

UNIVERSITY LECTURES.

ASTRONOMY.

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LECTURE VII.

Names of the primary planets.—Distance of Mercury from the Sun.—Its period and magnitude.—Inferior and superior conjunctions.—Its opacity and phases.—Eastern and western elongations.—Its seasons.—Synodical period.—Transits across the Sun's disc.—Height of mountains on Mercury.—Its period of rotation.—Intensity of the solar light and heat on its surface.—Common temperature of the celestial regions.—Mercury's orbital velocity.—Its mass.—The planet Venus, including the various characteristics attending Mercury.—Mars and its characteristics.—Jupiter's distance and period, conjunction and opposition.—Velocity of light.—Jupiter's magnitude and rotation.—Effects of the combination of its orbital and relative velocities.—Great variations of gravity on its surface arising from rotation.—Mass.—Weight on its surface.—Rapidity of the vibrations of a clock pendulum on Jupiter's surface.—Density.—Its zones, seasons, belts, and atmospheric currents.—Satellites.—Weight of bodies on the Satellites.—Their densities, volumes and masses.

MERCURY.

We shall next proceed to give a brief sketch of the primary planets of the solar system; the names of which we here give in the order of their distances from the sun, namely, Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune. Of these, the earth has already been under our investigation; and the principal phenomena exhibited in relation to its motions, the form of its orbit, the time of its revolution, etc., have been explained. And as there are many of these characteristics similarly manifested by all the rest of the planets, it will be unnecessary to repeat the illustrations in each individual case of these bodies. The planet Mercury is the first in order. This planet performs a revolution around the sun at the mean distance of about 36,000,000 of miles; its periodic time is about 88 days; its diameter is about 3,200 miles; its bulk is about sixteen times less than our globe. This planet is supposed to be placed nearest to the sun, yet it is possible that there may be several planetary bodies still nearer, as it would be very difficult to observe such bodies even though we were assured of their existence; the bright glare of the sun would probably shield them from our view.

It is very likely, that if such bodies existed, we should occasionally behold them crossing, like small black dots, the sun's disc; but no such phenomena have been observed. It is also very probable that if such bodies existed, their perturbations upon the planet Mercury would be rendered visible. The gravitating force of each planet affects every other planet, more or less, according to the distance and quantity of matter in the disturbing planet. These mutual disturbances are such as to cause the planets to deviate from the true elliptic paths which they would pursue if no such disturbances existed. Now the planet Mercury does not appear to be greatly disturbed by any planetary body within its orbit; and therefore, from these negative evidences we have grounds to suppose Mercury to be the nearest planet to the Sun. The orbit of Mercury is enclosed within that of the Earth, being about 59,000,000 of miles from the path pursued by our globe. It follows, therefore, that the illuminated hemisphere of Mercury will assume every variety of position in relation to the earth; for Mercury is an opaque body, and only shines as it is shone upon. That hemisphere which is turned towards the Sun will be highly illuminated, while the opposite hemisphere will be in the dark and consequently invisible to us. Now the illuminated hemisphere will be turned from us, when Mercury is in that portion of its orbit between the Sun and Earth, consequently it will be invisible. In this position the planet is said to be in its inferior conjunction. When the planet is in that portion of its orbit most distant from the Earth, or when it is nearly on the opposite side of the Sun from us, it is said to be in its superior conjunction; it is then that the Sun illuminates the hemisphere of the planet which is turned towards the earth, and if the bright glare of the Sun did not prevent us from seeing the planet, its disc would appear round and full. At all intermediate positions between the inferior and superior conjunctions, the planet will assume every phase exhibited by our moon, between her conjunction and opposition; if it were possible to

perceive through the telescope, the planet, when near its inferior conjunction, it would appear like a crescent, becoming more and more slender the nearer it approaches the line between the earth and sun; this crescent would have precisely the shape of the new moon. As the planet recedes from its inferior conjunction, so as to be in a line drawn from the sun at right angles to the line of vision by which we see the planet, it will then appear like a half moon, one half of the enlightened hemisphere being visible, and the other half invisible, because it is turned from us. From this point, as it still recedes from us towards its superior conjunction, a greater portion of the enlightened hemisphere gradually comes in view, exhibiting a gibbous phase precisely of the shape of the moon between the full and second and third quarters, but as it now approaches its superior conjunction, the great intensity of the sun's rays will overpower the feeble rays of reflected light from the planet, and it will be hid in the glorious splendor of day. It is therefore, only for a few days, when near its greatest eastern and western elongation, that it can be easily seen with the naked eye.

