MAN'S PLACE IN THE UNIVERSES: A FURTHER NOTE ON THE VIEWS OF DR. A. R. WALLACE.

DR. A. R. WALLACE, in the number of this REVIEW for March, 1903, gave reasons for reverting to the belief that man occupied a central and unique position in the universe. He considered that this belief had been too hastily abandoned in the light of modern additions to knowledge: that the new facts called for some revision in form of statement merely, and did not necessarily challenge the statement itself. Thus we can no longer regard the earth as fixed, with the heavenly bodies revolving round it as centre, for we now know that the earth itself rotates and also circles round the sun: we know further that the stars are suns similar to our own, and probably have planets revolving round them somewhat similar to our earth. But according to Dr. Wallace it is by no means probable that these planets are inhabited by men; he thinks it quite possible, and even likely, that our earth may be the only inhabited planet in the universe. It is not proposed to recall here most of the arguments he used in support of this view, nor most of the objections to it, some of which were stated by the present writer in the following number of this REVIEW (April, 1903). The purpose of the present article is to give wider publicity to a totally new fact which has since come to light, and which not only has a direct bearing on Dr. Wallace's views, but is in itself of startling importance.

It is an essential part of Dr. Wallace's argument that the universe of stars is of finite dimensions, and that our solar system is situated near its centre. If the first proposition is true, the second cannot be true for long, since the solar system is moving among the stars, and at its present rate would traverse Dr. Wallace's finite universe of stars from end to end in a time not much greater than geologists assign to the life of our earth. Still, the present rate may not be permanent or even lasting; we may be going to turn back presently, and so to oscillate near the centre; if Dr. Wallace likes to assert this, it is impossible to prove him wrong.

What alters the case completely is the recent discovery that the universe of stars is not single, but multiple in character; we are surrounded by not one universe, but *at least two*, and we cannot be permanently at the centre of both, for they are

in relative motion. The only way to render Dr. Wallace's position still tenable is to make the extravagant supposition that the relative motion of one universe with reference to the other is oscillatory; that they are both finite and have approximately the same centre, at which our solar system is placed, and that each stellar universe is oscillating with reference to that centre. This would give the sun a proud position indeed, but we may be pardoned for doubting whether anyone will claim it on his behalf.

The honour of the discovery of a second universe of stars belongs to Professor J. C. Kapteyn, of Gröningen, who devoted his address at the Congress of Arts and Sciences at St. Louis in 1904 to this topic, pointing out how the existence of more than one stellar universe was indicated, without, however, giving details for distinguishing one from another. Following up the suggestion, Mr. A. S. Eddington, recently appointed Chief Assistant at the Royal Observatory, Greenwich, has found it possible to demonstrate the existence of at least two universes, and to estimate their relative numerical strength and relative motion one through the other. His paper was read to the Royal Astronomical Society in November last, and is printed in their *Monthly Notices* (Vol. LXVII., p. 34). It may be added that, before Professor Kapteyn's St. Louis address had been published or otherwise made known to him, Mr. H. C. Plummer, of the Oxford University Observatory, independently pointed out (*Monthly Notices*, Vol. LXV., pp. 566–9) that known facts indicated the existence of more than one universe. We proceed to give a general idea of the method by which such conclusions were reached.

It is a familiar experience, when walking along a road, hoping to be overtaken by a tram or a 'bus, to meet a great number coming in the reverse direction before at last the wished-for lingerer comes up from behind. The phenomenon is not wholly due to the perversity of Providence; our own imprudence in walking on is responsible for a larger share in it than we might think. If we walk forward at four miles an hour, and the 'buses are running at six miles an hour, we shall meet on the average ten for every two that overtake us. This is the "cold calculating rule," viz.:—Add the two paces in one case, and subtract them in the other; any excess over the ratio thus indicated we may then reasonably ascribe to malice on the part of Fate. But it is readily seen that even a small rate of advance will produce a sensible disparity between the number of 'buses meeting and overtaking us; for instance, a gentle saunter of two miles an hour would make the ratio eight to four, or two

to one, which is already conspicuous, while as our pace approaches that of the 'buses themselves the ratio becomes enormous; in fact, if we walk at the same rate as they run, none will ever overtake us at all, though we shall continue to meet plenty. If we walk even quicker than this, we begin to overtake 'buses running in front of us, which will in effect slowly come back to us from the same direction as those we actually meet; both services are approached from the same direction. But there may be more swiftly-moving vehicles—say, motor-cars—which will still overtake us from behind; to these the same rule would apply—add our own pace to the pace of the motor-car (if anyone can gauge it) in the one case, subtract it in the other, and the results represent the ratio of the number of cars met to those which come up squawking from behind.

