

FAREWELL TO DESERET.

BY PARKY P. PRATT.

Holy, happy, pure, and free,  
Bless'd indeed, and dear to me,  
Are thy loved ones, Deseret,—  
Friends I never shall forget,  
While far off, my pilgrim feet shall roam.

Where, O where, is holy ground?  
Where, O where, does truth abound?  
Where on earth is freedom found,  
Deseret, beyond thy bound?  
Where, far off, my pilgrim feet shall roam.

Is it found on yonder shore,  
Mid the heaps of shining ore?  
No—the sons of truth divine  
Worship not at mammon's shrine;  
Where, far off, my pilgrim feet shall roam.

Is it found on yonder isles,  
Where eternal verdure smiles?  
Mid the fields of evergreen,  
Neath the benignant sky serene,  
Where, far off, my pilgrim feet shall roam?

Shall I turn to China's coast?  
Scan the ancient Bramin's host?  
India's spicy isles explore?  
Search the Moslem records o'er?  
Where, far off, my pilgrim feet shall roam?

Search the earth, explore the sea;  
Who can solve the mystery?  
Who, with keys of truth divine,  
Bids the light in fulness shine?  
Where, far off, my pilgrim feet shall roam.

Vain the search, through every realm;  
Deseret is at the helm;  
There the Kings majestic stand,  
Holding keys for every land;  
While far off, my pilgrim feet shall roam.

LECTURES ON ASTRONOMY.

BY PROF. ORSON PRATT.

LECTURE FIFTH.

All that we have stated in our former lectures 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 distance 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 a person wishes to know the exact distance from this Council House 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 2 or 3 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 at far south of the equator we are north. At the same observer at the equator will see the sun directly overhead, or in the zenith; it will appear to him in the same position as it would to an observer placed at the center 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 on the same meridian in the northern and southern hemispheres; the distance between the stations, being equal to the diameter of the earth, 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. Towards 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 transits of Venus across the sun's disk; 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 seconds. By a simple trigonometrical calculation this parallax gives the sun's distance equal to 24,049,191 times the mean radius of the earth; the mean semi-diameter of the earth is equal to 3958 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 ( $=1.0167836$  and  $0.9832164$ ) which 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 respectively 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 semi-diameter is half the sum of the major and minor axes of the orbit.

Over this vast distance the earth passes every year. The average velocity of the earth per year is 1,635,838 miles. The average per hour is 68,160 miles. During the time that this audience have been listening to my lecture, they have been voyaged with an average velocity of 1136 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 its

contents, 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 2271 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 it 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 those who may desire to know the process of calculating the velocity of the earth at any point of its elliptic orbit, we will give the formula, expressed in words, instead of algebraical symbols.

Let twice the distance from the upper focus of the ellipse be multiplied into the square of the velocity which the earth would have if it revolved in a circle whose radius is equal to its distance from the sun, and the product be divided by the major axis of the orbit, and the square root of the quotient will be equal to the velocity of the earth at any point of its orbit.

In consequence of the unequal velocity of the earth, it describes one half of its angular distance around the sun much sooner than the other half. If we consider a right line drawn through the sun at right angles to the major axis, and extended on each side to the earth's orbit, that portion of the circle on the perihelion side of this line will contain an equal number of degrees that the other portion contains; but the portion of the orbit on the perihelion side is much shorter and also is described with greater velocity than the other. The difference of time in the description of these two portions of the orbit is about 7 days and 17 hours.

Consequently our summer is about 8 days longer than our winter; that is, the sun is about 8 days longer in the six signs on the northern side of the equator than it is in the other six, or the southern side.

During the time that the earth performs one annual revolution, the inhabitants experience a variety of seasons.