What we mean by the planet's greatest eastern and western elongation is that position in its orbit, when just one half of the enlightened hemisphere is turned towards the earth; this happens, on an average, about six or seven times during the year, alternately on the east and then on the west of the sun. The greatest distances at which the planet is seen on the east and west of the sun, varies from 16 deg. 12 minutes to 28 degrees 48 minutes. The principal cause of this variation is the great eccentricity of the elliptic orbit of Mercury, which is nearly one-fourth of the planet's mean distance from the sun; and as the sun is situated in one focus of the ellipse it is evident that when the earth is in a line at right angles to the major axis of Mercury's orbit, the elongations which happen at that time near the perihelion, will be only a little over one half what they would be at or near the aphelion point of the orbit.

When the planet is at its greatest eastern elongation, it will be seen in the west, just after sunset; and when it is at its greatest western elongation, it will be seen in the morning just before sunrise. When the planet is seen with the naked eye, it exhibits a very brilliant white light, like Venus, only much smaller. The best or most favorable seasons of the year to view this planet are when its greatest elongations happen.

The further you recede from the orbit of Mercury the more difficult it will be to perceive this planet. It is extremely probable that the inhabitants on the most distant planets of our system have never been favored with a view of Mercury, and are, it is presumed, altogether ignorant of its existence, unless they have seen it apparently crossing the sun's disc, like a small black point; for in all other positions it would be overwhelmed in the brightness of the solar rays.

We have already observed that Mercury revolves around the sun in about 88 days; this, therefore, is the length of one year to the inhabitants of that planet, each of the four seasons will alternately take place in the short period of 22 days. During the time that Mercury performs one complete revolution around the sun, the earth performs about one quarter of its revolution; hence if they both set out together from the inferior conjunction, that planet has to describe one complete revolution and about one third of another, in order to bring itself again into conjunction with the sun and earth; this requires a period of about 116 days, and is called the *synodical period*. In this period happen all those phases which have been described. The real time of one complete revolution is called the *sidereal period*, and is exactly equal to 87 days, 23 hours, 15 min. 43.9 sec.

If the orbit of Mercury were in the same plane as that of the earth, at each inferior conjunction, that planet would, through the telescope, be observed to enter the sun's disc on the eastern limb, and pass across the same to the western limb, being observed as a small dark spot, and requiring from five to seven hours to traverse the disc. But as the orbit of Mercury, instead of being coincident with the plane of the earth's orbit, is considerably inclined to that plane, namely $7^{\circ} 0' 9''$, the transits do not happen, only at intervals of several years. The transits of Mercury that will happen during the present century, will take place as follows:

Visible, 1878, May 6,.....	11. 10. a.m.
Visible for a short time, 1881, Nov. 7,.....	5. 12. p.m.
Visible for a short time, 1891, May 9,.....	7. 17. p.m.
Visible, 1894, Nov. 10,.....	10. 49. a.m.

The time of the transits here expressed is the mean civil time at Salt Lake City, which place we have assumed to be 7 hours and 28 minutes west of Greenwich. We have only given the time in which they will be seen in the middle of their paths at Greenwich. They will be seen nearly in the same position on the sun's disc from this city as from Greenwich. The few seconds deviation will be principally owing to the parallax.—These transits will require the telescope to render them visible.

Owing to Mercury's dazzling appearance, it is very difficult to discover any prominent marks upon its surface; yet Schroeter, a German astronomer, has been enabled, not only to discern spots, but mountains also upon its disc. The height of two of these

mountains, he has calculated, one of which is about 14 miles high; the other about 104 miles, or about eight times higher than the twin peaks on the east of this valley. The highest mountains on Mercury are said to be situated in the southern hemisphere of that planet.

When the horns or cusps of this planet are carefully observed, at the time when it appears of a crescent form, it is ascertained that they vary from day to day. By these variations, the time of the rotation of the planet is determined to be 24 hours, 5 min. and 28 sec. Hence the length of days and nights upon that planet do not differ, only by a very small fraction, from those enjoyed upon our globe.