In short, whatever miscellaneous traffic there may be on the road, provided it is moving backwards and forwards equally, we can calculate the ratio of vehicles which meet us to those catching us up if we know our own pace and the general pace of the vehicles. The proviso should be noted, and we shall presently return to it. The vehicles must not be travelling generally in one direction, like carts on a market day, or it will upset our calculations; they must be moving backwards and forwards equally. Further, the words "general pace" must not be taken as equivalent to average pace in the ordinary sense of average; we must give them rather a special meaning, though we need not stop to consider it here. The important fact for us, indeed, is not that we can calculate our pace, but that we can infer very easily our direction of movement (supposing us to be unconscious of it) by counting the vehicles coming in opposite directions. We are moving in that direction from which come most, and away from that which sends least.

Before applying these considerations to "the stars in their courses" we must modify some important details. We have to be so tiresomely complete in scientific explanations; the artist can leave out a good deal that we have to put in. "Mr. Conductor," Mark Twain is reported to have asked the official of a slow railway in the West, "did you ever see a snail?" "Wy, sutt'nly." "Then I suppose you met him, for you could scarcely have overtaken him!" Artistically, the conception is complete, and conveys at once much of what is above laboriously explained; scientifically, one is driven to call attention to the omitted alternative that the snail might have overtaken the train. Perhaps Mark Twain, knowing Western etiquette, refrained from the more insulting suggestion as being just over the shooting-line.

In the interests of completeness, then, we proceed to note

that the stars do not meet or overtake us—at least, not within human knowledge. No doubt they have done so in the remote past, and will do so again, but in the few thousand years of our acquaintance their total movements have not much altered their apparent positions. But they have moved, and their movements are measurable, even at the immense distances which separate us from them. These great distances merely render the measurement more laborious and more difficult; they do not prevent it. A more important consideration is that the stars are not in general moving straight towards us or from us, as are vehicles on our own road; we see them as we might see these same vehicles from a balloon travelling high in the air, or, to adopt a more modern comparison, from one of the airships which Mr. H. G. Wells has "discovered in the future," and of which Mr. Rudyard Kipling has already written the history. Let us suppose we are travelling in such an airship by night, and regarding vehicles, betrayed only by their lights, travelling in all directions and at all paces below us. By the principle above indicated, we could tell the direction of our own motion (though we might be moving so smoothly as to be unconscious of it) by simply counting the number of lights travelling towards different points of the compass. Having ascertained from which quarter *most* appeared to come, we should know that we were travelling *towards* that point; or, if we prefer it, we might identify the quarter from which *fewest* appeared to come, and this would be the point *from* which we were travelling.

But a new element has been introduced into the discussion, which requires some notice. While still on the road we confined our attention to the vehicles on the same road, which could only go either forwards or backwards. Now that we are in the air we see them travelling in all directions, and it is not quite clear that the rule is still applicable. The necessary modifications are not, however, very serious. By travelling north we shall increase the number of vehicles which appear to come from the north, and diminish those from the south, while the number from east or west will, of course, not be affected. What about those from north-east and north-west? There will be a certain apparent increase, due to the fact that we are half-heartedly sidling in those directions, but the increase will not be so great as northwards. Similarly, for those from south-east and south-west there will be a decrease, but not so marked as the decrease southwards. As we go round the points of the compass there will be one maximum and one minimum, and we can infer our direction of travel as that towards the maximum or from the minimum.

Now that choice of alternatives is the key to the discovery of the new universe. Suppose the second method does not give the same result as the first, what then? That is to say, suppose the maximum—the direction from which most lights are coming—is not precisely opposite to the minimum, how should we interpret the fact? Each direction should indicate, by our rule, the direction of our own motion, and yet we cannot be travelling in two directions at once; there must be something wrong.

In such a case it is necessary to revert to the assumptions originally made, and we remember the proviso to which attention was called a few paragraphs back, that the traffic must be moving indifferently in both directions, or, as we should now re-state it, in all directions. If this is not the case, our rule will not apply, and conversely, if our rule does not apply, the movements, whether of vehicles or stars, cannot be indifferently in all directions—that is to say, the traffic of vehicles or the universe of stars cannot be considered as a uniform whole, but must be made up of portions having different systematic movements.

