THE SUN WILL BE IN TOTAL ECLIPSE

NOTABLE ASTRONOMIC EVENT EXPECTED ON MONDAY.

An Expert Analysis of the Physical Constitution of the Sun, and Some of the Things Astronomers Expect to Establish During the Totality of May 28.

From the Pittsburg Dispatch.

A total eclipse of the sun is one of the most interesting phenomena of nature, but occurring as it usually does over widely-separated parts of the earth, and over a comparatively narrow belt of land, it is by any one person witnessed but seldom, even by professional astronomers.

On May 28 there will be a total eclipse of the sun visible in the southeastern part of the United States. Its path, the track of the moon's shadow, within which alone the interesting phenomena of the eclipse are visible, covers a belt about 50 miles wide, the center of which stretches in a nearly straight line between a point a little south of Norfolk, Va., and another a little north of New Orleans. The time during which the sun is totally eclipsed is short, being 72 seconds on the line of centrality near New Orleans and 100 seconds near Norfolk.

However, brief as is the interval of totality on this occasion, it does not even under the most favorable circumstances quite equal eight minutes. But so valuable is the knowledge to be gained during the few seconds of a total eclipse, and to be obtained, be it said, at no other occasion, that even at the risk of clouds robbing him of the fruits of his labor, the astronomer is fully justified in the great expense of time and money connected with a distant voyage to observe a total eclipse of the sun.

A STUDY OF THE SUN.

To understand in a measure the scientific importance of a total eclipse—the problems it may solve—some idea of what modern research has revealed concerning the nature of the sun is necessary.

The importance of the sun to the life of man has been recognized, even at the dawn of civilization, when he worshipped it as a god, as indeed some savage tribes do still. However, few are aware of our absolute dependence upon its light and heat. Not only does every form of life depend directly on the sun, but all forms of energy, except contact electricity, that part of the tidal wave due to the attraction of the moon, and the interior heat of the earth, have their origin in the sun's rays.

It is the heat of the sun that moves the vast mechanism of the earth's atmosphere, that evaporates the enormous quantity of water which descends in the form of rain or snow, and the energy of its rays that enables plant life to absorb the carbon from the carbolic acid gas in the air and build it into its tissue, while the purified oxygen is restored to the atmosphere. How great the work done by circulating the water through the atmosphere will appear when we consider that if all the water annually evaporated at the equator were collected in a basin the size of the United States it would fill it to a depth of about 200 feet. Of the power which this would yield in again descending to the sea, the 2,000,000 horse-power, which it is estimated the Niagara Falls would yield, is but a very small fraction.

ESSENTIALITY OF SUN-RAYS.

How important the chemical action of the sun's rays is, not only to plant life, but also in purifying the atmosphere, is seen from the estimate that the breath of man adds annually to the atmosphere five and one-half billion tons of carbonic acid gas, which if permitted to accumulate, would double the normal amount in the air in about 600 years, and render the process of breathing exceedingly difficult. Even the heat obtained from coal which we use to warm our homes and drive our engines comes originally from the sun, for coal is known to be of vegetable origin. Thus in burning coal we are using the energy of sunlight stored up long before the advent of man.

These facts, though interesting, furnish no accurate value of the light and heat received from the sun. For the purposes of science definite measurements must be made. The quantity of light and heat which falls on a given area of the earth when the sun is directly overhead must be determined. Actual measurements show that when the sun is overhead on a clear day it will light up a sheet of white paper as brightly as 288,000 standard candles at a distance of 40 inches. A 10,000-candle power arc lamp is one of the brightest lights generally produced, but it must be brought to within eight inches to illuminate a sheet of white paper as brightly as the sun. Bond found that sunlight is 470,000 times as bright as the light of the full moon.

NOT ALL RAYS VISIBLE.

By measuring the heat of the sun the energy of all its rays is determined—that of the dark heat rays as well as of the visible rays. There is no real difference in the nature of the visible rays we call light, and those which can be detected merely by their heating effect or by means of photography. The difference lies in our sense organs, which respond to some rays more readily than to others.