Those who live in the southern hemisphere have their seasons in the reverse order of those in the northern. November, December, and January are their summer months; while here, they are our winter months. Their spring corresponds to our autumn; their winter to our summer; their autumn to our spring. When the days in the northern hemisphere are the longest, in the southern they are the shortest; and vice versa; when they are the shortest here, they are the longest there. From the 21st of March to the 21st of September, the sun is above the equator, without any intermission on our north pole while the sun is on the 21st of September to the 21st of March, the south pole is constantly enlightened by the sun, while our north pole is left in darkness. The whole order of the seasons in the northern hemisphere is repeated in the southern, but during the opposite time of year.

If the earth revolved around the sun directly from west to east, that is, if the plane of the earth's orbit coincided with the plane of the equator, there would be no variety of seasons, and also the days and nights over the whole earth would be of equal length. If the earth revolved around the sun from south to north, and back again to the south, then our seasons would have the greatest possible change that could be given to them. The difference between the length of days and nights would increase with much greater rapidity and the extremes of temperature between summer and winter would also be far greater. On the 21st of March the days and nights would be equal; from that time until about the 10th of May the days would in our latitude, increase from 12 hours to 24, while the nights would decrease from 12 hours to nothing. From the 10th of May to the 21st of August, the days would not set to us, but he would be seen among our circumpolar stars, exhibiting the same apparent phenomenon as we now see in the stars about the 21st of August; the sun would remain set in the south of which would now increase until the 21st of September when the days and nights would again be equal; from the 21st of September the length of the nights would increase until about the 11th of November, when the sun would set and remain below the southern horizon about 80 days, or until about the 31st of January, when the day would set in being only a few minutes long at first, but increasing rapidly in length until the 21st of March, when day and night would again be equal.

Thus if the earth revolved in an orbit whose plane was perpendicular to the plane of the equator, the vicissitudes of the seasons, the length of day and night, would be such as to render our globe unfit for the habitation of man. At one season of the year he would be scorched not only with a vertical sun, but with an accumulation of heat arising from the great length of the day; while at another season he would be exposed to all the severity of cold, experienced in the polar regions.

If the earth should revolve around the sun in any other direction, except the two that we have already mentioned, the difference of the seasons and of day and night, would be proportional to the inclination of the ellipse to the plane of the equator as the angle of inclination increases so would the differences in the seasons and of day and night. This inclination of the two planes is called the Obliquity of the Earth, which is about 23 deg. 27 min. 31.04 sec. for the beginning of the present year.

From the 21st of December to the 21st of June the earth pursues a d direction, not due east, but nearly east-south-east; from the 21st of June to the 21st of December its direction is nearly east-north-east. In December the earth is in Cancer while the sun appears in Capricorn.

It is evident, that while the earth goes east-south-east from Cancer to Capricorn it must pass from the north through the equinoctial plane to the south; the sun crosses the equinoctial about the 21st of March; it is then in the first point of Aries, while the sun appears in the first point of Libra. As the earth goes round its annual circuit it maintains its axis parallel to itself, that is, the angle of its inclination to the plane of its orbit remains the same throughout an entire revolution; consequently the axis will be directed towards one particular point in the infinite sphere of the heavens; in other words, if the parallel lines, represented by the parallel position of the sun in every point of its orbit, were produced to the circumference of the celestial sphere, they would converge to one point. Therefore the stars, because of their great distance, would not exhibit any appreciable parallax or displacement by the earth's annual motion; that is, the whole orbit of the earth, if seen from a distance of the fixed stars, would appear like a mere point, subtending no apparent angle.

Now if a line be drawn from the sun to the earth, it will be perpendicular to the axis of rotation when the earth is in the vernal and autumnal equinoxes, hence the days and nights will be equal.

At all other seasons of the year, the angle which the radius vector makes with the axis of rotation, deviates from the perpendicular; this deviation on either side of the perpendicular is equal to the sun's north or south declination; when the sun is in either of the tropics, the deviation is at its maximum, and is then equal to the obliquity of the ecliptic.