It might be objected that one alternative has been lost sight of. May not the universe be still single, but be moving as a whole in some direction different from that of the solar system? Might not this introduce two directions of motion to our notice, and so explain the ambiguity observed? The answer is, that of the movement of the universe as a whole we can have no knowledge; we can only deal with its motion relative to us, or, to put it more politely, with our own motion relative to the universe. The general drift of market-carts may recur to us, but it is to be noted that while we are on the road among the carts we are concerned with three things in relative motion—there is the road, as well as the carts and ourselves. If we stand still and note that the carts all come in one direction, we have really noted that there are two universes, one moving relatively to the other, viz., the carts moving relatively to the road. If we climb in our airship and lose sight of the road, the drift of the lighted carts can no longer be interpreted with safety; it might mean equally well that they were all going to market, or that we were travelling away from market. If lamps were lit on the road, we should then once more become conscious of the two universes in relative motion—the carts and the road. And one evidence of their existence would be that the rule for finding our own velocity would give us different results when applied to different objects—those in front and those behind, say; the maximum would not be opposite to the minimum.

In just this way Professor Kapteyn inferred the existence of two sets of stars or universes. His actual words are :—

We thus in reality have determined the apex of the solar motion separately from the stars having direct motion, and from those having retrograde motion. Instead of finding the same point (or opposite points), we find two points lying about 125° apart.

We will conclude that there are two sets of stars. The motion of the sun relative to the mean (the centre of gravity) of the one set differs from that relative to the other set.

It follows that one set of the stars must have a systematic motion relative to the other.[1]

Professor Kapteyn proceeded to give a first approximation to the relative motion of the two streams. The line of approach and recession is that joining our sun to ξ Orionis, and lies almost exactly in the plane of the Milky Way. But he preferred to withhold further details until observations made with the spectroscope, which give a totally independent measure of stellar movements, should be available for confirmation. He added :—

I shall only mention that the way in which I conducted the solution points to the conclusion that all the stars without exception belong to one of the two streams (*loc. cit.*, p. 420).

This abstention does not, however, mean that Professor Kapteyn had not done a very great deal of work and obtained a fair measure of certainty in his conclusions; and with great interest we await the comparison of his unpublished details with those obtained independently by Mr. Eddington—independently in the sense that, though Mr. Eddington had Professor Kapteyn's paper before him, he studied a totally different selection of stars. Kapteyn took the stars which had been observed by Bradley about 1750; Mr. Eddington those observed by Groombridge about 1810. Modern observations compared with these give the movements of the stars in the interval—in the first case about a century and a half, in the second nearly a century. But Mr. Eddington found that his material gave him such consistent and definite conclusions that he has not hesitated to publish them. The reference to his paper is given above, and those who are not afraid of figures and diagrams will find it most interesting reading. Others who dislike figures may still have the patience to read the following attempt to reproduce one of his most effective points.

We have said that when observing a number of objects travelling indifferently in all directions, if the observer is himself travelling north, he will see most come apparently from the north, fewest from the south. Suppose him to represent the number

(1) *Congress of Arts and Science, Universal Exposition, St. Louis*, 1904, edited by Howard J. Rogers, A.M., LL.D., Director of Congresses. Volume IV. (Physics, Chemistry, Astronomy, Sciences of the Earth), p. 419. (Houghton, Mifflin, 1906.)

counted from any direction by a line drawn from a selected origin in that direction as many inches long as the count. The longest line would then be to the north, the shortest to the south, intermediate ones in other directions : and a curve running round the ends of the lines would form an oval boundary. Now when Mr. Eddington drew such a curve for his stars, he found that he did not get an oval at all, but an irregular curve, which some irreverent people, seeing it on the screen, compared to a rabbit. They were so far justified that it had a distinct neck—a contraction near one end which disqualified it as an oval; thus illustrating at once Professor Kapteyn's point that there was more than one stellar system. But the special ingenuity of Mr. Eddington was manifested in a more constructive manner : he took two regular ovals and pieced them together so as to give us a "rabbit" very like the one already exhibited. Taking them apart again, he was able to assign to each the universe producing it. To establish his conclusions firmly he did this six times with different groups of stars, and showed that they indicated satisfactorily the same pair of universes; or, as he prefers to call them, "drifts."