One of the simplest ways for determinating the heat effect of the sun is to expose to its rays a hollow copper disk covered on the side toward the sun with lampblack, so as to absorb all the heat, and filled with water in which is immersed a delicate thermometer. The rise in the temperature of the water after exposing the disk for a given time is measured, and this with the weight of the water heated, enables one to measure the quantity of heat. By such means it is found that the heat annually received by the earth would melt a layer of ice 126 feet deep all over its surface, if the sunlight were equally distributed in all latitudes; or using the known relation between heat and work, the heat received by each square yard when the sun is overhead is equal to about one and one-fourth horse-power of which about one-eight is mechanically available by the use of machines such as those constructed by Ericksson and Mondrot. It is found, however, that the cost of the machine for the power obtained makes it commercially impracticable.

MEASURING THE SUNLIGHT.

We live, however, at the bottom of a sea of air through which the sunlight must penetrate to the earth. How much of the sunlight which falls on the upper regions of the atmosphere penetrates to its depths? To make such measurements we cannot pass above the atmosphere, but we can ascend some high mountain, and, leaving half the mass of the air below, measure the sun's light and heat, and then determine the total effect of atmospheric absorption by computation.

A few years ago the director of the Allegheny observatory, Professor S. P. Langley, organized an expedition to Mount Whitney, Cal., for the purpose of making such measurements. Mount Whitney, which is 15,000 feet above the level of the sea, rises abruptly from a desert plane, in an atmosphere peculiarly dry and clear. By making measurements at the foot of the mountain and on its heights the absorptive power of the atmosphere could be determined. Professor Langley found that the atmopshere has a sifting action on sunlight, absorbing more of the blue and violet rays than of the red, so that should the air be removed the sun would appear blue.

It was also found that the atmosphere permits only half of the sun's heat to penetrate to the surface of the earth, while at the same time it acts as a blanket to prevent the heat from being immediately radiated into space.

On the mountain top the members of the expedition, when not exposed to the direct rays of the sun, suffered considerably from cold, but in the sun's light they suffered still more from its burning and blistering rays. Professor Langley estimated that, if the atmosphere were removed, the temperature even at noon would be far below freezing.

Having thus found that the heat which reaches the upper regions of the atmosphere is about 40 per cent. more than that which penetrates the surface of the earth, or about 1¾ horse power for every square yard, it can be calculated how much heat is radiated at the surface of the sun.

DIMENSIONS OF OLD SOL.

Now we know that the sun is a globe 866,500 miles in diameter, having a surface 12,000 times and a volume 1,300,000 times as great as the earth. The earth might be placed at the center of the sun, the moon still revolve about it as now at a mean distance of 239,000 miles and be but little more than half way toward the solar surface. About the sun the earth revolves in a nearly circular orbit, at a mean distance of 93,000,000. Imagine a sphere of this radius surrounding the sun. The earth will, of course, be on the surface of this sphere. We know the heat which falls on each square foot of the earth, when the sun is directly overhead, consequently we know how much heat falls on our imaginary sphere.

Now suppose this sphere shrinks until it touches the sun; there now falls on its surface the same total amount of heat as before, but each square foot receives more heat, as much more as the area of the sphere with the earth's distance from the sun for its radius exceeds the area of the sun itself.

This brings us to figures which stagger the imagination. It is found, to quote the language of Professor Young, that "this heat radiation at the surface of the sun amounts to over 100,000 horse power per square meter continually acting; that if the sun were frozen over completely to a depth of 50 feet, the heat emitted is sufficient to melt this whole shell in one minute of time; and that if an ice bridge could be formed from the earth to the sun by a column of ice 2 1-4 miles square at the base and extending across the whole 93,000,000 of miles and if by some means the whole of the solar radiation could be concentrated upon this column, it would be melted in one second of time, and between seven and eight seconds more would be dissipated in vapor."

TEMPERATURE OF THE SUN'S SURFACE.

What must be the temperature of such a body This question can be answered, if the law connecting the quantity of heat radiated by a body and its temperature be known. The answer, however, can only be given for the surface of the sun, not for its interior, and even then the assumption must be made that the sun radiates like an absolutely black body. The values found according to the law of radiation assumed ranged all the way from 1,500 degrees to 10,000,000 degrees. The former is evidently too low, the latter very much too high. Professor Langley first made dennite measurements to set a lower limit to the sun's temperature. He compared the surface of the sun with the molten steel in a Bessemer converter, and found that the brilliant stream of white hot liquid steel poured from a Bessemer converter appeared like black coffee in comparison with the sun, and that the solar surface radiated 87 times as much heat and 5,500 times as much light as an equal surface of the molten steel.