All the variety of the seasons, together with the differences of the length of day and night, are the results of the continual variation of this angle; and the variation of the angle which the radius vector makes with the earth's axis, is the result of the obliquity of the ecliptic, combined with the parallelism of the axis in different points of its orbit.

The ecliptic is divided into twelve equal parts, called signs; each sign, therefore, contains 30 degrees. These signs are reckoned from the vernal equinox; now are called, Aries, Taurus, Gemini, Cancer, Leo, Virgo, Libra, Scorpio, Sagittarius, Capricornus, Aquarius, Pisces. These signs are merely names given to the subdivisions of the ecliptic, commencing from the actual equinox which is constantly shifting its position in respect to the fixed stars, retreating upon the ecliptic westward at the rate of about 50.1 sec. per annum. The signs of the ecliptic, therefore, must not be confounded with the Constellations, or certain clusters of stars which are called by the same name. A little over 2000 years ago, the signs of the ecliptic were coincident with the constellations that bear the same name, but during that period the actual equinox has receded about one full sign; consequently, the constellations of the zodiac are about one sign in advance of the signs of the same name, marked on the ecliptic.

It was formerly the practice to reckon the longitude of the heavenly bodies by signs, degrees, minutes and seconds; but the practice of using signs in the reckoning of longitudes, is now being abandoned, in consequence of the misunderstanding liable to

arise from confounding these signs with the constellations; longitudes are now reckoned by degrees, & from 0, or the vernal equinox, to 360 degrees.

As the equinoxes recede upon the ecliptic, it is evident that the earth will not perform one complete revolution, as indicated by the stars, until it has arrived at the same equinox again; the amount which it lacks of one complete revolution is, as above stated, about 50.1 sec. of a degree; over this distance, the earth must move in order to complete one sidereal year. The time of describing this arc is 20 m. 19 s. Hence the sidereal year is so much longer than a tropical year; the former is equal to 365 d. 5 h. 48 m. 45 s. while the latter is equal to 365 d. 5 h. 48 m. 47 s. It is during the tropical, and not the sidereal year, that our seasons come round in the same order.

The longer axis of the elliptic orbit of the earth has a slow motion of 11.8 arc minutes in advance; that is, the perihelion advances eastward upon the ecliptic that once in a sidereal year this small arc, which is so much over one complete revolution, must be described before the earth can again reach the perihelion point of its orbit. The time occupied in so doing, is 4 m. 39 s.; this added to the sidereal year, gives the interval between two consecutive returns to perihelion. This interval is equal to 365 d. 6 h. 13 m. 49 s., and is called the Anomalous Year. The receding of the equinoxes and advance of the perihelion upon the ecliptic, are results flowing from the action of the forces existing in the solar system, and which we shall, probably, more fully explain when we come to investigate the law of those forces.

We have seen, however, that the sun is not at the geometric and Helio-centric place, but at a heavenly body. The Geocentric place is that position as it would be seen from the center of the earth. The center of the earth is chosen, as a convenient point of reference, because it is not affected by the diurnal rotation.

The Helio-centric place of a body is its position as seen from the sun, or rather from the center of gravity of the solar system, which is situated near the center of the sun. This point is chosen as a convenient point of reference because it is not affected by the diurnal rotation or the diurnal motions of the system.

The Geocentric position refers the situation of helios to the great sphere of the heavens concentric with the center of the earth.

The Helio-centric position refers them to the sphere of the heavens concentric to an eye situated in the center of gravity of the system.

The Helio-centric Longitude of the earth is its angular distance subtended at the sun, from the first point of Aries, reckoned eastward on the great circle of the heavens, formed by the infinite prolongation of the plane of the ecliptic.

The Helio-centric Latitude of a heavenly body is its angular distance, subtended at the sun, reckoned either north or south of the plane of the ecliptic, perpendicular to that plane. As the earth is situated in the plane of the ecliptic, its Helio-centric Latitude is nothing.

We shall now explain what is meant by the mean and true places of the earth in its orbit.

