Would Show Candle at 41,000 Miles

Astronomy

What may be done with the new telescope planned for California is here described in the words of one of America's distinguished astronomers, as presented at the scientific meetings in New York.

Place a candle 41,000 miles away from you—at about a sixth the distance of the moon. The light from it would be about the same as that of a twenty-fifth magnitude star, the faintest that will be revealed to astronomers with the new 200-inch telescope planned for the California Institute of Technology.

At the meeting of the American Astronomical Society, held in conjunction with the American Association for the Advancement of Science, some of the possibilities of the new instrument were explained in an address prepared by Dr. Walter S. Adams, director of the Mt. Wilson Observatory. The observatory is a neighbor of the California Institute, and the two organizations will cooperate in the building and use of the new telescope. As illness prevented an eastern trip for Dr. Adams, his address was read by his associate, Dr. Seth B. Nicholson.

"The efficiency of such an instrument in rendering visible faint stars will be extraordinary," said Dr. Adams. "The mirror will collect about one million times as much light as the human eye, and with all allowance made for losses in the telescope a factor of 700,000 should be conservative. As compared with the 100-inch telescope at Mount Wilson, the new telescope will have four times the surface, and an additional factor of advantage in its relatively short focal length as compared with aperture. It seems probable, accordingly, that it will show stars at least five to ten times fainter, and the gain may be even greater.

"With the 100-inch telescope stars of the 22d magnitude have been photographed, so that the 200-inch instrument may be expected to reach stars of nearly the 25th magnitude. In other words, stars may be observed whose apparent brightness as compared with Sirius is less than that of Sirius as compared with our sun. The brightness of a 25th magnitude star is about equal to that of a standard candle flame of the same color seen at a distance of 41,000 miles or one-sixth of the distance from the earth to the moon."

With the massiveness and light-gathering power of the new telescope, it may prove of value in ways that can not now be foreseen, he said.

"When the 100-inch reflector on Mount Wilson was designed, no one could foresee that by means of a 20-foot interferometer beam placed across the end of its tube the first measurement of the diameter of a star would be successfully carried out," stated the speaker. "In the case of the telescope it seems reasonable to predict that the brightness of the stellar and planetary images formed by the 200-inch mirror will make it possible to apply methods and instruments of analysis which hitherto have been limited to the sun or to bright sources of light in the physical laboratory. The possibilities in such directions form a most interesting field of study, both for the physicist and the physical astronomer."

The ability to gather more light than any other such instrument will shed new light on the spiral nebulae, our neighbor "universes".

"These immense systems of stars form the most conspicuous examples of a sequence of structural forms, apparently genetic in character, which includes all the spiral, elliptical, and globular nebulae," he said. "Their total number is enormous, a million or more being within reach of the 100-inch reflector, with the probability that the 200-inch will increase this number several fold.

"In some five or six of these objects Hubble has been able with the aid of the 100-inch telescope to resolve a part of the nebulosity into individual stars. Among these he has succeeded in identifying some as variable stars of the type known as Cepheids. The application of the method developed by Shapley for the determination of the luminosity of such stars then leads directly to values of the distances and dimensions of the nebulae in which they occur. In this way the distance of the Andromeda nebula has been found to be 870,000 light years, or about 5,000,000,000,000,000,000 miles, and its diameter approximately 45,000 light-years. The light which it gives out is about a billion and a half times the light of our sun, and its mass is probably five hundred million to a billion times as great. In other words, it is a huge universe of stars comparable to, but somewhat smaller than our own.

"The Andromeda nebula is one of the two largest and presumably nearest of the spiral nebulae. Among the millions of other spirals only three or four more can be studied in a similar way with existing telescopes. The assumption, then, that the fainter, smaller nebulae are similar systems but more distant in proportion to their faintness, although partially justified on independent grounds, rests on a slender foundation—our knowledge of stars of known types in half a dozen of the nearest systems.

"The new reflector will add very greatly to these meager results. A conservative estimate is that it will furnish reliable distances for 25 or 30 nebulae, instead of the present five or six, and less accurate values, but sufficient for statistical purposes, for possibly 200 more. Provided with representative material of this quality and extent the astronomer can venture upon the exploration of more distant space with a new order of confidence. From our present knowledge it seems probable that the 200-inch telescope will show nebulae of average size and brightness out to a distance of the order of 400,000,000 light-years, a minute appreciable fraction of the finite universe postulated from the theory of generalized relativity."

Other important uses of the telescope will be in the study of the spectra of the stars on a much larger scale, and in the measurement of the heat from the stars, and planets. In fact, he stated, it will really be possible to make a "weather map of Mars" because of the measurements that will be possible of Martian temperatures.

But unless a good location is selected, the new instrument will be limited in scope.