The burning glass frunishes another means for setting a lower limit to the sun's temeprature. It is known from theory that the burning glass cannot form an image hotter than the sun itself. The effect is as though the sun were brought nearer the earth. With such a glass 40 inches in diameter, which made the image of the sun as hot as its rays would be were it brought as near to the earth as the moon, Ceraski succeeded in not only melting, but reducing to vapor all available terrestial substances.

If, then, the earth should approach the sun as close as the moon is to the earth, it would not only be melted, but largely reduced to vapor. Recent experiments have shown that the radiation increases as the fourth power of the temperature. This law gives the temperature of the sun, allowance being made for the absorption by the solar atmosphere, at 8,000 degrees.

PHYSICAL CONSTITUTION OF THE SUN.

The question of the chemical constitution of the sun, and its physical state, whether solid, liquid or gaseous, seemed but a few years since to be beyond the reach of science. But in the hands of skilled astronomers the spectroscope has answered these and many other interesting questions. A brief description of the principle of this instrument will help in a measure to understand how these results are obtained.

If sunlight coming through a small hole in a dark room passes through a glass prism and the light then falls on a sheet of white paper, it will be be found to be drawn out into a rainbow-colored band of light, red at one end, violet at the other, with the rest of the colors between. This is the spectrum of sunlight. Examined, however, merely as above described, the spectrum is impure, adjacent colors overlap. By means of the spectroscope this overlapping of colors is prevented. This instrument consists essentially of a narrow slit about one one-thousandth of an inch wide, on which the light to be examined falls, a prism, usually of glass, which divides the light coming from the slit into its constituent colors, and a telescope for examining the light after passing through the prism. By means of such an instrument it is found that the light from a white-hot solid, liquid, or gaseous body, under great pressure, always gives a continuous spectrum, that is, an unbroken band of colors, a spectrum from which no color is missing. When, however, the light of an incandescent gas, such as apodium, or magnesium flame, an electric spark or an electric arc is examined, there is no continuous spectrum but instead a series of bright lines. Every element gives its characteristic bright line spectrum.

If now this incandescent gas be examined against the brighter background of a white-hot solid or liquid substance, hotter than the gas, there is seen a continuous spectrum interrupted by dark lines which coincide exactly with the bright lines of the gas. Now on examining sunlight with the spectroscope, we find it has a contiuous spectrum, broken by many fine, dark lines, which coincide with the lines of the spectra of a number of known terrestrial elements. We may, therefore, confidently say that that there elements are present in the solar atmosphere as incandescent gases.

How accurate this method is will in part appear from the fact that the element helium was first found on the sun and only later traced to earth. Among the elements discovered on the sun are potassium, sodium, magnesium, nickel, cobalt, calcium, silicon, titanum carbon, oxygen, copper, platinum and iron. Professor Rowland, who has made an extensive study of the solar spectrum, says that if the earth were heated as highly as the sun it would give precisely the same spectrum.

TO THE EYE AND CAMERA.

Visual photographic observations of the sun show that its brightness decreases from the center toward the limb, owing to the greater depth of solar atmosphere through which the latter is seen. It is found that less than one-half as much light and heat as is radiated at the center is given off at the limb of the sun. The action of the solar atmosphere is found to be similar to our own. Less of the violet light penetrates it than of the red.

Under the influence of the intense heat the sun's atmosphere is kept in a state of violent disturbance in comparison with which Western cyclones and West Indian hurricanes are mere zephyrs. Two photographs of the sun, the one taken ten minutes after the other, disclosed an evident change in the solar surface, which, to be detected at all, even under the most favorable conditions, implied a motion of at least 47 miles.

The visible surface of the sun is called the photosphere. Eamined under suitable atmospheric conditions with a special eyepiece to reduce the blinding intensity of the sun's image, it is found to be covered with minute granules much brighter than the background on which they lie, presenting an appearance which has been likened to snowflakes on a white sheet. These granules are bright incandescent clouds. Though they occupy less than one-half of the sun's surface, they radiate most of its light.