The mean place is the position it would occupy if it revolved with a uniform motion in a circular orbit with the sun in its center. Then its true longitude could be calculated by the following simple proportion:

One year : the time elapsed : 360 deg. :: the arc of longitude passed over from the vernal equinox

But as the orbit is not circular, and is not described with a uniform motion, this will not give the true longitude; the longitude thus obtained is called the mean longitude. As the earth's orbit does not revolve to any great extent from a circle, the true longitude does not differ to any great degree from the mean.

The former may be calculated from the latter by applying to it a correction which will be additive or subtractive, according as the earth is in advance or behind its mean place. The amount of this correction is computed upon the principle of the equidistant descent of areas about the sun in equal times.

The area swept over by the radius vector in any given time, may be ascertained by the following proportion:

One year : the time elapsed :: the whole area of the ellipse : the area of the sector swept over in that time.

And having thus obtained the area of the sector, there are various methods of obtaining the angle about the sun which this fractional area would subtend in any given position of the ellipse. By the principles of geometry, the true longitude of the earth could be calculated for any given moment.

To save the labor of calculating, tables have been formed, expressing the difference between the true and mean longitudes for any given time throughout the year. This difference is called the Equation of the Center. At the perihelion and aphelion the earth is at the mean and true places will coincide; from the perihelion to the aphelion the true place will be in advance of the mean, and from the aphelion to the perihelion, the true place will be behind the mean.

The greatest difference between the true and mean places amounts to 1 deg. 55 m. 33 s.; from this the difference diminishes to nothing, and is additive to the mean place, while the earth passes from the perihelion to the aphelion, and subtractive from the mean, while the earth passes from the aphelion to the perihelion.

It is a well known fact, that the sun comes to the mean and at distant seasons of the year, he is in the mean, as indicated by a well regulated clock, but sometimes before, and at other times after mean noon.

If the earth revolved with a uniform motion in a circular orbit with the sun in its center, and also in a plane coincident with the equator, the sun would always come to the meridian precisely at 12 o'clock. But as the earth's orbit is elliptical with the sun in one focus, and is described with velocities not uniform, the sun will not, on account of these causes, coincide with a true clock.

But independent of these, there is another cause which produces an inequality in the time of the sun's coming to the meridian, and that is the obliquity of the ecliptic; even if the earth did describe the circle of the ecliptic in equal times, these equal angles in the ecliptic, if projected on the equator at right angles to it, would give unequal angles, and therefore this would be another cause which would make the sun come to the meridian sooner or later than clock time. Time reckoned from the position of the sun is called apparent time; and when reckoned from a true clock it is called mean time. The difference between mean and apparent time is called the equation of time.

The causes just referred to, operate conjointly to increase this difference. The greatest fractional part of the increase, amounts to upwards of half an hour, being sometimes 16 1/4 minutes faster than mean time, and at other times 14 1/2 minutes slower.

Tables of the equation of time are calculated and inserted in almanacs; and by the application of the equation to apparent time, we can regulate our clocks and watches to mean time.

From December 24th, the sun begins to fall behind a true clock, the difference increasing daily until it attains a maximum on the 11th of February; then gradually decreases until the 15th of April; therefore from the 24th of December until the 15th of April the equation is to be added to apparent time in order to reach the mean time. On April 15th the sun begins to be in advance of a true clock, the difference increasing very slowly until it attains its maximum on May 14th, when it gradually diminishes until June 14th. From April 15th to June 14th, the equation must be subtracted from apparent time to obtain clock time. In like manner, from June 14th to August 31st, the equation must be added. A day from August 31st until December 24th, it must be subtracted.

Hence there are four days in a year when the sun and a true clock, or apparent and mean time agree; namely, April 15th, June 14th, August 31st, and December 24th. Between each of these periods the sun is out of the equation at its greatest distance from the mean time, and at other times 14 1/2 minutes slower.

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