Man's Place in the Universe

By William H. Pickering

[We have asked Professor Pickering, of the Harvard Observatory, to make the following comment on the extraordinary article of Alfred Russel Wallace we printed two weeks ago. Professor W. H. Pickering is a brother of Edward C. Pickering, Professor of Astronomy at Harvard, and is associated with him in the Harvard Observatory. He established a temporary observatory in Southern California in 1889, and in 1894 erected the observatory and telescope for Mr. Lowell at Flagstaff, Ariz. He also led an expedition to observe the solar eclipse in Georgia in 1900 and in the same year established an astronomical station for the Harvard Observatory at Jamaica, W. I. He is also interested in mountain climbing and is the author of several books and articles on this "most dangerous sport in the world" and astronomical subjects.—EDITOR.]

AN interesting article by Mr. Alfred R. Wallace appeared in THE INDEPENDENT of February 26th, on the somewhat unexpected topic of astronomy. The position of the professional astronomer when he reads any such paper, dealing with his own branch, is naturally that of criticism, and that is probably what the author himself would desire. While the present writer can in general find no fault with the facts as stated by Mr. Wallace, he cannot but feel that some of his conclusions are open to question. As the whole subject matter treated lies on the very outermost bounds of our knowledge, however, it is only possible to show that the facts as we know them may be interpreted in a somewhat different manner from that indicated in the article above mentioned.

It is true that the increasing power of our telescopes and cameras shows a constantly decreasing increment in the number of stars revealed by them, but this, it seems to me, does not indicate that we have reached the limits of the stellar system, but rather that we are still very far from them. An approach to the limits would be marked by a sudden instead of a gradual decline in the number of additional stars observed.

It may be shown mathematically, assuming all the stars to be alike, that with each additional magnitude we should increase the total number of stars four times. That is to say, suppose that in a certain region in the heavens we want to find 5 stars brighter than the sixth magnitude. Then we should expect to find 20 stars brighter than the seventh magnitude, 80 stars brighter than the eighth, 320 stars brighter than the ninth, and so on. In point of fact the ratio 4.0 is seldom reached, and never held long, even among the brighter stars, while among the fainter ones much smaller ratios are found to obtain. Thus among 825 stars in a part of the constellation of Orion the successive ratios between the sixth and fifteenth magnitudes were 3.7, 2.5, 1.7, 1.7, 1.8, 1.5, 1.4, 1.4, 1.4 and 1.3. Here we find no sudden drop in the ratio, indicating that we had found all the stars. What we do find is a steady and uniform decline, which, as far as we can see, might with more powerful instruments be continued indefinitely.*

This really means apparently one of three things: either, first, that as we recede from our sun the stars grow smaller; second, that as we recede, the stars grow further and further apart; or, third, that there is an absorbing medium in space which makes the remoter stars appear fainter than would otherwise be the case. It is possible that all three of these hypotheses are correct, but it is not likely that we are near the edge of the universe as yet.

Similar counts to the above have been made in other parts of the sky, giving similar results. Thus the mean ratio for 946 polar stars was 2.2, for 479 stars in the Pleiades 1.5. Both the Pleiades and the Orion are near the Milky Way, and if we consider the ratio of 1.5 to hold good for the whole of that stupendous object, since it contains far more stars than all the rest of the sky together, we may roughly compute the total number of stars in the sky which our largest telescopes will show. This number is usually given in the astronomies as one hundred millions, but using the small ratio which we actually find by count, the total number of stars visible to us down to the

* This subject has been treated several times in the Annals of Harvard College Observatory. See Volumes XIV, 477; XVIII, 201, and XXXII, 69.

seventeenth magnitude proves to be a trifle over twenty millions.

While the total number of stars so far counted is inadequate to give any very satisfactory result, yet these are the only counts that have so far been made, as far as I am aware, where all the stars of each of the fainter magnitudes have been grouped by themselves and the ratio for each separate magnitude determined. The Cape Photographic Durchmusterung, lately published, contains 445,000 stars of the tenth magnitude and brighter. Adopting the ratio 1.5, this would indicate that the total number of stars that we can see in the whole sky is about twenty-five millions.