CHEMICALS IN THE SUN.

The layer of gas lying just over the photosphere to a depth of about 500 miles contains most of the elements which produce the dark lines in the solar spectrum, and is for that reason called the reversing layer. The spectrum of the reversing layer photographed in the absence of light from the solar surface, as on the occasion of a total eclipse of the sun, consists of bright lines, the dark lines reversed. Above the reversing layer is the chromosphere, the sun's atmosphere of which the reversing layer is the lower lying strata. The chromosphere extends from 5,000 to 10,000 miles above the solar surface. It is composed principally of hydrogen and helium. Seen only on the occasion of a total eclipse it presents—to quote Professor Young—"the appearance of a scarlet flame, not composed of horizontal sheets, but of upright filaments. Its appearance has been compared very accurately to a prairie on fire." This, however, is not to be understood to mean that combustion takes place. The temperature is too high for that.

In the chromosphere are to be seen scarlet cloud-like objects suspended 50,000 or 60,000 miles above the photosphere, with which they are generally connected by means of slender filaments. These are quiescent prominences. They are masses of incandescent gases, principally hydrogen and helium. Other prominences are to be seen which differ from the quiescent in that they are much more brilliant and active. They appear to be cast up from the body of the sun by an explosive, or eruptive force, and hence are called eruptive prominences. They contain many other metals besides hydrogen. At times they change with astonishing rapidity, having been observed to move with velocities of 200 and 250 miles a second.

Prominences are visible during a total eclipse of the sun with a telescope, and occasionally even to the naked eye, presenting the appearance of crimson flames projecting from the black disk of the moon. By means of the spectroscope prominences may be observed without an eclipse, and a modified form of this instrument enables the astronomer to photograph them.

THE CORONA.

On the occasion of a total eclipse there may be seen, and seen at that time only, the silver bands and streamers of the corona extending radically from the sun. Photographic and visual observances of the corona are among the most important that can be made at a total eclipse. A comparison of accurate drawings with photographs of the corona shows that the two are substantially the same in appearance. The latter has the advantage of furnishing a permanent and accurate record not only of its general appeatance, but also of its minute details, and may be studied at leisure in the laboratory. The form and size of the corona, as well as its brightness, change greatly. In general the coronal streams are made up of bands and filaments often strangely curved and intertwined. Near the poles they resemble tufts of threads sharply defined. For the most part the length of the streamers does not exceed the sun's radius, but at times some of them are seen to extend far out into space, as was observed in the clear air of Colorado at the eclipse of 1878, where two of them were traced to a distance of 9,000,000 miles. The spectrum in the corona shows that it shines partly by reflected sunlight and partly by light emitted by the incandescent gasses which compose it, among which are calcium, hydrogen and a hitherto unknown gas called coronium recently said to have been discovered in Italy.

The corona is formed of matter ejected from the sun. Its substance must be inconceivably rare, since comets have passed through it without suffering a noticeable change in their motion. All methods heretofore tried for photographing or mapping the corona without an eclipse have failed because of the brightness of our atmosphere.

TO MEASURE LIGHT.

Among the interesting observations to be made at the coming eclipse will be measurements of the intensity of the coronal light, the distribution of the different gases in it by means of the spectroscope, the heat it radiates, the form of the coronal streamers and their variation in brightness at different distances from the sun. Spectroscopes will be used to photograph the spectrum of the reversing layer and determine if possible, the distribution in altitude of the different metallic gases and their probable temperature. Search will be made by means of photographs taken in the neighborhood of the sun to find if there be any undiscovered planet lying within the orbit of Mercury. Many useful observations can be made by amateurs and will, if found accurate, be published by the United States government. A pamphlet giving details of useful observations, photographic and visual, which may be made by amateurs with little or no apparatus can be obtained on application to Captain H. C. Davis, superintendent of the naval observatory, Washington, D. C.

Not all eclipses are total. At times the moon passes to one side over the face of the sun; there is then a partial eclipse. Again the apparent size of the moon may be smaller than that of the sun, so that when seen centrally over the solar disk the dark disk of our satellite is surrounded by a bright ring of the sun's surface; this is an annular eclipse. Total and annular eclipses are seen only over a comparatively narrow belt of land and last at most for a few minutes, but partial eclipses are seen over a much wider extent of the earth's surface and last much longer. The same eclipse which is total or annular along but a narrow strip of the earth's surface is seen as a partial eclipse over a much wider area.