"The atmosphere introduces a blurring and lack of definition into the telescopic images which impairs the accuracy of measurement, conceals the finer details of the surface of the sun or planets, and by spreading out the light reduces greatly the limiting brightness of the faintest star the astronomer can see with his eye or photograph on his plate," Dr. Adams said. "This quality of the images of celestial objects as affected by the earth's atmosphere, which astronomers for brevity call 'seeing', is the most important consideration in the location of any large (*Turn to next page*)

What 200-Inch Telescope Will Do—*Continued*

observatory. Good seeing is far more vital than transparency of the air, or within reasonable limits, even than clearness of the sky. Except in one or two special lines of work, few astronomical results of value can be obtained when the images given by the telescope are poor and ill-defined.

"The cause of so-called 'poor seeing' is easy to understand. Light in passing through the atmosphere is refracted or bent, and the amount of this bending varies with the temperature and density of the air. Consequently, when masses of air of different temperatures or densities pass rapidly in front of a telescope they refract the light of a star by different amounts, and the combined result is a quivering and blurring of the star's image, and the obliteration of planetary or lunar details. The twinkling of stars when seen with the naked eye is a familiar illustration of this effect, and extreme cases may be seen on any summer day in the desert where the heated air rising from the sands produces grotesque distortions of distant objects.

"As a result of the experience of observers in many part of the world, it is clear that the most favorable site for a telescope should be in a region in which the atmospheric conditions are very uniform, where abrupt changes of weather are infrequent, and where the average wind-velocity is low. Such conditions are probably most nearly fulfilled in those portions of the zones of the earth's surface lying between latitudes 30° and 35°, within which the so-called 'Mediterranean' type of climate prevails. This climate is characterized by wet and dry seasons, with a long nearly uninterrupted period of clear skies followed by a shorter period of unsettled weather with moderate or low precipitation.

"Speaking in general, therefore, the most advantageous location, so far as our present knowledge extends, would lie in a region having the Mediterranean type of climate, at an elevation sufficient to be above the fog and haze of the lower strata of the atmosphere, but not so high as to be subject to the intense cold and strong winds of the loftiest mountains. A height of some 4,000 to 8,000 feet has been found to meet these conditions adequately. In the high veldt country of South Africa, in some of the countries bordering the Mediterranean Sea, and in the extreme southwestern portion of the United States, including Central and Southern California and a part of Arizona, are probably the best locations which astronomers at present know for the most efficient operation of a large instrument."

Lunar Heat and Cold

Bathing in molten sulphur at noon and skating on frozen alcohol at night, would be possible for inhabitants of the moon, if there were any and they were physically able to stand the temperature extremes.

At the meeting of the American Astronomical Society, Dr. Seth B. Nicholson, of the Mt. Wilson Observatory, told of his researches in collaboration with Dr. Edison Pettit on the temperature of the moon.

The researches were made with the use of a thermocouple that converted the faint heat rays from the moon into electricity. A very thin glass was used to separate the light reflected from the planet from the heat. With observations without the thin screen, the total of both heat and light was measured, and with the screen the heat was eliminated, so that the difference was due to the heat.

When the sun is directly over a point on the moon's surface, that is, when it is lunar noon, the temperature reaches about 265 degrees Fahrenheit, higher than the boiling point of water, and high enough to melt both sulphur and iodine. For about a thousand miles on all sides of such a point, where the sun is directly overhead, or about an eighth of the entire area of the moon, the temperature is always above the boiling point of water.

An indication of what the dark, unilluminated side of the moon may be like was obtained when the astronomers made measurements during a recent lunar eclipse. A series of temperature measurements of a single point were made. Before the eclipse began, the temperature was 156 degrees Fahrenheit. At the end of the total phase it had dropped to 196 degrees below zero, Fahrenheit, the freezing point of alcohol. Half an hour after the eclipse was over, the temperature had returned to 135 degrees, nearly as hot as at the beginning.

The moon is thus shown to be of very low temperature conductivity, Dr. Nicholson pointed out. Of all the heat that falls on it, only about 6 per cent. is absorbed into the material, the rest being immediately reradiated away. During the short space of an eclipse, about a third of this is conducted out to the surface, and then radiated out into space.

Sunburn Rays Increase

People in Florida, southern California and Cuba may now be able to get a little more sunburned than they could a few months ago, for the ultraviolet rays of the sun, which cause sunburn, are now increasing. So reported Dr. Edison Pettit to the American Astronomical Society.

At the Mt. Wilson Observatory in California, Dr. Pettit has been making observations of the intensity of ultraviolet light for four years. The method is by comparing the radiation that penetrates a thin gold screen with that penetrating a thin one of silver.

Since the first observations were made in June, 1924, the monthly average intensities have on two occasions been half again as great as they were in that month. These were in October, 1925, and February, 1927. In no month since June, 1924, has the value been as low as it was then, though in September last it was only about 12 per cent. greater than at that time. The variation closely follows the number of sunspots, Dr. Pettit announced, and now seems to be increasing.

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