While the dark spaces in the sky, or coal-sacks, as Herschel called them, may really be empty spaces, as Mr. Wallace suggests, it is at least quite as probable that they are simply large clouds of non-luminous gas, which by its absorption would completely blot out the light of all the stars beyond them. Indeed, the sharpness with which they are often defined points very strongly to this explanation of them. As we find enormous masses of luminous gas, whose dimensions can only be measured by the number of years that light would require to traverse them, it is certainly possible that equally large masses of non-luminous gas may occur, whose presence is indicated to us only by its absorption. For all we know to the contrary the universe may extend to infinity in all directions, filled with this same non-luminous gas. In this vast space comparatively small scattered pockets may occur where the gas has begun to become luminous and to condense into stars and stellar systems. Near the center of one of these comparatively small pockets is located at the present time our own sun with its attendant planets, while what we in our ignorance call the whole universe may be simply one among many of these little isolated stellar regions.

Thus it does not appear from this point of view, as Mr. Wallace would have us believe, that the universe is a limited object that we have pretty nearly explored. It may be, for aught we know, and very likely is, infinitely larger than our most powerful instruments will ever permit us to examine.

Mr. Wallace's statement that proper motion gives us our best guide to the distance of the stars whose parallax is unknown is probably true, but his remark that "there is little or no relation between brightness and distance" is obviously erroneous. Some very bright stars, like Canopus and Rigel, are very remote, while very faint ones, like Ll. 21185, are comparatively near at hand, but there is not the slightest question that the average distance of twenty faint stars, taken at random, is greater than the average distance of twenty bright ones similarly selected. Of the eight brightest stars in the heavens, three—α Centauri, Sirius, and Procyon—are comparatively near. Proper motion and brightness form at present our two best guides to the distance of the stars, when parallax observations have not or cannot be obtained, but proper motion is probably on the whole the safer of the two.

With regard to our position in the exact center of the Milky Way, Mr. Wallace seems to have been led into error by the accuracy of the figures given by Sir John Herschel. Many astronomers, especially in former times, were in the habit of giving their numerical results in very small fractions of the second of arc, whereas, in point of fact, they could not measure the given distance perhaps within several minutes. This seems to be the case in the present instance. If the Milky Way were merely a hazy uniform band of light we might locate its medial line with some approach to accuracy. A close examination, however, shows that it is on the contrary a branching structure of most irregular form and brilliancy, sometimes one side being the brighter and sometimes the other, and it would not be possible for any two observers, or indeed for any single observer working on different nights, to agree within as much as a degree as to where the medial line should properly be drawn. As to locating it accurately within one minute of arc (one-thirtieth of the moon's diameter), a mere glance at the object on any clear night will show the reader the absolute futility of such an undertaking.

Admitting for the sake of argument that we are located within one degree of the medial plane of the Milky Way, there is no evidence whatever that we are located within ten per cent. of the radius

of the central position in that plane. Indeed, what evidence there is, as is pointed out by Sir John Herschel, shows rather that we are slightly to the south of the center. Assuming, however, that we are within one degree of the medial plane, and within ten per cent. of its central position, which is indeed quite possible, it may readily be shown that there are from one to ten thousand stars that are just as likely to hold the central position as we ourselves. That is to say, any one of our naked eye stars may be the central one.

But again, supposing our sun is the central star, what of it? If we are central to-day, since we are moving about fourteen miles every second straight toward one side of the Milky Way, we are not likely to remain central very long, and when the human race first appeared, perhaps 100,000 years ago, we certainly could not have been anything like central. It would therefore appear that our sun is no more likely to control the one favored planet of the universe, on this hypothesis, than any other of the three or four thousand stars that are visible to the naked eye upon a clear night. In any case, as Mr. Wallace himself admits, it is not possible to prove that any advantage would accrue to us from belonging to a central sun; we can merely guess that certain advantages might do so. That is not science, and it is not very satisfactory.

