THE SOLAR ECLIPSE.

OBSERVATIONS OF THE COAST SURVEY PARTY.

At the meeting of the California Academy of Sciences on Monday evening, Prof. Geo. Davidson, of the U. S. Coast Survey, said that, as heretofore, Capt. Patterson, the Superintendent of the Coast and Geodetic Survey, had given him permission to communicate to the Academy the general facts observed during the late solar eclipse. Then, with the aid of the blackboard, he described the points of interest in a very lucid manner. He said:

In the late eclipse the cone of shadow was so small, from the apparent diameter of the sun and moon being so nearly the same—the latter exceeding the former by only the two-hundredth part, that it made it hardly worth the while of astronomers to come here from different places to view it, especially as it took place so late in the afternoon. Being well acquainted with the topography of Monterey county, I chose the Santa Lucia mountains as the best place of observation, that being the highest point for a hundred miles. There were many minor difficulties to be encountered. The mountain was 6,000 feet high, and there being no trail, we had to cut our way through the chemisal. In the instructions for astronomers issued in 1878 for the eclipse of July of that year, it was especially mentioned that the English and American almanacs differed so that the estimated paths of totality differed three miles in location. I was desirous, though the arrangements could not be made, of having the north, south and central points determined by different observers at different points, and thereby rectify minute errors that might exist in the nautical almanac. It is from our knowledge of the path of total eclipses from before Christ, that we are enabled to check the secular changes of the moon.

It formerly required long and intricate calculations to determine the path of an eclipse, but so many of the constant quantities are now computed, that with most observers an hour or two of calculation, involving merely quantities depending on latitude and longitude, suffices to determine the times of the beginning and ending of the totality.

To meet the requirements as well as possible our party was equipped with a large equatorial of 6½ inch objective, one of 3 inches, two of 2¼, and one of 2½, all good glasses of high power and definition. These last qualities, as well as the quiet atmosphere and the high elevation which we sought to obtain, are necessary in order that the first and last points of contact may be accurately observed. The beginning all along the coast was similar to what you saw here.

The moon entered on the sun's disk on the lower limb at about 30° to the right of the vertical, and left the sun at a point about 16 degrees from the vertical on the left. By the high power and large aperture of my glass I was enabled to see the first contact of the limbs several seconds sooner than the others.

Both disks were real and not spurious. Spurious disks arise from the undulations of the atmosphere, occasioned by unequal refraction, and in that case the body of the sun or moon will not only appear too large, but there will be no well-defined point of contact at any phase. As the moon advanced we saw its contact with the sun's spots in three different groups. As totality advanced, several peculiar phenomena exhibited themselves. On account of the slight apparent diameter of the moon over that of the sun, the cusps became remarkably sharp. Observers at San Francisco and Oakland saw these cusps rounded instead of sharp, on account of the irregular refraction caused by the differently heated strata of the atmosphere. As the moon advanced, upon its edge became visible the lunar mountains. The darkness above the disk of the moon was less than the darkness of the moon on the sun, and yet the observers had failed to see the moon's disk before it touched the sun. Venus and Mercury have both been seen projected on the corona before their transits, and it has been supposed possible to see the dark body of the moon before it touches the sun.

My instrument was so arranged as to exclude all but one-tenth of the light and heat rays, whereby the eye is protected from the effects of heat, etc. The approach can be detected by spectroscopic methods before it quite touches, but not as a dark body. As the two disks became concentric, the crescent was remarkably prolonged, because the diameter of the moon was apparently only 1-200th greater than that of the sun. At that time the sun was passing into some cirrus clouds, and the points of the crescent were duplicated. I was somewhat surprised at the prolongation of the segment, which finally existed as a mere line of light 30 to 40 degrees in length. As it became narrow the phenomenon of Baily's Beads, a series of bright points of the sun hanging on the edge of the moon, caused by the irregularity of the waves of light from atmospheric vibration, was possible. This phenomenon was not visible owing to the clear atmosphere, but the line of light was broken into dots and dashes, like the Morse alphabet; the dots of light marking the depressions between the lunar mountains, as was proved by the fact that when one point of light disappeared it did not reappear, as in Baily's Beads, but was gone for good. Thirty seconds is a very short time, unless you are hanging by the neck. That was all the time we had, however. Each one of us attended to his assigned duty. I was seeking for an intra-Mercurial planet, and had one chance in a million. I had prepared a chart, with all the stars down to the seventh magnitude, and hoped to locate any unknown star by the configuration of those about it. I was satisfied beforehand, however, that the sky was too bright and that the cone of shade was too bright from a sort of re-illumination.