The intensity of light which Mercury enjoys, is far greater than what is enjoyed on the surface of the earth. It can easily be demonstrated, that the intensity of light varies inversely as the square of the distance. Therefore, if we divide the square of the earth's distance from the sun by the square of Mercury's distance, the quotient will be about 6 $\frac{1}{2}$. Consequently the intensity of light upon that planet is about 6 $\frac{1}{2}$ times greater than upon the earth. As the apparent disc of the sun is also in proportion to the square of the distance, it follows that the resplendent orb of day will appear nearly seven times greater to the inhabitants of Mercury than what he appears to us. Consider, for a moment, the mountains and valleys and all the objects with which we are surrounded, illuminated with a seven-fold splendor. Such a brilliancy would be far too great for the present constitution of our eyes; if the pupils of our eyes were contracted to about one-seventh part of their present dimensions, we should still be able, under the influence of a seven-fold intensity of light, to perceive every object with the same ease and distinctness that we do now.

The splendor of the scenery upon Mercury must be magnificently grand, the vividness of colors, radiated from surrounding objects must be exquisitely beautiful, and the whole landscape must be adorned as if with a gorgeous robe of light.

While Mercury enjoys 6 $\frac{1}{2}$ times more light than the earth, the planet Neptune only enjoys the 1-900th part as much as the earth; for Neptune is about 30 times the distance of the earth from the sun. The square of 30 is 900; hence the intensity of the sun's light on Neptune is 900 times less than what we receive; 900 multiplied by 6 $\frac{1}{2}$ is equal to 6,000; therefore the light on Mercury is 6,000 times greater than the light on Neptune. The sun at the distance of the outermost planet discovered in the system, will subtend an angle of $1/4^{\circ}$; and consequently will only appear about the size of the planet Venus, when nearest to the earth, or in other words the sun's apparent diameter will be only about one-half greater than the planet Jupiter's when in opposition.

Many have supposed heat to follow the same law as light; if so Neptune would have 900 times less heat from the sun than what we experience; and the proportion of the sun's heating power at the extremities of our system, would be as one to 6,000. But independent of the heating power of the sun, the planetary spaces and worlds no doubt have a natural temperature of their own, modified more or less by the heat of the sun, according to their proximity to that great luminary. One cause of the common temperature, which we have great reason to believe exists in the celestial regions, is the combination or united heat, emanating from the fixed stars which are known to be great suns, similar to our own.

Heat is no doubt generated, or, rather, set free by the chemical action of the materials of which the planets consist. From these two sources, it is very probable that the planets are maintained at a temperature far greater than what they would enjoy if they were dependent on the sun alone.

The amount of common temperature, existing in the celestial regions is very likely in proportion to the amount of star light; if so it is comparatively easy to calculate the amount or degree of this temperature, this has been calculated by a great number of different methods, and they all concur in showing that it does not differ much from 58 degrees below the zero of Fahrenheit's scale, or about 90 deg. below the freezing point of water. Now this is a degree of cold much less than what we are capable of producing artificially. Such a common temperature would operate to greatly diminish the cold that would otherwise exist in the more distant extremities of our solar system.

As Mercury is the nearest planet to the sun, its velocity, according to the law of mechanics governing centrifugal forces, is greater than that of any other planet. Its average velocity is equal to about 109,800 miles every hour; but as its orbit is much more eccentric than the earth's, its velocity varies from the mean to a much greater extent than that of the earth's. Its average velocity is 1830 miles every minute, and over thirty miles every second.

The density of Mercury is about six times greater than water; this is considerably greater than the density of the earth, and greater than the density of any other planet in the system.

The mass of this planet is 4,865,751 times less than that of the sun. But as the materials of which Mercury consists are much heavier than the sun's materials, its bulk is about 44 times less than it would be if composed of materials of the same density as the sun's; consequently it would require about 22,000,000 of globes of the

size of Mercury to compose one as large as the sun. The weight of bodies on the surface of Mercury is only about one-half as much as they would weigh at the surface of the earth.

VENUS.