The velocity of the first drift relative to the sun is very much greater than that of the second (ratio 17 to 5) . . . and for this reason the first drift is very much more prominent than the second in the diagrams. But the result of the analysis is to show that they contain nearly the same number of stars, drift II. containing a slightly greater proportion. Another very unexpected result is that the proportion of drift II. to drift I. stars is very nearly constant in the different regions. . . . The distribution of the stars is exceedingly irregular, and we should hardly have expected the two drifts to possess the same irregularities. We know, for instance, that stars are much more numerous near the Galactic plane than elsewhere; we might expect this to be a peculiarity due to one drift alone. Now the Galactic plane passes through region B and part of G, and we see that actually the special abundance of stars there is due to both drifts equally.

Do we belong to one of these drifts more than the other? The disparity in velocity rather suggests that we do. One of them is rushing past us—say, at seventeen miles a second; the other at only five miles. If we are, as Dr. Wallace supposes, at the centre of one of them, we shall remain in that neighbourhood longer if it is the five-miler. But then, what of the other, which contains an equal number of stars and is going the other way? Is there not room for at least one inhabited earth in that too? The new fact is, in all truth, a stupendous one, and brings home to us the immensity of space and time in quite a new way. That two "drifts" of stars should cross each other suggests times when they were separate, and when they will be separate again : and regions of space in which they may move as isolated specks. Has astronomy even vaster ideas than this in store for us in the future?

Without failing in recognition of Professor Kapteyn's claims as discoverer, we may dwell for a few moments with pardonable pride on the share which English astronomers have had in the establishment of these wonderful new facts. Kapteyn's researches were based on the Greenwich observations of our Astronomer Royal Bradley, with whom accurate knowledge of the heavens began. Bradley it was who first demonstrated the motion of the earth round the sun by comparing its velocity with that of light—the discovery known as the aberration of light. He also discovered the mutation of the earth's axis, and (as Mr. Chandler recently showed), was, at his death, on the high road to discovering the variation of latitude. Now his patient observations have led, in the able hands of Professor Kapteyn, to the revelation of another Universe.

The Royal Observatory at Greenwich has also a large and honourable share in the work used by Mr. Eddington, who is himself a recent and brilliant addition to its staff; but the foundations are due to one of our English amateur astronomers, a noble body of whom we have at least as much cause to be proud as of our National Observatory. Indeed, the National Observatory itself owes its origin to them, for it was an amateur astronomer, the Rev. John Flamsteed, who first pointed out the need of such an institution and was put in charge of it when built; and several of the Astronomers Royal who succeeded him, including Bradley, were drawn really from the same class—of which the greatest representative to-day is Sir William Huggins, recently President of the Royal Society. Devotion to science is happily peculiar to no country; but we look with pride on the long roll of Englishmen who, being possessed of a modest competence or of considerable wealth, have devoted their lives to astronomy. Of such was Stephen Groombridge, "astronomer and West India merchant," in the terse phraseology of the index to the Dictionary of National Biography. We can, perhaps, spare a few moments to glance at a portion of his record, as given in the annals of the Royal Astronomical Society at his death in 1832:—

> The late Stephen Groombridge, Esq., was well known for many years to this Society as one of the most laborious and intelligent of our members, and a sincere and early friend to our Association, in the formation of which (1820) he took a prominent share.
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> In the year 1806, he became possessed[1] of a splendid transit-circle, of four

(1) The instrument was set up at Blackheath. The house now used as a club—the Point House Club—near the top of Blackheath Hill, has two windows obviously constructed for the use of an astronomer (one in what is now a bath-room), and is said to have been Groombridge's at one time. But it was not there that he set up his transit-circle: the aspect was not favourable. His transit-circle observations were made in Eliot Place.

feet in diameter (the workmanship of our celebrated Troughton), so well known by his name and the excellent use to which he applied it; and he immediately commenced the task of forming an exact catalogue of the stars as low as the 8·9 magnitude within 50° of the North Pole.

In this arduous undertaking he persevered with singular assiduity for ten years, and in the year 1816 had completed about 30,000 observations in right ascension, and the same number in declination, on this part of the heavens —a series almost without a parallel in the annals of modern astronomy.

But Mr. Groombridge was not inclined to be satisfied with merely registering his observations : he applied himself with equal industry to the harassing labour of reduction, on which ten years more were exhausted, until, in 1827, he suffered a severe attack of paralysis, from which he never completely recovered.