In consequence of this, the effect of the eclipse was somewhat disappointing; there was no black shadow creeping over the earth and the ocean, as in a totality of three or four minutes, but only a brown area advancing to us over the ocean; and the atmosphere was so light that we could make all our observations without artificial light. Upon the mountains we could not perceive the shadow's course at all. The want of depth of shadow was a disappointment to me, knowing that an intra-Mercurial planet would probably be invisible, and particular attention was then given to the corona and the bright flames. There are four sketches of the corona made by our party, more consistent in their outlines than those by many more skilled observers with much more time. It is impossible to describe the magnificence of the sight that the eclipse presented. Huge masses of red flames burst out above the upper surface of the sun one-twelth or one-fifteenth of its entire diameter in size, from 50,000 to 70,000 miles in hight. The lower limb of the sun produced a broken, jagged line of rose-colored flame, extending around a third of the sun's circumference, above the apparent disc of the moon, and covering millions of miles in area; this reached 40,000 miles in hight. The flames were visible for one or two seconds after the disappearance of the sun, a rather unusual phenomenon. After the re-appearance of the sun a change of conditions occurred showing the effect of atmospheric causes. The atmosphere became disturbed and in watching the end of the eclipse the limbs of the sun and moon were remarkably disturbed. The smaller telescopes lost the point of contact first. As the moon went off the sun's disk, its outline appeared as a wavy line of black, that of the sun as a wavy line of red, and it was impossible to tell the exact moment of their separation. Had the atmospheric vibration occurred at totality we should have had an exhibition from this cause of Baily's Beads.

The phenomena visible at totality are the red flames, the chromosphere and the corona. A circle of light around the sun, in width equal to about one-eighth of the sun's diameter, marked the lower part of the corona. As a rule, this is the only circle seen, but on this occasion a second circle less bright was noticed outside the first.

Outside the chromosphere, which is the real atmosphere of the sun, the corona stretched out to a distance of about a diameter and a half in the direction of the sun's equator and to a smaller distance in the direction of its axis.

In the eclipse of 1869, the corona was sketched by several observers but the sketches differed widely. On this occasion, as has been said, the sketches agreed pretty closely, and two observers are confident that they saw the corona lengthen and shorten rapidly. As on the previous occasion three observers, placed side by side, produced widely varying sketches of its form, it is not impossible that the cosmical matter of which the corona is composed may be subject to sudden changes.

It has been thought that the corona and the zodiacal light may prove to have some physical connection, especially as the latter lies in the plane of the sun's equator. The zodiacal light was clearly visible on Santa Lucia on the evenings preceding the eclipse.

The corona shines partly by its own and partly by reflected light, and is therefore believed to be formed partly of solid particles which reflect the light, while the bright lines of its spectrum indicate the presence of gaseous vapors.

The chromosphere consists of the metallic vapors arising from the surface of the sun, but the chromosphere proper is only a comparatively thin stratum of one or two seconds of arc, or from one to two thousand miles thick.

The photosphere, or visible disk of the sun was, during totality, covered throughout with the mottlings known as "rice-grains." Among these were scattered those larger and more crooked lines of light known as "faculæ." These "rice-grains" and "faculæ" are the apices of bodies of flame shooting up from the surface of the photosphere, masses of flame which, when looked at edgewise during totality, appear as the magnificent "red-flames" which the spectroscope determines to be incandescent hydrogen, magnesium, etc. The photosphere is in constant motion and spots and groups of spots are generated by the matter immediately around them rushing in with cyclonic action, and so quickly that while the sun's surface was under observation one of these spots was divided in two.

Various theories as to the constitution of the sun have been put forth by Secchi, Young, Faye and others, but the one which appears to account most rationally for the phenomena presented and for the conservation of the solar heat is a modification of that of Faye.

According to this theory, the sun is not a solid body. It has long been evident to students of physics that no solid body could continue to give out a constant and regular supply of heat and light to the whole solar system. No chemical action can account for the heat, and actual fire would soon burn itself out. But if the sun is gaseous, and continually contracting, it has been calculated that a contraction of four miles in its diameter in a century would be sufficient to account for the amount of constant radiant heat now given off from its surface.

The mass of the sun must thus consist of incandescent gases in a highly compressed state, unable to soldify because of the intense heat caused by the constant contraction. When this contraction ceases, liquefaction or solidification will commence, and the radiation of heat will rapidly diminish.

In the corona there is seen by the spectroscope the green line called "1474," which occupies a position different from that of any line formed by the known elements of the earth; there is also present the helium line, preliminarily so called.

Several total eclipses will occur during the next twenty years, and will doubtless enable us to solve much that is now unknown in solar physics. The next total eclipse visible in the United States will be in the year 1900. The longest possible duration of a total eclipse is 7' 58", those occurring during the next twenty years will give us from three to six minutes of totality.