out expeditions to various quarters of the earth to accomplish this desirable object. The results of their combined observations and calculations give a horizontal parallax at the sun's mean distance equal to 8″. 58. By simple trigonometrical calculation, this parallax gives the sun's mean distance equal to 24,040.19 times the mean radius of the earth; the mean semi-diameter of the earth is equal to 3,956 miles; this multiplied into the above gives 95,102,992 miles; this distance can be relied upon as exact within a very small fraction of the whole amount.

By multiplying the mean distance by the proportional distances of the extremes (1.016786 and 0.9832164), which, as we have already shown, are deduced from the observed apparent diameters of the sun when in apogee and perigee, we obtain his greatest and least distances from the earth expressed in miles which are respectfully equal to 96,699,163 and 93,506,821.

The eccentricity of the orbit is obtained by taking the difference between the mean distance and either extreme, which is equal to 1,596,171 miles. About the 31st of December, when the earth is in that point of its orbit, called the perihelion, the sun is 3,192,342 miles nearer the earth than on the 1st of July, when it is in its aphelion. The circumference of a circle, whose semi-diameter is equal to the earth's mean distance from the sun, would be 597,549,722 miles, but the earth's orbit being elliptical, its circumference is about 42,000 miles less than this, or about equal to 597,507,637 miles, which is the circumference of a circle whose diameter is half the sum of the major and minor axis of the orbit.

Over this vast distance the earth passes every year. The average velocity of the earth per day is 1,635,858 miles. The average per hour is 68,160 miles. During the time that this audience have been listening to my lecture, they have been wafted with an average velocity of 1,136 miles every minute. Little do we realize that during every second of time, we are transported 19 miles in space. We are startled at the idea of a cannon ball flying 8 miles per minute, and wonder how it is possible for it to dart with such great rapidity. But how inconceivably more astonishing it is to contemplate this vast globe, with all it contains, flying through space with a velocity 144 times swifter than that of a cannon ball. If we were to travel both day and night on a railroad car with a velocity of 30 miles an hour it would require over 2,271 years to pass over a space equal to the earth's orbit.

We have already stated that the velocity of the earth in its orbit is not uniform. At its mean distance, its velocity in 24 mean solar hours is 1,635,973 miles; at the perihelion, its daily velocity is 1,663,668 miles; at the aphelion, it is 1,609,012 miles. The difference between the extremes of the daily velocities is 54,656 miles. About the 31st of December, we are carried about 38 miles per minute swifter than on the 1st of July.

For the benefit of the mathematical students of