Turning now to the facts, as far as we know them at the present day, it seems that we cannot do better than adopt the views first enunciated by that great astronomer, Sir William Herschel, that the stellar universe, as we know it, is in the form of a flattened disk, such as might be formed by two watch glasses, and that we are not far from the center of it.

To this statement the last few years have added the additional information that, as we knew it, the universe contains about twenty million stars, interspersed with enormous volumes of gas, some luminous and some not; that the stars are most crowded together at the center, in our vicinity, and diminish in density and perhaps in size as we approach the outer regions. In the central regions the stars are many of them of the so-called solar type, while in the outskirts they are generally of the Sirian or blue type. Many astronomers consider the solar stars to be older and cooler than the other kind. Comparatively speaking, they are few in number, less than one per cent. being of the solar type.

These facts would lead us to believe that the original nebula from which we spring began to condense into stars somewhere in our vicinity, and that the process of star formation is spreading out in all directions from us, having proceeded furthest so far in the direction of the Milky Way. Judging from its spectrum, our sun must be one of the older stars in the universe, but by no means the oldest. It seems to be a fair sized star, as stars go, but on the whole rather below the average, and not to be compared for a moment to such giants as Canopus and Arcturus, which in point of size compare to our sun somewhat as our sun does to the earth.

With regard to the habitability of the various planets, we may say at once that we know nothing about the surface conditions of the four outer ones, save that Jupiter is probably pretty hot, judging from the activity displayed in the formation and disappearance of its various cloud belts. Even on Neptune, the outermost one, the sunlight is fairly intense, and as bright as one of our electric lights at a distance of five or six feet. It would seem from their large masses, rapid rotation and uniformly cloudy atmospheres that they would be especially well adapted to maintain a uniform surface temperature for long periods of time—certainly far better so than the earth.

Of Mercury we know but little, as we can only vaguely trace some of its more distinct surface markings. What little we do know, however, leads us heartily to agree with Mr. Wallace that it would be a most undesirable place of residence. Of Venus we know nothing, save that it has an atmosphere much denser than our own, which is filled perpetually with clouds, completely masking the surface of the planet. From what the geologists tell us, it would seem now to typify pretty closely the conditions through which the earth passed a million or more years ago. While the moon apparently supports considerable areas of vegetation, or something very analogous to it,

we cannot believe that with its very rare atmosphere it can be the residence of any very intelligent life.

Possibly the same may be true of Mars, altho its marvelous canal system, when well seen, certainly gives it a very artificial aspect. In spite of its great distance from the sun, it evidently has a remarkable capacity for maintaining a comfortable surface temperature, as witness the rapidity with which its polar ice caps disappear at the time of the spring thaw. If human beings with no previous preparation can withstand for a few minutes a reduction of three-quarters of the atmospheric pressure, as has been the case in certain balloon ascents, it would certainly seem that by the gradual processes of nature an intelligent race might be bred that would flourish under the comparatively low atmospheric pressure to be found in Mars. What this pressure is we do not know, but it is believed not to exceed one-quarter or perhaps one-eighth of our own.

The present lack of permanent oceans on Mars would seem to have its drawbacks, but this may not have been the case in the past, when the race was young. Indeed, we must probably make up our minds to dispense with our own oceans some time in the future, when our interior has so far cooled down as to be able to accommodate them.

It has been said that if an angel were to have paid a brief visit to the earth once every 100,000 years, he would have come perhaps a thousand times since the earth first separated from the sun, but only once would he have found intelligent life upon its surface. From this we may argue that if we ourselves could now visit one thousand planets that were capable sooner or later of supporting life, on only one of them could we properly expect to find inhabitants of a degree of intelligence equal to that, let us say, of our own ancestors ten or twenty thousand years ago.

From this point of view perhaps we may claim that we really are the most intelligent animals in the universe, at the present moment. At the same time I fear we must admit that there is very little evidence from an astronomical standpoint which can be gathered in support of such a claim.

CAMBRIDGE, MASS