THE DIFFERENT ECLIPSES.

The distinction between the different eclipses may be simply illustrated by holding between the eye and a globe lamp a piece of circular cardboard, say of half the diameter of the globe. The shadow of the card may be divided into two parts; the umbra, the shadow cone converging to a point within which all light from the lamp is cut off; the penumbra a shadow cone diverging outward surrounding the umbra within it only a part of the globe is visible. If the eye be placed within the umbra the globe cannot be seen; it is totally eclipsed. Seen with the eye placed in the axis of the umbra but beyond its apex in the penumbra a bright ring is seen; this is an annular eclipse.

We may, therefore, regard eclipses thus: The moon always casts a shadow in space consisting of the umbra, a converging cone from which the sun's light is excluded, and a penumbra, a diverging case within which but a part of the sun's surface may be seen. If only the penumbra of the moon's shadow falls on the earth there is a partial eclipse. The umbra may converge to a point beyond the earth or fall short of it. If the axis of the umbra intersects the earth, but its apex does not reach it, the eclipse is annular. If the umbra itself falls on the earth the eclipse is total. It is because the moon's shadow is so small a diameter and moves so fast that a total eclipse is seen over so narrow a belt of land and for so short a time.

As the dark body of the moon encroaches on the sun it cannot be seen with the naked eye, until the exposed surface of the sun is reduced to a very thin crescent. Then suddenly this crescent is broken up into a string of bright beads, named after the astronomer who first described them as Bailey's beads. They are due to projecting mountain peaks on the limb of the moon, which first cut the bright crescent. From the distance is now seen rushing with surprising swiftness the dark shadow of the moon. Suddenly the sun's light vanishes, the stars shine out, nature is affected as if surprised by night, the body of the moon stands out black against the crimson photosphere surrounded by the silvery streamers of the corona. The eclipse is now total. Soon the moon moves off the sun, and a flood of light from its brilliant surface drowns the wondrous and beautiful spectacle.

OUR BEST PURCHASER.

Amount of Our Products Bought by England and Her Colonies.

From the Washington Star.

England buys 60 per cent. of all the products which the American farmer sends abroad, says Consular Agent E. L. Harris, at Eibenstock, in a recent report to the state department treating upon the extent of United States trade with Great Britain. England, he says, is our best customer for overproduction in food stuffs, and the British colonies present the greatest field for our manufactured products. Consular Agent Harris provides a table for the fiscal year, 1898-99, showing that England bought, in round numbers, $73,000,000 worth of our principal products, or 79 per cent. more than all the rest of Europe combined.

"This report," says Consular Agent Harris, "is based upon the statistics published by the Deutscha Kolonialzeitung, Bradstreet's annual report and on a statistical abstract for the several colonies and other British possessions issued in London. They are figures which every farmer, manufacturer and laborer in the United States should know. They are especially interesting when we consider that the English colonies are not included. The farmers of our great central states will see at a glance what the English market means to corn, wheat, flour, beef and pork. England buys 60 per cent. of all the products which the American farmer sends abroad. I may add that Great Britain has never shown the enmity toward these products which has characterized the actions of some European nations. The cotton grower of the south is aware of the value of the English market for his products. But the manufacturer of iron and steel has the greatest interest in the British empire as a market. His exports to England may be proportionately small, but in the colonies he is advancing with strides and bounds. He has more to hope for from these colonies in the future than from any other countries. Our bridge builders are busy in India and Egypt. Our steel rails, machinery and galvanic wires are in South Africa. British enterprise and stability in all these countries means increased opportunities and markets for our manufacturers. The more one becomes familiar with the continent of Europe the more one is satisfied that no lasting results can be obtained here with manufactured articles. The amount of labor spent in trying to secure markets in France, Germany and other European countries will have three and four-fold results in Africa, Siberia, China, Australia and South America. Cordial relations with Great Britain will carry us many a milestone on the way. We have thousands of laborers and skilled workmen who are dependent for their existence upon the sale of our overproduction. England is our best customer for overproduction in food stuffs. The British colonies present the greatest field for our manufactured products."