The planet Venus is the brightest and most conspicuous luminary, the sun and moon excepted, that shines in the heavens. Its diameter is 7,800 miles; it is therefore about the size of the earth, and revolves in an orbit from west to east at the distance of 68,000,000 miles from the sun, consequently, when situated in the nearest point of its orbit, it is only about 27,000,000 miles from the earth, and is the nearest to us of all the primary planets.

Its orbit being enclosed within that of the earth, it never departs over about 48 deg. from the sun. Hence it is never seen in the south during the night, and is never seen east of south after sunset, and never appears west of south before sunrise. When in that point of its orbit, the most distant from us, it is in its superior conjunction, being 163,000,000 of miles from the earth; and when in that point of its orbit between the earth and sun, it is in its inferior conjunction, and is then over 6 times nearer to us than when in the other conjunction. If the whole of the hemisphere of Venus, turned towards us, when at the inferior conjunction, were enlightened so as to be visible it would present a disc over 36 times greater than it appears at its superior conjunction. But when at the inferior conjunction its dark hemisphere is turned towards the earth, which renders it invisible.

The time occupied by Venus in passing from its inferior conjunction to the same conjunction again, is about 584 days. For about 35 hours previous to and after the inferior conjunction, Venus cannot by the telescope be easily seen; and for about 63 days preceding and following the superior conjunction, it is difficult, if not impossible, to see Venus in consequence of the splendor of the sun's rays. Therefore, by the aid of the telescope, Venus may be rendered visible 567 $\frac{1}{2}$ days out of 584; while to the unassisted eye, it will be visible only about $\frac{1}{2}$ of its synodical period, or 440 days. The real sidereal period of Venus is 224.7007869 mean solar days. One synodical revolution of Venus is more than 2 $\frac{1}{2}$ times longer than its real period.

Venus, like the planet Mercury, passes through every variety of phase, similar to the moon; these phases are easily perceived by the telescope, sometimes they appear of a crescent shape; sometimes half the disc is seen; at other times they are gibbous; and at other times they appear full.

Soon after this planet passes its inferior conjunction it will appear a short distance west of the sun, and consequently will be seen just before sunrise in the east; each succeeding morning it will rise a little earlier, moving gradually to the westward of the sun, until it attains to its greatest western elongation, when for a few days it apparently remains nearly stationary and then moves gradually to the east until it arrives at its superior conjunction.

From the inferior to the superior conjunction embracing a period of about nine months Venus is called the morning star, though for several days, when near the conjunction, it is not visible to the naked eye. After passing its superior conjunction, and emerging from the sun's rays it will appear on the east of the sun and will be seen soon after sunset. And each succeeding evening it will appear to have advanced to the eastward until it attains to its greatest eastern elongation, when it will, for a short period, appear to remain stationary, and then to apparently retrograde towards the sun or to the west; when near its inferior conjunction it will again be lost in the glare of the sun's light. At the greatest eastern and western elongation, Venus never rises above the eastern and western horizons over about 48 deg., or about one-half the distance from the horizon to the meridian.

By the motions of the telescopic spots observed on Venus it has been ascertained that it has a rotation upon its axis in 23 hours 21 minutes. The position of the axis of a planet is determined by observing the direction of the spots across its disc; this has not been, as yet, very accurately observed in regard to Venus; but from the few imperfect observations which have been taken, it is believed, that the axis of Venus, has a position in reference to its orbit very different from that of the earth; while the axis of the earth, is inclined only 23 deg. 28 min., from the perpendicular, the axis of Venus appears to be inclined 75° from the perpendicular to the plane of its orbit. This circumstance will render the seasons on Venus far more changeable than upon the earth. The inhabitants in the same latitude, will, in the period of 225 days, experience every vicissitude of climate manifested in the torrid, temperate and frigid zones of the earth. The inclination of the axis of Mercury is also believed to be much greater than that of the earth, if so, the variety of changes in Mercury's seasons will be much greater than what is experienced on our globe.

The degree of heat and light received from the sun on Venus will be nearly double the amount which we receive; and the sun's disc will appear about as large again to the inhabitants of Venus as it does to us. But the temperature will doubtless be greatly modified by surrounding circumstances, such as the density of the atmosphere the amount of clouds sur-