Fortunately the work was completed and published by the assistance of a grant from the Board of Longitude, and on the dissolution of that Board, continued by "the Lords of the Admiralty, with the readiness which has always so honourably distinguished their Lordships." The catalogue was published in 1838.

Such is the brief record of a heroic piece of labour, of which the labourer did not even see the completion, and of which he could never have hoped to see the fruits. For these could only come long after his death, when his patient observations were compared with others made after a sufficient interval. A valuable comparison of this kind was made at the Radcliffe Observatory, Oxford, about 1845 ; but the comparison used by Mr. Eddington was made after a much longer interval at the Royal Observatory, Greenwich. One of the famous star catalogues produced by our National Observatory at intervals of about ten years was devoted to the re-observation of Groombridge's stars and was published in 1900. To render the comparison of old and new more accurate and effective, the whole of Groombridge's calculations or "reductions" of his observations were revised in the light of modern knowledge, so as to make the best possible use of the material. The names of two members of the Observatory staff, Mr. F. W. Dyson (then Chief Assistant, but since appointed Astronomer Royal for Scotland) and Mr. W. G. Thackeray, are honourably associated with this work, which appeared in 1905. The result of it all is the admirable series of "proper motions," by means of which Mr. Eddington has divided the universe into two.

It is pleasant to record above the substantial aid accorded by the Lords of the Admiralty in this work. Not very long ago a less sympathetic attitude was manifested in high quarters towards the work carried on at our National Observatory, and similar researches, as not directly useful. It is true that we can as yet make but little use of the knowledge that there are two separate star drifts now that we have got it; but it is also true that we

may find it useful in some unforeseen way in the future. Who can tell? The discussion is not very profitable, and the existence of men like Stephen Groombridge reminds us that the desire for an immediate and useful outcome for scientific work is, at any rate, not universal. But one does not willingly forego the sympathy even of a portion of the community; and the writing of the earlier paragraphs of this article suggested incidentally a very definite prospect of usefulness for astronomical work of the highest accuracy which may be worth setting down here. We talked of future airships and imagined ourselves looking down from one on the lights of the earth below us and watching our course. If the future has these conveyances in store for us (and we have already reached the stage when newspapers are offering prizes for them), the early voyages will no doubt be guided in this way by watching earthly lights. But these will only correspond to the coasting voyages of the early navigators, when they dared not venture out of sight of land. Are there not, literally, higher flights possible to our imagination? May our grandsons not wish to put right out to air and leave the earth out of sight below the clouds? If so, they may have to guide their course by the place of the moon among the stars. The seaman's horizon has disappeared and they may not be able to find a substitute. They may find some way (say) of dropping something and watching its flight, which will satisfactorily indicate the vertical (and so the horizon); but this may not be found practicable, and they may have to go back to observations of the moon. In that case, all the refinements of our present astronomical skill will not be of much service: we must improve our apparatus for observation certainly, and probably our theoretical knowledge very considerably, before this method of steering an airship can be rendered practicable. All the researches which appear to have gone beyond usefulness for the sailors on the sea to-day may prove of vital importance to the sailors in the air that are to come.

Is this too imaginative? We are told by Mr. Wells that we are not nearly imaginative enough, and that we should gain by allowing a wider outlook to fancy. We certainly benefit in many ways when we allow him to act as guide; and yet, in thanking him for many pleasant hours, may a matter-of-fact astronomer ask why he and other writers have always stopped short at a certain point in their exciting flights of fancy? Videlicet, when they take us to the moon, it is always in some uncomfortable conveyance which leaves the earth behind: either M. Jules Verne's projectile, or the "repulsive" *Astronef* of Mr. George Griffith, or the "Cavorite" sphere of Mr. Wells himself. Why should we not go without disturbance on the earth itself, with all

our friends around us, to visit some other member of the solar system or of some distant star? It only needs some control of the law of gravitation, which is a mere trifle already familiar to these writers. And if they fear to leave the warmth of the sun, we could use radium to warm us; or, better still, why not take the sun with us too? And so by stretching our imagination further and yet further we have come back to the region of solid, sober fact; for this is exactly what we are doing. Sun and earth and planets—we are all travelling together to visit (let us hope at a respectful distance) other systems; and the latest bulletin of our journey is that we have a double series of visits to pay instead of one only. Dr. Wallace has claimed the universe for Man by tethering him to the centre of it. As though in protest, the universe has disclosed itself to us as two. We cannot be fettered to both: shall we not be content to believe that we have the freedom of both?

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